FOUR TERMINAL ELECTROLYTIC CAPACITORS WITH EXTREMELY LOW INDUCTANCE/IMPEDANCE FOR HIGH FREQUENCIES

MAIN APPLICATIONS: SMPS OUTPUT FILTERING AND FOR ENERGY STORAGE IN HIGH-END AUDIO EQUIPMENTS.

Datasheet, application notes

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Datasheet

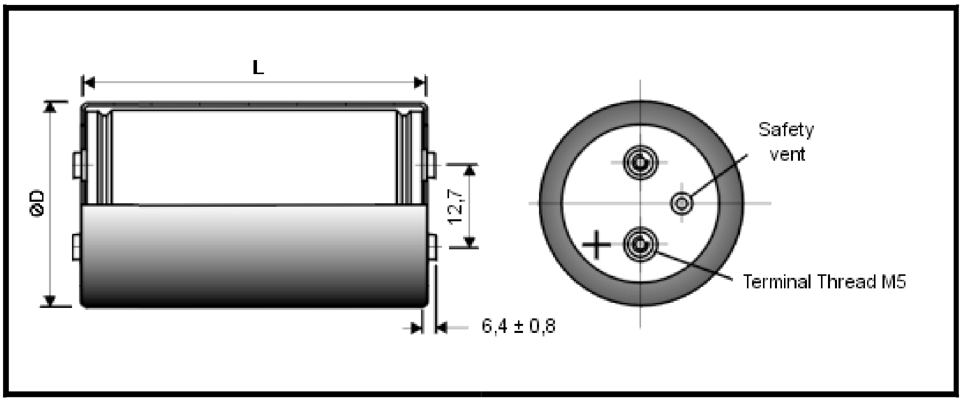
Construction

Very compact, macro- and micro vibration and microphony free design, made with paper tissues consisting of the finest fibres, high purity aluminium foils with fully controlled etching pore structure and impregnation electrolyte with special chemicals.

We offer the four terminal capacitors in two different constructions. Axial performance for high ripple current loads and radial performance with optimised C/V ratio.

- High ripple current, axial performance

The capacitor winding is encased in an aluminium tube, sealed with black nylon decks and rubber sealing rings in both ends. The end-decks are supplied with M5 screw terminals and safety vents. The input, output and the polarity is clearly marked, respectively on the case and the cover. The capacitors are delivered with sleeve insulation and with M5 screws, washers and spring washers for M5 attachment. Mounting clamp and accessories for mounting clamp are optional.
See the capacitor outline on the next figure:



The dimensions and the main electrical features are listed in the below data-table.

DATA TABLE FOR AXIAL PERFORMANCE HIGH RIPPLE CURRENT VERSION

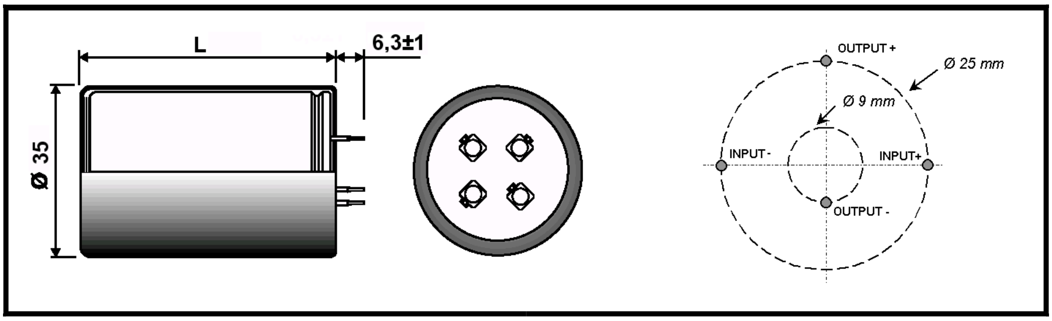
Rated capacitance [µF]	Rated voltage [V] DC	Dimension Ø D x L [mm]	Loss factor	Transfer impedance at 20°C and 50 kHz [mΩ]	Max. permissible pure AC load [A] 40°C ambient 100 Hz	10-50kHz
1500	100	35 x 56	0,09	1,2	4,4	7,3
2200	100	35 x 76	0,09	0,9	6,6	11,0
3300	100	35 x 96	0,09	0,8	8,8	14,6
3300	63	35 x 56	0,13	2,6	4,6	7,7
4700	63	35 x 76	0,13	2,0	7,7	12,8
8200	63	35 x 96	0,13	1,6	9,9	16,4
4700	40	35 x 56	0,20	1,6	5,5	9,1
10000	40	35 x 76	0,22	1,2	8,8	14,6
15000	40	35 x 96	0,24	1,0	11,0	18,3
6800	25	35 x 56	0,26	1,1	5,7	9,5
15000	25	35 x 76	0,28	0,8	9,2	15,3
22000	25	35 x 96	0,30	0,7	11,4	19,0
10000	16	35 x 56	0,35	1,1	5,7	9,5
22000	16	35 x 76	0,40	0,8	9,2	15,3
27000	16	35 x 96	0,50	0,7	11,4	19,0
15000	10	35 x 56	0,50	1,6	5,7	9,5
27000	10	35 x 76	0,56	1,2	9,2	15,3
39000	10	35 x 96	0,60	1,0	11,4	19,0

