



**BEST CAPACITORS
MADE IN GERMANY**



WIMA SuperCap Presentation



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Outline

- WIMA: Specialist in Capacitors
- Introduction
- Storage Technologies
- WIMA SuperCap Range
- Technical Performance
- SuperCap Applications
- Conclusion





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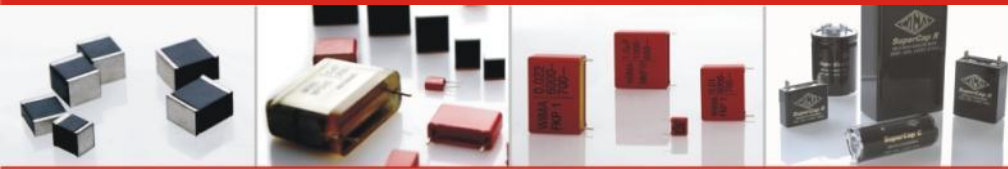


WIMA: Specialist in Capacitors

- **Foundation:** 1948
- **Fields of Activities:** Manufacture and sale of:

 - plastic film capacitors in SMD/through hole version and special caps
 - metallised paper capacitors
 - SuperCap double-layer capacitors
- **Ownership:** 100 % privately owned
 Wilhelm Westermann: 1948 - 1980
 Wolfgang Westermann: 1981 - today
- **Production Capacity:** up to 3 million pieces/day
- **Sites:** Administration and production in Germany only
- **Distribution:** Worldwide





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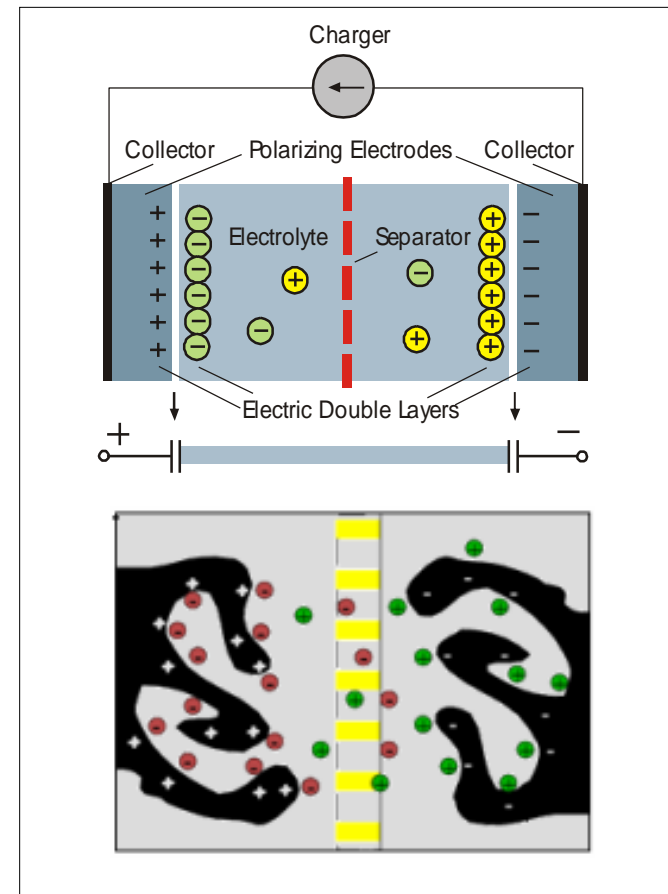
Characteristics of SuperCaps (Double-Layer Capacitors)

Basic characteristics:

- High volume capacity
- Extreme long life time expectation
- Maintenance-free
- Lowest internal impedance (a few mΩ only)
- No damage by deep discharging
- For power application

By using active carbon as a layer the surface of the electrodes is immense.

Dissociated molecules of the electrolyte adhere to the carbon surface with a distance of few Angström generating the double-layer.

