This specification is intended to be utilized in conjunction with Series CF & MCF data sheets.

RESISTOR SPECIFICATION

RCD Series CF, MCF
Carbon Film Resistors

RESISTORS • CAPACITORS • COILS • DELAY LINES

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RCD CF/MCF SERIES CARBON FILM RESISTORS

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1.0 SERIES CF PRODUCT HISTORY

RCD's CF Series was first introduced in 1978 as a substitute for carbon composition resistors. Although priced under half of the composition style, the carbon film construction resulted in improved performance especially in regard to Moisture Resistance, Noise, and Temperature Coefficient.

The CF Series has been constantly improved and expanded to achieve greater stability under various environmental conditions, a wider range of resistance values (up to 100MΩ on special order), miniature sizes, and surface mount designs (Series MCF).

RCD offers the widest range of Carbon Film resistors in the industry, the majority of which are available from stock.

2.0 PRODUCT DESCRIPTION

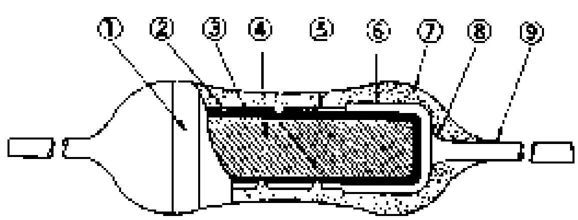
- Carbon film resistors are the lowest cost resistors available
- Designed for general purpose requirements
- RCD is the only company that offers a wide range of custom options on carbon film resistors including non-standard values, cut & formed leads, increased voltage, increase pulse capability, military screening, etc)

3.0 DESIGN FEATURES

- Tight distribution of resistance resulting from precision trimming equipment
- Low temperature rise resulting from use of high grade ceramic cores
- Low noise and high mechanical strength resulting from welded construction and high grade ceramic
- Improved temperature stability over competitive models
- Resistance to moisture, solvents, abrasion, and temperature extremes resulting from multilayer epoxy coating
- Flame retardant materials
- Miniature sizes
- Jam-free compatibility with all makes of automated processing equipment due to tight dimensional control and uniform taping
- Excellent high frequency performance

4.0 CONSTRUCTION AND MANUFACTURING PROCESS

The simple design and construction of the CF Series results in excellent reliability. In the first phase of production, the ceramic rods are exposed to gasified hydrocarbon compounds and heated to 1000°C which forms a carbon film on the surface of the ceramic. The carbonizing process is custom tailored to meet specific resistivity levels. Once the ceramic rods have undergone the degree of carbonizing required, metal caps are press fit onto each end. During the next stage the resistance film is trimmed to the required resistance value by cutting a helical groove around the body. Leads are automatically welded to the end caps (except MCF surface mount styles), and then processed through coating and color banding operations. Product is automatically tested to ensure zero defects.



1. Color code band
2. Spiral cutting point
3. Carbon film
4. Ceramic body
5. Subcoating
6. Iron cap
7. Epoxy coating
8. Welded point
9. Solder coated copper wire

