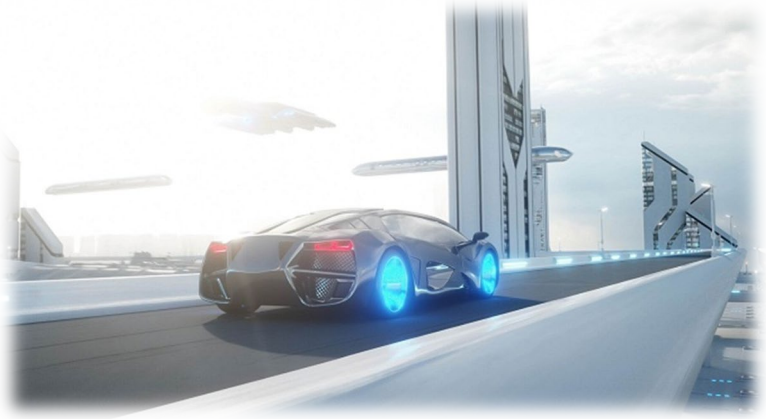
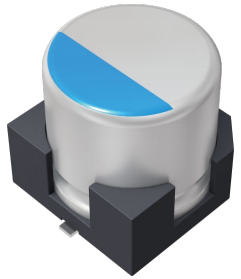


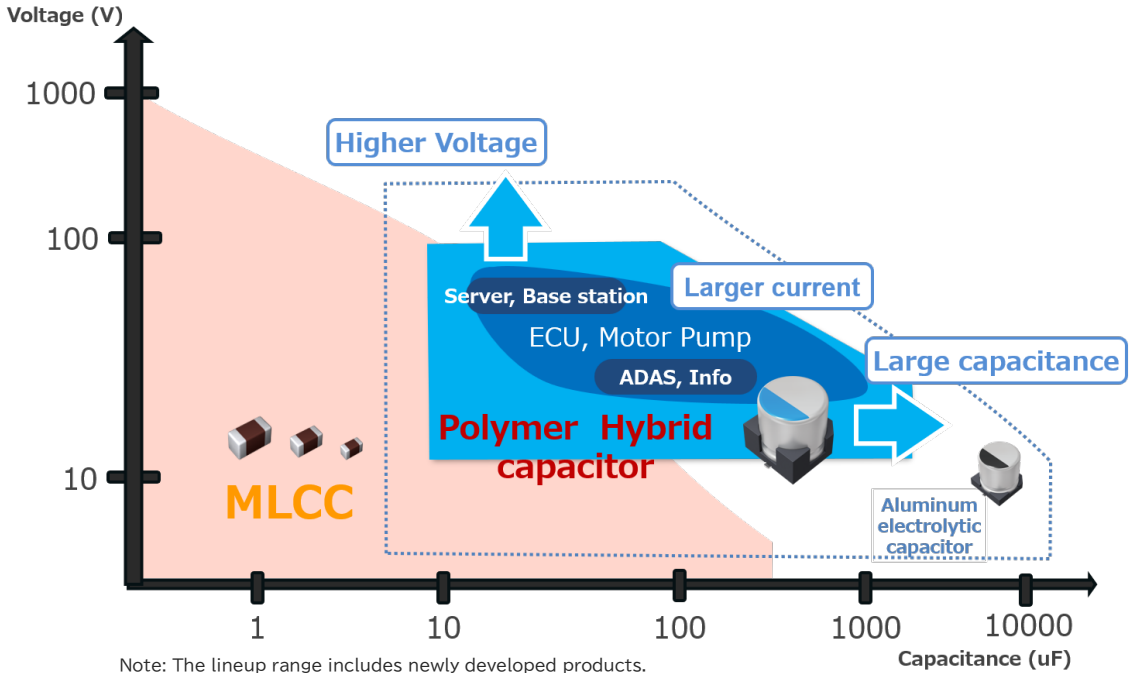
TAIYO YUDEN
Conductive Polymer Hybrid Aluminum Electrolytic Capacitors Achieve Industry-Leading Capacitance and Ripple Current Performance through Expanded Large-Case Lineup

~Contributing to Higher Density and Higher Output in Automotive 48V Systems, Data Centers, and AI Server Power Supplies~



TAIYO YUDEN CO., LTD.
As of September 2026

01 Challenges in Next-Generation Power Supply Design and Background of Hybrid Capacitors



Note: The lineup range includes newly developed products.

