High-Heat-Resistant Capacitor Defies Engine's Thermal Cap

Murata Manufacturing Co., Ltd. has developed the RHS capacitor series (Photo 1) for devices mounted in a severe thermal environment, such as areas surrounding an automotive engine room. The series consists of lead-type ceramic capacitors operable even at high temperatures of more than 150°C. This article describes the series.

Recently, in the automotive industry, an increase in powertrain control systems driven by a DC motor has been noted primarily to improve automotive fuel consumption. Capacitors are used in order to suppress electrical noise from the DC motor. Automotive control devices are used in severe thermal environments where the temperature may exceed 150°C and reach as high as approximately 200°C in a short time. Capacitors used in such environments need to have high heat resistance and high thermal shock resistance. Using conventional products in such environments might be difficult as cracks could generate on their coating resin, or another problem with thermal shock cycles could occur.

The new product is made up of a high-thermal-resistant multi-layer ceramic capacitor coated with newly developed high-thermal-resistant resin. This feature has made the capacitor series withstand operating temperatures of up to 200°C.

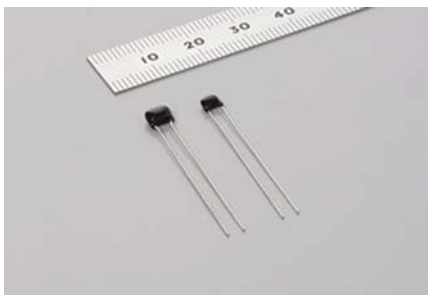


Photo 1: External appearance of the RHS Series

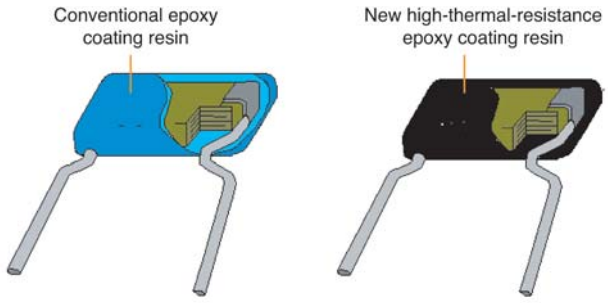
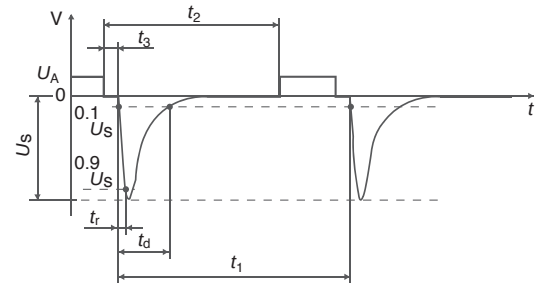


Fig. 1: The internal structure of the lead-type multi-layer ceramic capacitor

Key Features, Functions, Properties

The RHS capacitor series is compliant with AEC-Q200 and ISO7637-2 standard tests. AEC-Q200 is a reliability testing standard formulated by the Automotive Electronics Council, with which automotive components need to comply. Meanwhile, ISO7637-2 is a testing standard for resistance to noise from automotive electrical equipment. An example of a test pulse waveform is shown below. In ISO7637-2 (2011 edition) standard tests, the pulse below is applied 500 times.



Parameters	Nominal 12 V system	Nominal 24 V system
U_s	-75 V to -150 V	-300 V to -600 V
R_i	10Ω	50Ω
t_d	2 ms	1 ms
t_r	$(1\ ^{0}_{-0.5})$ µs	$(3\ ^{0}_{-1.5})$ µs
t_1[a]	≥0.5 s	
t_2	200 ms	
t_3[b]	<100 µs	

An example of test pulse waveform

This environment-friendly capacitor, which is free from lead and halogen, can withstand 1000 cycles of thermal shock testing from -55 to +200°C. This is made possible by the newly developed coating resin that has high thermal resistance as compared with existing products operable at 150°C (RHE Series). The new capacitor series guarantees a maximum operating temperature

of 200°C (use within 2000 cumulative hours at 200°C), and is suitable for use for a noise filter for small DC motors in the periphery of an engine where the temperature becomes almost 200°C only during a short time. The presence of leads allows the capacitor to be welded or connected by crimping near noise sources.

Contributes to noise suppression

Existing products operable at 150°C are difficult to use near a heating element exceeding 150°C, and so needed to be mounted away from such a heating element. The RHS Series can be used near a heating element exceeding 150°C, and so can remove noise near the noise source, improving noise removal effect.

