

TAIYO YUDEN Conductive Polymer Hybrid Aluminum Electrolytic Capacitors for Automotive Market

φ12.5 x 13.5L(mm) Large Capacitance (HVX/HTX-J Series)

Conductive polymer hybrid aluminum electrolytic capacitors (referred to hereafter as hybrid capacitors) combine liquid and conductive polymer electrolytes to deliver the high capacitance and voltage rating characteristics of aluminum electrolytic capacitors, together with the low ESR associated with conductive polymer solid electrolytic capacitors.

Hybrid capacitors feature high ripple current capability, low ESR at low temperatures, and long operational life. Their open-circuit failure mode further contributes to higher reliability at the system level.

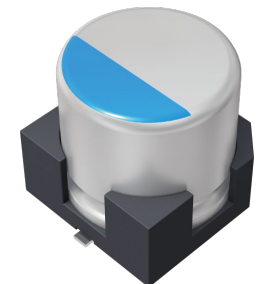
Leveraging extensive experience in the automotive and industrial equipment markets, TAIYO YUDEN delivers high ripple current, high capacitance, and a low profile of 13.5L(mm) with its industry-leading large case size (φ12.5).

This document introduces the HVX/HTX-J series, products that set industry-leading benchmarks in key characteristics, and explores the solutions they enable in the automotive market where 48 V systems are becoming mainstream.

01 Why Hybrid Capacitors Are Required

- In data centers, AI servers, automotive ECUs, and industrial equipment alike, the design requirements for power supply circuits are becoming increasingly sophisticated and diverse. Automotive applications, for example, now require power conversion in the 700 W to 1 kW range for 48 V systems. As a result, power supply capacitors face simultaneous challenges: (1) Handling increased ripple current, (2) Minimizing ESR during high-speed switching, (3) Achieving a low profile and reduced footprint, and (4) Maintaining compliance with AEC-Q200 automotive standards. Neither aluminum electrolytic capacitors nor solid polymer capacitors alone can fully satisfy all of these requirements.
- Aluminum electrolytic capacitors used in high-current devices may exhibit relatively high ESR and thermal self-heating, and carry the risk of capacitance degradation over time. Solid polymer capacitors, while offering low ESR, have difficulty achieving high voltage ratings (generally 16 V or below) and are prone to increased leakage current (LC) after reflow. Hybrid capacitors combine a conductive polymer (solid polymer) with a liquid electrolyte, achieving both the low ESR of solid-polymer capacitors and the high capacitance and high voltage capability of liquid-electrolyte capacitors. Since conductive polymer exhibits lower ionic conduction resistance than liquid electrolyte, it significantly reduces ESR in the high-frequency range. Lower ESR directly suppresses self-heating, allowing the capacitor to handle higher ripple current within the same volume.

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	Very Good	Not Good (16 V or below)	Good (25–80 V)
Large Case (φ12.5)	Very Good	Good (φ10 or below)	Good (φ10 or below)



02 Replacing Aluminum Electrolytic Capacitors with Hybrid Capacitors

- When comparing aluminum electrolytic capacitors (VVT series) and hybrid capacitors (HVK series) of the same rating and size (25 V 330 uF, $\phi 10 \times 10$ mm), the following differences have been observed.

Comparison Item	Aluminum Electrolytic (VVT)	Hybrid (HVK)
Rating	25 V 330 uF	25 V 330 uF
Size (mm)	$\phi 10 \times 10$	$\phi 10 \times 10$
Ripple Current	500 mArms	2,000 mArms (4x vs. Al-Elec.)
ESR	0.15 Ω	0.02 Ω (reduced to approx. 1/7)
Guaranteed Life	2,000 h	4,000–6,000 h (2–3x)

- The primary advantage of replacing aluminum electrolytic capacitors with hybrid capacitors is miniaturization, reduced component count, and a smaller PCB footprint, enabled by their higher-ripple current tolerance. For a 2,000 mArms system requirement, a single hybrid capacitor is sufficient, compared with four aluminum electrolytic capacitors in parallel. Service life is also estimated to increase by 2–3x.

- The following compares configurations that achieve an equivalent ripple-current rating (-1,600 mArms). When ripple current is the primary system requirement, hybrid capacitors enable downsizing from $\phi 18$ to $\phi 8$.

