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

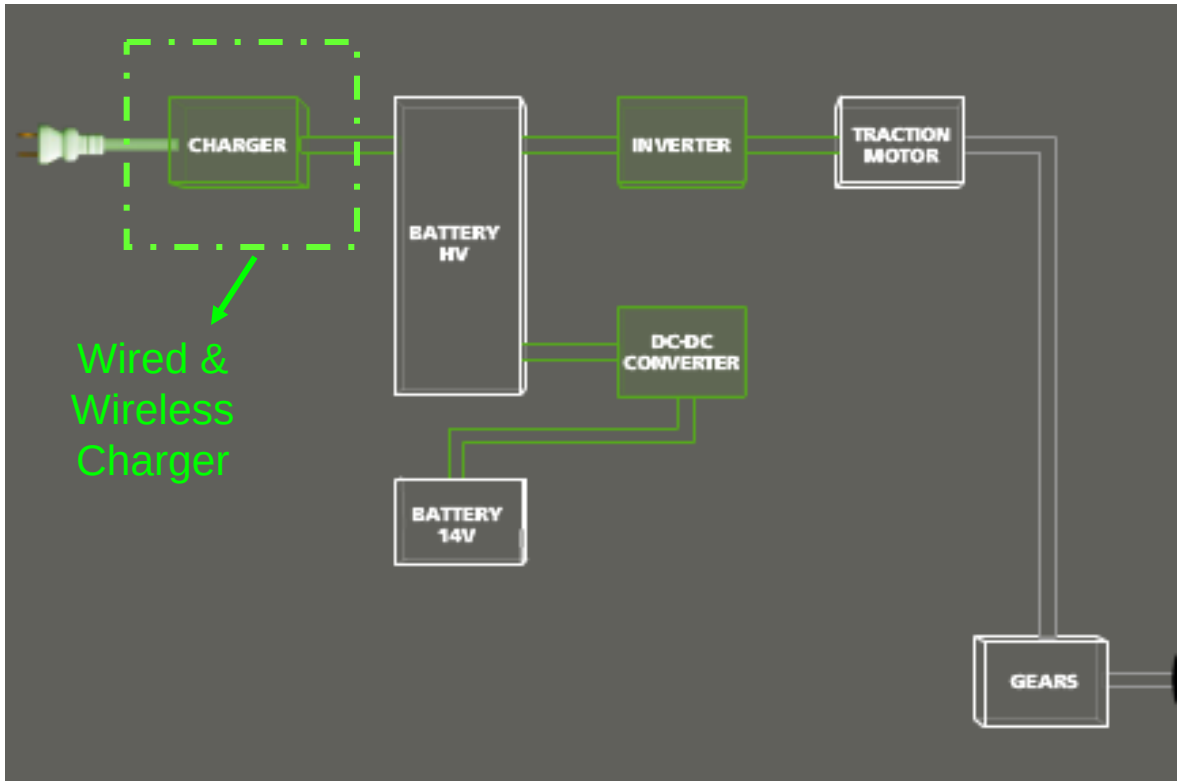
DC Link

E-Mobility

DC Link
Braking Energy Recuperation

Hybrid / Electric Vehicle

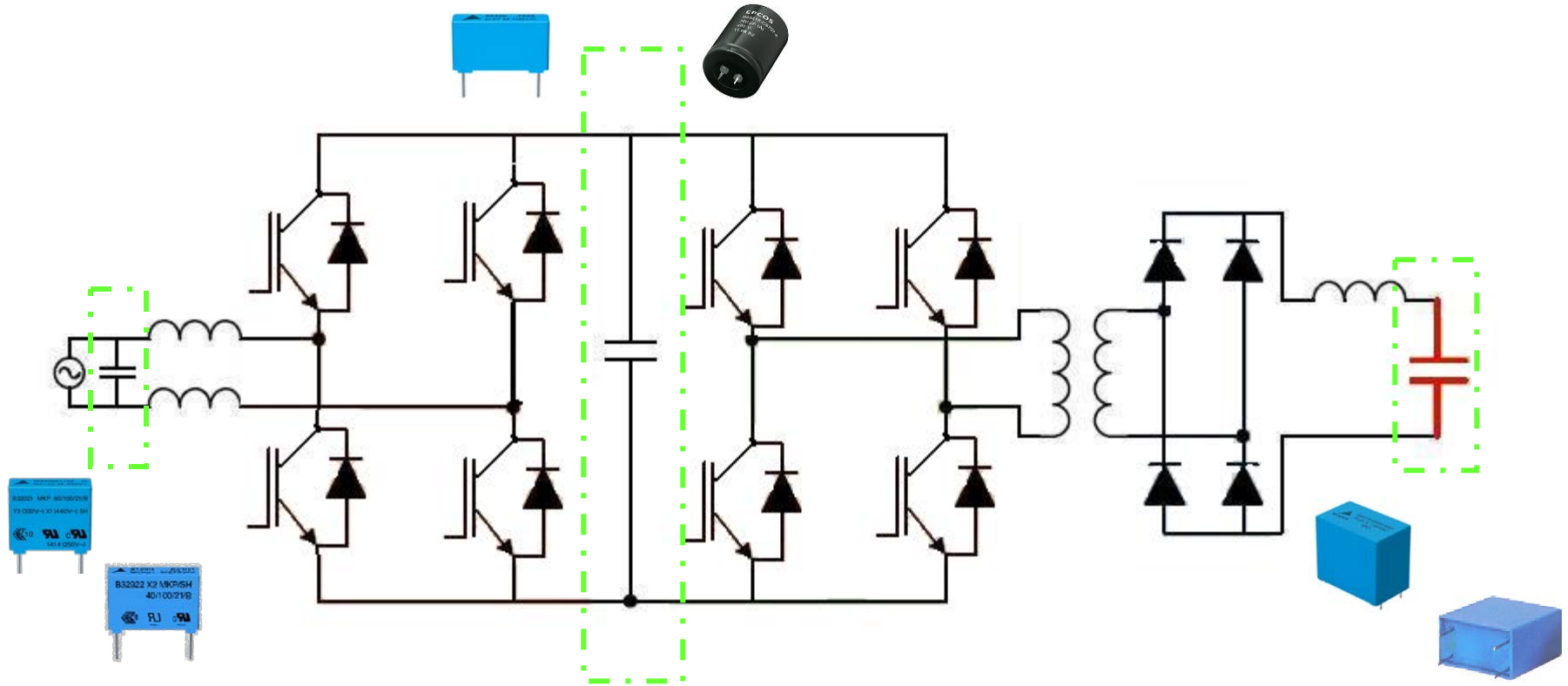
Battery Electric Vehicle (BEV) Block Diagram



The battery charger performs three electronic functions.

