Challenges and Opportunities in Powering Automotive SoCs

Raghu Nathadi, Sr. Marketing Manager

Nov 16, 2023

Webinar will begin at 8:00 AM PST | 11:00 AM EST | 5:00 PM CET

Agenda

1. Problems with today’s mobility
2. ADAS/AV market size
3. Evolution of automotive compute architecture
4. Traditional power management solutions
5. Advanced power management solutions
6. Example products from MPS

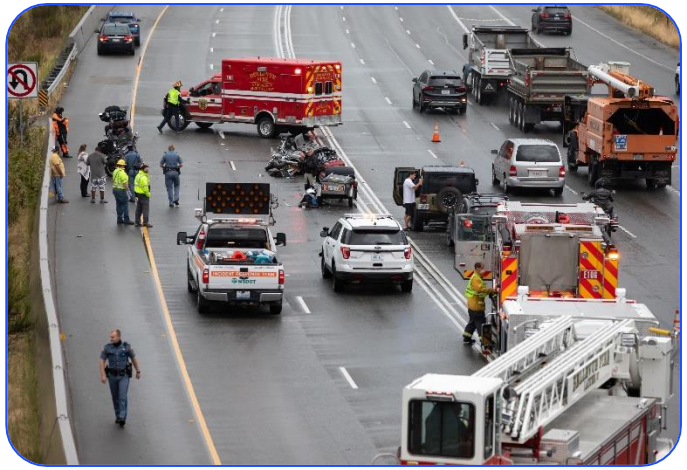
Automotive SoC Market Overview

Challenges with Today's Mobility

Today's mobility suffers from Congestion, Accidents, and Lack of Access

- Advanced driver-assistance systems (ADAS)
- Autonomous vehicles (AVs)
- Robotaxis / Shared Mobility

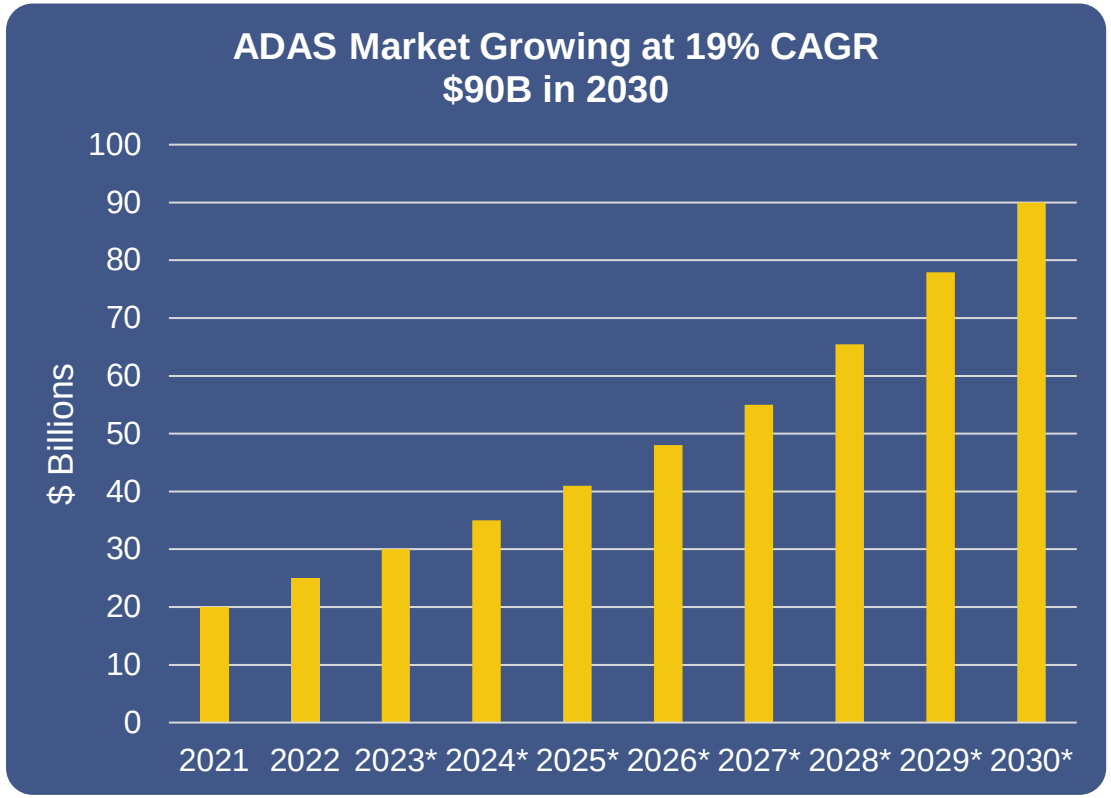
Convenient, Safe, & Economic Mobility



ADAS/AVs – Automotive's #1 Growing Sector

Catalysts for ADAS Growth:

- Increasing focus on safety
- Governments mandating use of advanced safety features
- Rising demand for comfort and luxury
- Heavy investments in technology & Infrastructure



Levels of Vehicle Autonomy

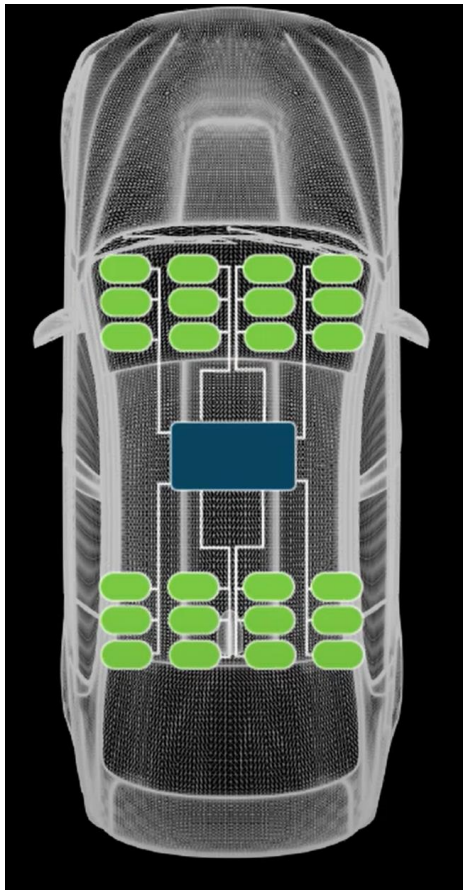
Vehicles are transforming into “servers on wheels” to enable higher levels of autonomy

Source: https://socionextus.com/blogs/design-demands-autonomous-electric-vehicles/

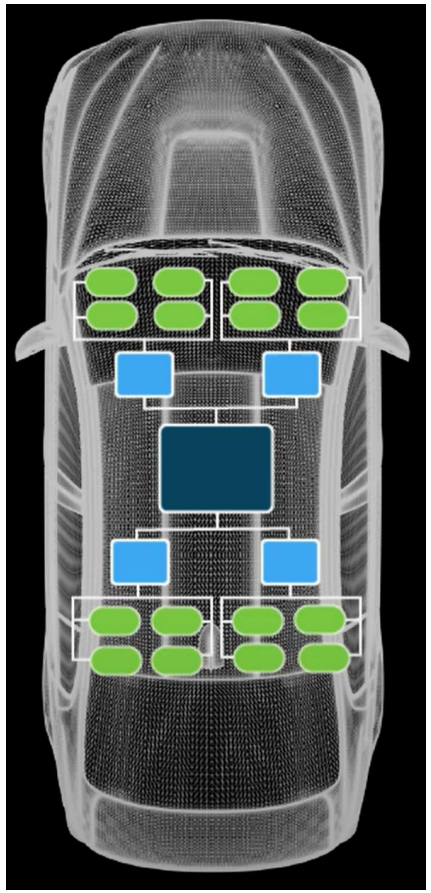
Evolving Vehicle Compute Architecture

ADAS and AVs are forcing the consolidation of ECUs, leading to a centralized compute architecture

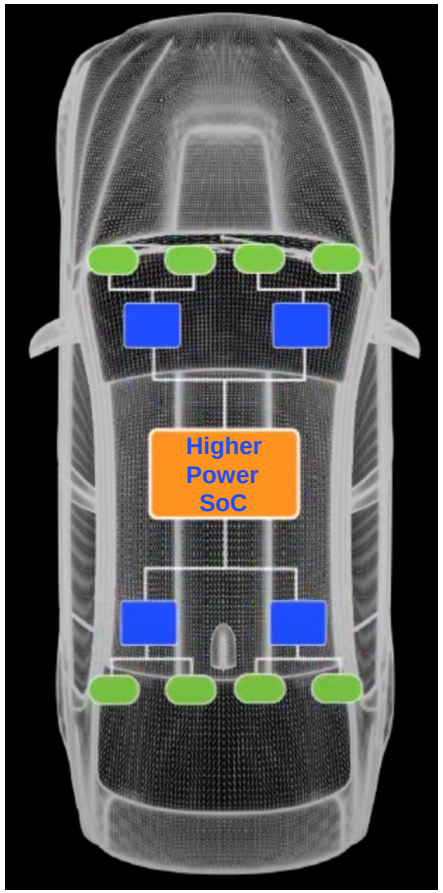
PAST (Distributed)



PRESENT (Domain ECUs)