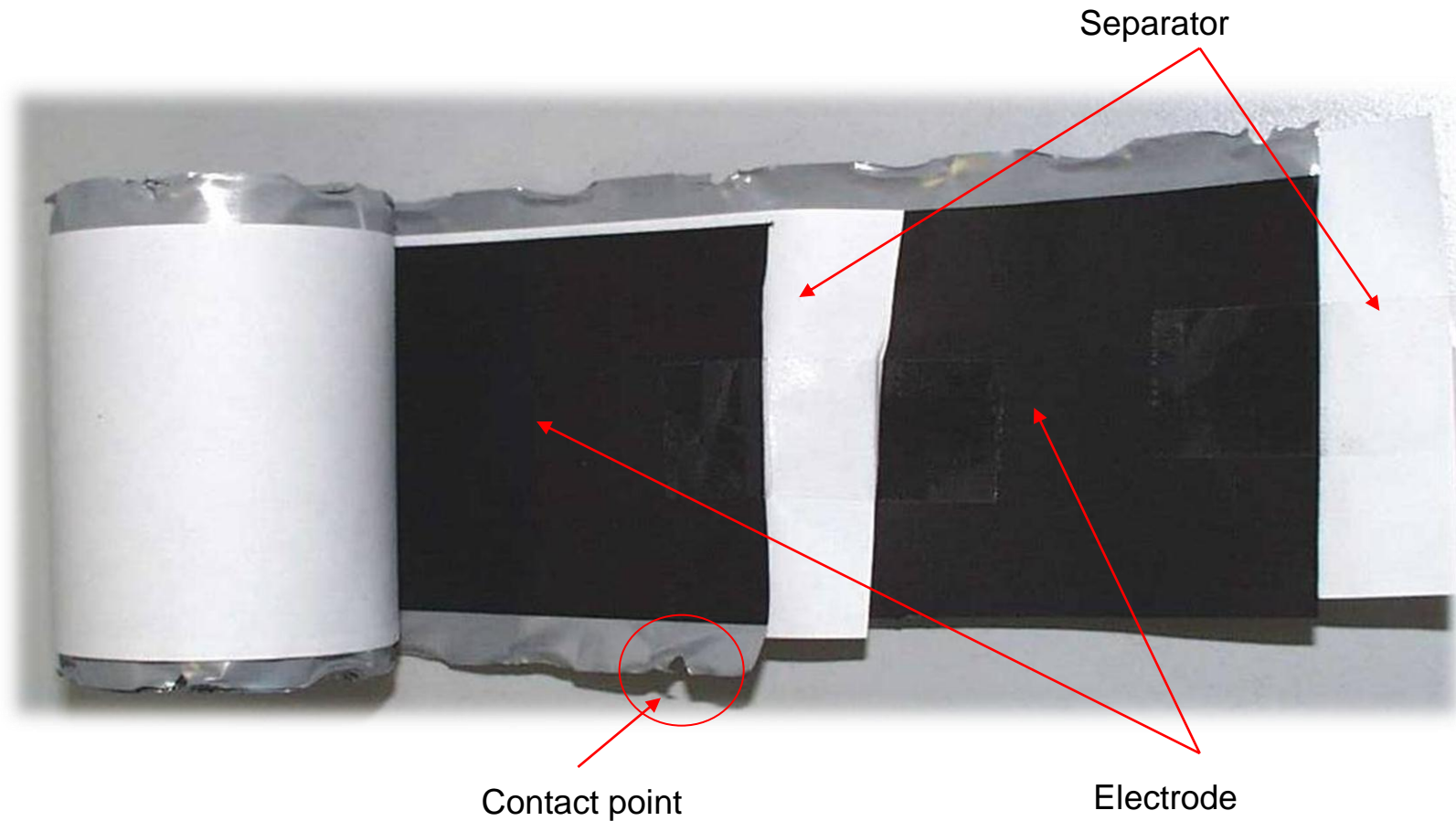




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Construction: Winding Element WIMA SuperCap C





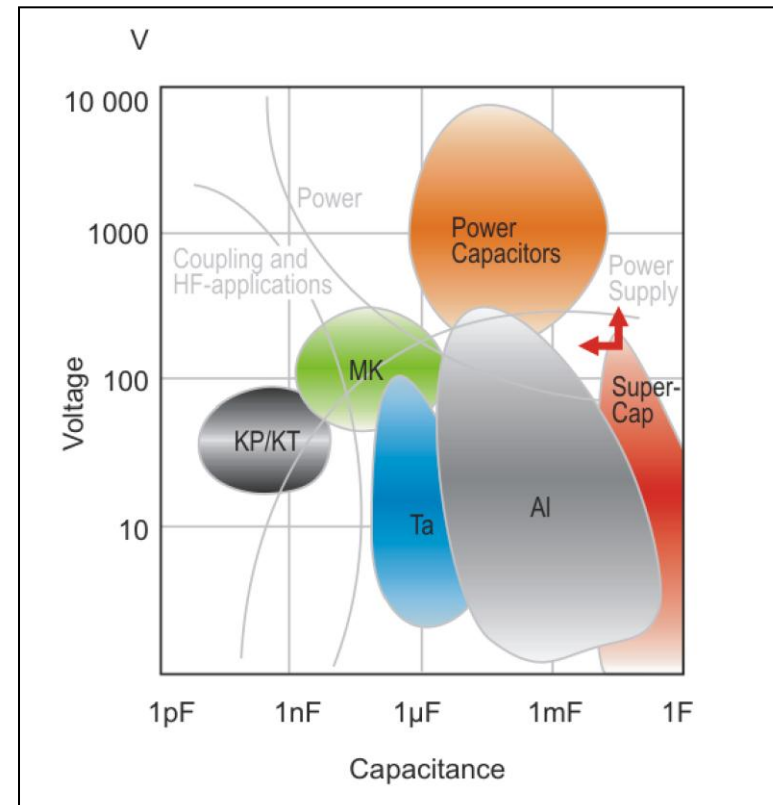
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Comparison of Different Storage Media

Advantages of SuperCaps

	Standard capacitor	SuperCap	Battery
Capacity per square	$< 1 \mu\text{F}/\text{cm}^2$	1 000 000 μF (1 F / cm^2)	
Density of energy	$< 0.01 \text{ Wh/kg}$	$< 10 \text{ Wh/kg}$	100 Wh/kg
Density of power	$< 0.1 \text{ kW/kg}$	$> 1 \text{ kW/kg}$	0.1 kW/kg





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Characteristics of Energy Storage Technologies

Batteries (Energy Application):

- Large energy density
- Accepted technology
- Low power density
- Temperature sensitive
- High internal resistance
- Low cycle stability
- High weight
- Limited life-time
- State of charge not visible
- High risk of damage due to over charging or deep discharge (LiPo)
- Possible failure mode: explosion or fire (LiPo)

SuperCap Module (Power Application):

- Low internal resistance (ESR)
- Very high power density
- High cycle stability
- Low weight
- High life-time expectation, maintenance-free
- State of charge is measurable
- Minus temperature up to -30°C accepted
- Low energy density
- New technology
- Deep discharge without any problems
- Uncritical failure mode

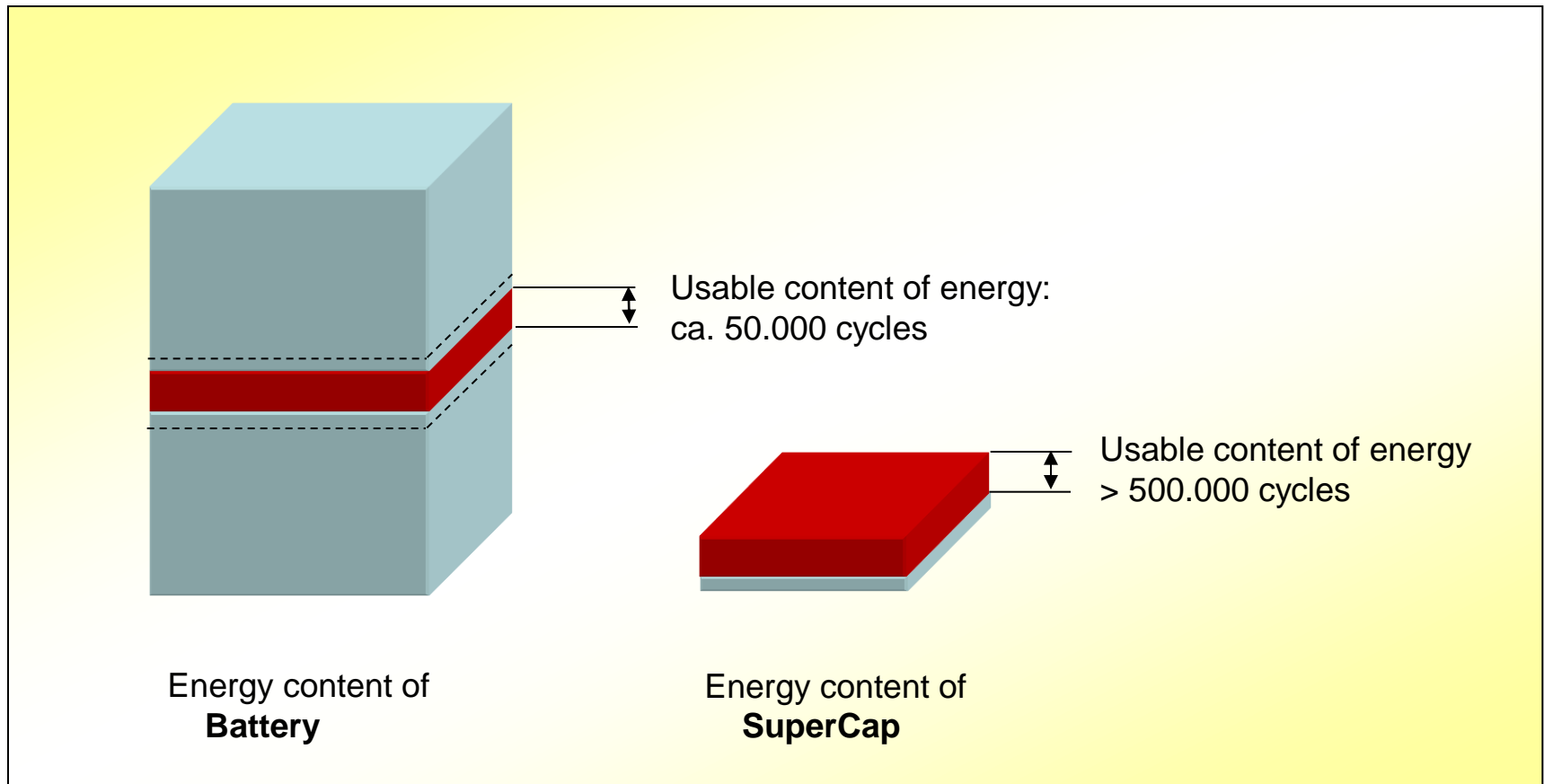
Conclusion: A SuperCap should be used as battery support rather than replacement of a battery



