GD3160: ADVANCED HV ISOLATED SIC GATE DRIVER FOR AUTOMOTIVE EPOWERTRAINS

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NXP

SECURE CONNECTIONS
FOR A SMARTER WORLD

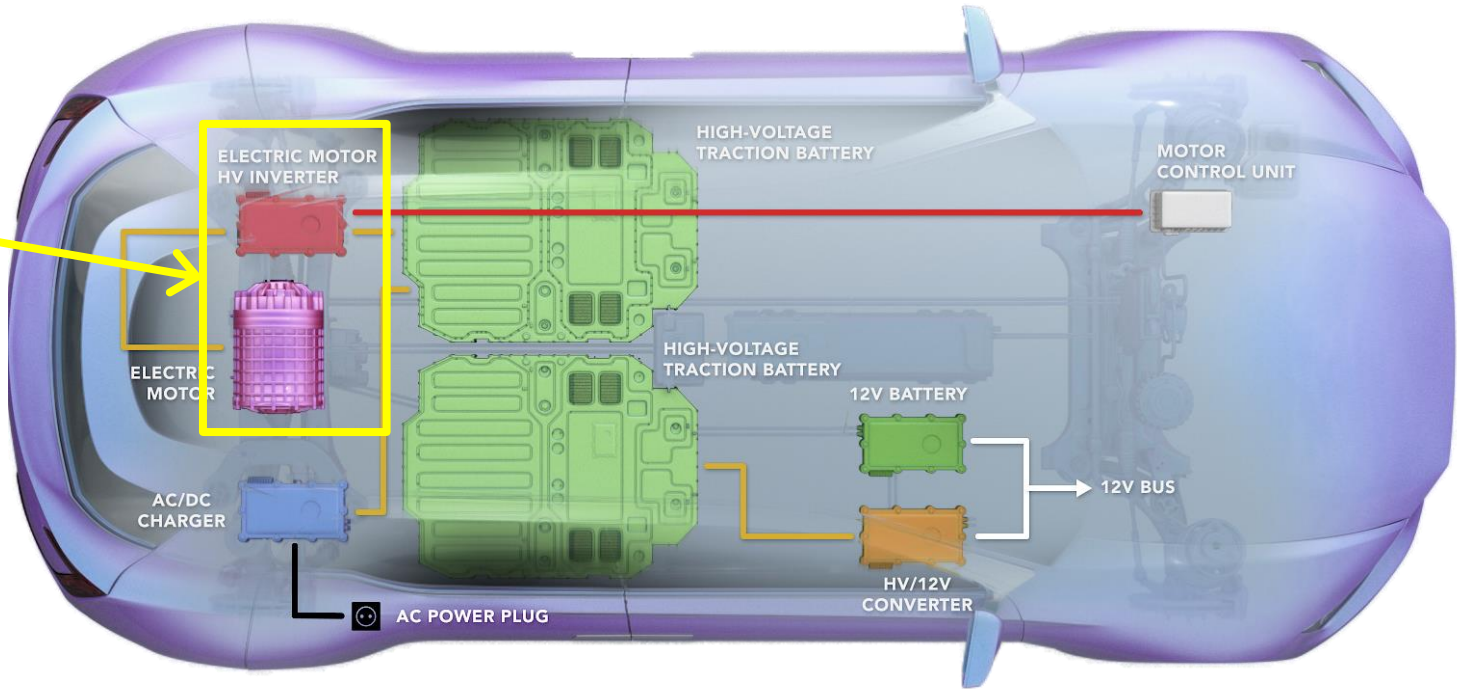## AGENDA

- HV Gate Driver Roadmap

- GD3160 Introduction

- GD3160 Key Features

- GD3160 Enablement

- Contact us

EFFICIENT SYSTEM PLATFORMS FOR OPTIMIZING POWER SYSTEM CONTROL

ELECTRIFICATION PORTFOLIO

	MCU	SBC	COMM	Driver	AFE
Battery management system	●	●	●	●	●
Motor control (inverters, HCUs)	●	●	●	●	●
48V eMachine (BSG, ISG, HVAC)	●	●	●		
DC/DC voltage domain converter	●	●	●		
On-board charger AC/DC converter	●	●	●		

