

A perspective view of a long, symmetrical aisle in a datacenter. On both sides are tall racks of server equipment, each with numerous glowing indicator lights in shades of blue, green, and yellow. The floor is dark and reflective, showing the racks and lights. A bright orange path runs down the center of the aisle, flanked by glowing blue lines. In the distance, the aisle leads to a brightly lit exit or another section of the facility.

# 48V Datacenter Solutions

DC/DC Power Conversion for Datacenter, Open Compute & AI Applications

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# Overview

Today's datacenters use an average of 3kW to 5kW per rack to power server, storage, and networking racks. Most are designed to power basic CPUs and to operate at high levels of efficiency. Hence, the traditional 12V power architecture has been widely accepted and implemented (see Figure 1).

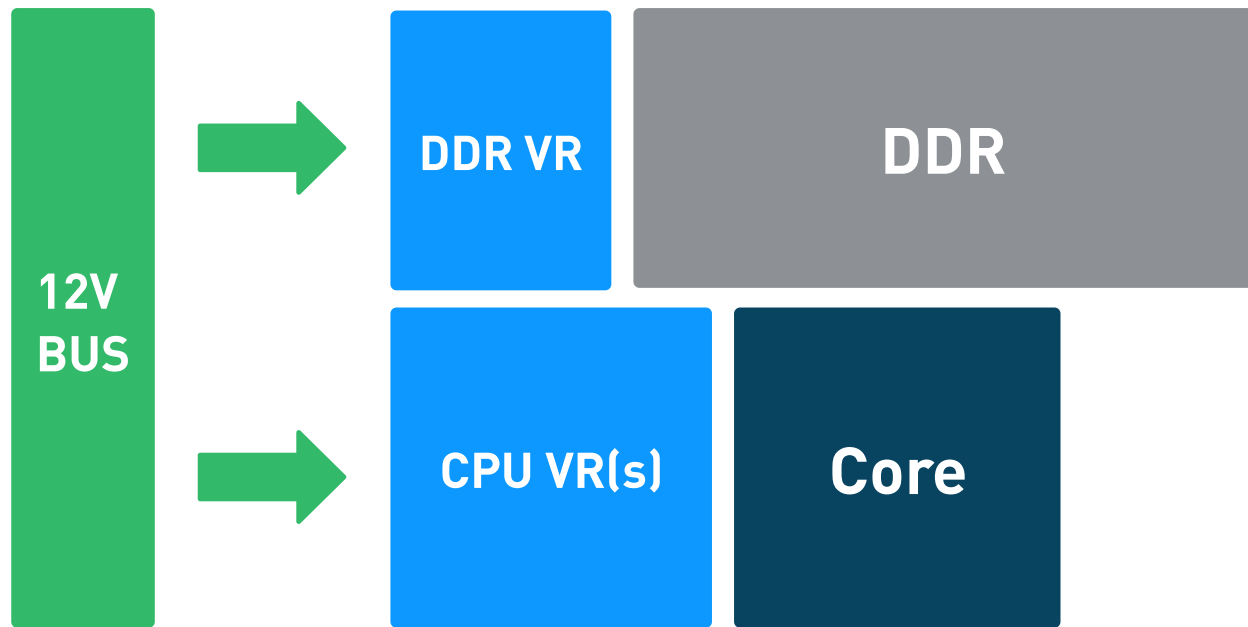


Figure 1: Traditional 12V Power Distribution

As the demand for cloud computing, AI applications, machine learning, high-performance computing, and supercomputers grows, datacenters are evolving to accommodate new, higher power requirements. For example, an early AI market supercomputer required 3200W for the entire power system. The second generation's power demand increased threefold, resulting in 10kW for the entire power system. Since the power lost in distributing high current increases by the square of the current ( $I^2R$ ), more copper must be used in the backplane or wiring harness to control the distribution losses. Ultimately, this limits the power delivery of the system.

In order to meet the industry's new power requirements, MPS has developed a new power architecture, using a 48V distribution voltage that is capable of a 16x reduction in power distribution losses, in addition to presenting a 48V datacenter solution to address new design challenges.

