

Isolated Power Solutions for Industrial, Renewable Energy and EV Ecosystems

Session 1: 8AM PDT | 11AM EDT | 4 PM CET

Session 2: 11AM PDT | 2PM EDT | 7 PM CET

November 2023



Agenda

- The Rise of Renewable Energy Applications
- EV and DC Fast-Charging System Overview
- Advantages of LLC Topologies vs. Flyback
- Isolated Gate Driver and Power Module Overview
- Digital Isolators

The Rise of Green Energy

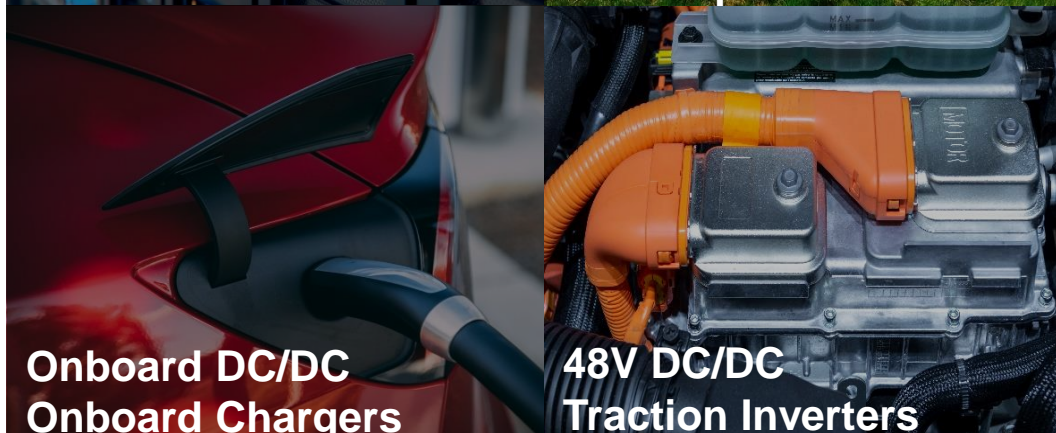


Charging Stations/Energy Storage



**AC/DC Conversion
Offline/Online UPS**

**Battery to Grid
Solar Inverters
Solar Optimizers**



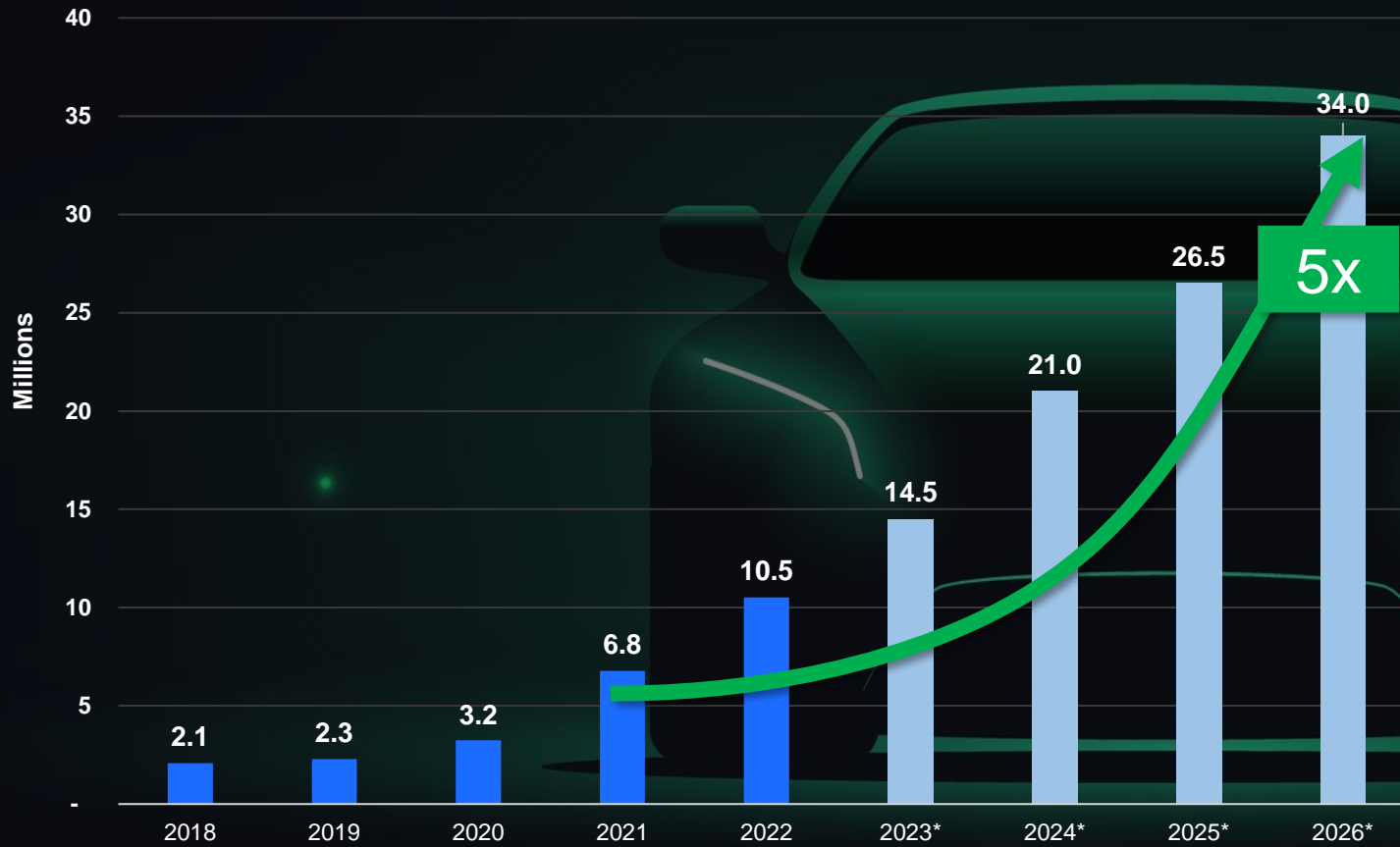
**Onboard DC/DC
Onboard Chargers**

**48V DC/DC
Traction Inverters**

- Decarbonization is driving a massive shift in renewable energy infrastructure
 - Solar inverters
 - DC charging stations
 - Electric vehicles
 - Energy storage
 - Automation and drives
- Many systems are shifting to 400V/800V, driving the need for SiC to maximize efficiency and power density
- To bias the SiC or IGBT MOSFETs, soft switching topologies are being used
 - Increased isolation
 - Smaller solution size

EV Sales Volumes Are Skyrocketing

BEV/PHEV Global Sales Projection 2018–2026



*2023–2026 are projections

Content by Application

OBC, DCDC,
BMS, Aux

~30%

PHEV/
BEV

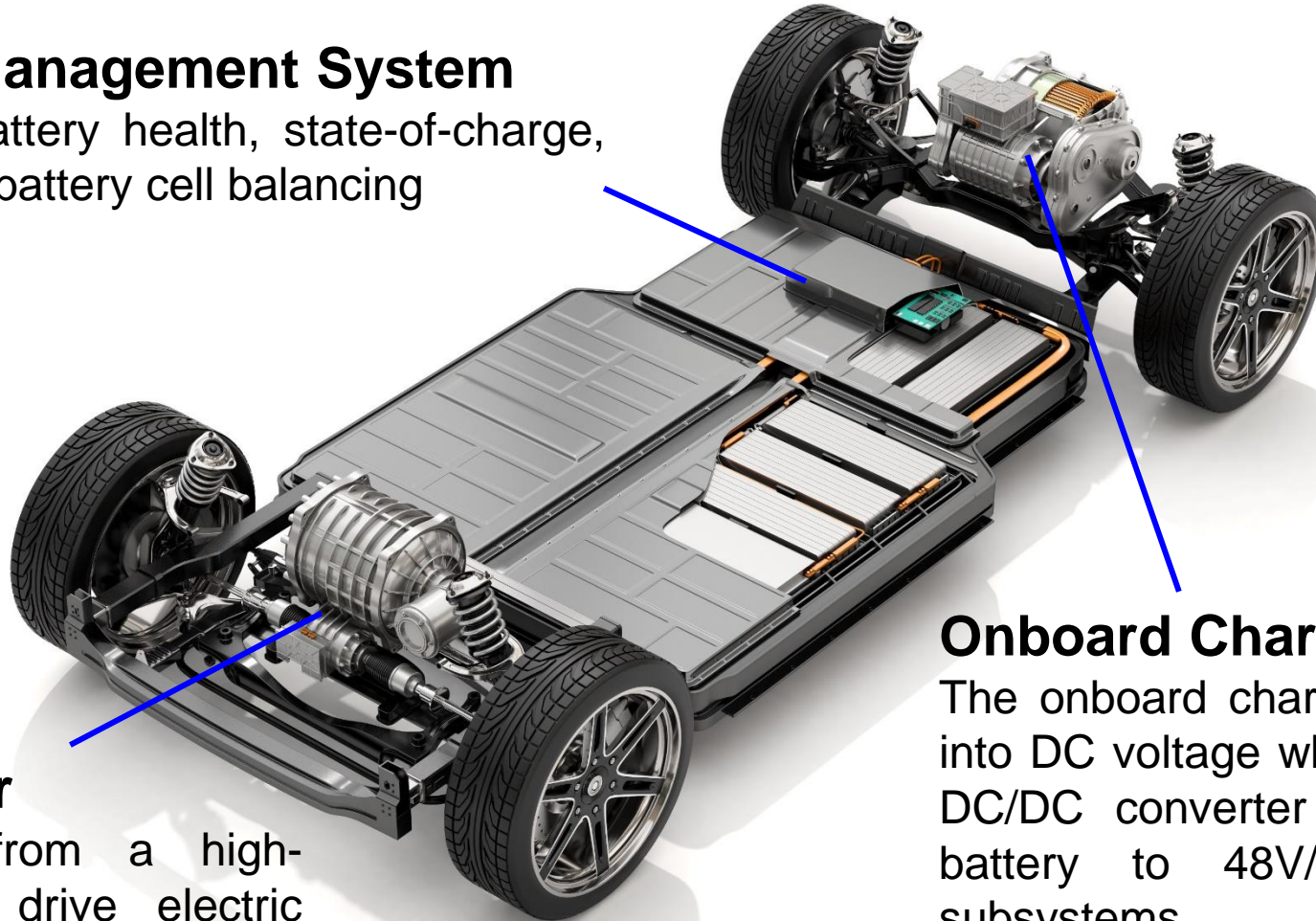
~70%

Inverter

Electric Vehicle Systems

Battery Management System

Manages battery health, state-of-charge, and vehicle battery cell balancing



Onboard Charger & DC/DC Converter

The onboard charger helps convert AC voltage into DC voltage when using an AC charger. The DC/DC converter is used to convert the HV battery to 48V/12V for powering vehicle subsystems

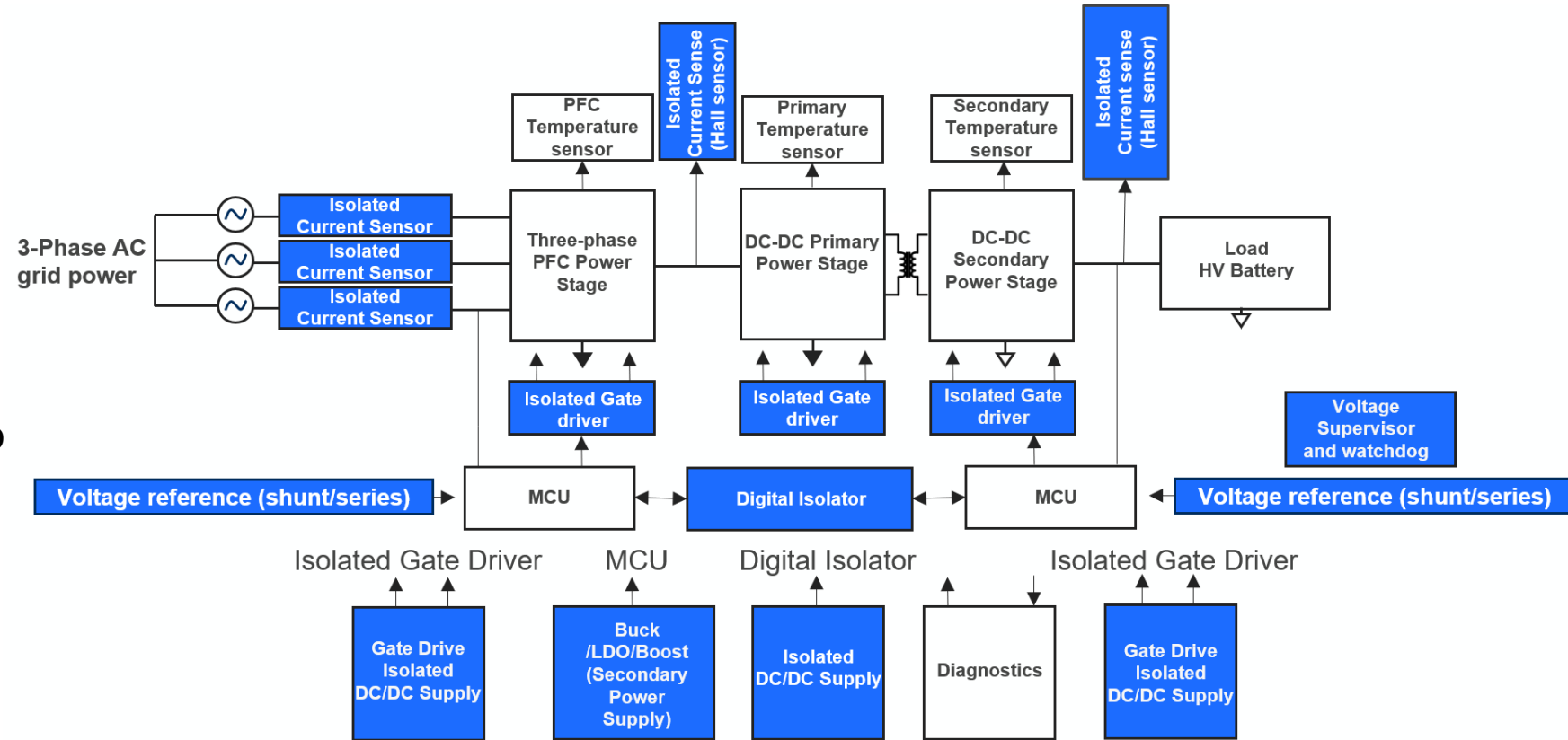
Traction Inverter

Converts energy from a high-voltage battery to drive electric motors as well as recuperate energy from regenerative braking

