JENSEN Capacitors

* Metal foil /paper in oil capacitors
  for tube amplifiers

* Speaker capacitors ,
  metal foil/ paper in oil or metallized paper.

* Air core inductors wound with metal foil and paper.

* 4 pole electrolytic capacitors.

www.jensencapacitors.com

November 2000

METAL FOIL/ PAPER IN OIL CAPACITORS FOR HIGH END AUDIO APPLICATIONS

Paper-in-oil dielectric high voltage (up to 1000 VDC or higher) foil capacitors for coupling applications in tube or solid state audio equipments.
Many audiophiles think that the oil capacitors sound warm. They simply sound correct, with the harmonic richness of the live music.

Electrodes: Aluminium (as standard) tin, copper or silver foil, extended foil construction.

Construction: Axial performance, hermetically sealed in aluminium tube (copper, brass, porcelain, glass encasing is also available for request). The terminal leads – available in tinned copper or pure silver – are solder-sealed to eyelets in the end-discs. The capacitor element is insulated from the tube.
The capacitors are supplies with an insulation sleeve, but in appliactions where it is assumed that the sleeve distorts the sound we can deliver without sleeve.

Preferred rated voltages: 250, 630, 1000 VDC

Capacitance tolerance: $C < 0.1\ \mu F$: -20/+30%
$C \geq 0.1\ \mu F$: -10/+20%
10% tolerance, special tolerances and matching are available on request.

Operating temperature range: -40/+85°C

Max. ripple voltage: The sum of the peak ripple voltage and the applied DC voltage should not exceed the DC rating of the capacitor.

Power factor (loss factor) : $tg\ \delta < 0.008$ at 1 kHz

Test voltages: Terminal to terminal and terminals to container 3 X Un.

Lifetime test: 250 hours at the maximum category temperature and 2 X Un, according to IEC 80 § 21.

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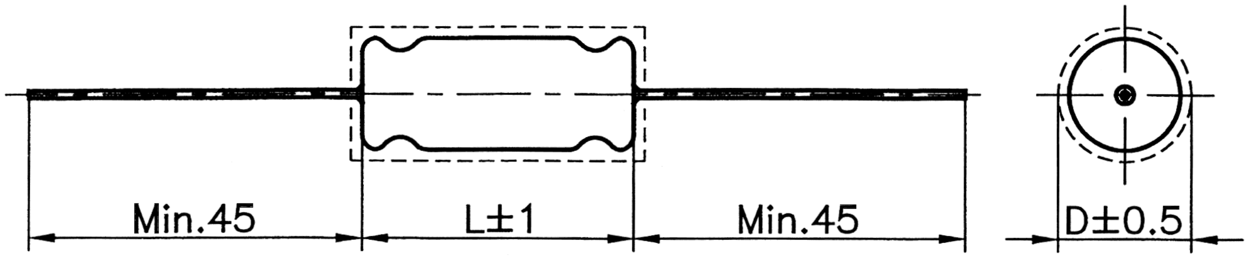
Drawing no.: 101-12221

Description: Metal foil/paper in oil capacitor
Rev.: 3 **Date:**22.08.2000. **Approved:** JJ



Metal foil or metallized paper-in-oil capacitors with higher capacitance and lower voltages for loudspeaker crossover network are also available. Please ask for our crossover filter capacitor brochures.

Aluminium foil paper in oil capacitor selection

Capacitance µF	630 VDC	1000 VDC
0.0022	9 x 17	11 x 21
0.0033	9 x 17	11 x21
0.0047	9 x 21	11 x 21
0.0068	9 x 21	11 x 21
0.01	9 x 21	11 x 23
0.015	11 x 21	11 x 32
0.022	11 x 21	11 x 32
0.033	11 x 32	14 x 33
0.047	14 x 33	14 x 33
0.068	14 x 33	16 x 33
0.1	16 x 33	16 x 43
0.12	16 x 43	18 x 43
0.15	16 x 43	19 x 43
0.18	18 x 43	22 x 43
0.22	19 x 52	22 x 45
0.27	22 x 52	22 x 52
0.33	22 x 52	25 x 52
0.39	25 x 52	25 x 61
0.47	25 x 52	25 x 71
0.68	25 x 71	30 x 71
0.82	30 x 61	32 x 72
1.0	30 x 71	35 x 72
2.2		
3.3		

Tin foil paper in oil capacitor selection, working voltage 630 VDC

Capacitance µF	Dimensions in mm Ø D x L
0.0015	14 x 35
0.01	14 x 35
0.015	14 x 35
0.022	14 x 35
0.033	14 x 35
0.047	16 x 35
0.068	16 x 35
0.1	16 x 35
0.15	20 x 36
0.22	25 x 36
0.33	30 x 36
0.47	25 x 52
1.0	35 x 54

