CISSOID
POWER SEMICONDUCTORS

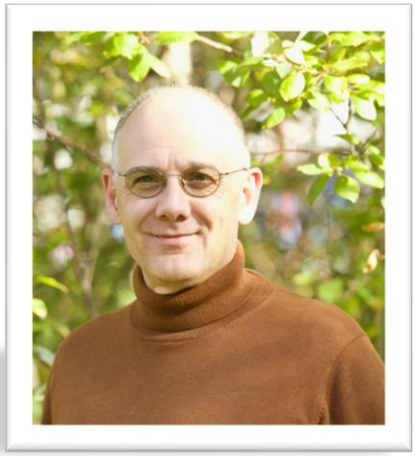
Silicon Mobility
An Intel Company

JOINT WEBINAR

OPTIMIZED PULSE PATTERNS

March 2026

JOINT COMPANY PRESENTATION



Mike Sandyck
Marketing Director
CISSOID

Company Information:

- Founded in July 2000
- HQ Location: Wavre/Brussels, Belgium
- Business model: Fabless

Patrice Brutinel
Technical Sales Director
Silicon Mobility

Company Information:

- Founded in December 2015, an Intel subsidiary.
- Headquarters in Sophia Antipolis, southern part of France
- Business Model: Fabless & software

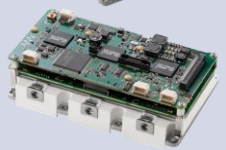
AGENDA

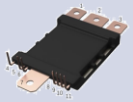
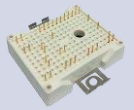
- SiC Inverter Platform
  - Inverter Control Modules
  - ACU T222 - Motor Control Processor
  - Advanced Control App – Motor Control Software
- Optimized Pulse Patterns
  - What is OPP?
  - How does it work?
  - Advantages
- Q&A

CISSOID PRODUCTS

Power Modules

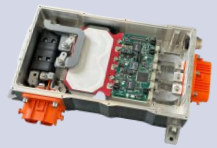
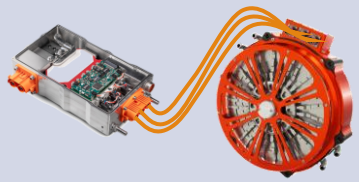
- 3 phase modules
- Different Power levels
- Overmolded
- Half Bridges

Systems

- Gate drivers
- Inverter ref designs
- Qualifying motors
- New systems (DCDC, BSS, MW CS)

MODULAR SiC INVERTER PLATFORM

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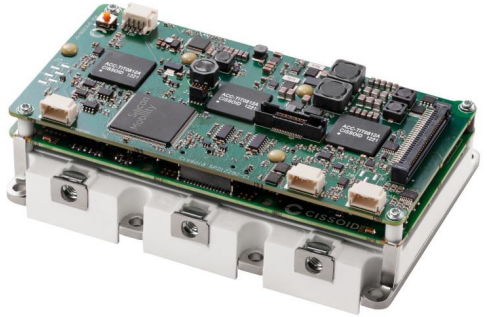
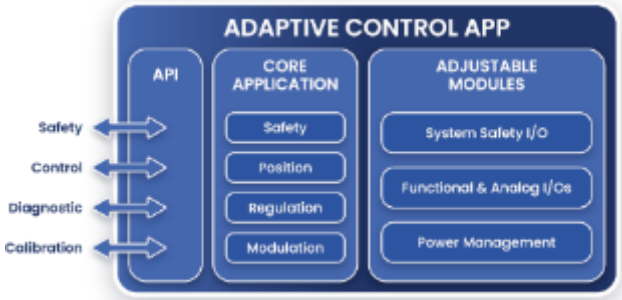
3-Phase 1200V SiC Intelligent Power Module

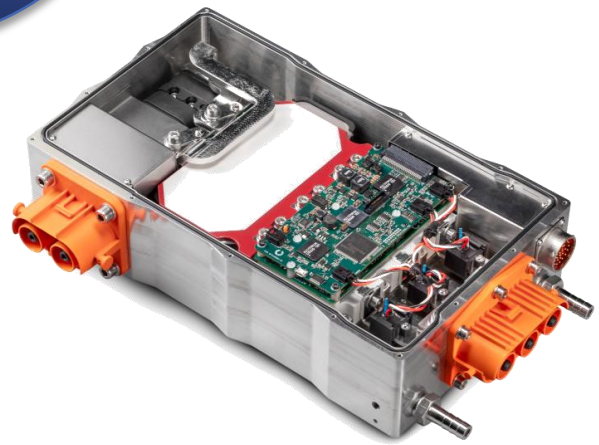


3-Phase 1200V SiC Inverter Control Module

Accelerate your Time-to-market

Customizable Inverter E-Motor Control Software





Modular Inverter Reference Design

INVERTER CONTROL MODULE (ICM)

