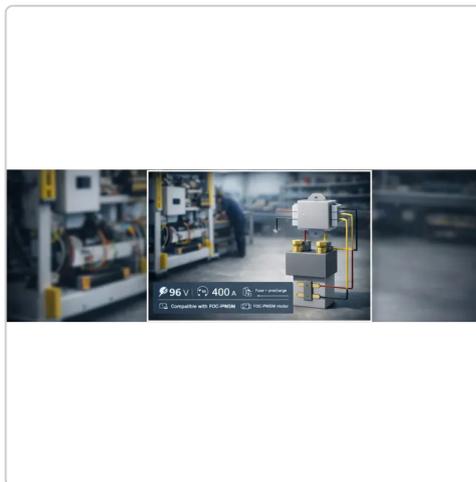
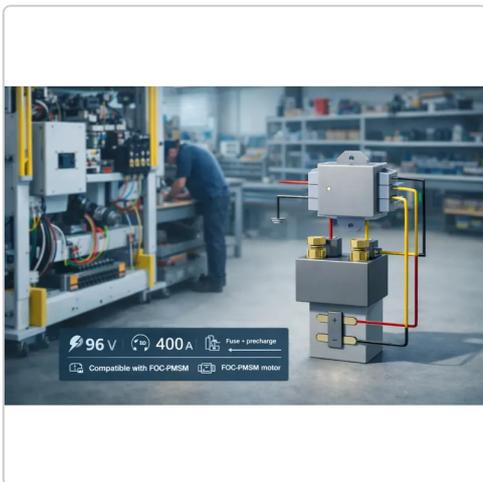


## FAQ: 96V architecture – precharge, protection and reliable wiring for electric traction



**Reference** : LND-003-96V-  
PRECHARGE-PROTECTIONS-  
CABLAGE

**Brand** : EVEA

**Options** :

No variants

**3D Model** : Not available

**EAN-13** :

A **96 V DC** architecture offers a practical voltage/current trade-off for electric traction, provided it is engineered as a **system**: coordinated protection devices, correctly sized **precharge**, vibration-robust wiring, thermal management, and a clear diagnostic strategy. This page consolidates key integration points for a **96 V DC bus** built around a **FOC** controller and a **PMSM** motor (e.g., a mid-drive).

### Why 96 V

For a given power level, increasing voltage reduces current. That lowers copper losses, eases connector thermal stress, and can simplify mechanical integration, but it raises insulation and switching-control requirements on a DC bus.

- **Lower  $I^2R$  losses** in links and improved thermal margins when sizing is consistent.
- Potentially optimized cable cross-sections, subject to thermal and mechanical validation.
- Stricter requirements on creepage/clearance, arcing risk, and switching events: **precharge** becomes a reliability-critical function.

On 96 V systems, available energy and the controller's input capacitance make inrush current at power-up a primary failure mode if the sequence is not controlled.

### Power chain

A robust architecture is built as a simple, diagnosable energy chain: short-circuit protection, main disconnection, DC-bus precharge, then controller and motor supply.

## Recommended layout

- 96 V battery (with BMS for lithium)
- Main fuse (cable protection + hard short-circuit protection)
- Main contactor (energy isolation)
- Precharge branch (resistor + precharge relay/contactor)
- DC bus to FOC controller, then motor phases to PMSM

## Main fuse

The fuse must protect **the harness and the system**, not only the source. Selection must match cable ratings and DC constraints.

- Rating aligned with the allowable **continuous current** of cables and connectors (often the limiting element)
- Capability versus transients (acceleration peaks, control-related surges, battery dynamics)
- DC-capable technology at 96 V with interrupt rating consistent with available fault energy
- Placement close to the battery to minimize unprotected length

## Contactor & safety

The main contactor must be qualified for **DC voltage**, realistic switching cycles, and the load nature (capacitive/inductive depending on the topology). The emergency stop is a **function**: safe opening command, state feedback, and associated diagnostic logic.

## 96 V precharge

Precharge prevents destructive inrush when powering the controller. A traction controller typically includes **DC-bus capacitors**; without precharge, closing the contactor can generate very high inrush currents (limited only by ESR, cable resistance, and the contactor).

## Typical risks

- High, repetitive inrush current that erodes electrical margins
- Contact wear: welding, sticking, accelerated aging of the contactor
- Controller faults: DC-bus instability, power-up errors, internal protection trips

## Sizing method

The goal is to charge the DC bus to a stable level before closing the main contactor (or before bypassing the resistor). Key parameters are: **Cbus**, battery voltage, allowable precharge current, and the target time.

