

Double-Layer Capacitors in Rectangular Metal Case with very High Capacitances in the Farad Range

Special Features

- Storage capacitors with very high capacitance values from 100 F to 600 F and a rated voltage of 2.5 VDC
- Discharge current up to 800 A
- Maintenance-free
- With rectangular metal case
- Series connection possible
- According to RoHS 2002/95/EC

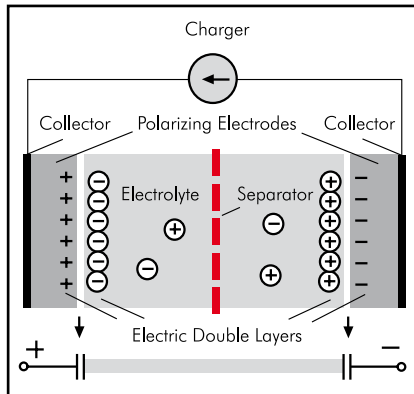
Typical Applications

Suitable for support, protection or replacement of batteries in the field of new traction technologies in

- Automotive
- Railway technology
- Wind power systems
- Uninterruptible power systems (UPS)

Construction

Internal construction:



Encapsulation:

Rectangular aluminium case, sealed by laser welding

Terminations:

FS 6.3 slip-on terminations according to DIN 46244.

Marking:

Colour: Black. Marking: Gold

Technical Data

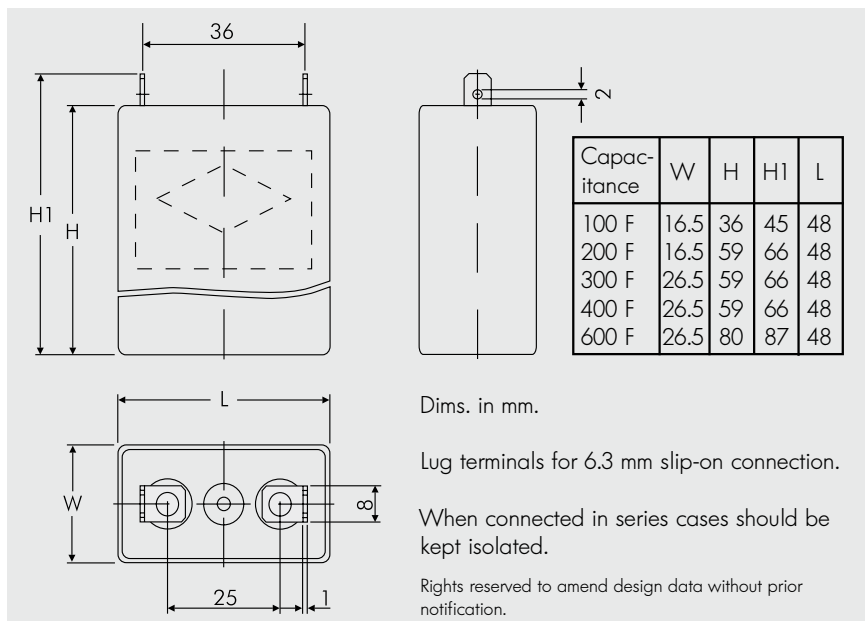
Capacitance:	C _N	100 F	200 F	300 F	400 F	600 F
Capacitance tolerance:	-	±20%	±20%	±20%	±20%	±20%
Rated voltage:	U _R	2.5 V	2.5 V	2.5 V	2.5 V	2.5 V
Rated current:	I _C	30 A	45 A	50 A	80 A	100 A
Pulse current:	I _P	up to 200 A	up to 350 A	up to 400 A	up to 600 A	up to 800 A
Internal resistance:	R _{BC}	12 mΩ	7 mΩ	6 mΩ	4 mΩ	3 mΩ
Max. stored energy: ±20%	E _{max.}	313 J	625 J	938 J	1250 J	1875 J
Operating temperature:	T _{op}	-30° C ... +65° C				
Storage temperature:	T _{st}	-40° C ... +70° C				
Weight:	m	40 g	62 g	90 g	95 g	120 g
Volume:	V	0.028 l	0.047 l	0.075 l	0,075 l	0,1 l