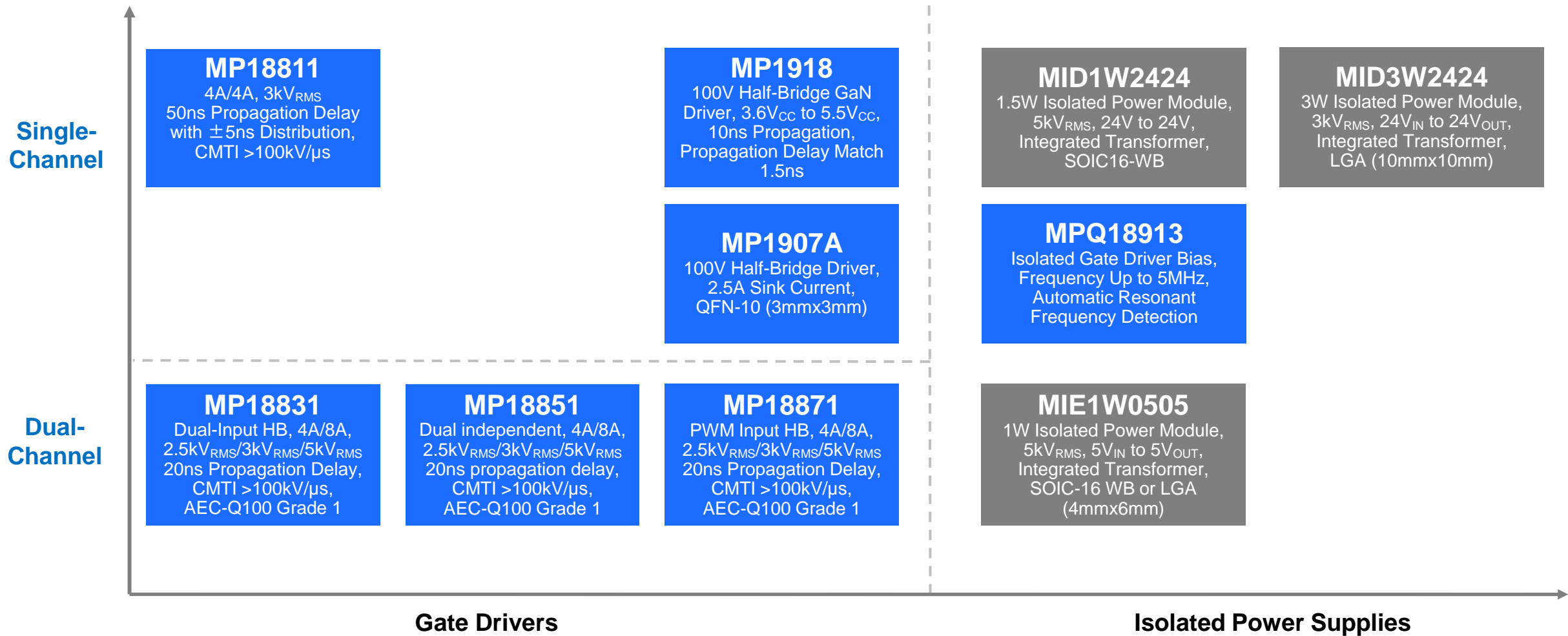
DC Fast-Charging Systems

DC Fast-Charging Station

- Converts a 3-phase AC voltage into a 250V to 800V DC voltage
- Contains several of the subunits on the right to get to a 350kW+ output
- Power factor correction (PFC) stage converts an AC voltage into an intermediate DC voltage
 - 3-phase, 3-level rectifier/inverter topology is typically used for the PFC stage
- Second stage converts the intermediate DC voltage into the target battery charging voltage



Isolated Gate Driver/Power Supply Roadmap



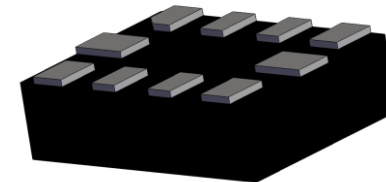
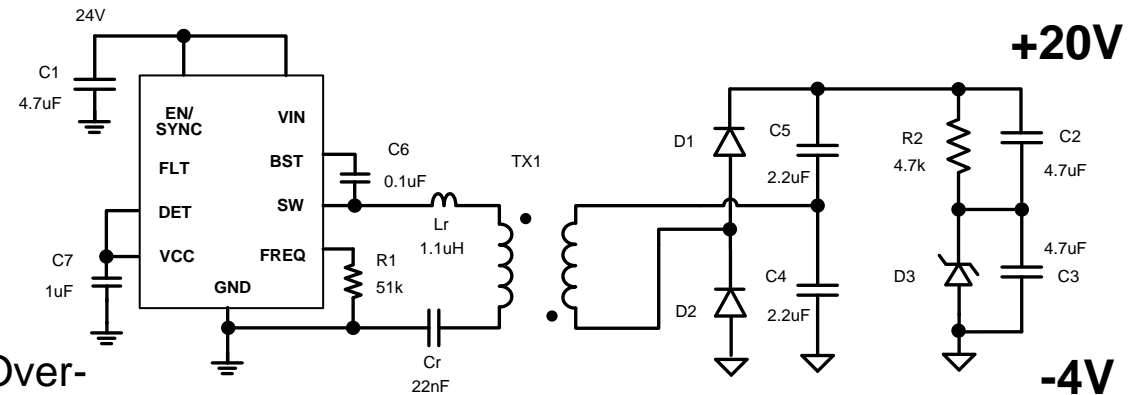
Sampling
Released



MPQ18913/4 – 30V, 0.5A LLC Transformer Driver for Isolated Bias Supplies

FEATURES

- 5V to 30V Input Voltage Range (50V Surge)
- Half-Bridge Transformer Driver for Isolated LLC Resonant Converters
- Configurable Frequency: 750kHz to 5MHz (MPQ18913) or 750kHz to 10MHz (MPQ18914)
- External Clock Input for Switching Synchronization
- Automatic Resonant Frequency Detection
- Optional Spread Spectrum for EMI Reduction
- Internal Soft Start
- Over-Current Protection (OCP), Short-Circuit Protection (SCP), Over-Voltage Protection (OVP), Over-Temperature Protection (OTP), and fault (FLT) Reporting
- Supports Up to 5W
- Available in a QFN-10 (2mmx2.5mm) Package with Wettable Flanks



Available in a QFN-10 (2mmx2.5mm) Package

Applications

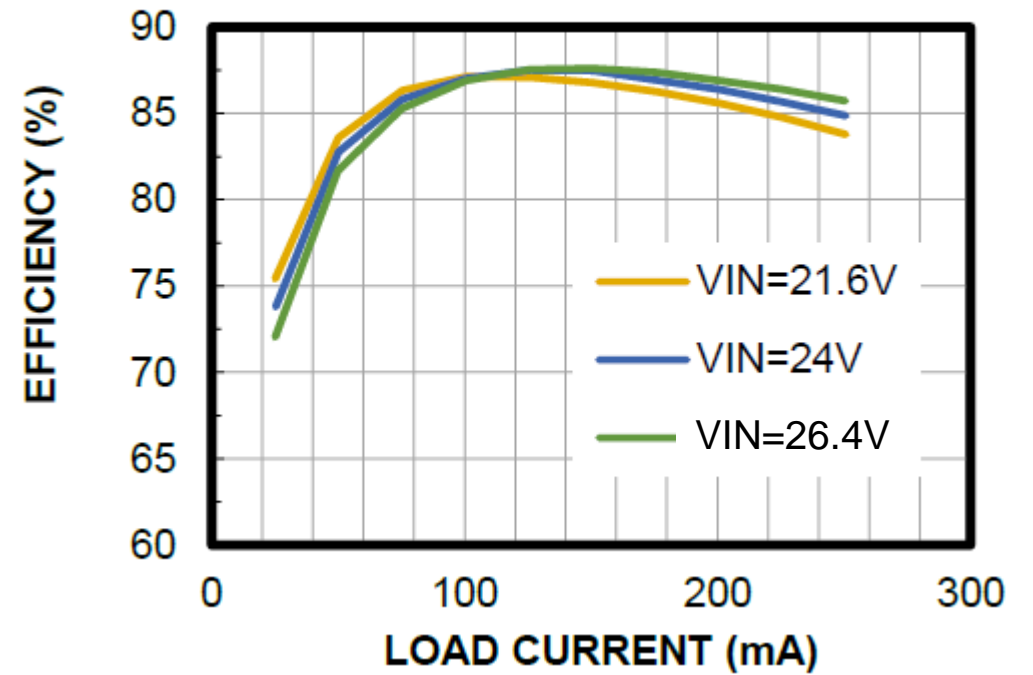
- IGBT/SiC Gate Driver Bias
- EV DC Fast-Charging Stations
- EV Traction Inverters/Onboard Chargers

MPQ18913 Evaluation Board



EVQ18913-D-00A Evaluation Board

24V_{IN}, 24V_{OUT}, 1.33MHz Efficiency vs. Load Current



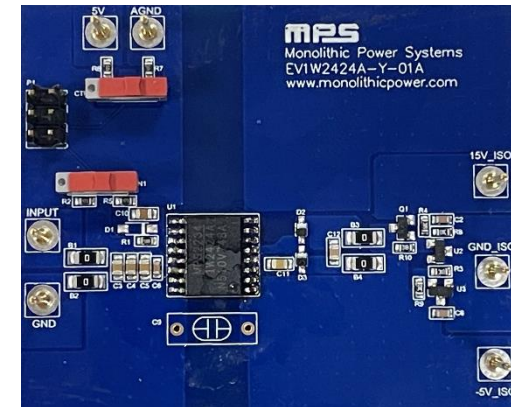
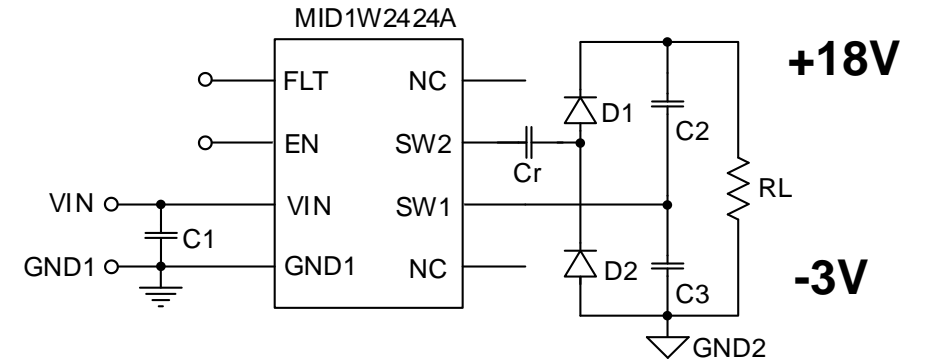
MID1W2424A – 1.5W 24V Isolated Module

FEATURES

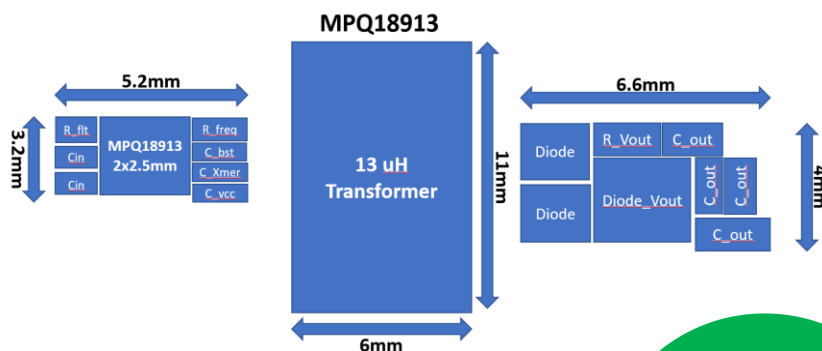
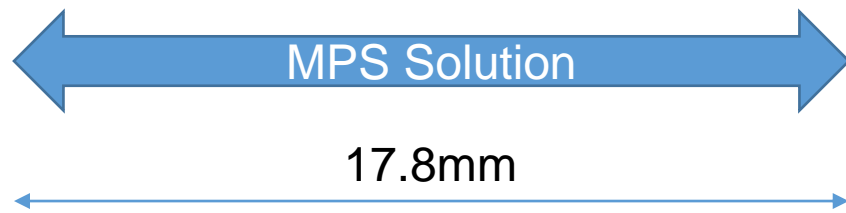
- 5V to 30V Input Voltage Operation Range (50V Surge)
- 3kV_{RMS}, 5kV_{RMS} Isolation Voltage Options
- **1.5W Output Power Options**
- **Integrated Transformer**
- 60% Efficiency with Full Load
- 100kV/ μ s CMTI
- **8pF Isolation Capacitance**
- Soft Start, Over-Current Protection (OCP), Input Over-Voltage Protection (OVP), Over-Temperature Protection (OTP), and fault (FLT) Indicator
- **AEC-Q100 Option Available**
- Available in an SOICW-16 Package (Only 2.65mm Tall!)

