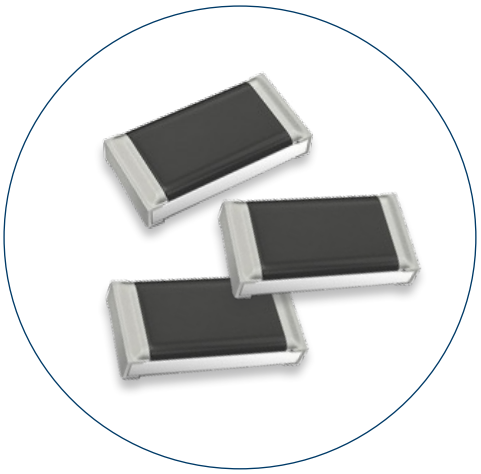
Panasonic
INDUSTRY

WHITE PAPER



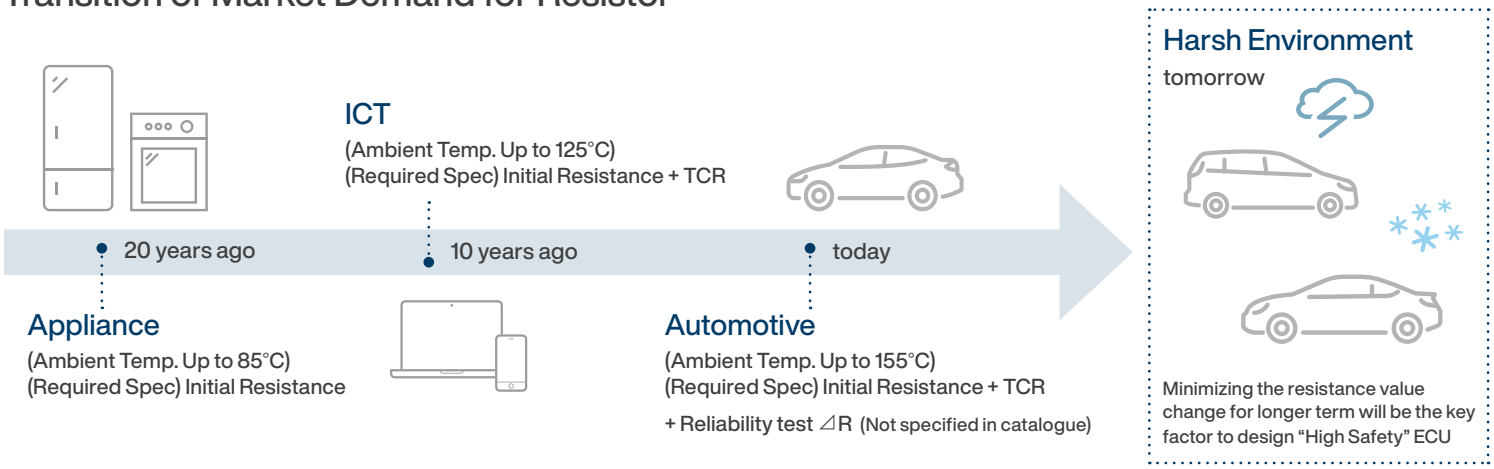
Understanding High-Performance Thin Film Chip Resistors

Thin Film Chip Resistors that provide high reliability and stability

Panasonic has a long, rich history of manufacturing Resistors.
Beginning in 1933, Panasonic started manufacturing Fixed Carbon Film Resistors, laying a solid foundation for what was, and is, to come. Our production of Thin Film Resistors started in 1992. As a market leader in Resistors, we continue to advance technology with an eye to the burgeoning markets of today and tomorrow. Panasonic has 90+ years of manufacturing experience in resistors.

Today, we offer a large variety of Resistors, including Thick Film and Thin Film technologies, covering a broad range of applications and markets with their unique requirements. From standard types to more specialty types, Panasonic is well-positioned to support and advance a multitude of equipment designs.

