Highly Integrated Electrical Drive System
Robert Kremsl / Magna Powertrain
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Topics

• Magna Powertrain Company Overview
  – Responsibilities and Challenge at Engineering Center Traiskirchen
• Possibilities and Advantages of Electrical Drive Systems
• Challenges for Development
• What does Integration mean
• Magna Electrical Drive Systems in the Past and Future
Magna Powertrain
Company Overview
Magna Powertrain Global Presence

As of September 2015 (excluding LITENS & Electronics)

Some facilities may be double-counted in the breakdowns above (i.e. an office may be both a production office, as well as a sales office). Please reference the forthcoming maps for further clarification.

* Employees
- Production sites
- Engineering; sales/admin sites
- Global sales by region (%)
MPT’s Portfolio

**DRIVELINE SYSTEMS**
- Actuators including System Control
- AWD/4x4 Disconnect Systems
- Coupling Systems
- Front and Rear Axle Drives
- Power Take-Off Units
- Rear Drive Modules
- Transfer Cases

**METAL-FORMING SOLUTIONS**
- Accessory Drives
- Clutch Hubs & housings
- Flexplates
- Geared Products
- Oil Pan Modules
- Planetary Carriers
- Transmission Clutch Modules

**ELECTRONICS**
- Near Field Applications/Multicamera Systems
- Far Field Applications/Data Processing
- Sensor Fusion Capabilities
- Control Units for different Applications
- Driver Assistance Systems
- Electronics Manufacturing Services

**FLUID PRESSURE & CONTROLS**
- Engine Oil, Vacuum and Water Pumps
- Tandem Pumps
- Transmission Oil Pumps
- e-Pumps (Coolant, Oil, Purge, Vacuum)
- Integrated Engine Front Cover Modules
- Thermal Management Modules
- Electronic Cooling Fans
- High Pressure Hydraulic Pumps

**ENGINEERING SERVICES**
- Internal & external
- Vehicle & Powertrain Engineering
- Testing Services
  - Engine
  - Drivetrain
  - Fatigue
  - Chassis Dyno
  - On- & Off Road
- Simulation & Technical Application Software
- Prototyping and Production

**NEW and ADVANCED PRODUCTS**
- e-Mobility Systems
  - Electric axles
  - Transmission for EV-Hybrid including E-Motor and Inverter
  - Advanced charging systems
  - Electric auxiliaries
- Powertrain efficiency improvements
  - Advanced charging systems
  - Variable Valve Timing / Compression systems
  - Mechatronics actuators
Magna Powertrain - Global Organization Chart

PRESIDENT
Jake Hirsch

DRIVELINE SYSTEMS
Greg Deveson, Sr. VP

FLUID PRESSURE & CONTROLS
Johann Ecker, Sr. VP

METAL-FORMING SOLUTIONS
Tom Rucker, VP

ELECTRONICS
Olaf Bongwald, VP

ADVANCED ENGINEERING
Dr. Claus Bischoff, Sr. VP

SALES & MARKETING
Peter Seidl, Sr. VP

FINANCE
Tom More, VP

GLOBAL MANUFACTURING STRATEGY/CAPEX/QUALITY
Manfred Kranner, Sr. VP

HUMAN RESOURCES
Brent Kearns, VP – NAS/A
Richard Piller, VP – EU/AP

PURCHASING
Steve Rush, VP

LEGAL
David Mims, Secretary & General Counsel

Albersdorf – Bad Homburg* – Concord – Pune (JV) – St. Valentin* – Shanghai – Tokyo – Traiskirchen – Troy

*these locations are home to both manufacturing and engineering
Advanced Engineering

We are the innovation leader in powertrain due to latest development methods and testing facilities.
We develop and provide products and solutions for the vehicles of the future.

Key Capabilities

• System Engineering & Architecture
• **Electrification of vehicles**
• Vehicle Engineering (Cars, Trucks, Off-Road, etc.)
• Engine Engineering
• Drivetrain Engineering
• Electrics / Electronics / Mechatronics
• Simulation and Testing Services
• Technical Application Software & Support
• Prototyping and Production

Engineering Locations

• Albersdorf, Austria
• **St. Valentin, Austria**
• Traiskirchen, Austria
• Resende, Brazil
• Concord, Canada
• Shanghai, China
• Bad Homburg, Germany
• Delhi, India
• Pune, India
• Tokyo, Japan
• Troy, USA
Location: Traiskirchen

- Name & Address: Engineering Traiskirchen
  MAGNA Powertrain GmbH & Co KG
  Wienersdorfer Straße 20 - 24
  2514 Traiskirchen
  AUSTRIA

- Employees: 75
- Main Topic: Development of E-Drive Components & Systems
Key Competences of Engineering Center Traiskirchen

- System Concepts
- System Architecture
- System Simulations
- Safety Concept
- Requirements Management

- System Integration
- System Test
Key Competences of Engineering Center Traiskirchen

System
Development & Test

Software
Development & Test

- SW Architecture
- Base SW Development
- Functional SW Development

- SW Module Test
- SW Integration
- SW Test (HiL)
Key Competences of Engineering Center Traiskirchen

System
Development & Test

Software
Development & Test

E-Motor
Design & Test

- Electromagnetic Design
- Fluid Dynamic Simulation
- Thermal Simulation
- Design Verification
Key Competences of Engineering Center Traiskirchen

System
Development & Test

Software
Development & Test

E-Motor
Design & Test

Electronic Hardware
Development & Test

• HW Architecture
• Simulation
• HW Design (Schematics + Layout)