# MPS 48V Power Structure

## 48V Power Structure: MPS's New 48V to 4.8V System

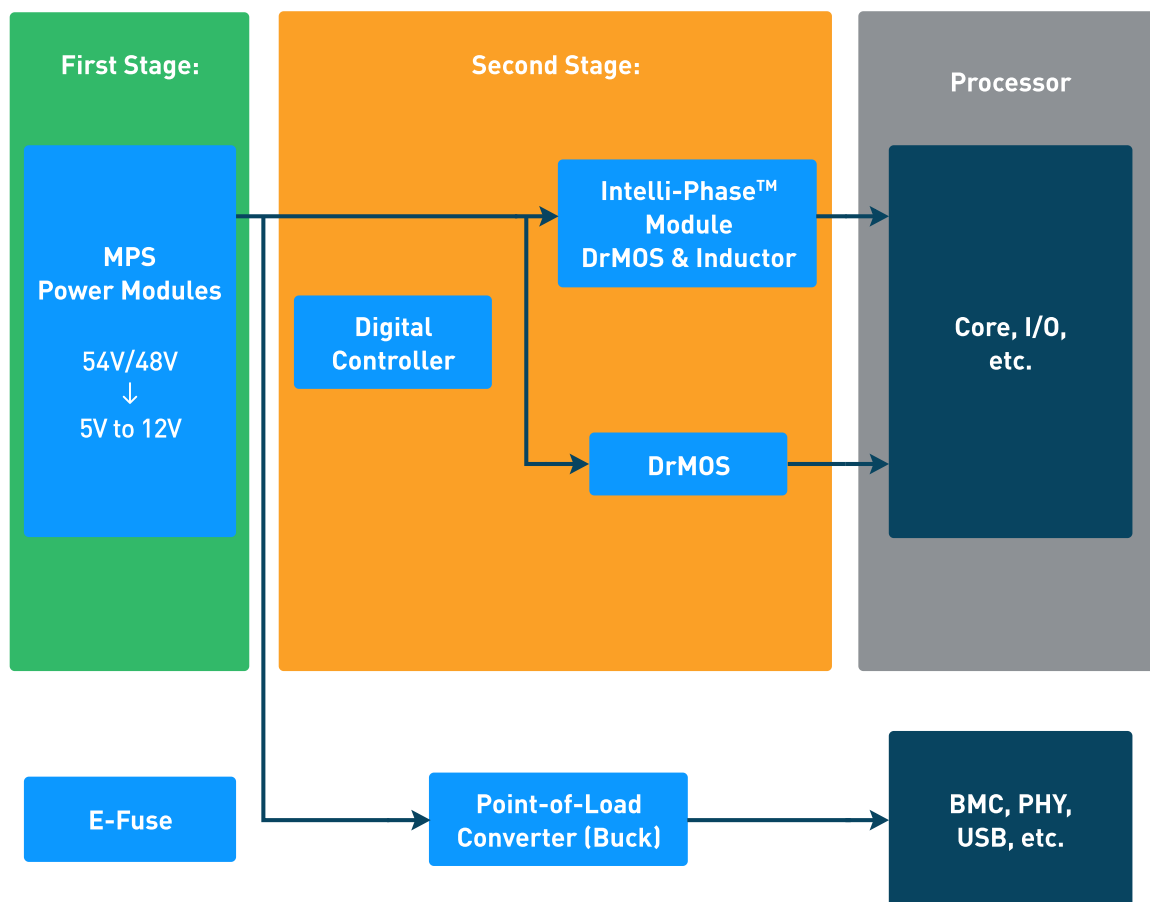


Figure 2: 48V Power Structure – MPS 4V to 6V System

- Total system efficiency is greatly optimized
- First-stage solution: MPS LLC power modules
  - 10:1 input-to-output ratio
  - Offered at various power levels
  - Parallel operation
- Second-stage solution: digital multi-phase controller + Intelli-Phase™ or Intelli-Module
  - The Intelli-Phase™ family offers continuous current ratings up to 90A
  - Intelli-Module solutions offer continuous current ratings up to 170A
- E-Fuse

Intelli-Modules are MPS's latest open-frame power modules, and are part of our second-stage solution. Intelli-Modules can achieve high power density and optimize thermal performance in space-constrained applications.

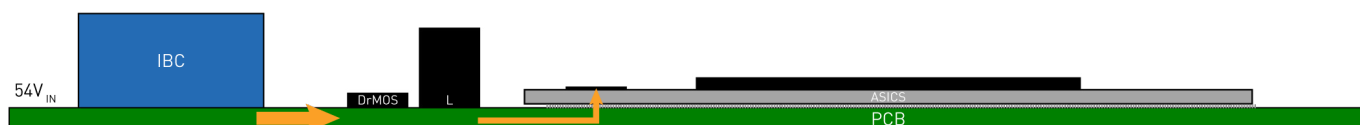
Intelli-Phase™ is MPS's state-of-the-art power stage technology. MPS's DrMOS uses our monolithic process to drastically improve performance, and incorporates advanced features, including current sense, temperature sense, and fault reporting.

## Lateral vs. Z-Axis Power Delivery™

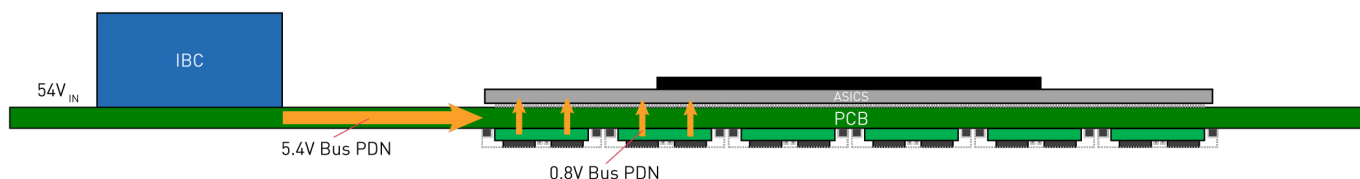
Today's datacenters use a lateral power delivery system, in which the power voltage regulators are placed on the top side of the board around the processor. As the current demand of CPUs and GPUs increases, the distance between the voltage regulator and the point of load become a significant factor for PDN losses. In addition, increased PDN means that the system requires a large amount of output capacitance for the voltage regulators.

Z-Axis Power Delivery™ is a method by which the voltage regulators are placed on the bottom side of the PCB below the processors. This results in a significant reduction (more than 10x) in PDN losses.

### Lateral Power Delivery <1000A



### Z-Axis Power Delivery™ >1000A



MPS offers power module solutions with <4mm height to fit in the limited space on the bottom side of the PCB.