Copper foil paper in oil capacitor selection

Capacitance µF	630 VDC	1000 VDC
0.0015	14 x 25	14 x 25
0.01	14 x 25	14 x 25
0.015	14 x 25	14 x 35
0.022	14 x 33	14 x 35
0.033	14 x 33	16 x 35
0.047	16 x 35	16 x 35
0.068	16 x 35	18 x 35
0.1	16 x 35	22 x 35
0.15	22 x 35	25 x 35
0.22	25 x 35	30 x 35
0.33	30 x 35	25 x 55
0.47	22 x 55 or 35 x 35	30 x 55
1.0	35 x 55	40 x 55
2.2		
4.0	60 x 65	

Silver foil paper in oil capacitor selection, working voltage 630 VDC

Capacitance µF	Dimensions in mm Ø D x L
0.005	14 X 35
0.01	14 x 35
0.02	14 x 35
0.047	14 x 35
0.1	16 x 42
0.22	22 x 42
0.33	30 x 36
0.47	30 x 42
1.0	45 X 56

Minimum expected lifetime for silver foil capacitors: 3000 hours or 2 years

For all capacitors, other capacitances dimensions and voltages are also available on request.

SPEAKER CAPACITORS FOR LOUDSPEAKER CROSSOVER FILTERS

We offer two different constructions in this product group.

Metal foil, paper-in-oil capacitors for top performance and ultimative sound quality with aluminium, tin or copper foil.
Cost effective oil impregnated metallized paper capacitors for higher capacitances in less space.

Metal foil, mineral oil impregnated, kraft paper axial performance speaker capacitor

Rated voltage: Max. 200 VDC

Electrodes: Aluminium (as standard) tin, copper or silver foil, extended foil construction.

Construction: Axial performance, hermetically sealed in aluminium tube. The terminal leads – available in tinned copper or pure silver – are solder-sealed to eyelets in the end-discs.
The capacitor element is insulated from the tube.
The capacitors are supplied with an insulation sleeve, but in applications where the sleeve distorts the sound we can deliver without sleeve.

Capacitance tolerance: -10/+20%
10% tolerance, special tolerances and matching are available on request.

Operating temperature range: -40/+85°C

Max. ripple voltage: The sum of the peak ripple voltage and the applied DC voltage should not exceed the DC rating of the capacitor.

Power factor (loss factor) : tg $\delta < 0.008$ at 1 kHz

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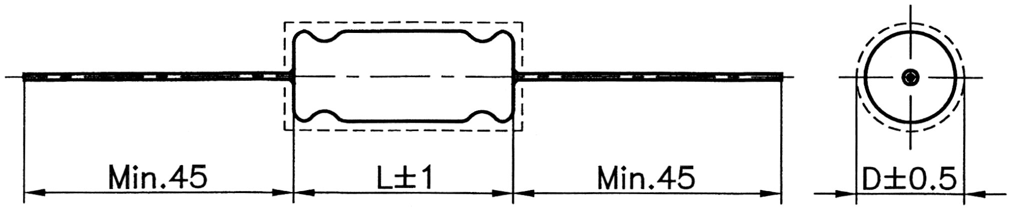
Test voltages: terminal to terminal and terminals to container 3 X Un.

Lifetime test: 250 hours at the maximum category temperature and 2 X Un, according to IEC 80 § 21.



Capacitance µF	Dimension Ø D X L in mm		
	copper foil types	tin foil types	aluminium foil types
1	30 x 60		25 x 52
1,5	35 x 60		35 x 55
2,2	40 x 60		40 x 55
3,3	50 x 60		40 x 55
3,9	55 x 60		45 x 55
4,7	55 x 60	55 x 60	45x80 or 50x55
5,6	60 x 65	60 x 65	50 x 55
6,5	65 x 65		
6,8	65 x 65	65 x 65	45 x 100
7,0	65 x 65		45x100 or 55x80
8,0			45 x 100
8,2			45 x 100
10,0	55 x 115		50 x 100
12,0			55 x 135
15,0	70 x 120		60 x 135
20,0			70 x 135

Other capacitances, voltages and dimensions are also available on request

Oil impregnated metallized paper axial performance speaker capacitor

Rated voltage: 100 VAC/ 200 VDC

Electrodes: Zink-metallized paper

Construction: TYPES MPA are metallized capacitors of high quality, impregnated under high vacuum. Hermetically sealed in aluminium tubes with axial tinned copper leads. If dielectric faults should develop due to conducting particles, or if a momentary surge of voltage should puncture the dielectric, self healing property functions to clear and isolate the fault. The capacitor then continues to operate normally in the circuit without interruption. Radial performance in aluminium can are available on request.
The capacitors are supplied with an insulation sleeve, but in applications where the sleeve distort the sound, we can deliver without sleeve.