For economical quantities other different capacitances, voltages or/and dimensions are available on request.

- **Optimised C/V ratio, radial performance**

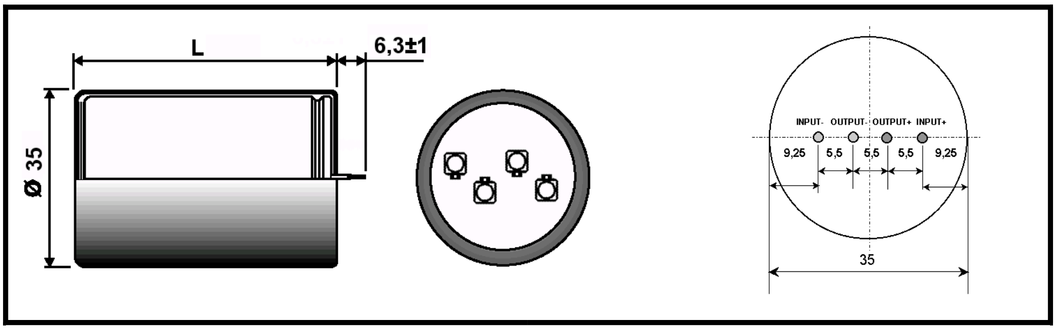
The capacitor winding is encased in aluminium can, sealed with polymer rubber/phenol paper deck supplied with pin tag termination. Safety vent on the aluminium case. The capacitor is supplied with plastic sleeve insulation.
Copper plated aluminum can for shielding or aluminum can with colored and insulating oxide layer for avoiding plastic insulation for better sound quality, are optional.
The capacitors are designed to be mounted by their termination alone. Fixing accessories are not necessary. The capacitors can be delivered with an asymmetrical and a symmetrical pin configuration.

Capacitor outline for **asymmetrical** pin configuration version:



For printed circuit the 4 pinholes must be of Ø1.3±0.1 mm on circles of Ø 25 and 9 mm. The negative terminals are marked on the rivets.

Capacitor outline for **symmetrical** pin configuration version:



For printed circuits the 4 pin holes are Ø1.3±0.1 mm. For capacitors with length of 70 mm this pin configuration is not available. The negative terminals are marked on the rivets.

The dimensions and the main electrical features are listed in the below data-table.

DATA TABLE FOR RADIAL PERFORMANCE OPTIMISED C/V RATIO VERSION

Rated capacitance [µF]	**Rated voltage [V] DC**	**Dimension Ø D x L [mm]**	**Loss factor**	**Transfer impedance at 20°C and 50 kHz [mΩ]**	**Max. permissible pure AC load [A] 85°C ambient**	
					100 Hz	**10-50 kHz**
150	450	35 x 30	0,10	3,6	0,75	1,25
220	450	35 x 40	0,10	3,3	0,90	1,50
220	385	35 x 30	0,10	3,0	0,85	1,40
330	450	35 x 50	0,10	3,1	1,20	2,00
330	385	35 x 40	0,10	2,9	1,15	1,90

