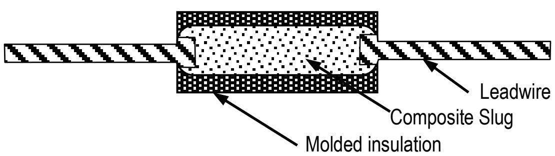
RCD SERIES CC
GENERAL APPLICATION GUIDE

RESISTORS • CAPACITORS • COILS • DELAY LINES

The following information has been compiled to aid in the selection and application of RCD hot-molded carbon composition resistors. Although some of the information can be applied universally to all composition resistors, the special high-density composite slug that makes up the Series CC resistance element, enables ratings of surge energy, peak voltage levels, and operating temperature ranges that are above some other carbon resistor models. This guide should be helpful in evaluating the use of RCD's carbon composition resistors in broad general terms, and are not to be interpreted as precise. The guide is only intended to offer assistance as a starting point toward the selection of the proper size resistor. RCD recommends that the customer thoroughly evaluate a suitable quantity of product under worst case conditions to ensure that the product fully satisfies all design/ performance/ safety/ etc. aspects of the application, and employs a suitable safety margin to achieve utmost reliability.

1. Pros and Cons of Carbon Composition Construction



Series CC Cutaway Illustration

RCD's carbon composition resistors offer excellent surge and high-frequency performance due to the bulk nature of the resistance element. Unlike wirewound and film resistors, there are no windings of resistance wire, nor any film depositions to open under overload pulses. Since the resistance element is a hot-molded solid core comprised of resin and carbon slug, without helical turns of resistance wire or film, the inductance is extremely low, essentially the same as a straight piece of wire. The trade-off for the excellent surge and high-frequency capability at such a low cost is a rather unstable environmental performance, particularly in humid environments, a condition well-known by most circuit designers. Carbon composition resistors therefore should not be utilized in precision applications, which are generally better suited by other resistor families (such as RCD's PR Series or CFZ Series). There is no single resistor family however that offers the unique specialty performance levels of the composition construction, but depending on circuit requirements, other models will often provide a suitable replacement.

2. Moisture/ Humidity Considerations

a. Resistance changes due to humidity/ moisture can be positive or negative (mostly positive) and is usually reversible by conditioning the resistors at 100-105°C or by dry storage. The military specification addressing carbon composition resistors (MIL-R-39008) specifies...

> **"6.9 Out-of-tolerance resistors. Resistance shifts due to absorption of moisture are inherent in carbon composition resistors. Before being considered failures, out-of-tolerance resistors should be conditioned in a dry oven at a temperature of 100°C +5°C for the duration shown below prior to conducting resistance measurements".**
>
> **Style RCR05 25 ±4 hours (1/8W model)**
> **Style RCR42 130±4 hours (2W model)**
> **All other styles 96 ±4 hrs (1/4W, 1/2W & 1W models)**

Some customers have had satisfactory results by baking 12-24 hrs at 110-120°C instead of at the longer periods listed by the Military specification. Regardless of the amount of baking, some units may not return to the original value.

b. Typical levels of shift due to the absorption of moisture is generally less than 10% after 10 days of cycled humidity at 80-100% RH levels. Low and medium-value composition resistors typically exhibit less change due to humidity than high-value resistors. Parts should be stored in low humidity conditions (45% RH max). Conditioned (dry) resistors are the most sensitive to humidity.

c. In operation, moisture absorption is minimized by operating the resistors with as little as 1/8th rated wattage load (the self-heating effect causes parts to dehumidify).

3. Leadwire Forming and Mounting Span-

Leadwires are molded into the carbon slug. The connection of the leadwire to the carbon is critical to achieve proper accuracy and stability. As such it is important not to impart stress to this joint during forming/ mounting/ soldering operations. The axial lead should remain straight for at least 2mm from the body extremity on 1/4W and 1/2W models, 3mm on 1W models. More importantly, it is crucial to provide proper strain relief during the bending operation to ensure that excessive pulling or bending forces are not applied to the termination. The typical result of excessive force is a positive shift in excess of 2-3%.