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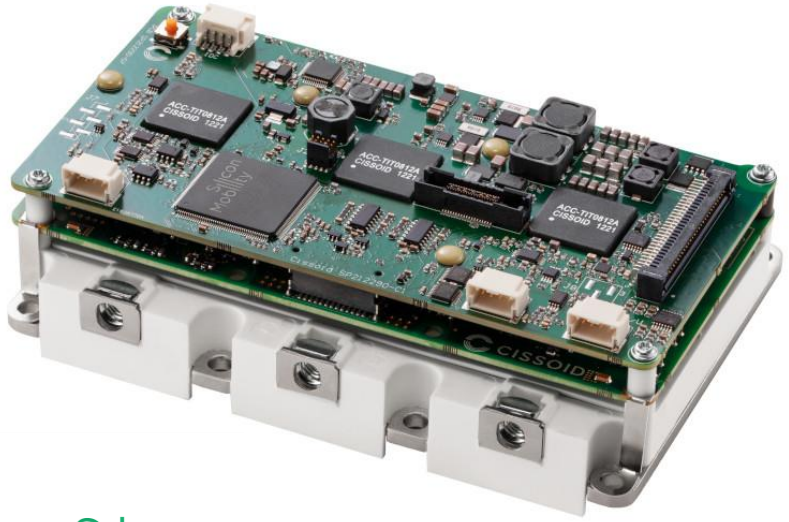
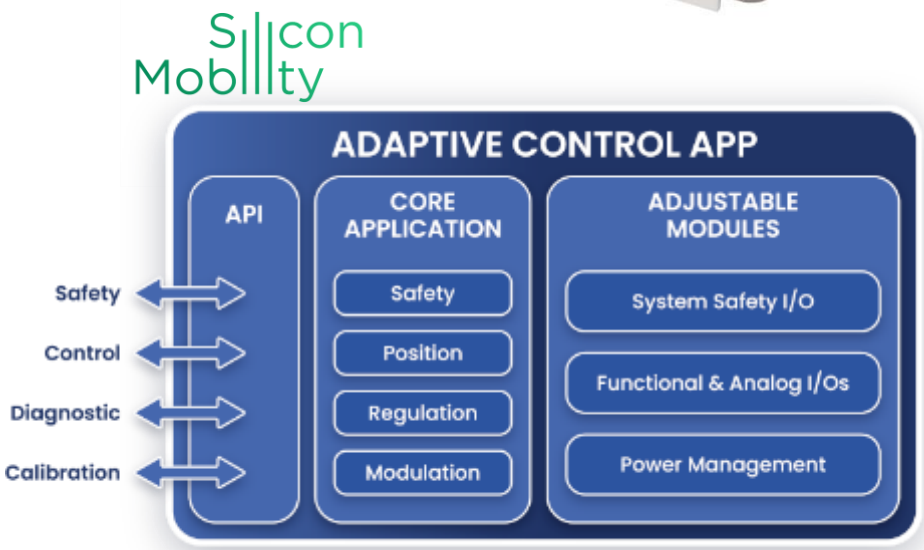
- **Adaptive Control Unit T222**
  - ACU T222 based Control Board mechanically & electrically integrated with CISSOID SiC IPMs

- **ICM Interfaces**
  - Power module: 3-Phase outputs & 3x2 Power Supply Pins
  - Motor: Resolver, encoder, current/temperature sensors
  - Vehicle: CAN, LIN & Battery supply
  - Developer: SWD (debug) & Trace Port Unit (real-time debug & calibration)

- **Adaptive Control App (by Silicon Mobility)**
  - Highly configurable inverter & motor control software
  - Advanced control algorithms for highly energy-efficient systems
  - Closed-loop current control based on Field Oriented Control regulation
  - Frequency scaling SVPWM and DPWM modulation up to 50 kHz with short dead time compensation