**Contact MPS for more information on Z-Axis Power Delivery™ EVBs**

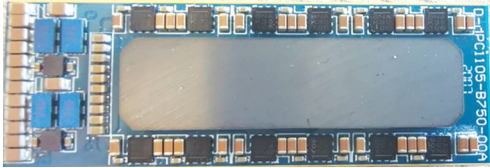


# First-Stage Solution: Power Modules

MPS offers multiple options for first-stage modules

## 10:1 IBC Modules

54V to 5.4V

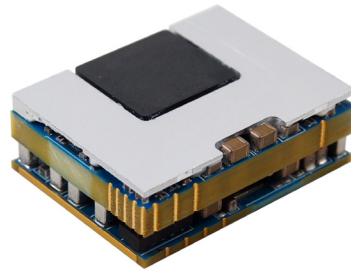


Enables a higher frequency second stage due to lower switching losses, which allows the use of a smaller, shorter inductor

- Best for Z-Axis Power Delivery™ (ZPD)

## 4:1 IBC Modules

54V to 13.5V



Higher power density, established common footprint in the market

- Best for lateral power delivery (LPD)

All of MPS's IBC modules can be paralleled to reach >1kW power levels.  
An application note with additional details is in development.

## MPC1100C-54 – High-Efficiency, Non-Isolated, Fixed-Ratio Digital DC/DC 300W Power Module

The MPC1100C-54 is an open-frame digital DC/DC power module with continuous power up to 300W. This module accepts up to a 60V input, and is configured in a 10:1 input-to-output ratio. It offers a digital controller with multiple-time programmability (MTP), which can be easily configured to quickly bring up the system and nimbly adapt to system requirements.

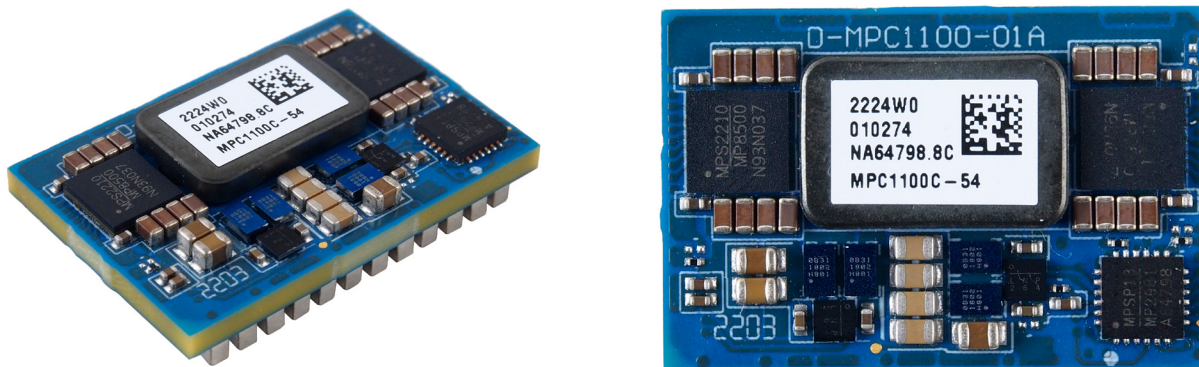


Figure 3: MPC1100C-54

### Features:

- Input Voltage Range: 40V to 60V
- 10:1 Input-to-Output Ratio
- Power Level: Up to 300W
- Power Density: 1700W/in<sup>3</sup>
- LLC Topology
- Compatible with Serial Interface
- Supports Parallel Operation
- Built-In MTP to Store Custom Configurations
  - Under-Voltage Lockout (UVLO)
  - $V_{OUT}$  Over-Voltage Protection (OVP) and Under-Voltage Protection (UVP)
  - OCP\_TDC/SPIKE
  - Over-Temperature Protection (OTP)
- GUI Configuration Software Provided
- Great for High-Current and High-Power Applications
- Pin-to-Pin Compatible with the MPC1102-54

### Dimensions:

27mmx18mmx6.1mm

Part Number	$V_{IN}$ (V)	$V_{OUT}$ Range (V)	Power Density (W/in <sup>3</sup> )	$P_{OUT}$ (W)	Peak Efficiency (%)	Efficiency @ 300W (%)
MPC1100C-54-0002	40 to 60	4 to 6	1700	300	96.7	95.3

## MPC11057-54-0750 – High-Efficiency, Non-Isolated, Fixed-Ratio Digital DC/DC 750W Power Module

The MPC11057-54-0750 is an open-frame digital DC/DC power module with continuous power up to 750W (see Figure 4). This module accepts up to a 60V input, and is configured in a 10:1 input-to-output ratio. It offers a digital controller with multiple-time programmability (MTP), which can be easily configured to quickly bring up the system and nimbly adapt to system requirements.