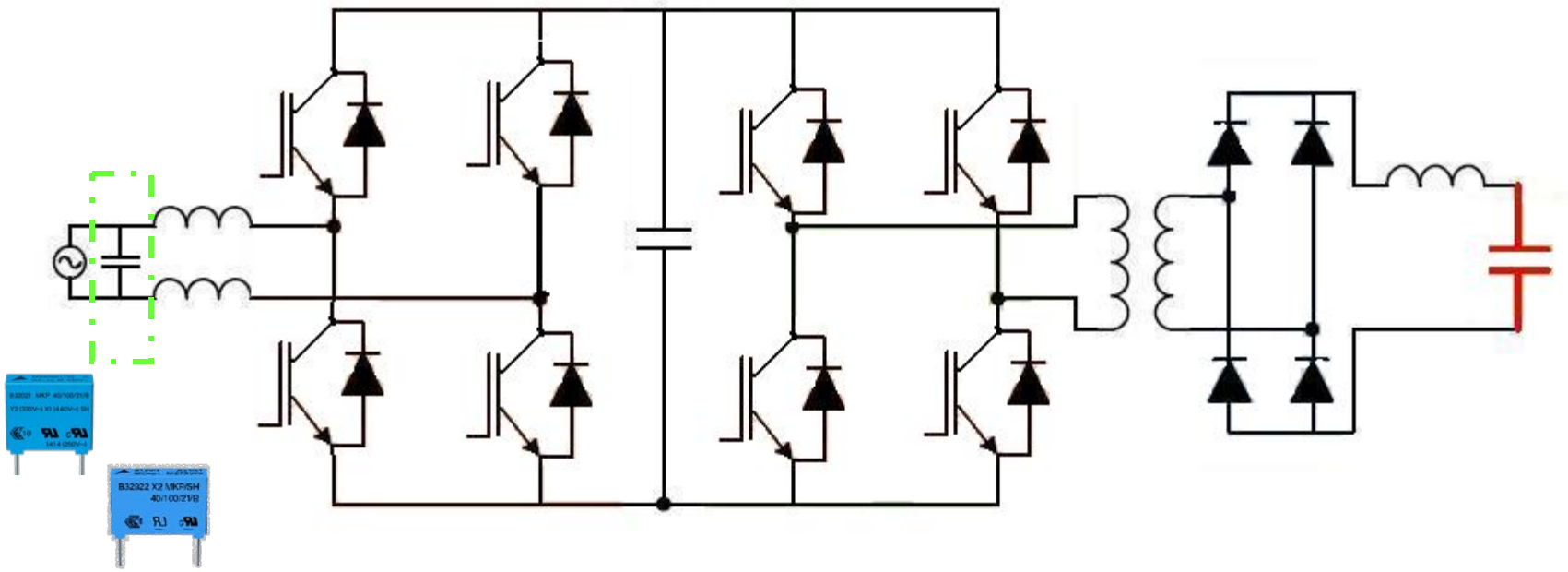
1. Enhanced phase adjustments made to the wall socket's alternating current.
2. The voltage is rectified to direct current (DC) voltage.
3. The final step is to up-convert the household voltage; enough to charge an EV with 40-mile all-electric range