470	450	35 x 70	0,10	2,7	1,90	3,15
470	385	35 x 50	0,10	2,5	1,59	2,64
680	385	35 x 70	0,10	2,3	1,90	3,15
680	200	35 x 30	0,10	2,0	1,60	2,66
1000	200	35 x 40	0,10	1,7	1,80	2,99
1500	200	35 x 50	0,10	1,5	2,30	3,82
2200	200	35 x 70	0,10	1,3	2,60	4,32
2200	100	35 x 30	0,10	1,2	1,50	2,49
3300	100	35 x 40	0,11	0,9	1,70	2,82
4700	100	35 x 50	0,12	0,8	1,90	3,15
6800	100	35 x 70	0,14	0,7	2,30	3,82
4700	63	35 x 30	0,15	1,7	2,10	3,49
6800	63	35 x 40	0,20	1,3	2,50	4,15
10000	63	35 x 50	0,22	0,8	2,80	4,65
15000	63	35 x 70	0,25	0,7	3,20	5,31
10000	40	35 x 30	0,25	1,3	2,10	3,49
15000	40	35 x 40	0,28	1,1	3,40	5,64
22000	40	35 x 50	0,30	0,9	4,62	7,67
33000	40	35 x 70	0,40	0,8	5,20	8,63
15000	25	35 x 30	0,30	1,1	2,40	3,98
22000	25	35 x 40	0,35	0,8	3,50	5,81
33000	25	35 x 50	0,45	0,7	4,95	8,22
47000	25	35 x 50	0,55	0,7	5,40	8,96
22000	16	35 x 30	0,45	1,2	2,30	3,82
33000	16	35 x 40	0,55	1,0	3,30	5,48
47000	16	35 x 50	0,65	0,8	4,85	8,05
68000	16	35 x 70	0,75	0,7	5,40	8,06
33000	10	35 x 30	0,65	1,5	2,20	3,65
47000	10	35 x 40	0,75	1,3	3,10	5,15
68000	10	35 x 50	0,85	1,0	4,10	6,80
100000	10	35 x 70	0,95	0,8	4,85	8,05

Capacitors for rated voltage above 100 V are usually not in stock and available only for order quantities over 100 pcs
For economical quantities other different capacitances, voltages or/and dimensions are available for request.

Considerable specifications

IEC 384-4 (Long Life Grade) DIN 41 332 sheet 1., DIN 41 250 (with partial validity), DIN 45910 (corresponds to CECC 30 300) LLG .

Applications categories

IEC 40/085/56 (temp. range: -40/+85°C) and DIN GPF according to DIN 40 004.

Rated capacitance/capacitance tolerance ranges

Capacitance range: 150 – 100.000 µF (measured at 100 Hz). Available capacitance tolerances:
-20/+20% (standard), -10/+30% or –10/+50% (optional).

Rated voltage

The rated voltage is 10-450 V DC.

Leakage current

The leakage current is measured at the input terminals after 5 minutes at 20°C and rated voltage.
The maximum leakage current value is I [µA] = 0.002 x C_r [µF] x U_r [V]. Where C_r is the rated capacitance and U_r is the rated voltage.

Loss factor

The loss factor, tg δ is measured on the input terminals, at 20°C and 100 Hz. For maximum values for each type see the data table last in this data sheet.

Transfer impedance

Unlike the traditional two pole electrolytic capacitors where the capacitor alternative current behaviour/resistance described with its ESR and impedance value in different frequencies the four terminal capacitor's most characteristic parameter is the transfer impedance. The transfer impedance is calculated by dividing the output AC voltage by the input AC current. It is measured in accordance with DIN 41 328 sheet 1. In this case the capacitor is operated as a classical four-pole device.

Ripple current (Max. permissible AC load)

The maximum permissible pure AC load - must be also used for calculation of DC/AC mixed load where Iac=100% - is the same as the admissible ripple current for the two pole capacitors.

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Application notes and FAQ

The short “life-story” of four pole electrolytics.

The four pole electrolytic capacitor appeared in the early 80's when Sprague introduced a low inductance, low ESR four pole axial capacitor mainly for switching converters and regulators. As the switched mode power supplies became common in the mid-80's the demand increased for high capacitance electrolytic capacitors having improved high frequency inductance characteristic. As these requirements could be fulfilled most economical and elegant by using four pole electrolytics, other companies - as i.e. FRAKO from Germany - followed Sprague, and developed four pole electrolytics.

Unfortunately most of designers of high frequency switching mode circuits did not care about elegancy, effectiveness and EMC problems or they simply were not aware of the existence of four pole electrolytics. They used mostly cheap and bulky standard components. As a consequence of these facts the four pole electrolytics sank into oblivion.

Reinvention now also for high-end audio application.

It was Tobias Jensen Production A/S (TJP) that “reinvented” it for high-end audio applications. Four pole electrolytics for switched mode power supplies in maritime communications systems has been produced at TJP since 1990, thus equipments that should last and work reliable even under extreme circumstances require the best design and components.

When TJP in the early 90's started to produce passive components in larger extent for the high-end audio market and became more and more conscious of the need of audio enthusiasts and audiophiles, we came to the recognition that four pole electrolytics are ideal reservoir capacitors for power supplies (and not only for SMPS) in sensible audio equipments.

The importance of attenuation and high frequency behaviour.

No matter how fast the amplifiers signal processing circuits are, you cannot utilize that speed if your power supply is too slow to follow rapid signal changes.
The power supply's reservoir capacitor constitutes a vital element in the amplifier chain, effecting the signals on the main signal paths as well, because most power amplifiers reservoir is conceptually placed in series with the loudspeaker line.

