CargoScooter Drive Train
Founded in 2000, Oxygen is the world leader in the development and manufacturing of electric scooters for the delivery business.

- **2000**: Oxygen launched first generation scooter for the consumer market (Lead-Acid Batteries).
- **2002**: First to introduce the fleet-model: the “PostScooter” with Nickel-Zinc technology.
- **2004**: Oxygen launches the CargoScooter with Saphion Lithium-Ion battery system.
- **2006**: Oxygen implements technology with Electric brake, a regenerative brake system and the advanced speed control.
- **2008**: Oxygen is the official provider of the largest zero emission postal delivery fleet in the world.
- **TODAY**: Oxygen continues to innovate and lead in the electric scooter industry.
Oxygen has ten years experience in LEV’s.

European professional companies rely on the CargoScooters.

Swiss Post n° scooter:

- 2006: 0
- 2007: 0
- 2008: 100
- 2009: 50
- 2010: 1000
Electric scooter as a job partner

User needs

- Reliability
- Safety
- High load capability
- Long life
- Stop and go “proof”
- Easy to park
- Maneuverable
- “Zero” parking constrains
- “Zero” mechanical vibration
- “Zero” maintenance
- “Zero” noise

PRODUCT DNA

- Customizable
- Flexible and modular
QFD CargoScooter Drive Train

• Mechanical configuration:
  • direct drive motor
  • motor control built in the motor arms
  • mechanical braking system integrate in the arm

• Electric configuration:
  • multi-voltage control unit

• Electrochemical configuration:
  • modular battery pack system

- Mechanical sizing and component choice:
  • We used aluminum component
  • 12” wheel
  • We maximize the arm and control unit case dimensions

- Electric sizing and component choice:
  • brushless motor

- Electronic sizing and component choice:
  • IXYS Trench Gate MOSFET Modules with lower Rds(on) GWM100-01X1-SMD

- Electrochemical components
  • We choose LiFeMgPO4 batteries for long life and safety performance

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<th>Tech. Specification</th>
<th>Customer Importance</th>
<th>Low Moving Part</th>
<th>No Fluids</th>
<th>High Torque</th>
<th>Linear Power</th>
<th>Power Erosion</th>
<th>Maintenance Part</th>
<th>Easy to Reach</th>
<th>Adjustable Performance</th>
<th>Low COG</th>
<th>Reverse Mode</th>
<th>Settable Drive Mode</th>
<th>Multi Voltage</th>
<th>LiFeMgPO4 Battery</th>
<th>Mechanical Transmission</th>
<th>Gear</th>
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Oxygen Macro-component Design for Assembly and to optimize the supply chain

**TRACTION BATTERIES**
- LiFeMgPO4 Modular battery pack:
  - 24 V 2.6 kWh
  - 36 V 2.6 kWh
  - 36 V 3.9 kWh
  - 48 V 5.2 kWh

**MULTI VOLTAGE AND MULTY FUNCTIONAL MOTOR CONTROL UNIT**
- 2-stages Drive: Booster+ 3 phase inverter with advance functionality:
  - Patent EHC system
  - Reverse mode
  - Safe drive mode

**SENSORED ELECTRIC MOTOR**
- 3 phase AC Brushless motor
  - 900 rpm
  - 150 Nm peak torque
  - Two sin/cos Hall sensors

**TROLLTE**
- Patent speed control algorithm
- 1 G working cycles

**HUMAN INTERFACE**
- Full graphics
- Customizable
- Adjustable

**CONNECTIVITY**
- Dedicate SW for:
  - Boot loader
  - Diagnostic
  - Tuning

**AUXILIARY SYSTEM**
- Light
- Horn
- Etc.

**TRAY**
- main electromechanical components
- Auxiliary 12V battery (supply the system if faulty traction batteries)
- DC-DC 100W insulated DC/DC Converter
- Main power contactor
- Advanced BMS

**ACTIVE SHOCK ABSORBER SYSTEM**
- 4 position adjustable

**BRAKING SYSTEM**
- Patented regenerative braking system integrate with mechanical disc brake system

**CHARGER**
- Universal Hi-frequency 1 KW
- On board battery charger
Main Drive Train Components Placement

The most heavy drive train components are placed close to the ground.
The battery charger and the tray are placed in a water protected compartment.
We minimize the power cabling length and we maximize the scooter handling and carrying capability.

Low CoG
All heavy weights below this line
(about 70% of the total weight)
Oxygen motor system

Oxygen designed a very compact motor system in order to:

• Minimize cabling length
• Optimize the thermal management especially in power peak
• Optimize the production and quality control process
• Saving space on the scooter in order to maximize the battery compartment
• Have a very simple wheel maintenance
• Have the integrate braking system

Full aluminum finned case:
- Light and corrosion resistant
- Top notch thermal performances

Structural aluminum arm:
- Wheel support
- Drive support
MULTIPLE BOARDS APPROACH:
- Flexibility
- Power/Logic isolation
- 3D construction

Texas Inst. TMS320F2808 high performance DSP
Multiple motor control modulation algorithms
Scooter specific I/O lines
CPLD controlled safety redundancy system

Pre-charge and brake resistors included in drive’s case
IXYS GWM100-01X1-SMD Trench gate MOSFET modules

DOUBLE STAGE ARCHITECTURE

Double stage motor control architecture advantages:
- Ultra wide input voltage range
- Stable output voltage (not depending on battery impedance)
- Ultra wide speed range regenerative braking
- High efficiency, motor speed range extension

Double stage motor control architecture function principles:
- Booster and deflux strategy combined to achieve higher motor speed and high motor torque at very low speed
- Booster give optimal bus voltage for each speed range
- Motor speed is only limited by MOSFET max Vdss

![Diagram showing double stage motor control architecture and voltage boost and deflux zones.](image)
**Data logger sample** (CargoScooter hi-speed prototype)

### TEST DATA

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<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
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<td>Average speed (rest time ex.)</td>
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Custom CargoScooter

- Several Front and Rear load Configurations
- Range extension
- Performance mapping
Custom CargoScooter

- GPS
- Fleet management system
- Fast charge unit
- Custom color and graphics
- Custom courtesy sound