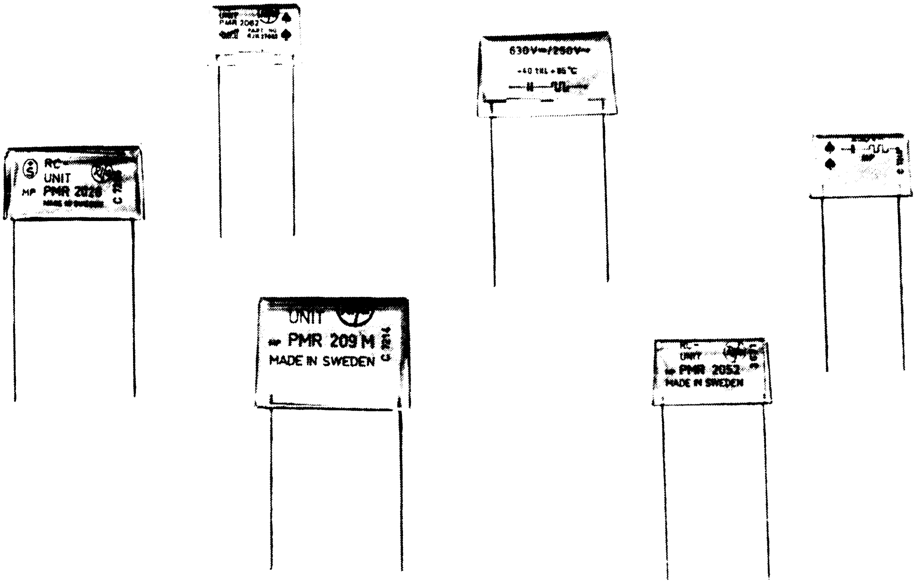
# INTRODUCTION




The Rifa RC networks are designed for use in DC and AC applications for

- Contact protection
- Interference suppression of contacts
- Transient suppression for protection of low-power thyristors and triacs
- du/dt suppression in thyristor and triac low-power circuits

## CONSTRUCTION

Rifa manufactures two types of RC units. One type consists of a metallized paper capacitor element in series with a carbon resistor (PMR 202). The other type consists of a metallized paper capacitor with the resistance in the metal layer utilized as the series resistance to the capacitor (PMR 205—209).

The RC units are encapsulated in epoxy resin with radial leads. The single moulded package makes a neat installation with only two solder joints. The form of the PMR RC unit makes it very suitable for insertion into printed circuit boards. Alternatively the unit may be mounted self-supporting.

## SELF-HEALING

If a voltage surge punctures the dielectric, an arc occurs at the point of failure which melts the surrounding metal and insulates the area of the breakdown. Such breakdowns may occur thousands of times without appreciably effecting life or other properties of the RC networks. This self-healing property makes the RC network very resistant to high transient voltages.

## WORKING VOLTAGE

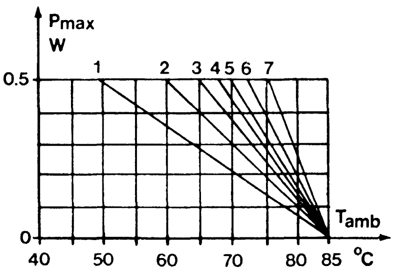
The columns RATED VOLTAGE given in the type specifications indicate the maximum permissible DC and AC voltages for continuous operation within the category temperature range. The columns PEAK PULSE VOLTAGE indicate the maximum permissible pulse voltage.

## CATEGORY TEMPERATURE RANGE

—40°C to +85°C.

## POWER RATINGS

The average losses may reach 0.5 W provided that a surface temperature of +85°C is not exceeded. The maximum allowable losses v ambient temperature are shown in figure below.




| Dimensions (mm) L | T | H | Curve |
|---|---|---|---|
| 18.5 | 5.2 | 10.5 | 1 |
| 19.0 | 7.3 | 13.0 | 2 |
| 18.5 | 7.8 | 13.5 | 2 |
| 20.0 | 8.3 | 15.0 | 3 |
| 23.5 | 7.6 | 13.5 | 3 |
| 24.0 | 7.6 | 14.0 | 3 |
| 24.0 | 9.0 | 15.5 | 4 |
| 27.5 | 8.5 | 15.0 | 4 |
| 23.5 | 11.3 | 16.5 | 5 |
| 24.0 | 11.3 | 16.5 | 5 |
| 27.5 | 11.5 | 16.5 | 6 |
| 27.5 | 15.5 | 21.5 | 7 |

Figure 1.
Maximum allowable power dissipation v ambient temperature and case size.