• Functional Verification
Key Competences of Engineering Center Traiskirchen

- Mechanical Design of E-Motor & Inverter
- Mechanical Integration

**System**
Development & Test

**Software**
Development & Test

**E-Motor**
Design & Test

**Electronic Hardware**
Development & Test
Key Competences of Engineering Center Traiskirchen

- System Development & Test
- Software Development & Test
- E-Motor Design & Test
- Electronic Hardware Development & Test

- Mechanical Design
- Verification

- Durability Test
- Environmental Test
- EMC Test
- Test bench management
Key Competences of Engineering Center Traiskirchen

- System Development & Test
- Software Development & Test
- E-Motor Design & Test
- Electronic Hardware Development & Test

- Mechanical Design
- Verification
- Project Management

- Quote Preparation
- Engineering Project Management
- Quality Assurance
- Engineering Process
- SPICE / ISO Compliance
Key Competences of Engineering Center Traiskirchen

**System**
Development & Test

**Software**
Development & Test

**E-Motor**
Design & Test

**Electronic Hardware**
Development & Test

**Engineering Center Steyr**
St. Valentin

**Mechanical**
Design

**Verification**

**Project Management**

**Power Mechanics**
Design & Test
Key Competences of Engineering Center Traiskirchen

- **System Development & Test**
- **Software Development & Test**
- **E-Motor Design & Test**
- **Electronic Hardware Development & Test**
- **Mechanical Design**
- **Verification**
- **Project Management**
- **Power Mechanics Design & Test**

**e-Drive System**
Highly Integrated Electrical Drive System
Overview
Usual configurations:
• P1 + P4 (Volvo V60, PSA 3008)
• P2 + P4
• Powersplit + P4 (Toyota Lexus RX)
BEV (Battery Electric Vehicle)

Typical example

Voltage nom. 360Vdc
Battery Capacity 25kWh
E-Motor 120kW

Typical example

Voltage nom. 600Vdc
Battery Capacity 100kWh
E-Motor 2x 120kW
PHEV (Plug-In Hybrid Electric Vehicle) with AWD

Single electric drive supports ICE on the conventional power train to both axles.

Additional rear axle drives appear typically in P2/P4 architectures.
Motivation for electric axle drives in PHEV

- Using Electric Energy
  (Plug In Battery Charging)
- Recuperation
- Boosting (Acceleration)
- AWD (Comfort & Safety)
- Weight balance

Fuel Economy
(CO₂ Reduction)

Performance
and Safety
Incremental costs for car manufacturer

- Electrical AWD
- Mechanic AWD

Axle Performance

- € 3,000
- € 2,000
- € 1,000

Today

Year 2025

1000Nm 2000Nm 3000Nm
Challenges for Development

1. **Price**
   - Very tight price targets

2. **Package / Weight**
   - Different available space for different customers
   - Usually very high power density desired

3. **Performance**
   - High peak torque and power
   - High continuous torque and power
   - High efficiency
   - High torque accuracy
   - Low response time

**Simplification:**
- Established parts
- Platform elements

**Integration:**
- Share common parts
- Compact weight
- Optimized package
- Reduce number of connectors
- Reduce wiring harness
- Optimize EMC characteristics
What does integration mean?

Integrated System

- E-Motor
- Actuator
- Inverter
- Reduction gear
- ECU
- Wiring harness
- Differential
Complexity of integrated systems

Big challenge for automotive industry

System contains
- Electronics
- Mechanics
- Hydraulics
- Software

Engineering & Manufacturing
- Resources
- Communications
- Expenditures
Advantages of integration?

- Number of parts can be reduced
- Number of interfaces can be reduced
- Weight optimized by common parts
- Optimize package volume
- Simplify vehicle integration
- Enhance quality
- Cover safety topics
Magna’s E-Drive Systems

Component design + production
- Inverter
- E-Motor
- Gearbox + Clutch

System design + production
- E-DRIVE SYSTEM
  - Inverter
  - E-Motor
  - Gearbox + Clutch
  - SOFTWARE

System integration

OEM

Vehicle integration
Vehicle integration is a multi-level challenge

- Integration to be done in
  - Mechanics
  - Communications
  - High voltage
  - Cooling circuits
Highly Integrated Electrical Drive System

Examples
eRAD - Electric Rear Axle Drive

- Compact coaxial design with planetary gearbox
- 50kW/200Nm Permanent Magnet Synchronous Motor
- Bi-stable dog clutch for disconnecting the axle
- Gear ratio 1:9.17
- Speed range 0 - 1.400rpm at wheels
- Torque range: 0 - 1.826 Nm at wheels
- Total weight: 47kg

Separated Inverter
E-Motor integrated into Gearbox and Clutch

- Planetary gear set
- Disconnect Clutch
- Differential
- E-Motor (PMSM)
- Rotor shaft
Next generation of electric axle drives

- E-Motor (ASM)
- Offset Gear Drive
- Parking Lock Actuator
- Rotor shaft
- Differential
- Integrated power electronics
- Offset Version
Next generation of electric axle drives

Differential

Planetary gear set

E-Motor (ASM)

Rotor shaft

Coaxial Version

Integrated power electronics
Outlook

• Electric axles will be the main powertrain in future
  ✓ Simple
  ✓ Effective
  ✓ Smart

• Costs are key for pushing electric drives towards larger volumes
  – Beside the battery the entire drivetrain has to be cost effective

• High level integration is a general way for evolving technology
  – Each automotive module does also experience proceeding integration
DRIVING EXCELLENCE.
INSPIRING INNOVATION.