Additional Data

Case:	-	Al _{99.5}	Al _{99.5}	Al _{99.5}	Al _{99.5}	Al _{99.5}
Lug terminals:	-	Brass	Brass	Brass	Brass	Brass

Comparative Data

Density of capacitance:						
gravimetric	C _d	2500 F/kg	3200 F/kg	3400 F/kg	4300 F/kg	6400 F/kg
volumetric	C _v	3600 F/l	4600 F/l	4400 F/l	5900 F/l	6660 F/l
Energy density:						
gravimetric	E _d	2.2 Wh/kg	2.8 Wh/kg	3.0 Wh/kg	3.8 Wh/kg	4.5 Wh/kg
volumetric	E _v	3.2 Wh/l	3.7 Wh/l	4.0 Wh/l	5.4 Wh/l	6.0 Wh/l



New values

Double-Layer Capacitors in Rectangular Metal Case with very High Capacitance in the Farad Range

Special Features

- Storage capacitors with very high capacitance value of 3000 F and a rated voltage of 2.5 VDC
- Discharge current up to 3000 A
- Maintenance-free
- With rectangular metal case
- Screwable terminations
- Series connection possible
- According to RoHS 2002/95/EC

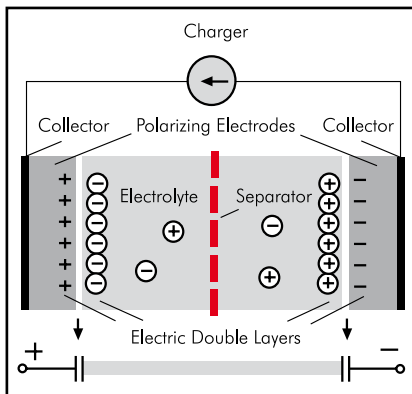
Typical Applications

Suitable for support, protection or replacement of batteries in the field of new traction technologies in

- Automotive
- Railway technology
- Wind power systems
- Uninterruptible power systems (UPS)

Construction

Internal construction:



Encapsulation:

Rectangular aluminium case, sealed by laser welding

Terminations:

Screw connection M8

Marking:

Colour: Black. Marking: Gold

Technical Data

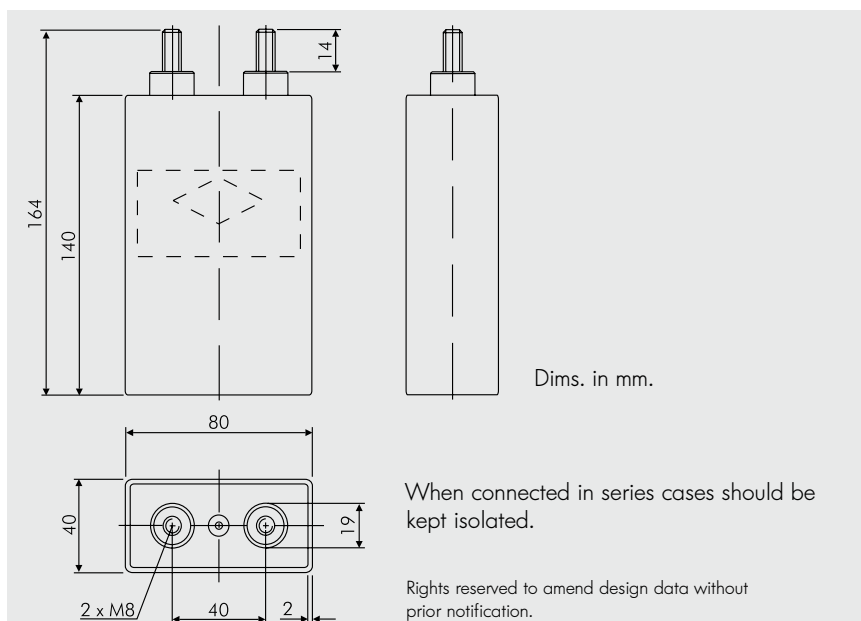
Capacitance:	C_N	3000 F
Capacitance tolerance:	-	$\pm 20\%$
Rated voltage:	U_R	2.5 V
Rated current:	I_C	800 A
Pulse current:	I_P	up to 3000 A
Internal resistance:	R_{DC}	0.7 m Ω
Max. stored energy: $\pm 20\%$	E_{max}	10000 J
Operating temperature:	T_{op}	-30° C ... +65° C
Storage temperature:	T_{st}	-40° C ... +70° C
Weight:	m	615 g
Volume:	V	0.45 l

