power integrations™

PowiGaN™ Switches Will Dominate the Market

May 2020

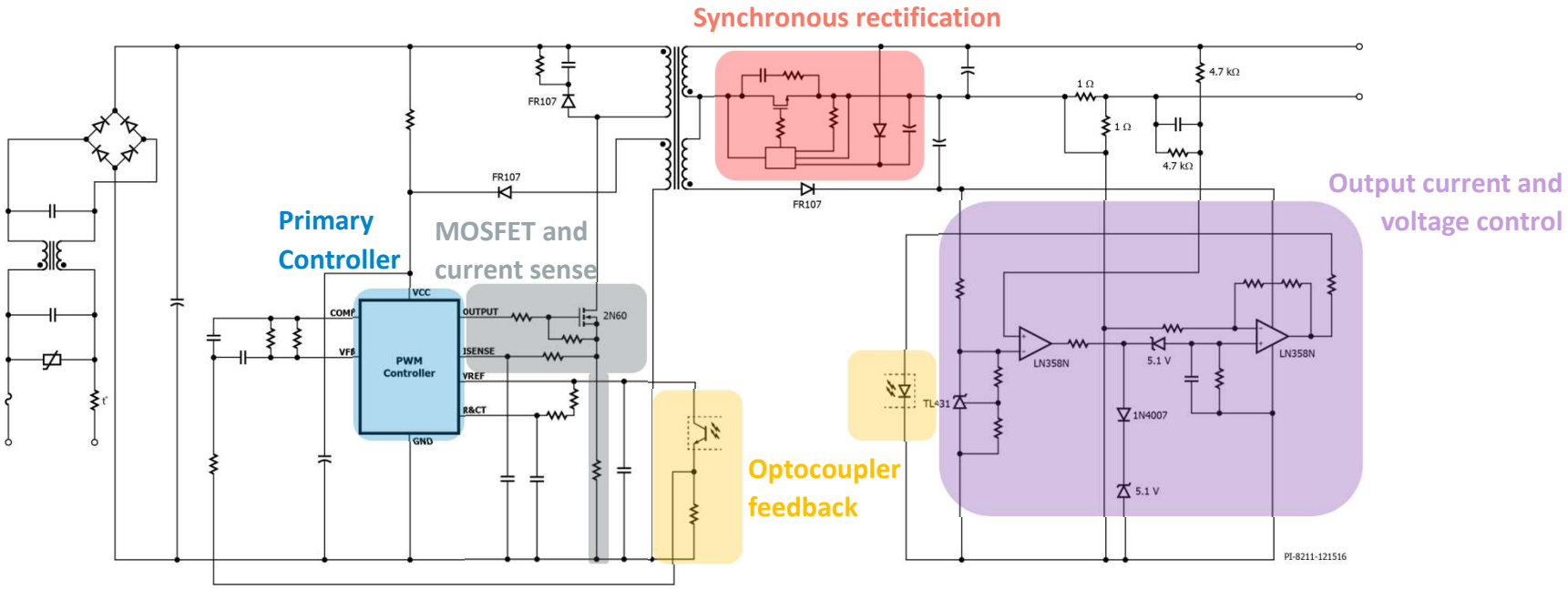
ac-dc converters led drivers gate drivers motor drivers

5 PI IC Families Already Feature PowiGaN Switches

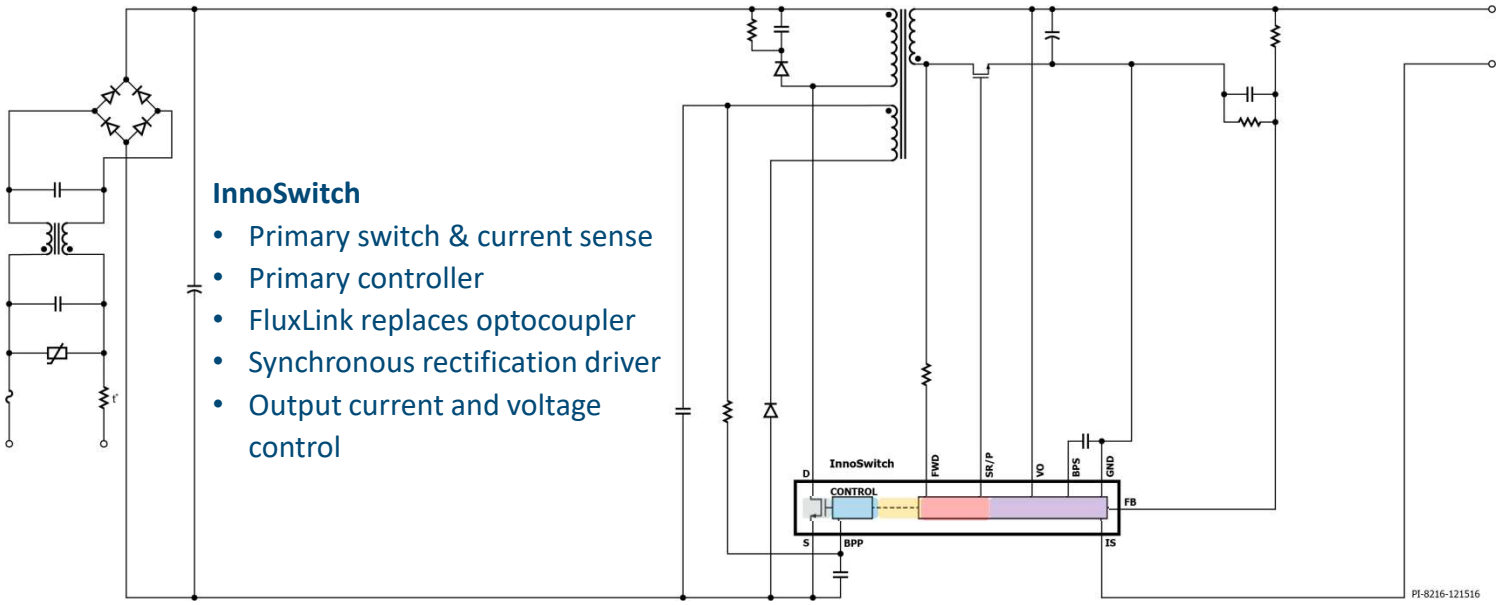
- **Integrated GaN switch used across multiple families**
  - InnoSwitch™3-EP
  - InnoSwitch3-CP
  - InnoSwitch3-Pro
  - LYTSwitch™-6
  - InnoSwitch3-MX