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:	105C
Capacitance range:	1nF - 45µF
Voltage rate:	300V_{AC}
Standard Safety Approvals	**UL / ENEC**
EPCOS solution:	EMI X2 / Y2 Cap

		AEC-Q200	
Film Capacitor	MKP X2	**MKT X2**	MKP Y2
Boxed	B3292X	**B3293X**	B3202X
Cap. range (µF)	0.01 - 45µF	0.047 - 10µF	1nF - 1µF
voltage range (V_{AC})	305	305	300
		Heavy Duty	
		85/85/1000/ 240	

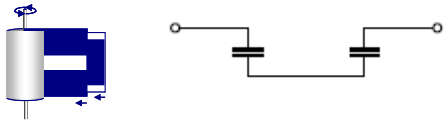
Recent test results:
Up to **2000Hrs!!!**

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:

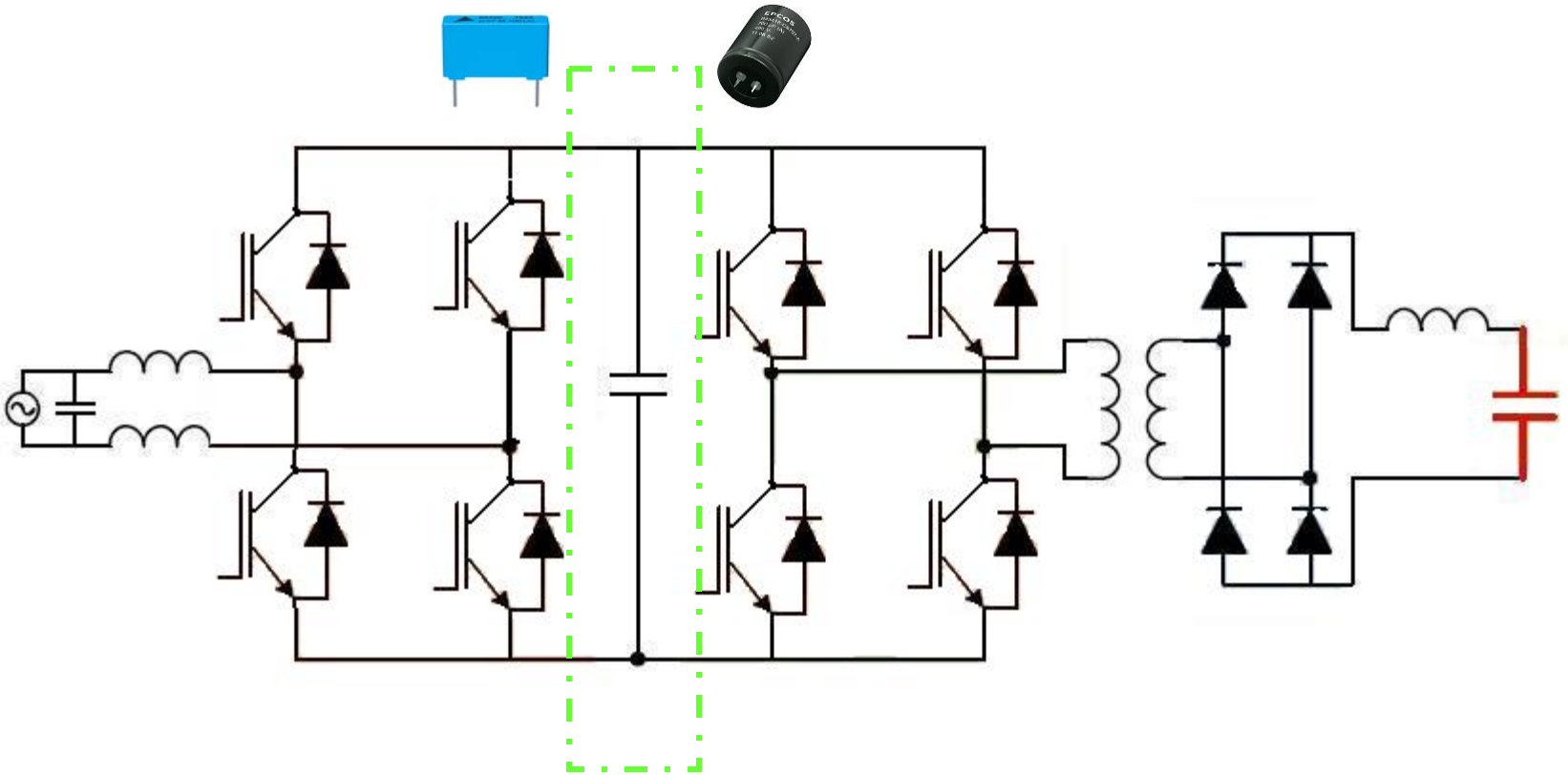
- **Internal series connection**
  Voltage per connection is divided by half so that avoiding the undesirable effects of AC voltage (i.e. partial discharges).