Applications

- IGBT/SiC Gate Driver Bias
- EV DC Fast Charging Stations
- EV Traction Inverter/On-Board Charger

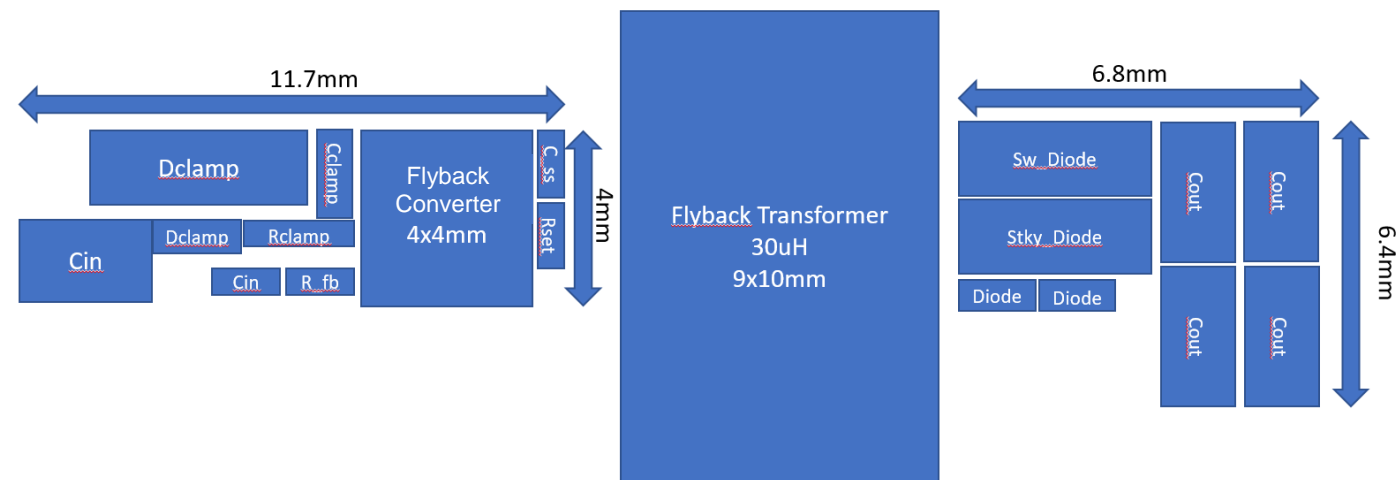
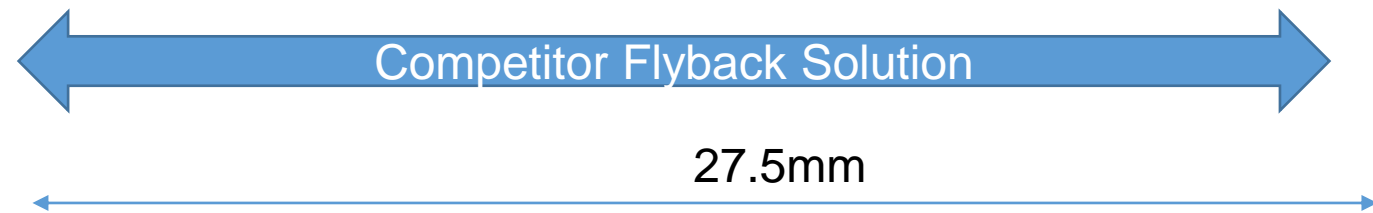


PCB Footprint Analysis – Isolated Bias Supply



Solution Size: 109mm²
Total Area: 196mm²
Components: 21

**40%
Smaller
Solution
Size!**



Solution Size: 180mm²
Total Area: 275mm²
Components: 26

MPQ18913 vs. Flyback BOM Cost Analysis

	MPQ18913 LLC Resonant Topology	PSR Flyback Converter Topology
HV Capacitor	11.6 μ F (= \$0.12)	4.7 μ F + 0.1 μ F (= \$0.05)
LV Capacitor	2 μ F (= \$0.01)	64 μ F + 47nF (= \$0.32)
Schottky Diode	2 (= \$0.08)	1 (= \$0.04)
Zener Diode	0	3 (= \$0.12)
Switching Diode	0	1 (= \$0.04)
Resistors	2 (= \$0.02)	3 (= \$0.03)
Transformer	13 μ H, 11x6mm (\$0.36)	30 μ H, 9mmx10mm (\$0.50)
IC	X	X
BOM Cost	= \$0.59 + X	= \$1.10 + X

**46%
Lower
BOM
Cost!**

LV capacitor assumed to be \$0.05/10 μ F
 HV capacitor assumed to be \$0.10/10 μ F

MPQ18913 vs. MID1W2424 BOM Size Comparison

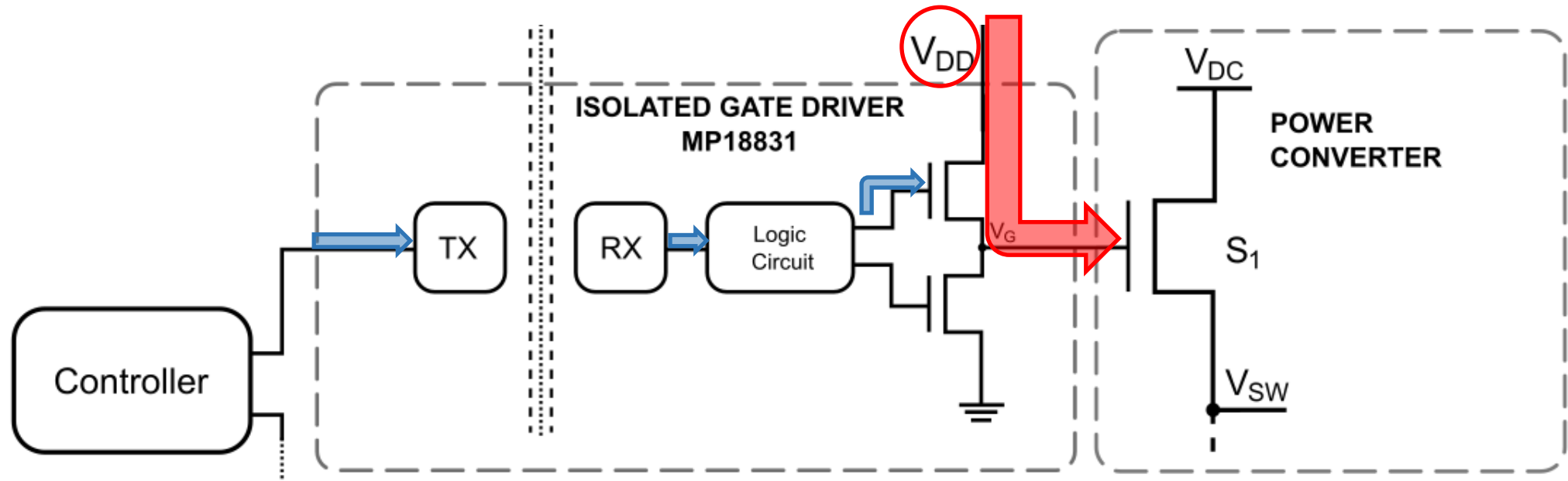
	Discrete Solution MPQ18913	Module Solution MID1W2424
PCB Area for LV Size	25mm ²	120mm ²
Transformer Size	7mmx9mm = 63mm ²	N/A
PCB Area for HV Size	30mm ²	30mm ²
Total Area	120mm ²	150mm ²
Max Height	9mm	2.65mm

- Transformer height is estimated by the creepage requirement of 7.1mm
- Discrete solution is smaller due to a small 63mm² transformer
- **The main advantage of module solutions are in the total height requirement from integrating the transformer**

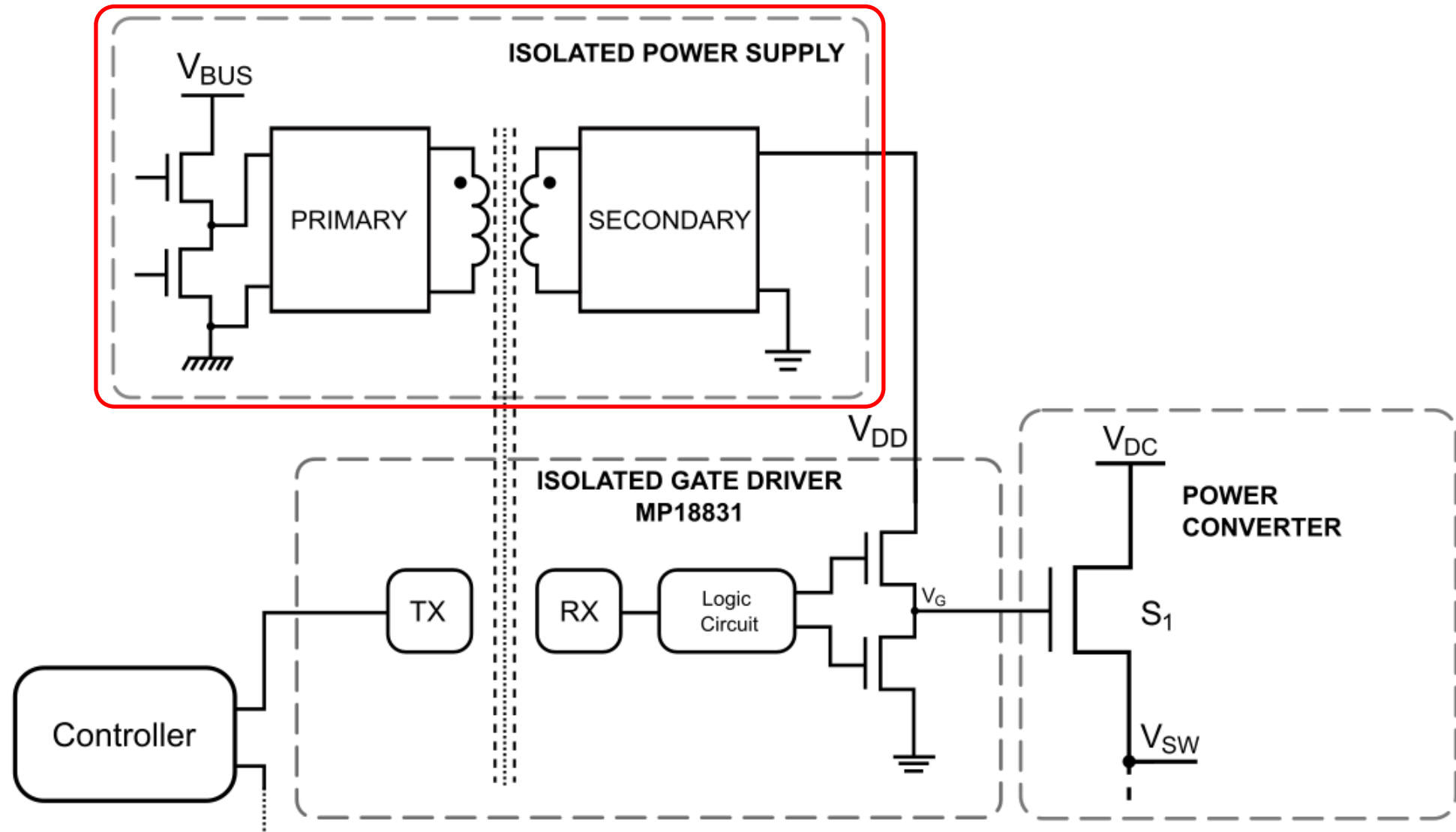
MPQ18913 vs. Flyback Topology

	MPQ18913/4 LLC Resonant Topology	Competitor PSR Flyback Topology
Switching Frequency	High (up to 10MHz)	Low (<400kHz)
Transformer Size	13 μ H (11mmx6mm)	30 μ H (10mmx10mm)
Leakage Inductance	Utilizes leakage inductance as part of resonant tank	Leakage inductance induces voltage spike and extra loss
Isolation Voltage	High (up to 5kV)	Low (1.5kV)
Isolation Capacitance	Low (6pF)	High (13pF to 25pF)
EMI Emissions	Better	Worse
Package Size	2mmx2.5mm	4mmx4mm
Diodes (including Zener)	3	6
Solution Size	109mm ²	180mm ²
BOM Components	21 components	26 components