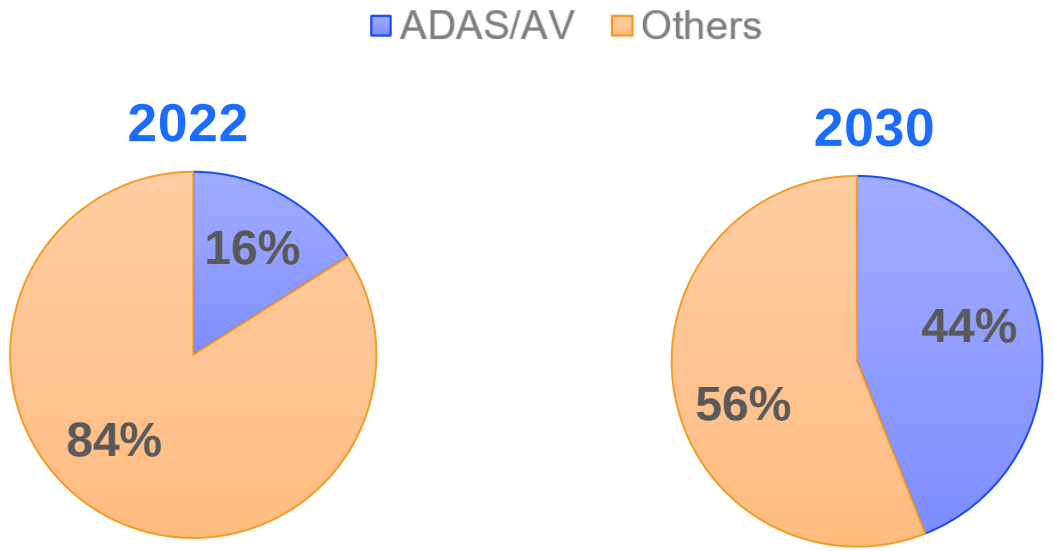
FUTURE (Central Computer)



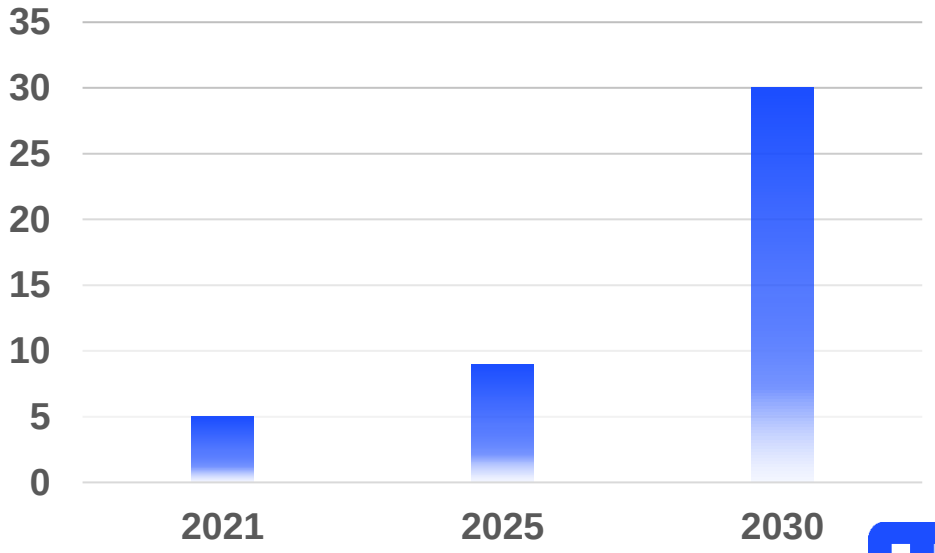
- Gateways
- Zone Controllers
- Central Computer
- Domain ECUs
- ECUs

Rising ADAS/AV SoC Spend

ADAS/AV SoCs will be 44% of total processor spend in a vehicle by 2030



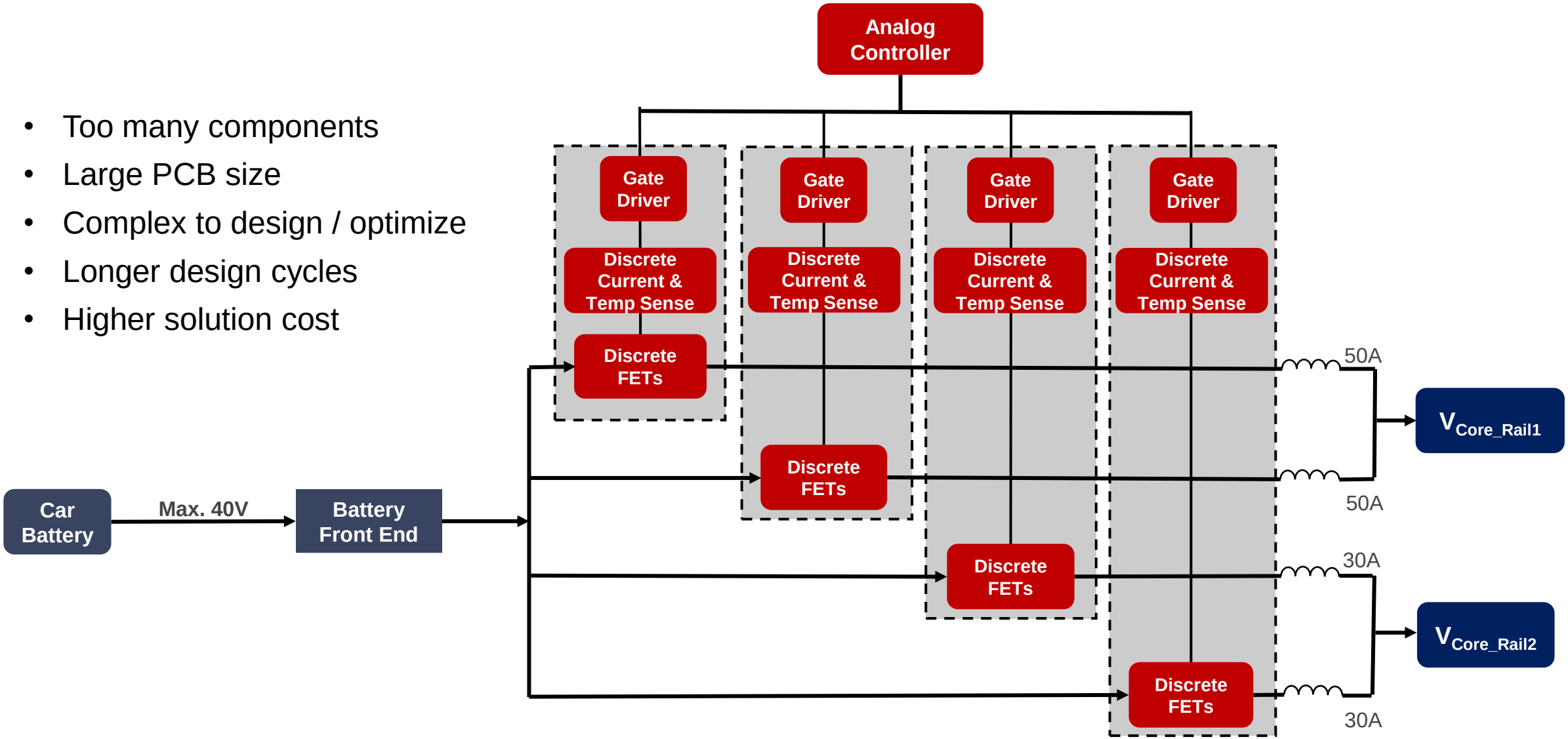
ADAS/AV SoC market will be $30B by 2030 at 26% CAGR from 2025–2030