ELECTRIC MOTOR HV INVERTER

ELECTRIC MOTOR

AC/DC CHARGER

AC POWER PLUG

HIGH-VOLTAGE TRACTION BATTERY

HIGH-VOLTAGE TRACTION BATTERY

MOTOR CONTROL UNIT

12V BATTERY

12V BUS

HV/12V CONVERTER

ANATOMY OF AN EV POWER INVERTER DRIVE SYSTEM

- Traction inverter converts DC voltage from a high-voltage battery into a high-current, multi-phase AC voltage to drive the traction motor
- Drive 3- or 6-phase motors ranging from 50 kW to 250+ kW
  - PWM frequencies of 8,000 – 40,000 Hz.
  - Power efficiency (> 95%) and power density (kW/L, kW/g) requirements are critical.
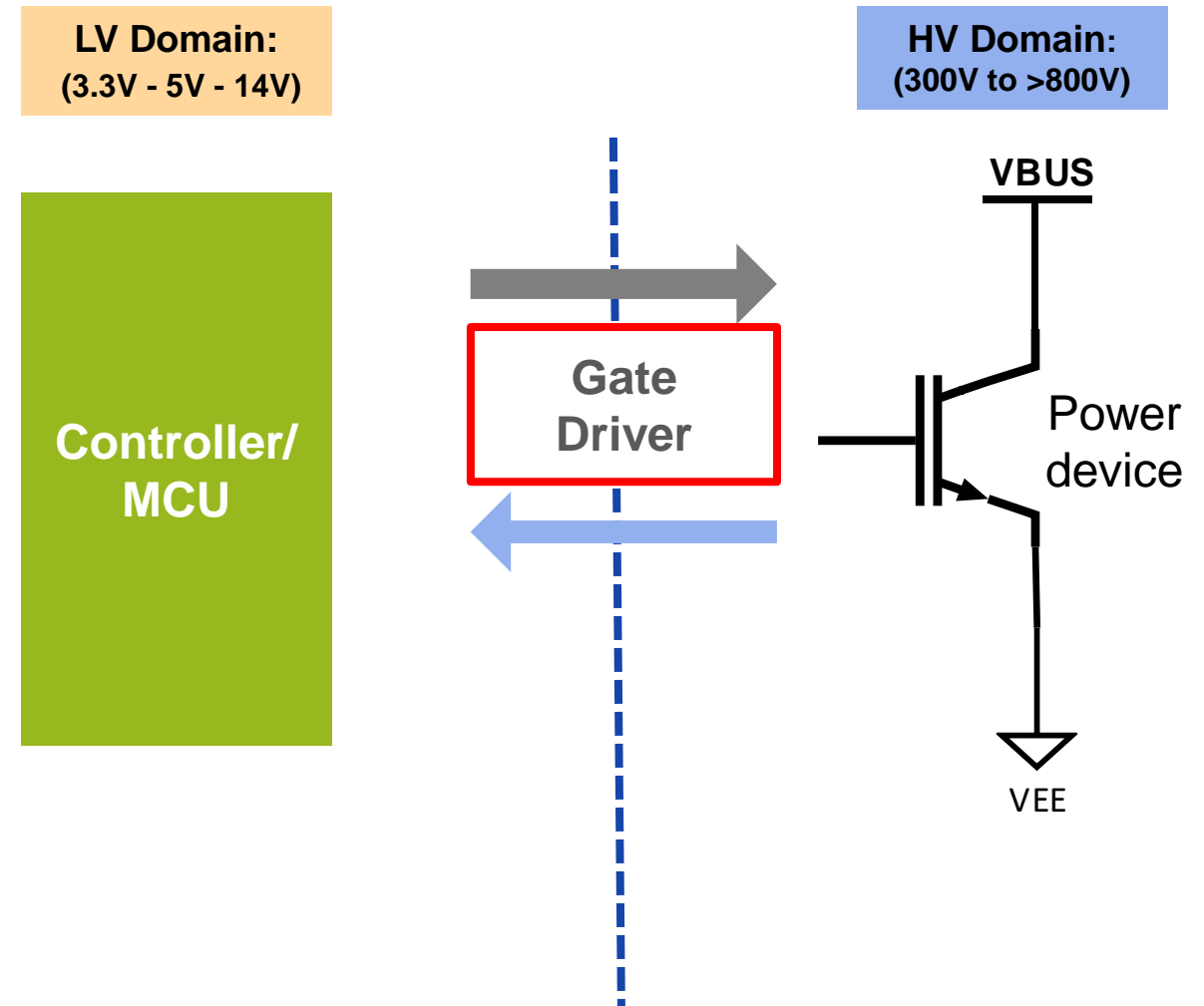- Functional safety requirement at ASIL-C or ASIL-D
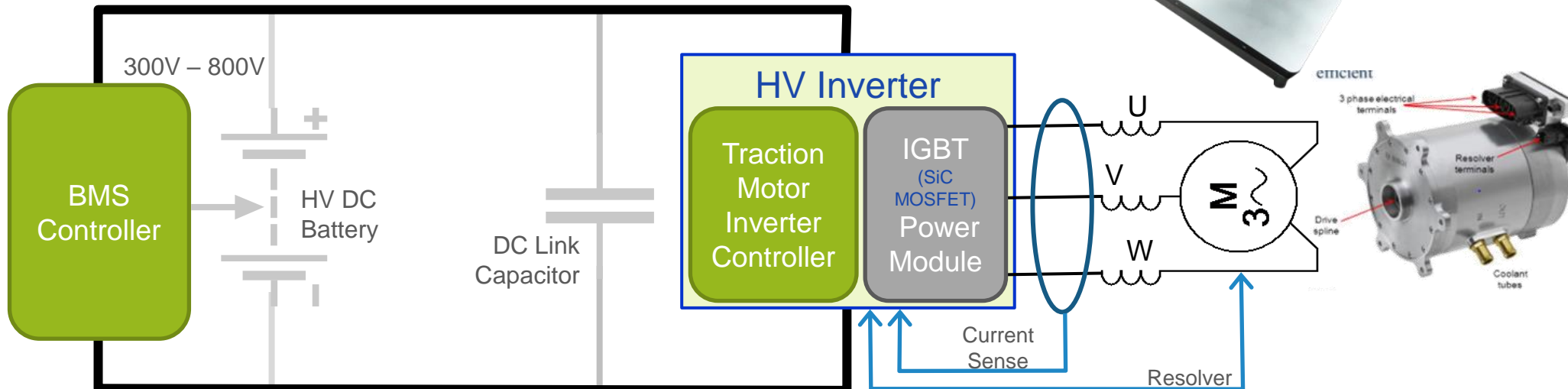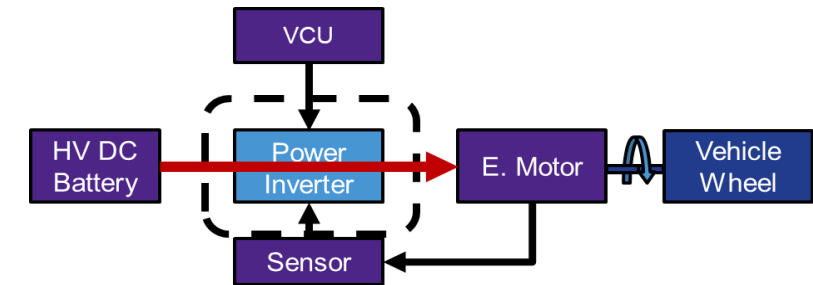
WHAT'S INSIDE AN INVERTER?
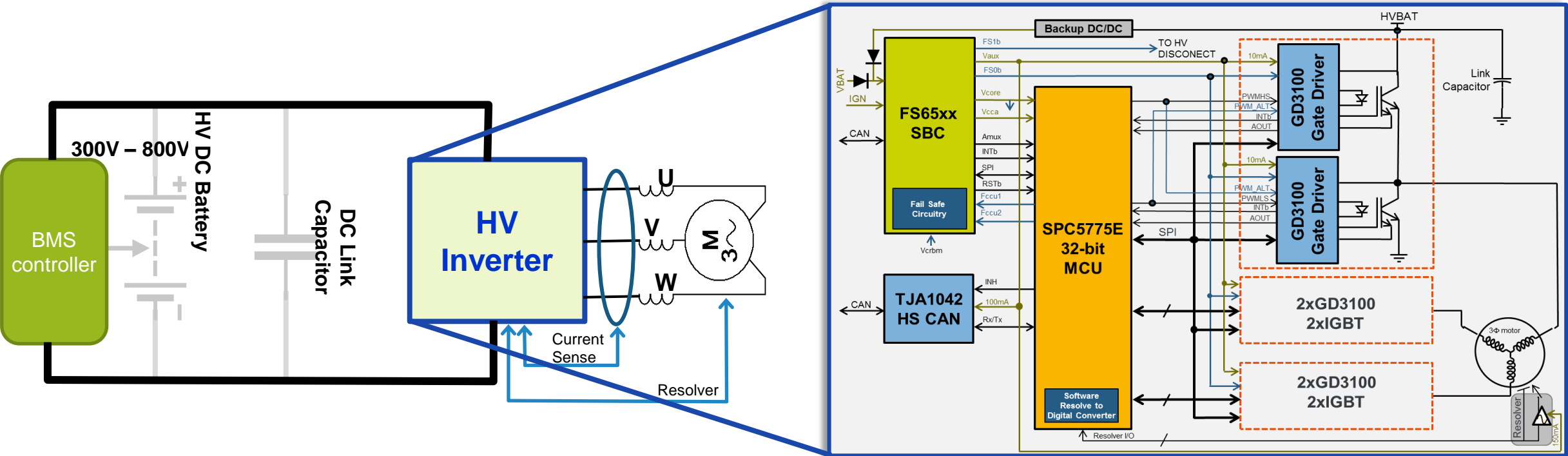
KEY FEATURES OF AN ISOLATED HV GATE DRIVER