## MARKING

Units are marked with type identification, capacitance, resistance, rated voltage, temperature range, manufacturer's name, date of manufacture and approvals.

## MOUNTING

Any normal method of soldering may be employed without the need for a heat sink. For self-supporting assembly, bending of the terminals does not damage the capacitor.

## HUMIDITY RESISTANCE

After a damp heat test according to IEC Publ. 68-2-3, test Ca, severity 56, the insulation resistance is still above specified limits.

## SOLDERABILITY

Wetting time $\leq$ 1 s when tested according to IEC 68-2-20, test T, solder globule method.

## BUMP TEST

IEC 68-2-29, test Eb. The capacitors, properly fixed, will withstand at least 4000 bumps with 390 $m/s^2$ retardation.

## MINIMUM LIFE EXPECTANCY

Under the worst conditions permissible, the minimum life expectancy is 200 000 000 relay operations.

## APPLICATION OF RC UNITS

The use of a capacitor and resistor in series has long been known as a most effective means of increasing the life of contacts. At the same time radio interference suppression is achieved.

RC units are also very suitable as du/dt and transient suppressors on thyristors and triacs in low power applications, for example in dimmers and speed regulators.

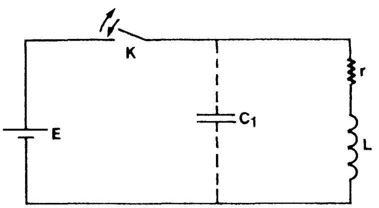
## RC UNITS FOR CONTACT PROTECTION AND INTERFERENCE SUPPRESSION

Relay contacts that break and make a current circuit are subjected to electrical erosion resulting from sparking and arcing.

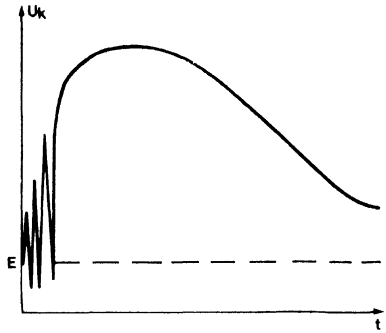
Spark suppressors used are RC units, non-linear resistors, shunt resistors, diodes and gas discharge valves. Amongst these devices the RC network is in most cases the best spark suppressor for the reduction of contact erosion. The advantages are:

- RC networks are non-polar and therefore suitable for AC applications.
- The relay operating time will not be very much affected.
- No current consumption.
- Radio interference suppression is achieved.

When the contact K (see figure 2 a) breaks, the voltage across the contact rapidly grows with the rate of $I/C_1$($C_1$ is the small capacitance of the wiring) resulting in a breakdown of K and a spark discharge of $C_1$. The discharge stops when the voltage across K has



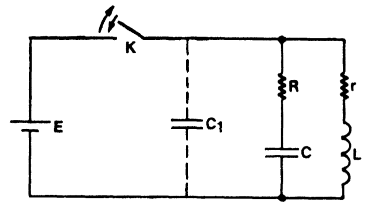

2 a



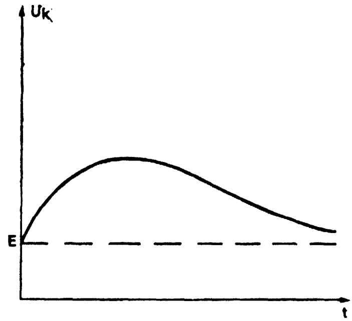

2 b

decreased to about 15 V. $C_1$ recharges and another breakdown occurs. This series of sparks stops when the contact clearance is long enough to endure the voltage without breakdowns (see figure 2 b).

By coupling a capacitor C over the contact (see figure 3 a) the voltage across the contact will be reduced and the voltage increase du/dt will be limited to I/C instead of $I/C_1$. As I/C is much less than $I/C_1$ the voltage increase over the contact will now be low enough to prevent breakdowns (see figure 3 b).