The InnoSwitch Advantage

Conventional High Efficiency Charger



InnoSwitch High Efficiency Charger



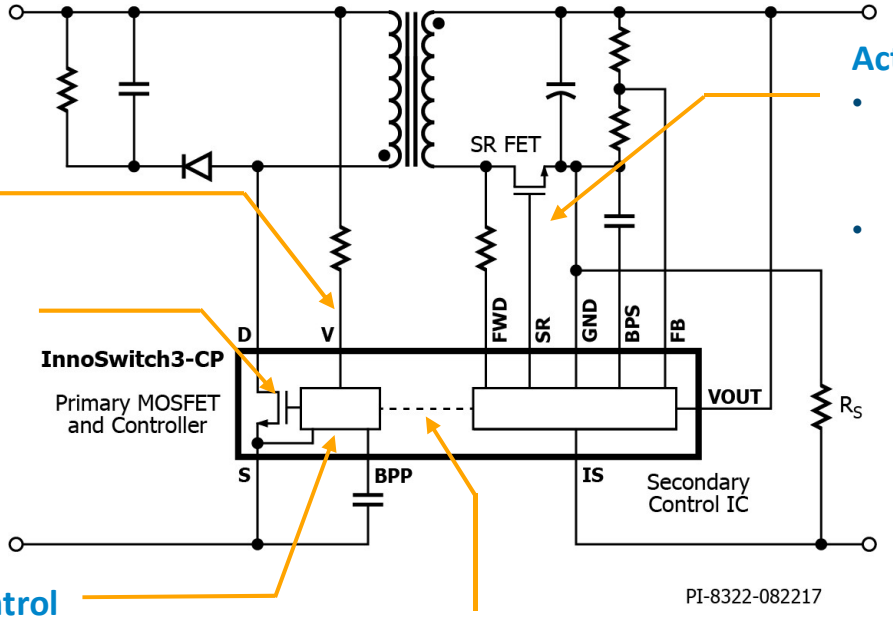
InnoSwitch

- Primary switch & current sense
- Primary controller
- FluxLink replaces optocoupler
- Synchronous rectification driver
- Output current and voltage control

InnoSwitch-3 Isolated Flyback Employs FluxLink™ Digital Feedback to Eliminate Optocouplers

Lossless Sensing
- Protection from line surges
- Adds < 2 mW to no-load

Integrated Power MOSFET
- 650 V / 725 V / 750 V



Active Control of SR MOSFET
- Reduced diode conduction increases SR FET conduction time for best efficiency
- Seamless DCM-CCM transitions

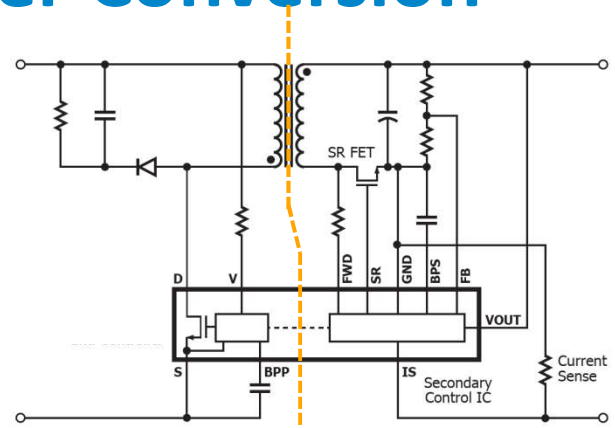
Characteristic	Specification
Voltage Tolerance	±3%
Current Tolerance	+/-5%
Transient Response	Excellent
No-Load Input Power including line sense	< 15 mW

Proprietary Switch and Control
- CCM and Quasi-resonant switching
- Highest efficiency
- Lowest losses

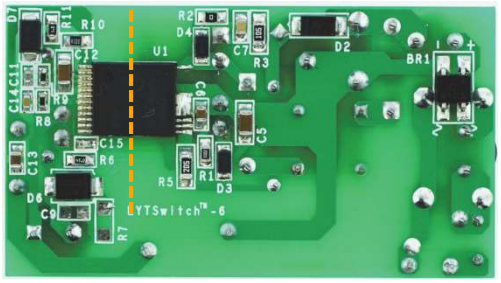
FluxLink – Isolated Feedback
- High reliability, lifetime

FluxLink Accurately Controls Power Conversion

- **Magneto-inductive coupling primary-to-secondary**
  - Benefits of secondary-side control
  - Simplicity of primary-side driver
  - Isolation without optocouplers
- **Crosses isolation barrier**
  - Controls both primary and secondary switching
    - Optimizes performance for highest efficiency
  - Meets all regulatory and hi-pot isolation requirements
- **Directly monitors output**
  - Accurate output voltage and current
- **Drives synchronous rectification MOSFET**
  - Simple design
  - Highly reliable under all conditions



FluxLink: Magneto-inductive coupling crosses the isolation barrier



CQC, UL and TUV certified isolation as barrier component

PowiGaN

InnoSwitch3 ICs with PowiGaN Technology Achieve >100 W

- **InnoSwitch3 silicon transistors are highly effective up to 65 W**
- **PowiGaN switches provide more power**
  - Lower $R_{DS(ON)}$ per unit area
  - Lower switching losses
- **PowiGaN devices**
  - InnoSwitch3-CP – constant power
  - InnoSwitch3-EP – for open-frame
  - InnoSwitch3-Pro – digital control