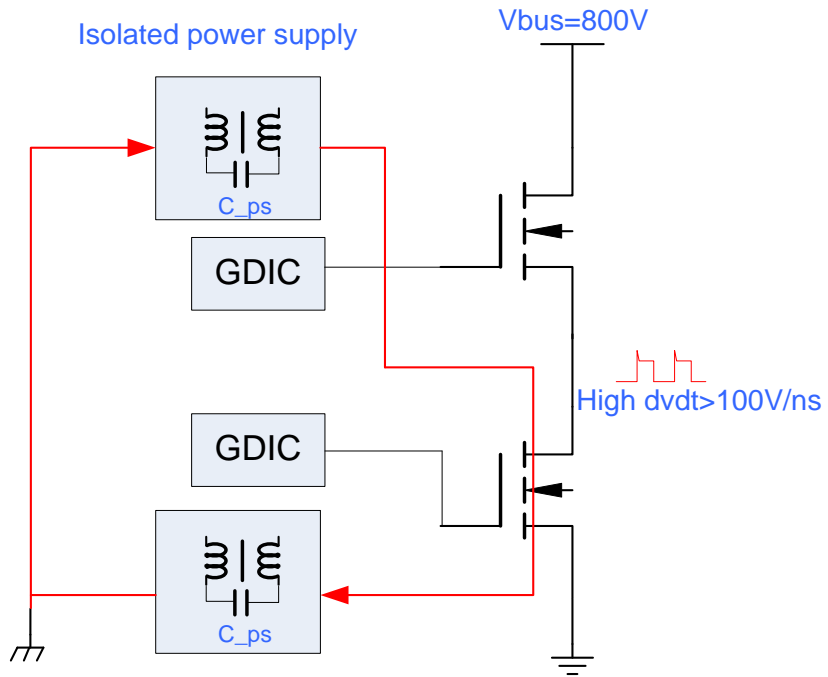
Isolated Power Supplies for Gate Drivers



Isolated Power Supplies for Gate Drivers (contd.)



Transformer Requirements for Gate Driver Power Supply



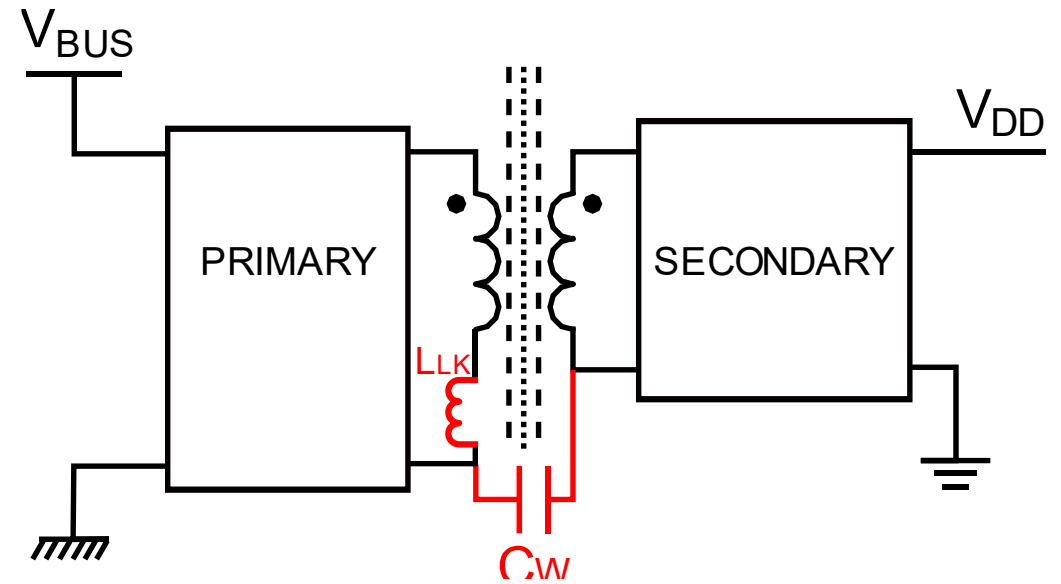
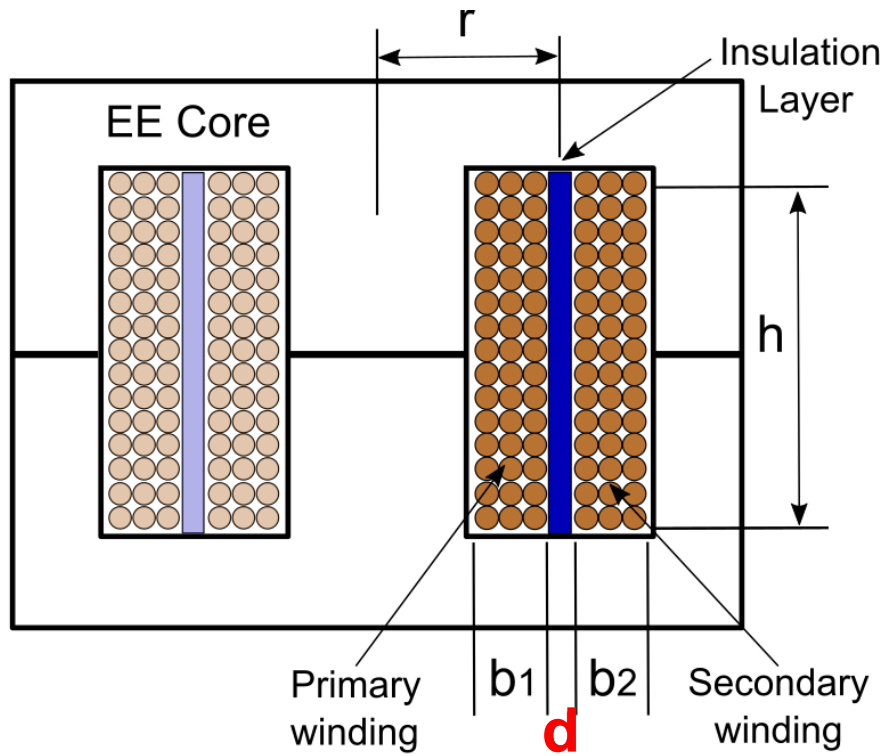
Trends on High-Power Systems:

- Bus Voltage Increase → Higher Isolation Voltage Needed for Transformers
- Higher dV/dt → Requires Lower Interwinding Capacitance
 - Assuming 20pF Capacitor
 - $I_{CM} = 100V/ns \times 20pF / 2 = 1A$
 - I_{CM} is disruptive to the MCU, GDIC, and GDPS

Low-Capacitance Transformer Design

$$C_W = \frac{\epsilon_0 \epsilon_r A}{d}$$

To decrease $C_W \rightarrow$ increase the distance between windings



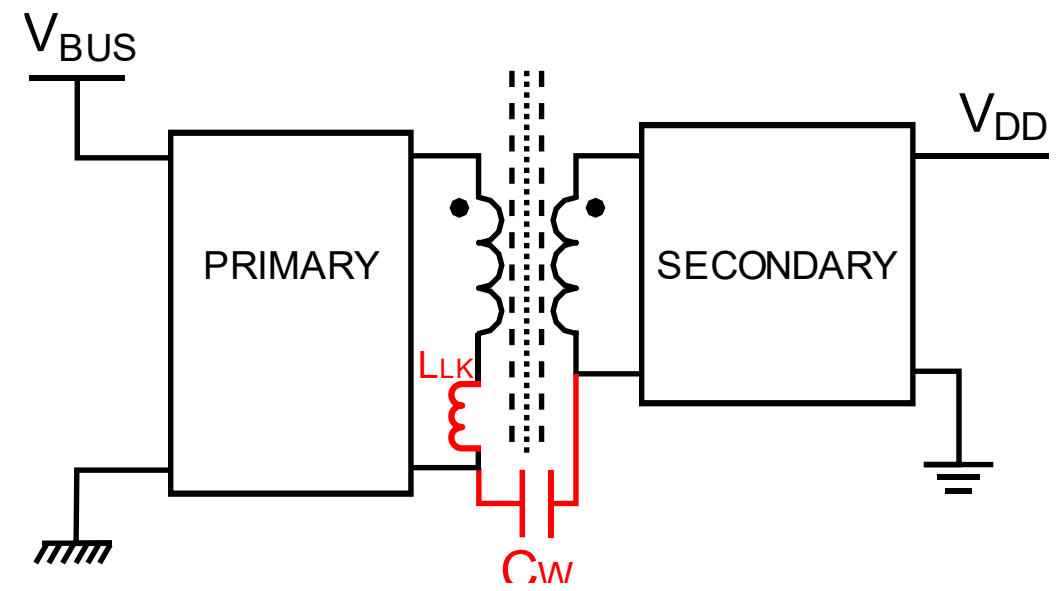
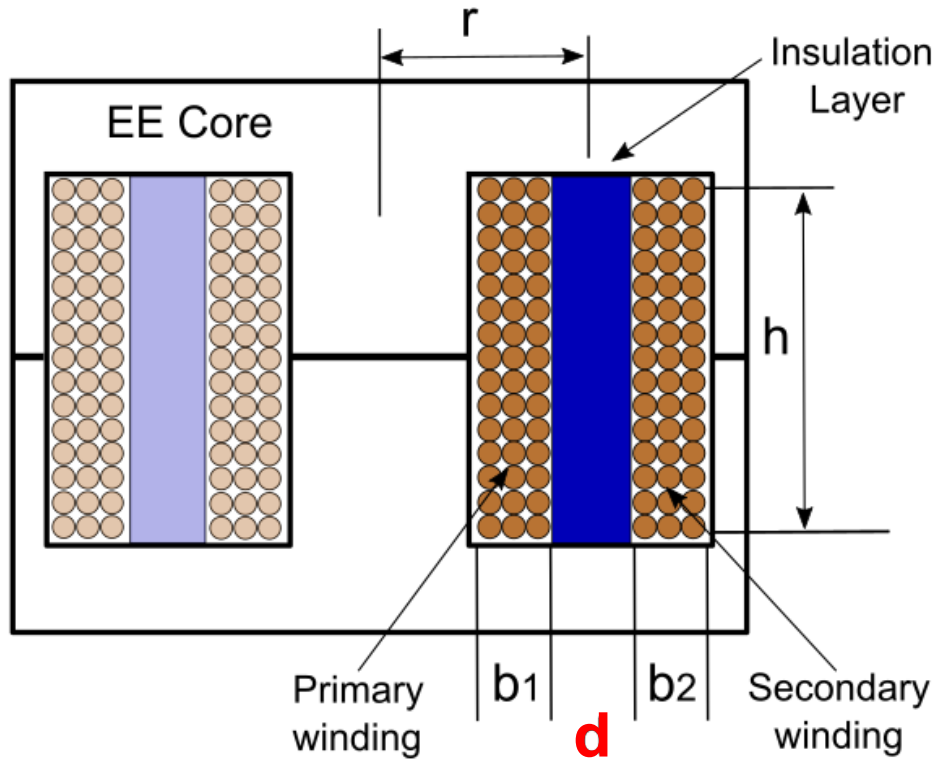
Low-Capacitance Transformer Design

$$C_W = \frac{\epsilon_0 \epsilon_r A}{d}$$

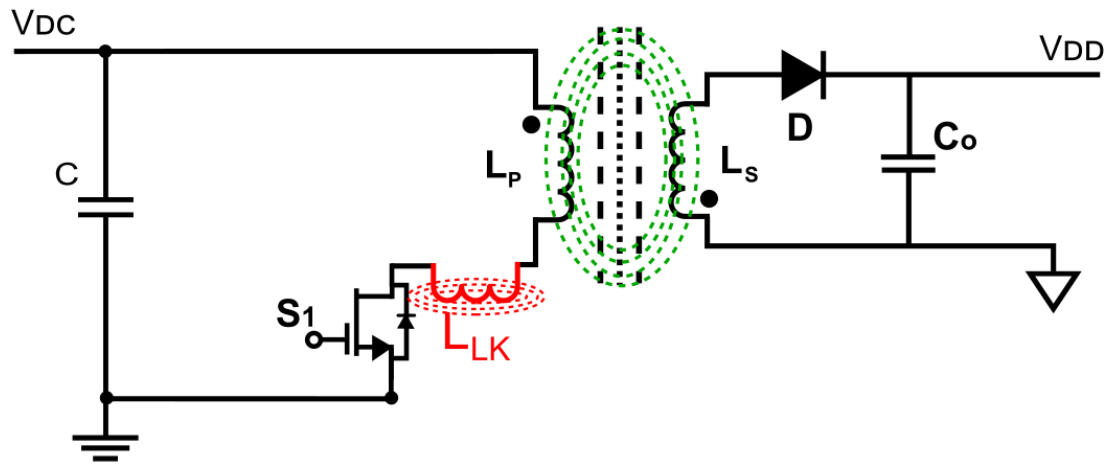
To decrease $C_W \rightarrow$ increase the distance between windings