In today's automotive ECUs, data centers, AI servers, and industrial equipment, requirements for power supply circuits are becoming dramatically more sophisticated and diverse due to improving processing performance and the advancement of electrification. Particularly with the adoption of "48V systems" in mild hybrid (MHEV) and battery electric vehicles (BEV), as well as the integration of 1 kW-class high-power conversion circuits, power supply capacitors are simultaneously subjected to extremely stringent requirements such as:

- Responding to increased ripple current (suppressing self-heating)
- Lower ESR during high-speed switching
- Low-profile and compact design to withstand high-density mounting
- High reliability and vibration resistance to withstand harsh automotive and industrial environments (AEC-Q200 compliant)

Conventionally, aluminum electrolytic capacitors and solid polymer capacitors have been used to address these challenges, but neither type alone can satisfy the above requirements. While aluminum electrolytic capacitors offer high voltage resistance and high capacitance, they present challenges such as relatively high low-temperature ESR, self-heating caused by ripple current, aging degradation, and characteristic deterioration at low temperatures. On the other hand, while solid polymer capacitors boast extremely low ESR, they are difficult to make with high voltage ratings (generally 16 V or less), carry the disadvantage of increased leakage current (LC) after reflow, and entail the risk of short-circuit mode failures.

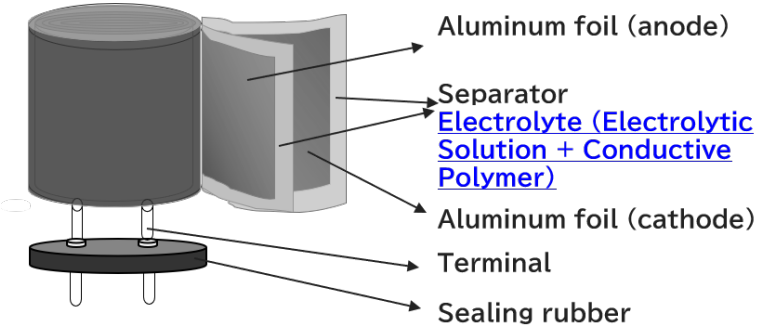
Conductive polymer hybrid aluminum electrolytic capacitors (hereinafter referred to as hybrid capacitors) are an attractive solution that fuses the advantages of both types of capacitors while eliminating their disadvantages. This document explains the basic characteristics of hybrid capacitors, TAIYO YUDEN's industry-leading "HVX/HTX-J Series", the new "-K Series" products that add an 80V high-voltage rating to the lineup to achieve dramatic downsizing, and the specific design solutions enabled by the industry-only "large case (ϕ12.5)" size.

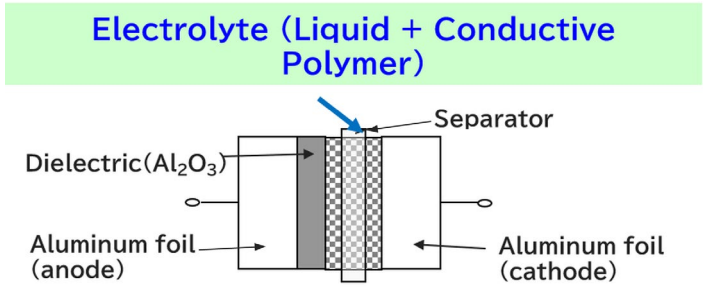
The names of series noted in the text are excerpted from part numbers that indicate the types and characteristics of the products , and therefore are neither product names nor trademarks.

02 Structure and Basic Characteristics of Hybrid Capacitors

➢ Hybrid Structure of Liquid and Solid

Hybrid capacitors feature an innovative structure that employs both a conductive polymer (solid) and an electrolytic solution (liquid) as electrolytes. By impregnating the separator with these two electrolytes, the strengths of each material are brought out in a synergistic manner.





Achieving Low ESR:

A conductive polymer (solid polymer) with extremely low ionic conduction resistance significantly reduces ESR in the high-frequency region.

High Voltage Resistance and Self-Healing (Low Leakage Current):

The excellent dielectric film repair action (self-healing property) of the liquid electrolyte suppresses the increase in post-reflow leakage current (LC)—which presents a challenge for solid polymers alone—and maintains stable LC characteristics equivalent to those of aluminum electrolytic capacitors.