- **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.

Battery Charger Circuit Diagram



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.

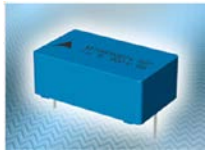
DC Link Capacitor – Film Capacitors

Techical requirements:

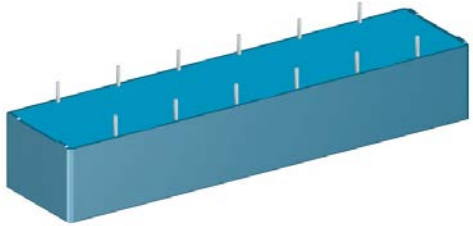
OperationTemperature:	105C
Capacitance range:	Up to 480µF
Voltage rate:	Up to 1300V_{DC}

High Reliability

EPCOS solution:



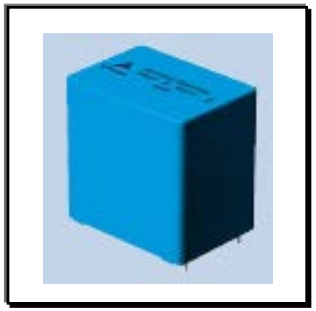
Capacitor	MKP DC Link
Cap. range(µF)	1.5 - 480µF (std)
voltage range (V_{DC})	450-1300

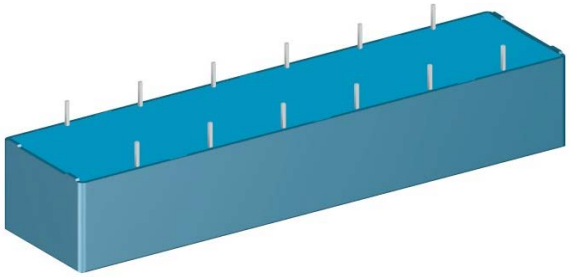


DC Link Capacitors

High Density DC Link B3277x series

NEW!!!





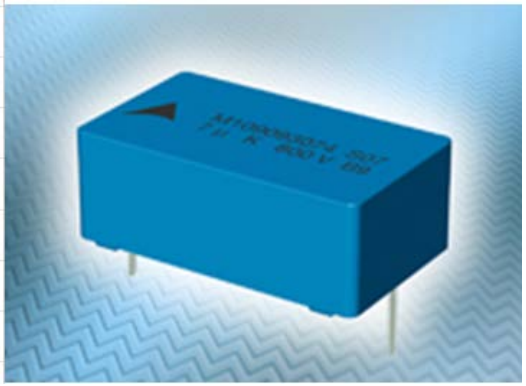
Lead Spaces (mm): 37.5 ~ 52.5				
Climatic Category: 40/100/56				
U_N / U_{OP}	450V	700V	900V	1100V
10 µF				
12 µF				
15 µF				
20 µF				
25 µF				
30 µF				
35 µF				
40 µF				
50 µF				
60 µF				
70 µF				
100 µF				
110 µF				

C (µF)	450 Vdc	575 Vdc	800 Vdc	900 Vdc	1100 Vdc	1300 Vdc
14						
25						
40						
60						
75						
80						
90						
100						
110						
120						
130						
140						
170						
180						
210						
250						
270						
320						
360						
480						

Low-Profile Capacitors, B32*6T series

NEW!!!