725 / 750 V Part Number	230 VAC +/- 15%		85 - 264 VAC	
	Adapter	Open Frame	Adapter	Open Frame
INN3x74C	20 W	25 W	15 W	20 W
INN3x75C	25 W	30 W	22 W	25 W
INN3x76C	35 W	40 W	27 W	36 W
INN3x77C	40 W	45 W	36 W	40 W
INN3x78C	70 W	75 W	55 W	65 W
INN3x79C	80 W	85 W	65 W	75 W
INN3x70C	90 W	100 W	75 W	85 W

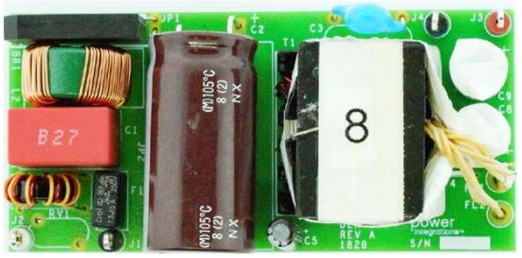
PowiGaN switches

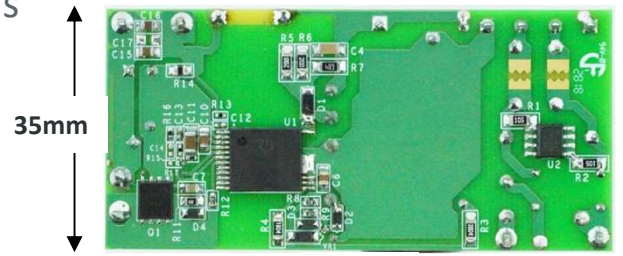
PowiGaN Delivers Best Performance

- **Highest efficiency conversion**
  - 95% efficient – flat across line and load
  - No heatsinks
  - Highest power density for smart-charging adapters

- **Safe, familiar, reliable – it just works**
  - Just another switching technology from Power Integrations
  - Looks and behaves like a silicon MOSFET
  - No EMI challenges
  - High operating voltage and increased surge margin
  - Less than 40 mW no-load consumption at 265 VAC

- **In production now**
  - More than 6 million parts shipped



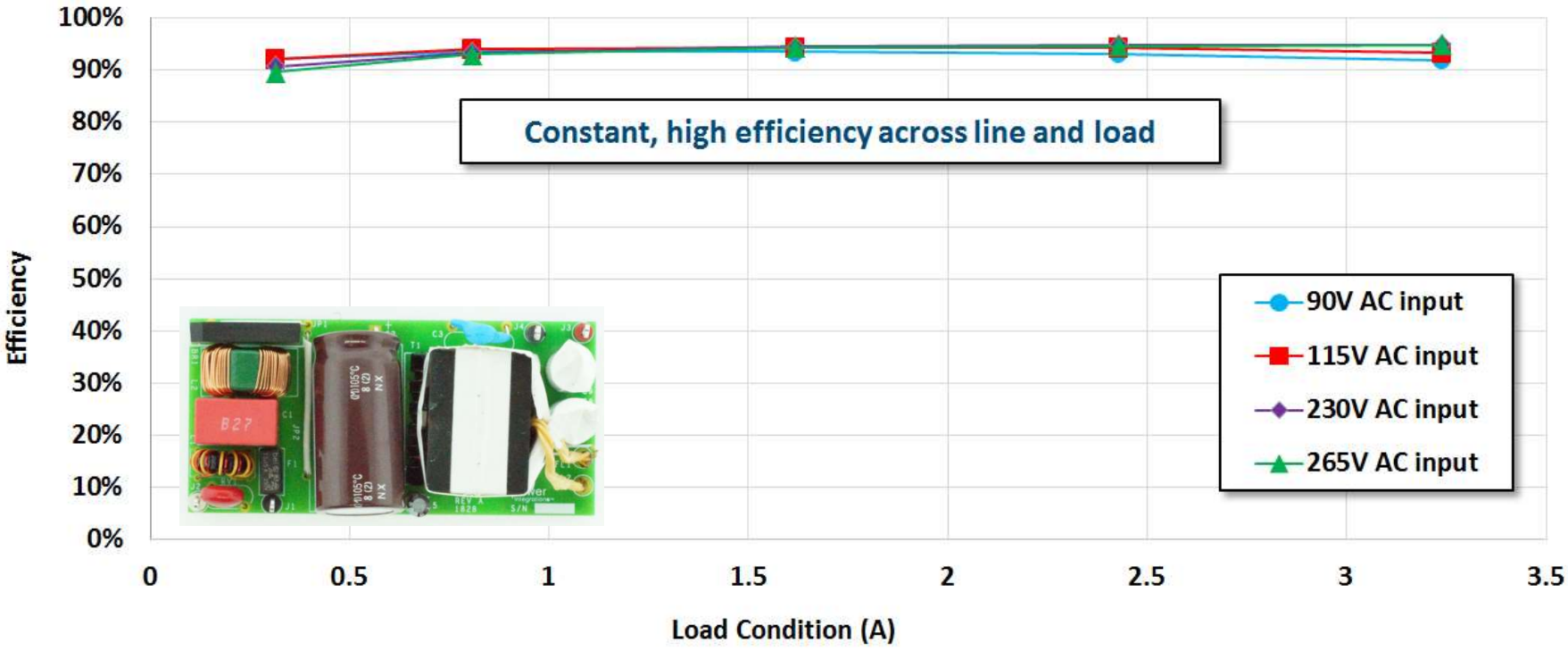


DER-747
65W 20V / 3.25A

The Small Step in Efficiency…. Got Bigger

Description	Full-Load Efficiency	Heat Energy (W)	Surface Area (Adapter)	Thermally Limited Volume
Legacy Adapter	87%	5.85	1	1
"High Efficiency" Design	90%	4.5	0.77	0.67
InnoSwitch	92%	3.6	0.62	0.48
InnoSwitch3	**94%**	**2.7**	**0.48**	**0.3**
InnoSwitch3 (with PowiGaN)	**95.5%**	**2.0**	**0.35**	**0.21**

