This specification is intended to be utilized in conjunction with Series RSF & RMF data sheet.
http://rcdcomponents.com/rcd/rcdpdf/rsf&rmf.pdf

RESISTOR SPECIFICATION

RCD Series RSF & RMF
Metal Oxide Film Resistors

RESISTORS • CAPACITORS • COILS • DELAY LINES

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RCD RSF/RMF SERIES METAL FILM RESISTORS

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1.0 PRODUCT HISTORY

RCD's RSF Series was introduced in 1981 as a low-cost replacement for medium power wirewound resistors. Although priced under half of the wirewound counterparts, the metal oxide film construction resulted in performance levels that were nearly equivalent.

The RSF Series has been improved over the years to enable improved accuracy and temperature stability. In addition, the series has been expanded to include a wider range of resistance values and sizes, flameproof construction, miniature sizes (Series RMF) , and surface mount designs (Series MPF).

RCD offers the widest range of Metal Oxide Film resistors in the industry, many of which are available from stock.

2.0 PRODUCT DESCRIPTION

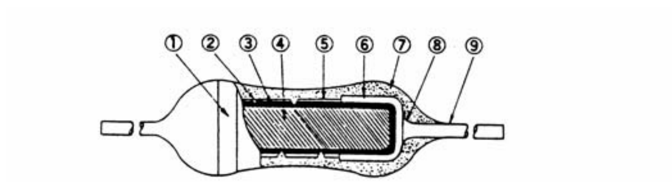
- Series RSF/RMF are the lowest cost medium-power resistors available
- Designed for semi-precision applications
- RCD is the only company that offers a wide range of custom options on metal oxide film resistors including non-standard values, cut & formed leads, increased voltage, increase pulse capability, 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 (available to 50 ppm/ºC)
- Resistance to moisture, solvents, and temperature extremes
- Flame retardant multilayer coating
- 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 RSF/RMF Series results in excellent reliability. In the first phase of production, the ceramic rods are deposited with a metal-oxide complex film matrix (tin and NiCr oxide) utilizing a proprietary vacuum film-coating technique (nickel alloy utilized on low values). The deposition process is custom tailored to meet specific resistivity levels. Once the ceramic rods have undergone the degree of metalization 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, and then processed through coating and marking operations.



Typical Contruction
Series RSF & RMF

1. Marking
2. Spiral trim
3. Resistive Film
4. Ceramic body
5. Film treatment
6. Plated steel cap
7. Flameproof coating
8. Weld point
9. Solder coated copper leads

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. Upon completion, product is automatically tested, enabling RCD to achieve SIX SIGMA (3ppm) 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

Refer to charts given on data sheet http://rcdcomponents.com/rcd/rcdpdf/rsf&rmf.pdf . Note: the temperature rise of low power resistors, particularly the smallest sizes, 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 proper component and PCB layout.

7.0 ELECTRICAL, ENVIRONMENTAL, AND MECHANICAL PERFORMANCE

7.1 Terminal Strength

The terminal welds shall not break, loosen, or exhibit other physical damage when tested per MIL-STD-202 method 211, pull test. Direct load shall be 5 pounds.

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 25°C ±2°C, and 3/8” from the ends of the resistor body, the reading must be within the specified tolerance of the nominal value.

7.5 Temperature Coefficient

When measured at 25°C and +125°C (referenced to 25°C), the TCR is 0 ± 200ppm/°C on values 1ohm and above (0 ± 350ppm/°C on values <1R). TC’s as tight as ±50 ppm are available.

7.6 Temperature Cycling/Thermal Shock

When subjected to 5 cycles from -55°C to 125°C per MIL- STD-202 Method 107 Condition B, the resistance shift shall not exceed 1% +.05Ω , and no physical damage.

7.7 Short Time Overload & Pulse Capability

When subjected to 2.5 times the DC voltage rating (but not to exceed 2 x the continuous maximum voltage rating) for 5 seconds, the resistance value shall not shift more than 2% +.05Ω, and no arcing, charring, or other physical damage.

RCD’s RMF & RSF power film resistors feature improved pulse capability compared to most other film resistors. Pulse capability is dependent on a variety of factors including resistance value, waveform, repetition rate, environmental conditions, etc.

Standard vs. Option P
Option P parts utilize a manufacturing process and material selection to ensure high pulse capability. The following chart is a general guide for Option P pulse resistant version, based on single or infrequent pulses. The maximum pulse capability for standard parts (without Opt. P) is 50% less. Ratings are based on resistors remaining within 5% of initial value. Increased pulse capabilities are available on customized basis.

Single Pulse Application Note

a) Pulse must not exceed peak power level given in chart for given time duration, and
b) Peak voltage must not exceed the following levels:

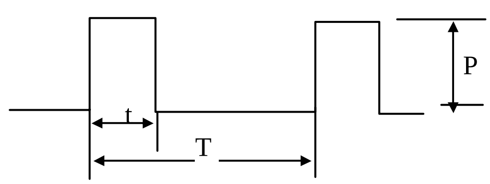
RMF1/2P=2000V, RMF1P=2500V, RMF2P=3000V, RMF3P=3500V, RMF5P=5000V, RMF5SP =4000V, RMF7P=5000V
RSF1AP=2000V, RSF1BP=2500V, RSF2BP=3000V, RSF3BP=4500V, RSF5BP=6000V, RSF7BP=8000V

c) Ratings based on 70ºC ambient temperature or below. If above 70ºC, derate peak wattage and voltage levels by .77%/ºC.