Comparison Item	Aluminum Electrolytic (VVT)	Hybrid (HVK)
Rating	25 V 2,200 uF	25 V 220 uF
Size (mm)	$\phi 18 \times 21.5$	$\phi 8 \times 10$ (approx. 80% reduction)
Ripple Current	1,550 mArms	1,600 mArms
ESR	0.042 Ω	0.027 Ω (reduced to approx. 1/1.6)
Guaranteed Life	5,000 h	6,000 h (1.2x increase)

- In addition to the ripple current advantages described above, hybrid capacitors offer superior characteristics in several other areas. They exhibit lower ESR than aluminum electrolytic capacitors across a wide frequency band, providing excellent performance over a broad range of operating frequencies. Furthermore, because ESR variation remains small even at low temperatures and is stable with respect to temperature changes, hybrid capacitors are well-suited for equipment that operates at low-temperature environments.
- Regarding leakage current (LC), solid-polymer capacitors typically show degraded LC after reflow. Hybrid capacitors, however, exhibit leakage-current characteristics similar to aluminum electrolytic capacitors after reflow, making them more stable than solid-polymer types.

03 HVX/HTX-J Series: Addressing the 48 V Automotive System Trend

- BEV (battery electric vehicle) power sources are predominantly lithium-ion batteries (400 V to 800 V), with higher voltage used on the motor-drive bus to increase motor output, particularly torque. Raising the auxiliary system bus from 12 V to 48 V also reduces current to one-quarter, enabling lighter wiring and improving overall BEV system efficiency.
- Regarding 48 V system adoption, surge-voltage requirements for components are defined in standards such as ISO 21780-2020 and LV148. Based on these requirements, rated voltages of 63 V / 80 V are commonly used for aluminum electrolytic capacitors in power supply circuits. Currently, 63V-rated products are gaining attention due to their advantage of achieving higher capacitance
- TAIYO YUDEN's HVX/HTX-J series maintains industry-leading high ripple current and high capacitance while offering 63 V products in multiple case sizes, supporting the diverse design requirements of 48 V systems. The series also achieves high ripple performance, high capacitance, and a low profile of 13.5L(mm) length with the industry-leading large $\phi 12.5$ case size.
- In general, for electrolytic capacitors - including hybrid capacitors- capacitance decreases at the given case size as the rated voltage increases. In 48 V systems, voltage ratings of 63 V or higher are required, making this effect particularly significant. To secure the necessary capacitance and ripple-current in $\phi 10$ products, the taller 16.5L(mm) length height option is gaining attention. TAIYO YUDEN's industry-leading large $\phi 12.5 \times 13.5$ L mm case size can achieve characteristics equivalent to $\phi 10 \times 16.5$ mm products while providing the added benefit of a lower 13.5L(mm) profile. This is a unique advantage of TAIYO YUDEN.

04 HVX/HTX-J Series $\phi 12.5 \times 13.5L$ mm Size: High Ripple Current and Large Capacitance

- TAIYO YUDEN's -J series offers a comprehensive 63 V lineup for 48 V systems, achieving a maximum capacitance of 63 V / 150 μ F in the $\phi 12.5 \times 13.5L$ (mm) case size.
- The current industry-standard $\phi 10 \times 16.5L$ (mm) size also achieves 63 V / 150 μ F, and the -J series $\phi 12.5 \times 13.5$ mm provides a lower profile while maintaining equivalent electrical characteristics. In addition, the -J series $\phi 12.5 \times 13.5L$ (mm) lineup includes high capacitance products such as 25 V / 1,000 μ F and 35 V / 680 μ F, supporting a wide range of rated voltages and capacitance requirements.

- In automotive electronic equipment, housings continue to become smaller and thinner due to space constraints, and height limits for components on circuit boards are becoming increasingly stringent. Height restrictions may also be imposed due to vibration or thermal-environment constraints.
- In this context, the ability to mount a capacitor with equivalent performance at 13.5L(mm) rather than 16.5L(mm) meaningfully expands housing design freedom. When clearance above the capacitor can be secured, designers gain more freedom in component placement and thermal management layout. For designs with strict height limits, the $\phi 12.5 \times 13.5L$ (mm) option provides a viable low-profile solution without sacrificing performance.