Open-Mode Failure:

Because the failure behavior is an “open mode,” it is ideal for decoupling applications directly connected to batteries in automotive and other systems where short-circuit mode failures are a concern.

➢ Capacitor Characteristics Comparison

Characteristic Comparison	Aluminum Electrolytic	Solid Polymer	Polymer Hybrid (HTX Series, etc.)
ESR	High	Very Low	Low
Ripple Current	Low to Medium	High	High
High Voltage Type	◎ (Up to High-Voltage Lines)	× (16 V or below)	○ (25~80 V)
Stability of leakage current (LC)	◎	× (Post-Reflow Increase)	○ (Stable)
Failure Mode	Open	Short	Open (Safe and Highly Reliable)

03 Replacement Benefits from Aluminum Electrolytic Capacitors and Circuit Design Innovation

Replacing aluminum electrolytic capacitors with hybrid capacitors not only improves performance but also directly contributes to dramatic circuit miniaturization, reduced component counts, and a smaller PCB footprint.

➢ Replacement Effects with Same Ratings and Size (Case 1)

When directly comparing an aluminum electrolytic capacitor and a hybrid capacitor of the same size(ϕ10 × 10L mm、rated 25V 330μF), the following dramatic improvements are observed:

- 4× increase in ripple current capability (from 500 mArms to 2,000 mArms)
- ESR reduced to approximately 1/7 (from 0.15 Ω to 0.02 Ω)
- 2 to 3× extension in lifetime (from 2,000 hours to 4,000 to 6,000 hours)

Consequently, if a system requires a ripple current of 2,000 mArms, it would require four aluminum electrolytic capacitors in parallel, whereas a single hybrid capacitor can satisfy the requirement.

➢ Downsizing Effects Based on Ripple Current Standards (Case 2)

When performing a replacement and redesign under the condition of securing equivalent ripple current (approximately 1,600 mArms), extremely dramatic space savings can be achieved, as shown below.

Comparison Item	Aluminum Electrolytic (VVT Series)	Hybrid (HVK Series)	Replacement Benefits
Rating	25V 2,200μF	25V 220μF	Optimization of capacitance (elimination of excessive capacitance)
Size	ϕ18 × 21.5L mm	ϕ8 × 10L mm	Approximately 80% reduction in mounting volume
Ripple Current	1,550 mArms	1,600 mArms	Maintaining equivalent or higher performance
ESR	0.042 Ω	0.027 Ω	Lower power loss (reduced to approx. 1/1.6)
Lifetime	5,000 hours	6,000 hours	1.2× longer lifetime achieved

➢ Superior Frequency Characteristics and Temperature Stability

Because hybrid capacitors exhibit extremely low ESR over a wide frequency band, they deliver stable filtering effects in circuits with various switching frequencies. Furthermore, even in extremely low-temperature environments (e.g., -40 °C), where aluminum electrolytic capacitors struggle to perform, the variation (increase) in ESR is remarkably small, demonstrating exceptional advantages in the design of automotive and outdoor equipment requiring cold starts.

04 Response to Automotive 48V System Trends and Surge Voltage (ISO 21780)

➢ Background of the Transition to 48V Power Lines

Driven by tighter emission regulations and demands for improved fuel efficiency, the shift toward BEVs is advancing. To reduce battery-related weight, automotive power supplies are transitioning from conventional 12V systems to 48V systems (such as mild hybrids). Increasing the voltage fourfold reduces the current required to deliver the same power to 1/4, enabling lighter wire harnesses and improved overall system efficiency. Additionally, auxiliary equipment with extremely high power consumption, such as electric power steering (EPS) and e-compressors, are now powered directly from the 48V line.

➢ Surge Standard “ISO 21780” and Capacitor Selection Challenges

In 48V systems, surge voltage standards required for components are strictly defined (ISO 21780-2020, LV148, etc.). In particular, the “Short-term overvoltage” test requires withstanding surge applications of “70V, 40ms, 1,000 cycles,” demanding an overvoltage tolerance of 70V or higher even at the individual component level.

To meet this test, many design engineers are forced to select high-cost, large-sized “80V-rated products” with a safety margin. However, the higher the rated voltage, the lower the capacitance efficiency of the capacitor, leading to increased size and higher costs.

