SUCCESS
EPCOS Capacitors

EPCOS Inc.
Capacitors Group
April, 2012
EV / HV / E-Mobility

Battery charger system & Inverter
On Board and Off Board Assembly
Trend: Wireless Charging

DC/DC Converter Filtering

DC Link

E-Mobility
DC Link
Braking Energy Recuperation
Hybrid / Electric Vehicle
The battery charger performs three electronic functions.

1. Enhanced phase adjustments made to the wall socket’s alternating current.
2. The voltage is rectified to direct current (DC) voltage.
3. The final step is to up-convert the household voltage; enough to charge an EV with 40-mile all-electric range.
Battery Charger Circuit Diagram

1. Filter Capacitor – EMI protection - X & Y caps
2. DC Link Capacitor – Alu Snap-in, MKP Cap
3. Output Capacitor – MKT and MKP caps
Battery Charger Circuit Diagram

1. Filter Capacitor - Due to the connection to the net for the external charging for the battery and the high currents we are facing inside the car, on some positions real X2 and Y2 capacitors with the standard safety approvals (ENEC and UL) are necessary.
Filter Capacitor for Charging / Plug In System

Technical requirements:

- Operation Temp: 105°C
- Capacitance range: 1nF - 45µF
- Voltage rate: 300V_{AC}
- Standard Safety Approvals: UL / ENEC

EPCOS solution:

- EMI X2 /
- Y2 Cap

<table>
<thead>
<tr>
<th>Film Capacitor</th>
<th>MKP X2</th>
<th>MKT X2</th>
<th>MKP Y2</th>
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<tbody>
<tr>
<td>Boxed</td>
<td>B3292X</td>
<td>B3293X</td>
<td>B3202X</td>
</tr>
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</table>

- Cap. range (µF):
  - 0.01 - 45µF
  - 0.047 - 10µF
  - 1nF - 1µF
- voltage range (V_{AC}):
  - 305
  - 305
  - 300

Heavy Duty: 85/85/1000/240

Recent test results: Up to 2000Hrs!!!
DC Film Capacitors

Heavy Duty X2 Series, B3293x

EPCOS has designed and developed a new series of MKT film capacitors for AC applications (B3293x - Heavy Duty X2 series).

This series offers high durability and very low capacitance drift even after being subjected to tests of **1000-hours at 85ºC / 85%RH and 240Vac**. Their maximum capacitance change is expected to be less than 10%. The B3293# series cover a capacitance range from 0.047µF to 10µF and are designed for a nominal voltage of 305 Vac. Their maximum operating temperature is 105º C. In addition, capacitance values up to and including 2.2µF are safety certified as X2’s capacitors.

Some features for the Heavy Duty Design:

- **Internal series connection**
  Voltage per connection is divided by half so that avoiding the undesirable effects of AC voltage (i.e. partial discharges).

- **Polyester (PET) as dielectric material**
  Due to its higher dielectric constant than polypropylene (PP), it allows a higher density of capacitance per volume, reaching smaller sizes. Better resistance to higher temperatures (i.e. 125º C)

- **Electrode metallization**
  No use of Zn material, for high resistance to humidity.
2. DC Link Capacitors - The main objective is energy storage. A high energy and high capacitance by voltage product that can withstand high temperatures and offer long life.
DC Link Capacitor – Film Capacitors

Technical requirements:
Operation Temperature: 105°C
Capacitance range: Up to 480 µF
Voltage rate: Up to 1300 V\textsubscript{DC}
High Reliability

EPCOS solution:

<table>
<thead>
<tr>
<th>Capacitor</th>
<th>MKP DC Link</th>
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<tr>
<td>Cap. range (µF)</td>
<td>1.5 - 480 µF (std)</td>
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<tr>
<td>Voltage range (V\textsubscript{DC})</td>
<td>450-1300</td>
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DC Link Capacitors
High Density DC Link B3277x series

Lead Spaces (mm): 37.5 ~ 52.5
Climatic Category: 40/100/56

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<th>Capacitor Value (µF)</th>
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NEW!!!
Low-Profile Capacitors, B32*6T series

- Low-profile with heights of only **15 or 19 mm**
- Good self-healing properties
- High reliability
- Long useful life
- Very high mechanical resistance to vibrations and shocks

NEW!!!

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<tr>
<th>Product Series:</th>
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<td>Dielectric:</td>
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<td>Climatic Category:</td>
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DC Link Capacitor – ALU Capacitor

Technical requirements:
Operation temperature: 105°C
Service Life: 15 years / 120,000 km
Ripple capability: 8Arms, 60°C, 10kHz
Capacitance range: 1,500µF - 2,000µF
Voltage: 450Vdc

EPCOS solution

Type
Snap-in

Series
B43540 / B43508

Operation Temp
up to 105°C

Cap. range (µF)
100 - 470µF

voltage (V_{DC})
450V

Qualified according
AEC Q200 (*)

(*) in qualification - Jun. 2012
Samples available

High vibration strength up to 40g
3. Output Capacitor - Capability to withstand over-voltages, and transients coming from the mains. Capability to withstand high current pulses together with a high frequency harmonics

International approvals such as UL/IEC are not always required for this position.
Output Filter Capacitor

Technical requirements:
Operation Temperature: 105°C
Capacitance Range: 0.47 - 220µF
Voltage rate: 63-450V\text{DC}
Ripple Capability: 20A, 70°C, 10KHz
Useful life: 100Khrs/70degC