Capacitance tolerance: C < 1 µF : -10/+20%
C ≥ 1 µF : -10/+10%
5% tolerance, special tolerances and matching are available on request.

Operating temperature range: -40/+85°C

Max. relative humidity: 95%

Max. ripple voltage: The sum of the peak ripple voltage and the applied DC voltage should not exceed the DC rating of the capacitor.

Power factor (loss factor) : tg $\delta < 0.008$ at 1 kHz

Test voltages: terminal to terminal and terminals to container 1.5 X Un.

Capacitance µF	Dimension Ø D x L in mm
1	14 x 45
2,2	18 x 45
3,3	25 x 45
4,7	25 x 45
5,6	30 x 45
7,0	25 x 62
8,0	25 x 62
10	30 x 62
14	35 x 62
15	35 x 62
22	40 x 65
25	45 x 65

HIGH PURITY COPPER FOIL AND PAPER WOUND, WAX IMPREGNATED AIR-CORE INDUCTOR FOR LOUDSPEAKER CROSSOVER NETWORKS

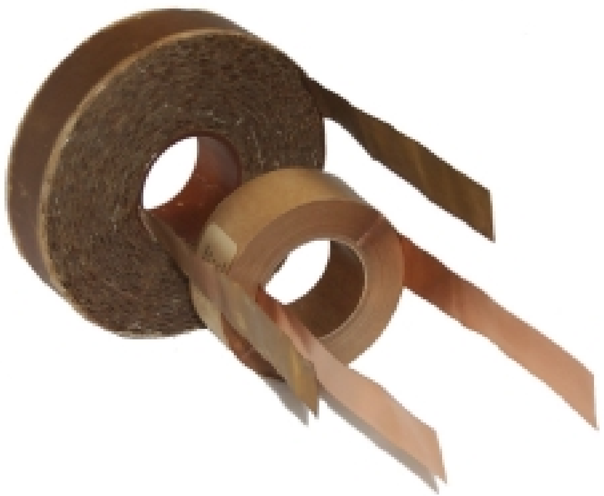
Unlike other brands, Jensen foil wound inductors don't contain plastic, only natural materials, providing particular sonic benefits.
The high purity, oxygen free and very thick copper foil is wound onto a phenolic paper tube.
The dielectric is very thin (20 µm) high-density special paper impregnated with pure mineral wax.
The manufacturing process, during which the inductors have been wound with a high and fully controlled winding tension, dried and impregnated under high vacuum, ensures a uniform and unique sonic quality.

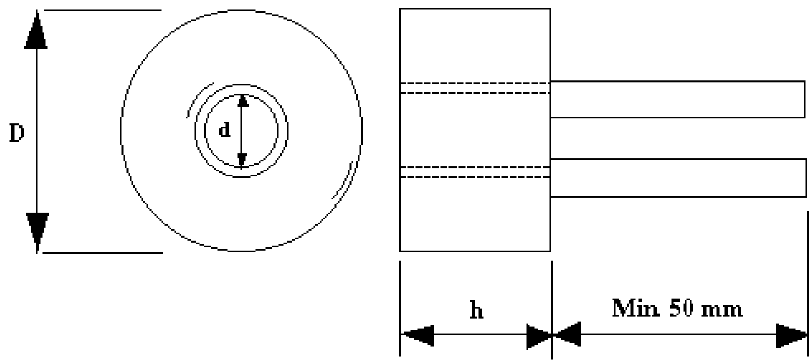
Due to the thickness of the copper foil the inductors have an extremely low resistance resulting in reduced power loss and high current capability. Two cross-section inductors are available; 12 AWG for no compromising low resistances and 14 AWG for low resistance for affordable price.

Negligible skin effect and flat inductive reactance from 20 Hz to 300 kHz.

The lead-outs of the inductors are folded of the copper foil in the winding itself, eliminating the need of welding or soldering, which are usually sources of undesired harmonic and phase distortions.

The most transparent inductor made up to now, rapidly becoming the inductor of choice in high end speaker systems.