- **Deliver high efficiency** with fast and efficient power device switching
- **Provide galvanic isolation** between low-voltage and high-voltage domains
- **Enable control & status channels** between low-voltage (<14 V) and power (>300 V) domains
- **Monitor and protect** power devices
- **Function reliably** over temperature, voltage, lifetime
- **Ensure robust operation** in harsh and noisy environment
- **Minimize cost** BOM and footprint
- **Support safety** in automotive & functional safety requirements

LV Domain:
(3.3V - 5V - 14V)

HV Domain:
(300V to >800V)

VBUS

Controller/ MCU

Gate Driver

Power device

VEE

NXP

HV GATE DRIVER ROADMAP

Products in Production:

HV Gate Drivers

GD3100: *1 ch Isolated HV IGBT/SiC Gate Driver:* SPI Programmable, ±15A gate drive, < 2.0 us VCE DeSat SC,>120 V /ns CMTI, ISO26262 (ASIL-D)

Pin compatible

GD3160 – *Single ch Isolated HV SiC MOSFET/IGBT Driver:* SPI Programmable, ±15A and +23 /-7V gate drive, < 1.2 us VCE DeSat SC detect, VGE and VCE monitoring, 2x program. Fault INT pins, >120 V /ns CMTI ISO26262 compliant (ASIL-D)

GD3162 *– enhance SiC / IGBT gate driver*

GD3101: better integrate

GD310x: low-cost

Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	2019				2020				2021				2022				2023				2024		

Product Idea	Product Study	Approved Concept	In Development	In Production
not yet fully committed. Indicative timing only	Idea only, not yet fully committed, resource estimate. Indicative timing only after PI-gate	Product concept, indicative timing only after PCA-gate	Project, resources, timing committed, after PPA-gate	Product in production, after R-gate