ADAPTIVE CONTROL UNIT (ACU) T222

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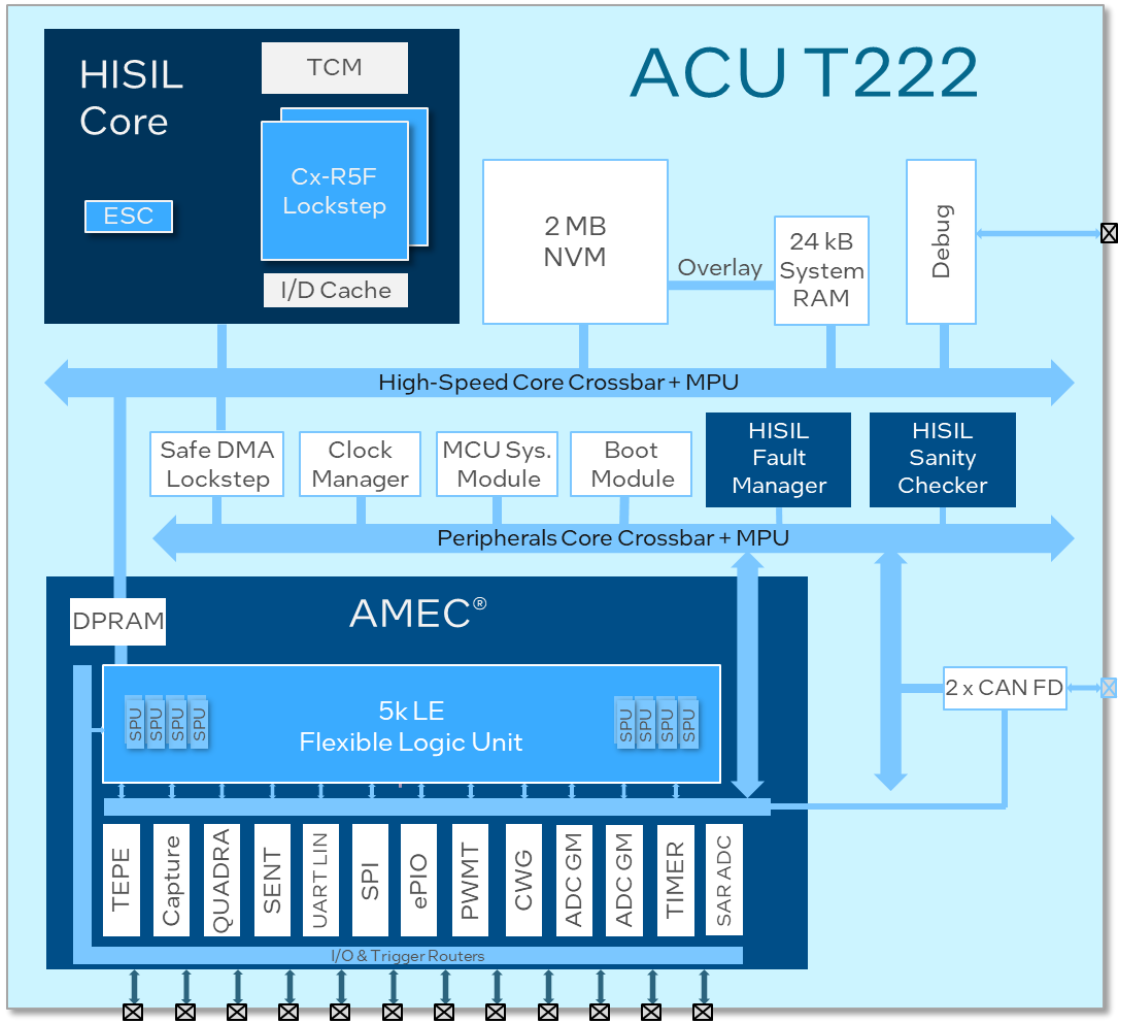
- **Ultra-fast real-time processor**
  System-level fault detection, correction and containment in tens of nanoseconds
  - **40x faster processing compared to standard MCUs**
  - **1000x faster fault detection compared to standard solutions**
  - **Real-time - 100% timing predictability**

- **HISIL Core – Functional Safety Integrated**
  - Dual 200MHz ARM Cortex R5F in Lockstep
  - Safe DMA transfers with CRC checks

- **AMEC – Advanced Motor Event Control**
  - HW programmable Flexible Logic Unit
    - 4560 Programmable Logic Elements
    - 20x 24-bit Signal Processing Units
  - Parallel access for acquisition & control