Increase the distance between windings \rightarrow increase L_{LK}

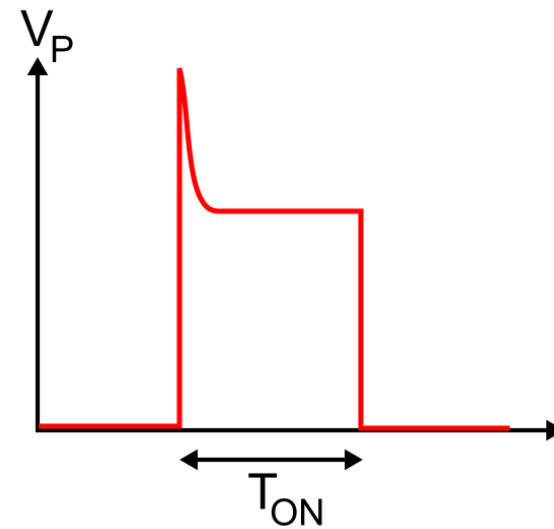
$$L_{LK} = \frac{8\pi^2 \times r \times N_P^2}{h} \left(d + \frac{b_1 + b_2}{3} \right)$$



Flyback Converter Operation with L_{LK}

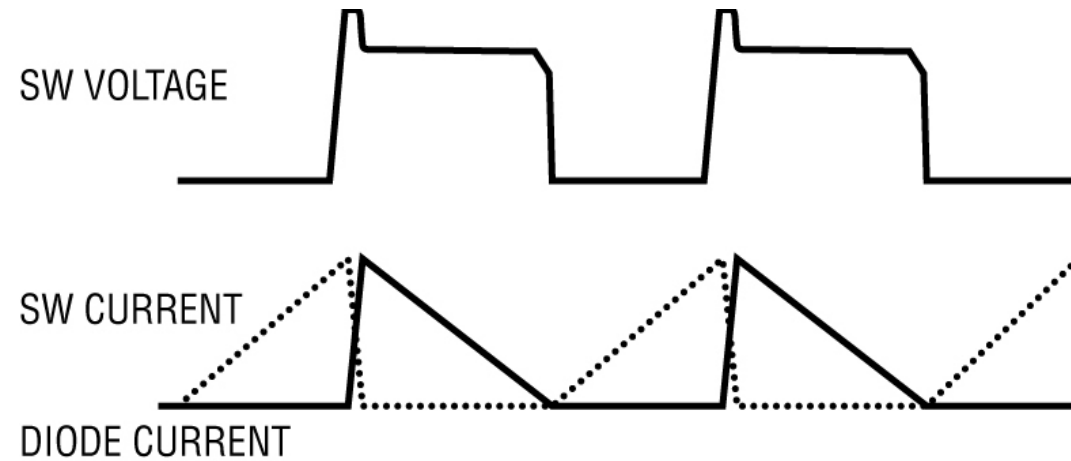
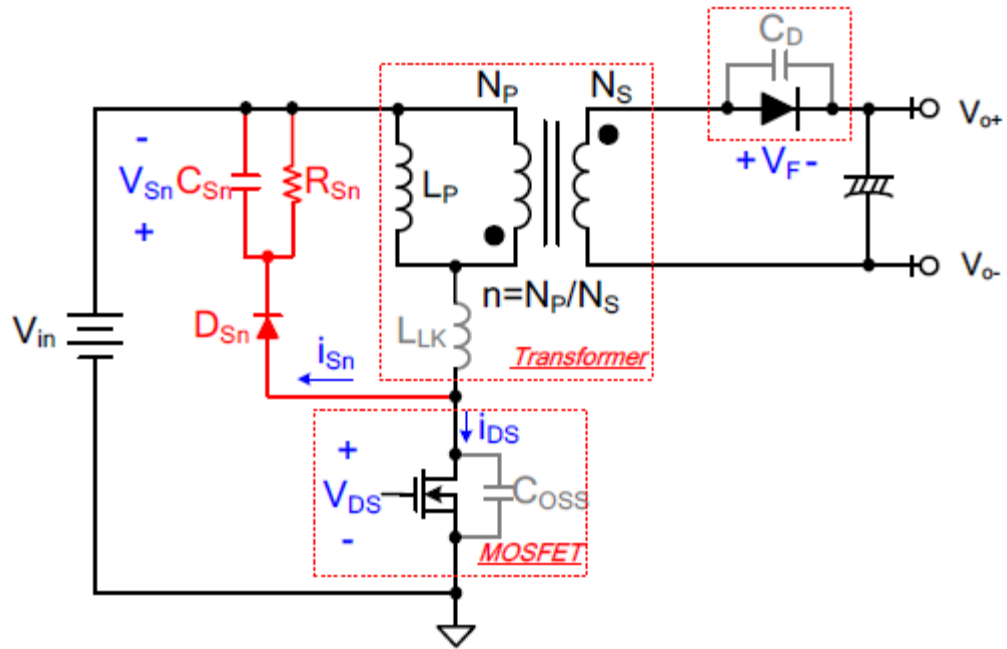


Flyback Converter



Voltage across Primary

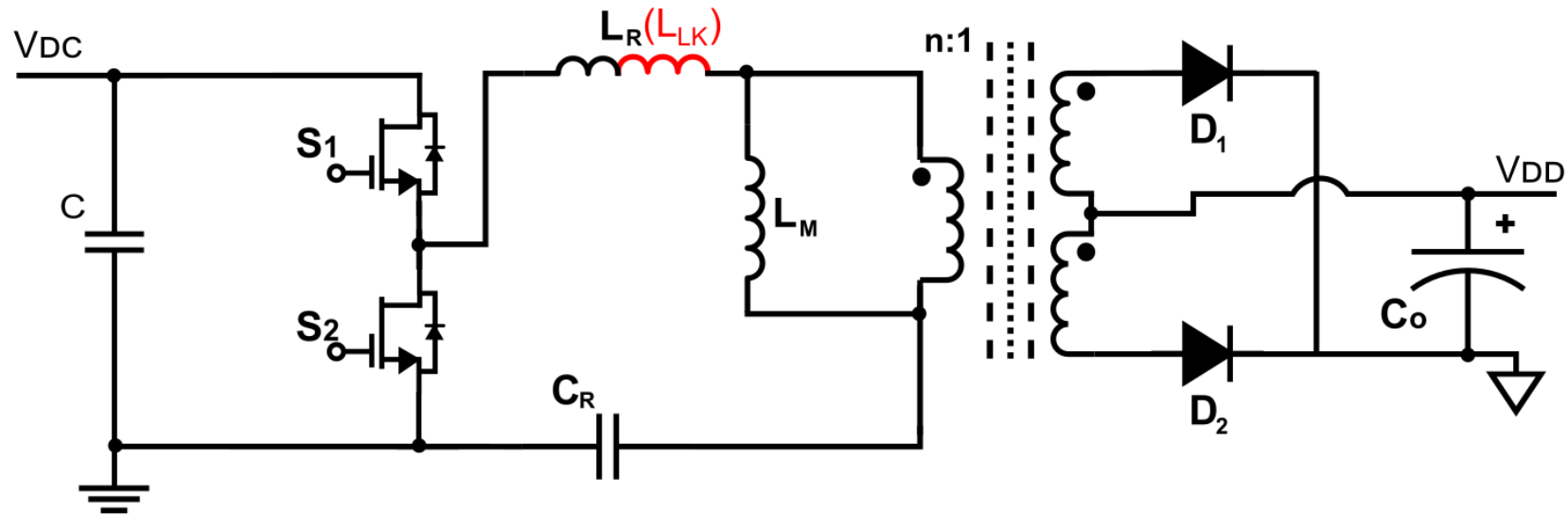
Flyback Converter with Clamping Circuits



SW voltage spikes increase the device rating, complicate snubber design, generate loss and noise, and limit the max operating frequency.

The larger the leakage, the worse the performance of the flyback.

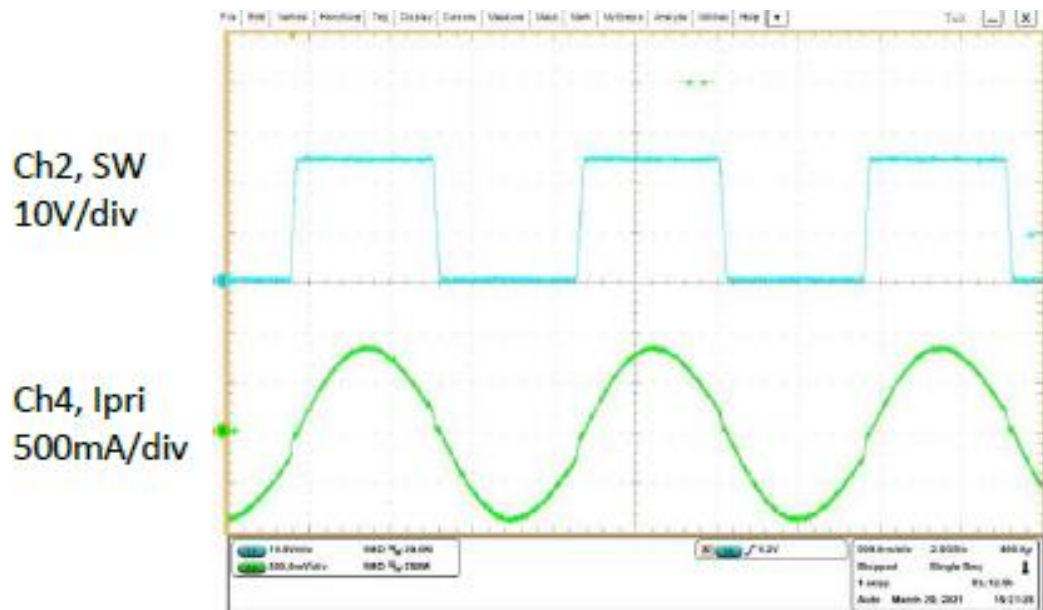
LLC Converter Operation with L_{LK}



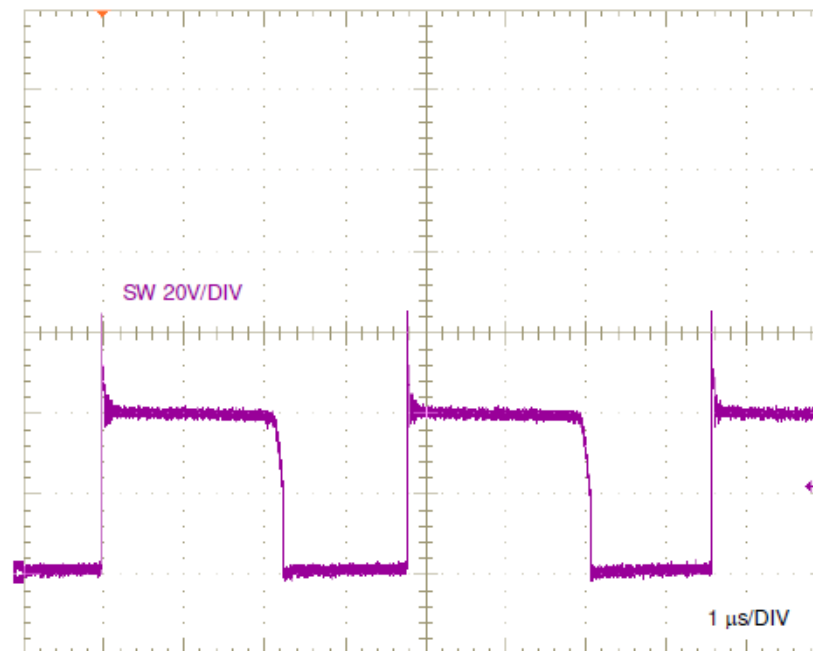
Soft Switching - ZVS \rightarrow High Switching Frequency Achievable with LLC

MPQ18913/4 vs. Flyback SW Waveform

The MPQ18913 uses a soft switching topology, resulting in no overshoot/ringing on the switch node, vs. hard switching in a flyback that has overshoot and ringing on the switch node.