3 a




3 b

In order to limit the current through the contact when it makes the resistor R must be coupled in series with the capacitor.

The values of the capacitor and the resistor depend on the inductance and resistance in the load, the applied voltage and type of contact (i.e. how exactly the contact breaks and makes and its current rating). The protective capacitance must be large enough to prevent the contact voltage from rising to a value greater than the air breakdown value at any instant. This value depends on the contact separation but is never less than 300 volts. With few exceptions, a 0.1 μF capacitor will be large enough to hold the peak voltage to less than 300 volts.

Limiting the voltage rise across the contacts to less than 300 volts peak will not necessarily prevent all breakdowns of the gap. At the very first instant of contact breaking the contact separation is so minute that low-voltage breakdowns of the gap may occur. To minimize this possibility it is the practice to impose the additional requirement that the contact protection capacitor shall limit the rate of voltage rise immediately after the contact breaks to 1 volt per microsecond. This requirement will be met if the ratio I/C is less than unity where I is given in amperes and C is in microfarads. For slow moving contacts even larger capacitors are used.

With sufficient capacitance in the circuit for protection when the contact breaks, a resistor is needed for protection when the contact makes. The network capacitor is charged to the full voltage when the circuit is open. Closing the contacts effectively short-circuits this voltage, so a resistance is connected in series with the network capacitor to limit the current through the contact. The resistor thus reduces erosion as the contact makes, but also tends to increase it as the contact breaks. The sudden diversion of the steady-state current into the protection network on contact breaking immediately produces a voltage across the contacts due to the current flowing through the protection resistance. A compromise value is therefore necessary, and it is general practice to have a resistance that gives the same current through the contact on closure as the steady-state current.

The RC network can be connected across the contact or across the load. If there is a long wiring between the contact and the load, connecting the RC network across the contact is to be preferred.

At the same time as the contact is protected by the RC network, radio interference suppression is achieved as the sparks (which contain a high frequency spectrum) are avoided.

## RC UNITS AS DU/DT SUPPRESSORS ON THYRISTORS AND TRIACS

The junctions of any semiconductor exhibit some unavoidable capacitance. A changing voltage impressed on this junction capacitance results in a current, i=C du/dt. If this current is sufficiently large a regenerative action may occur causing the SCR to switch to the on-state. This regenerative action is similar to that which occurs when a gate current is injected.

High du/dt may occur from other thyristors switching-on or off or be due to reapplied du/dt. Consider the full-wave phase control circuit in figure 4, with an inductive load. When the current reaches zero (the triac commutates), (point A), the supply voltage (which is not zero) must then appear as a forward bias across the triac. The rate-of-change of this voltage is dependent on inductance and capacitance in the load circuit,

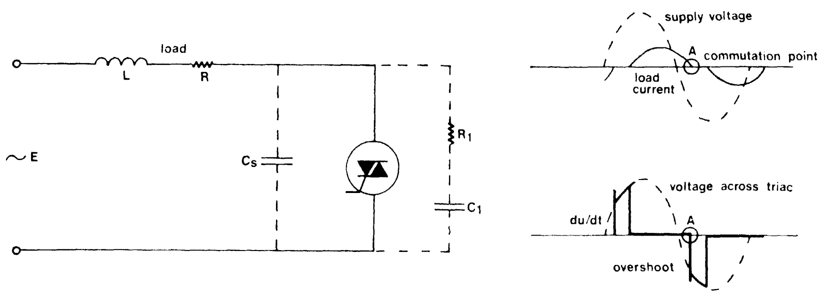



Figure 4

as well as on reverse recovery characteristics of the triac. The application of a series RC circuit in parallel with the triac or with the load, can reduce the du/dt to acceptable limits. The values of R and C are functions of the load, line voltage and triac used. Since circuit impedances for a particular application are not usually well known the values of C and R are often determined by experimental optimisation. For triacs 0.1 $\mu$F+100 ohms are often used.

Rifa's RC units PMR 2026 and PMR 209 are well suited as du/dt protectors in low power circuits. As the tolerance of capacitance and resistance is not critical PMR 209 will offer satisfactory operation.