➢ TAIYO YUDEN: “63V Product Support” and “Latest 80V High-Voltage Products”

To address this challenge, TAIYO YUDEN proposes two approaches to maximize design flexibility:

1) Technical Support for 63V Product Adoption:

TAIYO YUDEN can provide test reports on actual performance under surge guarantee conditions based on JIS standards (room temperature, 1.15 times the rated voltage = approx. 72.4V for 63V products, 30-second application, 5-minute 30-second discharge, 1,000 cycles). TAIYO YUDEN supports customer decisions regarding the use of “63V-rated products” in their circuits. As a result, TAIYO YUDEN can propose realizing designs with a single 63V 220 uF capacitor instead of two parallel 80V 120 uF capacitors, contributing to a 50% reduction in mounting area and component count.

2) New -K Series “80V High-Voltage Product” Lineup:

TAIYO YUDEN has added 80V high-voltage products to its new -K series lineup. This contributes to miniaturization while maintaining high ripple current and high capacitance, even for equipment requiring higher surge voltages.

●Surge Guarantee for Electrolytic Capacitors (JIS)
Guarantee Conditions
Room temperature/Rated voltage x 1.15 (former JIS standard x 1.25)/
30-second application/5-minute 30-second discharge/1,000 cycles

Applied voltage:63 V x 1.15 approx. 72 V
(63 V x 1.25 approx. 79 V)
➡ Guarantees tests at 70 V or higher
➡ Applicable with 63V products

05 Low-Profile, High-Capacitance Solutions via TAIYO YUDEN's Proprietary "Large Case (φ12.5)"

The housings of automotive electronic devices are becoming thinner and more compact year by year. Combined with the severe heat and vibration environments inside engine compartments and behind dashboards, "height restrictions (low-profile requirements)" for discrete components such as capacitors are becoming even more stringent. Generally, tall components (e.g., φ10 × 16.5L mm) increase the risk of terminal fracture due to mechanical vibration.

➢ Industry-Largest "φ12.5 × 16.5L mm" -K Series

Achieves high capacitance (such as 63V / 330 μF) with an even larger case size. It makes it possible to consolidate two conventional competitor products into a single unit of this size (reducing component count and mounting area by approximately 25%).

➢ Industry-Only "φ12.5 × 13.5L mm" -J and -K Series

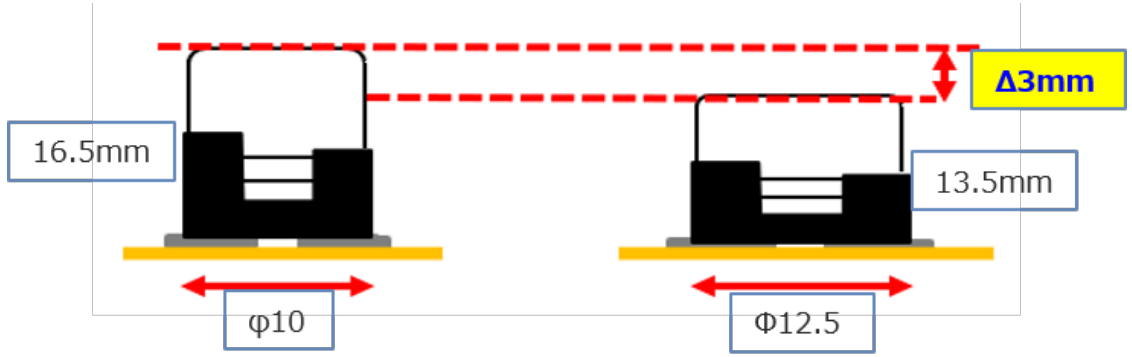
TAIYO YUDEN offers the industry's only large case size of "φ12.5 × 13.5L mm".

Value Brought by a 3mm Height Reduction:

While maintaining electrical characteristics equivalent to the industry-standard φ10 × 16.5L mm products (e.g., 63V / 150 μF, rated ripple current of 5,000 mArms or higher), the height can be reduced to 13.5 mm.

Improved Freedom in Housing Design:

Because clearance above the capacitor is secured, it provides greater flexibility for arranging heat sinks and designing ultra-thin housings.



Recommended for units with strict height restrictions

06 Technological Innovation: Introducing the “-K Series”

TAIYO YUDEN offers its latest series to meet market demands for higher ripple current, higher capacitance, higher voltage ratings, and downsizing.

