BOURNS®

On-Board Charger Protection

APPLICATION BRIEF

Situation

An electric vehicle (EV) on-board charger (OBC) converts single- or three-phase AC grid power into regulated DC for the vehicle's high-voltage battery pack. It sits between the grid and the battery, and every stage of the OBC faces surge, transient, and ESD events that can damage sensitive components.

This application brief maps Bourns® Circuit Protection devices to each OBC stage, aligned with IEC 61000-4-5 and IEEE C62.41.2 surge requirements.

Solution

A modern OBC moves power through seven stages (Figure 1):

1. **AC input with EMI filtering**—suppresses conducted emissions and blocks external disturbances
2. **Rectifier and power factor correction (PFC)**—converts AC to DC at high power factor and efficiency
3. **DC link**—buffers energy and stabilizes voltage
4. **Active clamp**—limits voltage spikes on switching nodes
5. **Isolated DC-DC converter**—steps down and regulates voltage to match battery requirements, with galvanic isolation
6. **DC output**—delivers conditioned DC to the battery pack
7. **Control unit**—manages charge profiles and vehicle communication (CAN, LIN)

Because the OBC connects directly to the grid, it sees:

- High-energy surges from lightning strikes and grid switching
- Fast transient overvoltages from inductive loads and switching devices
- Electrostatic discharge (ESD) on communication and control lines

These events reach microcontrollers (MCUs), battery management ICs (BMICs), gate drivers, and Si, SiC, and GaN power semiconductors. Protecting these components requires layered protection across the full power path, not a single device at a single point.

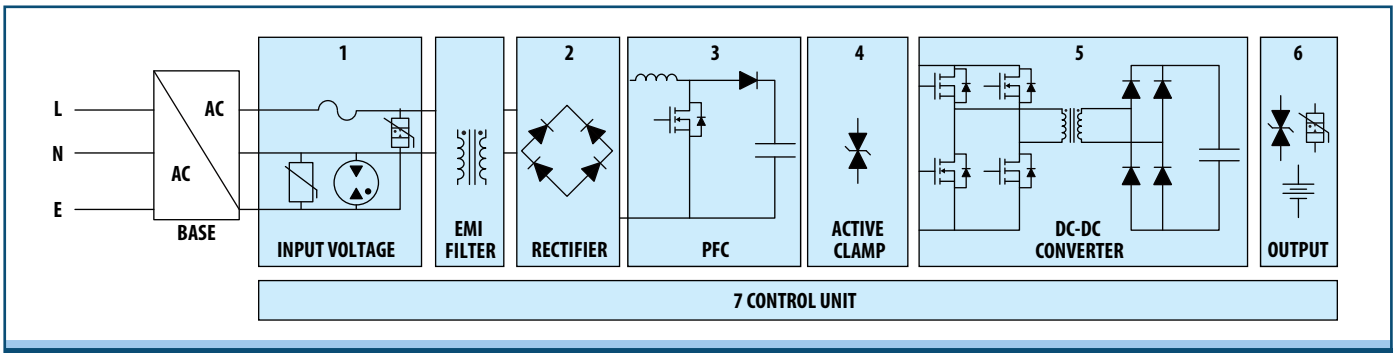

Figure 1 | *On-Board Charger block diagram*

Benefits

Bourns covers every stage of the OBC with one protection portfolio.

The table below maps each numbered block in Figure 1 to the recommended Bourns technology, series, and protection role.

Stage	Technology	Series	Protection Role
1	Metal Oxide Varistor	CVQ, SV, GMOV	Clamps high-energy AC line surges from lightning and grid switching
1	Fuse	PF-K	Provides overcurrent interruption on the AC input
1	GDT	SA-2-xx	Diverts high-energy surges to ground ahead of sensitive front-end circuitry
2	PTVS Diode	PTVS6	Clamps fast transients across the rectifier stage
3	TBU® HSP	TBU-CA	Reacts in nanoseconds to isolate downstream circuits during a fault
3	TISP® device	TISP4xx	Crowbars the PFC stage against sustained overvoltage events
4	PTVS Diode	PTVS6	Clamps voltage spikes on switching nodes in the active clamp circuit
5	TVS Diode	SMBJ TVS	Clamps transients at primary- and secondary-side switching nodes
5	TBU® HSP	TBU-CA	Protects the isolation barrier during fault conditions
5	Diode Array	CDSOD-323	Shunts ESD on low-voltage signal and sense lines
6	TVS Diode	SMBJ TVS	Clamps transients on the DC output to the battery
6	MOV	MOV-14D	Absorbs higher-energy transients at the DC output stage
7	TBU	TBU-CA	Isolates control lines during fault conditions
7	Diode Array	CDSOD-323	Shunts ESD on CAN, LIN, and other communication lines

Surge Protection Standards

The devices on the previous page are selected to meet the two surge standards that define OBC protection design:

IEC 61000-4-5 specifies combination-wave test levels from 0.5 kV/0.25 kA up to 4 kV/2 kA. Bourns® MOV, GDT, and TVS devices at stages 1 and 2 are rated to survive these levels at the AC input.

IEEE C62.41.2-2002 defines load categories for AC power circuits. Category B (6 kV/3 kA, 2 Ω source impedance) represents the higher-energy case used to qualify stage 1 protection devices.

The table below shows IEC 61000-4-5 peak voltage and current.

Open-Circuit Peak Voltage (kV)	Short-Circuit Peak Current (kA)
0.5	0.25
1	0.5
2	1
4	2

The table below shows IEEE C62.41.2-2002 load categories.

Load Category	Voltage (kV)	Current (kA)	Impedance (Ω)
A	6	0.5	12
B	6	3	2

Next Steps

Search the full Bourns circuit protection portfolio and request samples at **bourns.com/products/circuit-protection**, or contact a Bourns Field Applications Engineer for a coordinated protection review of your OBC design.