### Features:

- Input Voltage Range: 40V to 60V
- 10:1 Input-to-Output Ratio
- Power Level: Up to 750W
- Power Density: 1840W/in<sup>3</sup>
- LLC Topology
- Compatible with Serial Interface
- Built-In MTP to Store Custom Configurations
  - $V_{IN}$  Under-Voltage Lockout (UVLO)
  - $V_{OUT}$  Over-Voltage Protection (OVP) and Under-Voltage Protection (UVP)
  - OCP\_TDC/SPIKE
  - Over-Temperature Protection (OTP)
- GUI Configuration Software Provided
- Great for High-Current and High-Power Applications

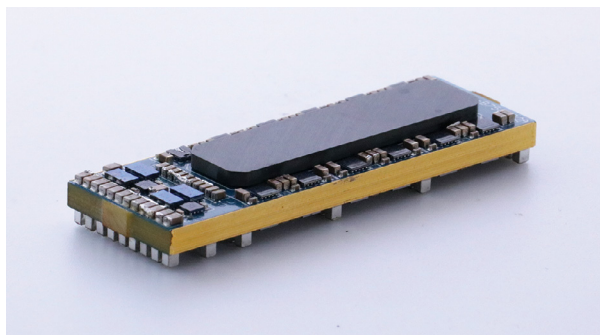


Figure 4: MPC11057-54-0750-xxxx

### Dimensions:

53mmx18mmx7mm

Part Number	$V_{IN}$ (V)	$V_{OUT}$ Range (V)	Power Density (W/in <sup>3</sup> )	$P_{OUT}$ (W)	Peak Efficiency (%)	Efficiency @ 750W (%)
MPC11057-54-0750-xxxx	40 to 60	4 to 6	1840	750	97.6	96.9



## MPC12106-54-0750 – High-Efficiency, Non-Isolated, Fixed-Ratio Digital DC/DC 750W Power Module

The MPC12106-54-0750 is an open-frame digital DC/DC power module with continuous power, up to 750W. This module accepts up to a 60V input, and is configured in a 4:1 input-to-output ratio. It offers a digital controller with multiple-time programmability (MTP), which can be easily configured to quickly bring up the system and nimbly adapt to system requirements.

### Features:

- Input Voltage Range: 40V to 60V
- 4:1 Input-to-Output Ratio
- Power Level: Up to 750W
- Power Density: 3310W/in<sup>3</sup>
- LLC Topology
- Compatible with Serial Interface
- Built-In MTP to Store Custom Configurations
  - V<sub>IN</sub> Under-Voltage Lockout (UVLO)
  - V<sub>OUT</sub> Over-Voltage Protection (OVP) and Under-Voltage Protection (UVP)
  - OCP\_TDC/SPIKE
  - Over-Temperature Protection (OTP)
- GUI Configuration Software Provided
- Great for High-Current and High-Power Applications

### Dimensions:

24mmx18mmx8.6mm

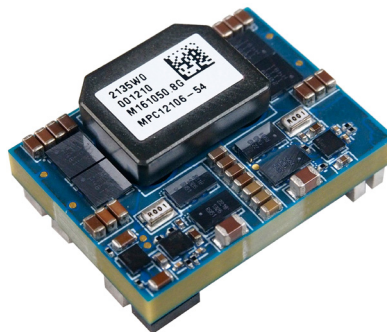


Figure 5: MPC12106-54-0750

Part Number	V <sub>IN</sub> (V)	V <sub>OUT</sub> Range (V)	Power Density (W/in <sup>3</sup> )	P <sub>OUT</sub> (W)	Peak Efficiency (%)	Efficiency @ 750W (%)
MPC12106-54-0750-xxxx	40 to 60	10 to 15	3310	750	98.1	97.5

## Second-Stage Solution: Digital Multi-Phase Controller + Intelli-Phase™ or Intelli-Module

MPS has a robust product portfolio of digital multi-phase controllers and Intelli-Phase™ and Intelli-Module solutions. For more information, visit [monolithicpower.com/en/products/power-management/data-center.html](https://monolithicpower.com/en/products/power-management/data-center.html)

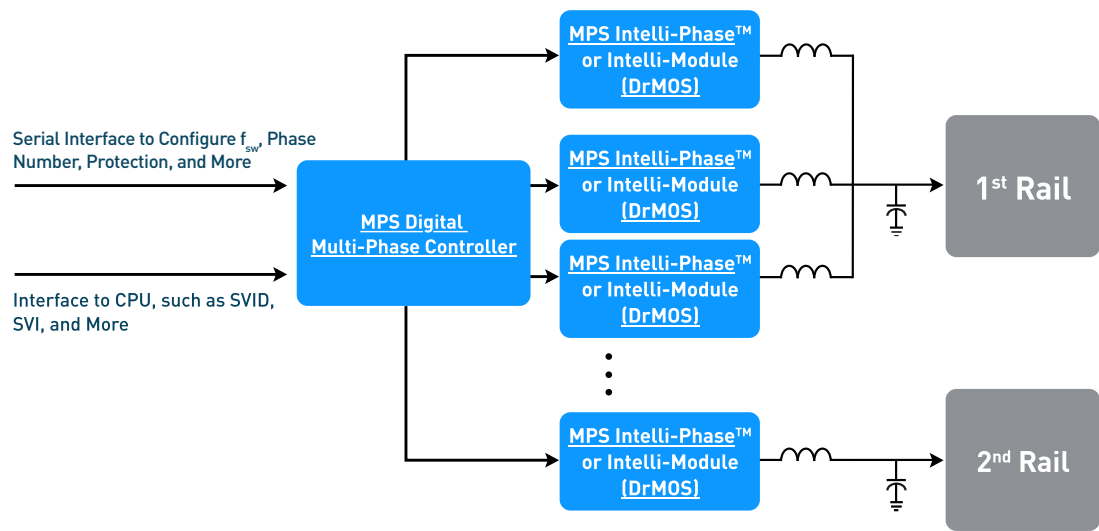


Figure 7: Second-Stage Digital Multi-Phase Controller + Intelli-Phase™ or Intelli-Module Block Diagram