Automotive SoC Power Architecture

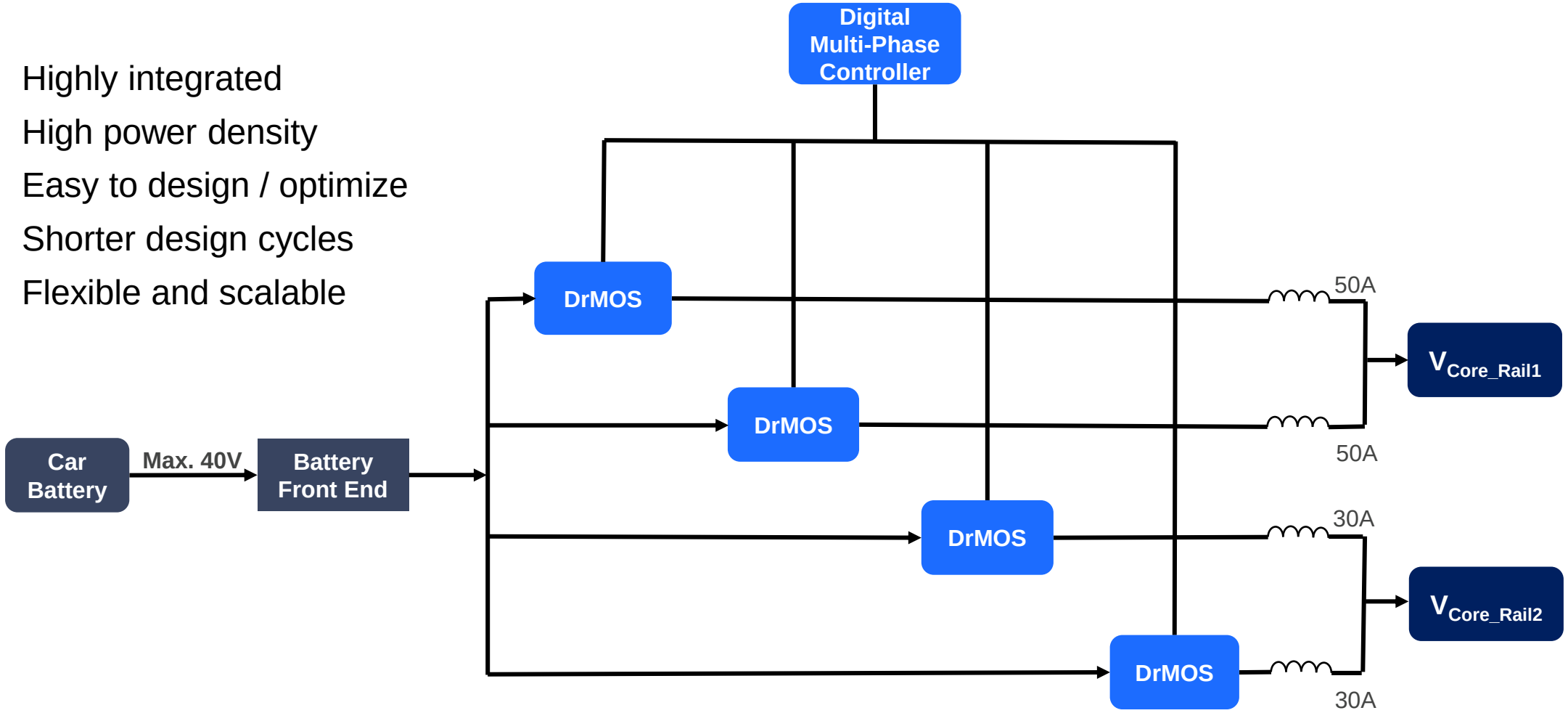
Traditional Solution with Discrete Components

- Too many components
- Large PCB size
- Complex to design / optimize
- Longer design cycles
- Higher solution cost

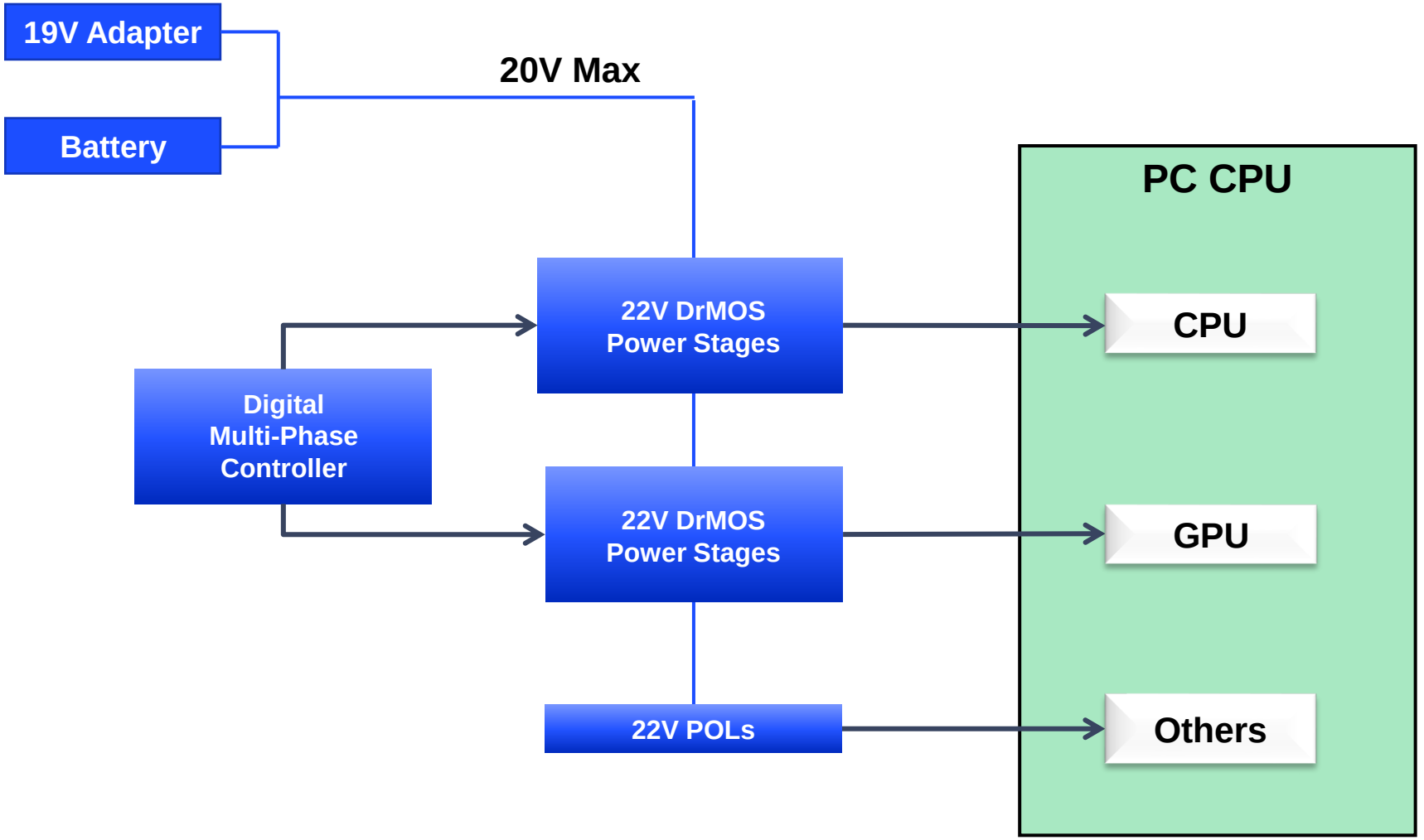


Advanced Solution with Digital Controllers + DrMOS

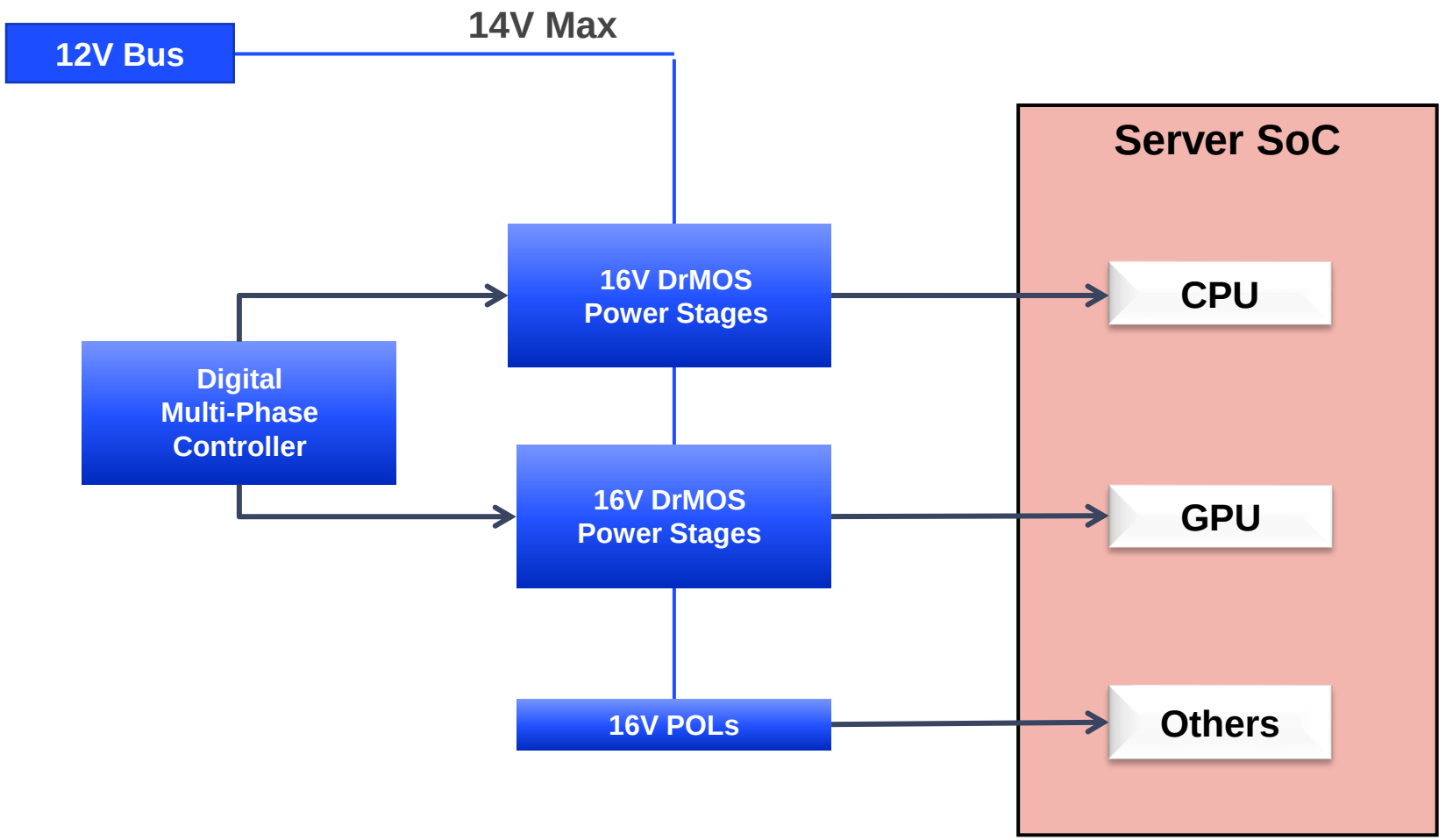
- Highly integrated
- High power density
- Easy to design / optimize
- Shorter design cycles
- Flexible and scalable