△ ES
▲ CES   ★ Production
◆ CQS   (R-gate)

THE BENEFITS OF SILICON CARBIDE

What is Silicon Carbide?
- Semiconductor base material and epitaxi

Types of SiC Power Products:
- Schottky Diodes
- MOSFETs
- Standard packaged discrete, bare die and power modules

Silicon Carbide vs. Silicon in Similar Devices:
- Higher power conversion for given die size
- Faster switching speeds
- Improved thermal performance
  - Lower thermal impedance
  - Higher potential operating temperatures

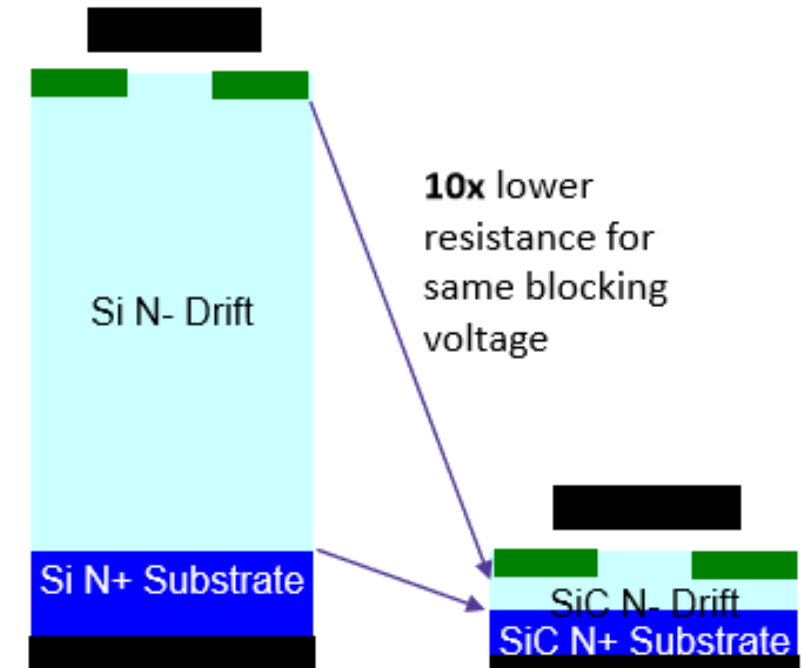## SiC ENABLES SYSTEMS THAT DELIVER UP TO:

50% Less losses

3X Smaller size

20% Lower system costs

WHEN COMPARED TO Si

SIC MATERIAL PROPERTIES

Materials property	Si	SiC-4H	GaN	Comment
Band gap (eV)	1.1	3.2	3.4	Higher temperature operation
Critical field (10^6V/cm)	0.3	3	3.5	Lower channel resistance; higher voltage
Saturated electron drift velocity (10^6cm/s)	10	20	25	Higher switching frequency
Thermal conductivity (W/cm^2K)	1.5	5	1.3	Better heat transfer

Si N- Drift

Si N+ Substrate

10x lower resistance for same blocking voltage

SiC N- Drift
SiC N+ Substrate

Realization of the switch with SiC is closer to an ideal switch!

INTRODUCING THE GD3160

Universal gate driver with wider parametric range covering <u>both</u> IGBT and SiC MOSFETs.

New features better enable SiC:

- Increased gate voltage range (23 V)
- Programmable gate regulator (14 – 21V)
- Enhanced SC detection (< 1.0 µs)
- Optimized Segmented Drive
- Additional report channel (INTA) for fault or real-time power device status
- Pin-to-pin compatible with GD3100