➢ Key Specifications of the K Series

Rated Voltage [V]	D Dimension [mm]	L Dimension [mm]	Capacitance [uF]	Ripple Current [mArms(125℃)]	ESR [mΩ]
25	10	16.5	1,200	5,700	12
	12.5	13.5	1,200	5,700	12
	12.5	16.5	1,800	6,500	11
35	12.5	16.5	1,200	6,500	11
63	10	16.5	220	5,200	15
	12.5	16.5	330	6,000	13
80	10	16.5	120	4,700	18
	12.5	16.5	180	5,500	16

➢ Dramatic Downsizing and 80V High-Voltage Expansion with the K Series

Adopting the latest -K series makes it possible to significantly reduce size (downsizing) while improving or maintaining characteristics compared to conventional product designs. It boasts an exceptional track record of miniaturization, particularly in the newly developed 80V high-voltage products.

Rated Voltage [V]	Capacitance [μF]	Conventional Product			Downsizing		
		Size [mm]	ESR [mΩ]	Ripple Current [mArms]	Size[mm]	ESR [mΩ]	Ripple Current [mArms]
25	820	Φ12.5 × 13.5L	15	4,000	**Φ10 × 12.5L**	**15**	**4,800**
	680	Φ10 × 12.5L	18	3,000	**Φ10 × 10L**	**15**	**4,600**
63	100	Φ10 × 12.5L	26	2,000	**Φ10 × 10L**	**18**	**4,000**
	56	Φ10 × 10L	30	1,400	**Φ8 × 10L**	**23**	**3,300**
80	33	Φ10 × 10L	36	1,200	**Φ8 × 10L**	**25**	**3,000**

07 Application Benefits by Automotive Sector

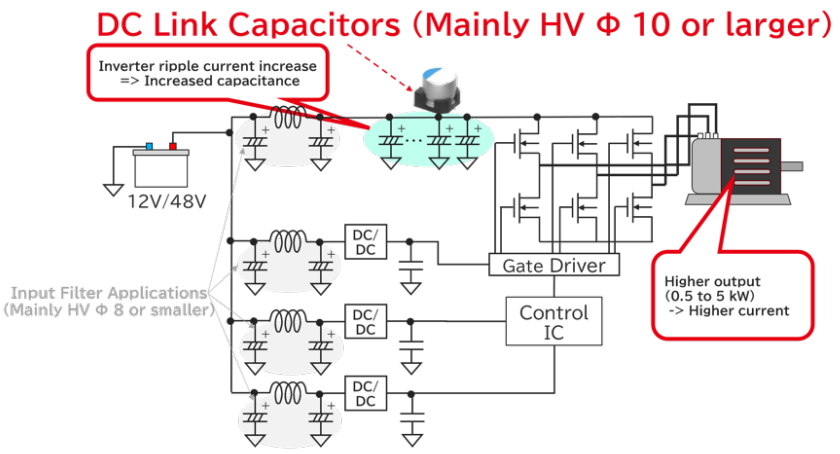
➢ High-Power Motor Equipment (EPS, Electric Brakes, Various Actuators, etc.)

Operating Environment and Challenges:

In inverter circuits for driving motors involving high outputs of 0.5 to 5 kW, sudden high-current loads and the resulting increase in inverter ripple current pose significant challenges.

Solution:

Adopt large hybrid capacitors (HVX/HTX-J and -K series, ϕ10 or larger) as DC link capacitors. Their high allowable ripple current capability prevents capacitor self-heating while ensuring long-term operation.



Increased use of high-power motors for auxiliary equipment accompanying powertrain electrification

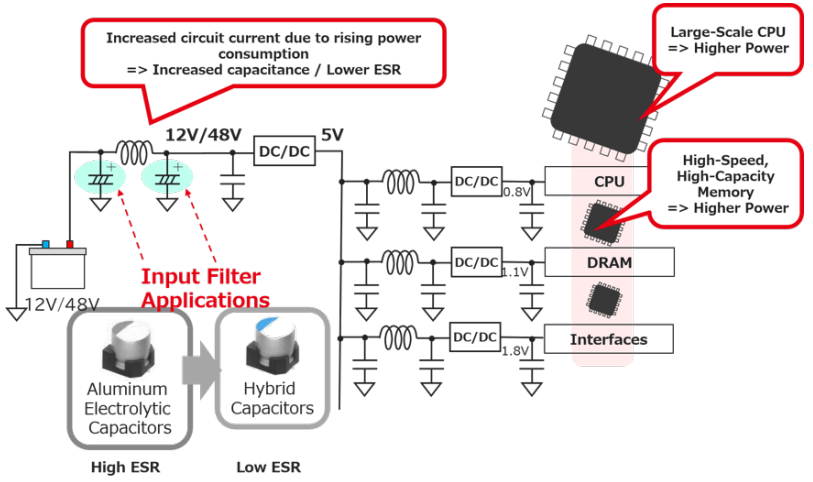
➢ High-Power ECUs and Autonomous Driving Processors (ADAS, Central Computers, Zone ECUs, etc.)