PC SoC Power Architecture

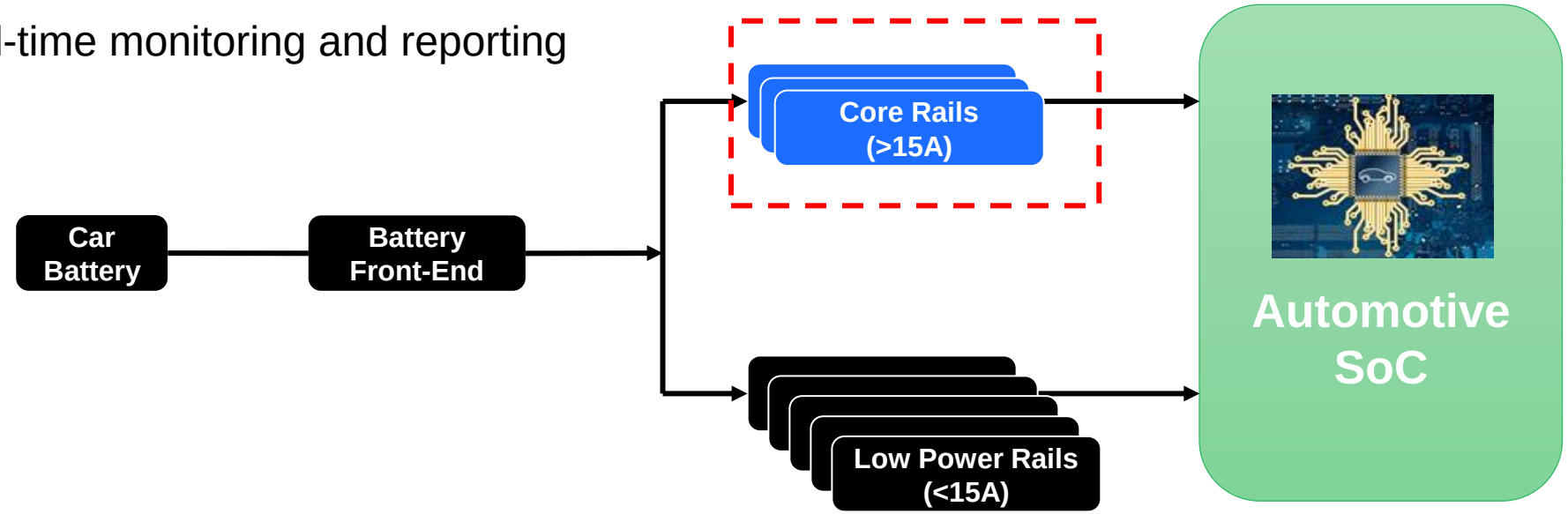


Server SoC Power Architecture



Automotive SoC Power Architecture

- Similar power architecture to PC and server SoCs
- Low-current rails can use PMICs or discrete point-of-load (POL) converters
- High-current core rails require advanced power management solutions for:
    - High efficiency
    - Fast transient response
    - Dynamic voltage/frequency scaling
    - Real-time monitoring and reporting



Automotive SoC Power Key Requirements

Important for SoC power in any market application

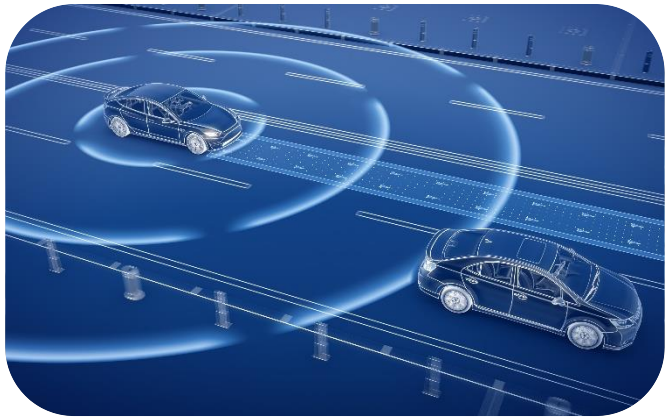
- High efficiency
- High power density
- Fast transient response
- Dynamic voltage/frequency scaling
- Real-time monitoring and reporting
- Scalability and flexibility

Added requirements for automotive SoC power

- AECQ qualification
- ASIL Functional Safety

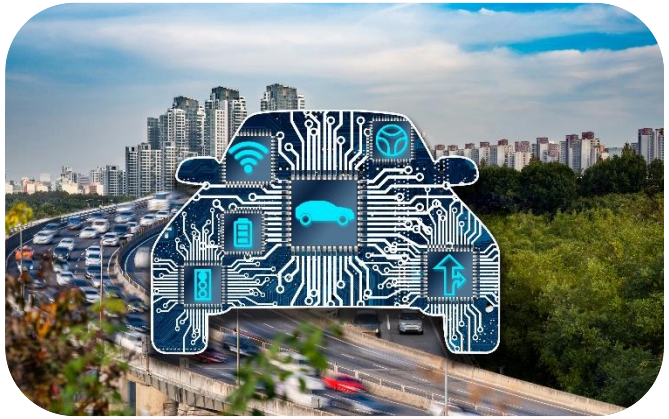
MPS's Experience Powering SoC Core Rails

- Generations of SoC core power leadership in PC, server, and datacenter markets
- Applying the same winning technology and know-how to automotive SoC core power
- Ground-up design to meet AECQ qualification
- MPSafe™ ASIL-D Functional Safety



ADAS

Infotainment



High-Performance Computing

Digital Controller + DrMOS = Efficient, Compact Solution

Digital Control

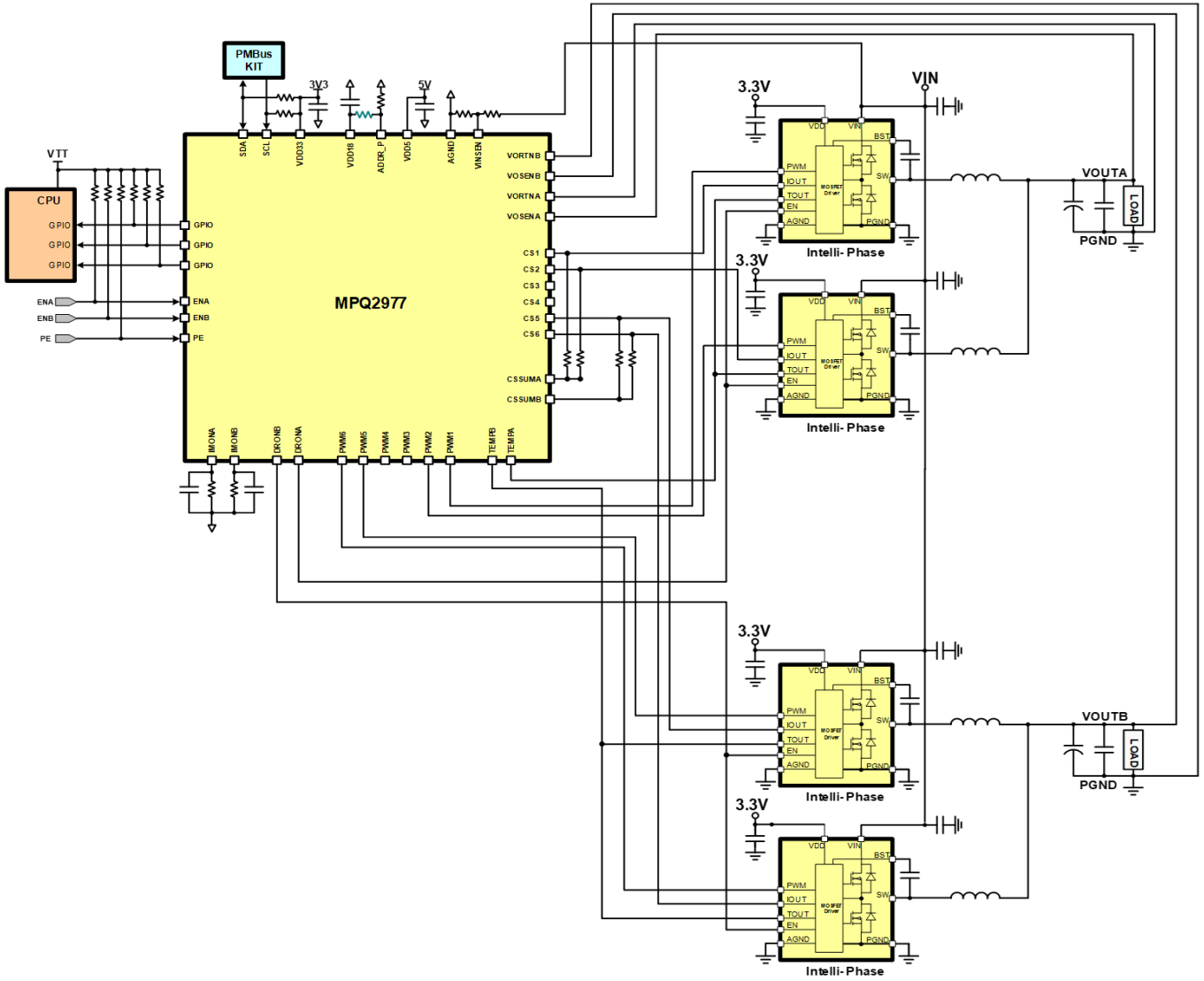
- Easy compensation
- Fast transient response
- Better current balancing
- Programmability and flexibility
- Real-time monitoring and reporting
- Comprehensive protection