Transition of Market Demand for Resistor



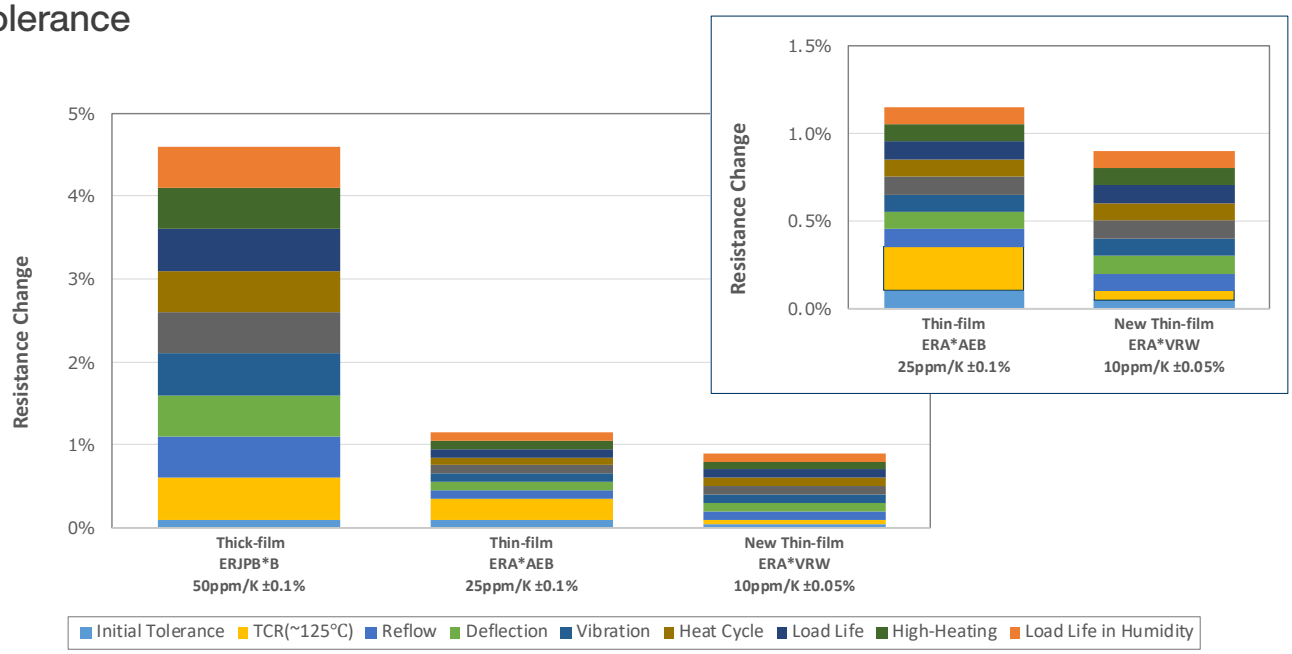
Market Requires the Parts with Higher Accuracy and More Robustness Under Harsh Condition

Here we will focus mainly on Thin Film Chip Resistors for applications requiring a high degree of precision. Thin film generally has a better Temperature Coefficient of Resistance (TCR) than Thick Film. Besides precision, Thin Film also features low noise and tight tolerances.

Panasonic Thin Film Chip Resistor Features

Requirement	Series
High-Reliability for multiple markets where long-life is crucial	ERA-A
High Stability and Reliability for harsh environments, e.g., ESD	ERA-V/K
High Voltage and High Accuracy, limiting element voltage: 500V	ERA-P

Total Tolerance



Thin Film ERA Series Tolerance and Total Tolerance Considerations

Tolerance should be an important consideration in the case of early design of an application. Another important consideration is a basic tolerance of the resistor at standard conditions. We have Thin Film tolerances ranging from +/-0.05% to +/-0.5%

For end equipment to function properly, especially those operating in strenuous or harsh environments, we must also factor in other sources of error, coming to a total tolerance. To guarantee increased accuracy of design spec – keep tolerance low / small – close to target specification. For temperature variation, there is the Temperature Coefficient of Resistance (TCR) in Parts Per Million per Degree (ppm/K). For our Thin Film, these range from 10 to 50 ppm/K. Another consideration is Drift over time or Endurance test tolerance. Generally, this is 1000-hour data.

We can see the total tolerance advantage for using high-precision Thick Film and moving to Thin Film. This enables one to improve system performance and provide a greater design margin, improving reliability in more severe environmental conditions. It is also ideal for longer-life products.

Panasonic's ERA-A type and ERA-V/K type Thin Film Resistors are both high-quality and reliable products. However, they have some key differences in design and performance characteristics.

The ERA-A type is a general-purpose Thin Film Resistor that is suitable for use in a wide range of applications, including automotive, industrial, and consumer electronics. They offer excellent stability, accuracy, and temperature coefficient of resistance (TCR), making them an ideal choice for precision circuits.