■ -J Series $\phi 12.5 \times 13.5L$ (mm)

Part Number	Rated Volt. [Vdc]	Cap. [μ F]	ESR(max) [Ω]	Rated Ripple(max) [mA _{rms}] (Temp.[$^{\circ}$ C]/Freq.[Hz])	Rated Ripple(max) ² [mA _{rms}] (Temp.[$^{\circ}$ C]/Freq.[Hz])
RAHVX102M1TGL5005J	25	1,000	0.012	4,000 (135 / 100k)	5,700 (125 / 100k)
RAHTX102M1TGL5005J	25	1,000	0.012	4,000 (135 / 100k)	5,700 (125 / 100k)
RAHVX681M1GGL5005J	35	680	0.013	4,000 (135 / 100k)	5,700 (125 / 100k)
RAHTX681M1GGL5005J	35	680	0.013	4,000 (135 / 100k)	5,700 (125 / 100k)
RAHVX271M1UGL5005J	50	270	0.015	3,800 (135 / 100k)	5,300 (125 / 100k)
RAHTX271M1UGL5005J	50	270	0.015	3,800 (135 / 100k)	5,300 (125 / 100k)
RAHVX151M4EGL5005J	63	150	0.016	3,100 (135 / 100k)	5,000 (125 / 100k)
RAHTX151M4EGL5005J	63	150	0.016	3,100 (135 / 100k)	5,000 (125 / 100k)

■ -J Series $\phi 10 \times 16.5L$ (mm)

Part Number	Rated Volt. [Vdc]	Cap. [μ F]	ESR(max) [Ω]	Rated Ripple(max) [mA _{rms}] (Temp.[$^{\circ}$ C]/Freq.[Hz])	Rated Ripple(max) ² [mA _{rms}] (Temp.[$^{\circ}$ C]/Freq.[Hz])
RAHTX102M1TFP5002JX	25	1,000	0.012	4,000 (135 / 100k)	5,700 (125 / 100k)
RAHTX681M1GFP5002JX	35	680	0.013	4,000 (135 / 100k)	5,700 (125 / 100k)
RAHTX271M1UFP5002JX	50	270	0.015	3,800 (135 / 100k)	5,300 (125 / 100k)
RAHTX151M4EFP5002JX	63	150	0.015	3,600 (135 / 100k)	5,200 (125 / 100k)

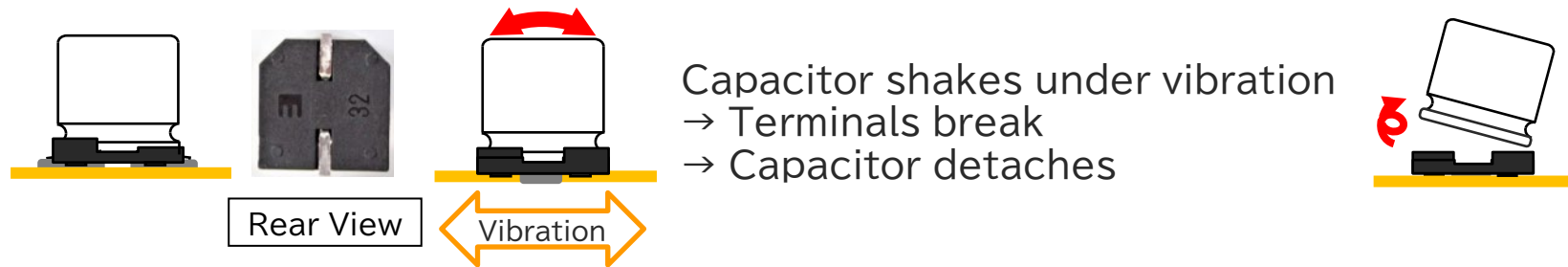
*Series names, which have been extracted from part numbers, describe product segments including product types and characteristics.