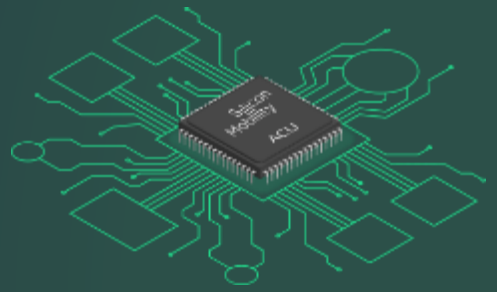
Silicon Mobility

HISIL = Hardware Integrated Safety Integrity Level

Adaptive Control Solution

Silicon Mobility

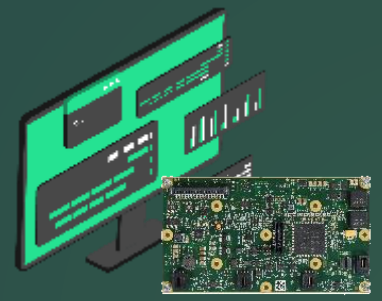
Adaptive Control Solution – ACS



Adaptive Control Unit

Semiconductor

ISO 26262 ASIL-D Design Ready



Adaptive Control Composer

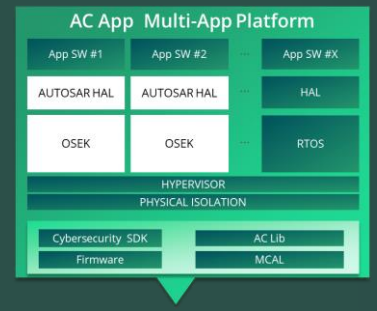
Design Environment

ISO 26262 Compliant certified for the design of **safe systems up to ASIL-D**

Adaptive Control Lib

Algorithms toolbox

ISO 26262 Compliant certified for the design of **safe systems up to ASIL-D**



Adaptive Control App

Embedded Application Platform

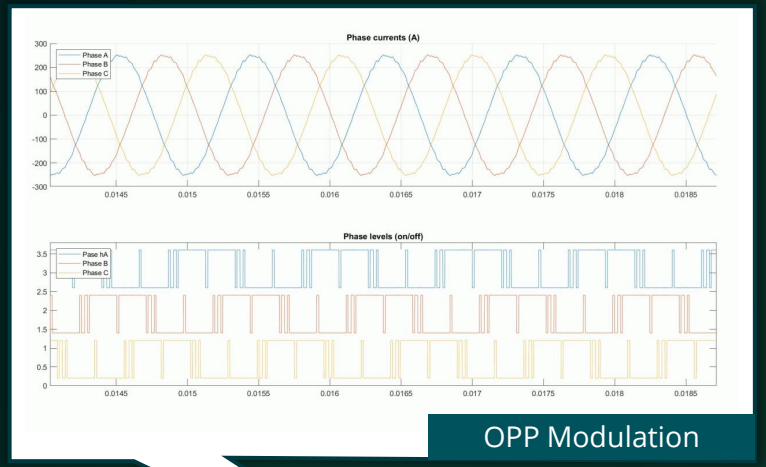
ISO 26262 ASIL-D Compliant

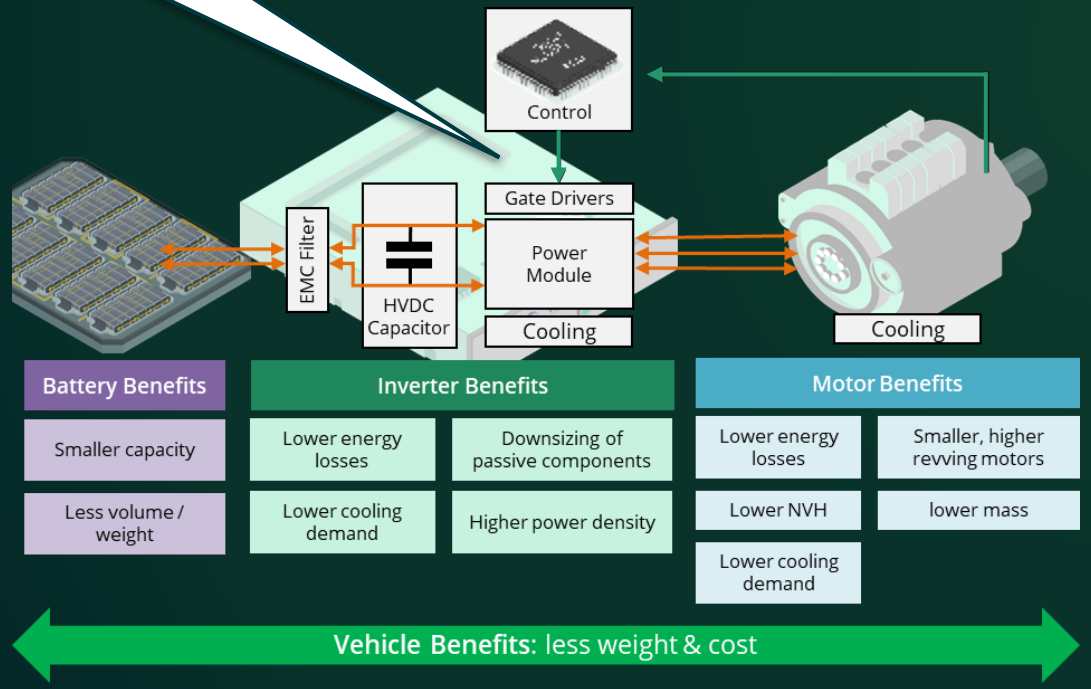
Dev Kit

AUTOMOTIVE SPICE®

All embedded software are **Automotive Spice Level 2**

What is Optimized Pulse Pattern (OPP) ?

