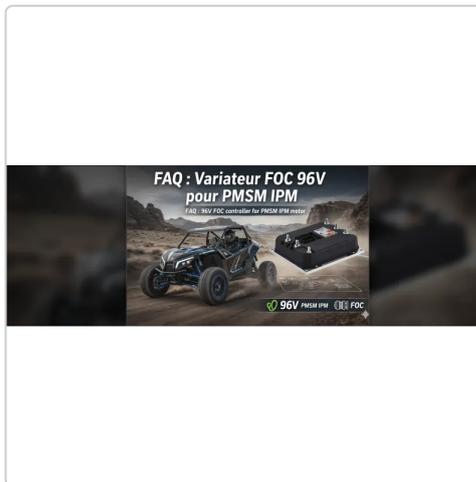# FAQ: 96V FOC inverter for IPM PMSM (ABZ encoder): engineering criteria & CAN BMS integration

Reference : FAQ-002-96V-FOC-IPM

Brand : EVEA

Options :
No variants

3D Model : Not available

EAN-13 :

Selecting a **96V FOC inverter** for an **IPM PMSM** is not about ticking "FOC" on a datasheet. The real differences show up in the controller's ability to exploit IPM control (*Id/Iq*, MTPA, *field weakening*), the stability of the **base speed → field weakening** transition, robustness against the **position sensor** (here an **ABZ incremental encoder**), and, above all, a repeatable **commissioning** process in a real system (BMS, harness, vehicle).

This page provides an **engineering selection method** for traction integration, then illustrates it on the **SiAECOSYS SIA155-64** motor (96V, 12 kW nominal / 29 kW peak).

Key takeaways

- Target motor: **SiAECOSYS SIA155-64**, **96V** IPM PMSM, typical usable torque **~70 Nm** (85 Nm claimed), max speed **7–8 krpm**.
- At 96V, **field weakening** typically starts around **~4,000 rpm**: this is the most sensitive tuning zone.
- Sensor: **ABZ incremental encoder**, **single-ended**, with **Z index** used in practice.
- Current: **125 A continuous**; typical dynamic setting: **250 A / 10 s** with **~2 min** back-to-safe regime.
- Recommended architecture: **CAN BMS ↔ inverter** (charge/discharge limits), VCU rarely required.
- Typical controllers: **ZAPI BLE2 96V**; **Curtis 1236SE 96V** and, when needed, **Curtis F2/F4**.

Need to validate SIA155-64 ↔ inverter compatibility (BLE2 / 1236SE / F2-F4) and the CAN BMS strategy? EVEA can qualify the motor/controller pair and frame the critical parameters (commissioning, field weakening, current limits, regen).

IPM: inverter requirements

Id/Iq, MTPA, and field weakening

With an **IPM PMSM** (interior magnets), the inverter controls two current components: **Iq** (torque-producing current) and **Id** (flux current). **Iq** produces traction torque, while **Id** is used to maximize torque per amp (**MTPA**) and to enable **field weakening** above base speed (*negative Id*).

Practically, an "IPM-ready" controller must allow a clean **base speed → field weakening** transition, without torque plateaus or discontinuities, and with explicit limits so that field weakening is not used "at any cost" (efficiency drop, heating, magnet stress).

SIA155-64 case: a versatile motor (urban / enduro / track), typical usable torque **~70 Nm**, max speed **7–8 krpm**. At **96V**, field weakening around **~4,000 rpm** makes the transition a key tuning area.

Traction FOC: commissioning

Why setup quality dominates outcomes

On industrial platforms (ZAPI, Curtis), the difference between "it runs" and "it runs well" is mostly in **parameterization**. A poor setup typically shows up at the **base speed ↔ field weakening** transition, more than at very low speed.

- **Plateau then sudden "release"** during acceleration: field-weakening transition not correctly tuned.
- **Step-like regen**: interaction between FW/regen tuning and battery/BMS limits.
- **Underwhelming performance**: sensor phasing, motor identification, or current limits too conservative.