The maximum allowable power dissipation in the RC units is limited to 0.5 W. The calculation of the power dissipated in the RC-units when used as du/dt suppressors can be made as follows:

The energy in the capacitor is

$$E = \frac{1}{2} CU^2$$

where U is the voltage and C the capacitance.

Each time the thyristor goes from off-state to on-state this energy will be dissipated in the resistor. If the thyristor goes to on-state N times per second, the power dissipated in the resistor will be

$$P = \frac{1}{2} CU^2 \times N$$

A triac will be conducting each half-period when using a sinusoidal voltage. If the triac starts to conduct on the top of each half-period of 220 V 50 Hz voltage the power dissipated is

$$P = \frac{1}{2} \times C \times (220 \times \sqrt{2})^2 \times 2 \times 50 = 5 \times 10^6 \times C$$

This power must not be more than 0.5 W.

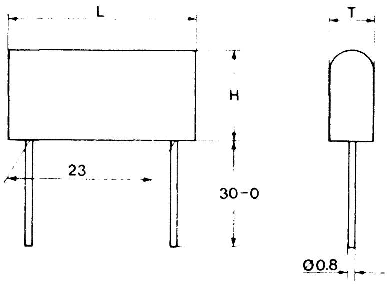
$$0.5\ W \geq 5 \times 10^6 \times C$$
$$C \leq 0.1 \times 10^{-6} = 0.1\ \mu F$$

Furthermore, the case temperature must be limited to 85°C. Therefore, the maximum allowable power dissipation must be derated at higher temperatures. For maximum allowable power dissipation versus ambient temperature and case size see POWER RATINGS in the type specification.

# PMR 202

PMR 202 is a metallized paper capacitor in series with a carbon resistor. The unit is encapsulated in epoxy resin and has tinned copper wire leads.

| | |
|---|---|
| **Temperature range** | —40°C to +85°C |
| **IEC category** | 40/085/56 |
| **Approvals** | PMR 2026 is approved as radio interference suppressors class a (X) by SEV (SEV 1017/1959, Switzerland) for 630 VDC and 250 VAC. |
| **Capacitance tolerance** | ±10% for C $\geq$ 0.5 μF<br>±20% for C $<$ 0.5 μF |
| **Resistance tolerance** | ±10% |




Printed circuit version.
Add A to code number.
Example: PMR 2026A 0.5+22
Lead spacing 22.9±0.5 mm

## SPECIAL TECHNICAL FEATURES

| | |
|---|---|
| Series resistance | The series resistance is defined as $R = \frac{\tan\delta}{\omega C}$ at 100 kHz. The resistance value so defined is very close to the value of the carbon resistor used and for all practical purposes constant up to 1 MHz. |
| Capacitance | The capacitance is measured at 1 kHz. |
| Current ratings | The maximum current allowable is limited only by the rated peak pulse voltage and the resistance value. |
| Power ratings | The average losses may reach 0.5 W provided the surface temperature does not exceed +85°C. For maximum allowable power dissipation v temperature see "Introduction" RC NETWORKS. |
| Insulation resistance | PMR 2022: $\geq$ 500 ΩF<br>PMR 2026: $\geq$ 12 000 MΩ for C $\leq$ 0.33 μF<br>$\geq$ 4 000 ΩF for C $>$ 0.33 μF<br>Measured with 100 volts DC (500 VDC for PMR 2026) at +20°C after one minute of electrification. |