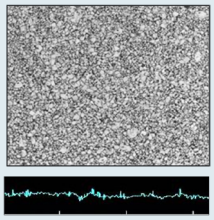
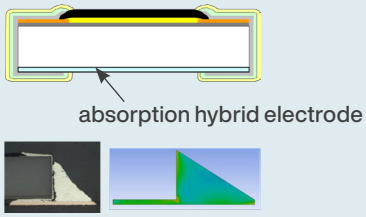
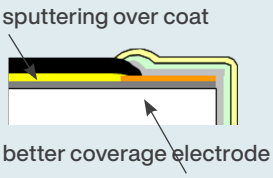
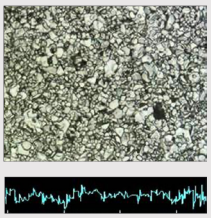
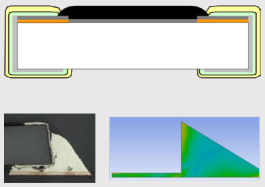
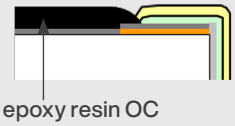
On the other hand, the ERA-V/K type is specifically designed for use in harsh environments, such as automotive applications, where the resistors may be exposed to Electrostatic Discharge (ESD), sulfur corrosion, and thermal stress. These have a special structure that provides better protection against these environmental factors, making them more reliable and durable in these applications.

ERA-V/K Series

ERA-V/K Series is our flagship model developed for use in harsh environments due to their unique structure and technical advantages. The ERA-V/K Series have a bottom absorber which makes them more resilient to thermal stress and redesigned protective coat that prevents foreign materials from entering the resistor and causing sulfur corrosion.

Additionally, ERA-V/K Series Resistors have a smoother substrate compared to ERA-A Series Resistors, which allows for better ESD (electrostatic discharge) withstanding characteristics. This is important in harsh environments with high levels of electrostatic discharge or other types of interference.

Structure Characteristics

	Smooth Surface Substrate Achieve Better ESD Withstanding	Bottom Stress Absorber Even Tough Against Thermal Shock	Protective Coating Realize Higher Sulfur-proof
New ERA-V/K			
Current ERA-A			

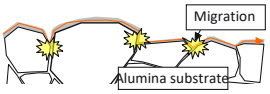
ESD Characteristics

There is a concern of damage from ESD. Compared with the general use ERA-A Series, the ERA-V/K Series offers a higher level of protection, with its Thin Film thickness regulation, avoiding thinner spots, so better avoidance of localized overcurrent intensity is achieved. In addition, the difference in internal structure, expands the actual resistor pattern length, thus reducing the Electric Field strength.

ESD Robust Design

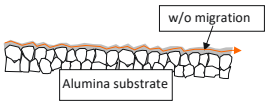
Smooth Surface Substrate

Rough Grain diameter



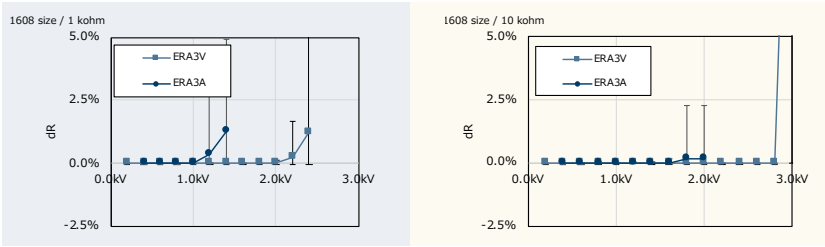
Unevenness occurs at the interface of the alumina grains

Smooth Grain diameter



Smooth surface prevents current concentration

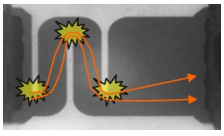
ESD Test Result



ESD condition (refer to AEC-Q200-002)
C = 150 pF,R = 2 kohm, positive 5 times, negative 5 times

