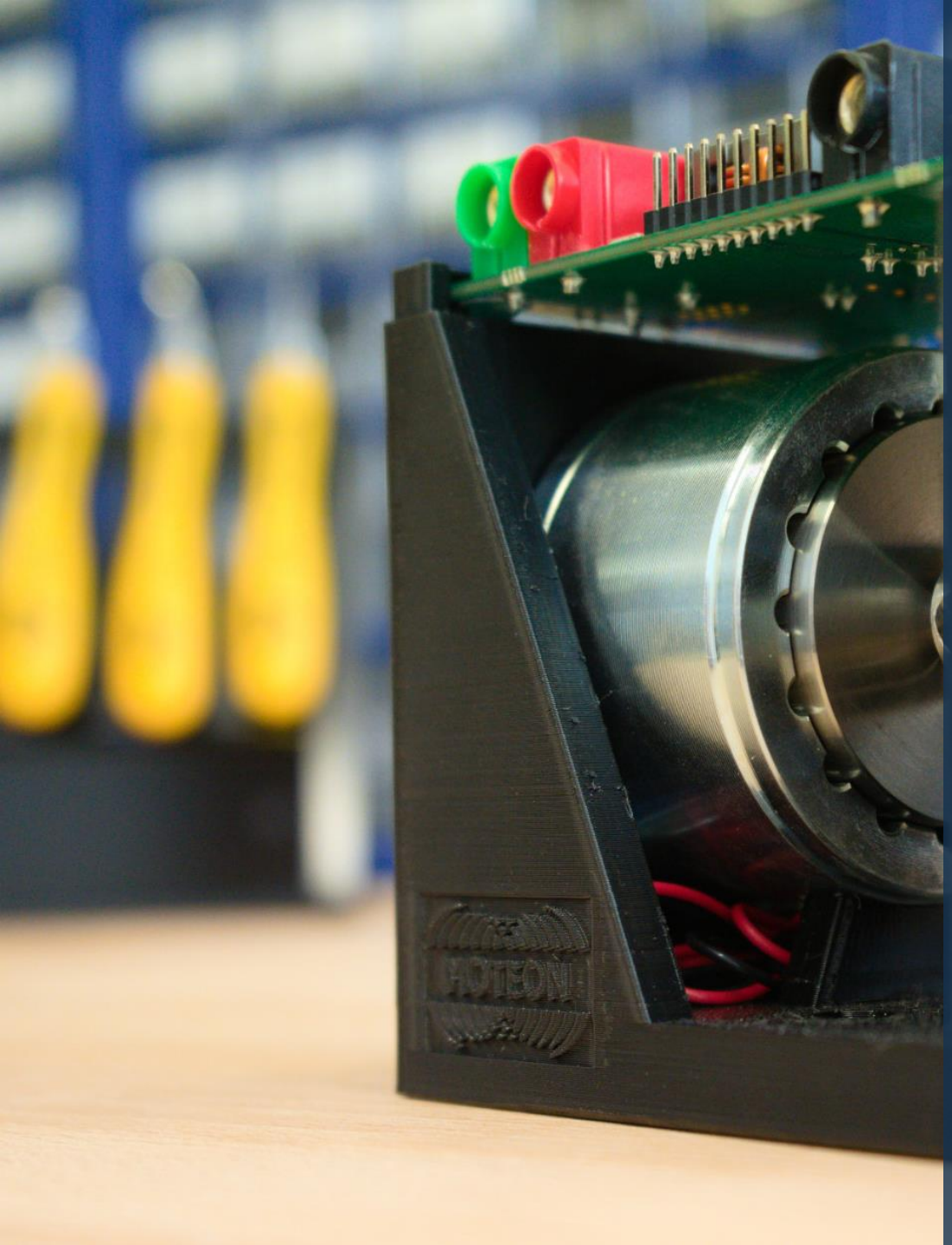


MOTEON GmbH – Introduction

MOTEON - the leading expert for motor control system solutions

our company

Founded: 2020

36 employees

Location: Ilmenau, Germany

ISO 9001:2015

our expertise

- **Motor control system solutions** with know-how in Embedded Software, Mechatronics & system concept & modeling
- **Long-standing expertise in automotive & industrial markets**
- **Long-term expertise for ARM®-based microcontrollers**
- **System Level Test & Automated Test Equipment**

our business

SaaP

- MOTIX™ SW

Service

- Consulting/Prototyping
- SW Development
- HW Development

Test/Dev Tools

- HW Test Equipment
- HW/SW Development Equipment
- System Simulation Models

End-to-end engineering service offering for motor control applications from software, engineering to testing and tools

Software	Engineering Services	Engineering Tools

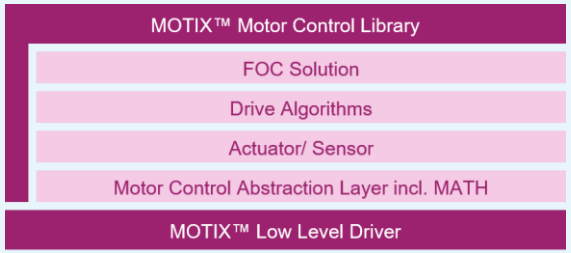
Consulting & Training

- Feasibility studies
- On-site / remote motor control training

Software Libraries

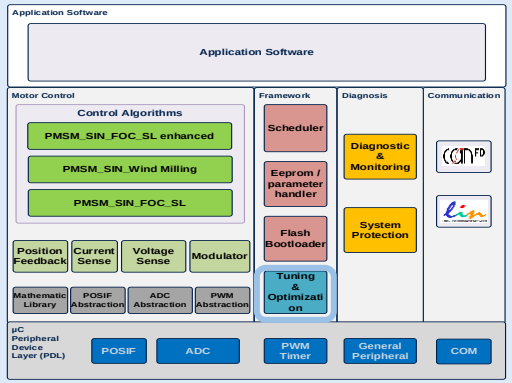
Software as a Product (SaaP)

- MOTIX™ Motor Control Library
- MOTIX™ Low-Level Driver (LLD)
- MOTIX™ Peripheral Driver Library (PDL)
- Motor-Software-Launch Service



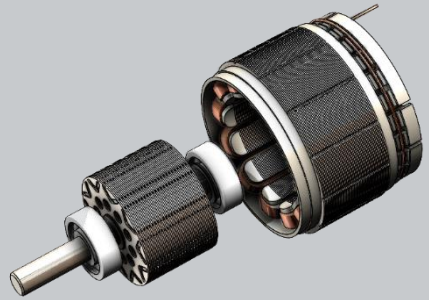
Software Development

- Customized application software solution



Mechatronic Development

- Design of embedded motors
- Electronics design for system integration
- CFD based thermal simulation

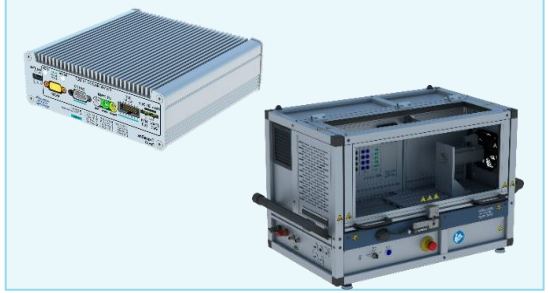


Testing

- Motor identification
- Testing as a Service
- System verification

Tools

- TraceBox
- Mobile Motor Test Bench
- Motor Analysis Tool



Prototyping – Proof of Concept (PoC)

- PoC for software, electronics, motor and system

MOTEON accelerate your development process and minimize risks with our software library, advanced simulation and debugging solutions

- Identify and rectify design flaws to **minimize project risks and mitigate potential redesigns**
- Employ professional software parameterization for customer electronics and motors, significantly **reducing the time typically spent on trial and error**
- Enjoy a **70% cost-saving advantage** compared to in-house development when using MOTIX™ software
- Achieve a **16x increase in speed** for debugging complex algorithms with the aid of professional data tracing
- Drastically reduce test automation verification time **from 3 weeks to approximately 34 minutes**, saving valuable time and resources