## STANDARD UNITS

| Cap. µF | Series Resistance Ohms | Rated Voltage (AC for 40-60 Hz) | Peak Pulse Voltage | Max. dimensions mm L | T | H | Weight g | Order Number²) |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 22 | 200 VDC 125 VAC | 300 V | 27.5 | 8.5 | 15 | 5 | PMR 2022/0.5+22 |
| 0.5 | 33 | | | | | | | PMR 2022/0.5+33 |
| 0.5 | 47 | | | | | | | PMR 2022/0.5+47 |
| 0.5 | 68 | | | | | | | PMR 2022/0.5+68 |
| 0.5 | 82 | | | | | | | PMR 2022/0.5+82 |
| 0.5 | 100 | | | | | | | PMR 2022/0.5+100 |
| 0.5 | 150 | | | | | | | PMR 2022/0.5+150 |
| 0.5 | 220 | | | | | | | PMR 2022/0.5+220 |
| 0.5 | 330 | | | | | | | PMR 2022/0.5+330 |
| 0.5 | 470 | | | | | | | PMR 2022/0.5+470 |
| 0.5 | 680 | | | | | | | PMR 2022/0.5+680 |
| 1.0 | 22 | | | 27.5 | 11.5 | 16.5 | 7 | PMR 2022/1.0+22 |
| 1.0 | 33 | | | | | | | PMR 2022/1.0+33 |
| 1.0 | 47 | | | | | | | PMR 2022/1.0+47 |
| 1.0 | 68 | | | | | | | PMR 2022/1.0+68 |
| 1.0 | 100 | | | | | | | PMR 2022/1.0+100 |
| 1.0 | 150 | | | | | | | PMR 2022/1.0+150 |
| 1.0 | 220 | | | | | | | PMR 2022/1.0+220 |
| 0.1 | 22 | 630 VDC 250 VAC | 900 V | 27.5 | 8.5 | 15 | 5 | PMR 2026/0.1+22 1) |
| 0.1 | 33 | | | | | | | PMR 2026/0.1+33 1) |
| 0.1 | 47 | | | | | | | PMR 2026/0.1+47 1) |
| 0.1 | 68 | | | | | | | PMR 2026/0.1+68 1) |
| 0.1 | 100 | | | | | | | PMR 2026/0.1+100 1) |
| 0.1 | 150 | | | | | | | PMR 2026/0.1+150 1) |
| 0.1 | 220 | | | | | | | PMR 2026/0.1+220 1) |
| 0.1 | 330 | | | | | | | PMR 2026/0.1+330 1) |
| 0.1 | 470 | | | | | | | PMR 2026/0.1+470 1) |
| 0.25 | 22 | | | 27.5 | 11.5 | 16.5 | 7 | PMR 2026/0.25+22 1) |
| 0.25 | 33 | | | | | | | PMR 2026/0.25+33 1) |
| 0.25 | 47 | | | | | | | PMR 2026/0.25+47 1) |
| 0.25 | 68 | | | | | | | PMR 2026/0.25+68 1) |
| 0.25 | 100 | | | | | | | PMR 2026/0.25+100 1) |
| 0.25 | 150 | | | | | | | PMR 2026/0.25+150 1) |
| 0.25 | 220 | | | | | | | PMR 2026/0.25+220 1) |
| 0.25 | 330 | | | | | | | PMR 2026/0.25+330 1) |
| 0.25 | 470 | | | | | | | PMR 2026/0.25+470 1) |
| 0.5 | 22 | | | 27.5 | 15.5 | 21.5 | 14 | PMR 2026/0.5+22 1) |
| 0.5 | 33 | | | | | | | PMR 2026/0.5+33 1) |
| 0.5 | 47 | | | | | | | PMR 2026/0.5+47 1) |
| 0.5 | 68 | | | | | | | PMR 2026/0.5+68 1) |
| 0.5 | 100 | | | | | | | PMR 2026/0.5+100 1) |
| 0.5 | 150 | | | | | | | PMR 2026/0.5+150 1) |
| 0.5 | 220 | | | | | | | PMR 2026/0.5+220 1) |

¹) Approved by SEV (SEV 1017/1959) for 630 VDC, 250 VAC.
²) For printed circuit version add A to code number. Example: PMR 2026A 0.5+33.

# PMR 205, PMR 207

PMR 205 and PMR 207 are epoxy impregnated metallized paper capacitors with the resistance in the metal layer utilized as series resistance to the capacitance.
PMR 205 is encapsulated in an epoxy resin. Tinned copper clad steel leads.
PMR 207 is encapsulated in a self-extinguishing epoxy resin. PVC insulated tinned copper leads.