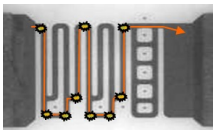
Robust Pattern Design

Wide



Localized current density→migration

Narrow



Reduced current density→robust for ESD

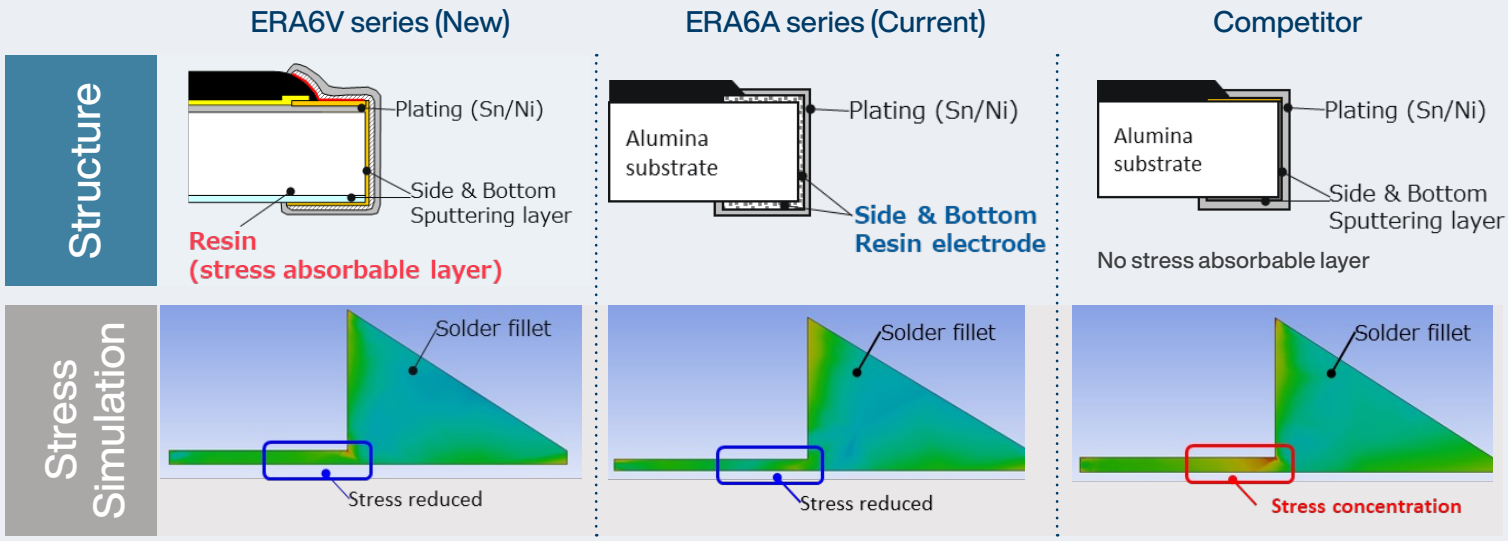
ESD/ Rated Power Comparison

	0.25W	0.125W	0.1W	0.063W
0402			ERA2V (1.0 kV)	ERA2A(-)
0603		ERA3V (1.5 kV)	ERA3A (-)	
0805	ERA6V (2.0 kV)	ERA6A (-)		
1206	ERA8V (2.0 kV)			