MOTIX™ Ecosystem Customer Journey
SW demo, TraceBox leasing and simulation tool for easy evaluation

1 Getting Started
Run your own motor

2 Develop own Solution

3 Verification and Validation

MOTIX™ Evaluation License

MOTIX™ Low-Level Driver Library for TLE987x

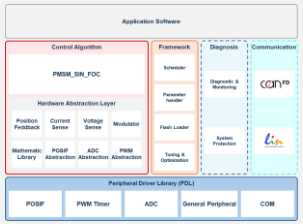
MOTIX™ FOC demo with TLE987x

MOTIX™ FOC demo with TLE989x

Access demo software

MOTIX™ Development License

- Special development pricing
- Access to all software artefacts
- **1x TraceBox**



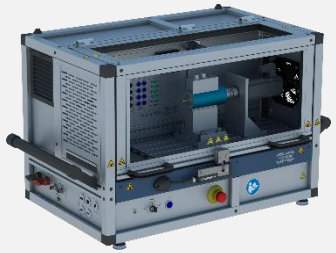
MOTIX™ Solution Designer

- Configure **MOTIX™ Motor Control Library** with static & dynamic parametrization
- **MOTIX™ Oscilloscope** (inside Solution Designer) for real-time debugging

Access to tool

Mobile Motor Test Bench & TraceBox

Automated your test environment and reduce test times form weeks → minutes



Time-stamped signal for professional debugging and fault analysis via SPI

Motor Analysis Tool / Motor-Software-Launch Service

- **Torque-Speed-Characteristic** with efficiency lines and target points for different operations
- **Motor-SW-Launch Service**: verify design of electronics, identify motor parameters, simulation target-operation-points and parametrize software for testing

Access to tool

Testing as a Service (TaaS)

Offer will be based on test specification

Will be conducted on MOTEON's MTB or mMTB based on required test

Consulting –
Simulation and feasibility study allows project assessment of customer

Consulting

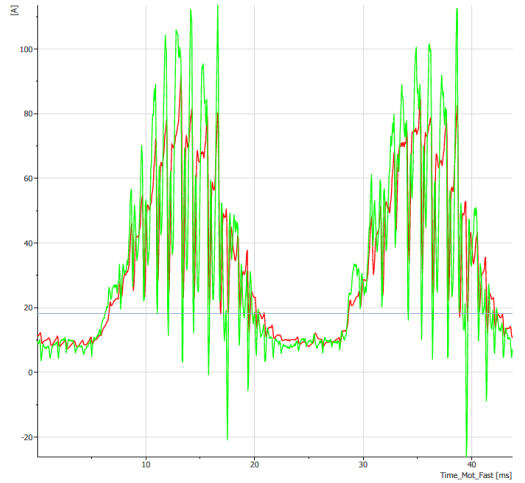
End-to-end motor control know how to simulate performance and load points as well as root-cause analysis of existing systems

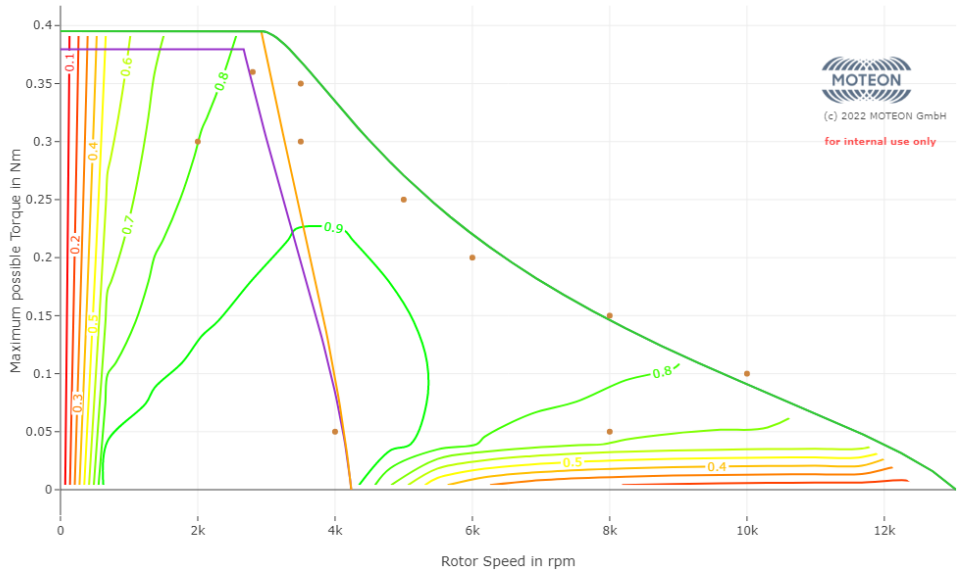
Key features

- Performance assessment: CPU Load, RAM and run-time
- Motor Analysis Tool: torque-speed, target operation points, efficiency analysis
- System simulation (MATLAB plant model simulation)
- Root-cause analysis (motor, inverter, electronic and control method)
- Feasibility analysis of customer specification (compliance matrix)

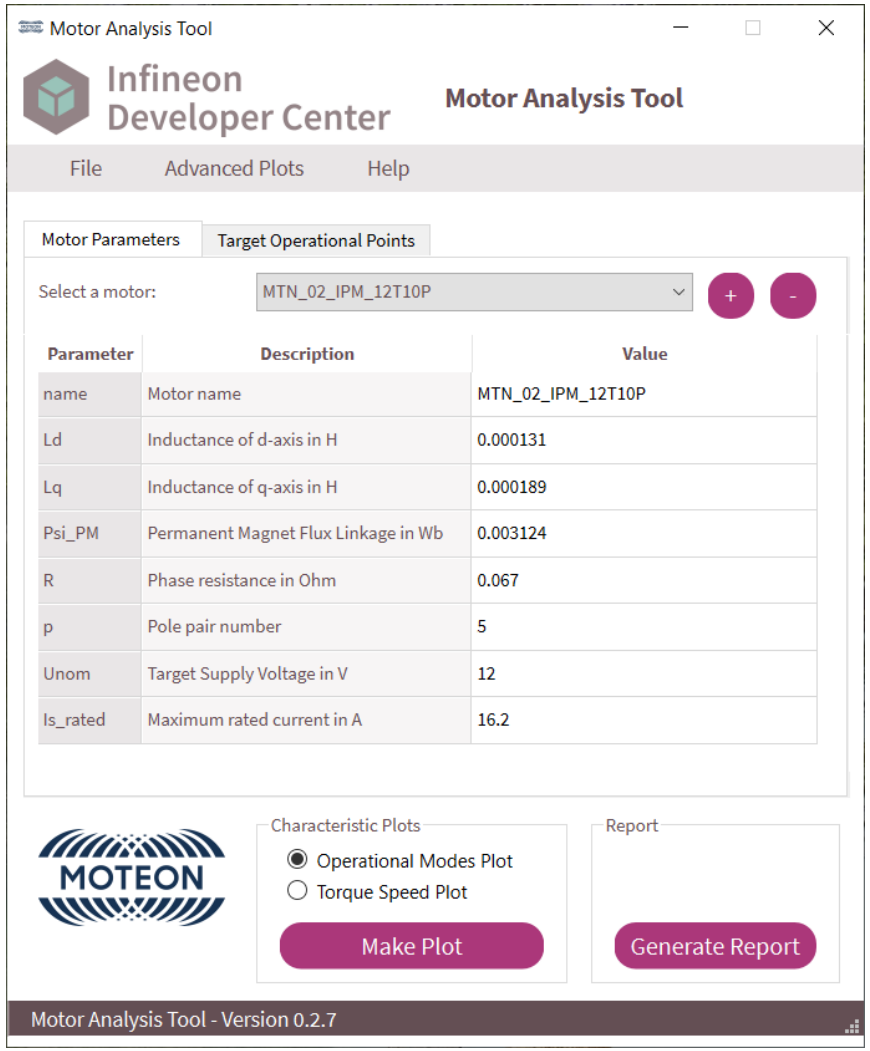
Your benefits

- **Reduction of project risks and threats of redesigns**
- **Take timely decision for concept idea and project approvals**
- **Holistic assessment of entire mechatronic system**
- **Solutions with minimum impact on design**