Monolithic DrMOS

- Monolithic design → fewer components, more robust
- Switching loss reduction → higher efficiency
- Superior current-sense accuracy

Fewer External Components

- Lower cost
- More compact design



Single-Stage / Two-Stage Power Architecture

MOSFET Figure of Merit (FoM)

- Lower FoM could be realized with a device with lower voltage ratings:
  - Lower $R_{DS(ON)}$ reduces the power MOSFET's conduction loss
  - Lower Qg value reduces the power MOSFET's switching loss
  - The size of the power MOSFET can be reduced to realize the same or lower $R_{DS(ON)}$

V_{DS_MAX} Rating	25V	30V	40V	60V
$R_{DS(ON)} \times Q_g$ (mΩ·nC)	23.1	37	57.6	93.6
$R_{DS(ON)}$ (mΩ)	2.2	2.4	3.6	3.9
Q_g (nC)	10.5	15.4	16	24

12V Battery: Single-Stage Power Conversion

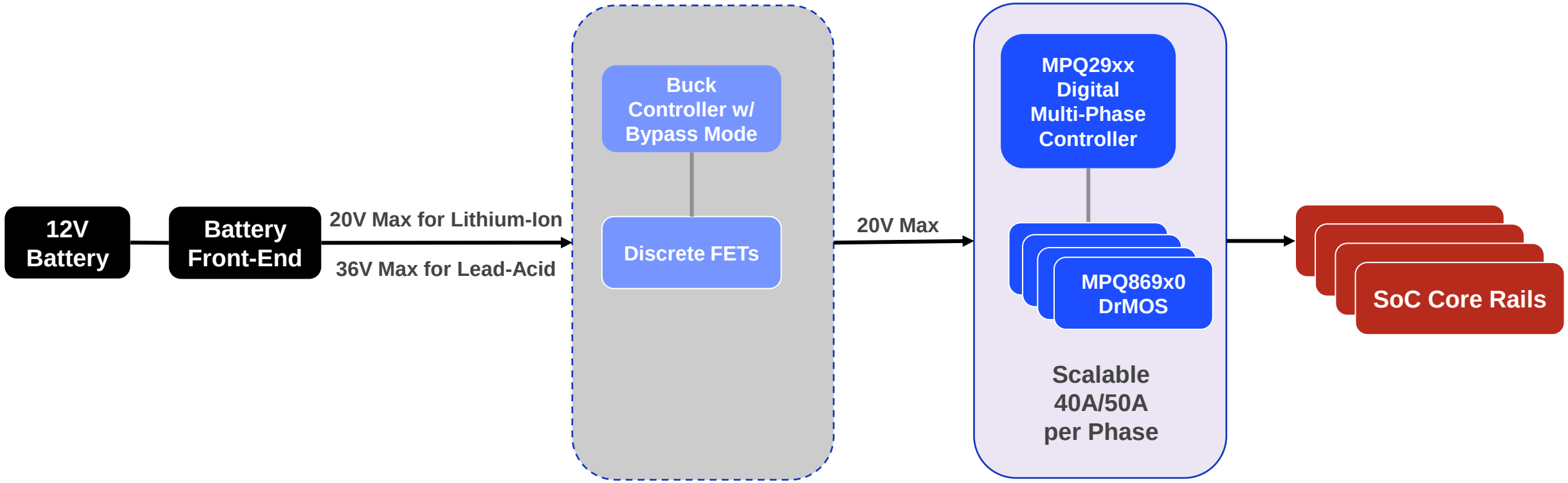
Optional Pre-Regulator

Just a pass-through when V_{IN} < 20V

Step-down during V_{IN} transients > 20V

Multiple High-Current SoC Rails

Scalable 22V DrMOS Power Stages



MPQ2967 – 2-Rail, 4-Phase Digital Controller

CUSTOMER BENEFITS

- ACP™ for lower output capacitance and predictable EMI
- Digital control for flexibility, optimized tuning, and fast design cycles

FEATURES

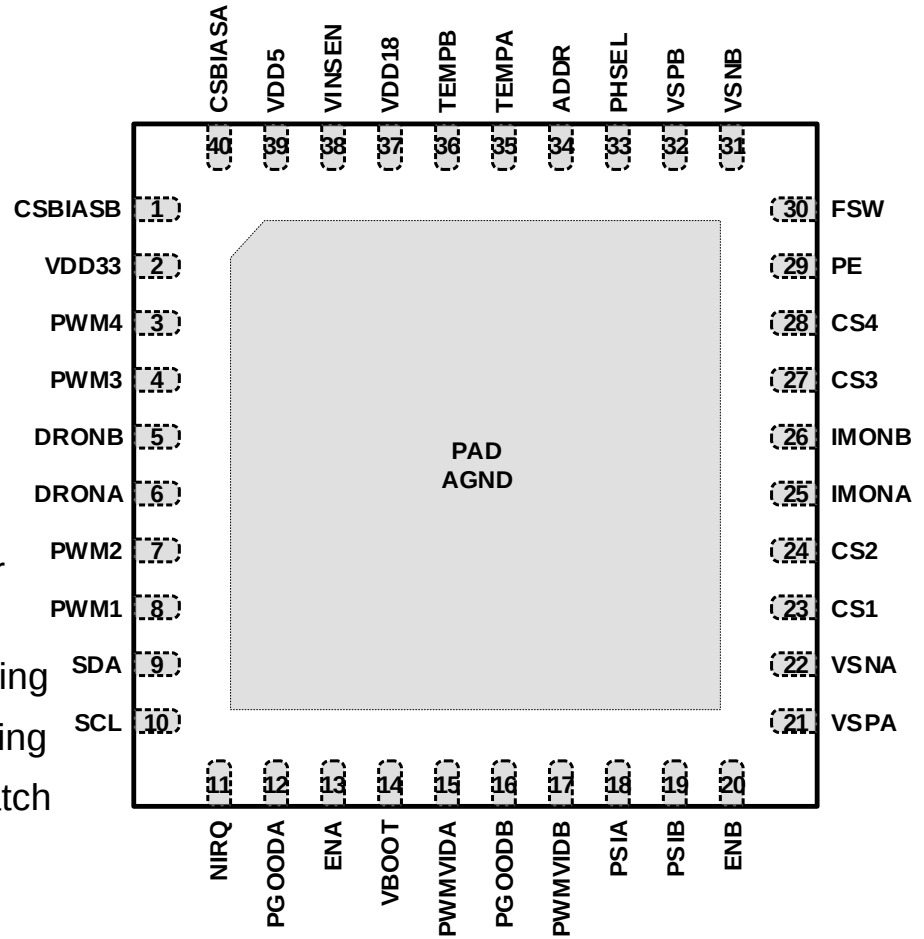
- Digital interface for programming and monitoring
- PWM-VID interface compliant
- Built-in multiple-time programmable (MTP) memory to store custom configurations
- Under-voltage lockout (UVLO), over-voltage protection (OVP), under-voltage protection (UVP), over-current protection (OCP), and over-temperature protection (OTP) with register telemetry flag
- Input voltage (V_{IN}), output voltage (V_{OUT}), output current (I_{OUT}), and regulator temp monitoring
- Automatic loop compensation, phase-shedding, and phase-to-phase active current balancing
- Runtime register cyclic redundancy check (CRC), and packet error checking (PEC) mismatch check
- Separate EN for each rail

APPLICATIONS

- Automotive SoC core rails

MPSafe™ ASIL-D

Released



Available in a QFN-40 (6mmx6mm) Package with 0.5mm Pitch

MPQ86960 – 50A Intelli-Phase™ DrMOS

CUSTOMER BENEFITS

- Monolithic design offers higher switching frequency to reduce inductor and capacitor size
- Optimized process technology for best efficiency to extend EV battery range