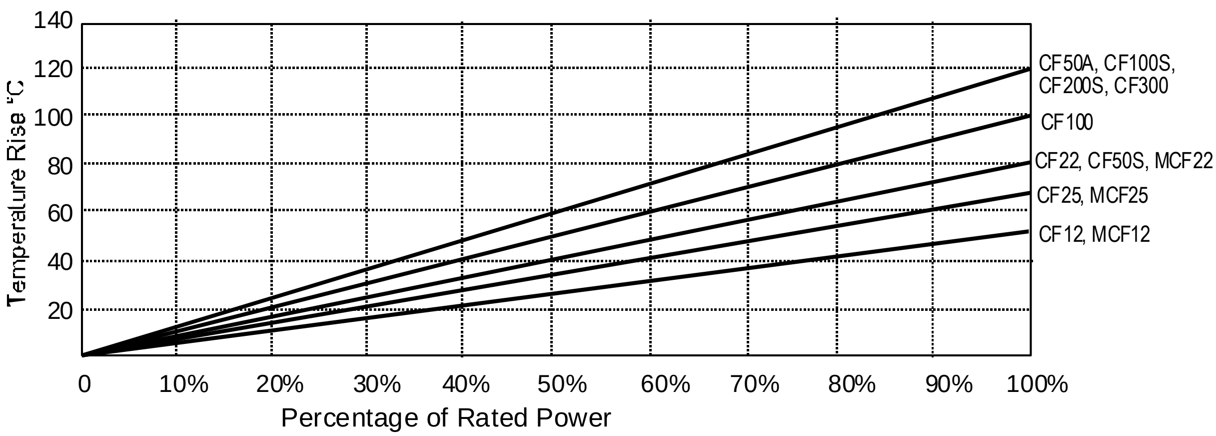
5.0 QUALITY CONTROL

As part of RCD's ABZED program (ABsolute ZEro Defects), all key stages of production are monitored by Statistical Process Control (SPC) to ensure optimum uniformity. In addition, product is 100% tested on an automated basis, which enables RCD to achieve SIX SIGMA (3ppm) or better quality levels. In addition, RCD performs an outgoing inspection on packaging, labeling, and taping quality to ensure 100% compliance.

Refer to Section 8 “Reliability/Failure Rate” for additional information.

6.0 TEMPERATURE RISE

The temperature rise of low power resistors, particularly surface mount models, depends largely on heat conduction through the leads or end terminations, which can vary significantly depending on PCB material and layout (i.e. pad size, trace area, copper thickness, air flow, etc.). It is recommended to evaluate product in actual use conditions to ensure that the proper component and PCB layout is utilized.



7.0 ELECTRICAL, ENVIRONMENTAL, AND MECHANICAL PERFORMANCE

7.1 Terminal Strength

The terminal welds shall not break, loosen, or other physical damage when tested per MIL-STD-202 Method 211, pull test and twist test. Direct load (as specified for equivalent body sizes in MIL-R-10509) shall be 2 pounds on 1/8W through 1W sizes, and 5 pounds on 2W and larger sizes.

7.2 Solderability

When resistors are tested per ANSI-J-STD-002 Cat.1, the dipped surface of the lead shall be at least 95% covered with new solder coating.

7.3 Solvent Resistance

When resistors are tested as specified in MIL-STD-202 Method 215, there shall be no mechanical damage and the markings shall remain legible.

7.4 Resistance Measurement

When measured at 25ºC ±2ºC, the reading must be within the specified tolerance of the nominal value.

7.5 Temperature Coefficient

When measured at 25ºC and +85ºC the TCR is negative (except on low values) and shall not exceed the limits in the following table (referenced to 25ºC)...

Temperature Coefficient	CF12, CF22, MCF10, MCF12, MCF22	CF25, CF50A, MCF25, MCF25S	CF50S, CF100S, CF100, CF200S, CF300
±400 ppm/ºC	<470Ω	≤10KΩ	≤22K
≤600 ppm	470Ω to 470K	11K to 150K	24K to 470K
≤800 ppm	51K to 470K	160K to 1.3MΩ	510K to 2.2MΩ
≤1400 ppm	510K to 1M	1.5MΩ to 5.1MΩ	2.4M to 10MΩ