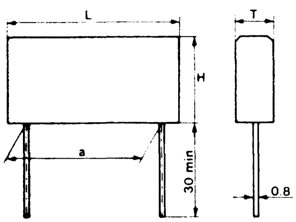
**Temperature range** —40°C to +85°C

**IEC category** 40/085/56

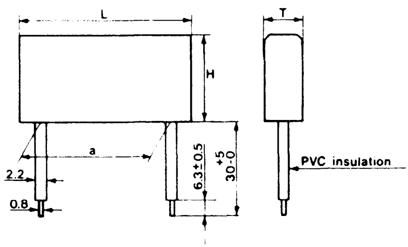
**Capacitance tolerance** ±20%

**Resistance tolerance** ±30%

PMR 205




PMR 207




## SPECIAL TECHNICAL FEATURES

| | |
|---|---|
| Series resistance | The series resistance is defined as $R = \frac{\tan\delta}{\omega C}$ at 1 kHz for RC $\geq$ 50 $\mu$s and at 100 kHz for RC $<$ 50 $\mu$s. |
| Capacitance | The capacitance is measured at 1 kHz. |
| Current ratings | The maximum current allowable is limited only by the rated peak pulse voltage and the resistance value. |
| Power ratings | The average losses may reach 0.5 W provided the surface temperature does not exceed +85°C. For maximum allowable power dissipation v temperature see "Introduction" RC NETWORKS. |
| Insulation resistance | $\geq$ 3000 MΩ for C $\leq$ 0.33 $\mu$F<br>$\geq$ 1000 ΩF for C $>$ 0.33 $\mu$F<br>Measured with 100 VDC and at +20°C after one minute of electrification. |

## STANDARD UNITS

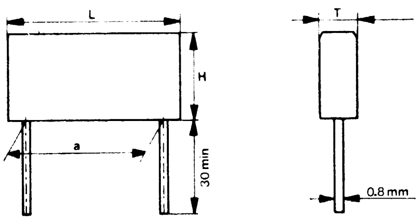
| Cap. µF | Series Resistance Ohms | Rated Voltage (AC for 40-60 Hz) | Peak Pulse Voltage | Dimensions mm L Max | T Max | H Max | a ±0.5 | Weight g | Order Number |
|---|---|---|---|---|---|---|---|---|---|
| **PMR 205** | | | | | | | | | |
| 0.1 | 33 | | | | | | | | PMR 2052/0.1+33 |
| 0.1 | 47 | | | | | | | | PMR 2052/0.1+47 |
| 0.1 | 100 | | | 18.5 | 5.2 | 10.5 | 15.2 | 1.6 | PMR 2052/0.1+100 |
| 0.1 | 220 | | | | | | | | PMR 2052/0.1+220 |
| 0.1 | 330 | | | 19.0 | 7.3 | 13.0 | 15.2 | 2.8 | PMR 3052/0.1+330 |
| 0.1 | 470 | | | 19.0 | 7.3 | 13.0 | 15.2 | 2.8 | PMR 2052/0.1+470 |
| 0.15 | 68 | | | | | | | | PMR 2052/0.15+68 |
| 0.15 | 100 | | | | | | | | PMR 2052/0.15+100 |
| 0.22 | 47 | | | | | | | | PMR 2052/0.22+47 |
| 0.22 | 100 | | | | | | | | PMR 2052/0.22+100 |
| 0.22 | 220 | | | | | | | | PMR 2052/0.22+220 |
| 0.22 | 330 | | | | | | | | PMR 2052/0.22+330 |
| 0.22 | 470 | | | 19.0 | 7.3 | 13.0 | 15.2 | 2.8 | PMR 2052/0.22+470 |
| 0.25 | 200 | **250 VDC** | **375 V** | | | | | | PMR 2052/0.25+200 |
| 0.25 | 350 | **125 VAC** | | | | | | | PMR 2052/0.25+350 |
| 0.25 | 600 | | | | | | | | PMR 2052/0.25+600 |
| 0.33 | 47 | | | 18.5 | 7.8 | 13.5 | 15.2 | 3 | PMR 2052/0.33+47 |
| 0.47 | 33 | | | | | | | | PMR 2052/0.47+33 |
| 0.47 | 47 | | | | | | | | PMR 2052/0.47+47 |
| 0.47 | 100 | | | 24.0 | 7.6 | 14.0 | 20.3 | 4 | PMR 2052/0.47+100 |
| 0.47 | 220 | | | | | | | | PMR 2052/0.47+220 |
| 0.47 | 270 | | | | | | | | PMR 2052/0.47+270 |
| 0.47 | 330 | | | | | | | | PMR 2052/0.47+330 |
| 0.47 | 470 | | | 24.0 | 9.0 | 14.0 | 20.3 | 5 | PMR 2052/0.47+470 |
| 1.0 | 47 | | | | | | | | PMR 2052/1.0+47 |
| 1.0 | 68 | | | | | | | | PMR 2052/1.0+68 |
| 1.0 | 100 | | | 24.0 | 11.3 | 16.5 | 20.3 | 6 | PMR 2052/1.0+100 |
| 1.0 | 220 | | | | | | | | PMR 2052/1.0+220 |
| 1.0 | 470 | | | | | | | | PMR 2052/1.0+470 |
| **PMR 207** | | | | | | | | | |
| 0.25 | 200 | **250 VDC** | | | | | | | PMR 207HA625+200 |
| 0.25 | 350 | **125 VAC** | **375 V** | 18.5 | 7.8 | 14.0 | 10 | 2.9 | PMR 207HA625+350 |
| 0.25 | 600 | | | | | | | | PMR 207HA625+600 |