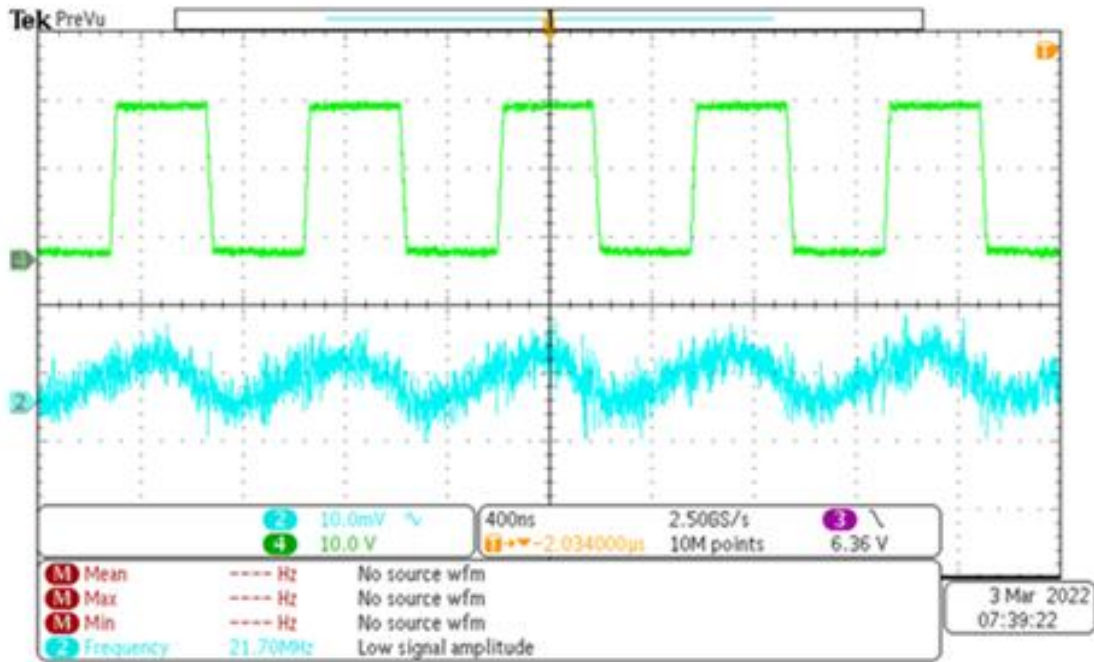
MPQ18913 SW Waveform (Top)



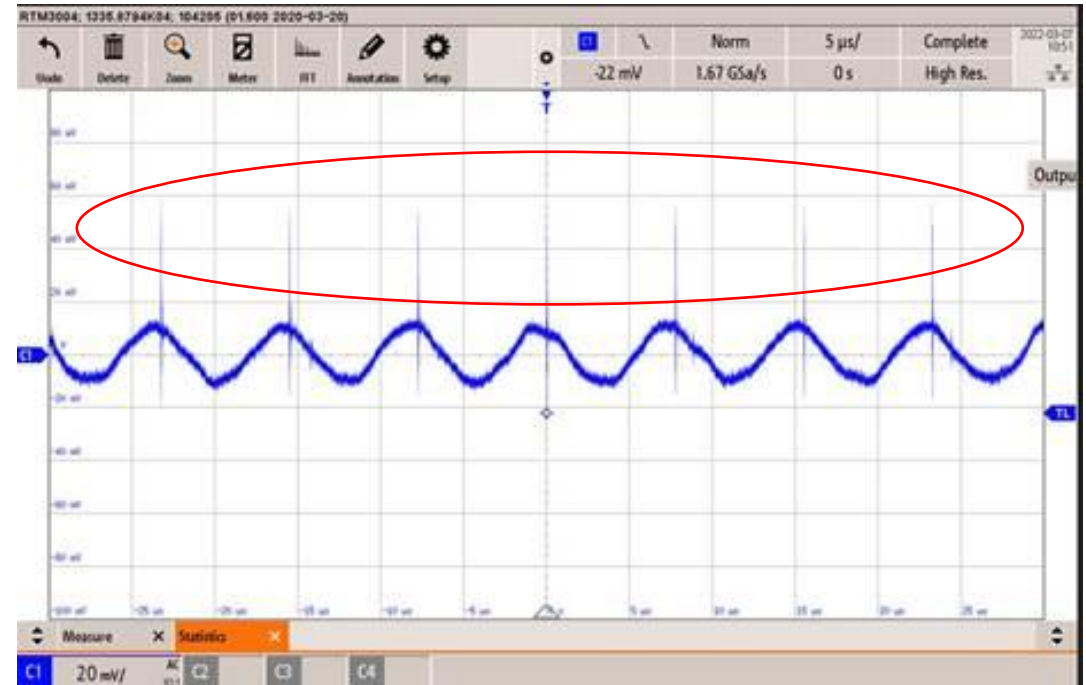
Competitor Flyback SW Waveform

MPQ18913/4 vs. Flyback Topology Input Waveform

The MPQ18913 uses a soft switching topology, resulting in better EMI performance vs. hard switching in a flyback that can couple switching noise to the input rail (circled in red).

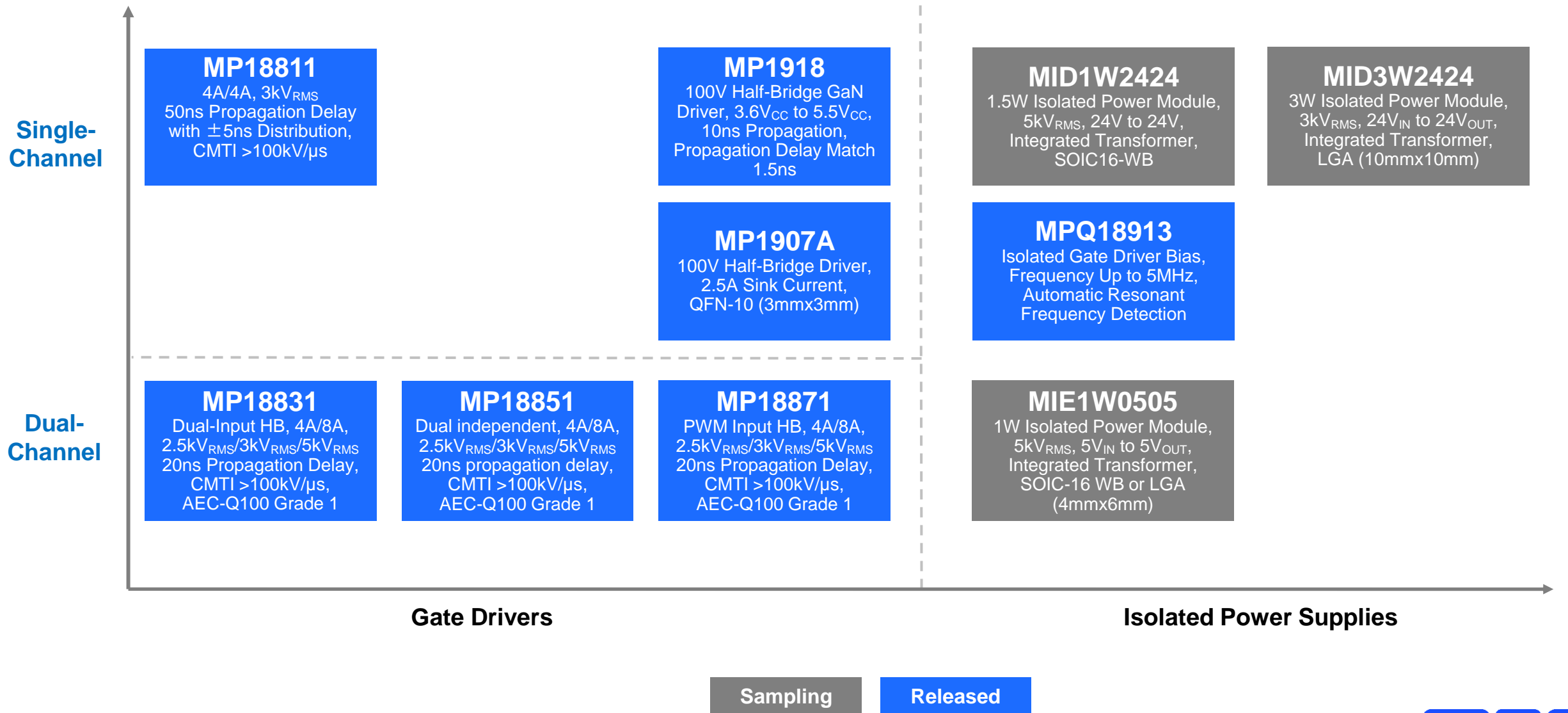


MPQ18913 Input Voltage Waveform (Bottom)



Competitor Flyback Input Voltage Waveform

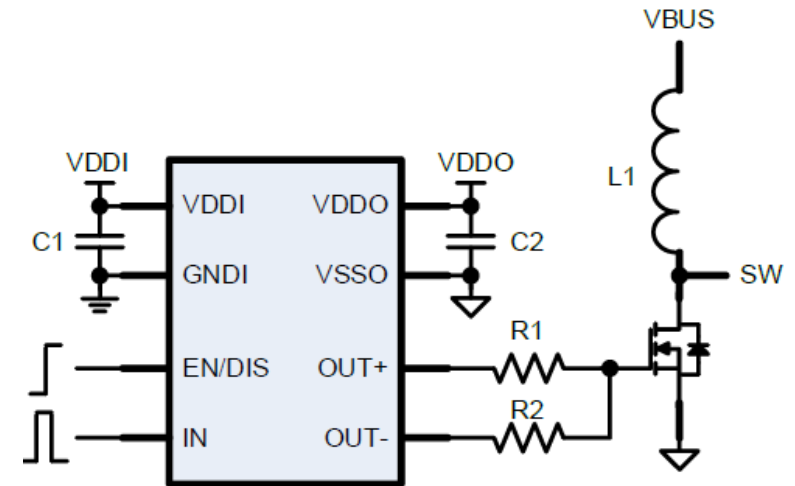
Isolated Gate Driver/Power Supply Roadmap



MP(Q)18811 - Isolated Single-Channel Gate Driver

FEATURES

- $3kV_{RMS}$ Input to Output Isolation (SOIC-8 NB)
- $CMTI > 100kV/\mu s$
- TTL and CMOS Compatible Inputs
- Differential-Input Control
- Up to 30V Output Drive Supply with UVLO Options (5V/8V/10V/12V/15V)
- Output Configurations: Single-Output with Miller Clamp or Split Outputs
- 4A Source/4A Sink Peak Current Output
- 50ns Typical Propagation Delay
 - Tight $\pm 5ns$ Distribution from Part to Part
- Active Miller Clamp
- Operating Junction Temperature Range $-40^{\circ}C$ to $+150^{\circ}C$
- **Narrow Body SOIC-8/Wide Body SOIC-8**



P2P narrow body SOIC-8/wide body SOIC-8

MP1883/5/71 – Isolated Dual-Channel Gate Driver

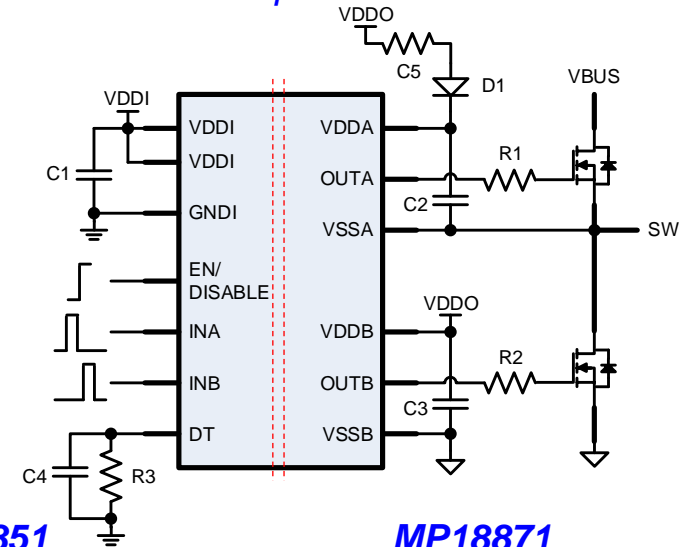
FEATURES

- Flexible Configuration: Rich Family, Independent Dual-Channel Driver, Dual-/PWM-Input Half-Bridge Driver
- Up to $5kV_{RMS}$ Isolation
- $CMTI > 100kV/\mu s$
- TTL and CMOS-Compatible Inputs
- 30V Output Drive Supply with UVLO Options (5V, 8V, 10V, 12V, or 15V)
- 4A Source/8A Sink Peak Current Output
- 50ns Typical Propagation Delay (40ns Typical for the MPQ188xx)
 - Tight $\pm 5ns$ Distribution from Part to Part
- Operating Junction Temperature Range $-40^{\circ}C$ to $+150^{\circ}C$
- Available in Standard Narrow-Body SOIC-16, Wide-Body SOIC-16, LGA-13 (5mmx5mm) Packages

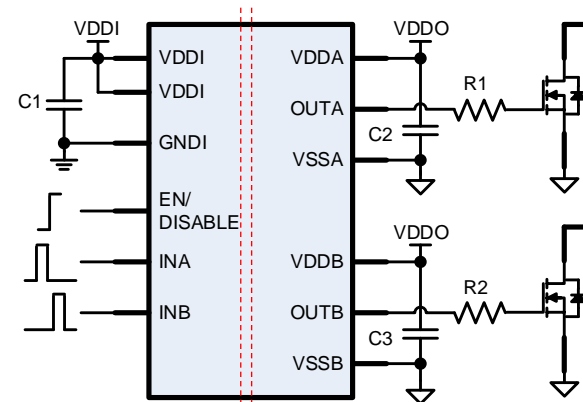
Applications

- Solar Inverters
- DC/AC Inverters
- Offline Isolated AC/DC Converters, Half/Full-Bridge Converters
- Bias for IGBT/SiC/MOSFETs