Inductance in mH	AWG	d in mm	D in mm	h in mm	DC resistance in mΩ	Weight in g
0,068	12	16	41	25	32	165
0,1	12	16	45	25	40	200
0,1	**14**	**35,5**	**48**	**40**	**57**	**150**
0,15	12	16	50	25	50	260
0,18	12	35,5	65	25	56	290
0,22	12	35,5	66	25	60	330
0,22	**14**	**35,5**	**52**	**40**	**83**	**220**
0,33	12	35,5	68	25	80	385
0,33	**14**	**35,5**	**55**	**40**	**109**	**275**
0,39	12	16	62	25	88	430
0,39	**14**	**35,5**	**56**	**40**	**122**	**295**
0,47	12	35,5	74	25	156	490
0,47	**14**	**35,5**	**58**	**40**	**138**	**330**
0,50	12	35,5	75	25	116	510
0,56	12	35,5	76	25	110	540
0,68	12	35,5	80	25	123	610
0,68	**14**	**35,5**	**61**	**40**	**161**	**390**
0,70	12	35,5	80	25	126	615
0,80	12	35,5	83	25	136	665
0,82	12	35,5	83	25	140	690
0,90	12	35,5	85	25	147	720
1,0	12	35,5	88	25	156	750
1,0	**14**	**35,5**	**66**	**40**	**219**	**525**
1,2	12	35,5	91	25	173	855
1,2	**14**	**35,5**	**69**	**40**	**243**	**585**
1,4	12	35,5	94	25	190	930
1,5	12	35,5	96	25	200	965
1,5	**14**	**35,5**	**71**	**40**	**280**	**675**
1,55	12	35,5	97	25	205	1015
1,6	12	35,5	98	25	220	1045
1,8	12	35,5	101	25	225	1070
1,8	**14**	**35,5**	**74**	**40**	**306**	**740**
1,9	12	35,5	103	25	232	1150
2,0	12	35,5	104	25	241	1175
2,1	12	35,5	105	25	245	1215
2,2	**14**	**35,5**	**76**	**40**	**340**	**800**
2,5	12	35,5	108	25	290	1355
2,7	12	35,5	113	25	297	1370
3,9	12	35,5	124	25	360	1800
4,0	12	35,5	125	25	370	1850
5,0	12	35,5	133	25	420	2100
4,7	**14**	**35,5**	**93**	**40**	**540**	**1390**
6,0	**14**	**35,5**	**97**	**40**	**560**	**1540**
7,0	**14**	**35,5**	**101**	**40**	**680**	**1670**
8,0	**14**	**35,5**	**105**	**40**	**742**	**1840**
15,0	**14**	**35,5**	**122**	**40**	**1100**	**2700**

Inductance tolerance : ± 5%
Other values and dimensions are also available on customer request.

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Description: Air-core inductor

Rev.: 4 | **Date:** 18.05.2000. | **Approved:** JJ

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 and FAQ

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

Datasheet

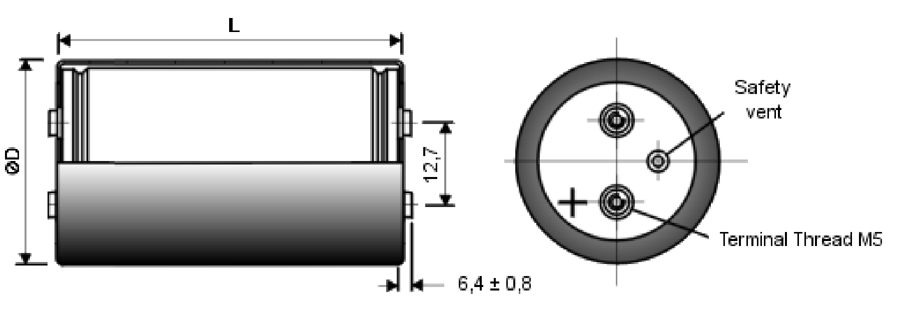
Construction

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

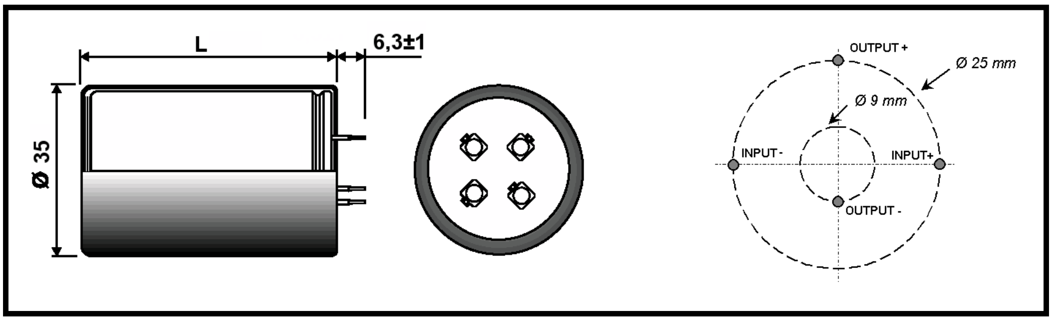
Rated capacitance [µF]	Rated voltage [V] DC	Dimension Ø D x L [mm]	Loss factor	Transfer impedance at 20°C and 50 kHz [mΩ]	Max. permissible pure AC load [A] 40°C ambient 100 Hz	10-50kHz
1500	100	35 x 56	0,09	1,2	4,4	7,3
2200	100	35 x 76	0,09	0,9	6,6	11,0
3300	100	35 x 96	0,09	0,8	8,8	14,6
3300	63	35 x 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 for request.