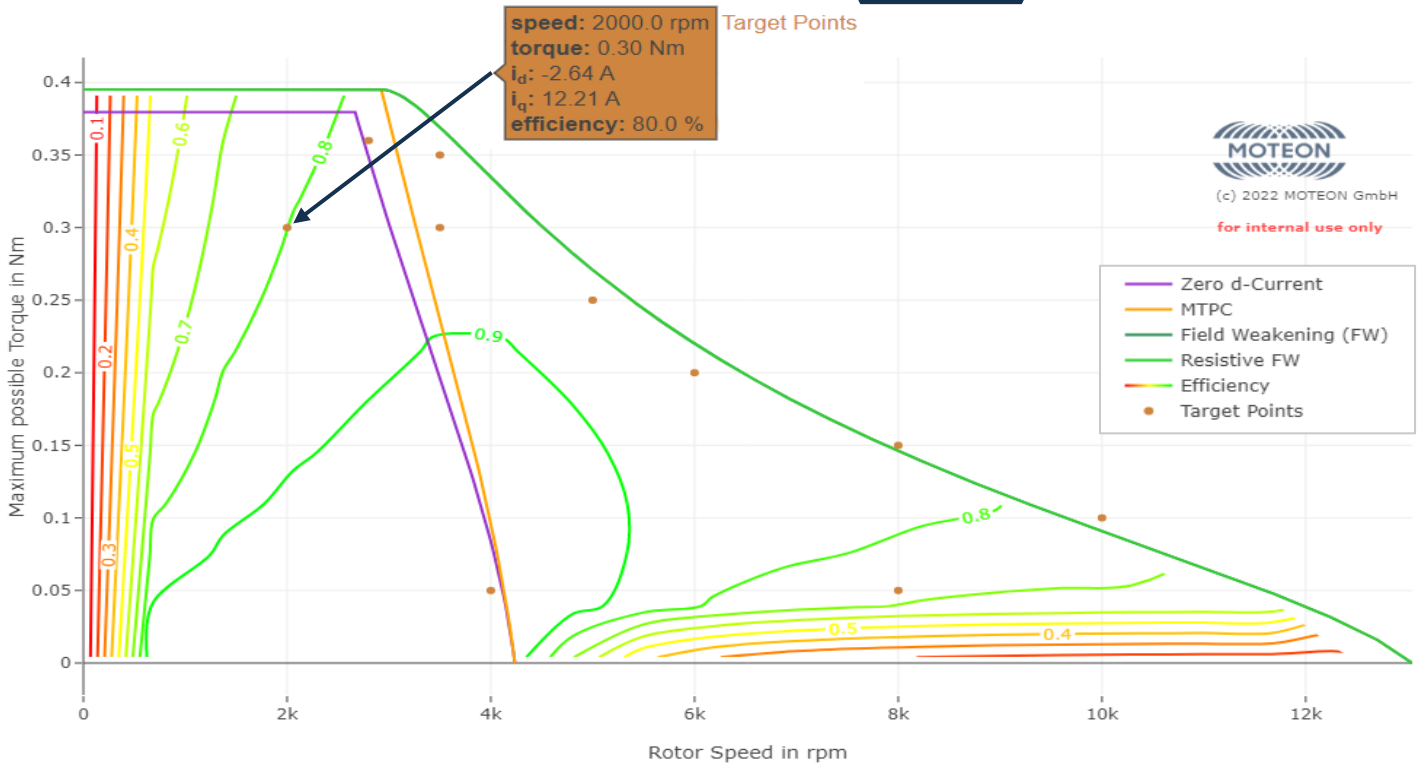




Motor Analysis Tool // Torque-Speed-Characteristic with efficiency lines and target points for different operational modes



https://softwaretools.infineon.com/tools/com.ifx.tb.tool.motoranalysistool



Training –
A few days or one week intensive motor control knowledge leverage

Training

Remote or on-site professional motor control training customized for your needs and tailored to the level of expertise

Key features

- Physical basics *(generated torque & voltages, B6 bridge operation, terminal voltages)*
- Rotor position detection algorithms *(BEMF, comparator based, ADC, Flux, inductance)*
- Commutation schemes *(FOC, sinus, table based, lead-angel control, stepper)*
- Current measurement/diagnostic techniques
- Motor control phases *(external drive, low-speed, field-weakening or over-modulation)*
- Peripheral support on MOTIX™ µC *(BEMF – comparator, ADC, CCU, current measurement)*
- SW implementation hints *(Architecture, program base structure, timing and interrupts)*