The main issue is not only that the capacitor can give you enough charge and quickly enough, but the attenuation of the power supply toward the amplifier. In spite of the fact that the audio band is nominally 20 Hz -20 kHz, the stability of the amplifier and the overall sound quality is strongly influenced by reservoir capacitor behaviour at very high frequencies.

The function of the reservoir capacitor is not only to store energy, but also filtering, providing decoupling between the power supply and the amplifiers signal processing circuits. For energy storage a conventionally constructed aluminium electrolytic capacitor with sufficient Capacitance (F) x Voltage (V)/ Volume (cm^3) ratio and satisfactory low ESR and inductivity at higher frequencies would be suitable. However the capacitors filtering characteristic plays a very important role in decoupling and suppressing unwanted transients and i.e. digital high frequency noises.

Extremely low inductance makes excellent high frequency capabilities.

The high inductance value of a capacitor is particularly harmful when they are used for filtering at higher frequencies, as the impedance of a high capacitance capacitor over the resonance frequency - which is typically a few tens of kHz - is strongly dominated of the inductance of the capacitor winding.
In consequence of the construction, the conventionally designed, even multitabbed or extended foil electrolytic capacitors provide a significant undesired and increasing impedance vs. frequency response in the critical frequency field. The most acceptable compromise and so far the most utilized solution for this problem was the usage of several high capacitive electrolytics in parallel connection, in order to reach the desired low inductance value.

The best and the ultimate solution no doubt a four pole electrolytic capacitor having the same Capacitance x Voltage/Volume ratio as the best high capacitive electrolytics with an inductance which is only the fraction of theirs. Let us take a typical reservoir capacitor size of 15.000 µF 40 V and compare the Z impedance versus frequency characteristic of a traditional and a four pole device. The curve B shows the traditional two pole, and curve A the four pole capacitors frequency versus impedance characteristic. (Figure 1.)

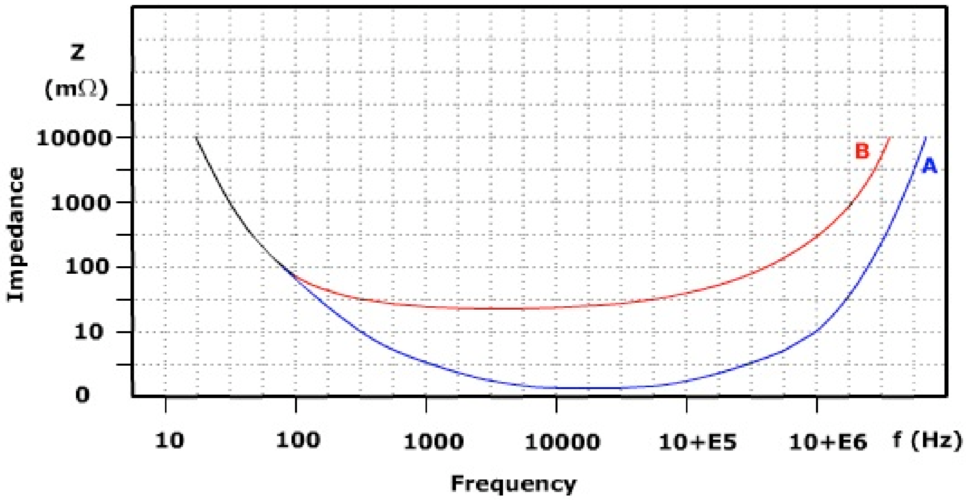

Figure 1.

(The impedance of a four-pole device rather called as transfer impedance, defined as the quotient of the output AC voltage and the input AC current and measured according to DIN 41 328 sheet 1.)

The two curves run together for a while, but already before the resonance frequency the curve A is falling steeper than B and reaching a minimum value of 0.5-0.8 mΩ in the frequency interval of 10-50 kHz. This value is almost two orders of magnitude lower than the impedance of a traditional two pole electrolytic capacitors. At the resonance point the inductive and the capacitive part of the impedance is zero and only the pure ohmic component (ESR) define the impedance.
From this point the capacitor behaves as an inductor and the impedance consisting mainly of the inductive component increases again. It is very easy to realize that not only the equivalent serial resistance (ESR) but also the inductance of a four-pole reservoir capacitor is only a fraction of a conventional capacitor in a wide high frequency range. The very low transfer impedance value at higher frequencies make the four pole capacitor applicable also in other high frequency and digital signal handling equipments and circuits as preamplifiers, A/D and D/A converters, switched mode power supplies etc.