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

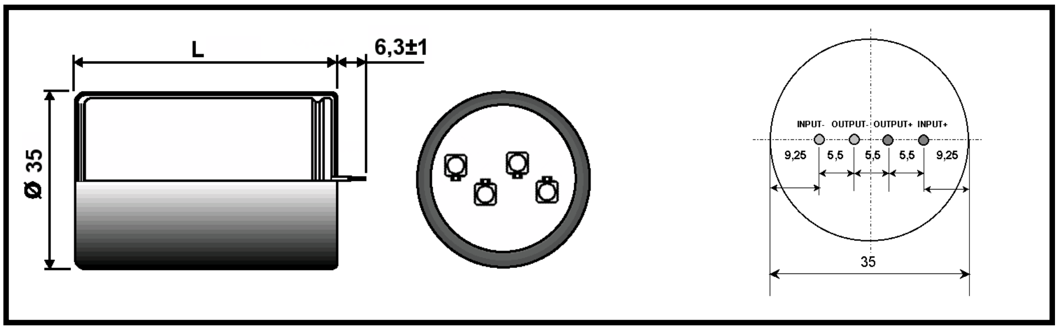
The capacitor winding is encased in aluminium can, sealed with polymer rubber/phenol paper deck supplied with pin tag termination. Safety vent on the aluminium case. The capacitor is supplied with plastic sleeve insulation.
Copper plated aluminum can for shielding or aluminum can with colored and insulating 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.

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.

Application notes and FAQ

The short "life-story" of four pole electrolytics

The four pole electrolytic capacitor came first 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 the most economical and elegant way fulfilled by using four pole electrolytics other firms - 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 has sunken 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, 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 is, 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 the 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 20-20 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 other 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.)

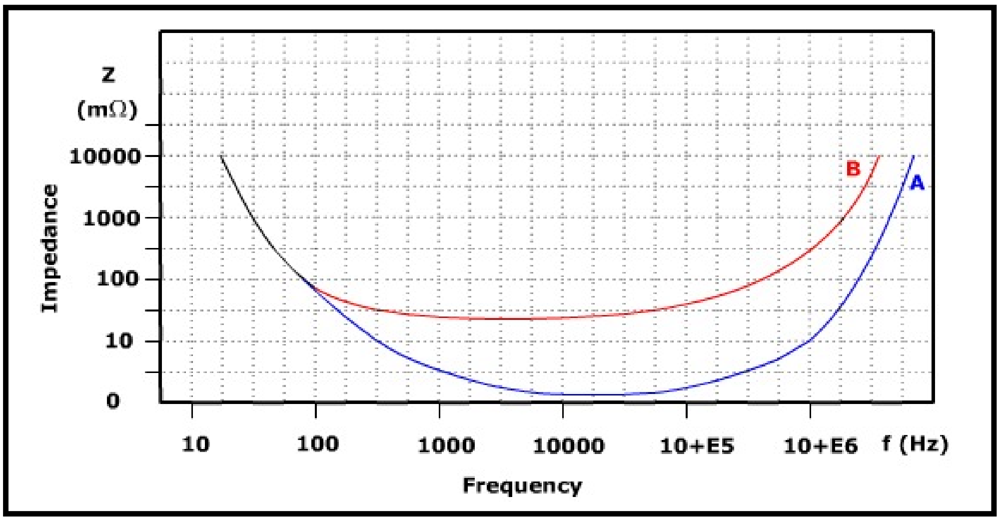


Figure 1.

(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 in 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 the 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.

The capacitor also works as a filtering/attenuation circuit

The four pole electrolytic capacitors have other additional advantages, which are especially useful for reservoir capacitors in high-end amplifiers. If you use a two terminal, two pole capacitor the entire AC and all noises coming from the power supply appear on the capacitor and sent toward to the high frequency signal path, disturbing the load because of the common resistive and inductive parts which force the input and the output together electrically. (Figure 2.).