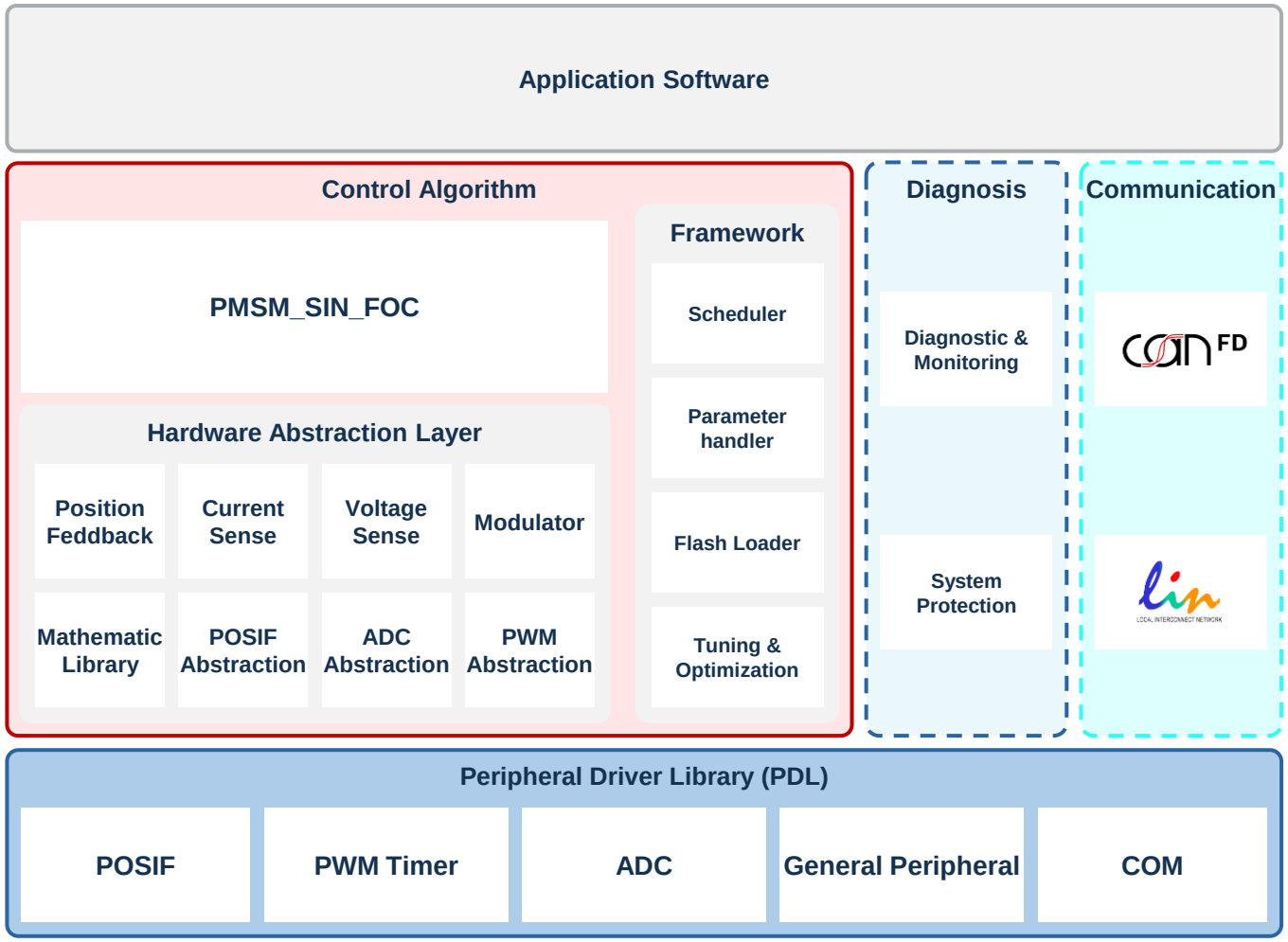
Your benefits

- **Improved knowledge, skills, productivity and employee satisfaction**
- **Build up knowledge and leverage know how for new applications**
- **Hardware equipment (motor, eval-board and TraceBox) will be provided**

Training details: scope and content alignment - Template

Software as a product: MOTIX™ Software

SW top level architecture



PMSM_SIN_FOC Key features

- Closed loop start & low speed control
- Maximum-torque-per-current (MTPC)
- Field-weakening
- Closed-loop blockage detection
- DC link voltage limitation
- Windmill detection / catch start

Standards

- ASPICE L1 certified and MISRA C (2012) compliant

Supported tools

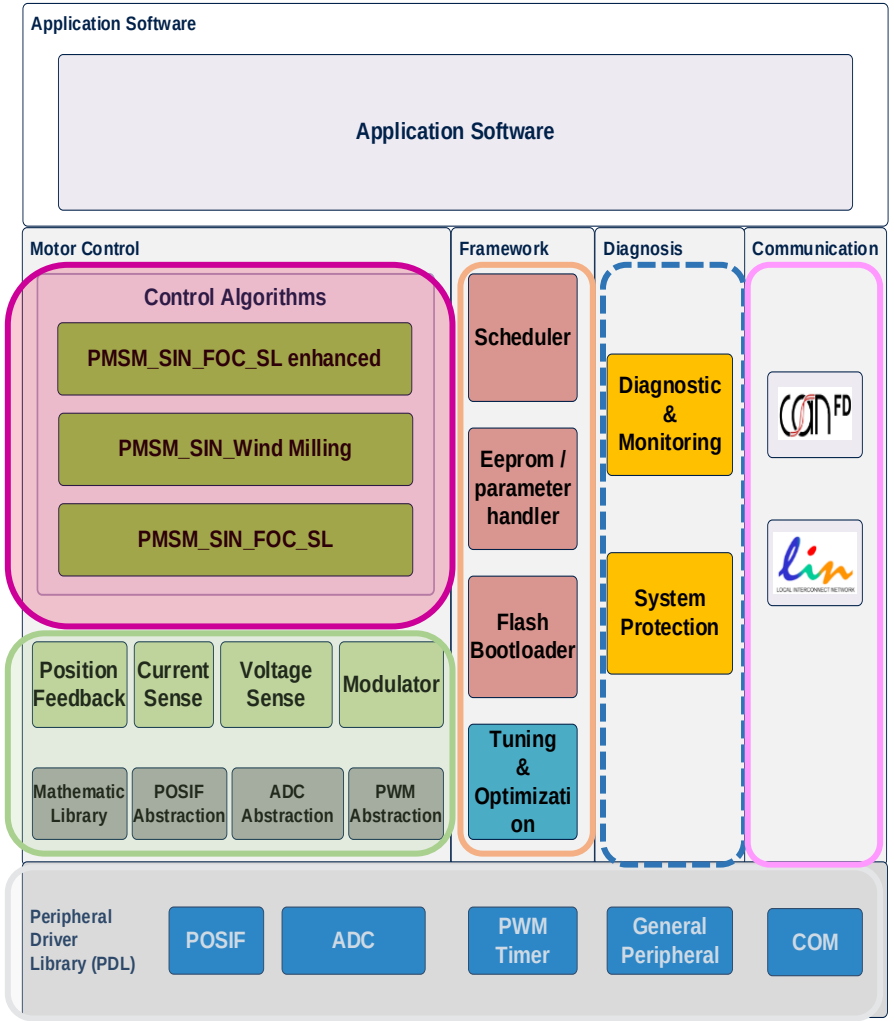
- MOTIX™ MCU Solution Designer
- SDK
- Compiler: ARM v5/ 6, GNU v7

Supported microcontroller

- TLE987x, TLE989x – available
- TLE995x – 2025

Software as a product:
MOTIX™ Software (Target product libraries in v2.0)

Target architecture



Component Libraries Overview (Release V2.0)

Control Algorithms – PMSM_SIN_FOC enhanced
MTPV, windmill detection (ADC based),
rotor block detection, load predictive control
6

Control Algorithms – PMSM_SIN_Wind Milling
Windmill detection (BEMF sensing),
Windmilling catch start
5

Control Algorithms – PMSM_SIN_FOC
State machine, I/f, Zero-d-current control
Closed loop start & low speed control via CWA
Maximum-torque-per-current (MTPC)
Field-weakening, Closed-loop blockage detection
DC link voltage limitation
4

Hardware Abstraction Layer (incl. Actor-Sensor Lib)
µC/board abstraction, Math Lib, Pattern generator,
BEMF sensing
Modulator, Analog Signal Sensing (current/voltage sense),
2

Framework (incl. tuning)
Task scheduler, Parameter handler, RetainMemory

TraceBox streaming, Monitoring, Oscilloscope
3

Diagnosis
Diagnostic & monitoring, system protection, Errorhandler, logbook, diagnostic parameters
7

COM
Process communication stack and protocols 3rd party COM-stack

Low-Level Driver (LLD) / Peripheral Driver Library (PDL)
µC peripheral driver + supported configuration
1

On Roadmap (not in V2.0 release)

MOTIX™ Motor Control software offering for motor control for TLE987x, TLE989x and TLE995x

	Evaluation License	Development License	Productive License
Purpose	**Evaluation Purpose** Demonstrates[1] **device performance**, enables customers to spin motor successfully, (**first user experience**, **NO productive use**)	**Development Purpose** Provision of **full documentation & test reports to develop** motor control application (**NO productive use**)	**Productive Purpose** Provision of **test coverage report**, process-compliant motor control **software libraries**
Documentation & Test Reports	Getting Started User Manual, API documentation, Errata / Delta-sheet, Release notes	Getting Started UM, API documentation, Errata / Delta-sheet, Release notes, **Library User Manual, Quality Package[2], Source Code**	Getting Started UM, API documentation, Errata / Delta-sheet, Release notes, **Library User Manual, Quality Package[2], Source Code**
Support	**Self service support** based on provided documentation	**Premium customer support** is covered in fee, limited to 20 hours of 1st level support	**Premium support** is covered in fee, limited to 50 hours of 1st/2nd level support
Access & Tools	Self-service download via IDC	Access granted via MOTEON **one TraceBox included**	Access granted via MOTEON **one TraceBox included**
Standards	Compliant to MISRA C:2012	Compliant to MISRA C:2012; **ASPICE L1**	Compliant to MISRA C:2012; **ASPICE L1**
Costs	**Free-of-charge** for max. 6 months	**30% of Project License Fee** for 18 months (credited when upgrading to project license)	Project **License Fee**