Operating Environment and Challenges:

With the advancement of autonomous driving, the computational load of automotive SoCs/CPUs is increasing explosively. DC/DC capacitors for core voltage supply are required to have extremely low ESR to support low-voltage, high-current operation, as well as high-speed response to sudden load fluctuations.

Solution:

By replacing everything from the primary power supply (48V/12V line) input filters to secondary-side circuit decoupling with low-ESR hybrid capacitors, large-amplitude noise is strongly suppressed. For 80V line designs, the new -K series 80V lineup enables design with the minimum possible footprint.



➢ LED Driving Circuits

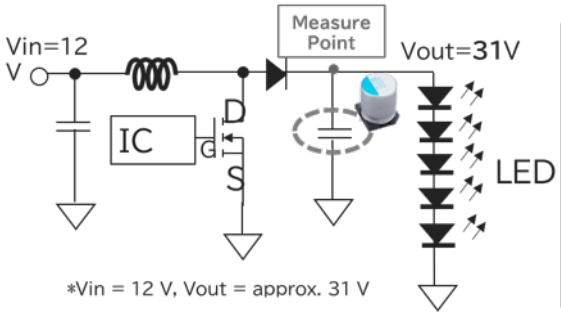
Operating Environment and Challenges:

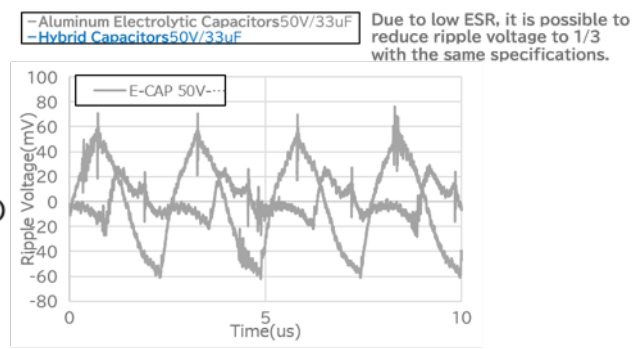
These circuits perform step-up operations (40 V to 50 V) to drive a large number of LEDs in series, generally making 63 V products the preferred choice. In addition, minimizing ripple voltage is essential to suppress luminance variations in LED lights.

Solution:

Replacing aluminum electrolytic capacitors with hybrid capacitors reduces ripple voltage to 1/3. This eliminates LED flicker while simultaneously reducing mounting space and costs.

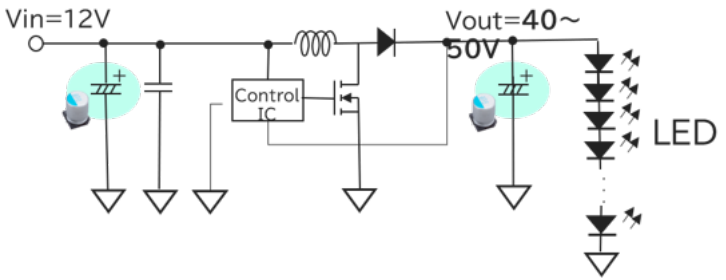
LED Backlight (Circuit Diagram)





Due to low ESR, it is possible to reduce ripple voltage to 1/3 with the same specifications.

LED Headlight (Circuit Diagram)



① Reduced mounting cost through reduced component count
② Miniaturization and space-saving
③ Extended lifetime

Since LED drive sections connect many LEDs in series, the driving voltage becomes high, centering around the use of 63 V products.