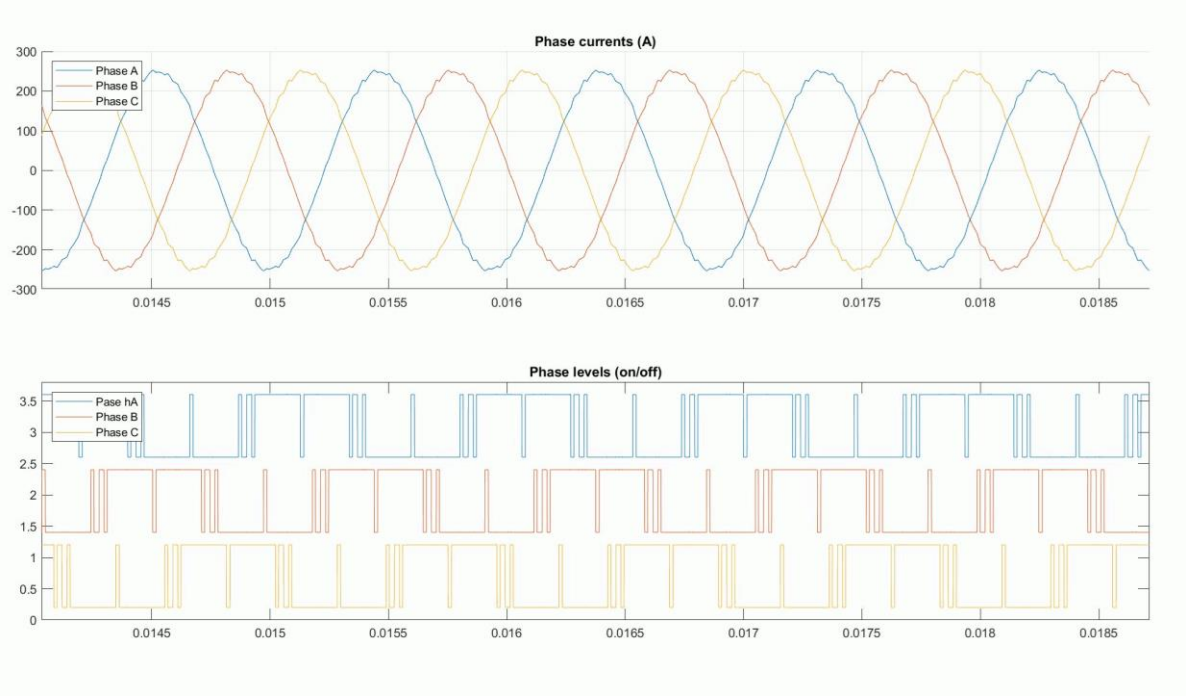




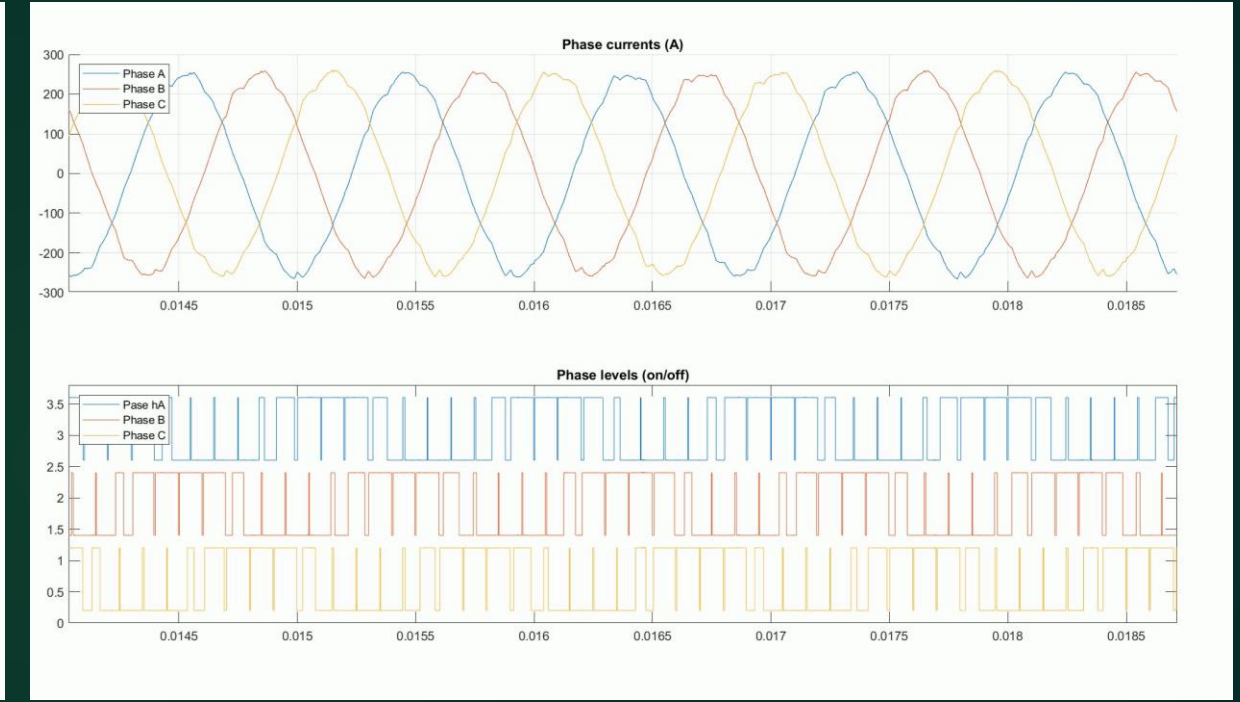
- OPP is an inverter switching method replacing SVPWM, DPWM or six-step schemes. The OPP modulation is based on the electrical angle. It is not a time-based modulation such as conventional modulations.
- An Optimized Pulse Pattern is a list of switching angles, within the range [0, 2π], used to control the inverter and the electrical motor to achieve the desired setpoint (torque/speed) with the best performances possible.
- Transistor switches can be located at any angular position: no PWM carrier exists.
- OPPs are characterized by their modulation ratio and their number of switching angles while being optimized for a motor speed-torque range
- Full freedom on where to place switches by removing the constraint of the fixed frequency and symmetries on the gate pulses
- Patterns are computed offline based on inverter-motor models.
- Number of switches and related angle positions are determined to optimize the modulation upon different criteria : Lower Energy Losses, Reduce THD, Ripples, and NVH.