4. Soldering Considerations

a) Resistance changes due to soldering can be positive or negative (mostly positive) and may be permanent if the resistor has excessive moisture present in its body. This can be greatly minimized if resistors are dry at the time of soldering. Thus, it is recommended that parts be conditioned just prior to wave soldering, as per Sec.2.a above.

b. RCD recommends rinsing parts in alcohol instead of aqueous-based cleaning processes to prevent the absorption of moisture.

c. The level of resistance shift due to soldering is typically 2-3% or less (when leadwires are immersed 4mm from body in 245°C solder pot for 3 seconds). Higher levels of shift may indicate damage due to excessive heat or entrapped moisture.

d. Although moisture may be "baked out" during the soldering operation, it is important not to heat the parts too rapidly or this can cause the moisture in the package to vaporize. The resulting pressure can exceed the yield strength of the molding material which can cause electrical or physical damage. Electrical damage is generally detected as a large positive shift. Visual defects are generally not obvious, but may include cracked package, missing package material, bulging or deformed package (visual anomalies do not necessarily imply device failure).

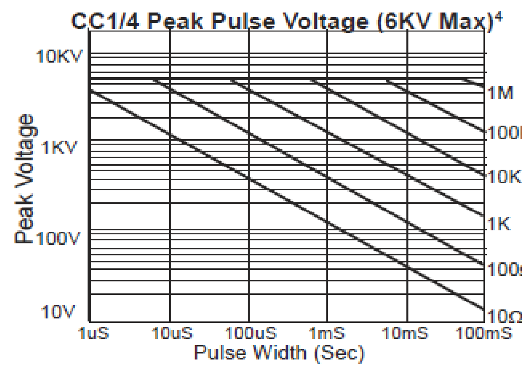
5. Specifying the Most Appropriate Resistance Tolerance

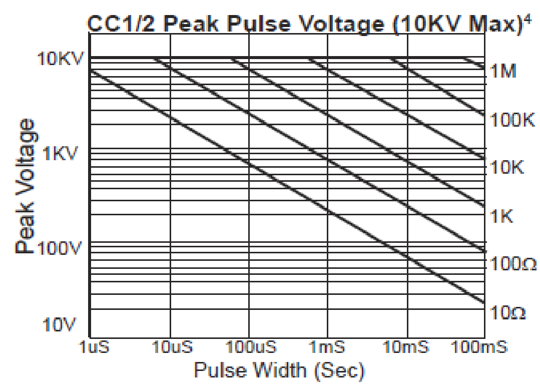
In order to prevent "false negatives" (i.e. parts being rejected as "out of tolerance" that are actually within the expected guidelines of temporary shift), the general practice utilized by most circuit designers, is to specify 5% parts for 10% circuit board accuracy levels, and (far more commonly) to specify 10% parts for 20% circuit board accuracy levels. Specifying 5% tolerance resistors for applications that actually require 5% circuit board accuracy is not recommended due to the shift associated with moisture, soldering, forming, etc. In these cases, RCD can provide customized conditioning, cut & forming of the leadwires, specialty dry-packing, and/or screening to a tightened tolerance level. The cost for these specialty options can easily outweigh the cost of the parts themselves, especially the lower-cost 1/4W and 1/2W models, so a different product family is often the better choice.

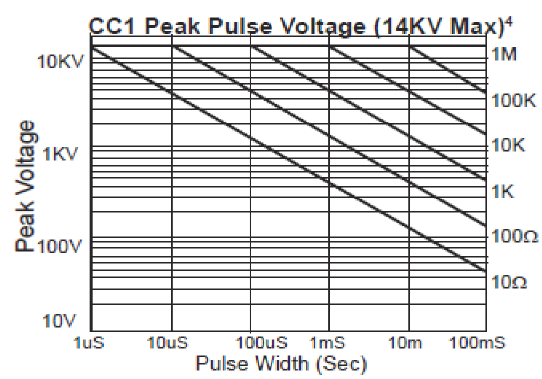
6. Surge Capability

a. Surge performance is excellent due to high density composite slug element. Depending on size, resistance value, pulse waveform, etc., the CC series is capable of pulses up to a peak 20 joule 14KV rupture level. Design engineers should employ a suitable safety factor (i.e. a minimum of 25-50%, or greater for repetitive pulse streams) to ensure stability and reliability. Consult factory for assistance.

b. **Peak Pulse Voltage**: the charts below indicate the maximum peak pulse (rupture) voltage based on a capacitive discharge non-inductive circuit. The pulse width equates to one RC discharge time constant. For square wave pulses, derate the pulse width by 50% on charts below (e.g. if a part is capable of 1KV pulse for 1mS in a capacitive discharge, it is capable of 1KV pulse for 0.5mS square wave surge).







c. **Pulse Energy**- The typical rupture joule levels are as follows. The ratings are dependent on resistance value, pulse waveform, repetition rate, and environmental conditions (ambient temperature, humidity, and altitude).