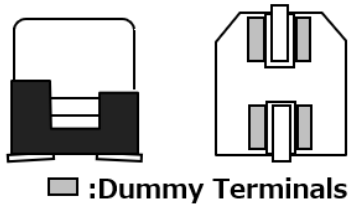
08 High-Reliability Technology and Environmental Compliance Meeting Automotive Requirements

Hybrid capacitors provide optimal solutions for the distinct power supply challenges of each section within automotive systems.

➢ “Vibration-Resistant” Structure Realizing 30G Assurance

To support installation in locations exposed to severe mechanical vibration, such as ECUs near engine mounts or directly attached to the chassis, TAIYO YUDEN offers a lineup of “vibration-resistant products (such as the HTX series).”

30G Guaranteed Product
Acceleration: Maximum 30G
Displacement: Maximum 1.5 mm
Frequency: 10 to 2,000 Hz
Duration: 2 hours

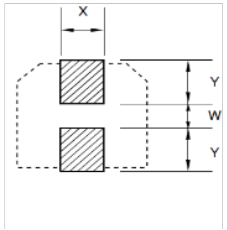


Challenges of Standard Seat Bases:

Under severe mechanical vibration, the mass of the capacitor causes the body to shake violently, and repetitive stress concentrates on the lead terminals at the base. As a result, solder cracks and terminal fractures occur.

Vibration-Resistant Seat Base Solution:

The side walls of the seat base are designed higher to securely hold the aluminum body of the capacitor, thereby suppressing the vibration itself.



(Unit : mm)

Case Size φD	Land Size X	Land Size Y	Land Size W	Thickness of Solder paste
6.3	3.0	4.0	1.6	0.20
8	5.0	4.0	2.5	0.20
10	5.0	4.8	3.6	0.20
12.5	7.0	6.6	3.2	0.20

Addition of Dummy Terminals:

Electrically unconnected “dummy terminals (solder anchors)” are placed at the bottom of the seat base. Soldering to the board at multiple points significantly enhances solder joint strength.

30G Assurance:

Clears severe vibration test conditions of up to 30G acceleration and 1.5 mm displacement (10 to 2,000 Hz, 2 hours) (standard products have a capability of 10G).

➢ Fully Compliant with AEC-Q200

TAIYO YUDEN’s automotive hybrid capacitor product lineup (automotive-grade products prefixed with “A”, e.g., “RAHVX...”) complies with “AEC-Q200,” the global standard reliability test specification for automotive electronic components. Manufactured under rigorous quality control processes, they pass the stringent selection criteria of Tier 1 manufacturers and OEMs with a high margin.

09 Summary: Advantages Brought by TAIYO YUDEN's Hybrid Capacitors

Conductive polymer hybrid aluminum electrolytic capacitors provide ripple characteristics that outperform conventional aluminum electrolytic capacitors, ultra-low ESR, and exceptional reliability through an advanced electrolyte structure combining an electrolytic solution and a conductive polymer. The advantages of choosing TAIYO YUDEN's products are summarized in the following three points:

1. Industry-Only Large Cases

"Low-Profile" Solution (φ12.5 x 13.5L mm): Achieves a 3 mm height reduction while maintaining electrical characteristics equivalent to the industry-standard high-profile phi 10 x 16.5L mm product. It offers optimal packaging for thin circuit boards with strict height restrictions and locations demanding high vibration resistance.

"High-Capacitance" Solution (φ12.5×16.5L mm): Proposes high ripple current and high capacitance for hybrid capacitors in the industry's largest package size.

2. Substantial Miniaturization, High Ripple, and High Voltage Ratings via the Latest "-J" and "-K" Series

Achieves high allowable ripple current through the adoption of a new structure (-J). Furthermore, the "-K series," which achieves identical performance in a one-class-smaller case size, eliminates dead space on the board to the utmost limit. In addition, the newly added 80V high-voltage lineup strongly supports space-saving designs for high-reliability 48V systems.

3. 48V System & Surge Compatibility (63V/80V Options) and 30G Vibration Resistance

For automotive 48V system surge test specifications such as ISO 21780, we provide test data that allows for the safe proposal of 63V products, while presenting the ultra-compact -K series 80V products for designs that prioritize safety margins. Combined with a 30G-assured vibration-resistant structure, they accommodate all operating environments.

For detailed specifications on our latest products, requests for surge test reports, or design-in consultations, please feel free to contact Taiyo Yuden's web search system "TY-COMPAS" or our sales representatives.

Item Specs

TY-COMPAS

Contact