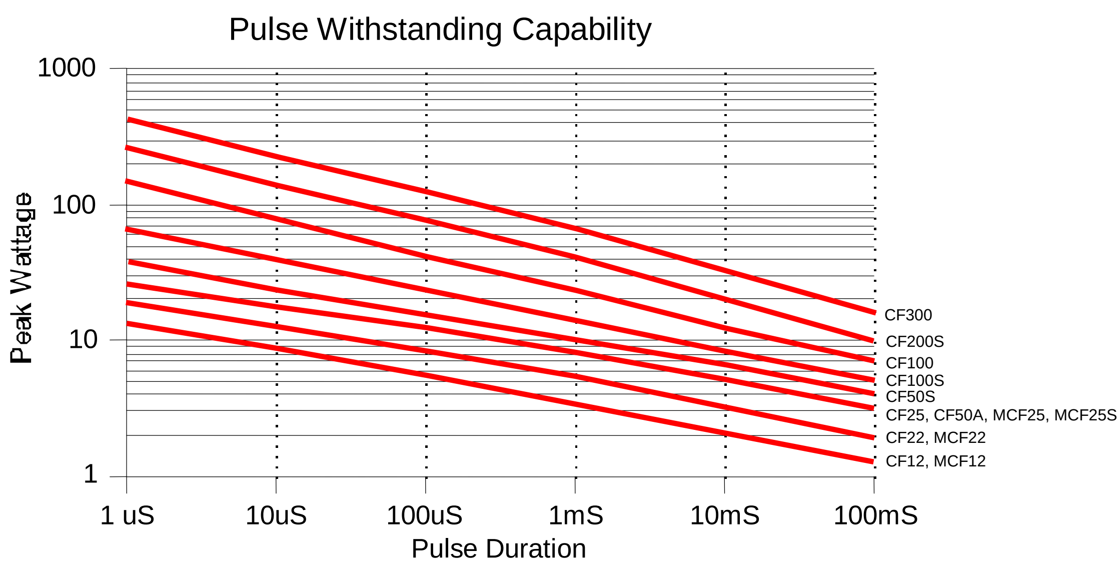
7.6 Thermal Shock

When subjected to 5 cycles from -55ºC to 125ºC per MIL- STD-202 Method 107 Condition B, the resistance shift shall not exceed 2%, and no physical damage.

7.7 Short Time Overload & Pulse Capability (Refer to **CFZ Series** for high pulse version)

When subjected to 2.5 times the DC voltage rating (but not to exceed the specified "maximum overload voltage") for 5 seconds, the resistance value shall not shift more than 1% +.05Ω (5% on mini sizes CF22, CF50A, CF100S, MCF22, and MCF25S), and no arcing, charring, or other physical damage.

For shorter term pulses utilize following chart as guide. Pulse capability is dependent on resistance value, waveform, repetition rate, temperature, current, etc. (refer to Engr report R-42 for derating factors). Consult factory to ensure optimum component selection. Chart is based on non-repetitive pulses, 25ºC ambient, with voltage levels not exceeding 600V CF12/MCF12/CF22/MCF22; 750V CF25/MCF25/CF50A/MCF25S; 850V CF50S; 1KV CF100S; 1.2KV CF100, 1.5KV CF200S; 2.5KV CF300. A specialty design which enables increased pulse capability is available (refer to CFZ Series).



7.8 High Temperature Exposure

When subjected to 125ºC for 100 hours, the resistance value shall not shift more than 3% +.05Ω and marking shall remain legible.

7.9 Moisture Resistance

When tested per MIL-R-11 Par. 4.6.9, the resistance shift shall not exceed the following range...

10Ω to 56K 2% Max.
>56K to 470K 3% Max.
>470K to 10M 5% Max.

7.10 Load Life

When subjected to full rated power at 25ºC (cycled 1½ hours on, ½ hour off) for 1000 hours, the resistance value shall not shift more than 3% (+.05Ω) on standard sizes, and not more than 5% (+.05Ω) on "mini" sizes (CF22, CF50A, CF100S, MC22 and MC25S).

7.11 Vibration

When subjected to Vibration per MIL-STD-202 Method 201 (6 hours), the resistance value shall not shift more than 1% and no mechanical damage.

7.12 Dielectric Withstanding Voltage

When tested per MIL-STD-202 M.311 using V-block mounting, there shall be no evidence of flashover, mechanical damage, arcing, or insulation breakdown. Dielectric rating is as follows...

300V CF12, CF22, MCF10, MCF12, MCF22
500V all others

7.13 Insulation Resistance

Insulation resistance shall be 10,000 MegΩ Minimum, when tested per MIL-R-11 Par.3.11.