CC1/4 1.8 joules
CC1/2 6.4 joules
CC1 20 joules

7. Load Life Stability

Resistance change due to load life is permanent and can be in positive or negative direction (usually ultimately negative except low values which tend to be positive). Resistance change due to load life can be minimized by utilizing a 50% derating. This same result can be attained by limiting the maximum operating surface temperature of the resistor under load to 100°C. Typical shift for resistance values below 1megohm after 1000 hrs at full-rated cycled power (not to exceed the voltage rating) is approximately 5% (10% max). Higher values typically shift more, roughly 8% (not to exceed 15%).

8. Product Options-

a. **Hi-Rel Screening and Burn-In-** Series CC resistors are available with a host of screening/burn-in plans to achieve improved stability and reliability levels. The most common of these is Option #37, which subjects the lots to Group A screening per MIL-R-39008. Even more stringent screening plans for critical-use applications such as military/medical/aerospace applications are available.

b. **RoHS & Tin-Lead Termination Finish**- the standard construction is RoHS-compliant with 100% tin-plated copper leadwires. As an option, the resistor leadwires can receive a tin-lead finish (specify termination ‘Q’).

c. **Various Options**- Series CC are available in a variety of cut&formed shapes for horizontal or vertical mounting; various packaging and tape/reeling options; hot solder-dipped leadwires for improved solderability and shelf-life; non-standard resistance values; increased voltage capability; flameproof encasement; custom marking, etc.

9. Safety Considerations

a. Among other things, the circuit design needs to include failsafe mechanisms to ensure safety, especially if the product is to be used in equipment where a defect may cause significant damage, such as damage to vehicles, traffic lights, medical equipment, aerospace equipment, heating systems, combustion/gas equipment, etc. The products are not designed for use in life-saving or life-sustaining applications.

b. These products generate joule heat when energized. Position these products so that their heat will not affect other components or the PCB.

c. Series CC are not considered as failsafe or flameproof.

10. Temperature Rise

a. The estimated average body temperature rise is as follows (depends on PCB material, mounting geometry, etc.)...

CC1/4 140°C per watt (1/4W = 35°C + ambient temp.)
CC1/2 100°C per watt (1/2W= 50°C + ambient temp.)
CC1 50°C per watt (1W= 50°C + ambient temp.)

b. Resistors should be mounted away from each other and other heat-generating components to achieve the best performance and reliability.

11. Thermal Stability

a. The Temperature Coefficient of Resistance can be positive or negative. The TCR is generally lower around room temperature and the amount of shift increases as the temperature increases or decreases. Typical TC is less than 0.1%/°C over the 20 to 60°C instrument range.

b. Low values typically have the best TCR. For example, the typical temporary shift due to increasing the temperature from 25 to 100°C for values below 1Kohm is estimated at 5%; 10Kohm 7%, 100Kohm 10% , 1Megohm 13%.

12. High Frequency Characteristics

The carbon composition construction typically has the lowest inductance and highest operating frequency of the various resistor constructions. Depending on the resistance value and size, operating frequency is typically 0.1-100MHz with lower values offering the best performance.

13. Voltage Coefficient

a. The voltage coefficient is relatively consistent but is not linear, especially when tested at low voltage levels. When tested at .1 and .9x rated voltage, the VC is typically -.02% to -.1% per volt.

b. In conditions where both significant voltage and elevated temperature are present, the voltage coefficient and temperature coefficient can sometimes cancel each other out (depending on resistance value, etc.)

14. Effects of Radiation

RCD has no direct experience or test data regarding the effects of radiation. It is our understanding that resistance changes on the order of 5% to 10% have been observed on carbon composition resistors when exposed to nuclear reactor radiation of $10^{12} – 10^{14}$ n/cm^2, or proton accelerator radiation of 2.5 x 10^4 - 5 x 10^5 rad, and no significant damage from gamma radiation of 5 x 10^4 - 10^7rad.

15. Intended Use

a. Series CC is manufactured for use in general electronic equipment, and not intended for use in oil, water or solvent environments; direct sunlight or outdoors; in salty air or air with high concentration of corrosive gas; ESD and electromagnetic environment; high humidity or where the products can by subject to or cause dew condensation; sealed/coated circuits.

b. When used according to published ratings and recommendations, RCD's Series CC Carbon Composition resistors offer excellent reliability.

RCD Components, Inc. 520 East Industrial Park Drive, Manchester, NH, USA 03109
Tel: (603) 669-0054 Fax: (603) 669-5455 www.rcdcomponents.com