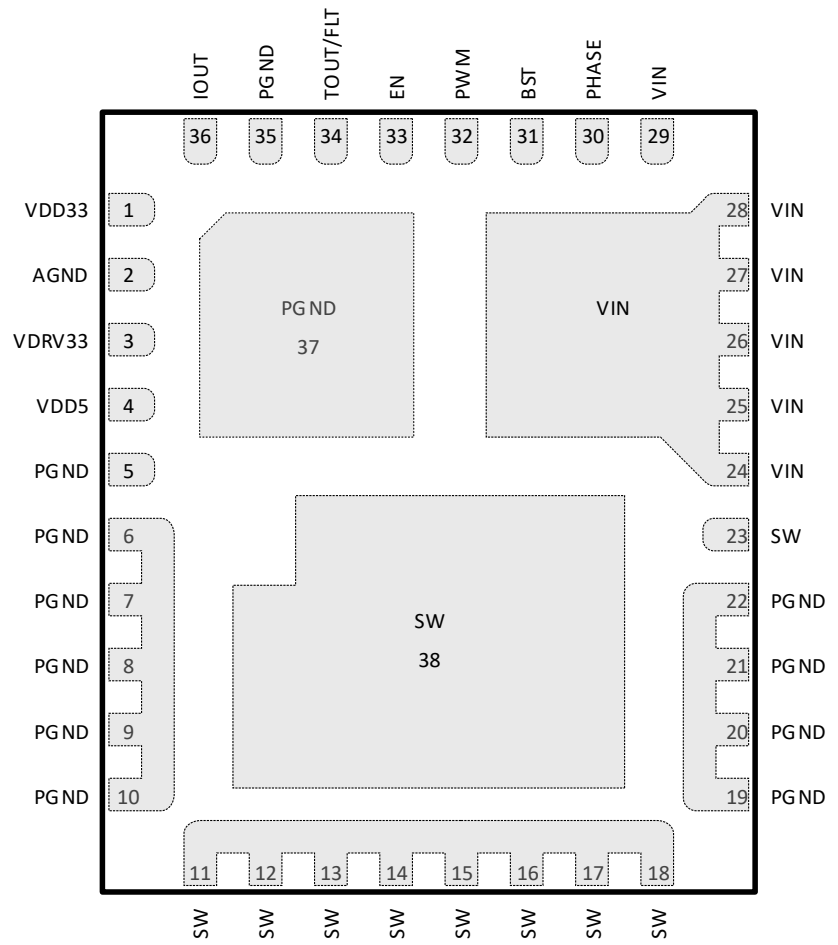
FEATURES

- Wide 3V to 22V operating input voltage (V_{IN}) range
- 5V VDD input
- VDRV33 and VDD33 supported by internal low-dropout (LDO) regulator
- Accu-Sense™ current sensing
- Temperature sensing
- Accept tri-state PWM input
- Current-limit protection
- Over-temperature protection (OTP)
- Fault reporting

APPLICATIONS

- Automotive SoC core rails

Released

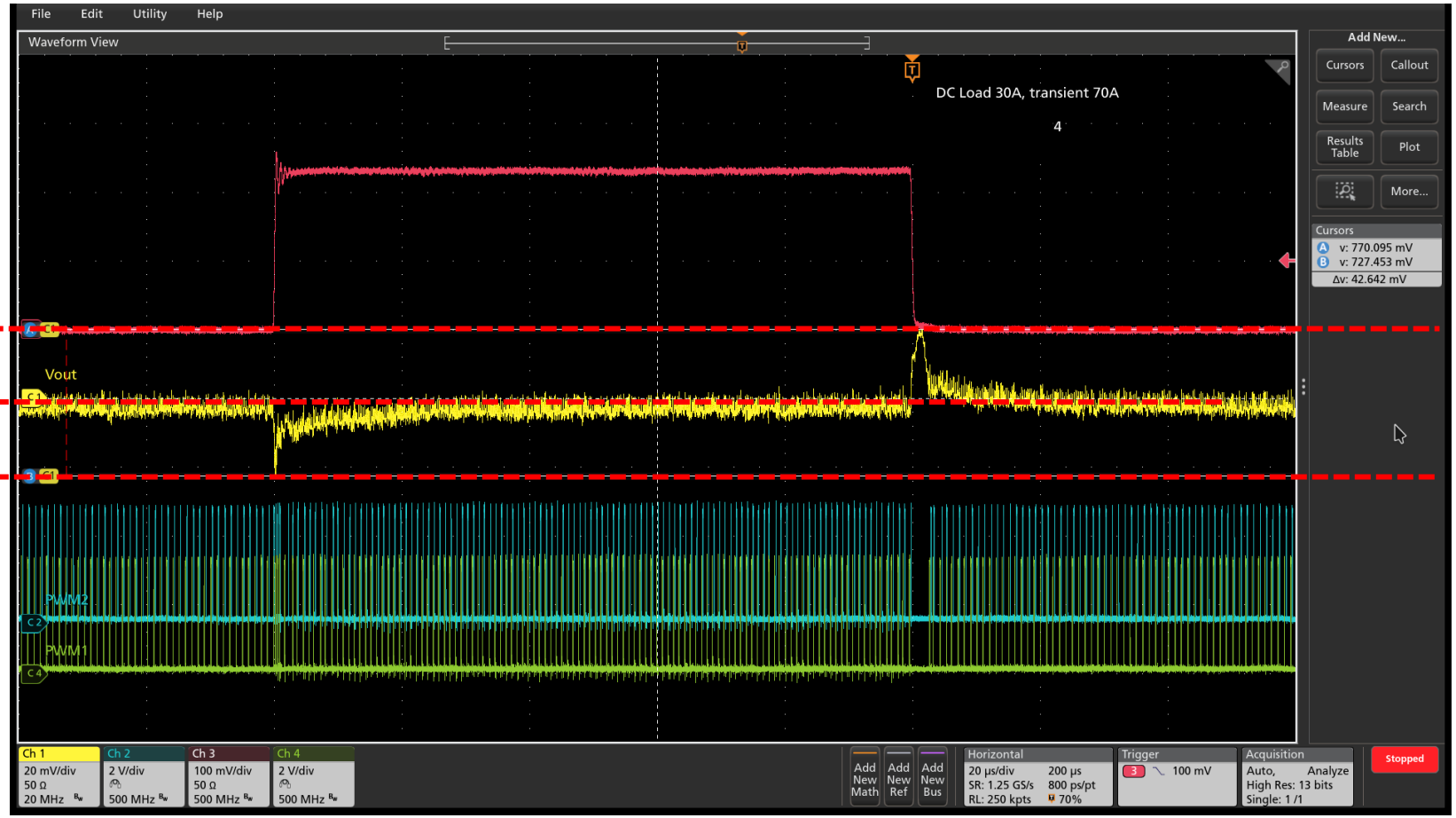


Available in an LGA (5mmx6mm) Package

Design Example: MPQ2967 + MPQ86960

950mm^2 PCB size, 90% peak efficiency

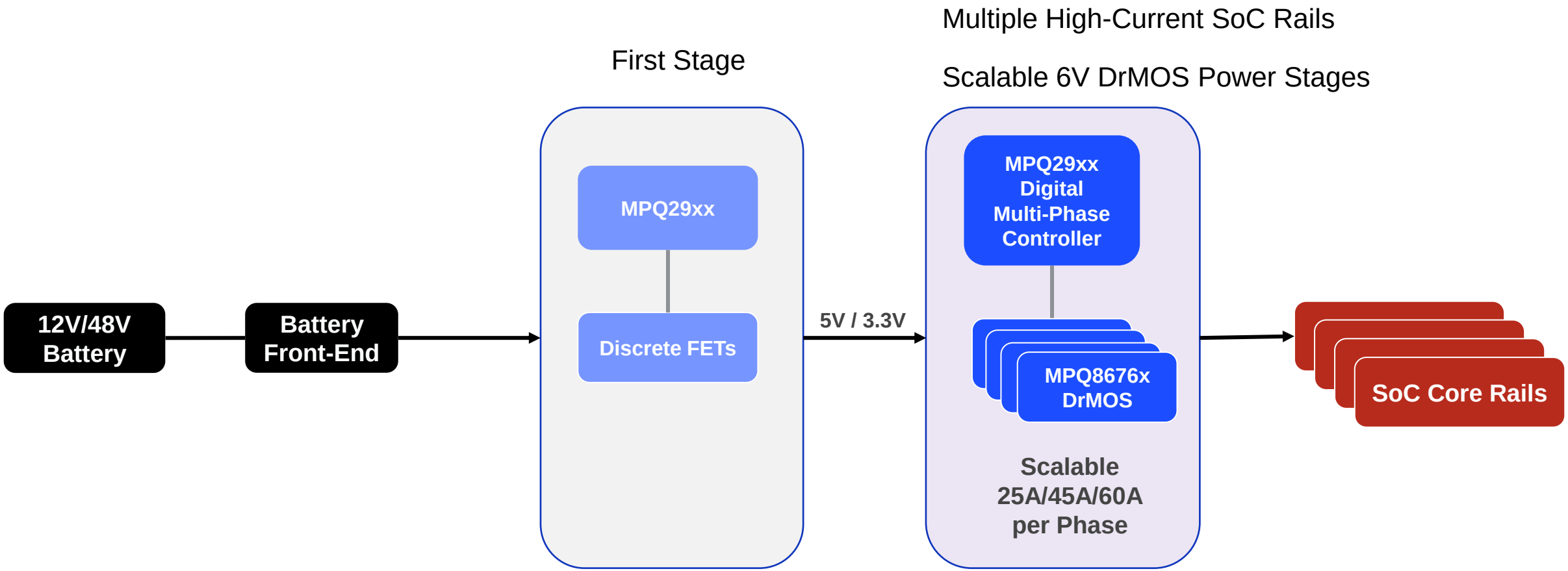
Test Conditions: V_{IN} = 12V, load step = 30A to 100A at 100A/µs slew rate, V_{OUT} = 0.75V / 100A, transient tolerance = ±22.5mV (3%), f_{SW} = 500kHz