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Comparison of Energy Storage Technologies (identical geometric volume)





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WIMA SuperCap Range

WIMA Double-Layer Capacitors

SuperCap C / C 60



SuperCap R



SuperCap Modules MC / MR





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WIMA SuperCap Standard Portfolio

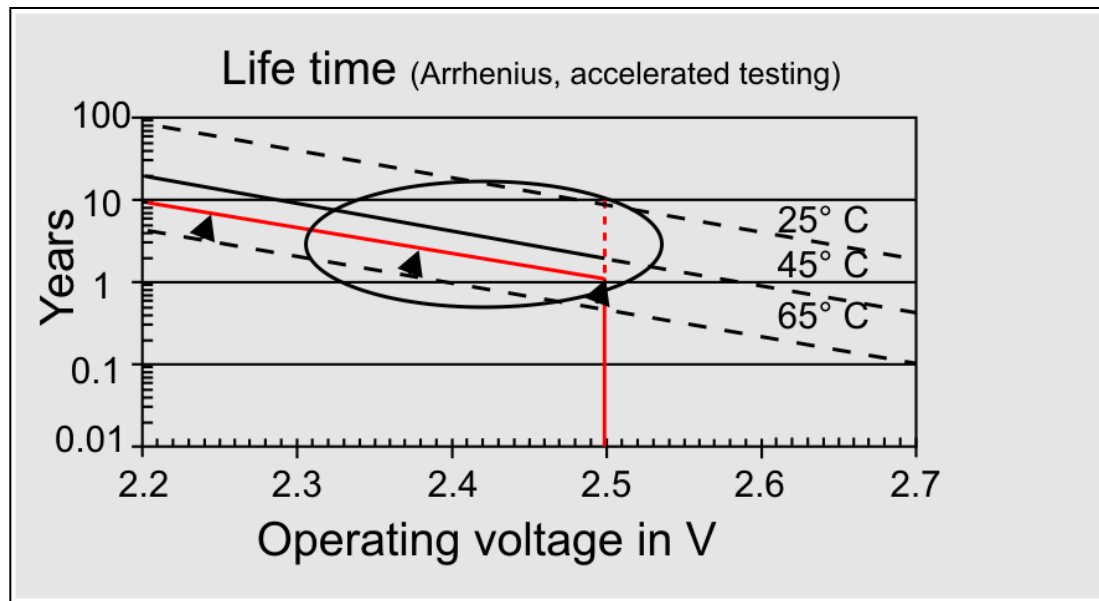
WIMA SuperCap													
Single Cells		Modules						Single Cells		Modules			
with cylindrical metal case	with cylindrical metal case	series connected, actively balanced						with rectangular metal case		series connected, passively or actively balanced			
SuperCap C	SuperCap C 60	SuperCap MC Multipurpose		SuperCap MC Powerblock				SuperCap R		SuperCap MR Powerpack			
Dielectric	Electric Double-Layer	Electric Double-Layer	Electric Double-Layer		Electric Double-Layer				Electric Double-Layer	Electric Double-Layer		Dielectric	
Rated current	30 A to 1000 A	84 A to 130 A	400 A to 650 A		400 A to 1000 A				30 A to 800 A	50 A to 800 A		Rated current	
Pulse current	up to 5000 A	up to 2200 A	up to 2500 A		up to 5000 A				up to 3000 A	up to 3000 A		Pulse current	
Operating temperature range	-30°C to +65°C	-30°C to +65°C	-30°C to +65°C		-30°C to +65°C				-30°C to +65°C	-30°C to +65°C		Operating temperature range	
Max. stored energy (+20°C):	up to 18 kJ	up to 11 kJ	up to 22 kJ		up to 330 kJ				up to 10 kJ	up to 70 kJ		Max. stored energy (+20°C):	
Voltage VDC	2.5	2.7	14	28	14	28	56	112	2.5	5	14	16	Voltage VDC
Capacitance	110 F	1500 F	55 F	110	55	28	12	100 F	100 F	100 F	100 F	450 F	Capacitance
	200 F	2000 F	110 F	200	100	50	24	200 F	300 F	300 F	400 F	600 F	
	600 F	3000 F	200 F	420	230	115	300 F	400 F	600 F	3000 F	additional custom-made solutions on request	additional custom-made solutions on request	
	1200 F			840	420	210							
	2700 F		additional custom-made solutions on request										
	5000 F												
	6500 F												
SuperCap Type C										SuperCap Type R			



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Life-Time Tests of SuperCaps



Criteria:

DC/C > 30%
ESR > two fold

Remark:

For making modules
→ adjust correct
individual cell voltage

No relaxation by reduction of voltage and temperature during test

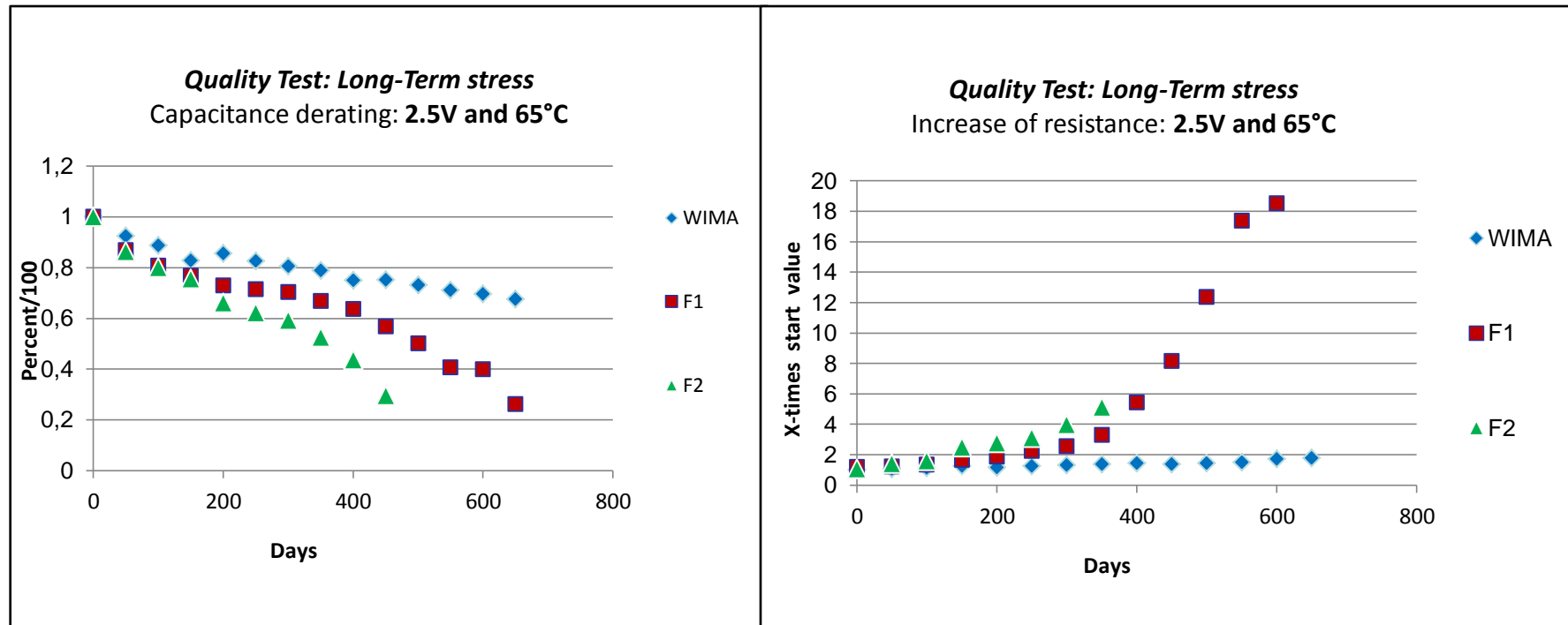
Arrhenius law: Reduction of the voltage load by 0.1 V → doubling of the life time
Reduction of the temperature by 10 K → doubling of the life time



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Life-Time Analysis by Higher Rated Voltage and Temperature



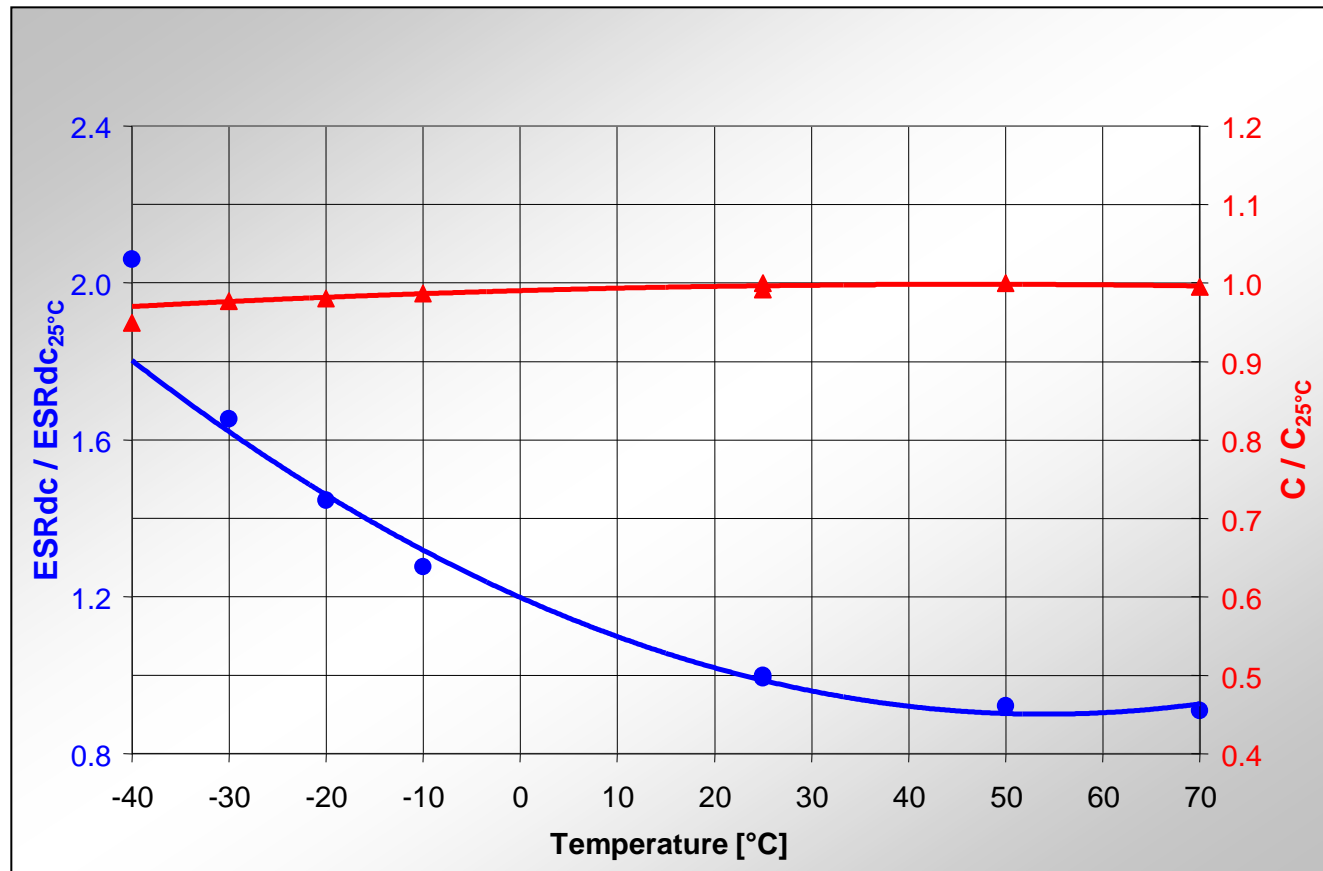
Test: No relaxation by reduction of voltage and temperature allowed