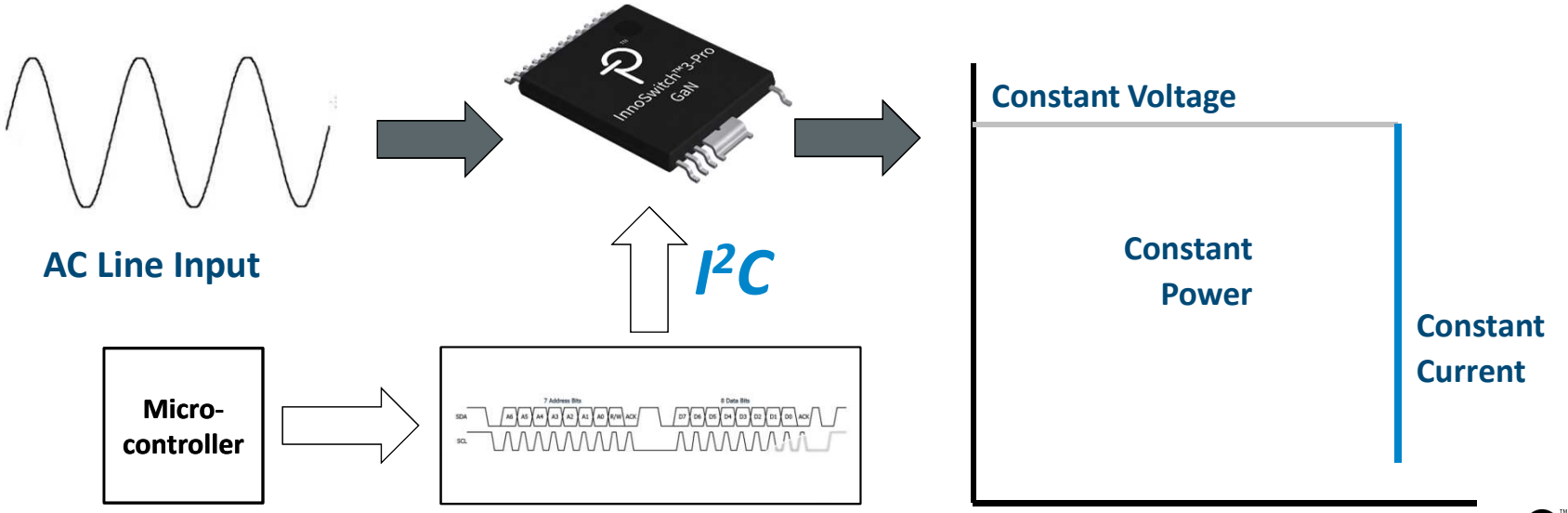
65 W DER-747 PowiGaN Constant High Efficiency Across Line and Load



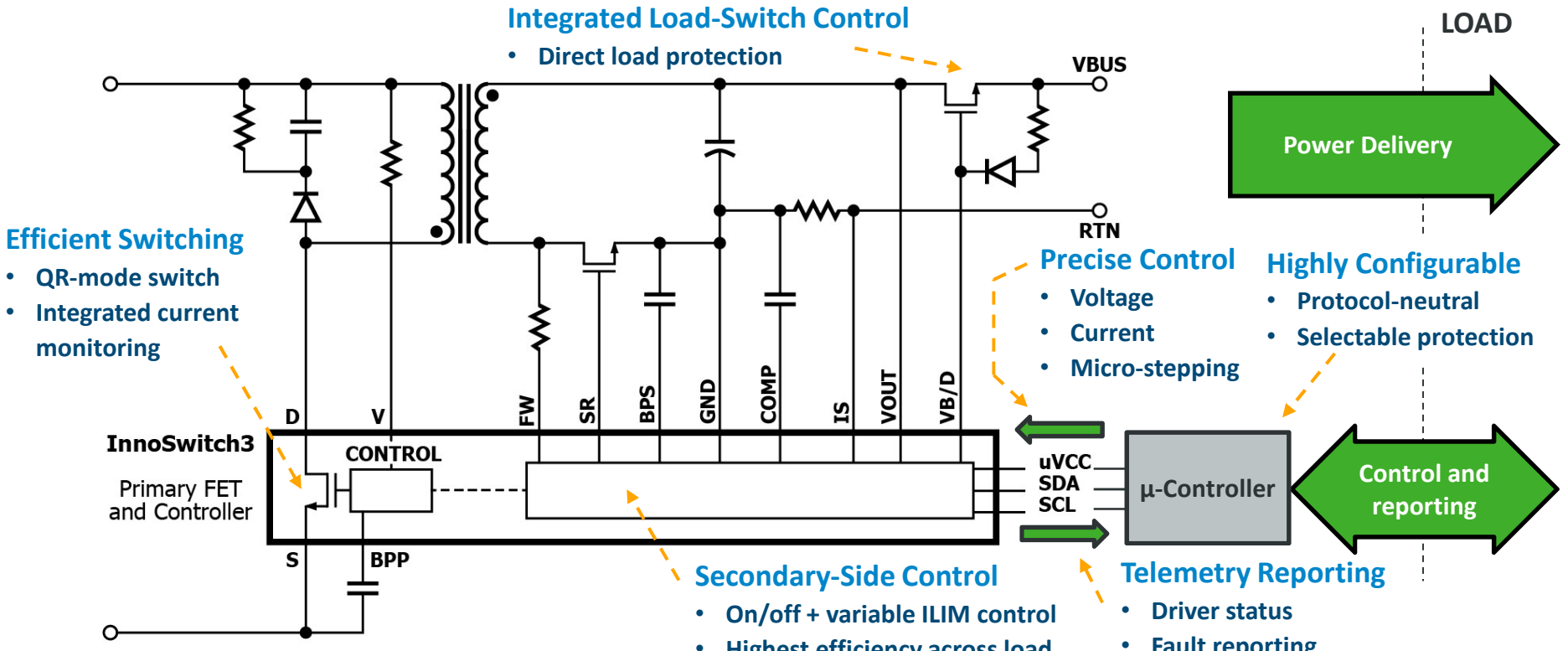
InnoSwitch3-Pro

InnoSwitch3-Pro: Digitally Programmable Power Conversion

- **Advanced control engine with digital interface (I^2C)**
  - Output voltage and current control - CV/CC/CP output characteristic
  - Configurable protection – enable/disable, shutdown/auto-restart, trigger-points