Digital Multi-Phase Controller Features:	Intelli-Phase™ Features:	Intelli-Module Features:
<ul style="list-style-type: none"><li>Patented Constant-On-Time (COT) Control</li><li>Multiple Loops, Flexible Phase Assignment</li><li>Interface Options: SVID, SVI2/3, OVR, or Serial Interface</li><li>Fault Handling and Telemetry Capabilities</li></ul>	<ul style="list-style-type: none"><li>Family of Devices Ranges from 10A to 90A</li><li>Wide f<sub>sw</sub> Range: Balance between Transient and Efficiency</li><li>Built-In ZCD, OCP, NOCP, OTP, and SCP</li><li>Minimal External Components</li></ul>	<ul style="list-style-type: none"><li>High Power Density in Space-Constrained Applications</li><li>Flexible Output Assignment</li><li>Support Parallel Operation for Higher Power Delivery</li><li>Optimized for Top-Side Cooling</li></ul>

Power Structure	Type of Product	Part Number	Part Description
12V & MPS's new 4V to 6V architecture	Digital multi-phase controller	MP2888A	Single-loop, 10-phase digital multi-phase controller
		MP2882 (contact MPS for samples)	Dual-loop, 16-phase digital multi-phase controller
		MP2972 (contact MPS for samples)	Dual-loop, 12-phase digital multi-phase controller
12V architecture	DrMOS Intelli-Module	MP87006	16V, 90A Intelli-Phase™ in 4mmx6mm package
		MP87000	16V, 90A Intelli-Phase™ in 5mmx6mm package
		MPC22163 (contact MPS for samples)	16V, 130A Intelli-Module in 9mmx10mmx8mm footprint
		MPC22164 (contact MPS for samples)	16V, 130A Intelli-Module in 9mmx10mmx4mm footprint
MPS's new 4V to 6V architecture	DrMOS	MP86972 (contact MPS for samples)	12V, 60A Intelli-Phase™ in 3mmx6mm package
		MP86976 (contact MPS for samples)	7V, 70A Intelli-Phase™ in 3mmx6mm package

## MPC22163-130 – Two-Phase Intelli-Module with Quiet Switcher™ Technology

The MPC22163 is a non-isolated, step-down power module with 130A of continuous peak output current. This module integrates driver MOSFETs and an inductor in a compact package to save layout space and achieve a higher power density. It is scalable for many modules in parallel, up to 2kW+ of power. The 8mm maximum height makes it suitable for many applications, such as OAM form factor boards.

### Features:

- Input Voltage Range: 4V to 16V
- Output Voltage Range: 0.5V to 2V
- 130A Output Current
- Top-Side Cooling Package
- Current Sense: Accu-Sense™
- Temperature Sense
- Current Limit Protection
- Supports Parallel Operation
- Over-Temperature Protection (OTP)
- Fault Reporting
- Common Footprint LGA-72 (9mmx10mm) Package

### Dimensions:

9mmx10mmx7.5mm

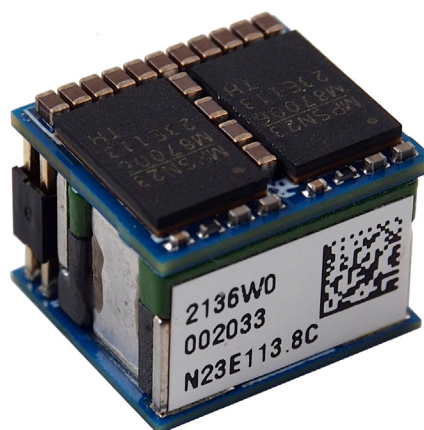


Figure 8: MP22163-130

Part Number	V <sub>IN</sub> (V)	V <sub>OUT</sub> Range (V)	I <sub>OUT</sub> (A)	f <sub>sw</sub> (kHz)	Power Density (W/in <sup>3</sup> )	Peak Efficiency (%)
MPC22163-130	4 to 16	0.5 to 2	130	600 to 1500	2475	88.7

# MPC22166-130 – Two-Phase Intelli-Module with Quiet Switcher™ Technology

The MPC22166 is a non-isolated, step-down power module with 130A of continuous peak output current. This module integrates driver MOSFETs and an inductor in a compact package to save layout space and achieve a higher power density. It is scalable for many modules in parallel, up to 2kW+ of power. The 4mm maximum height makes it suitable for many applications, such as Z-Axis Power Delivery™ and PCIe form factor boards.