Comparison OPP Vs SVPWM

OPP



SVPWM



	Same THD with limited number of switching event		Improved THD with equivalent number of switching event	
	OPP	SVPWM	OPP	SVPWM
Fsw [kHz]	3.85	10	9.35	10
THD	4.2%	4.7%	2.4%	4.7%

What are the benefits of OPP ?

Better Efficiency

+3% to +5% efficiency gain on the most critical WLTP pain points

‘000 to ‘0,000 Watts of battery energy saved from losses (~40% of the overall total losses)

Superior TCO Vehicle

25% smaller e-motor for similar performances

20% battery voltage reduction for similar range

Up to 2x reduction of audible e-motor noise and vibrations at similar speed

Smaller BoM

40% → 50% size and weight reduction of cooling subsystem

50% → 66% size and weight reduction of DC link capacitor

$40 → $70 direct impact on BoM just by software

Greater User Experience

A better drive car…

… Longer range – Faster charging …

… Lighter and cheaper …

… and so much more sustainable!

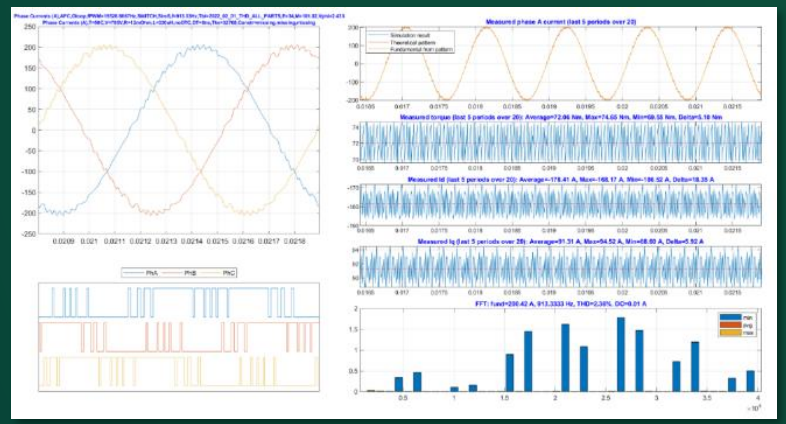
A Model-Based Predictive Control

1

OFFLINE

Optimized Pulse Patterns Generator / Solver

Based on Losses Models



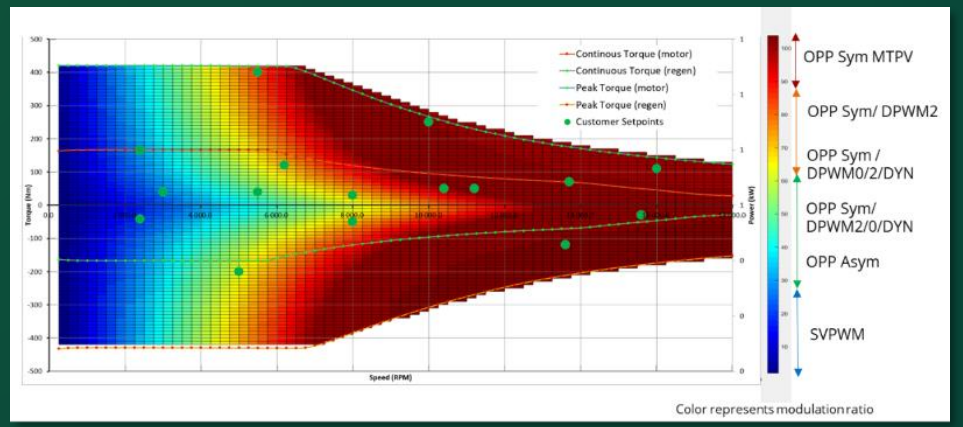
OPP

2

ONLINE

Dynamic control using adaptive PWM switching with ACU T222 and AC App Inverter

Commuting between SVPWM/DPWM/OPP



How is OPP Working with ACU?

I. OFFLINE

using modeling

Tweak and optimization of criteria for best patterns

1 System Parameters Collection

E-motor model
- PMSM equations
- Motor properties
- Steinmetz equations
- 2D and 3D models

Inverter properties
- DC-link voltage & capacitance