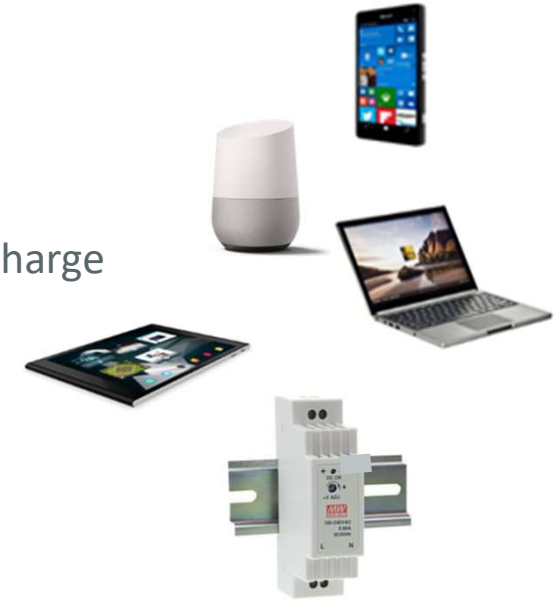


Adding Output Control to Proven InnoSwitch3



InnoSwitch3-Pro Supports a Wide Range of Applications

- **Virtually any dynamic rapid-battery-charging protocol**
  - Smart phones, notebooks/laptops/tablets, smart speakers
  - USB PD 3.0 + PPS “load-directed” charging protocol
  - Supports all rapid charge protocols including USB PD, Rapid Charge



- **Field-programmable and region-centric protection**
  - Multi-voltage lighting ballasts, DIN-rail power supplies
  - Protection features that match regional preferences

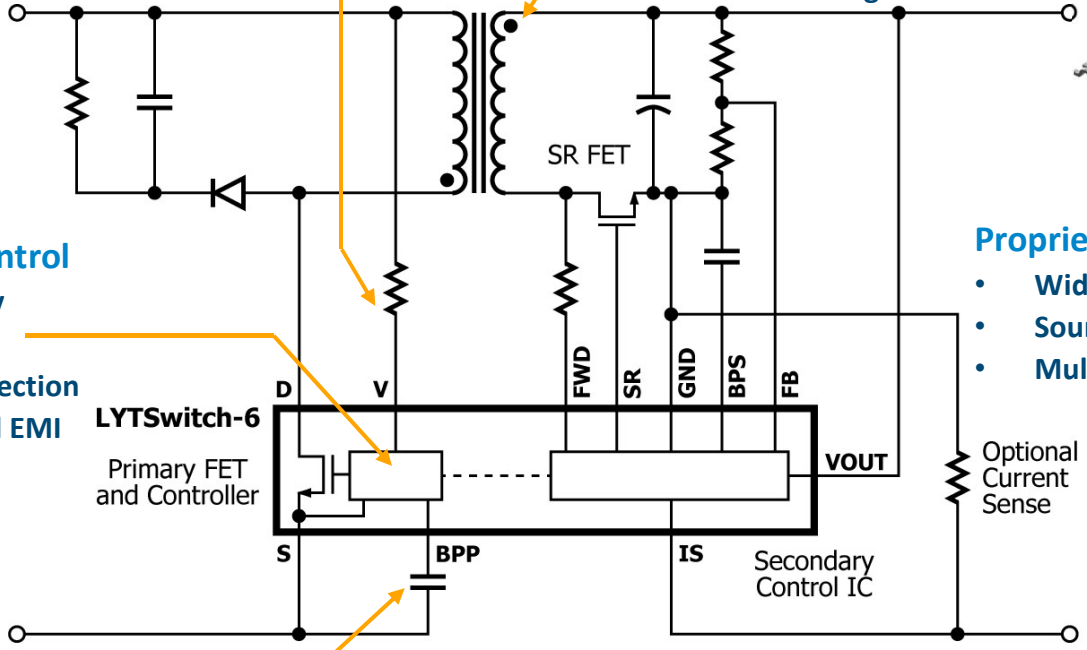
- **Programmable performance in non-charging applications**
  - Multiple solutions from single power supply design
  - Reduces design-time, reduces production, approvals and inventory costs

LYTSwitch-6

LYTSwitch-6 Uses PI Innovations for Best Performance

Lossless Line Voltage Sensing
- Minimizes no-load

Transformer
- Shield windings reduce EMI



Proprietary Switch and Control
- Highest full load efficiency
- Lowest light load losses
- Accurate reliable fault detection
- Frequency jitter – reduced EMI

Proprietary InSOP-C Package
- Widest creepage and clearance
- Source potential heat transfer
- Multiple pins for sense/control

Integrated Start-Up
- Internal tap driven
- No external start-up components

DER-801: 100 W Wide-Range Ballast

Features

- Constant voltage and constant current mode LYTSwitch-6 (LYTSwitch-6079C)
- 90-305 VAC and active PFC with HiperPFS-4
- 3-in-1 dimming (0-10 V, PWM and resistor)
  - Dimmable to 1% and dim-to-off
- Low component count
- Flicker-free operation

Typical Specification

Output voltage:	48 V
Output current:	2080 mA
Output ripple current:	<5% of nominal
Efficiency:	>90% at 230 VAC
Power factor:	>0.9 at full load
Surge withstand:	2.5 kV differential