7.14 Voltage Coefficient

Typical levels are given for CF25 - CF50S and MCF25 -MCF25S. The voltage coefficient typically varies inversely to body size, i.e. larger parts generally have lower VC. VC is measured at 10% rated voltage and 100% rated voltage.

1KΩ	-14 ppm/V
10KΩ	-12 ppm/V
100KΩ	-10 ppm/V
1MΩ	-8 ppm/V

7.15 Noise

Typical levels are given for CF25-CF100. The current noise level is a function of construction, resistance value, body size, and operating frequency. The noise level typically varies inversely with body size, i.e. larger parts generally have lower noise levels. Higher values exhibit higher noise levels. Higher operating frequencies generally exhibit lower noise levels.

1KΩ	-20 dB
10KΩ	-15 dB
100KΩ	-5 dB
1MΩ	+5 dB

7.16 Operating Temperature Range

-55°C to +155°C

7.17 Power/ Voltage/Current Derating

Derate 1.18%/°C when ambient temperature exceeds 70°C (CF100S & CF300 derate 0.87%/°C above 40°C).

7.18 Flame Retardancy

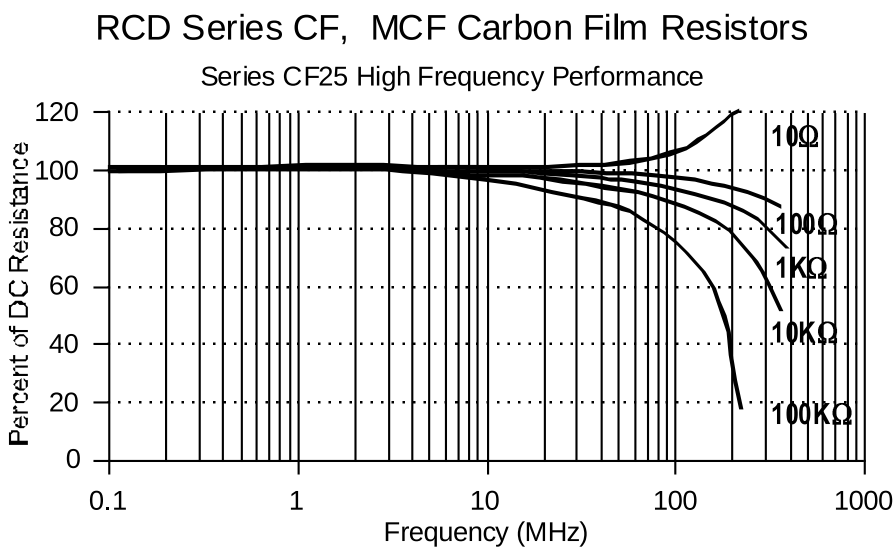
Series CF and MCF are flame retardant in accordance with UL-94-V1. Series CFF meet the requirements of UL-94-V0.

7.19 Shelf Life

Typical shelf life stability is better than 1% ΔR/year

7.20 Reactance and High Frequency Performance

The reactance of RCD's CF Series is primarily capacitive, typically .1pF to . Lower values may be inductive at high frequencies. External factors such as length of leads, layout of the circuit, stray capacitance, etc., may have a significant impact. Typical high frequency performance is given in the following chart.



8. RELIABILITY / FAILURE RATE

Reliability is affected by the applied voltage and operating conditions. When this product is to be used where moderate to high reliability is required, it is recommended that the maximum voltage/wattage/current be limited to 50% or less of the rated levels. When using alternating current, the peak voltage should be limited to the maximum working voltage. RCD offers military screening and burn-in options for improved reliability.