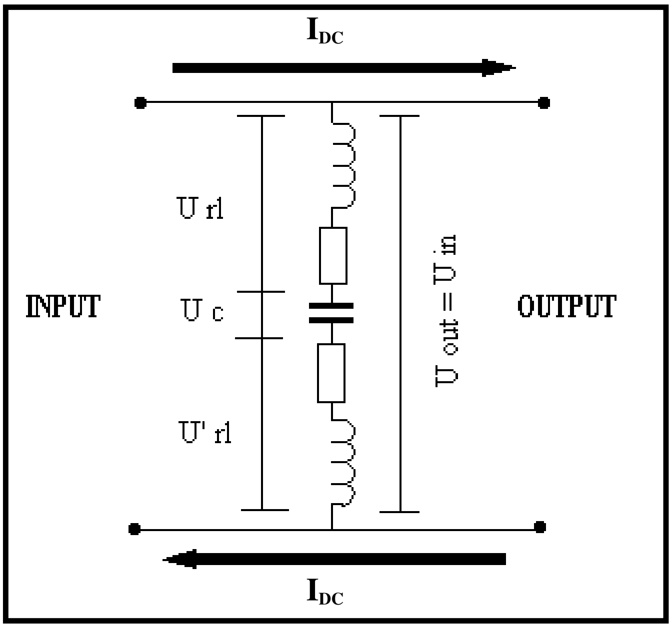


Figure 2.

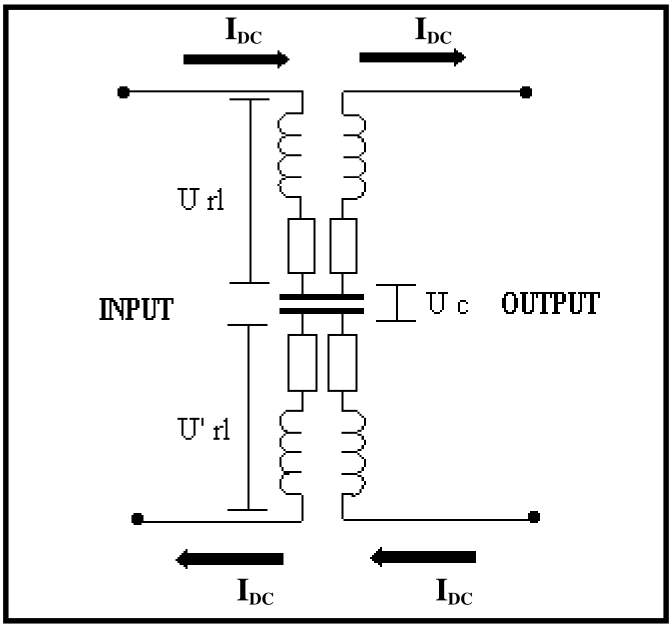


Figure 3.

All these disturbances can be avoided by using four terminal capacitor constructions, where the AC on the input terminal is decoupled from the load. The inductances and resistances coming from the lead to foil connections (tab foils) form and advantageous filter circuit which attenuation increases with frequency. (Figure 3.)
As a consequence of the damping/suppressive effect of this inherent LR filtering, often a single four-pole capacitor can replace a complicated filter arrangement.

Complex construction inside

The filter capability (the measure and the frequency dependence of the attenuation) and the transfer impedance of a capacitor is determined by the inside construction and different geometrical factors of the capacitor winding itself. As these factors depends on the dimension of the can, the length and width of the used capacitor and tab foil, and are different from type to type, the optimisation process must be accomplished for every single capacitance/voltage/dimension combination.

The manufacturing of the four-pole capacitor is also more complex then the traditional one.
As the yield capacitance value of the electrolytic capacitor foils (anode- and cathode-) can vary up to 20%, the length of the foil should also be adjusted accordingly to achieve the needed nominal capacitance.
On the other hand this adjustment will destroy the hair-fine geometrical balance optimised for best filtering and impedance so you either need to re-optimise the capacitor with the new foil length or use raw materials, which have always the same features. It’s a really technical and economical challenge.

Application remarks/advices

Due to the special construction of the capacitor the DC load current pass trough the capacitor.

Any heat generated by this DC current must be taken into account when the capacitor's operating temperature is calculated.
The mixed DC/AC load can be calculated with the help of the Figure 4.

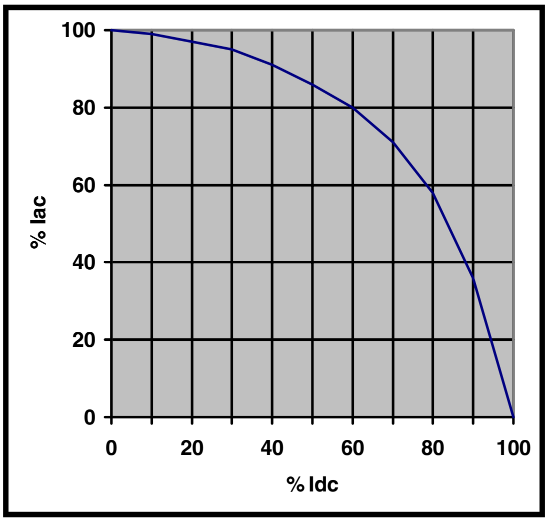


Figure 4.