LYTSwitch-6: Better than the Competition

- **± 3% CV and CC output characteristic**
  - Single design covers multiple applications
- **Low no-load <15 mW (without PF)**
  - Easily meets DOE-6 and ENERGY STAR® for North America
- **Supports analog and PWM dimming**
- **Very high efficiency**
- **Fast control reduces output ripple**
  - Less output capacitance required
- **Excellent load regulation and instantaneous transient response**
  - Ideal for multi-string applications, such as RGB with highly variable independent loads

Expanding the LYTSwitch-6 Power Range

Part Number	MOSFET $V_{DS(max)}$	Output Power - Open Frame		
		277 VAC (± 15%)	90-305 VAC	380 - 450 VDC
LYT6063C	650 V	15 W	12 W	
LYT6073C	725 V			25 W
LYT6065C	650 V	30 W	25 W	
LYT6075C	725 V			40 W
LYT6067C	650 V	50 W	45 W	
LYT6077C	725 V			60 W
LYT6068C	650 V	65 W	55 W	
LYT6078C	750 V	75 W	65 W	90 W
LYT6079C	750 V	85 W	75 W	100 W
LYT6070C	750 V	95 W	85 W	110 W

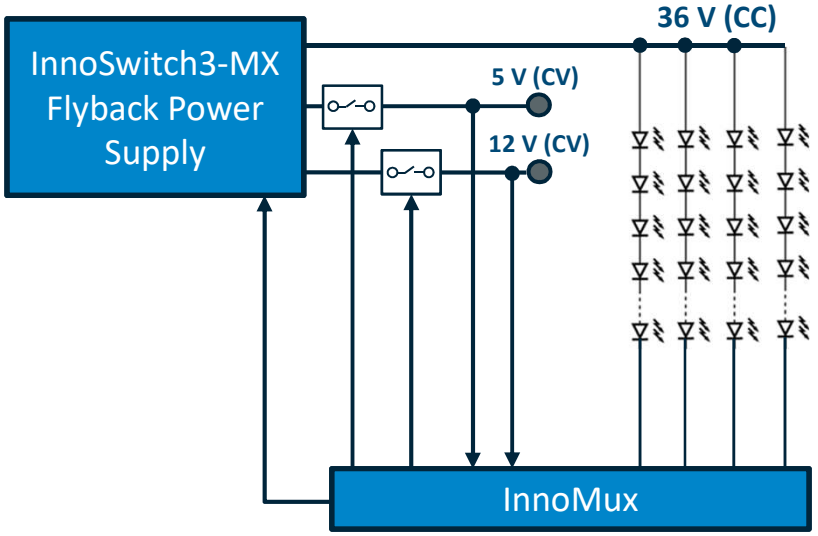
Advanced InSOP-24 package

- Reduced board space
- No heatsinks required
- Extended creepage and clearance

PowiGaN

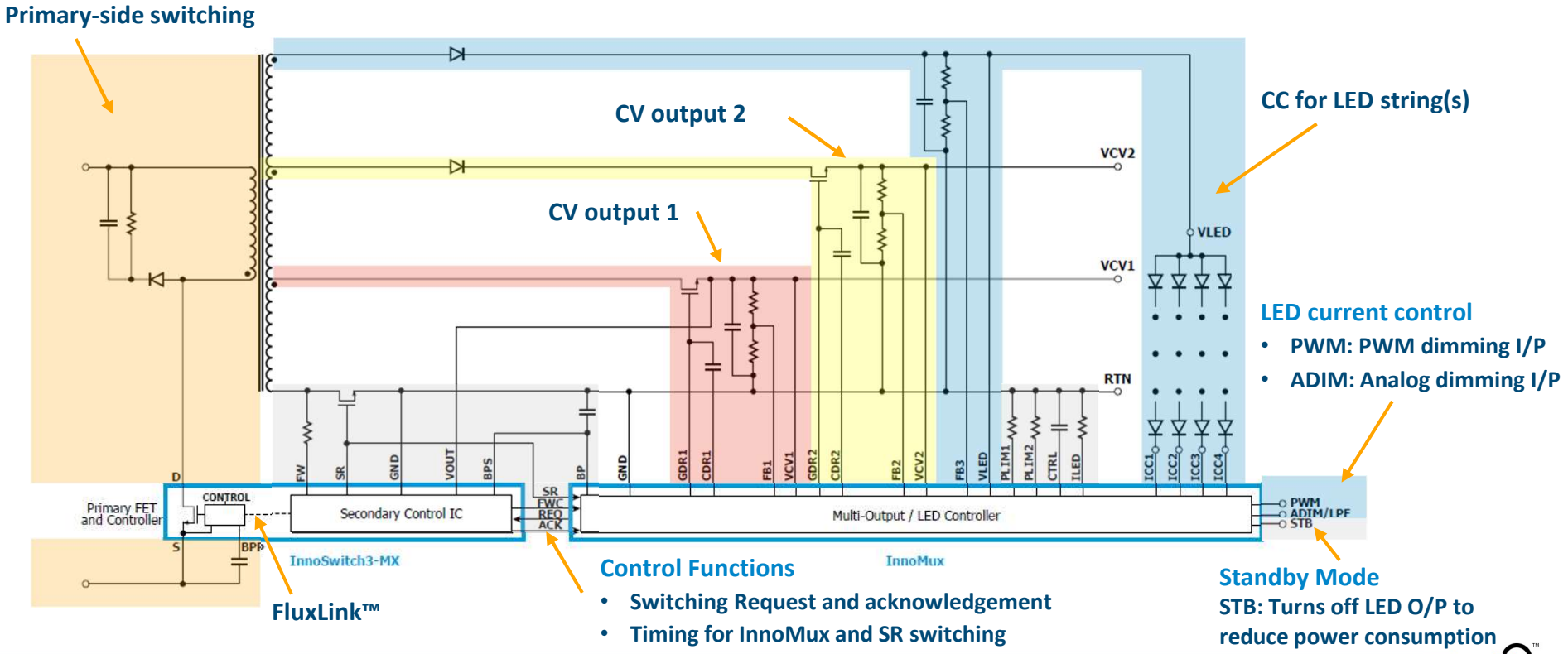
InnoSwitch3-MX

InnoMux™ A Single Stage Power Structure for Display Application



InnoSwitch3-MX Plus InnoMux Single-Stage Conversion Provides CV and CC Outputs

InnoSwitch3-MX Provides Power when Asked InnoMux IC Sends it ONLY Where Needed



InnoMux Chipset Provides Up to 75 W Output

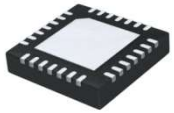
InnoSwitch3-MX

Part Number	Primary MOSFET ($V_{DS(MAX)}$)	Power (W) 85 – 264 VAC
INN34X5C	650/725	20
INN34X6C	650/725	25
INN34X7C	650/725	32
INN3468C	650	40
INN3478C	750	55
INN3479C	750	65
INN3479C	750	75

InSOP-24D (C-Package)
MSL-3 Rated - wave solder and reflow

InnoMux

Part Number	Channels		Package
	LED strings	CV O/Ps	
IMX101J	1	1	QFN
IMX101U	1	2	HSOP
IMX102U	4	1	HSOP



QFN-28 (J-Package)
MSL-1 Rated - reflow

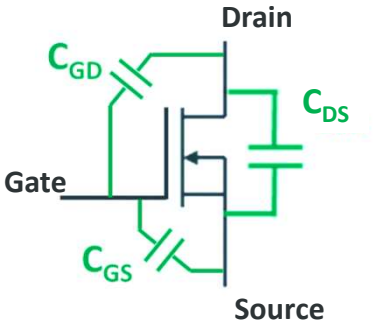
HSOP-28 (U-Package)
MSL-1 Rated – Wave Solder

Reference Design	Typical Application	Input (VAC)	Power (W)	Part Number		O/P 1 Const. Voltage	O/P 2 Const. Voltage	O/P 3 Const. Current	Dimming
				InnoSwitch3-MX	InnoMux				
DER-636	Monitors	90 - 264	40	INN3468C	IMX102U	5 V@ 3 A	-	36 V @ 0.6 A	PWM/Analog

Why GaN is Taking Over

GaN Switches Significantly Reduce Losses

- **MOSFET output capacitance is discharged through itself at turn-on**
  - Parasitic capacitances are proportional to the size of the MOSFET
  - Bigger MOSFET = more switching loss
    - Also lower $R_{DS(ON)}$ means less conduction loss