GD3160 datasheet is available → Docstore

GD3160 ARCHITECTURE & PRODUCT FEATURES
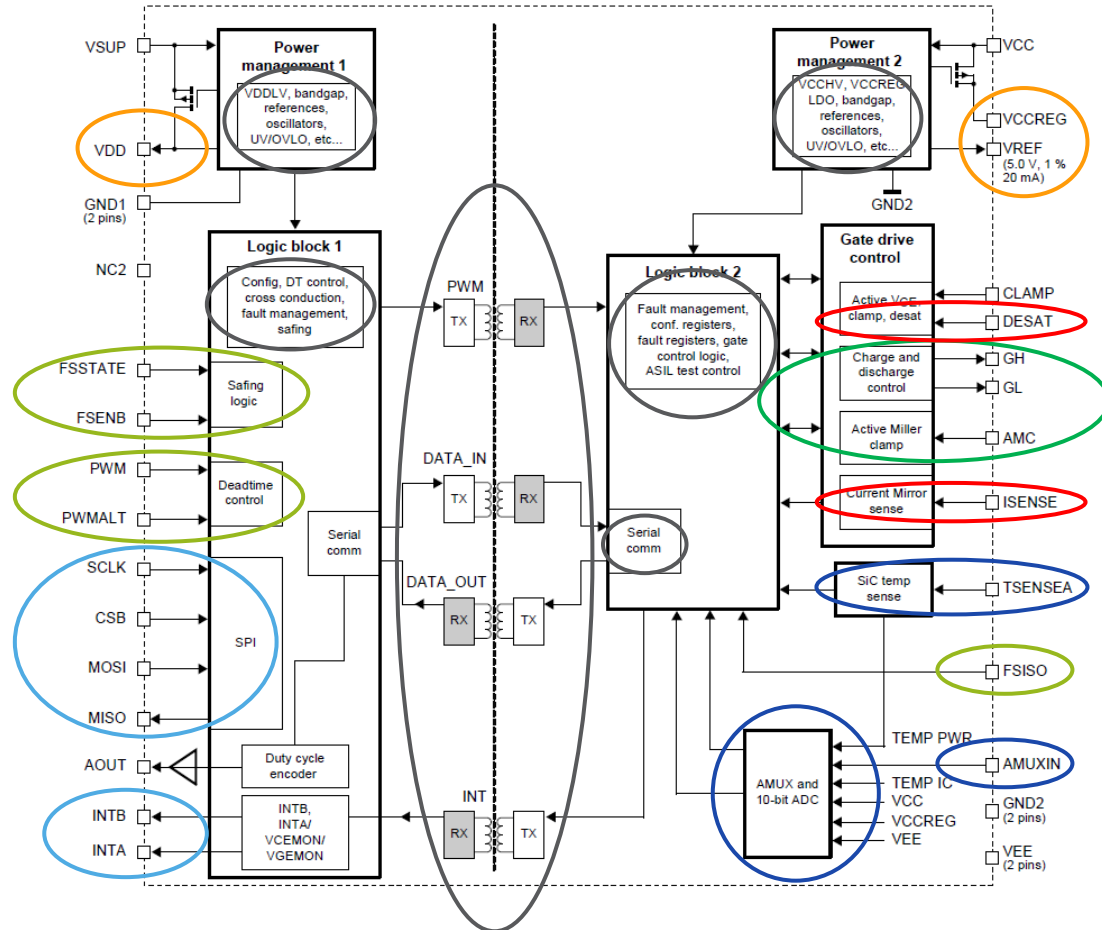
Features:

- ISO26262 ASIL C/D compliant
- Integrated galvanic isolation in compact 10 x 11 mm SOIC
- High gate current capability **15A** peak source/sink current
- Separate gate drive outputs (GL/GH) and integrated active miller clamp (AMC) reduce BOM
- Programmable fault response: Two Level Turn-off and Soft shutdown
- Fast short circuit protection via current-sense enabled power devices
- Programmable desaturation protection for standard IGBT/SiC.
- Integrated power device and IC temperature sense for system warning/shutdown
- Integrated ADC for monitoring and fault detection
- Programmable PWM deadtime & coherency check
- Failsafe state management from LV or HV side
- Integrated regulators for LV logic supply and HV gate supply/reference
- SPI bus for configuration, data, and error reporting
- INTB: System fault notification with < 1 µs response time
- INTA: Configurable report for fault or real-time power device status