Thermal Stress

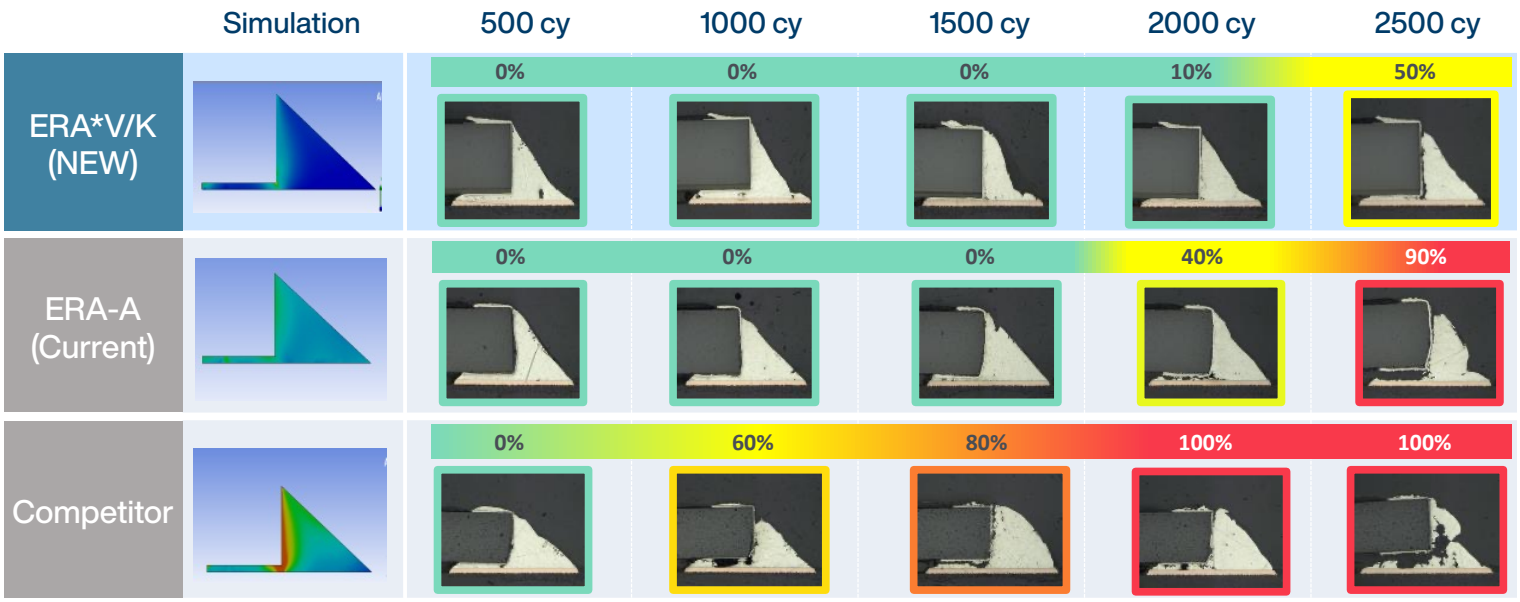
Highly accurate, the ERA-A and ERA-V/K Series Resistors provide tight resistance tolerance and low temperature coefficient of resistance, which is achieved using Panasonic's Thin-Film process. Adding a resin bottom or back-side layer helps to avoid solder joint cracking which can be seen in Temperature Cycling data from the resulting thermal expansion and contraction, compared with conventional thin film chip resistors.

Robust for Thermal Shock



Stress distribution in Solder fillet (25 deg.C to 155 deg.C)

Resistance to Thermal Shock (Solder Cracking)



Test Condition: -55°C to 155°C
*Simulation condition: 25°C to 155°C

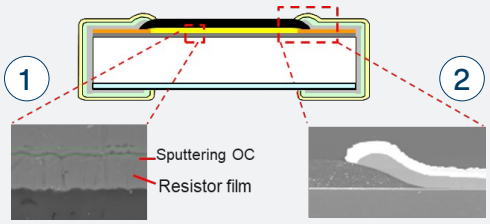
With bottom absorber structure, ERA-V/K performs the best against solder cracking

Sulfur Resistance Characteristics

Another environmental concern for chip resistors is avoiding damage to the device from exposure to sulfur. Sulfur can be found where there is oil, for example, in factories, automobiles, and other transportation applications. Anti-Sulfur (or Sulfur tolerance) of the ERA-V/K is improved by introducing edge sputtering of the electrode, covering the gap between the protective film and metal plate.

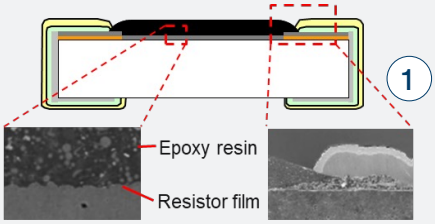
Structure to Enhance Robustness Against Corrosion

New ERA-V/K



① Electrode structure makes better coverage
② High density sputtering over coat

Current ERA-A



① Epoxy resin overcoat

ERA-P Series

Where High Voltage and High Accuracy is needed, the ERA-P is an ideal choice. An application example is in a Battery Management System (BMS) Voltage Detection circuit, using an external voltage divider for Voltage detection (VD).

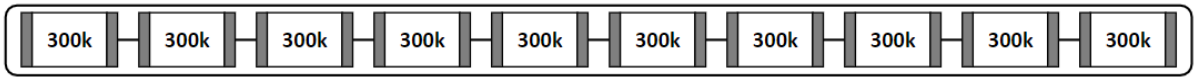
Here we see a proposal for a voltage sensing application with a Working Voltage of 1500V (Assuming worst case design, calculated double based on working voltage of approx. 750V). Rather than using other companies' 10 pcs 0805 case size, 300kOhm Thin Film Resistors to achieve this, we suggest 3 pcs 1206 case size 1M Ohm from the ERA-P series e.g. P/N ERA-8PEB1004V. This results in about a 48% reduction in Printed Circuit Board (PCB) area and fewer assembly, pick and place operations.