- 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

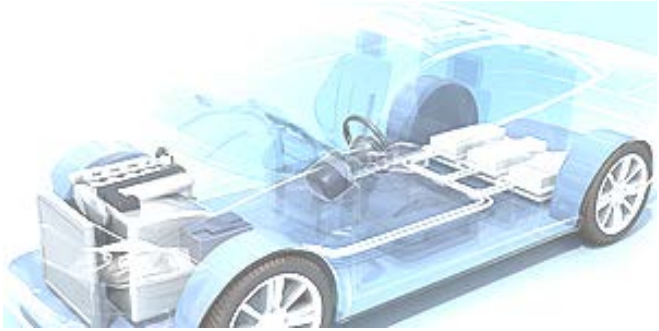


Product Series:	B3722					
Dielectric:	MKP					
Lead Spaces:	37.5 - 52.5mm					
Climatic Catergory:	40/85/56					
C V	**450**	**575**	**800**	**900**	**1100**	**1300**
9						
13						
14						
17						
20						
17						
22						
25						
30						
40						
55						

DC Link Capacitor – ALU Capacitor

Technical requirements:

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



EPCOS solution

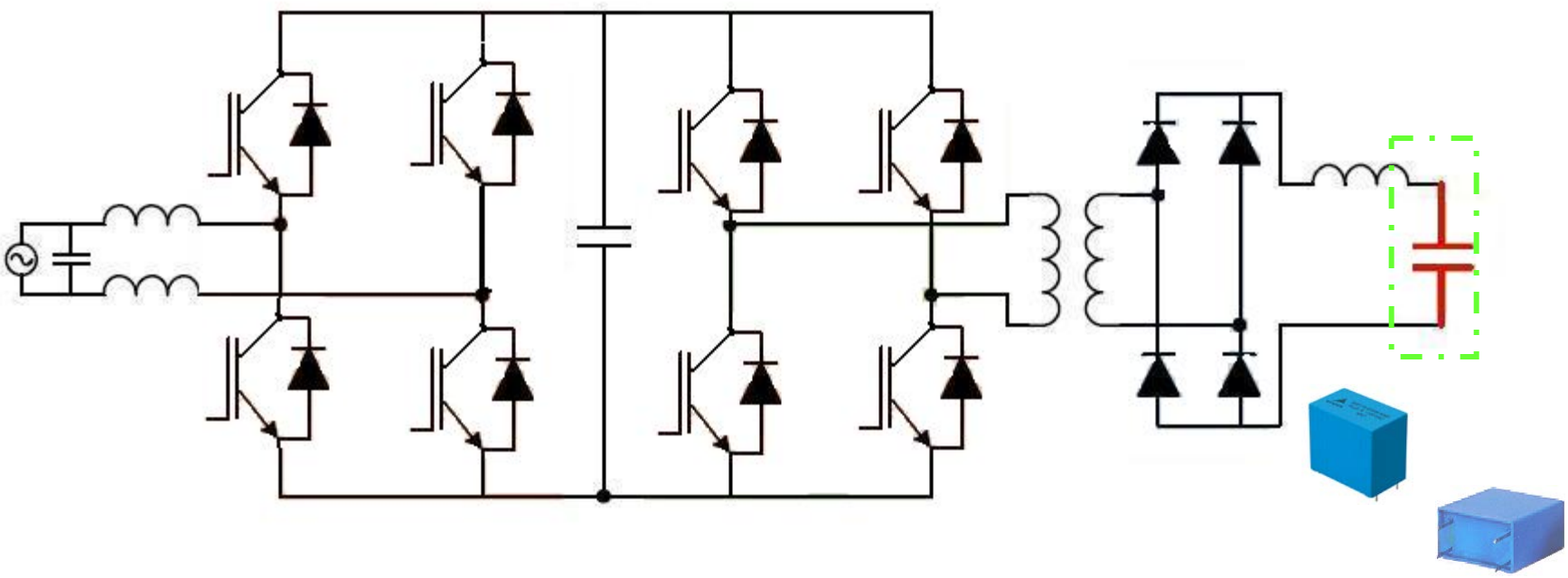
Type	Snap-in
Series	B43540 / B43508
Operation Temp	up to 105C
Cap. range (µF)	100 - 470µF
voltage (V_{DC})	450V
Qualified according	AEC Q200 (*)

(*) in qualification - Jun. 2012

Samples available

High vibration strength up to 40g

Battery Charger Circuit Diagram



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

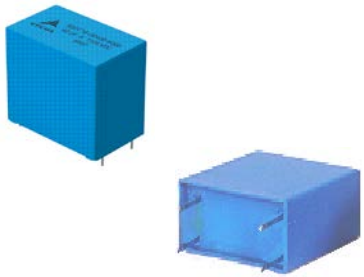
International approvals such as UL/IEC are not always required for this position.