Axial type Ø D x L [mm]	Radial type Ø D x L [mm]	Idc [A]
35 x 56		3,9
35 x 76		5,5
35 x 96		6,9
	35 x 30	2,7
	35 x 40	3,4
	35 x 50	4,1
	35 x 70	5,5

The 100% of Idc is coming from the DC resistance and the construction of the capacitor, and mainly depends on the heat dissipation capability of the capacitor. For Idc values of different types and constructions see the table above. For calculation of the full load the Iac values are given as max. admissible ripple current values on the capacitor data chart.

When it is necessary the DC load can be increased by means of a by-pass ferrite core winding according to Figure 5. (Not recommended for high-end audio applications).

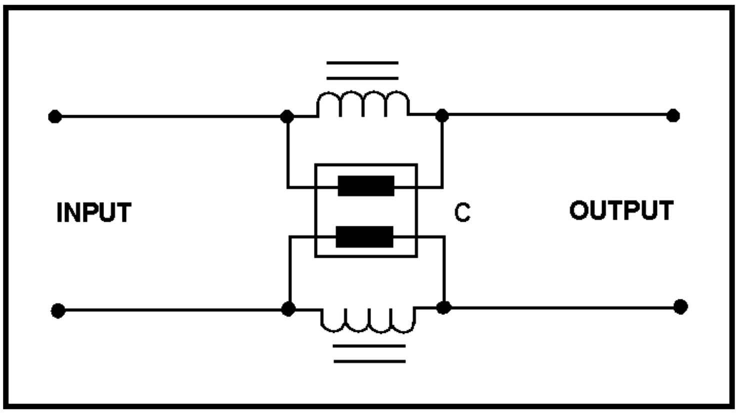


Figure 5.

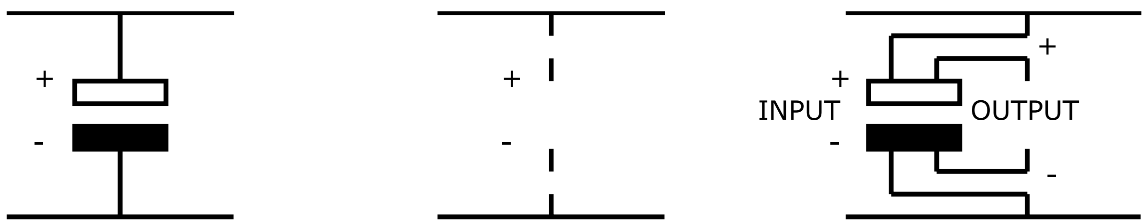
As a rule of thumb the DC resistance of the by-pass winding must be about the 1/20 of the capacitors DC resistance (measured between the input and output terminals on the same polarity poles) and its AC resistance is about 20 times higher than the capacitors AC resistance (impedance) on the working frequency.

The input and output terminals are marked on the capacitor. It is recommended to use this connection thus the inherent inside filter is optimised for this signal direction. However reversing the inputs with the outputs will not damage the capacitor and the consequence is only shown as decreased damping/suppression effect and slightly higher transfer impedance.

Frequently asked questions

- I would like to replace the traditional two pole capacitors in my power supply with four pole ones. Is it possible and how?

Yes it is possible and neither so difficult. You should make some minor changes in the circuit where the traditional two pole capacitors should be replaced by the four pole ones.
First of all remove the two pole capacitor and mark the polarity on the panel or circuit board. When you have a two pole capacitor in the circuit, you have also wires leading to positive and the negative pole of the capacitor. These two wires (or in printed circuit copper band leads) should be cut off near to the original capacitor connection. By this way you get two wires for each pole. One, which leads toward to the circuit and an other which leads to the old two pole capacitors connection point. Simple connect the short wire, leading to the positive terminal of the two pole capacitor to the positive output and the other part of this positive wire leading toward the circuit to the positive input of the four pole capacitor. Make the same on the negative side and your four pole capacitor is connected.

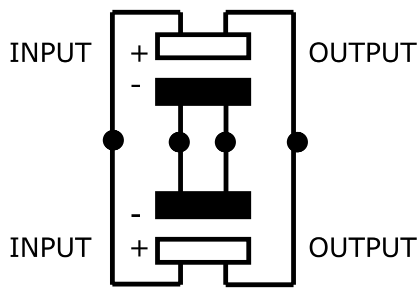


- What kind of improvement of the sound quality can I expect when I replace the traditional two pole electrolytics with fire pole ones in the power supply of my CD player/amplifier?