ERA-P Benefits

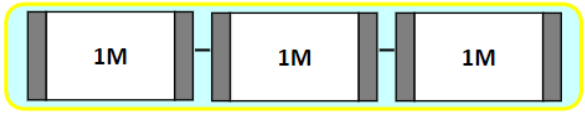
- Improve accuracy in high voltage circuit
- Contribute to reduce the usage of the high resistance value resistors

High Voltage Monitoring

① Conventional Solution
Size 0805 x 10pcs



② NEW Solution
Size 1206 x 3pcs



Total resistance value ——• Keep
Limiting Element voltage —• Keep
Mounting Area ——— • **Smaller**

Resistor	# of pcs	Tol	TCR	Limiting Element Voltage	Mounting Area*
① Ref.0805 Competitor Thin-Film Resistor	300kΩ×10series	±0.1%	±25pp	150V×10=1500V	40.25mm2
② 1206 HV Precision type ERA8PEB (Under development)	1MΩ×3series			500V×3=1500	21.15mm2 (47.5% Size down)

*Mounting area is calculated from the recommended land area

Panasonic Thin Film Resistor Contribution

Panasonic's Thin Film Resistors are widely used in various markets due to their high precision and reliability. Here are some examples of how they are used in different applications:

1. Automotive Market:

Our Thin Film Resistors are commonly used in various electronic control units (ECUs) and sensors in the automotive market. For example, they are used in engine control modules, anti-lock brake systems, and airbag control units. The benefit of using ERA-A Series or ERA-V/K resistors in these applications is their high precision and stability, which help ensure the reliable and accurate operation of these critical systems.

2. ICT Market:

In the ICT (Information and Communications Technology) market, ERA-A Series resistors are used in a wide range of applications, including servers, routers, switches, and mobile devices. For example, they are used in power management circuits, memory modules, and signal amplifiers. The benefit of using ERA-A Series resistors in these applications is their high precision and low noise characteristics, which help ensure stable and reliable operation of these devices.

3. Industrial Market:

In the industrial market, our Thin Film resistors are used in various applications, including power supplies, motor control systems, and industrial automation equipment. The benefit of using ERA-A Series resistors in these applications is their high precision and stability, which help ensure accurate and reliable control of these systems.

4. Consumer Market:

In the consumer market, ERA-A Series Resistors are used in a wide range of applications, including audio amplifiers, LED lighting, and home appliances. For example, they are used in tone control circuits, power supplies, and temperature sensors. The benefit of using ERA-A Series resistors in these applications is their high precision and low noise characteristics, which help ensure high-quality sound and stable operation of these devices.

Recommended Application (ERA-A)

Test Measurement Equipment

A key application for Thin Film Resistors is in test and measurement equipment. In these applications, ERA-A Series resistors are often used in high-precision circuits that require low noise and high stability. For example, in a digital multimeter, the ERA-A Series resistors are used in voltage divider circuits to measure voltage accurately.

The benefits of using ERA-A Series resistors in test and measurement equipment are their high precision and low noise characteristics, which help to minimize errors and ensure accurate measurements. In addition, the ERA-A Series resistors have excellent stability over time and temperature, which is important for maintaining accurate calibration of equipment.

In a digital multimeter, the ERA-A Series Resistor acts as a voltage divider, dividing the input voltage by a precise ratio. The resulting voltage is then measured by the analog-to-digital converter in the multimeter. The precision and stability of the ERA-A Series resistors ensure that the voltage is accurately divided and that the measurement is accurate and reliable.

Overall, the high precision and stability of Panasonic's ERA-A Series resistors make them an excellent choice for use in test and measurement equipment, where accuracy and reliability are critical.

For more information:

ERA-A
https://industrial.panasonic.com/cdbs/www-data/pdf/RDM0000/AOA0000C307.pdf

ERA-V/K
https://industrial.panasonic.com/cdbs/www-data/pdf/RDM0000/RDM0000C331.pdf

ERA-P
https://industrial.panasonic.com/cdbs/www-data/pdf/RDM0000/ast-ind-219290.pdf

Compliant to IEC 60115-8, JIS C 5201-8 and JEITA RC-2133C Reference Standards, devices in the ERA Series are also RoHS/REACH Compliant.