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Low Temp. Behaviour: Resistance and Capacitance only Marginal Influenced





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Safety of SuperCaps

- Studies show the service reliability of WIMA SuperCaps even under hardest conditions
- Constant quality assessment is part of WIMA's philosophy
- Each individual WIMA SuperCap is tested according to DIN IEC 62391-1 and -2
- Under operation according to specification, SuperCaps are safe
- Even under extreme operating conditions (cell voltage and temperature above spec., mechanical stress, high power peaks), WIMA SuperCaps are safe and reliable
- Energy density too low to cause serious damage
- Commonly used materials implemented: mainly activated carbon to absorb chemical liquids
- Hermetical sealed housings, laser welded or IP65 sealed



Safety of SuperCaps

	Testing	Results
<p>High Mechanical Stress/Deformation</p> <p>ENDURANCE TEST</p>	<ul style="list-style-type: none"> • Crash test • Deformation at continuous force 	<ul style="list-style-type: none"> • No hazardous reaction. Laser welded, hermetically sealed construction prevents leakage and liquid release • Only few free liquid is suck in surrounding resin
<p>Cell Venting</p> <p>TEST WITH NAILS</p>	<ul style="list-style-type: none"> • Electrical overload (with subsequent internal electrolysis) • Atmospheric overpressure test • Nail test 	<ul style="list-style-type: none"> • Safe, controlled opening through pressure relief mechanism • Opening starts above 11 bar only
<p>Fire</p> <p>TEST OF FIRE RESISTANCE</p>	<ul style="list-style-type: none"> • Exposition to fire • Exposure to petrol-accelerated fire 	<ul style="list-style-type: none"> • Cell rupture after several 10 minutes • Flammable material burns passively

Risk Types



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R & D Goal:

Increase of rated voltage

by simultaneous **prolongation of life time**

without losing electrical performance

- Process optimization → **achieved**
- Usage of „clean“ materials → **build up samples for approval**
- Increase of rated voltage → **build up initial sample, under preparation**



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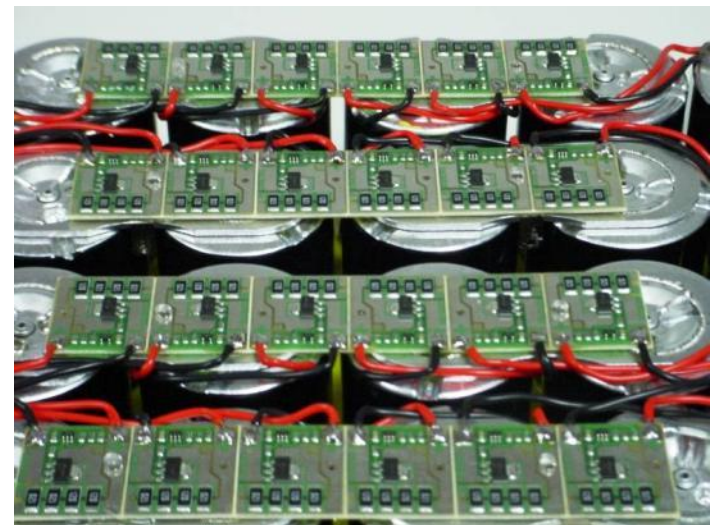
SuperCaps Modules (MC)

Basic construction principles:

- Modular construction system
- Laser beam welded
- Active or passive balancing
- Vibration resistant
- Available in IP 65 standard on request
- Plug-In solutions

Additional features available:

- Fast plug connection (automotive approved)
- Thermal sensor
- External monitoring of each cell
- Heat shrinkage
- Fuse protection (e.g. 40A)

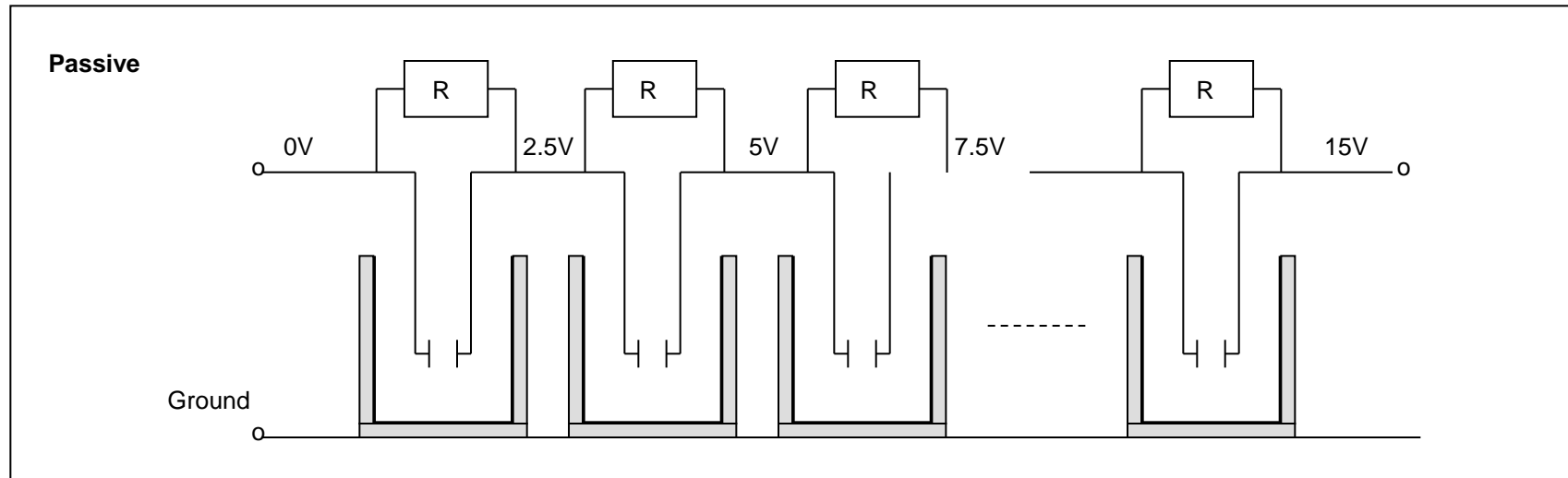




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Cascading: Passive Balancing



Assembly conditions:

Voltage balancing and insulated assembly is necessary!

Voltage should not exceed 2.5 V: Decomposition of the electrolyte!