- Transistor model
- Switching losses
- Conduction losses

2 Optimization Criteria Definition

Scoring functions
- Harmonics weighting (THD, SHE, SHM, NVH)
- Inverter & motor losses
- Current ripple

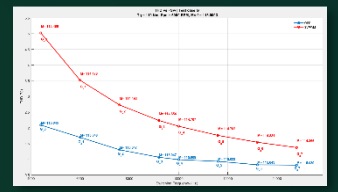
Constraints
- Symmetry/asymmetry
- Modulation ratio requirement
- Minimum pulse width (DT related)
- Torque ripple requirement
- Vbus ripple requirement

3 Patterns Generation

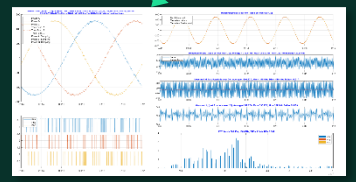
- Digital solver across multi-dimensional search space
- GPU and computer farm acceleration
- 4-5 hours for all tables

4 Patterns Analysis and Validation

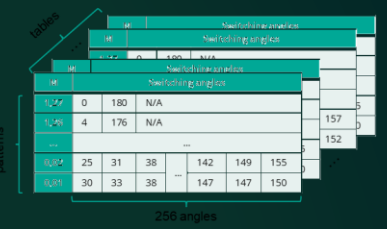
- Scoring graphs
- MiL simulation



Scoring Graph



Simulation Results



OPP Tables

II. INLINE

With ACU and AC APP

5 AC APP INVERTER Configuration

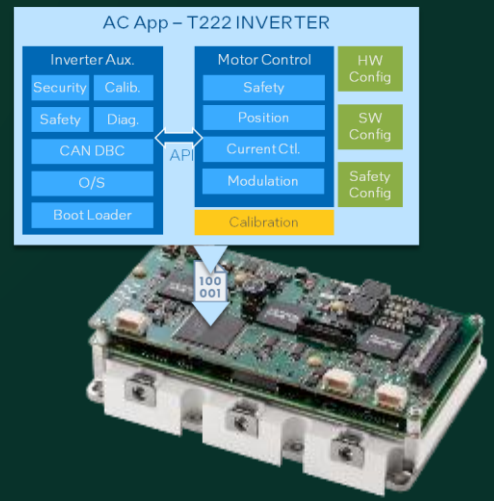
- OPP tables are played by the AC APP INVERTER software in ACU T222 chip
- Each pattern can have up to 256 angles for 360°
- Resolution of 0.1% for the modulation ratio (0 – 127%)
- Up to 20 tables can be stored in ACU T222

6 Dynamic Control

- The Adaptative PWM Control (APC) algorithm generates the pulses
- Commuting between SVPWM/DPWM/OPP upon Torque/Speed setpoint in map
- The main control loop operates at 100 kHz
- The electrical angle is determined using an integrated Position Tracking Loop (PTL) at 20MHz

7 Dynamic Performance

- Patented Field Oriented Control loop adapted to OPP
- Transition between OPPs is smooth with low ripple and high response time with better performance than SVPWM