[1] with pre-compiled FOC solution from v2.0 onwards

[2] Test Specification, Test Report, Unit Test Requirement Traceability Report, BlackDuck Report, Code Coverage Report, MISRA Report; Further Incl. all known dependencies and Compiler all known dependencies and versions for Java Interpreter versions (incl. settings and optimization levels)

Facilitate initiation of series development by employing professional software parameterization for customer's electronics and motor

Motor-SW-Launch Service

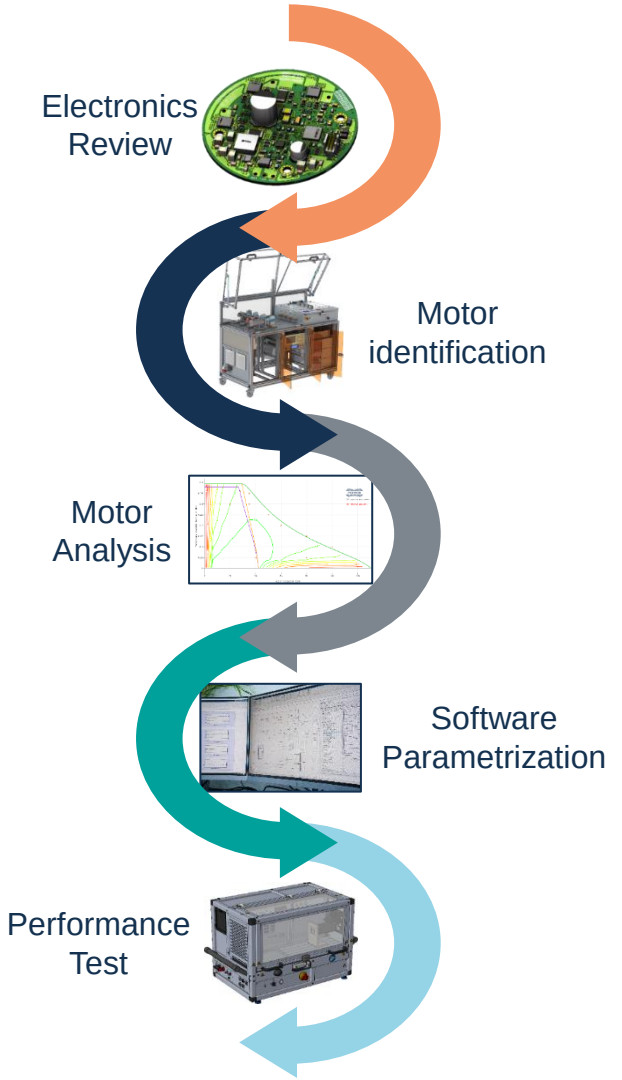
Professional launch service in 5-steps to verify design of electronics, identify motor parameters, simulation target-operation-points and parametrize software for testing

Key features

- Electronics Review
- Motor parameter identification
- Motor Analysis Tool: simulation of torque-speed, target operation points and efficiency
- Professional software parametrization
- Motor performance measurement incl. CPU usage & runtime

Your benefits

- **Understand system performance** and which algorithms are needed to reach ToP
- **Saving weeks of work** during initialization phase
- **Avoid trial/error** in parametrization for unknown motors
- **Identifying design issues** in early phase of project

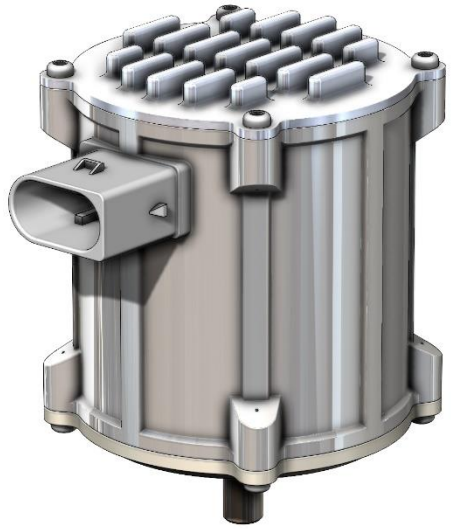


https://www.moteon.com/motor-launch-service.html

Prototyping -
Rapid prototyping via proof of concept to achieve OEM nomination

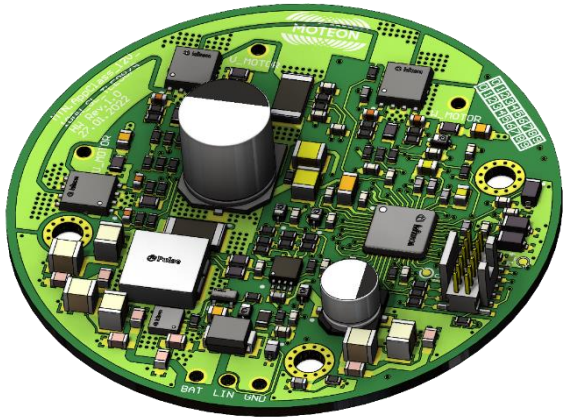
Prototyping

Proof of Concept (PoC) for embedded software, electronics, motor and mechatronic system



Key features

- Target cost development
- PCB design & component selection
- Embedded software demo code for evaluation
- Prototype production (up to 100 PCB or 10 motors)
- Test and evaluation of design, functionality and performance on test bench / lab



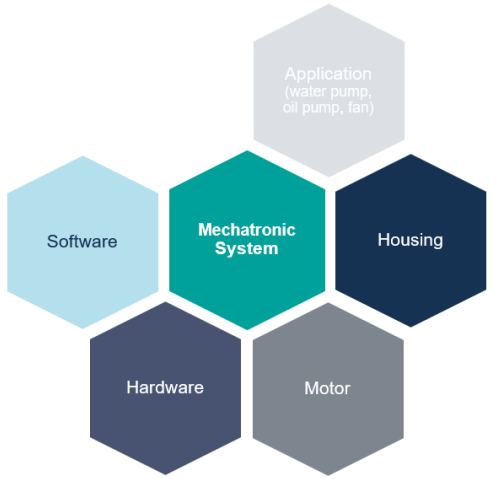
Your benefits

- **Achieve B-sample nomination** from OEM
- **Low financial risks** before committing to a full-scale development
- **Faster time-to-market** by quickly test and evaluation of the concept
- Identifying and addressing design issues **reduces development costs**

Mechatronic System Development - Efficiently integrate function and volume

Optimized system solution

Architecture based system development to optimize the system design and cover the associated system requirements

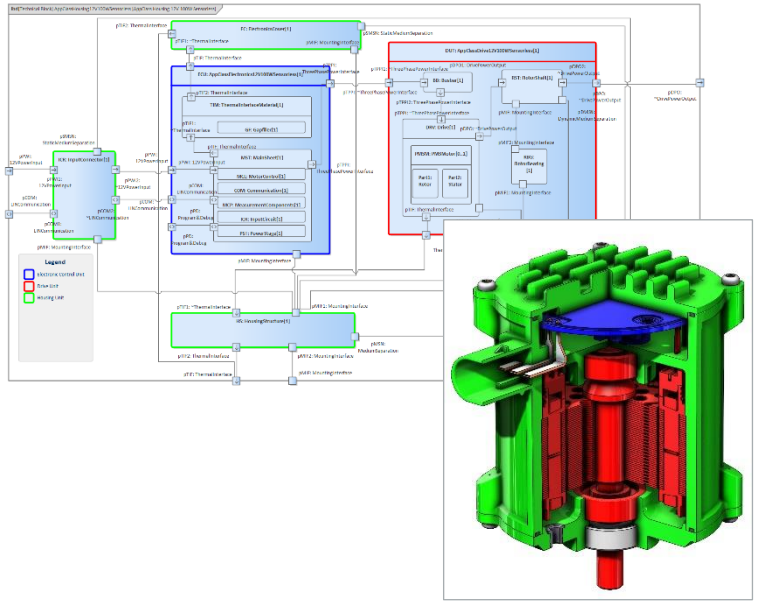


Key features

- Functional analysis
- Functional system architecture design
- Technical system architecture design
- System specification