The engineering goal is to **learn** and **reproduce** a stable calibration, then refine it in the real context (inertia, drivetrain, aerodynamic load, mass distribution).

Sensor: ABZ incremental

Single-ended + Z index: compatibility checks

The **SIA155-64** uses a **single-ended ABZ incremental encoder**. Channels **A/B** (quadrature) provide incremental position and direction; the **Z index** (one pulse per revolution) provides a reference and is commonly used in traction setups.

ABZ is valued in traction environments for its **EMC robustness**: edge-based digital decoding tolerates noisy power environments better than analog Sin/Cos signals. The trade-off is that ABZ single-ended support may depend on **specific inverter references**.

- Confirm native support for **single-ended ABZ** and **Z index** handling.
- Validate **logic levels** and encoder supply per encoder spec (typically TTL/CMOS), plus harness requirements (shielding, routing).
- Prefer platforms with sensor diagnostics: signal coherency, loss detection, offsets/phasing.

Commissioning method

Repeatability and per-motor recalibration

In practice, manufacturing tolerances (motor + encoder mounting) justify a simple rule: **new motor = recalibration**. The goal is not to "redo all FOC", but to secure sensor learning and intrinsic motor parameters.

1. Commissioning with **free shaft** in a safe configuration.
2. Keep **UVW** wiring consistent; reverse direction **logically** in the inverter (not by swapping phases physically).
3. **ABZ encoder learning/characterization** at multiple speeds: coherency, offsets, measurement range, Z reference.
4. **Auto-tune** when available: R_s, L_d, L_q, flux, etc.
5. Torque optimization: adjust electrical angle/advance to maximize torque at a given current (ideally with **locked shaft** for clean measurement).
6. Loop tuning with special attention on **field weakening** (the most sensitive transition).
7. Bench validation then **vehicle refinement** (inertia, drivetrain lash, mass, aero): "perfect at no-load" is not a field truth.

Command & regen

Rideability and battery limits

Industrial inverters originate from material-handling applications: rideability is achieved through **mapping** and ramps. Choices differ between speed command (industrial, marine) and torque command (vehicle).

- **Speed control**: typically **linear** (command = speed), common in marine / pumps.
- **Motorcycle**: "soft then aggressive" throttle map: first half progressive (fine control), second half steeper (strong response).
- **Throttle-off**: EVEA's typical approach is **freewheeling** (not one-pedal).
- **Regen**: triggered by the **brake** (switch), with a dedicated ramp; optional brake-pressure sensor depending on the project.
- Regen is limited by battery acceptance: do not command more charge current than the pack can absorb.

CAN BMS + inverter

VCU usually optional

A robust 96V traction architecture is often **CAN BMS ↔ inverter**. The BMS provides **max discharge current** and **max charge current**, and the inverter limits traction torque and regen accordingly.

Two "feel" effects are expected and should be designed-in:

- **Full battery**: regen reduced/disabled → it may feel like "the vehicle no longer brakes electrically".
- **Low battery**: traction limited → it may feel like "the vehicle no longer pulls".

These are not defects: they are direct consequences of battery protection using dynamic limits.

Current & field weakening

Continuous vs peak, duty cycle

Current sizing must match the use case: **continuous** (thermal) vs **peak** (dynamic), and the field-weakening strategy. For the SIA155-64, typical operating orders of magnitude are:

Key parameter	Indicative value	Integration note
Continuous current (RMS)	**125 A**	Baseline for sustained operation; thermal stability reference.
Manufacturer peak	**300 A / 10 s**	Motor limit; reserve for controlled transients.
Typical EVEA dynamic setting	**250 A / 10 s**	With **~2 minutes** back-to-safe regime.
Field-weakening onset (96V, typ.)	**~4,000 rpm**	Critical tuning zone; transition must remain progressive.
Typical exploitable max speed	**7–8 krpm**	Depends on project, cooling, and FW limits.