- Identify or measure **Cbus** (datasheet or instrumented tests) and verify repeatability versus temperature
- Set a precharge current compatible with the resistor, precharge relay, and battery capability
- Prefer sequencing based on **DC-bus voltage feedback** rather than a fixed timer when available
- Handle degraded cases: incomplete precharge, undervoltage, contactor fault, hot restart, limited retry logic

## DC wiring

Sizing is not only about copper cross-section: it must cover continuous and peak current, voltage drop, losses, harness heating in bundles, and mechanical robustness in mobile environments.

### Engineering approach

1. Start from **maximum continuous current** and **peak current** (acceleration/transients).
2. Apply environment factors: ambient temperature, confinement, proximity to heat sources, bundle grouping.
3. Validate mechanical constraints: vibration, abrasion, bend radius, fixation points.
4. Verify critical points: lugs, crimps, connectors (local heating and contact resistance).

### Voltage drop

Peak voltage drop must remain compatible with controller undervoltage thresholds and battery dynamics. A simple "losses + temperature rise" check on links and connectors avoids nuisance trips under load.

### EMC & vib.

On 96 V traction systems, intermittent faults often come from routing and EMC issues (encoder, CAN, sensors). Clear power/signal separation and a coherent grounding strategy significantly reduce these risks.

### Traction routing

- Physically separate **power** (DC bus, motor phases) and **signals** (encoder, CAN, sensors)
- Reduce current loops: keep return paths close, minimize lengths, twist pairs where relevant
- Shield sensitive signals (encoder/communication) with consistent terminations at system level
- Define a grounding strategy: avoid "accidental" return paths, control references under high di/dt

### Field robustness

- Provide service loops and clearances to avoid bending loads on connectors
- Use connectors suited to mobile use: locking, IP rating, vibration resistance
- Qualify the harness: pull tests, thermal cycling, crimp inspection and retention checks

## Diagnostics

A robust architecture must **detect, log**, and support fast service return. Diagnostics should be designed alongside protection devices and control logic.

- Event logging: DC-bus under/overvoltage, overcurrent, overtemperature, precharge fault, contactor fault.
- Useful measurements: DC-bus voltage, battery current, controller temperature, cable/terminal temperature at hot spots.
- Limiting strategies: torque/power derating on overtemperature, controlled ramps, thresholds aligned with BMS logic.

## IP67 system

An IP67 component does not guarantee an IP67 system. Leaks typically come from interfaces (cable exits, connectors, condensation, mechanical deformation of seals).

- Map every interface and define the IP level **at system level**.
- Identify common leak paths: glands, sleeves, connectors, gaskets, bulkhead passages.
- Plan pragmatic validation: visual inspection, targeted water test, torque checks, inspection after thermal cycles.

## 96 V example

A mid-drive **IP67** motor with encoder feedback typically integrates with a **96 V FOC** controller compatible with PMSM/IPM, a controlled precharge sequence, and coordinated protection (fuse, contactor, emergency stop, software limits).

- Encoder compatibility (supply, levels, wiring) and EMC robustness.
- DC link sizing for continuous and peak current with vibration-qualified connectors.
- Instrumented precharge validation (Cbus, inrush current, stability) and fault handling.
- Coherent hardware protections and battery/BMS logic.

## 96 V checklist

Integration review checklist before road testing / production ramp: focused on repeatability (pre-series) and field robustness.

Block	Checks
DC fuse	Rating aligned with cables/connectors, DC technology, interrupt rating, close-to-battery placement
Contactor	DC voltage, current, cycles, safe control, state feedback for diagnostics
Precharge	Resistor + relay, voltage-based sequencing if possible, fault handling and limited retries
Wiring	Cross-section, voltage drop, heating, routing, mechanical protection, connector hot spots
EMC	Power/signal separation, encoder/CAN shielding, grounding strategy, loop reduction
Thermal	Controller temperature, harness/terminal hot spots, derating strategy
IP	Critical interfaces, connectors, cable passages, condensation, validation after cycling
Diagnostics	Fault logs, test procedures, safe shutdown criteria, event traceability

## Next steps

The following topics are typically decisive to secure a 96 V architecture:

- **96 V FOC** controller compatibility with PMSM/IPM and encoder (protections, parameterization, voltage/current limits).
- Instrumented precharge validation (Cbus, inrush current, temperature stability).
- EMC best practices for encoder and communication links in mobile environments.

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