Your benefits

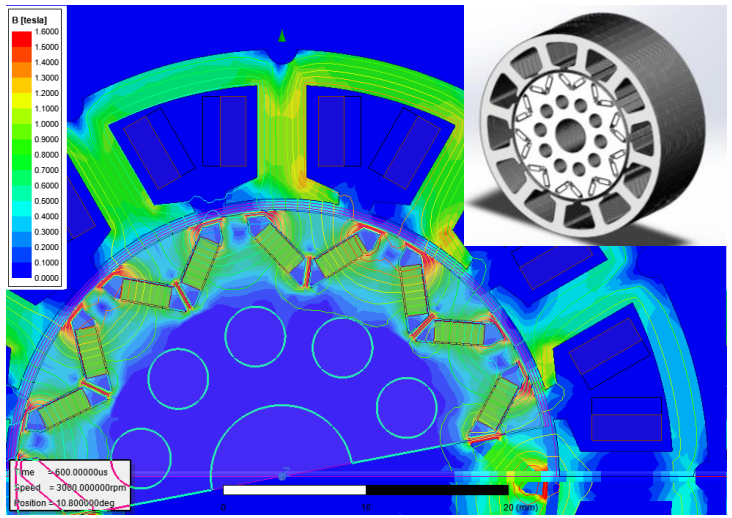
- **Verification** of the **requirements coverage**
- **Identification** of **system functions and related system requirements**
- **Development** of the **target system design** (avoid over-engineering)
- **Optimized** function and volume **integration**

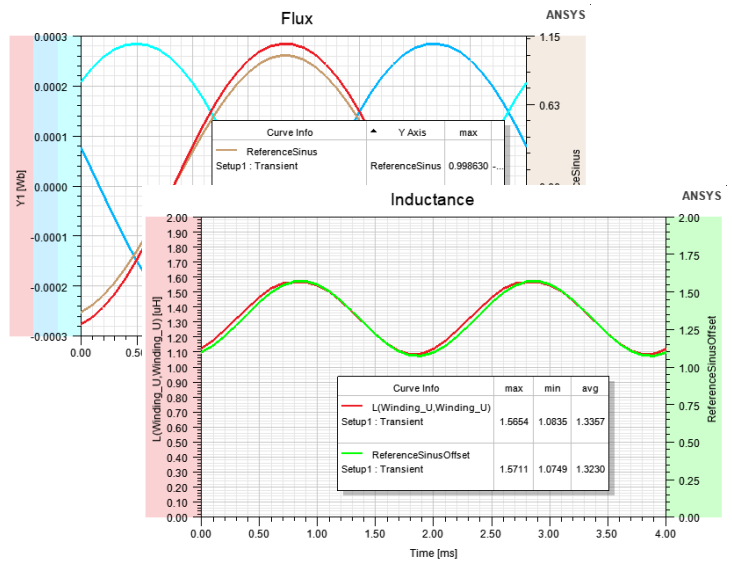


Mechatronic Development - Design of embedded motors in mechatronic systems

Concept, design, analysis and motor samples

Concept and design of application-specific motor topology, considering cost efficient magnet material selection and manufacturing of prototypes





Key features

- FEM design of permanentmagnet synchronous motor (PMSM), brushless direct current (BLDC)
- FEM design of synchronous reluctance motors (SRM)
- Evaluation of the best suited motor topology (number of pole pairs, coils, magnetic material)
- Analyzing and benchmarking of existing motors
- Manufacturing of prototyping motors for fast development and test purposes

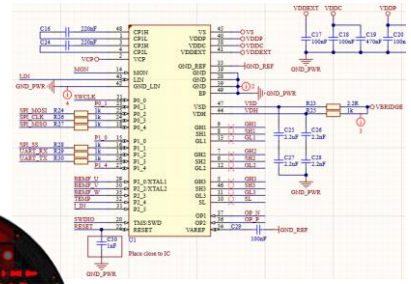
Your benefits

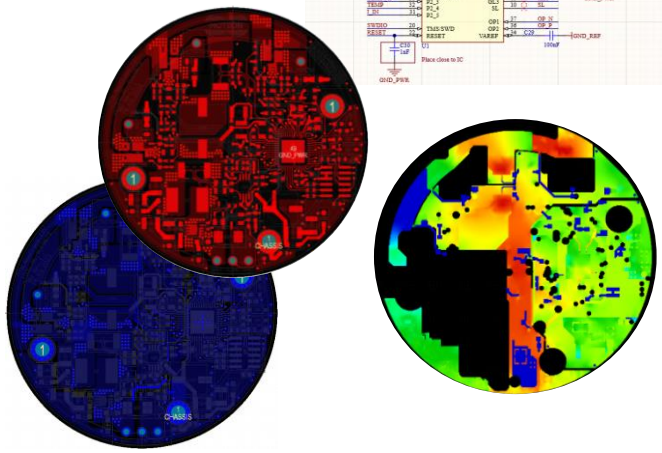
- Optimized **mechatronic design approach**
- **Identifying efficiency bottlenecks** in the magnetic circuit, **maximizing material utilization**
- Best suited motor design for application allows **minimized series costs**
- Design data set as starting point for **industrialization**

Mechatronic Development - Application-specific electronics design for system integration

Development of application electronics for fast functional samples

Design of application-specific electronics on functional sample level and manufacturing of prototypes for target system integration



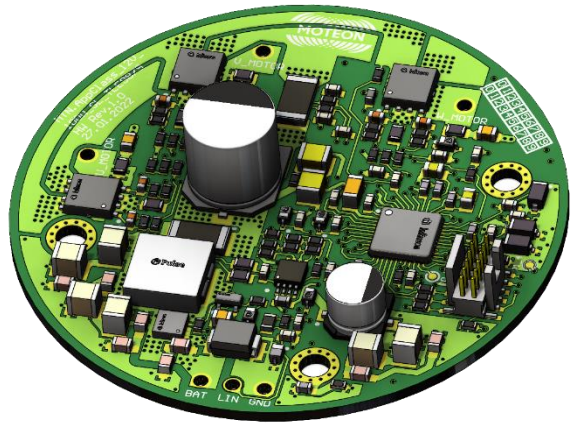


Key features

- Schematic and PCB design
- Application-specific component selection
- Thermal and electrical simulations to validate the design
- Generation of production data and manufacturing of prototypes with EMS
- Electronics initial testing

Your benefits

- Basis for **price indication** for series production
- Identifying and addressing design issues **reduces development costs**
- **Early integration** of the electronics in the target system
- Design data set as starting point for **industrialization**



Thermal Simulation as a Service - Early detection of potential design weaknesses

CFD based thermal simulation to support the system design process

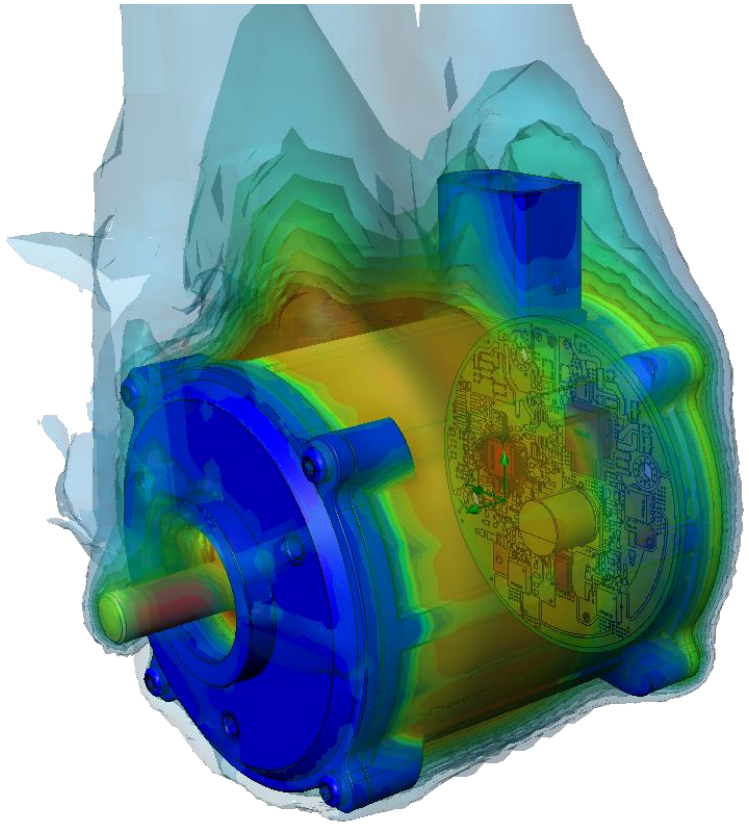
Mechanical design investigation with the assistance of CFD (Computational Fluid Dynamics) flow simulations enable early detection and optimization of critical thermal paths.