Additional Data

Case:	-	Al _{99.5}
Screw terminations:	-	2 x M8

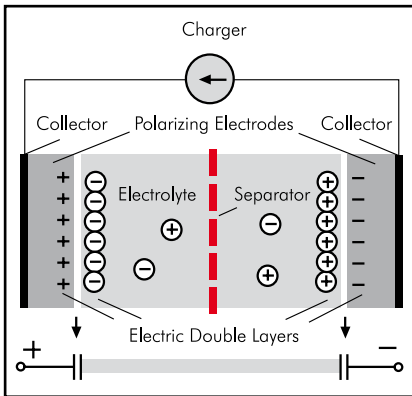
Comparative Data

Density of capacitance:		
gravimetric	C_d	5300 F/kg
volumetric	C_v	7360 F/l
Energy density:		
gravimetric	E_d	4.7 Wh/kg
volumetric	E_v	6.3 Wh/l



Construction Principle

The construction principle of a Double-Layer Capacitor can be described as a plate capacitor where the most important aim is to obtain electrodes with an extremely large surface. For this purpose activated carbon is ideally suited, as it allows to achieve capacitance values of up to 100 F/g of active mass of the electrode. The electrolyte, the conductive liquid between the electrodes is a conducting salt dissolved in an aqueous or organic solvent which permits to apply voltages of 2.5V.



Construction principle of the WIMA Double-Layer Capacitor

The actual double-layer consists of ions which, when voltage is applied, attach to the positive or negative electrode corresponding to their opposite poles and thus create a dielectric gauge of a few Angstrom only. This results in a very high capacitance yield caused by the very huge surface of the electrode in accordance with the formula

$$C = \epsilon \times \frac{\text{Surface}}{\text{Distance}}$$

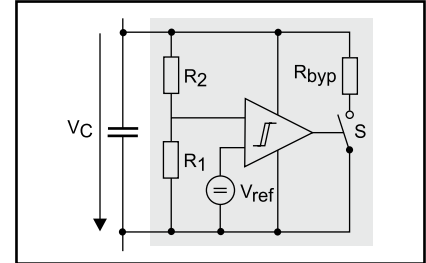
To visualise this, the internal surface of a Double-Layer Capacitor would cover a football pitch.

A permeable diaphragm acting as a separating layer and called separator avoids short-circuit between the two electrodes and considerably influences the characteristics of the capacitor. Charge or discharge of the Double-Layer Capacitor is combined with the transformation of the layers in the electrical field and thus with the movement of the charge carriers in

the solvent - even through the separator film. This phenomenon represents the main reason for the limited voltage capability of 2.5V only and the steep decrease of capacitance versus frequency exhibited by Double-Layer Capacitors.