Capacitance tolerance and aging of cells „vary“ voltage drop: over voltage might occur

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

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



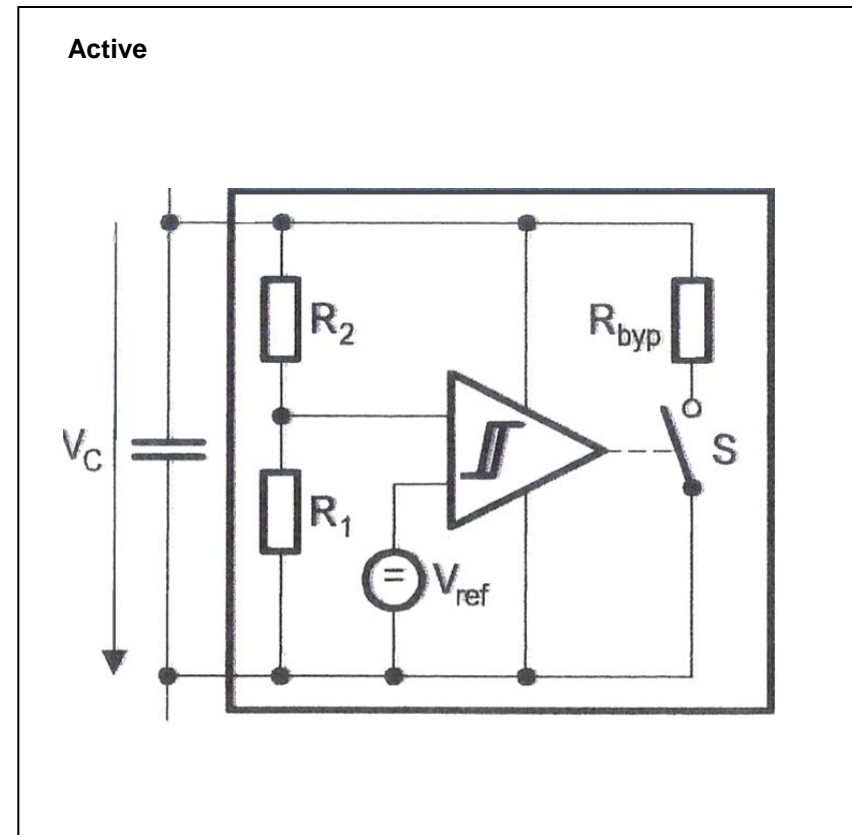
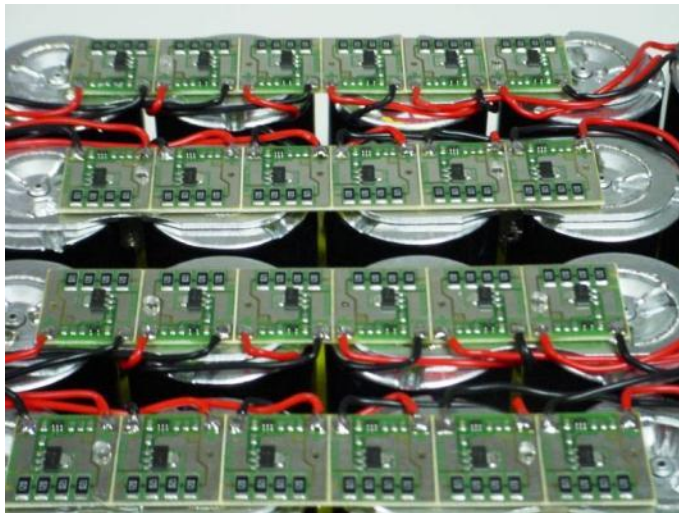
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Cascading: Active Balancing = ASB

**Active balancing happens with less losses.
Leakage current of the cells remains only.**

Comparator compares voltage at the capacitor with a reference voltage and switches in order to discharge through a bypassing resistor (until over voltage has declined)

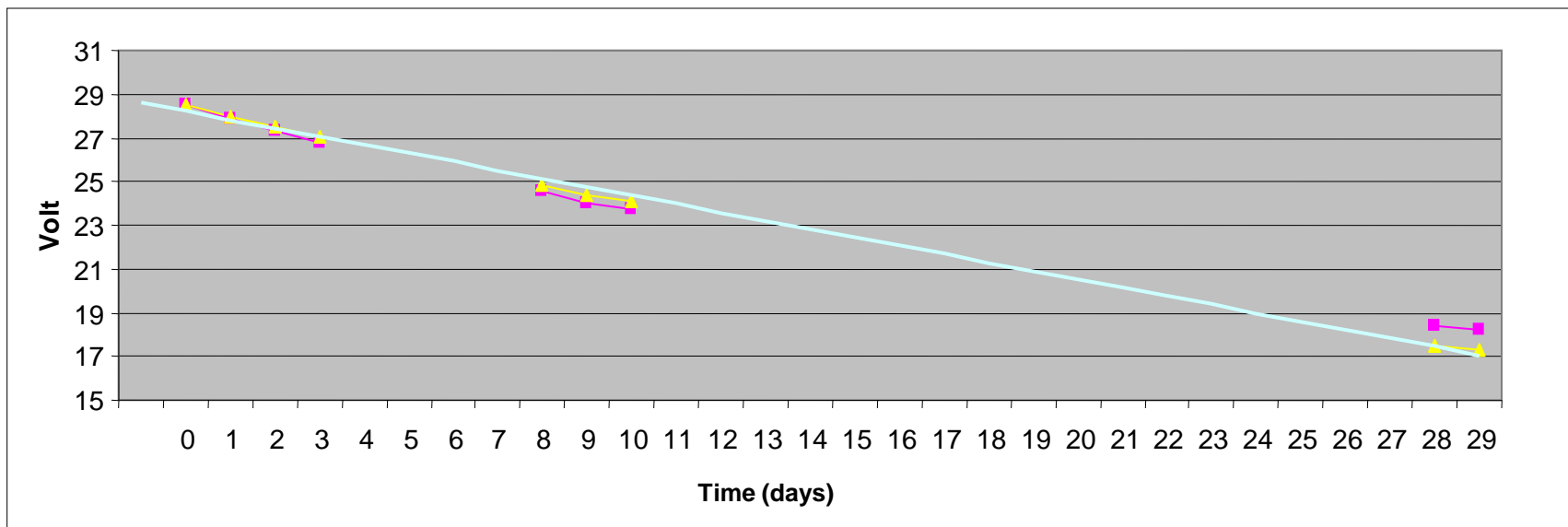




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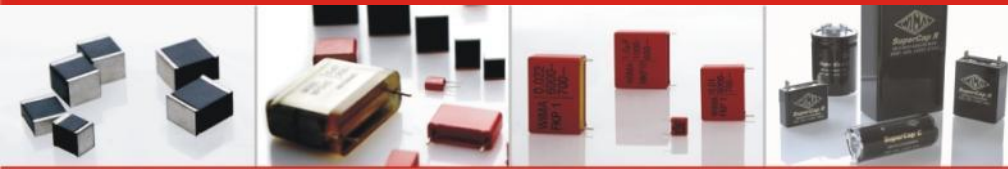
Self-Discharge Properties of WIMA SuperCap MC 55F/28V