### Features:

- Input Voltage Range: 4V to 16V
- Output Voltage Range: 0.5V to 2V
- 130A Output Current
- Top-Side Cooling Package
- Current Sense: Accu-Sense™
- Temperature Sense
- Current Limit Protection
- Supports Parallel Operation
- Over-Temperature Protection (OTP)
- Fault Reporting
- Common Footprint LGA-72 (9mmx10mm) Package
- Extremely Low Height: Maximum 4mm
- Pin-to-Pin Compatible with the MPC22163

### Dimensions:

9mmx9.9mmx3.9mm

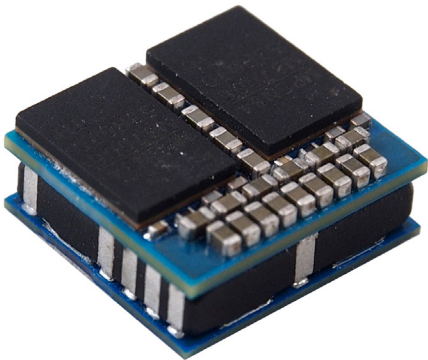


Figure 9: MP22166-130

Part Number	V <sub>IN</sub> (V)	V <sub>OUT</sub> Range (V)	I <sub>OUT</sub> (A)	f <sub>sw</sub> (kHz)	Power Density (W/in <sup>3</sup> )	Peak Efficiency (%)
MPC22166-130	4 to 16	0.5 to 2	130	600 to 1200	5034	90

## MPC22167 – 130A, Two-Phase, Intelli-Module™ with Quiet Switcher™ Technology

The MPC22167 is a non-isolated, step-down power module with 130A of continuous peak output current. This module integrates driver MOSFETs and an inductor in a compact package to save board space and achieve a higher power density. It is scalable for many modules in parallel, up to 2kW or more of power. The 8mm maximum height makes it suitable for a wide range of applications, such as OAM form factor boards.

### Features:

- Input Voltage Range: 10V to 16V
- Output Voltage Range: 0.5V to 2V
- 130A Output Current
- Top-Side Cooling Package
- Current Sense: Accu-Sense™
- Temperature Sense
- Current Limit Protection
- Supports Parallel Operation
- Over-Temperature Protection (OTP)
- Fault Reporting
- Common Footprint LGA-72 (9mmx10mm) Package

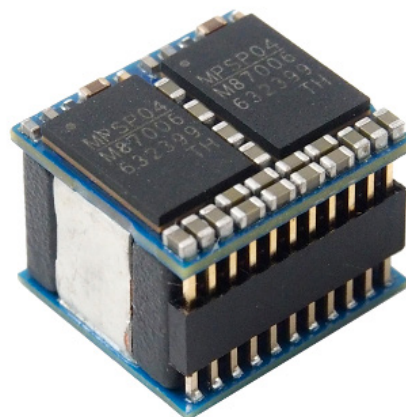


Figure 10: MPC22167

### Dimensions:

9mmx9.9mmx7.65mm

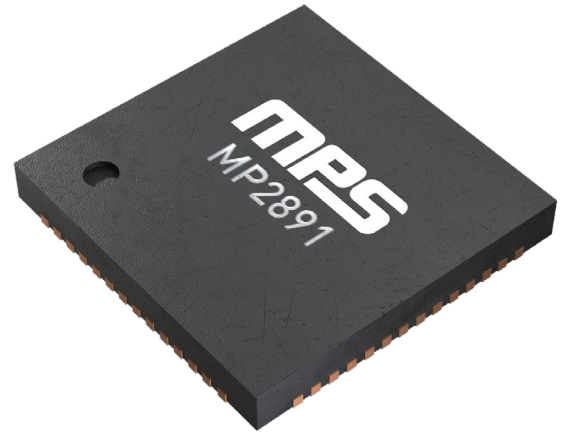
Part Number	$V_{IN}$ (V)	$V_{OUT}$ Range (V)	$I_{OUT}$ (A)	$f_{SW}$ (kHz)	Power Density (W/in <sup>3</sup> )	Peak Efficiency (%)
MPC22167-130	4 to 16	0.5 to 2	130	500 to 1200	2475	91.3



## MP2891 – Dual-Loop, OVR4i+ 16-Phase Controller

### Features:

- Highest Phase Count
  - Dual-Loop, 16-Phase Controller Provides Power for NVIDIA PWM-VID Core Power
  - Max 16 Phases for Rail 1 and 8 Phases for Rail 2
- Digital Control
  - Digital Loop Compensation and Load-Line Regulation
  - Nonlinear Control Reduces Output Capacitor Requirements for Transients
- Digital Configurability and Monitoring
  - Compatible with Serial Interface
  - $V_{OUT}$ ,  $I_{OUT}$ ,  $V_{IN}$ ,  $P_{IN}$ , and Temperature Telemetry
  - Intelli-Phase™ Fault Diagnosis
  - Integrated NVM to Store VR Configurations and for Black Box Capability
- Design Flexibility
  - Switching Frequency Up to 3MHz
  - Automatic Phase-Shedding Improves Light-Load Efficiency
  - Configurable Voltage, Current, and Temperature Protection



**Package:**  
QFN-56 (7mmx7mm)

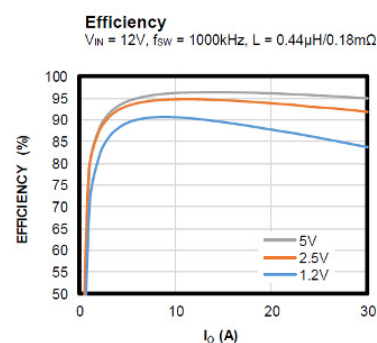
## MPQ8645P – 16V, 30A, Scalable, Digital, Synchronous Step-Down Converter with Serial Interface