Cascaded SuperCap Modules

Several SuperCap cells can be built up to enormous capacitances of the desired voltage by means of series or parallel connection (cascade). When cascading SuperCaps, the voltage of single cells must not exceed 2.5V (decomposition of the electrolyte!) Hence, series connections need in any case to be balanced since a possibly slightly different aging of the individual cells due to temperature may over time cause deviating capacitances and thus different voltage drops at the cell. The balancing will be factory-mounted into a module. This can be made passively and in a cost-efficient way by simple resistors in those cases where additional losses as bypass current through the balancing resistors can be tolerated by the application. Alternatively, an active balancing can be made by keeping each cell at a certain voltage by means of a reference source. That means if the comparator circuit detects a commencing overload of any cell individual discharge is initiated by a bypass resistor. Except the leakage current of the cells there are no considerable losses created during active balancing.

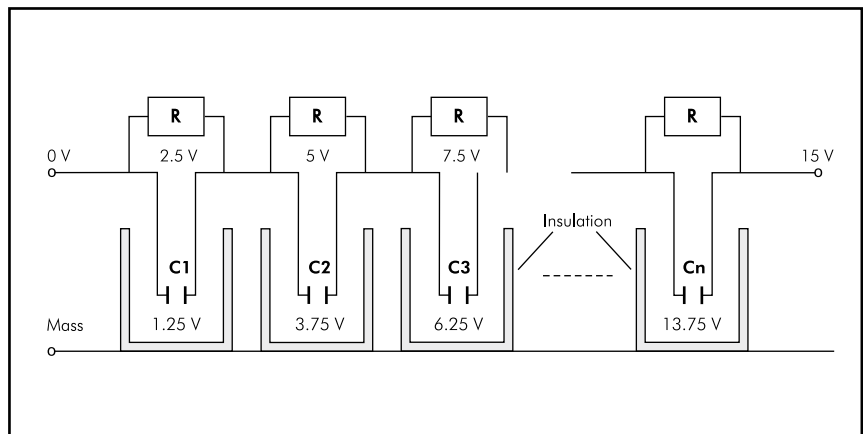


Active balancing.

Comparator compares voltage at the capacitor by a reference voltage and switches in order to discharge through a bypassing resistor until overvoltage has declined.

Operational Life

For physical reasons it is unavoidable that Double-Layer Capacitors are subjected to aging which follows the logarithmic dependence of voltage applied and ambient temperature (Arrhenius behaviour) that can be observed with other components, too. However, continuous studies have shown that WIMA products exhibit a significantly improved behaviour in terms of life time being achieved by a laser-welded, hermetically sealed construction of the cells in metal cases which makes penetration from outside impossible; they cannot dry up and can withstand a certain thermal expansion movement. Only by this innovation one can consider the component being suitable for long-year maintenance-free application.



Passive balancing.

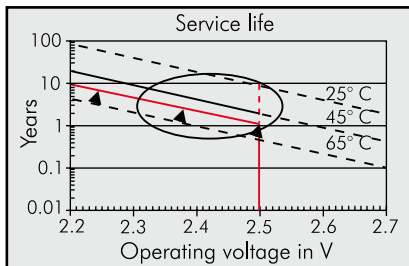
Without resistors: U reciprocal-effect to C - thus locale overvoltage easily can occur

With resistors: U proportional-effect to R - thus voltage is fixed



Technical Data and Applications of WIMA Double-Layer Capacitors

When properly treated WIMA SuperCaps have a service life beyond 10 years and can easily sustain more than 500.000 charge/discharge cycles. The efficiency is far higher than 90%.



Life time expectancy for WIMA SuperCaps

Advantages in Comparison with other Energy Storage Solutions

WIMA SuperCaps are showing following advantages in comparison with other energy storage solutions:

- **Low internal resistance (less than 1/10 of what a usual battery exhibits)**
- **Release of high currents (10 to 100 times more than batteries)**
- **Maintenance-free operation**
- **No risk of damage due to complete discharge of the component**
- **High life expectancy**
- **Usage in isolated systems, e.g. inaccessible areas, is unproblematic**
- **Comparatively low weight**

WIMA Double-Layer Capacitors are particularly suitable in applications where high and even highest currents - not in pure AC operation - occur. By combining the advantage of conventional capacitors as fast suppliers of electricity with that of batteries as notable energy reservoirs the SuperCap represents the link between battery and conventional capacitor.