In field weakening, the goal is not to "hold speed at all costs". If the application forces negative Id to the point where efficiency and temperature collapse, it is usually a sign that **motor/application sizing** should be revisited (or higher cooling capability).

Compatible inverters

ZAPI and Curtis reference set

For a 96V traction integration with **SIA155-64** and a **single-ended ABZ encoder**, the following references are solid baselines:

- **ZAPI BLE2 96V**: particularly suitable platform (rating depends on version).
- **Curtis 1236SE 96V**: a coherent alternative for IPM traction.
- **Curtis F2 / F4**: possible options depending on generation and project constraints.

Important: single-ended ABZ is supported **natively** through **specific references** (not an add-on option). This impacts **selection** and sometimes **availability**.

Decision matrix

BLE2 vs 1236SE vs F2/F4

Integration criterion	ZAPI BLE2 96V	Curtis 1236SE 96V	Curtis F2 / F4
Single-ended ABZ + Z index support	Yes (compatible reference)	Yes (compatible reference)	Yes (reference-dependent)
Base speed → field weakening tuning stability	Commissioning-dependent, robust baseline	Commissioning-dependent, stable when phased	Commissioning-dependent, newer generation
Commissioning tools / diagnostics	Workshop-ready, useful auto-tune options	Vendor tools, useful diagnostics	Recent tools depending on version
CAN BMS integration (charge/discharge limits)	Common architecture	Common architecture	Common architecture
Regen strategy (brake input, ramps, levels)	Configurable, matches EVEA approach	Configurable	Configurable
Supply-chain (ABZ less common)	Specific reference → plan availability	Specific reference → plan availability	Specific reference → plan availability
Best-fit use cases	IPM traction + kit approach	IPM traction + kit approach	Evolving projects / newer generation

The matrix does not replace commissioning: it frames platform selection. Final performance depends on calibration and vehicle integration.

Field diagnostics

5 symptoms → likely causes

- **Plateau then "release"** on throttle: base speed ↔ FW transition not tuned (FW, sensor phasing, motor parameters).
- **Step-like regen**: FW/regen tuning + CAN BMS charge limit; brake map to review.
- **Weak pull / "soft" behavior**: incomplete auto-tune, encoder offset/phasing, current limits too conservative, or BMS limiting.
- **No regen on full battery**: BMS max charge limit (normal behavior).
- **Limited traction on low battery**: BMS max discharge limit (normal behavior).

Engineering checklist

- Motor: 96V IPM PMSM, target torque/speed envelope, base speed ~4,000 rpm, FW up to 7–8 krpm depending on the project.
- Inverter: **single-ended ABZ** + Z index support, commissioning tools, sensor diagnostics, IPM parameter handling.
- Currents: **125 A continuous**; typical dynamic **250 A / 10 s** with a back-to-safe strategy.
- Commissioning: multi-speed encoder learning, auto-tune Rs/Ld/Lq/flux, torque optimization, FW tuning.
- CAN BMS: charge/discharge limits applied to traction/regen torque; anticipate "feel" at SOC extremes.
- Command: progressive motorcycle throttle map, coherent ramps and interlocks.
- Regen: brake-triggered (switch / pressure sensor), throttle-off freewheeling when relevant, bounded by battery acceptance.
- Validation: bench + vehicle tests (inertia, drivetrain lash, aero), iterate on base speed ↔ FW transition.

Technical FAQ

Why does ABZ narrow inverter choices?
Because single-ended ABZ is less standard than other sensors on some product lines; compatibility often depends on specific references.

What is the Z index used for in traction?
It provides a once-per-revolution reference that helps with indexing and certain learning/phasing sequences.

Why does regen disappear on a full battery?
The BMS limits allowable charge current. When the pack is full, acceptance drops and regen is reduced or disabled.

Why recalibrate per motor?
Motor and encoder mounting tolerances shift phasing and identified parameters. Recalibration ensures stability and performance.

Why is the base speed → field weakening transition critical?
This is where control switches to negative Id strategy. If tuning is off, it is felt immediately (plateau, steps, non-linearity).