Overshoot: 20.1mV

Undershoot: 22.5mV

12V/48V Battery: Two-Stage Power Conversion



MPQ86760 – 45A Intelli-Phase™ DrMOS

Released

CUSTOMER BENEFITS

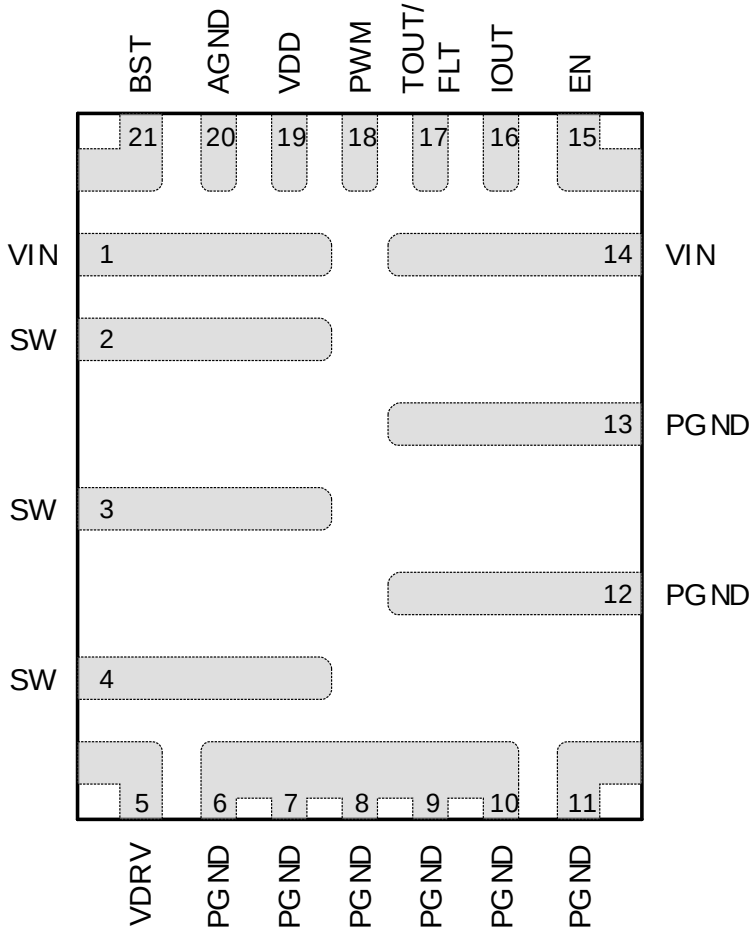
- Monolithic design offers higher switching frequency to reduce inductor and capacitor size
- Optimized process technology for best efficiency to extend EV battery range

FEATURES

- 3V to 6V operating input voltage (V_{IN}) range
- 3.3V VDRV/VDD input
- 45A continuous output current (I_{OUT})
- Accu-Sense™ current sensing
- Temperature sensing
- Accept tri-state PWM input
- Current-limit protection
- Over-temperature protection (OTP)
- Fault reporting
- Ultra-low quiescent current (I_Q)

APPLICATIONS

- Automotive SoC core rails

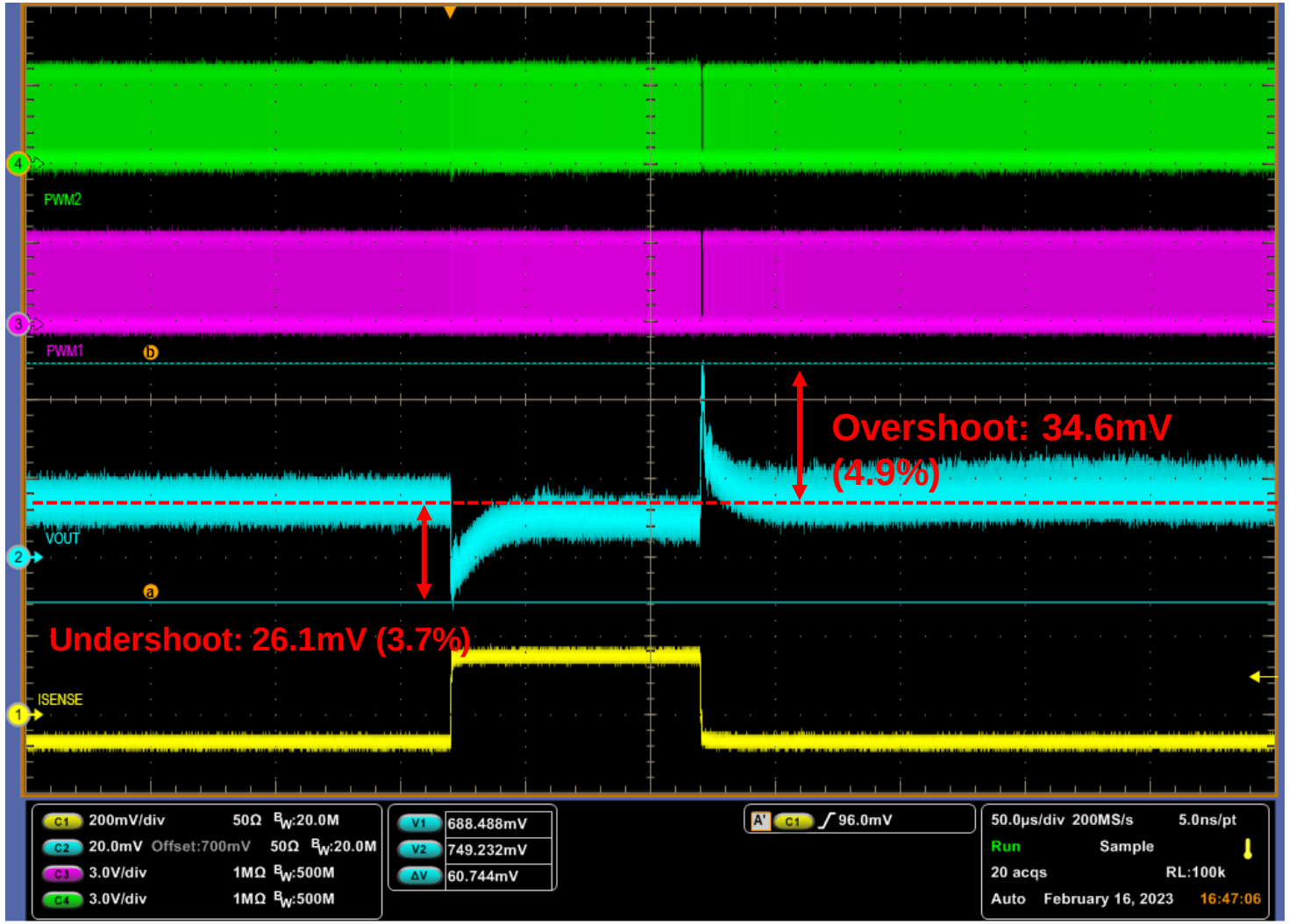


Available in a TQFN-21 (4mmx5mm) Package

Design Example: MPQ2946 + MPQ86760

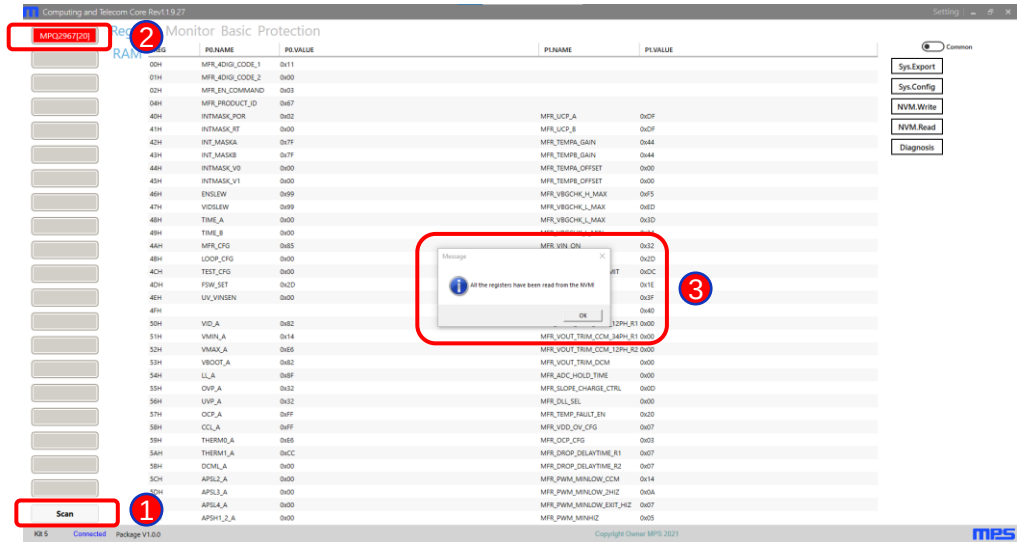
770mm^2 PCB size, 88% peak efficiency

Test Conditions: V_{IN} = 5V, V_{OUT} = 0.7V, I_{MAX} = 150A, I_{DC} = 90A, I_{OUT} = 20A to 90A @ 100A/µs, f_{SW} = 2MHz