	Standard Capacitor	SuperCap	Battery
Capacitance per Surface	<1 $\mu\text{F}/\text{cm}^2$	1000 000 μF (1 F/cm ²)	
Energy-density	<0.01 Wh/kg	<10 Wh/kg	100 Wh/kg
Power-density	<0.1 kW/kg	>1 kW/kg	0.1 kW/kg

Application Examples

In general Double-Layer Capacitors are applied for voltage support, for saving or for replacing conventional battery or charger solutions. The typical application is the quick supply of several 100A to 1000A in the direct current field.

Slip Control in Wind Power

In large-scale wind turbine systems, slip controllers are used to control the rotation speed by altering the angle of the rotor blades. The drives are mains-independent and if electrically controlled use the energy stored in batteries or double-layer capacitors. These storage devices have to meet stringent requirements. During winter time the temperatures in the wind tower top housing often reach around -40°C , and during summer time they may easily go up to more than $+60^\circ\text{C}$ during operation. The current of 200A necessary for the breakaway torque of e.g. a 3 kW motor presents big problems to batteries due to the ambient conditions described. Their short life time and frequently necessary maintenance renders them unsatisfactory. However, when properly dimensioned, modern SuperCap solutions enable a maintenance-free usage of the electrical storage device of minimum 10 years.

Start of Micro-Turbines, Fuel Cells or Diesel-Electric Generator working as Power Set

For micro-turbines driven with natural gas for generation of electrical energy on oil platforms, in part also for gas pumping stations, in sensible areas like hospitals and huge factories the use of SuperCap modules to replace conventional starter batteries (by experience needing replacement every 2 to 3 years) is the optimum choice. Usually about 300 kJ of electrical energy at a system voltage of 240V are needed for a turbine start-up time of 10 to 20 s.

When starting special micro-turbines or for bridging during start of a fuel cell working as emergency power supply, generally a few 100 kJ of electrical energy are required for a system start time of approx. 10 to 20 sec. The stored energy time is approximately 20 s. Due to the system voltage of 48 V, 22 cells of 1200 F are cascaded in a

module to achieve the setpoint voltage in order to replace a battery block.

For start-up of generators for energy supply of autonomous telecommunication stations which are located decentrally in a tight network but supplied with fuel the new double-layer capacitors would provide a solution. Right now tests are run with 14V series connections (70 to 100 F) which should render a maintenance-free service. After three starting processes in a sequence their energy with 300 to 500 A each flowing (depending on the size of the motor) is used up. The now running generator, however, immediately supplies them with electrical energy again.

Starting huge Railway, Naval or Truck Motors

The start of V16 or V24 cylinder motors (6000 kW), e.g. for generator drives of diesel-electric trains or start of a naval diesel engine requires considerably high currents. 1300A are quite usual which can be covered by capacitor units of 450 to 600 F at 28 V. Frequently the crankshaft is turned by two starters on both sides (e.g. 7 kW each with a positive switch off after 9 s for 2 min), in order to avoid torsion of the huge mass. The low total internal resistance of less than $3\text{ m}\Omega$ which is beyond reach for batteries the capacitor solution is outstanding.

Recuperation of Braking Energy

In times of resource shortage of fuel the highest possible recuperation of braking energy is a challenging aim. While recuperation in electric train drives or in hybrid busses is already practiced since long, for non-mains connected vehicles the energy recuperation to the on-board battery has only be realized to the extent of few per cent. The basic reason is the charge current limitation of batteries where the recuperable energy is obtained at very high currents in a scope of milliseconds. If for example 1 ton shall be decelerated from 100 km/h to 0 km/h 400 kJ are released, for 10 tons it is ten times as much. So far no suitable high-energy storage devices were available (guideline values: 500 A to 1000 A). This is the domain of the new SuperCaps since in the foreseeable future even most modern battery systems will not be in a position to cope with such energy.