EPCOS solution: Film Capacitors

<table>
<thead>
<tr>
<th>Film Capacitor</th>
<th>MKT</th>
<th>MKP AC Filter</th>
<th>MKP DC Link</th>
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</thead>
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<tr>
<td>Boxed</td>
<td>B32524A</td>
<td>B3279x</td>
<td>B3277x</td>
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<tr>
<td>Cap. range (µF)</td>
<td>4.7-220µF</td>
<td>0.82-75µF</td>
<td>1.5 - 480µF</td>
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<td>Voltage range</td>
<td>63-250V\text{DC}</td>
<td>250-400V\text{AC}</td>
<td>450-1300 V\text{DC}</td>
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</table>
Trend: Wireless Charging

Wireless power transfer technology is not a new technology; however, recent developments have allowed it to become more practical, and recent interest in the consumer market has brought it to the center of attention.

Wireless charging, also known as inductive charging, removes the need to run a cable from the device to the charging point and instead sends energy between two flat plates – one in the device and one on (or in) the ground below it – which charges the battery.
Trend: Wireless Charging

EPCOS Capacitors
Battery Electric Vehicle (BEV) Block Diagram

The DC/DC converter is responsible for converting High DC Voltage from batteries to Low DC Voltage on general applications.
DC/DC converter – Filtering

Since in most of the hybrid drives there is no starter and no alternator, the DC/DC converter has to be bi-directional.

The voltage level in the hybrid circuit is at the level of 200 – 400 Vdc.

**DC/DC converter for hybrid / electric vehicle**
- Used for the conversion of the battery voltage of 14V to a higher voltage level (42V or even more) and vice versa. (Typical application: Power steering)
- The film capacitor is used as an input and output filter
DC/DC converter - Filtering

Requirements:
- Very high reliability
- Vibration resistance
- Excellent current handling capability
- Low ESR

Solutions from Epcos
MKT B3252x and MKP B3277x
- different lead configurations for vibration resistance:
  - normal 2-pin
  - 4-pin or multi-pin
  - flat terminals
- low ESR at high frequencies
- high current handling capability

<table>
<thead>
<tr>
<th>Series</th>
<th>B3252x</th>
<th>B3277x</th>
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<td>MKT</td>
<td>MKP</td>
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<td>C_R (µF)</td>
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</table>
Battery Electric Vehicle (BEV) Block Diagram

The DC Link is responsible for supplying energy or smoothing voltage ripple during the conversion of DC High voltage for the motors.
DC Link Capacitors for Automotive Applications

Customer Demands

- Compact Size
- Higher Temperature Ratings (105 ambient)
- Higher Currents
- Customized terminals
- Lower ESL

Specifications

- Capacitance: 300 to 1000 μF
- Voltage Rating: 450 to 600 V DC
- Ripple Current: 112 to 240 A
DC/DC Converter - DC Link Capacitor – ALU Capacitor

Function: the inverter controls the energy flow between electric motor and the hybrid battery while the DC/DC converter couples the hybrid battery to the overall power supply system.

Requirements:
- Voltage bank – 160V
- High reliability up to
- High current capability – 10A / cap
- Vibration resistance up to 40g
- Excellent current handling capability
- Low ESR

EPCOS solution Type Axial / Soldering Star
Series B43693 / B43793
Operation Temp up to 105C
Cap. range (µF) 100 - 470µF
Voltage (V ) 160 - 200V
Qualified according AEC Q200

High vibration strength up to 40g
E-Mobility – New Application

- Hybrid DC-Link with MOSFET Technology – 110V operating voltage at high ripple current

- Axial-lead capacitor in Soldering star mechanical configuration
- e.g. 21 x 49 mm, 400 µF, 160 V with max. 9 Arms at 125°C
E-Mobility – New Application

- Energy recuperation via braking system, **high ripple current and vibration resistance** >40 g

The cooperative regenerative braking system ensures that as much braking energy as possible is recuperated and stored as electrical energy. To do this, the generator is used to slow the vehicle down. As soon as the braking requirements exceed the braking capacity of the generator, the classic wheel brakes are applied.

- Axial-lead capacitor
- e.g. 20 x 29 mm, 500 µF, 63 V with max. 9.5 Arms at 125°C
Comfort Electronics - EMC Protection

All these motors are causing radiofrequency emissions!!!
Comfort Electronics - EMC Protection

To ensure successful operation of all electronic modules in the car, these interferences must be caught directly at each motor

**Requirements:**
- thermal stability up to 125°C even up to 150°C for special applications like the waterpump
- high pulse handling capability according ISO 7631
- high reliability
- flexible mounting possibilities

**Typical applications:**
- Power windows
- Windscreen wipers
- Power seats
- Sun / Moon roof
Comfort Electronics - EMC Protection

MKT boxed B3252x series

- Customized mechanical configuration available
  - Bent leads
  - Longer leads
  - Lead-frames

- AEC Q200 qualified

<table>
<thead>
<tr>
<th>Leadspace</th>
<th>5.0 mm</th>
<th>7.5 mm</th>
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Why TDK-EPC Capacitors?

- Long-standing experience in developing reliable Capacitors for Automotive applications.
- High end product technologies with long life & high ripple capability
- ALU Cap with vibration strength up to 40g
- Wide voltage range from 25V up to 1kV
- Specialist for customized solutions
- Local resource able to provide strong technical support to customers' engineers