# PMR 209

RIFA

PMR 209 is an epoxy impregnated metallized paper capacitor with the resistance in the metal layer utilized as series resistance to the capacitance. The unit is encapsulated in epoxy resin and has tinned copper clad steel leads.

| | |
|---|---|
| **Rated voltage** | |
| Continuous | 630 VDC<br>250 VAC 40-60 Hz |
| Transient peak | Max 1000 V |
| **Temperature range** | —40°C to +85°C |
| **IEC category** | 40/085/56 |
| **Approvals** | VDE, SEV, NEMKO (see STANDARD UNITS) |
| **Capacitance tolerance** | ±20% |
| **Resistance tolerance** | ±30% |




## SPECIAL TECHNICAL FEATURES

| | |
|---|---|
| Series resistance | The series resistance is defined as $R = \frac{\tan\delta}{\omega C}$ at 100 kHz. |
| Capacitance | The capacitance is measured at 1 kHz. |
| Current ratings | Max. 12 A repetitive. Max. 20 A for occasional transients. |
| Power ratings | The average losses may reach 0.5 W provided the surface temperature does not exceed +85°C. For maximum allowable power dissipation v temperature see "INTRODUCTION" RC NETWORKS. |
| Insulation resistance | $\geq$ 3000 MΩ for C $\leq$ 0.33 µF<br>$\geq$ 1000 ΩF for C $>$ 0.33 µF<br>Measured with 500 volts DC and at +20°C after one minute of electrification. |

## STANDARD UNITS

| Cap. μF | Series Resistance Ohms | Dimensions in mm $L_{max}$ | $T_{max}$ | $H_{max}$ | a ±0.5 | Weight g | Order number | Approvals*) as interference suppressors |
|---|---|---|---|---|---|---|---|---|
| 0.047 | 47 | 19.0 | 7.3 | 13.0 | 15.2 | 2.7 | PMR 209M547+47 | SEV |
| 0.047 | 100 | 19.0 | 7.3 | 13.0 | 15.2 | 2.7 | PMR 209M547+100 | SEV |
| 0.1 | 47 | 24.0 | 7.6 | 14.0 | 20.3 | 3.6 | PMR 209M610+47 | SEV, VDE |
| 0.1 | 100 | 24.0 | 7.6 | 14.0 | 20.3 | 3.6 | PMR 209M610+100 | SEV, VDE, N |
| 0.22 | 47 | 24.0 | 11.3 | 16.5 | 20.3 | 6.1 | PMR 209M622+47 | SEV |
| 0.22 | 100 | 24.0 | 11.3 | 16.5 | 20.3 | 6.1 | PMR 209M622+100 | SEV |
| 0.47 | 47 | 30.5 | 15.3 | 22.0 | 25.4 | 14.5 | PMR 209M647+47 | SEV |
| 0.47 | 100 | 30.5 | 15.3 | 22.0 | 25.4 | 14.5 | PMR 209M647+100 | SEV |

*) SEV = Switzerland (SEV 1017.1959) 250 V~/630 V=
VDE = Germany (VDE 0560-7) 250 V~
N = Norway (NEMKO 132/56) 250 V~/630 V=