Test conditions:

After charging >240 h (SD approx. 0.4 V/day)
here $I_{\text{leakage}} < 1\text{mA}$

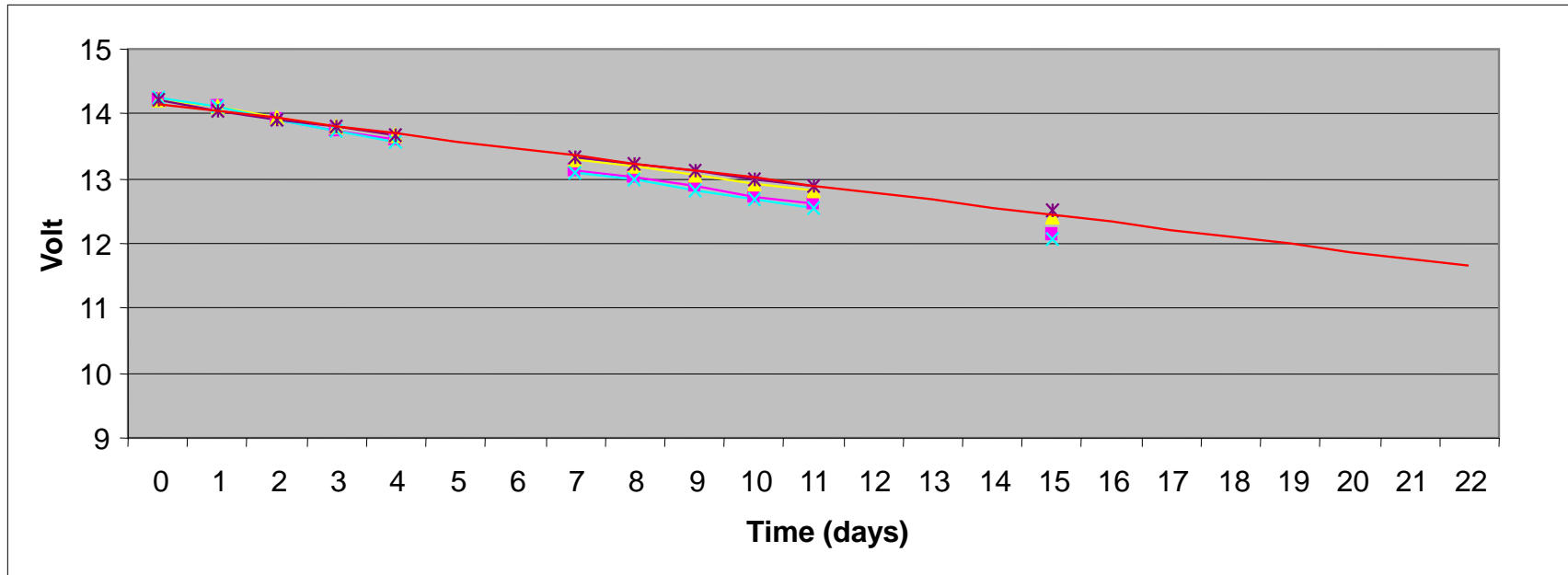
- Sample Module 1: charged/discharged several times
- Sample Module 2: charged one time



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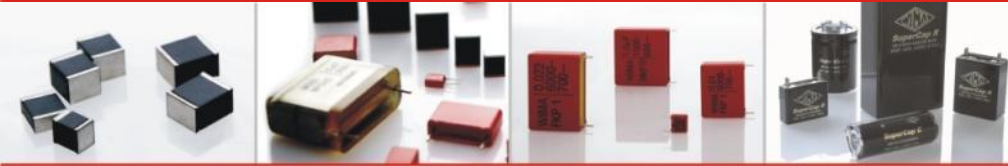


Self-Discharge Properties of WIMA SuperCap MC 200F/14V



Test conditions:

After charging >150 h (SD approx. 0.1 V/day) but nevertheless „air-port test“ possible



Overview: Applications for WIMA SuperCaps

Wind power: - Pitch control / emergency switch off system

Automotive:

- Recuperation of brake energy
- Lifetime extension of batteries in hybrid vehicles
- Cranking of the engine
- Load levelling in fuel cell drives
- Support of on-board electrical systems in cars
- Increase of performance/ acceleration in electric cars

Railway:

- Replacement of starter batteries in diesel-electric engines
- Energy recuperation and network support in local traffic systems

UPS: - Covering of voltage deeps

Solar systems: - Short-term storage, energy buffer





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Application: Cranking of Engines / On-Board Power Supply

- $I_{\text{Puls}} > 2000 \text{ A}$
- $\text{ESR} < 5 \text{ m}\Omega$
- Direct recharge after engine start
- No voltage peaks after switch off
- About 1.000.000 cycles
- Maintenance-free



200 F / 14 VDC
170 x 130 x 115 mm
2.2 kg



55 F / 28 VDC
325 x 60 x 90 mm
3.4 kg



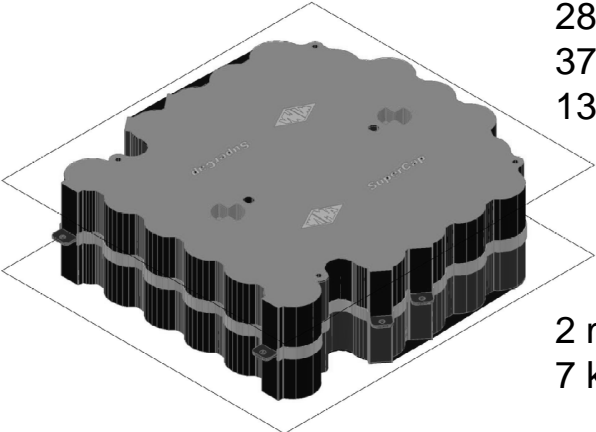

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Application: Pitch Drive of Windmills



- Pitch control functionally independent of line voltage
- Continuous adjustments of rotor blade angle
- Emergency stop at blackout
- Life-time 20 years
- Maintenance-free