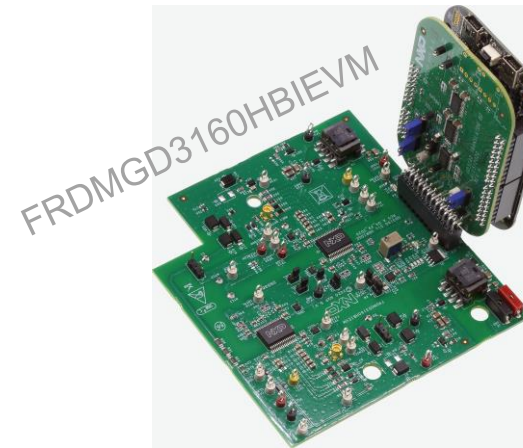| Part #	Option	Pkg	Release
PGD3160AM515EK	5.0V VDD	SOIC32	Samples
PGD3160AM315EK	3.3V VDD	SOIC32	Samples

32-Pin
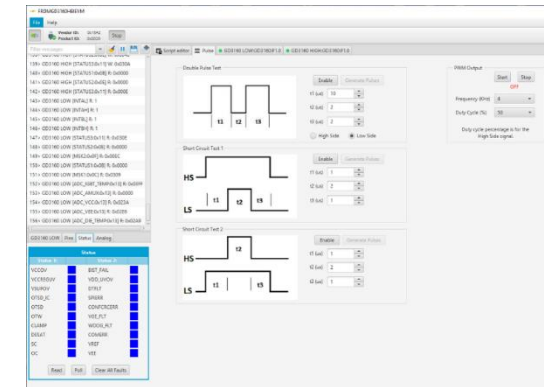SOIC-WB

GD3160 ENABLEMENT: DEVELOPMENT TOOL SUITE

- Hardware Development Tools
  - FRDMGD3160HBIEVM (Half Bridge board for HPDrive IFX, FlexGUI)
  - RDGD3160I3PHEVB (3PH Board HPDrive ST/Onsemi, No GUI)
  - FRDMGD3160XM3EVM(Half Bridge board for Cree XM3, FlexGUI)

- Software Development Tools
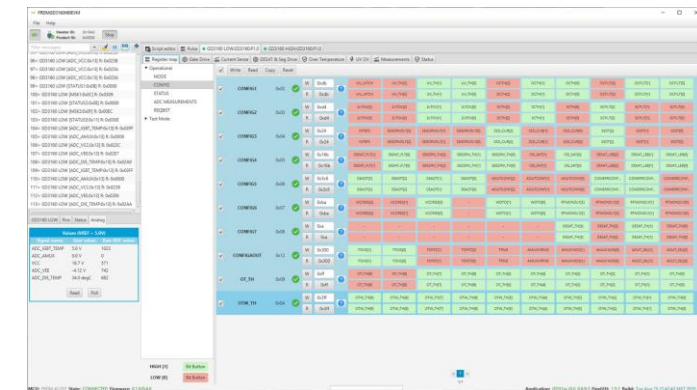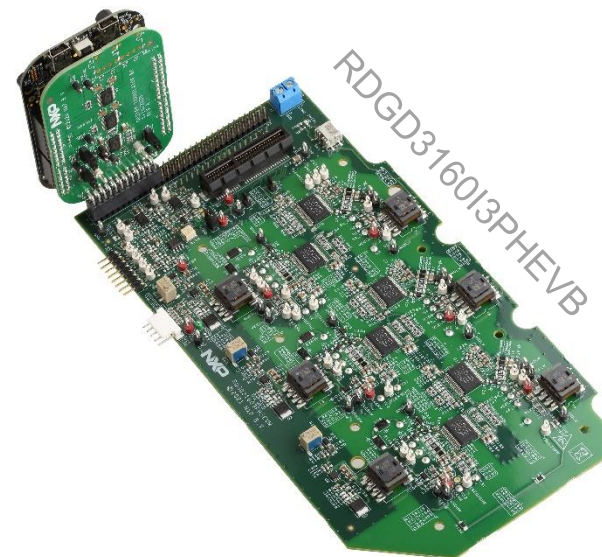 - HB EVB: SPIGEN USB to SPI interface
  - 3PH board: Sample Code, .c