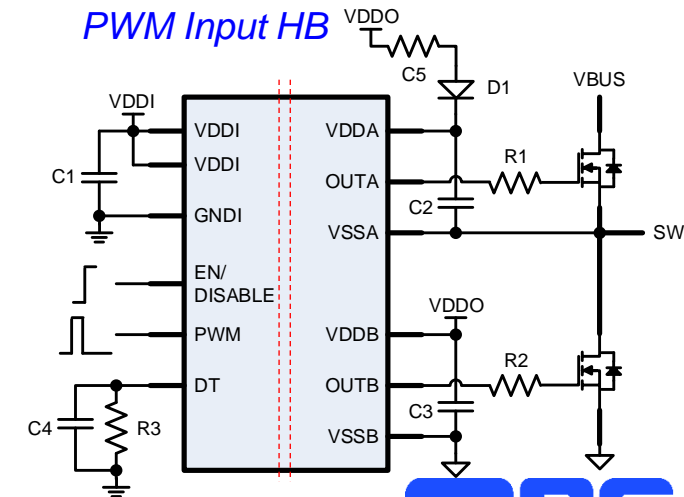
MP18831
Dual-Input HB



MP18851
Dual Independent Drivers



MP18871
PWM Input HB



MIE1W0505A – 5V to 5V Isolated Module

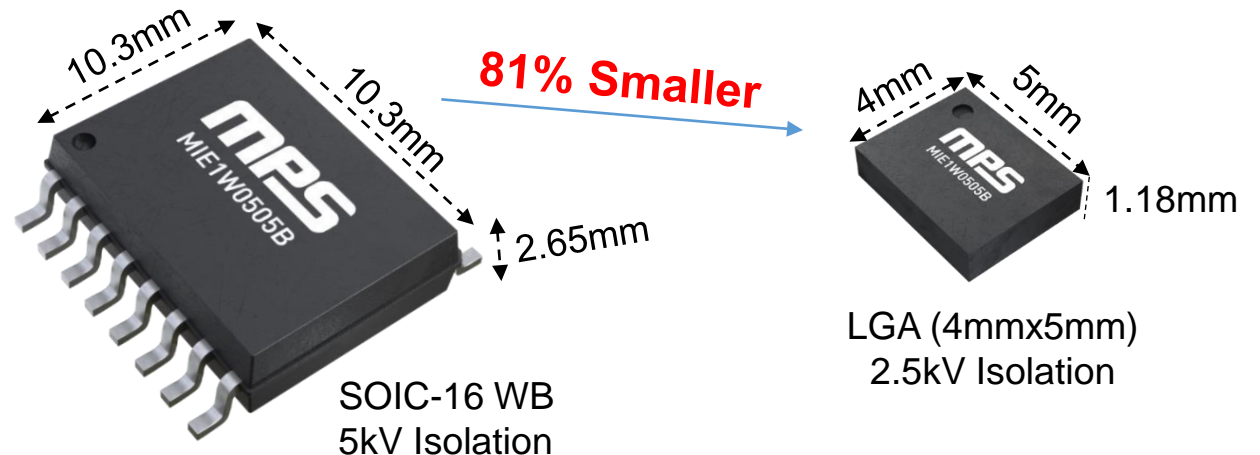
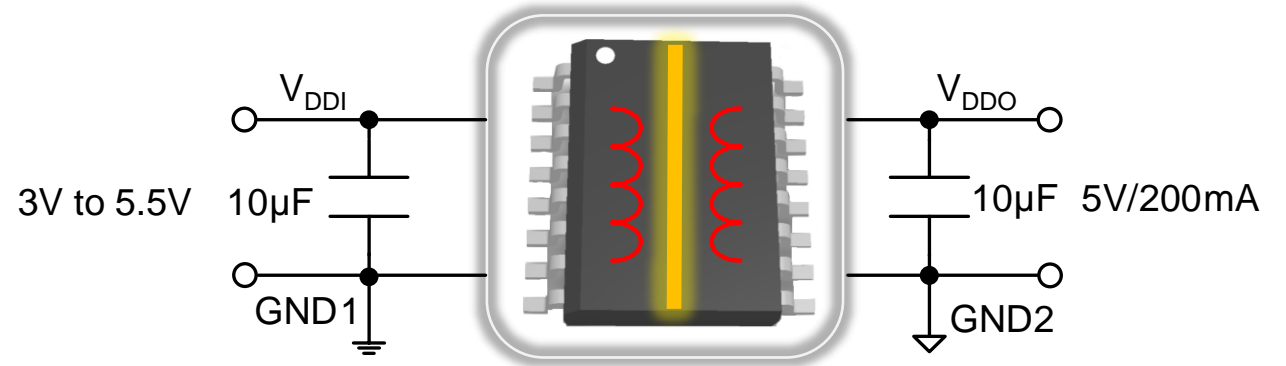
FEATURES

- 3V to 5.5V Input Voltage Range
- 5V/3.3V Output Voltage
 - 5V → 5V or 5V → 3.3V >200mA (1W)
 - 3.3V → 3.3V >50mA (0.165W)
- Excellent Load/Line Regulation Performance
- **1W Output Rating Option**
- Short-Circuit Protection (SCP), Over-Current Protection (OCP), and Over-Temperature Protection (OTP)
- 5kV_{RMS} Isolation (SOIC-16 WB)
- 3kV_{RMS} Isolation (SOIC-8 WB)
- **2.5kV_{RMS} Isolation (Tiny LGA 4mmx5mm)**
- Low Emissions: Meets CISPR 32 Class B Requirements
- Available in a Small SOICW-16, SOIC-8 WB, or Tiny LGA (4mmx5mm) Package

Applications

- BMS
- Digital Isolator Bias Supplies

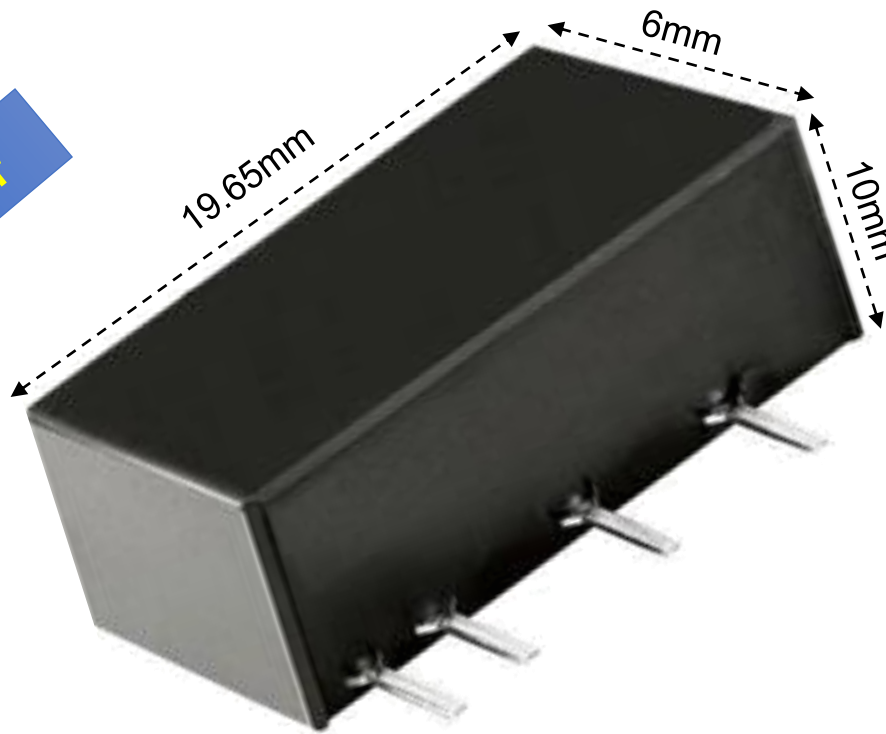
Typical Circuit



MIE1W0505BGLVH Is Incredibly Small

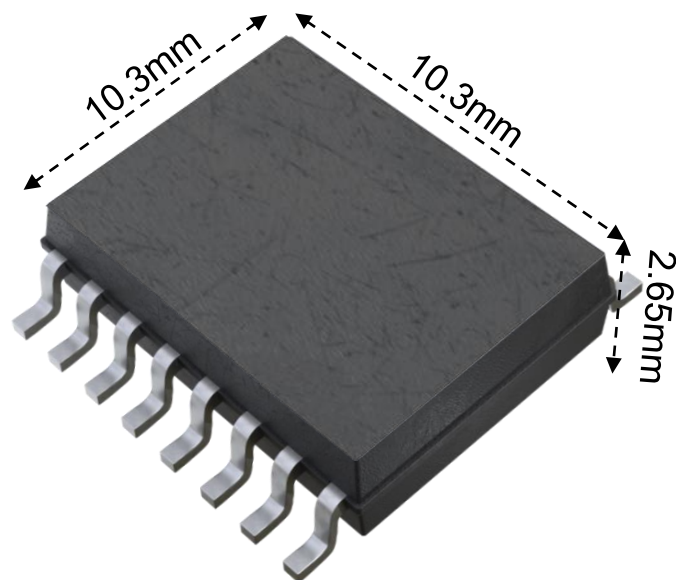
MPS's solution (LGA 4x5mm) is only **10%** the total size of the market SOIC package, and only **2%** of a traditional SIP package.

5x Smaller

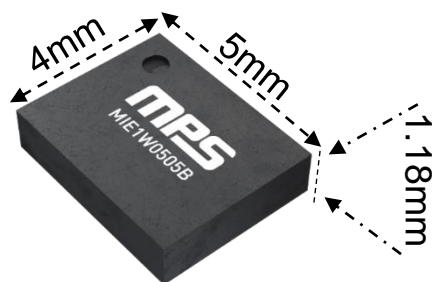


Traditional **SIP** Package

10x Smaller



Market **SOIC-16W** Package



MPS **LGA (4mmx5mm)**
Package

MID3W2424A – 24V to 24V Isolated Module

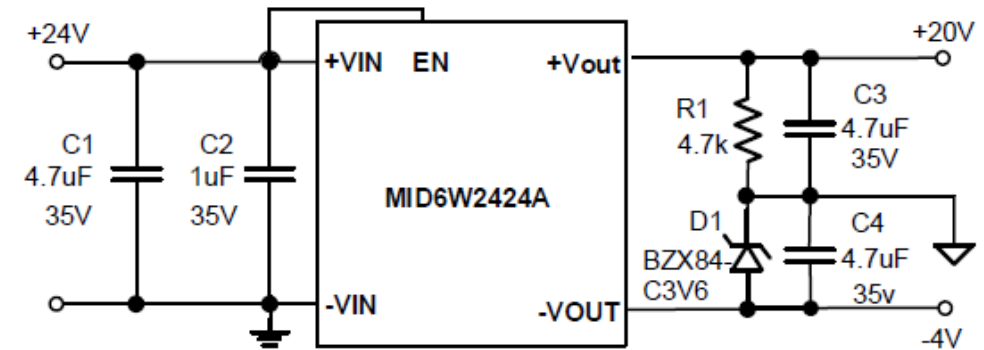
FEATURES

- 5V to 30V Input Voltage Range (Typically 24V \pm 10%)
- Power Level 3W/6W, **87% Peak Efficiency**
- Transformer Turns Ratio
 - MID6W1224/MID3W1224: 1:2 Turns Ratio
 - MID6W1524/MID3W1524: 1:1.6 Turns Ratio
 - MID6W2424/MID3W2424: 1:1 Turns Ratio
- **Strong Magnetic Field Immunity**
- Short-Circuit Protection (SCP), Over-Current Protection (OCP), and Over-Temperature Protection (OTP)
- 3kV_{RMS} Isolation
- Available in an LGA (10mmx10mm) package
- -40°C to +105°C Operating Temperature

Applications

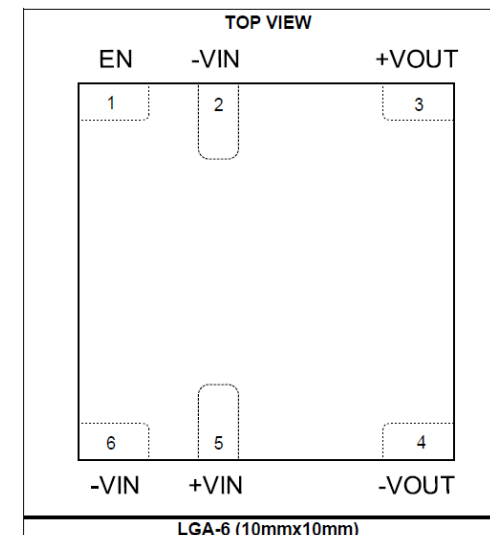
- SiC/IGBT Gate Drive Power Supplies
- Industrial Automation, PLC I/O Modules
- Grid Protection Relays