Key features

- Determination of power losses for motor and electronics based on model-based simulations (Matlab)
- Processing of extensive electronics models (Altium Designer) including detailed electrical losses for electrically conductive components and paths
- Simulation of time-dependent heat transfer and dynamic load behavior
- Simulation under realistic environmental and load conditions (consider free/forced convection and radiation)
- Possibility of further processing of results in an FEM strength analysis

Your benefits

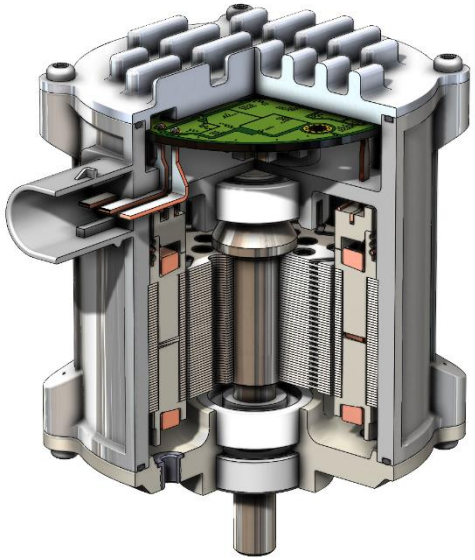
- **Verification of the cooling concept** based on the mechanical system design
- **Identification of thermal path weaknesses** still in the design phase
- **Efficient optimization** by means of targeted design adaptation
- **Direct processing of CAD models** possible without time-consuming simplification



Mechatronic Development -
In-house development and prototyping of system demonstrators

Integration of mechanics, motor, electronics and software into functional samples and system demonstrators

Full in-house mechatronic system development and prototyping capability as well as customer-specific adaption of subcomponents



Key features

- In-house design and prototyping of custom housings and mechatronic components with focus on structure and connection technology for sample systems
- Integration of new electronics into existing customer products as proof-of concept or functional sample for integration tests
- Custom test bench adaption to facilitate measurements of customer-provided systems/motors

Your benefits

- **Early proof-of-concept, in-house verification** of mechatronics design
- **Evaluation of thermal / electrical / mechanical performance** with real-world data
- **Flexible customer-specific adaption** of subcomponents in existing systems
- **Sample manufacturing** with external partners in case of industrialization topics

Simulation Model - Matlab/Simulink - Plant and motor control models help to develop a robust system

Models of motor, mechanical load and motor control in MATLAB/Simulink

Plant and motor control models help to understand the system behavior and leverage the development process

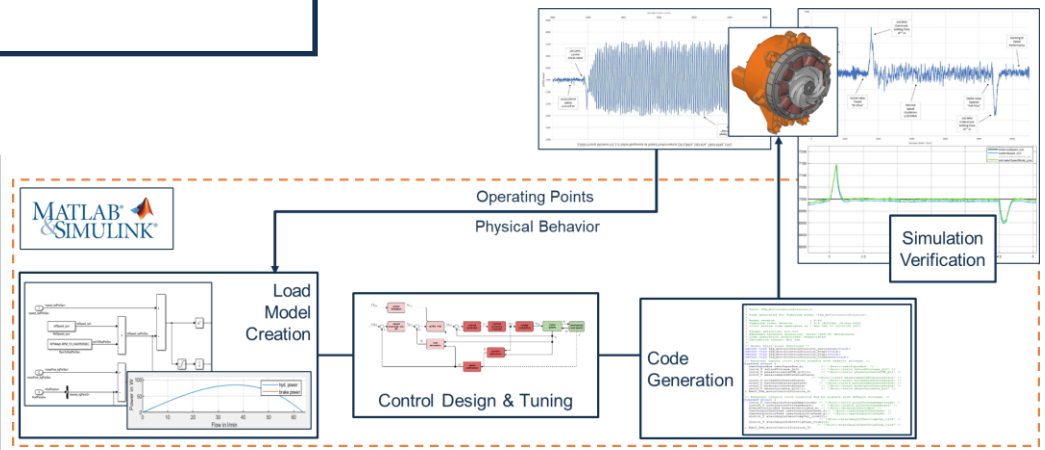
Key features

- Models of the inverter, motor and load (plant model) as well as extension towards the motor control to understand physical and control behavior as MATLAB/Simulink model

1. **Plant model** – Simulation of the system with powerstage, motor and load
2. **Generic motor control model –** Reproduce the generic motor control behavior & adaptations
3. **Replication of MOTIX™ SW** – Exact model reproduction of implemented code

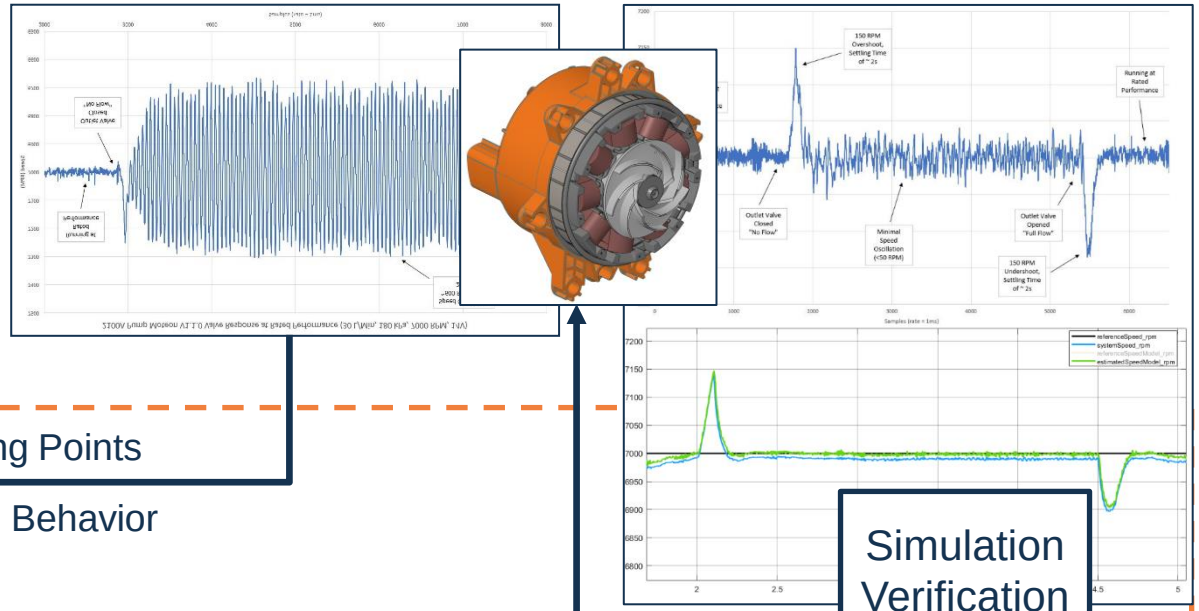
Your benefits

- **Early proof-of-concept, in-house verification** of concept
- Error and fault analysis and **simulation of corrective measures in model**
- Parametrization study to **improve robustness and performance**
- **Design controller independent** from physical system availability