8.1 FAILURE RATE DETERMINATION

For resistors, the failure rate is generally specified in failures per million hours. Another common method is to specify % failures per 1000 hours of testing. For example a failure rate of 0.1% per 1000 hours when tested under load life conditions means 0.1% of parts fail each 1000 hours of testing. Other measures utilized in reliability analysis are FIT (Failure In Time), MTTF (Mean Time To Failure), and MTBF (Mean Time Between Failure). 1 FIT = 1 failure per billion hours. FIT = FR x 1000 (if FR=1 per 10^6 hours this equates to 1000 FITS). The MTTF is the reciprocal of the failure rate, MTTF = 1/FR (if FR= 0.1 per10^6 hours then MTTF= $10x10^6$ hours). 100 FIT = .01% per 1000 hours = 0.1 failures per million hours = 100 failures per billion hours = 10 million hour MTTF. Note: MTBF differs from MTTF by including the length of time required to replace or repair failing units in the end product. Since the repair time is generally insignificant, MTTF is essentially equal to MTBF, and therefore used interchangeably.

The failure rate of resistors is related to 5 major factors...

- Ambient Temperature
- Power Dissipation
- Resistance Value
- Quality Factor
- Environmental Factor

1. **Ambient Temperature**: higher temperature levels result in increased stress on the resistance element and subsequently an increase to the failure rate.

2. **Power Dissipation**: The general rule of thumb towards achieving high reliability is to derate parts by 50% (i.e. in actual use the parts should only dissipate half of their rated wattage). The higher the wattage dissipated, the higher the temperature rise and stress level on the resistance element. The "base" failure rate is considered to be the failure rate attributable to ambient temperature and power dissipation.

3. **Resistance Value**: In many types of resistors, particularly wirewound and thin-film models, higher resistance values are more susceptible to stress, weak welds, etc., and therefore exhibit increased failure rate levels. Non-Inductively wound parts generally exhibit higher failure rates since they're wound with finer wire sizes.

4. **Quality Factor**: Parts that are manufactured according to one Military specification may have a different failure rate than those manufactured per a different Mil-spec or a commercial spec. This is due to different processing controls and conditions as well as varying amounts of testing and burn-in. RCD's standard commercial-grade failure rate can be improved by specifying Mil-style screening (available as an option on most product families).

5. **Environmental Factor**: the failure rate of components is highly dependent on how the part is used. For instance, if a part is utilized in a piece of test equipment that is located in an office, hospital, or laboratory with controlled temperature and humidity, the failure rate will be much less than parts utilized in unsheltered Naval applications, helicopters, and cannon launchers.

Estimated failure rate (FR) based on actual use conditions may be determined using the formula...

$$FR = B \times R \times Q \times E$$

B = Base failure rate
R = Resistance factor
Q = Quality factor
E = Environmental factor

B: Base Failure Rate

Ambient Temp (°C)	B @ 10% rated wattage*	B @ 30% rated wattage*	B @ 50% rated wattage*	B @ 70% rated wattage*	B @ 90% rated wattage*
20	.00073	.00091	.0011	.0014	.0017
40	.00088	.0011	.0014	.0017	.0022
70	.0012	.0015	.0019	.0025	.0032

* or percent of rated voltage when resistance exceeds critical value

R: Resistance Factor

Resistance Range	Multiplier
<100KΩ	1.0
100KΩ to 1MΩ	1.1
>1MΩ to 10M	1.6
>10M	2.5

Q: Quality Factor: Multiply base rate by 5 for standard parts, multiply by 1 for option 38 parts (option "38" is high reliability Military-screened version and includes burn-in)

E: Environmental Factor

Multiplier	Description	Multiplier	Description
1.0	Ground use, temp. and humidity controlled	4	Cargo Plane
2.0	Ground use, fixed	8	Fighter Jet
8	Ground use, mobile	19	Helicopters
4	Naval use, sheltered	10	Missile Flight
14	Naval use, unsheltered	28	Missile Launch

EXAMPLE: Type CF25 100Ω to be utilized at 0.125W (50% rated power) at 40ºC in controlled environment...
FR= BxRxQxE B= .0014, R= 1, Q=5, E= 1
Failure Rate = .0014x1x5x1 = .007 failures/10^6 hours = 7 FIT
MTTF= 1÷FR = 143 million hours
The same part with Option 38 Mil Screening would have 714 million hour FR (1.4 FIT)