Output Filter Capacitor

Technical requirements:

Operation Temperature:	105C
Capacitance Range:	0.47 - 220µF
Voltage rate:	63-450V_{DC}
Ripple Capability:	20A, 70C, 10KHz
Useful life:	100KHrs/70degC

EPCOS solution: Film Capacitors



Film Capacitor	MKT B32524A B32526A	MKP AC Filter B3279x	MKP DC Link B3277x
Boxed			
Cap. range (µF)	4.7-220µF	0.82-75µF	1.5 - 480µF
Voltage range	63-250V_{DC}	250-400V_{AC}	450-1300 V_{DC}

Trend: Wireless Charging

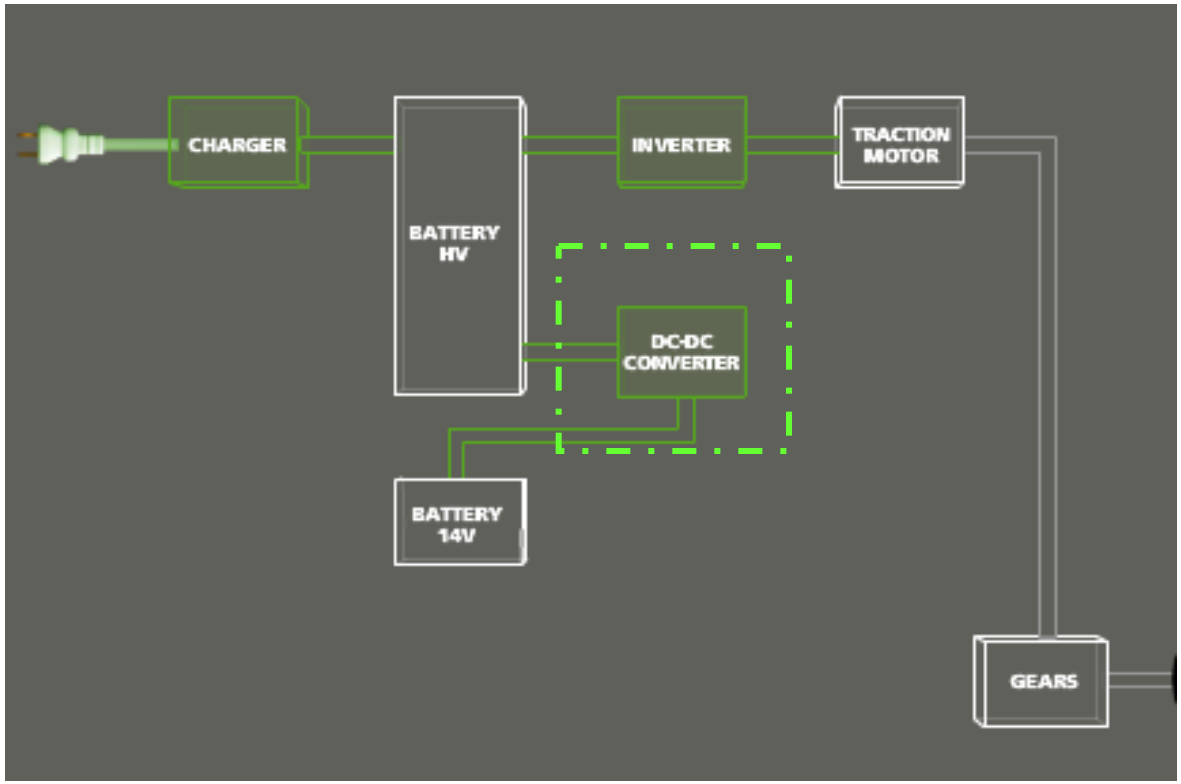
**Wireless power transfer technology is not a new technology;
however, recent developments have allowed it
to become more practical, and recent interest in the consumer market has
brought it to the center of attention**

**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

ntom EE (aka 102EX) uses wireless charging technology. A pad connected to a the ground so all the driver need do is drive over it and park in roughly the right position - magnets ensure proper alignment.