### Features:

- Digital Point-of-Load (POL)
  - $V_{IN}$ ,  $V_{OUT}$ ,  $I_{OUT}$ , and Temperature Telemetry
  - Rich Feature Selection
  - User-Accessible NVM to Save Configurations
- Flexible for Multiple Rails in System
  - Scalable Up to 8 Phases
  - Input Voltage Range: 3.1V to 16V
  - Supports 3.3V, 5V, and 12V Inputs
  - Supports Zero-ESR, MLCC Output Capacitors
  - Configurable Current Limit Offers Flexible Inductor Choice
- Adaptive Constant-On-Time Control
  - Minimizes Number of Required Output Capacitors
  - 0.5% Accurate Reference



**Package:**  
TQFN-25 (4mmx5mm)



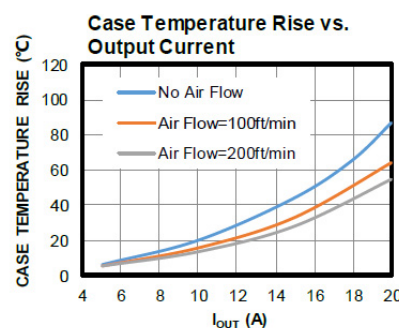
## MP5048 – 60V, 15A, 7mΩ $R_{DS(ON)}$ Hot-Swap Intelli-Fuse Solution

### Features:

- 60V E-Fuse with Highest Industry Current
- Flexible for Multiple Phases in System
  - Input Voltage Range: 24V to 60V
  - Scalable for Standalone or Parallel Operation
  - Configurable Output Voltage Soft Start Supports Inrush Current Control
  - 1.5% IMON Reporting Accuracy Supports Accurate System Power Reporting
- Full System Protections
  - Configurable Over-Current Protection (OCP) Limit
  - Accurate On-Die Temperature Sensing and Thermal Shutdown
  - Pin-Configurable Latch-Off and Hiccup Protections
  - Fault Pin Indicator (FLTBI)



**Package:**  
QFN-30 (5mmx5mm)



## Second-Stage Module vs. Traditional Discrete Solution

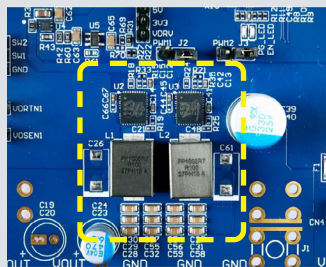
As the current demand of CPUs and GPUs increases and package sizes expand, designers are often left with very small areas on the board to fit multiple phases of voltage regulators (VRs). The Intelli-Module approach to VR design increases power density by 2.5x and allows placement of the voltage regulators closer to the processor to reduce PDN losses.

### Intelli-Modules: DrMOS + Inductor



Intelli-Module Solution Offers the Best Combo of Efficiency and Size  
90mm<sup>2</sup> Layout Area

### DrMOS (Discrete Approach)



Traditional VR Solution  
225mm<sup>2</sup> Layout Area

## OAM Form Factor Power Solutions

MPS provides end-to-end power solutions following OCP standards for common designs, such as OAM form factors. These capabilities are demonstrated with this reference design (max 2000A), which features our 4:1 first-stage modules and second-stage Intelli-Modules.

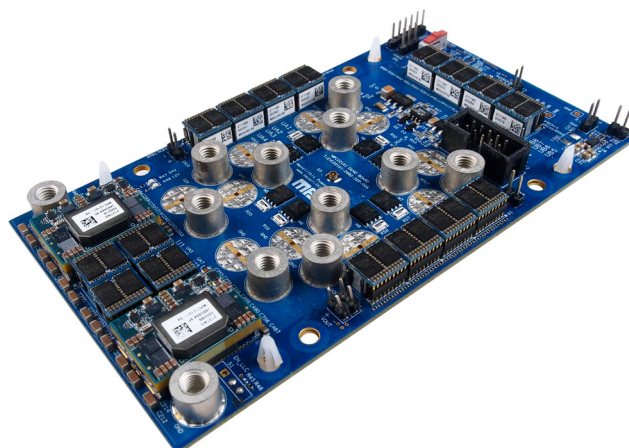
### 2000A Reference Design

#### Specs:

- 54V Input Voltage, 0.8V Nominal Output Voltage
- 1000A Output Current, Max 2000A
- Embedded Load Slammer for Transient Testing
- Second Stage Uses the MP2891 16-Phase Controller and the MPC22167, the Next Generation of the MPC22163 Module with the Same Footprint and Higher Efficiency
- This 2000A EVB Is Now Available for Sampling

#### AI Accelerator Card:

- OAM
- SXM
- etc.