ACU T222 equipped with AC App – T222 Inverter software on CISSOID ICM

CONCLUSIONS & AVAILABILITY

ICM Certification & Availability

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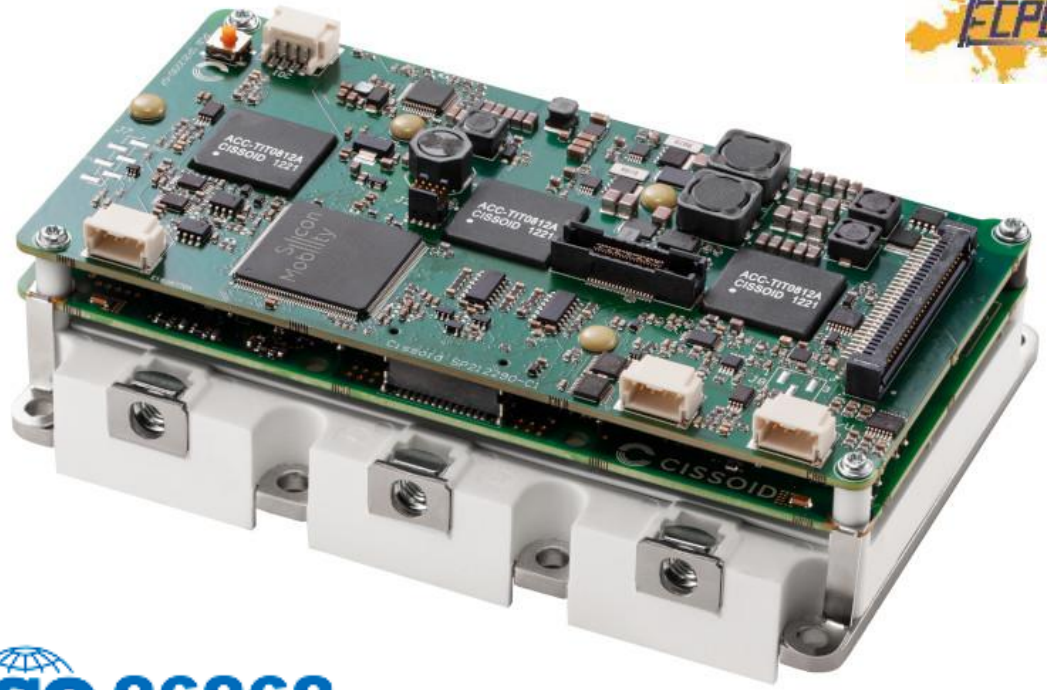
Processor & SW certification (ACU T222)

- ISO26262 ASIL-D

ICM Certification

- ISO26262 ASIL-C Ready
- AQG-324

Ordering References	Max Output Power	Max Phase Current	Base-plate
CXT-ICM3SA12340AAA	305kW	295A_{RMS}	Pin fin
CXT-ICM3SA12450AAA	405kW	390A_{RMS}	Pin fin
CXT-ICM3SA12550AAA	475kW	460A_{RMS}	Pin fin
CXT-ICM3SB12340AAA	330kW	320A_{RMS}	Flat



ISO 26262

SGS TÜV SAAR ASIL C READY Functional Safety www.sgs-tuev-saar.com

SiC Inverter Reference Designs

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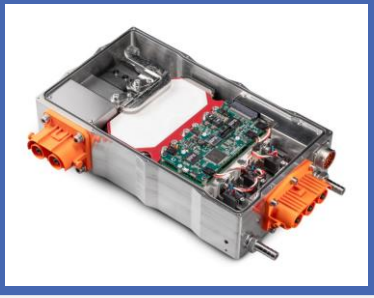
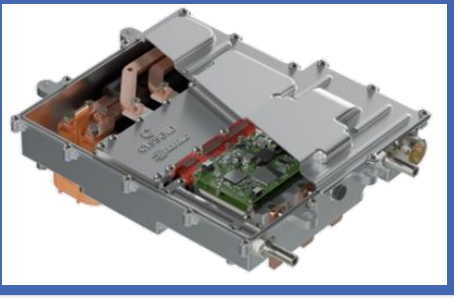
High Voltage SiC Inverter Reference Designs	Bench-top	On-board	Custom
			
Purpose	Lab testing	In-vehicle testing	In-vehicle integration
Peak Voltage/Power	900V/330 kVA	900V/450 kVA	900V/450 kVA
Availability	Off-the-shelf	Off-the-shelf	Via EDAG partnership
Lead time	8-12 weeks	8-12 weeks	18-24 weeks
Easy access to Connectors	✓		
Compact design		✓	✓
Motor Control Software	✓	✓	✓
Extensive EMC shielding		✓	✓
Hermetically sealed		✓	✓
Vibrations resistant		✓	✓

KEY TAKEAWAYS

- Full stack solution from Silicon Mobility for e-motor/inverter control application with a powerful system-on-chip and application software supporting Optimized Pulse Pattern modulation.
- OPP reduces inverter/motor losses and increases efficiency up to 5%.
- OPP reduces NVH & ripples: Variable angular switches minimize current harmonics, HVDC ripple, and noise/vibration for smoother, quieter and cheaper drivetrains.

Available today:

- CISSOID's SiC Inverter Control Modules powered by AC App Inverter control software with OPP
- Open & modular hardware platform
- Fast prototyping with inverter reference designs

Contacts

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