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

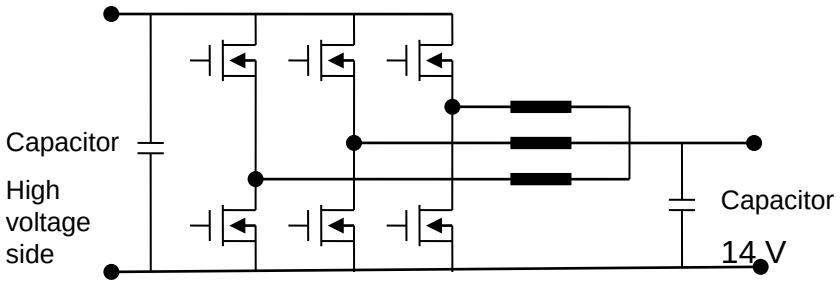
DC/DC converter – Filtering

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:

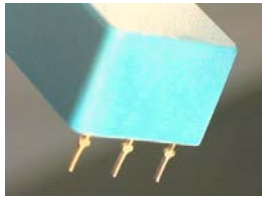
- Very high reliability
- Vibration resistance
- Excellent current handling capability
- Low ESR

Series	B3252x				B3277x
Type	MKT				MKP
V_R (Vdc)	63	100	250	400	450
C_R (µF)					
5					
10					
22					
33					
50					
68					
100					
110					
150					
200					
220					