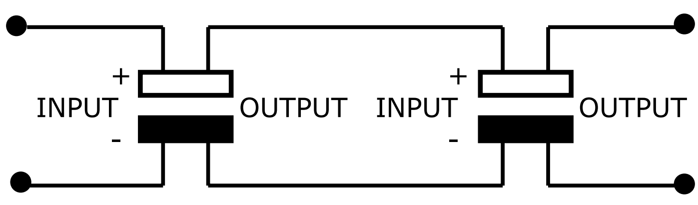
The degree and the type of the improvement you will get replacing the two pole electrolytic capacitors (even they were one of the highly regarded types with graphite particles in the capacitor paper or with ceramic particles in the electrolyte) with the four pole ones is of course depends on your equipment, but we guarantee a significant and audiable improvement in transparency, high frequency capabilities, detail, dynamics and microdynamics, immediacy and clarity.

- I need large capacitances in my circuit; can I parallel connect the fire pole capacitors to increase the capacitance and at the same time maintain the advantageous filter/suppression effect?

Yes you can and what is more you can also parallel connect two pole capacitors to the four pole ones and by this mean reuse your old two pole capacitor and in meantime take advantage of the four pole capacitors filter and suppression effect.
When you connect the four pole capacitors in parallel, on the classical way by connecting one capacitor’s positive input to the others positive inputs, the positive output to the others positive output and so on, you are not only getting the capacitance multiplied but at the same time the direct current resistance reduced, as the resistance of the foils are also parallel coupled.
It is very advantageous when you need high DC current flow on the capacitor bank.



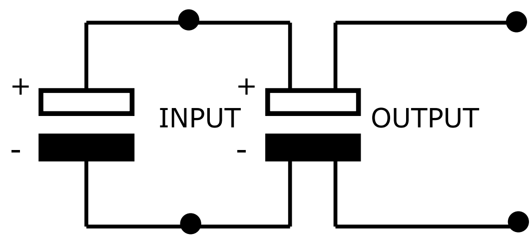
By parallel coupling of the four pole capacitors, their filter/suppression effect is fully maintained. It means that the transfer impedance corresponds to the capacitance value you have achieved by parallel coupling of two or more four pole capacitors.
For example 10.000 μF 40 V four pole capacitors transfer impedance is about 1.3 mΩ (check in the table on the datasheet). When two of them are parallel coupled the capacitance is the double, about 20.000 μF and the transfer impedance is about 0,9 mΩ, almost same as the transfer impedance of a 22.000 μF 40 V capacitor seen in the table. In case of parallel coupling of three pieces of the same type, the transfer impedance decreasing to about 0,7 mΩ and so on.
The filter/suppression effect is fully maintained but the DC resistance is multiplied when you parallel couple four pole electrolytics by connecting the first capacitors positive output to seconds positive input and the first’s negative output to the seconds negative input and so on if you want connect more capacitors.



This method has both advantages and disadvantages. The disadvantage is coming from the fact that the DC current must flow trough both the anode and cathode foil of all capacitors you connect in parallel. The DC resistance could be up to a few ohms, when coupling three or more capacitors in parallel by this way. The loss coming from this source together with losses caused by the ripple will be so high that this coupling method could be considered as unacceptable in most of the applications.

However if your current requirement is low or you definitely need to implement a few ohms of inductance free resistance in the line, this coupling method is your choice. The wiring of this variation is also much more simple.

Parallel coupling of two pole and four pole electrolytics is just straightforward.
The only rule is that the two pole capacitors must be connected to the input terminals of the four pole. The transfer impedance of the system depends only the resulting capacitance and can be calculated as it is described above.



- I have a tube amplifier and I need electrolytic capacitor with a rated voltage above 600 V. Thus you don't have fire pole capacitors of this rated voltage if I serial connected two 385 V or three 250 V fire pole capacitors I could reach the desired voltage. Is it a work around of the problem?

No, we do not recommend series connecting of our four pole electrolytics.
The voltage on the series connected electrolytic capacitors is divided in proportion of the capacitance of the capacitors. Thus the capacitance tolerance of the electrolytic capacitors is generally rather wide (-10/100% to –10/+30%). it could happen that one of the series connected capacitors get a higher voltage, than it was originally calculated to.
The voltage overload reduces the lifetime of the capacitor, make unbalances in the circuit and in worth case might make the capacitor to explode.
There are of course work arounds for the problem as i.e. using capacitors with very similar characteristics or the application of bleeder resistors in parallel connection with the capacitors.
In spite of that this solutions might work satisfactory in different power applications as welding machines and laser equipments, they are unacceptable for high end audio applications.