05 Vibration-Resistant Products

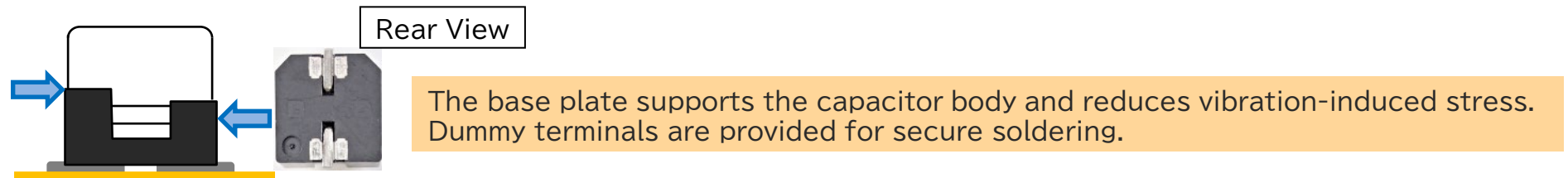
- In automotive applications, vibration resistance is required depending on the location and environment in which the unit is installed. Because standard base plates carry the risk of terminal breakage and capacitor detachment, it is recommended to use a vibration-resistant base plate for vibration-resistant products.
- TAIYO YUDEN offers products guaranteed up to 30G, using dual fixation with a vibration-resistant base plate and dummy terminals.

Item	Standard Product	Vibration-Resistant Product (HTX Series)
Fixing Structure	Standard Base Plate (Terminals Only)	Vibration-Resistant Base Plate + Dummy Terminals (Enhanced Soldering)
Vibration Resistance Guarantee	Actual: 10G Disp. 1.5 mm 10-2,000 Hz, 2 hrs	Guaranteed: 30G Max. Acc. 30G / Disp. 1.5 mm 10-2,000 Hz, 2 hrs

With Standard Base Plate



With Vibration-Resistant Base Plate



06 TAIYO YUDEN Hybrid Capacitor Lineup

- TAIYO YUDEN’s hybrid capacitors support a wide range of temperatures and lifetimes, from 105°C / 10,000 h to 150°C / 2,000 h. Multiple series allow designers to select the optimal product based on operating temperature and required lifetime, providing flexibility across diverse applications.
- The broad range of case sizes is a unique advantage, and the industry-largest $\phi 12.5 \times 13.5L$ (mm) is not merely an additional high-capacitance option; it also offers designers a low-profile alternative for 48 V system designs.

Series	Shape	Temperature / Lifetime	Rated Voltage	Features
HVX-J / HTX-J	$\phi 8 \times 10 \sim \phi 12.5 \times 13.5L$ (mm)	125°C / 4,000 h 135°C / 4,000 h	25-63 V	High Ripple Low Profile Large Size
HVX / HTX	$\phi 6.3 \times 5.8 \sim \phi 10 \times 12.5L$ (mm)	135°C / 4,000 h	16-63 V	Standard Series
HVQ / HTQ	$\phi 8 \times 10 \sim \phi 10 \times 10L$ (mm)	150°C / 1,000 h	16-63 V	High Heat Resistance
HVY / HTY	$\phi 8 \times 10 \sim \phi 10 \times 10L$ (mm)	150°C / 2,000 h	16-63 V	High Heat Resistance Long Lifetime
HVL / HTL	$\phi 8 \times 10 \sim \phi 12.5 \times 13.5L$ (mm)	125°C / 8,000 h	25-63 V	Ultra-Long Lifetime

*Series names, which have been extracted from part numbers, describe product segments including product types and characteristics.

07 Summary

- Conductive polymer hybrid aluminum electrolytic capacitors, with their electrolyte structure combining liquid electrolytic and conductive polymer, offer advantages over aluminum electrolytic capacitors in ripple current tolerance, ESR, and service life.
- TAIYO YUDEN's greatest strength is its industry-exclusive $\phi 12.5 \times 13.5L$ (mm) large case. This case size can achieve electrical characteristics equivalent to $\phi 10 \times 16.5L$ (mm) products while providing the added benefit of a 13.5L(mm) low-profile height. This is a unique advantage of TAIYO YUDEN.
- The HVX/HTX-J series offers an extensive 63 V lineup for 48 V systems, achieving a maximum capacitance of 63 V / 150 μ F in the $\phi 12.5 \times 13.5L$ (mm) size.
- The $\phi 12.5 \times 13.5L$ (mm) case size also supports high-capacitance values such as 25 V / 1000 μ F and 35 V / 680 μ F, covering a wide range of rated voltages.
- Vibration-resistant products (HTX series) achieve 30 G guarantee through a dual fixation structure using a vibration-resistant base plate and dummy terminals, with full AEC-Q200 compliance across all part numbers.

Product
Specifications
[TY-COMPAS](#)

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