Use case: model-based design of motor control

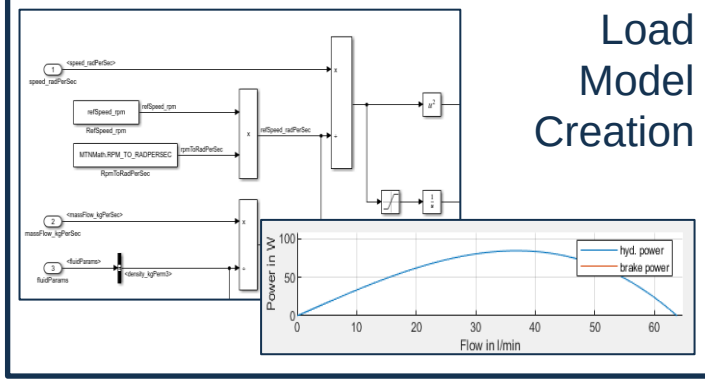
- **Model-based Software design** of control architecture and parameters with simulation model and code generation
- Model of motor and mechanical load allows designing controller independent from physical system availability



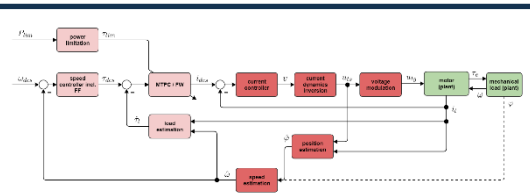
MATLAB & SIMULINK

Operating Points

Physical Behavior



Load Model Creation



Control Design & Tuning

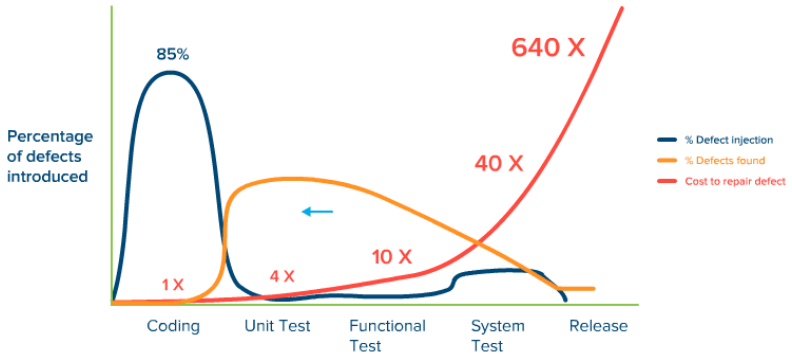
Code Generation

Simulation Verification

Testing as a Service -
Provides optimal parametrization and shorten time-to-market

Reproducible automated testing for system verification

Automated Testing & Verification Services
Rapid verification if system and validation of embedded software



Jones, Capers. *Applied Software Measurement: Global Analysis of Productivity and Quality.*

Key features

- Emulating load profiles torque = f(speed, position)
- High speed and accuracy of real physical signals and software variables timestamped (50µs)
- Automated Test Report Generation
- Real Time Industrial Motion Controller for load control
- Identification of motor parameters

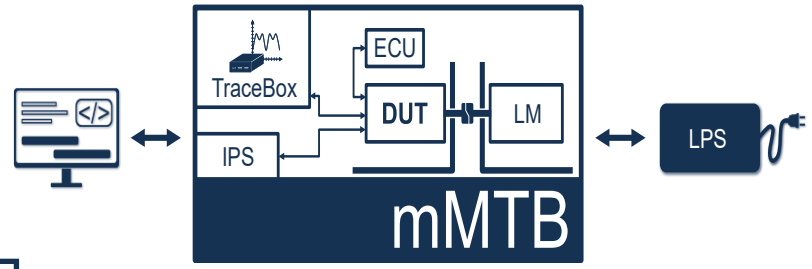
Your benefits

- **Rapid verification** of MCTRL algorithms & signal analysis
- Identification of bugs throughout development phase **decrease project risks/costs**
- Efficient parametization to avoid trial & error and **reducing time-to-market**
- **Reproduceable validation** of software adaptions within hours with improved test coverage
- **Automated testing** reduces verification effort by 97%

Mobile Motor Test Bench (mMTB) - The compact way of testing motors and electronics

MCTRL analysis tool with integrated data tracing & debugging

Mobile Motor Test Bench (mMTB)
Compact motor test bench to **develop and test a variety of motors**



Key features

- Load structure: 1x customer motor with 1x ECU
- DC voltage up to 60 VDC and current up to 50 A with a max power of 1 kW for test objects
- Determine efficiency maps for motors, inverters, and combinations of these components
- Torque up to 4 Nm (peak 20 Nm) and speed up to 12,000 rpm
- MOTEON TraceBox integrated

Your benefits

- **Rapid verification** of MCTRL algorithms & signal analysis
- **Root cause analysis** throughout the entire development phase
- Compact and robust design **specifically constructed for office use**
- **Automated testing** reduces verification effort by 97%
- **OfficeFit Technology:** secured, compact, remotely accessible for office environment

H:W:L 55 x 55 x 90cm

https://www.moteon.com/mobile-motor-test-bench.html

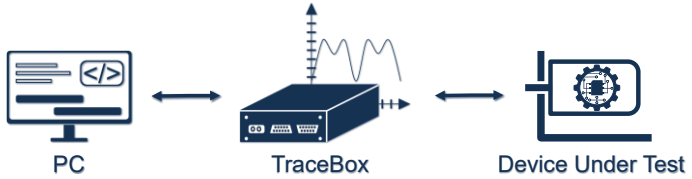
TraceBox -
The easy way of validating motor control software

Software debug & data tracing tool

TraceBox
A versatile data acquisition and communication **tool for the development and validation of motor control** (MCTRL) **software** that can be used in conjunction with real target hardware.

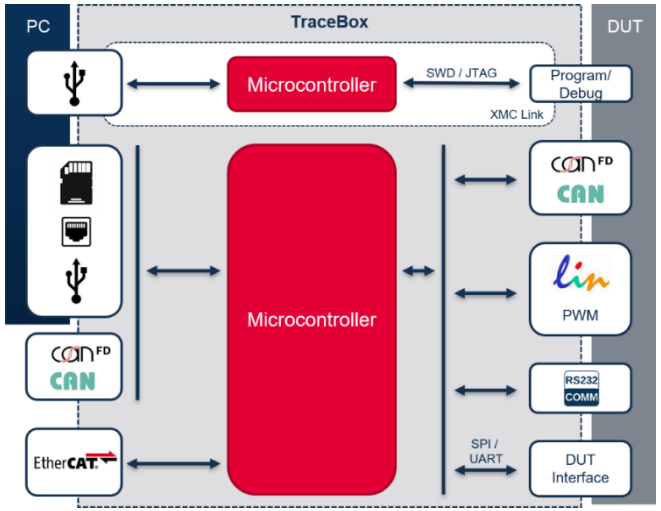
Key features

- Data streaming via SPI/UART optimized for low-cost microcontroller
- Target communication with various application protocols and interfaces
- Flashing and debugging via SWD (XMC™ Link functionality)
- Time synchronization via EtherCAT master in embedded test environments



Your benefits

- **Verification** of MCTRL algorithms & signal analysis
- **Identification** of issues throughout the entire development phase
- **Validation** of software adaptions in the ongoing development process
- **Debugging** of complex algorithms is 16x times faster with time stamped data
- One **standard device** for various use cases



https://www.moteon.com/tracebox.html

www.moteon.com