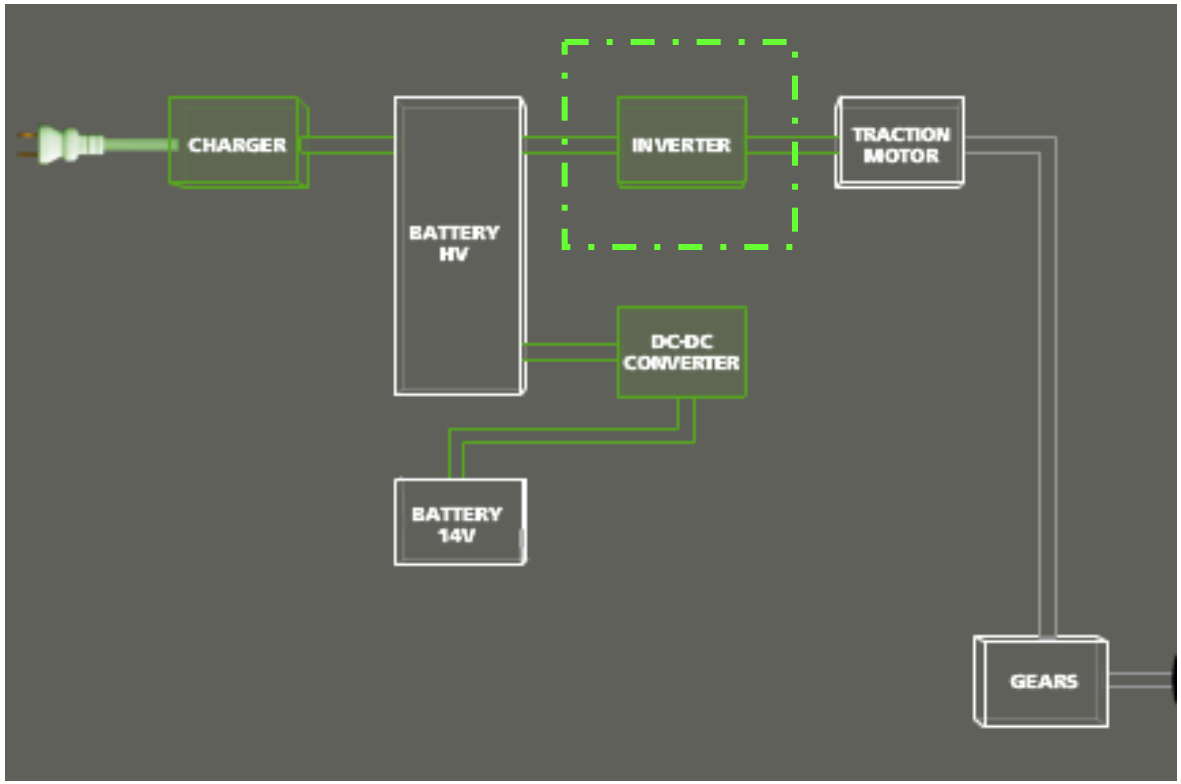
Solutions from Epcos

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



Battery Electric Vehicle (BEV) Block Diagram

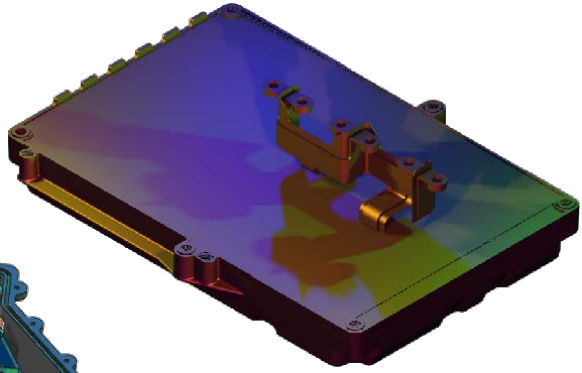


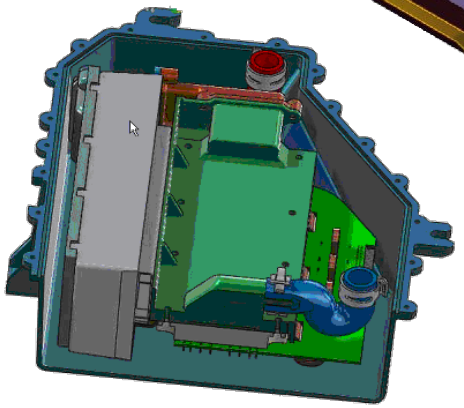
The DC Link is responsible for supplying energy or smoothing voltage ripple during the conversion of DC High voltage for the motors.

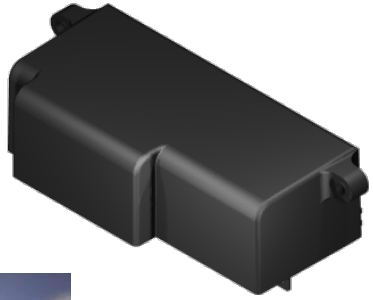
DC Link Capacitors for Automotive Applications

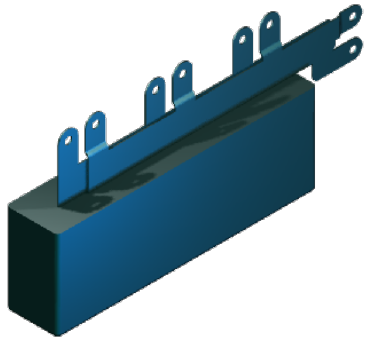
Customer Demands

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









Specifications

- Capacitance: 300 to 1000 uF
- 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

E-Bike (BEV)

E-Scooter(BEV)

E-Stapler (BEV)

Mild-HEV

- 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

Power seat

Wiper

Smart Parking

Mirror control

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:

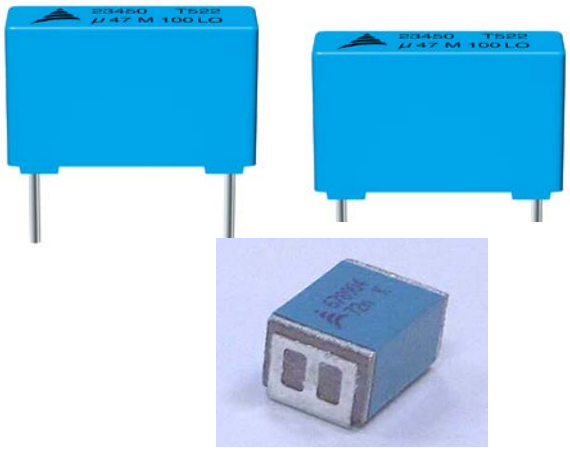
- Power windows
- Windscreen wipers
- Power seats
- Sun / Moon roof

Comfort Electronics - EMC Protection

MKT boxed B3252x series

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

- AEC Q200 qualified



Leadspace	5.0 mm		7.5 mm		10.0 mm		15.0 mm	
Type	B32529		B32520		B32521		B32522	
V_R (Vdc)	63	100	63	100	63	100	63	100
V_{rms} (Vac)	40	63	40	63	40	63	40	63
C_R (µF)								
0.1	■	■	■	■				
0.22	■	■	■	■				
0.33	■	■	■	■				
0.47	■	■	■	■	■	■		
0,68	■	■	■	■	■	■	■	■
1.0	■	■	■	■	■	■	■	■
1.5	■		■		■		■	■
2.2	■		■		■		■	■
3.3	■				■		■	■
4.7	■						■	■
6.8							■	
10.0							■	

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