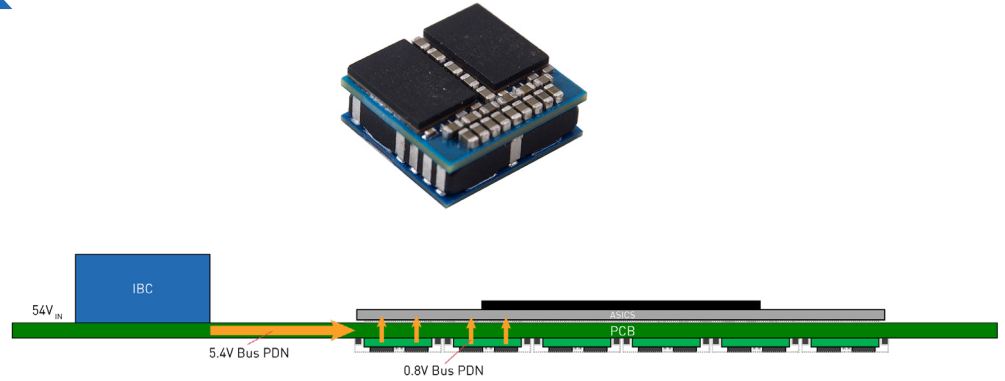


For samples and more information on Z-Axis Power Delivery™ solutions, contact MPS

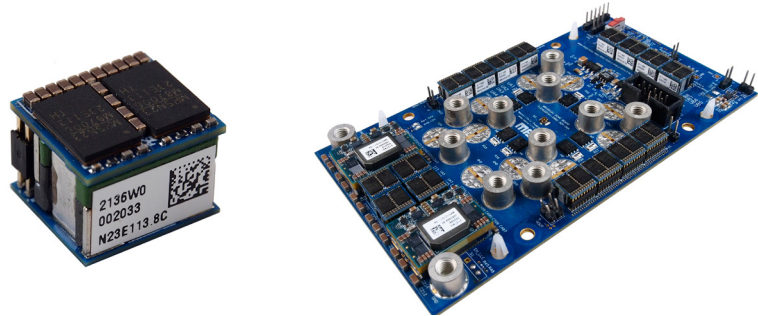
# Adapting Power Solutions to the Increased Current Requirement of AI Processors

Increased Current Requirements

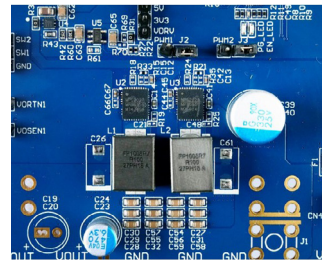
Z-Axis Power Delivery™  
Ex: MPC22166



Lateral Power Delivery Using Modules  
Ex: MPC22163



Lateral Power Delivery Using DrMOS  
Ex: MP87006



## Quality Assurance & Reliability Commitment

The MPS Quality Assurance organization develops, coordinates, and champions strategic quality initiatives throughout MPS Inc., its foundries, and subcontractors. Its mission is to enable MPS to design, develop, manufacture, and deliver products to our customers with world-class quality and reliability that meet and exceed our customers' expectations.

### MPS and Its Supplier Quality Systems and Certificates:

- ISO9001:2008 (MPS)
- EU RoHS/HF/REACH Compliant (MPS)
- Sony Green Partner (MPS & Suppliers)
- TS16949 (Suppliers)
- ISO14001 (Suppliers)

### Product Quality:

- Automotive Products Qualified per AEC-Q100 Standard
- Standard Products Qualified per JEDEC and Military Standard
- Reliability Failure Rate <10FIT
- Product Quality Level <1.0ppm

### Quality Control and Monitor:

- On-Site Foundry and Assembly Teams for Real-Time Actions
- Quarterly Supplier Quality Review and Annual Supplier Audit
- Short-Term Reliability Monitor Test – Daily
- Long-Term Reliability Monitor Test – Monthly
- Real-Time Engineering Actions on Monitor Failure
- Quarterly Reliability Monitor Reports



## About MONOLITHIC POWER SYSTEMS

### Who we are

We are creative thinkers. We break boundaries. We take technology to new levels. As a leading international semiconductor company, Monolithic Power Systems (MPS) creates cutting-edge solutions to improve the quality of life with green, easy-to-use products.

### What we do

We make power design fun! With our innovative proprietary technology processes, we thrive on reimagining and redefining the possibilities of high-performance power solutions in industrial applications, telecom infrastructures, cloud computing, automotive, and consumer applications.

### Where we come from

It started with a vision. Michael Hsing, pioneering engineer and CEO, founded Monolithic Power Systems, Inc. in 1997 with the belief that an entire power system could be integrated onto a single chip. Under his leadership, MPS has succeeded not only in developing a monolithic power module that truly integrates an entire power system in a single package, but also it continues to defy industry expectations with its patented groundbreaking technologies.

### Our values

#### We cultivate creativity

As a company we believe in creating an environment that encourages and challenges our employees to collaborate and think outside the box to excel beyond their preconceived capabilities.

#### We do not accept the status quo

We do not believe in limitations. It is not about what is, but what can be. Possibilities are endless at MPS.

#### We are passionate about sustainability

It's about the future. From materials to finances, we are committed to conservation. We will not tolerate waste in an effort to improve and preserve the quality of life.

#### We are committed to providing innovative products to our customers

Let us do the heavy lifting. We relentlessly strive to make system design versatile and effortless to meet our customers' specific needs. We'll do the work, so our customers can have the fun!

## CONTACT & ORDERING



**FAST  
RESPONSE**

**Quotes, Availability, Engineering Support & Samples**  
[MonolithicPower.com/Quote-Samples-Support](http://MonolithicPower.com/Quote-Samples-Support)

### US Offices

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- **MPS San Jose**  
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Tel: +1 408-826-0600
- **MPS Detroit**  
19499 Victor Parkway  
Livonia, MI 48152, USA  
Tel: +1 248-907-0222
- **MPS Phoenix**  
2065 S. Cooper Road, Suite 3  
Chandler, AZ 85826, USA

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