Multiple Pulse Application Note

a) Must meet the criteria for a single pulse given above
b) Average power must not exceed the following wattage levels at 70ºC:
RMF1/2 &1/2P =.5W, RMF1 &1P=1W, RMF2 &2P=2W, RMF3 &3P=3W, RMF5 &5P=5W, RMF5S &5SP=3.7W, RMF7&7P=5.2W
RSF1A & RSF1AP = .7W, RSF1B & 1BP = 1W, RSF2B & 2BP = 2W, RSF3B & 3BP =3W, RSF5B & 5BP =5W, RSF7B &7B =7W

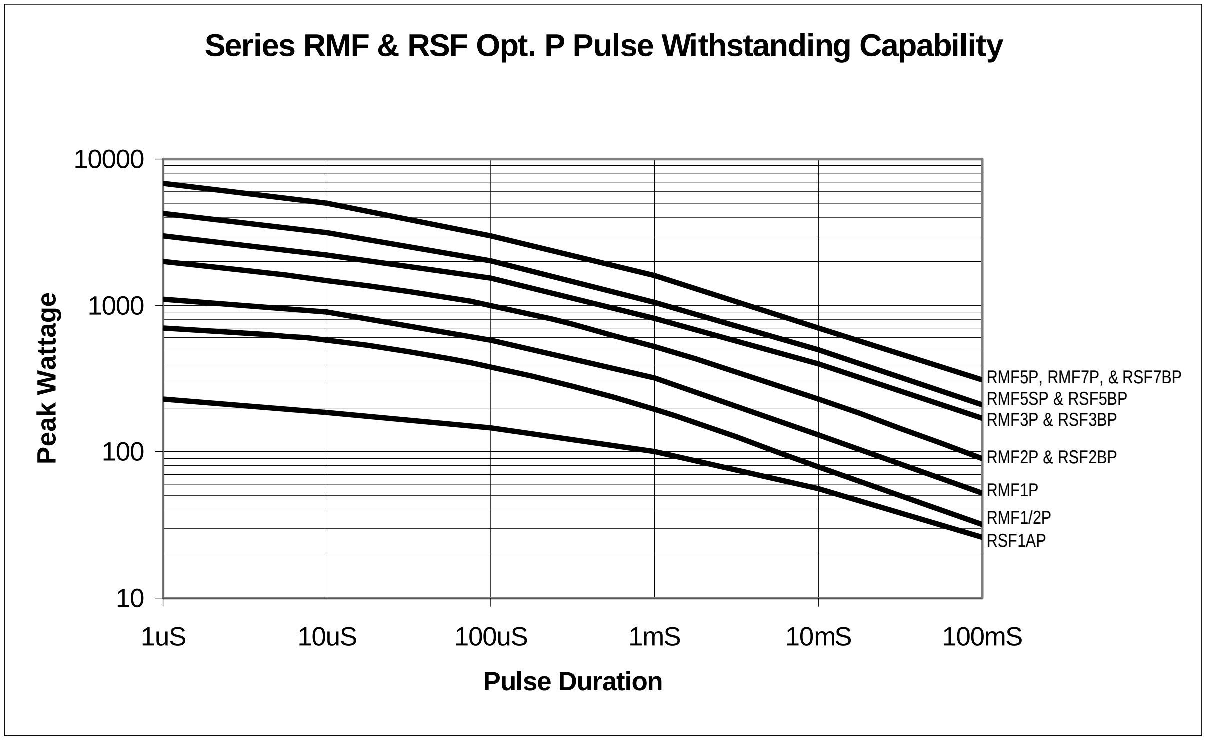
Average Power = Pt/T
P= Peak Power (Watts)
t= Pulse duration (Seconds)
T= Cycle Time



Example: Peak Power (P)= 1000W, pulse duration (t) = 10uS, cyle time =
60Hz (.01667S)... 1000W x .00001S / .01667S = .6 Watts average power.

Product Selection for Pulse Applications

For improved performance and reliability, a 30% safety factor is recommended (50% if parts are subjected to multiple pulses). Complete RCD's "Surge Questionnaire Form" if standard RMF or RSF won't suffice so that we can recommend the optimum resistor for your application. Increased pulse levels are available via modified construction or by switching to a more durable series (such as wirewound or composition). Information is provided as a general guideline only. Always verify selection by evaluating protoypes under worst-case conditions.



7.8 High Temperature Exposure

When subjected to 125°C for 100 hours, the resistance value shall not shift more than 1% +.005Ω, when subjected to 200°C for 100 hours, the resistance value shall not shift more than 4% +.005Ω. Marking shall remain legible (color bands and coating may exhibit difference in color shading).