	<p>28 F / 87.5 VDC 370 x 355 x 110 mm 13 kg</p> <p>2 modules in series 7 kW up to 15 sec</p>
	<p>35 F / 24 VDC 425 x 190 x 150 mm 9 kg</p> <p>4 modules in series 10 kW up to 20 sec</p>

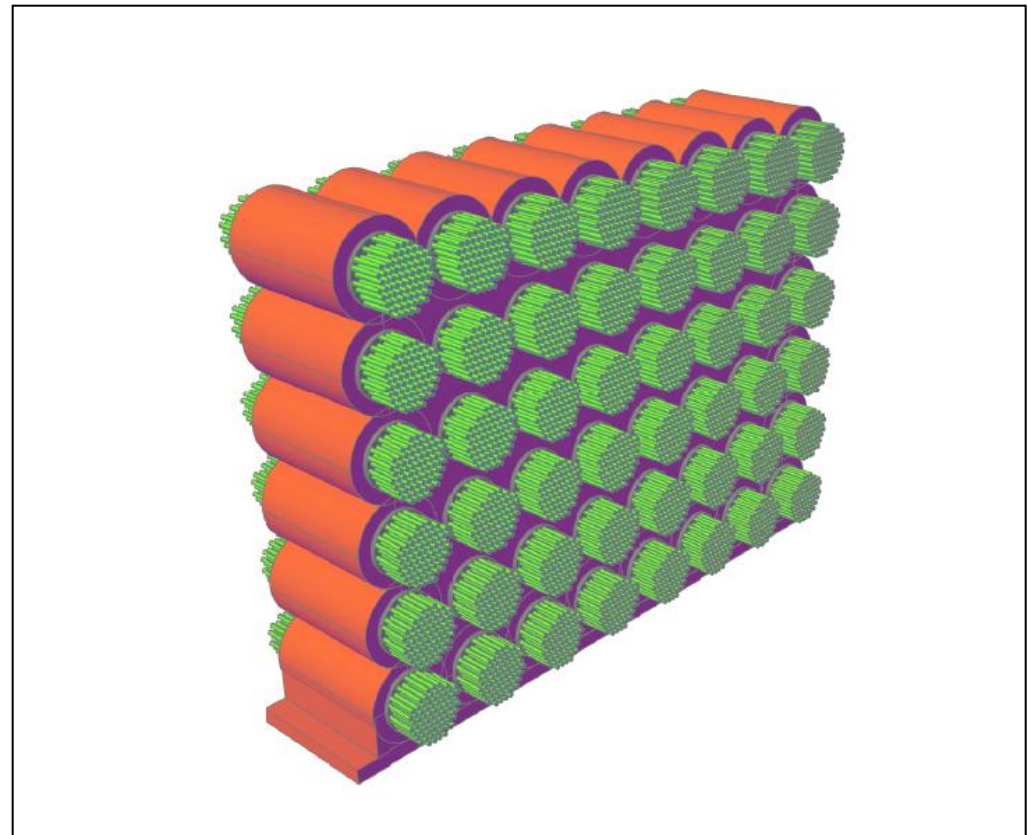


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Application: Recuperation of „Rolling Stock“ (Subway, Train, etc.)

- 300 kW up to 10 sec
- Storage of braking energy
- Support of acceleration
- Efficiency > 98 %
- Integrated heat sinks
- Maintenance-free





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Application: UPS Function for DC Link Voltage (400 – 1000 VDC)

- Power in the range of 250 - 1.000 kW for up to 2 sec can be provided by serial and parallel connection
- No downtime after short blackouts
- Peak load relieving
- Life-time > 10 years
- Maintenance-free



50 F / 56 VDC
330 x 225 x 115 mm
7.5 kg



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Application: Motor Start

Motor start (e.g. 16-cylinders) for:

- Trains
- Vessels
- Military vehicles

Starting current approx. 1000 - 3000 A
(example: 1 - 3 times with 220 F at 30 V)

→ saving: approx. 90% of battery weight, thus
gain 25% in range due to more fuel





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Application: Emergency Power Supply

Special (emergency) power supplies for:

- Oil and gas extraction
- Telecommunication
- Hospitals, etc.

Micro turbine start:

(example: 100 x 1000 F at 240 V corresponding to 63 F and 300 kJ)

Fuel cell start bridging:

(example: 22 cells 1200 F at 48 V corresponding to 55 F and 100 kJ)

Diesel generator start: starting current approx.

500 - 600 A

(example: 6-pack module / 400 F at 15 V corresponding to 7 kJ)





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Further Examples of WIMA SuperCap Modules



33 F / 7 V
3 x 100 F



450 F / 16 V
7 x 3000 F
with heat sink



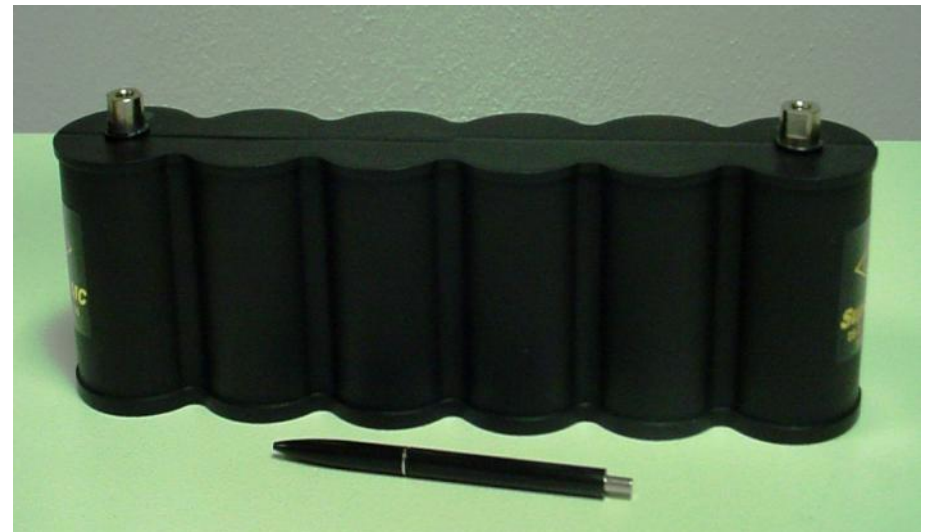
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Further Examples of WIMA SuperCap Modules



70 F / 14 V
6 x 400 F



110 F / 14 V
6 x 600 F
IP 65



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WIMA SuperCap Philosophy

- ✓ **Highest quality**
- ✓ **Reliability**
- ✓ **Highest life-time expectation**
- ✓ **Innovation**
- ✓ **Cost effectiveness**
- ✓ **Environmental friendly**

ISO 9001
EN 14001



Designed for the Future!





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Thank You !

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