- Relevant Documentation and Training
  - Full datasheet under NDA
  - Application note
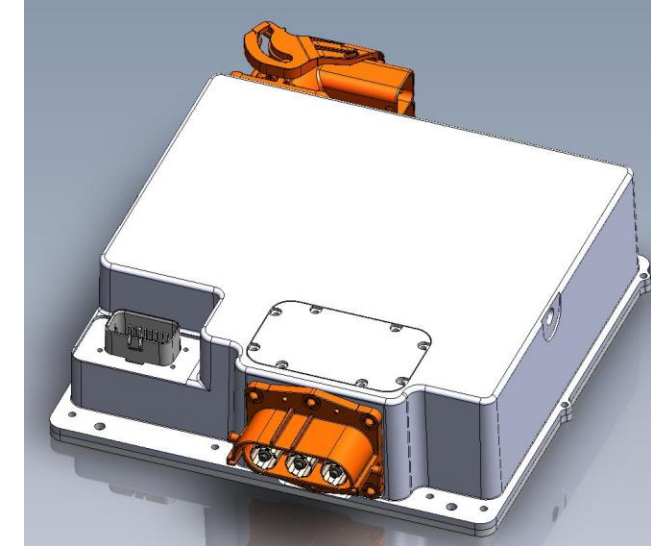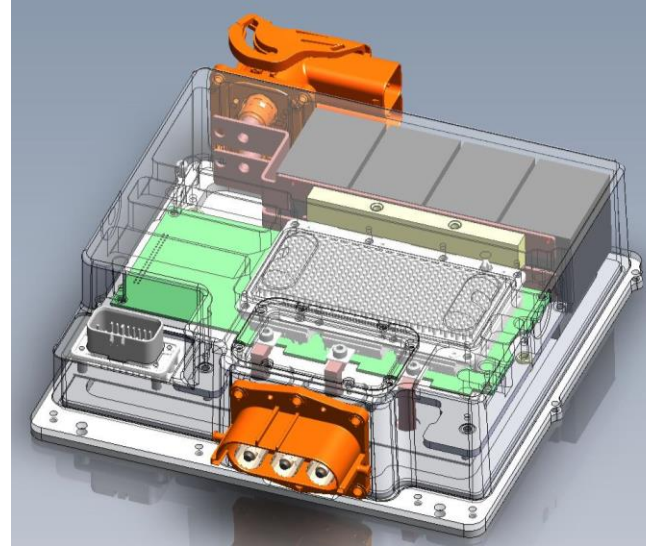 - All FuSa Doc/Certification

- Schedule:
  - GD3160 SOP in Dec 2021

FRDMGD3160HBIEVM

RDGD3160I3PHEVB

1ST GEN SIC MOSFET-BASED TRACTION MOTOR INVERTER PLATFORM

Inverter Performance Target:

- 3-phase PMSM motors
- Peak Power: **≥180 kW**
- Top speed: **≥15k rpm**
- Continuous current: >220 A, rms
- Peak current: >420 A, rms
- Min DC Link Voltage: > 350 VDC
- Max DC Link voltage: **600** VDC
- Power efficiency: >97%
- Power Device: 1200V/600A 13mOhm **Cree SiC MOSFET**s in StarPower P6 "HybridDRIVE" module:
- Target Power density: **> 20 kW/L**

❖ 30% increase in max DC Link voltage
❖ 40%-50% increase in max power output
❖ > 20% increase in max motor PWM frequency
❖ > 80% increase in power density

SiC MOSFETS offer a potential 5%-10% improvement in inverter efficiency (compared to IGBTs) and significant reduction in system thermal cooling

CREE ⇆ Wolfspeed.

NXP

VEPC⚙

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