Table 1: Product lineup and electrical characteristics of the RHS Series

Series name	RHS
Dimensions (L × W)	Size 1: 4.0 × 3.5 mm max Size 2: 5.5 × 4.0 mm max
Operating temperature range Temperature coefficient (ppm/°C)	7J: -55 to +200°C Temperature characteristic code: 7J -55 to +25°C: -750 +120/-347 +25 to +125°C: -750 +/-120 +125 to +200°C: -750 +347/-120
Rated voltage	200Vdc, 500Vdc (The rated voltage for 200°C is reduced to 25%.)
Electrostatic capacitance	100pF to 0.01µF

Adaptable to rapid changes in temperatures

In applications where the temperature exceeds 150°C, a rapid change takes place as the temperature goes from low to high when the car starts up. Repetition of such rapid temperature change may cause a crack on the coating resin. If the crack widens, another crack may also develop on the ceramics because of the high adherence between the coating resin and the ceramics, resulting in a short-circuit failure in the product. Therefore, a new coating resin that withstands thermal shock testing was developed for the RHS Series. Figure 1 shows the internal structure.

The new high-thermal-resistant epoxy resin withstands a rapid temperature change; it is far superior in thermal shock resistance compared to conventional coating resin, and does not cause any coating resin crack after 1000 cycles. Figure 2 shows comparative data between the new and the conventional coating resins.

Table 1 shows the product lineup and electrical characteristics of the RHS Series.

For derating of voltage/temperature, if the product temperature exceeds 150°C, it is necessary to reduce the voltages to be applied to the capacitor from the rated voltages, as shown in Figure 3.

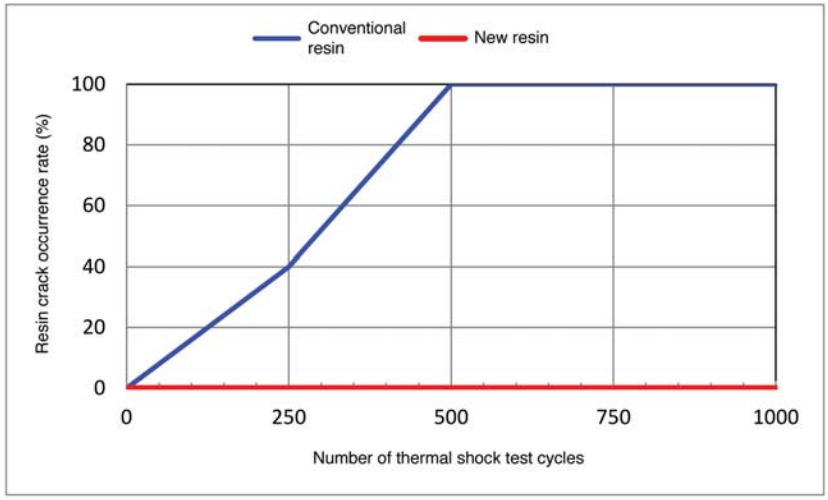


Fig. 2: Thermal shock test (test conditions: -55°C to +200°C, 1000 cycles)

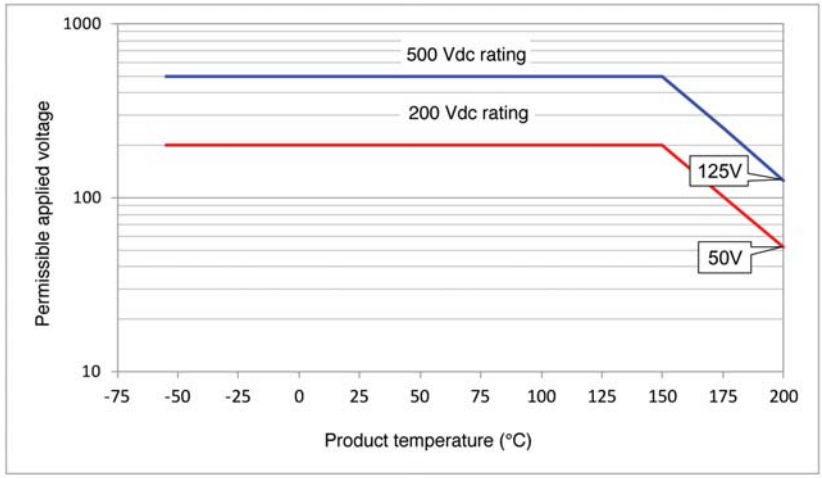


Fig. 3: Reduction of voltages to be applied

Future Plans

Samples of the RHS Series, shown in Table 1, have been made available for mass production. Murata Manufacturing will make efforts to expand the rated-voltage lineup, responding to a wide range of high-temperature requirements for automotive applications.

About This Article:

The author is Masaru Igawa, Product Engineering Sec. 1, Capacitor Div. 2, Izumo Murata Manufacturing Co., Ltd.