7.9 Moisture Resistance

When tested per method 106 per MIL-STD-202, the resistance shift shall not exceed 3% + .05Ω, and 5% + .05Ω on values >10KΩ.

7.10 Load Life

When subjected to full rated power at 25°C (cycled 1½ hours on, ½ hour off) for 1000 hours, the resistance value shall not shift more than 5% (+.05Ω).

7.11 Vibration

When subjected to Vibration per MIL-STD-202 Method 201 (6 hours), the resistance value shall not shift more than 0.2% (+.05Ω), and there shall be 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...

350V RSF1A, RSF1B, RMF1/2, RMF1
500V all others

7.13 Insulation Resistance: Insulation resistance shall be 1,000 Megohm Minimum, when tested per method 302A of MIL-STD-202.

7.14 Voltage Coefficient: 2-10 ppm/volt typical. 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.

7.15 Noise

Typical levels are -15dB on values below 15KΩ, -15 to +10dB/decade above 15K. 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 slightly lower noise levels. Higher values exhibit higher noise levels. Higher operating frequencies generally exhibit lower noise levels.

7.16 Operating Temperature Range

-55°C to +200°C (+235°C for RSF Series).

7.17 Power/ Voltage/Current Derating

a) RMF1/2 through RMF5: when ambient temperature exceeds 70°C, derate power/voltage/current ratings by 0.77%/°C
b) RMF5S and RMF7: when ambient temperature exceeds 25°C, derate power/voltage/current ratings by 0.57%/°C
c) RSF1A through RSF7B: when ambient temperature exceeds 70°C, derate Series RSF 70°C power/voltage/current ratings by 0.61%/°C. When ambient is between 25° and 70°C, derate Series RSF 25°C power/voltage/current ratings as follows…
RSF1A 0.667%/°C
RSF1B 0.74%/°C
RSF2B 0.74%/°C
RSF3B 0.889%/°C
RSF5B 0.636%/°C
RSF7B 0.494%/°C

7.18 Flame Retardancy

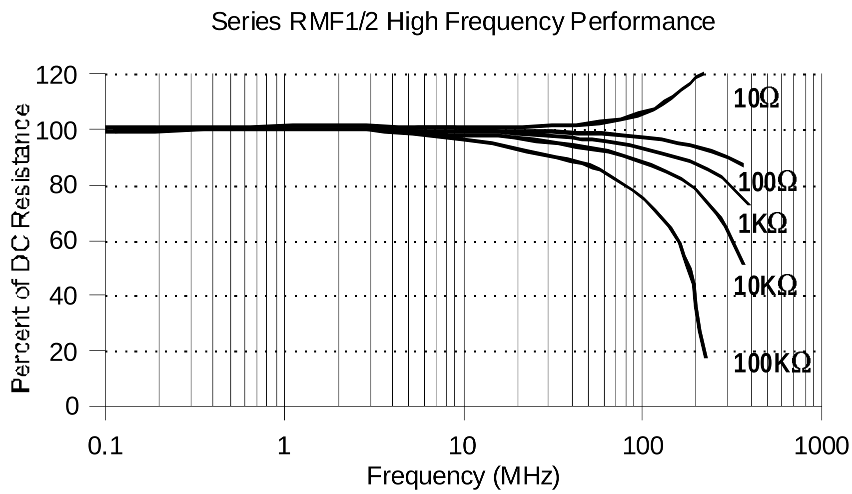
Series RSF and RMF are flame retardant in accordance with UL-94-V0.

7.19 Shelf Life

Typical shelf life stability is better than 0.25% △R/year

7.20 Reactance and High Frequency Performance

The reactance of RCD's RSF and RMF Series is primarily capacitive, typically .1pF to 1pF. 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 generally related to 5 major factors (this does not consider overloads or other excessive-use scenarios)...
1. Ambient Temperature
2. Power Dissipation
3. Resistance Value
4. Quality Factor
5. 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 for Series RSF/RMF Metal Oxide Film Resistors (Ref. MIL-STD-217 and MIL-R-22684)

Ambient Temp (°C)	B @ 10% rated wattage @70ºC*	B @ 30% rated wattage @70ºC *	B @ 50% rated wattage @70ºC *	B @ 70% rated wattage @70ºC *	B @ 90% rated wattage @70ºC *
20	.00067	.00084	.0010	.0013	.0016
40	.00078	.00098	.0012	.0016	.0019
70	.0010	.0013	.0017	.0021	.0027
100	.0013	.0018	.0023	N/A	N/A

* or percent of rated voltage when resistance exceeds critical value

R: Resistance Factor

Resistance Range	Multiplier
<100KΩ	1.0
100KΩ to 1MΩ	1.1

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 RSF2B 100Ω to be utilized at 1W (50% rated power) at 40°C in controlled environment...
FR= BxRxQxE   B= .0012, R= 1, Q=5, E= 1
Estimated Failure Rate = .0012x1x5x1 = .006 failures/10^6 hours = 6 FIT
MTTF= 1÷FR = 166 million hours
The same part with Option 38 Mil Screening would have 830 million hour estimated FR (1.2 FIT).