GUI for Design / Development

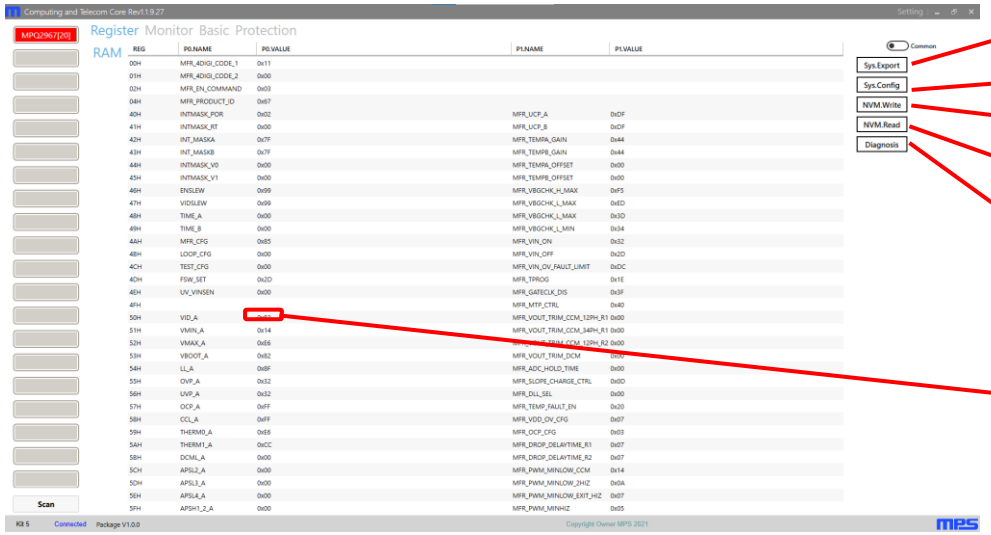
- GUI is available with EVBs
- Quick PC set-up
- Read and monitor registers
- Write and rewrite
- Helps reduce design time



① → Click the “Scan” button.

② → Select the target device.

③ → Wait until the “Message” window prompts, then click “OK” to load the selected device.



Export the configuration code from the selected device.

Import a configuration code to the selected device.

Store the RAM contents to the NVM.

Restore the MTP contents to the RAM.

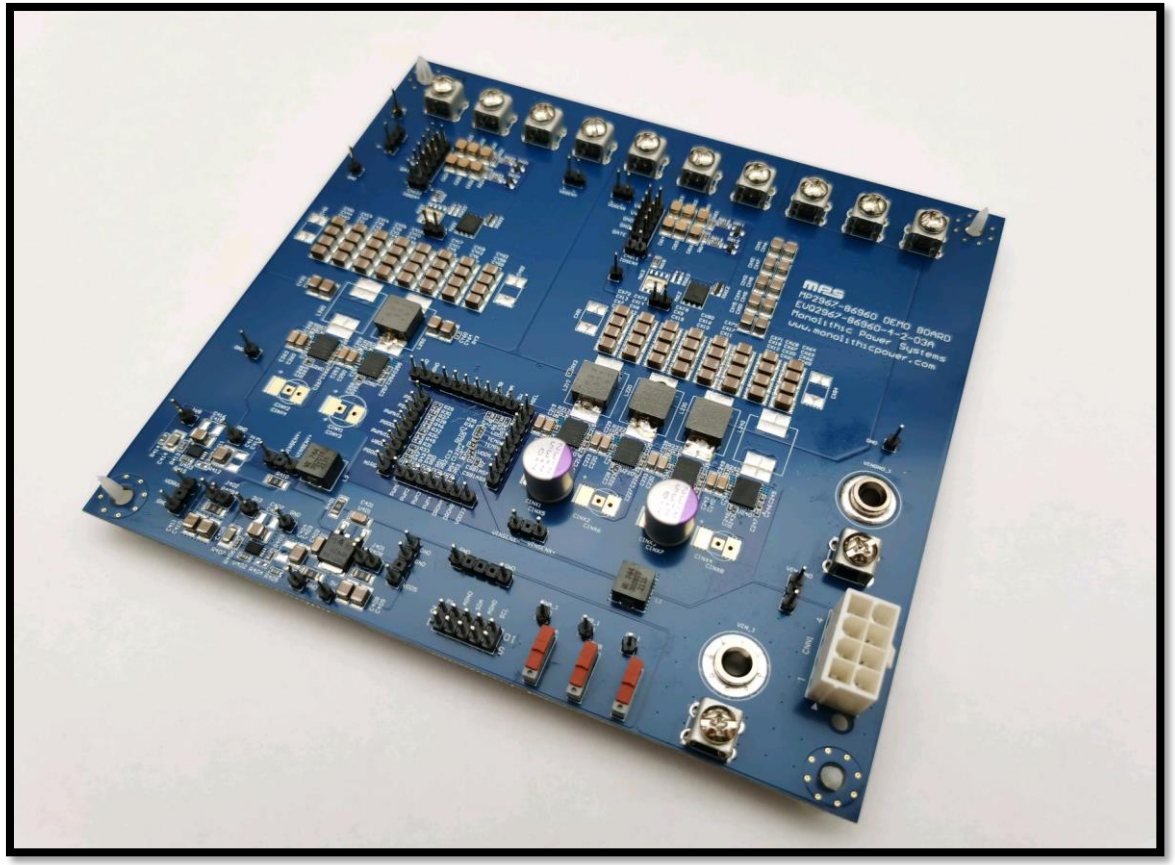
Check the differences between the configuration files.

Double-click “P0.VALUE” to prompt the sub-window, which shows the detailed register configuration

Evaluation Boards

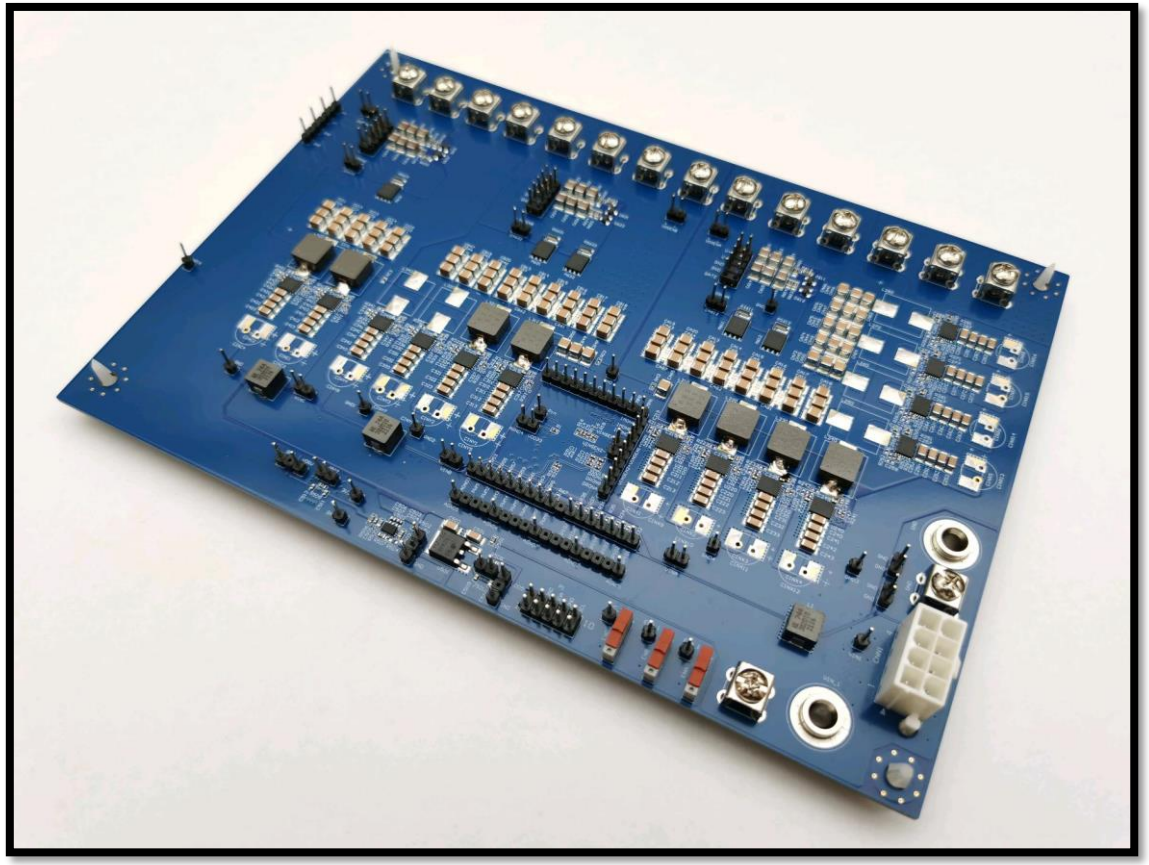
MPQ2967: 2-Rail, 4-Phase Digital Controller

MPQ86960: DrMOS Configured as 3 + 1



MPQ2977: 3-Rail, 8-Phase Digital Controller

MPQ86760: DrMOS Configured as 4 + 2



Summary

Summary

- The automotive industry is undergoing a digital transformation to solve problems with today's mobility
- The ADAS/AV market is skyrocketing with rising demand for automotive safety and comfort
- Powerful SoCs are at the center of automotive central compute architecture
- Automotive SoCs require advanced power management solutions for core rails
- PC, server, and datacenter applications used digital multi-phase controllers + DrMOS for generations
- MPS is well-positioned with a broad portfolio of ***AECQ digital multi-phase controllers + DrMOS*** products

Q&A