Typical Circuit



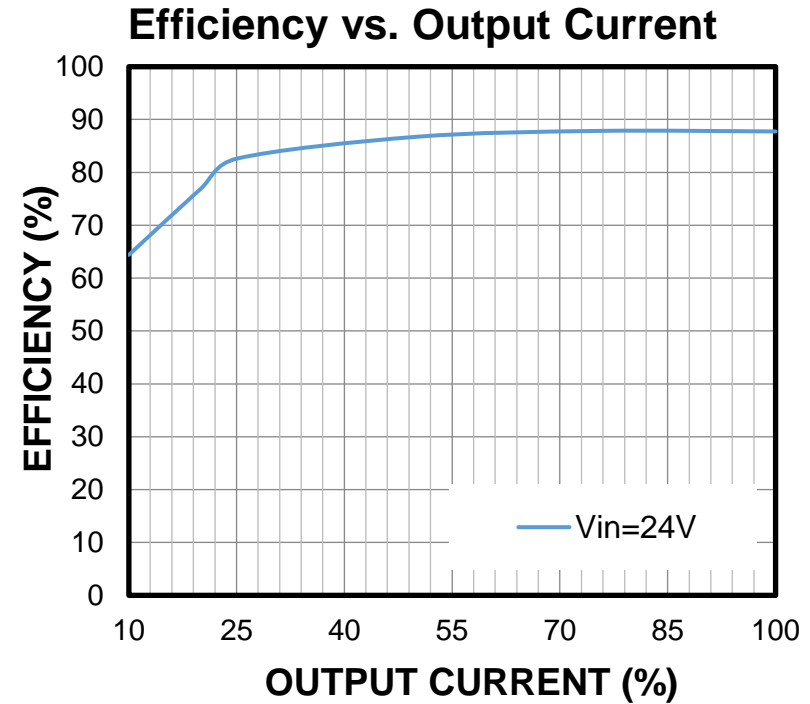
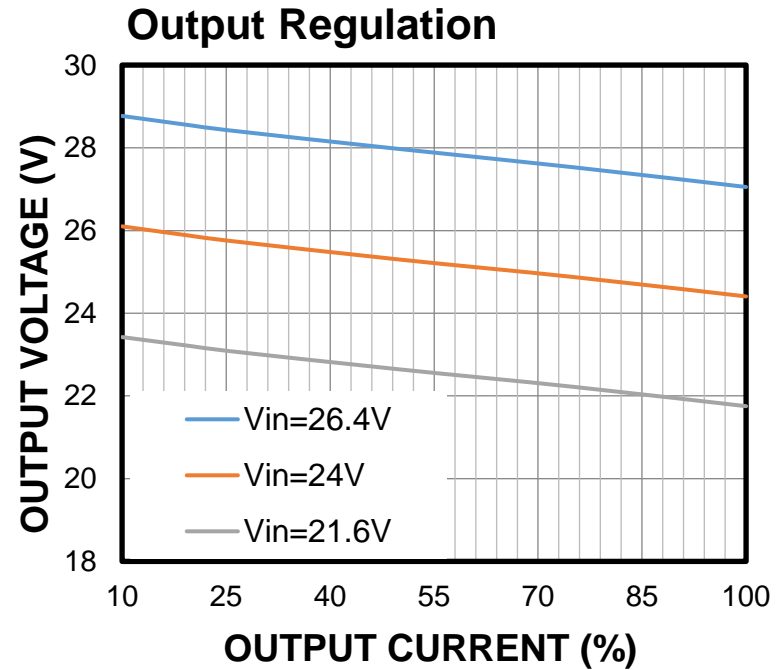
SiC Gate Driver Power Supply

PACKAGE REFERENCE

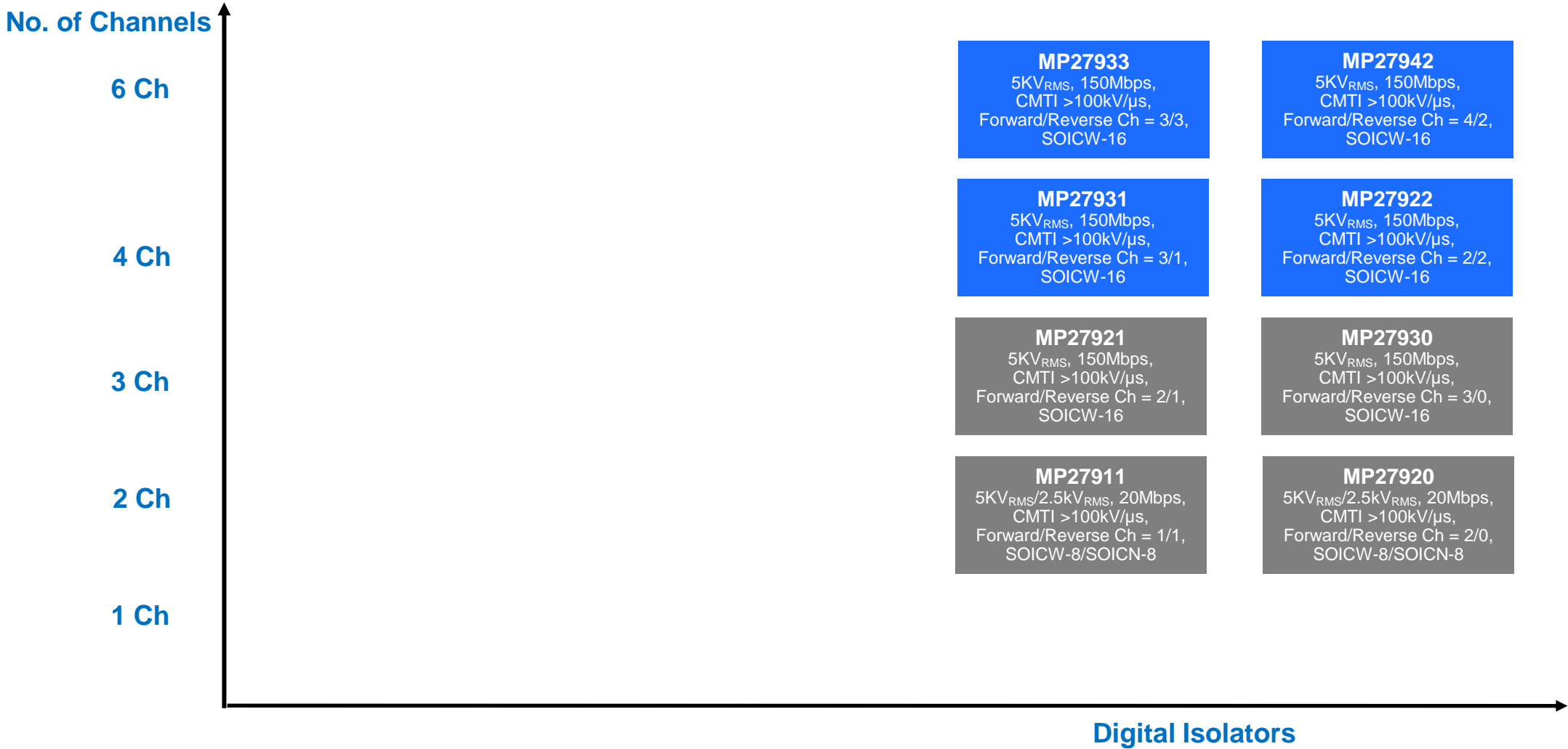


MID3W2424A Performance

$V_{IN} = 24V$, $I_{OUT} = 0.25A$ (Full Load), $T_A = 25^\circ C$



Digital Isolator Roadmap



Sampling

Released



MP279xx – 4-Channel to 6-Channel Digital Isolator

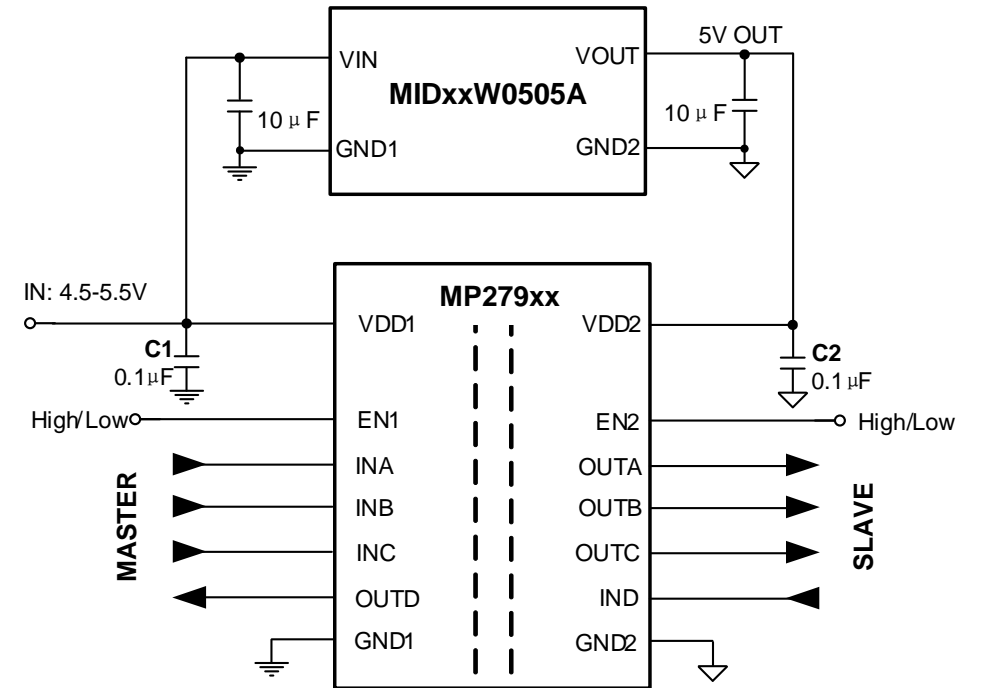
FEATURES

- Wide 2.5V to 5.5V Input Voltage Range
- Up to 150Mbps Data Rate, 20Mbps Option
- Ultra-Low Power Supply Current
- High Electromagnetic Immunity
- $>\pm 100\text{kV}/\mu\text{s}$ Common-Mode Transient Immunity (CMTI)
- 13ns Propagation Delay for 5V Operation
- 5kV_{RMS} Isolation
- Selectable Channel Direction
 - 4-Channel (4/0, 3/1, 2/2)
 - 6-Channel (6/0, 5/1, 4/2, 3/3)
- Selectable Output Default Value
- Available in a SOICW-16 Package

Applications

- E-Meters
- Isolated ADCs and DACs
- Motor Control and Industrial Automation
- SPI Isolation

Typical Circuit

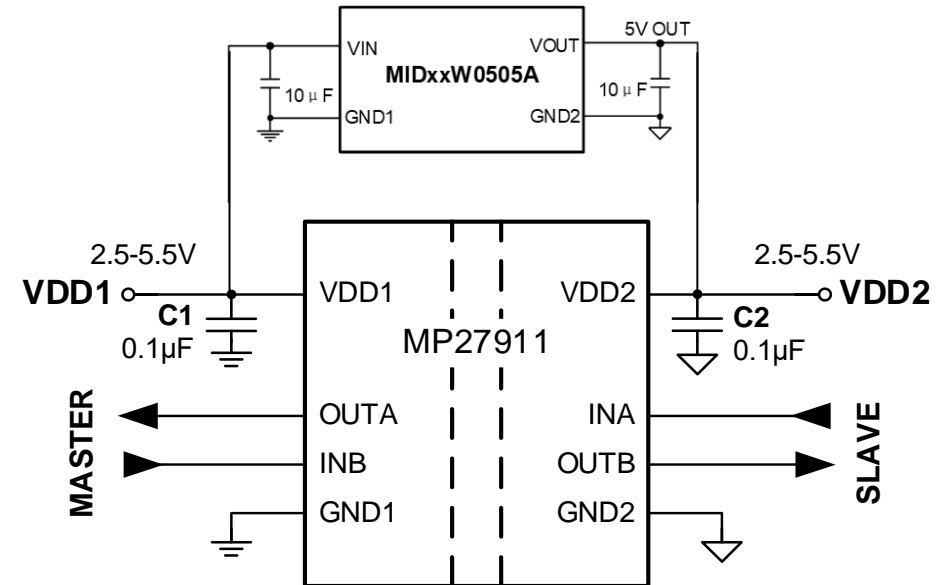


MP279xx – 2-Channel Digital Isolator

FEATURES

- Wide 2.5V to 5.5V Input Voltage Range
- Up to 150Mbps Data Rate
- Ultra-Low Power Supply Current
- High Electromagnetic Immunity
- $>\pm 100\text{kV}/\mu\text{s}$ Common-Mode Transient Immunity (CMTI)
- 13ns Propagation Delay for 5V Operation
- 5kV_{RMS} (WB) or 3kV_{RMS} (NB) Isolation
- Selectable Channel Direction
- Selectable Output Default Value
- Available in an SOIC-8 NB or SOIC-8 WB Package

Typical Circuit



Thank You!

✓ Electrification

Si Carbide
Solutions

Integration

Low component count
Lower solution cost

800V Solutions

Enable High Voltage
Charging Solutions

✓ Technology

MPS Power | Analog
B C D

950+ SKUs

Broad portfolio with flexible,
scalable solutions

MPSafe™
ASIL D Ready

✓ Experience

12 Years

Automotive industry

2+ Billion

Automotive units shipped

✓ Quality

0.1 DPPM

Quality record



Run cooler



Design faster



Push higher
performance



Achieve EMC
Resilience



Capacitive
Isolation



Integrated
Solutions



Improve quality



Extend battery
Runtime

Thank you!