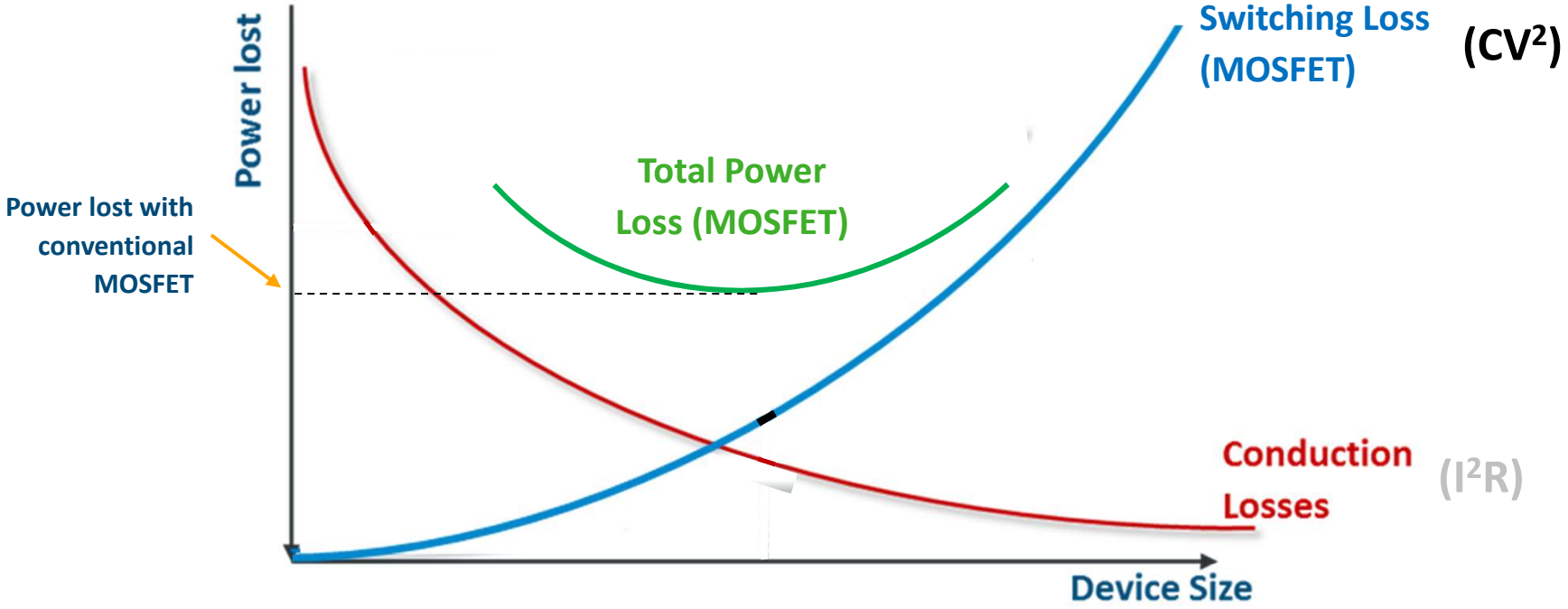


$$C_{OSS} = C_{DS} + C_{GD}$$

$$P_{(Loss)} = \frac{f \cdot C_{OSS} \cdot V^2}{2}$$

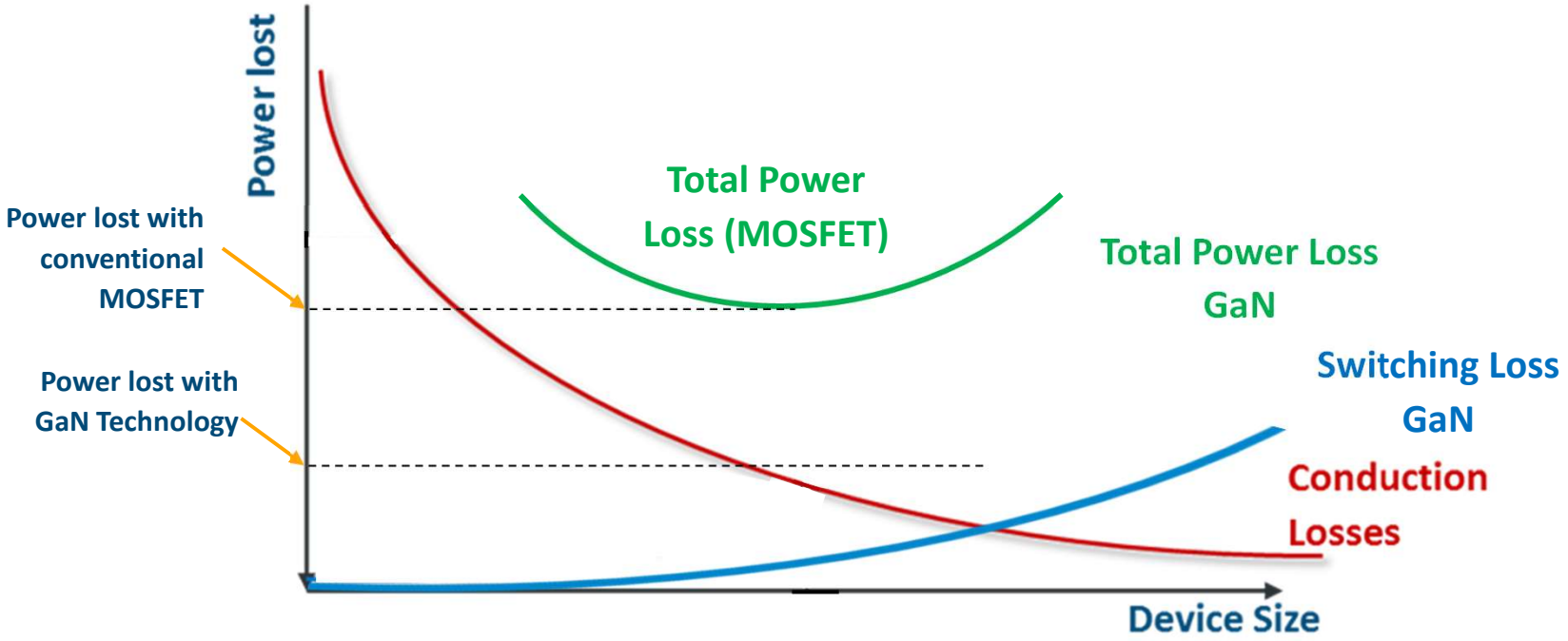
f = Switching frequency
V = Peak of VAC ~ 400 V

Switching Losses Increase with FET Size
Conduction Losses Decrease with FET Size



Conduction losses and switching losses work in opposite directions

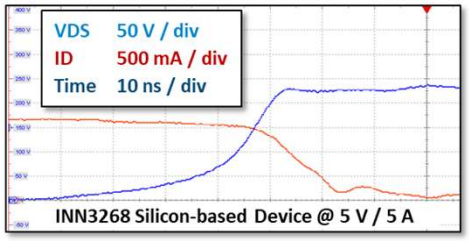
GaN Switches Change the Curve

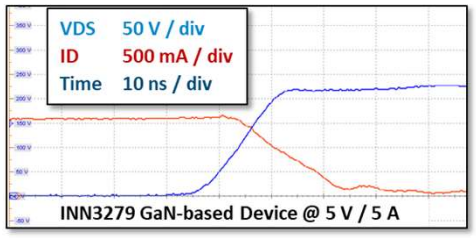


Conduction losses and switching losses work in opposite directions

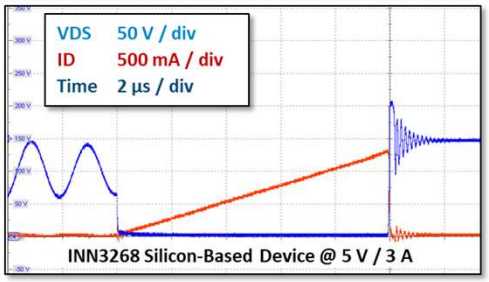
Integration Solves Fast Switching Challenges

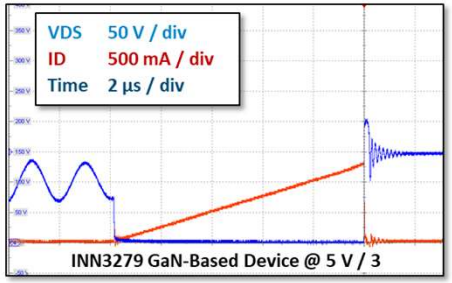
- **Control of gate drive and circuit impedance via integration of driver stage controls switch transition rates**
  - Switch transition maximum slope same for silicon and GaN devices
  - No special EMI issues for GaN
  - Reduces fast di/dt voltage overshoot
- **Integrated switch and control stage**
  - Optimized gate drive for each switch size
  - Very accurate and fast SC/detection
  - No external current sense elements
    - Reduces circuit losses
  - Reduces circuit inductance and capacitance
    - Reduces voltage overshoot
    - No false-triggering of protection





Low-line CCM Turn-off Comparison (100 V_{DC})

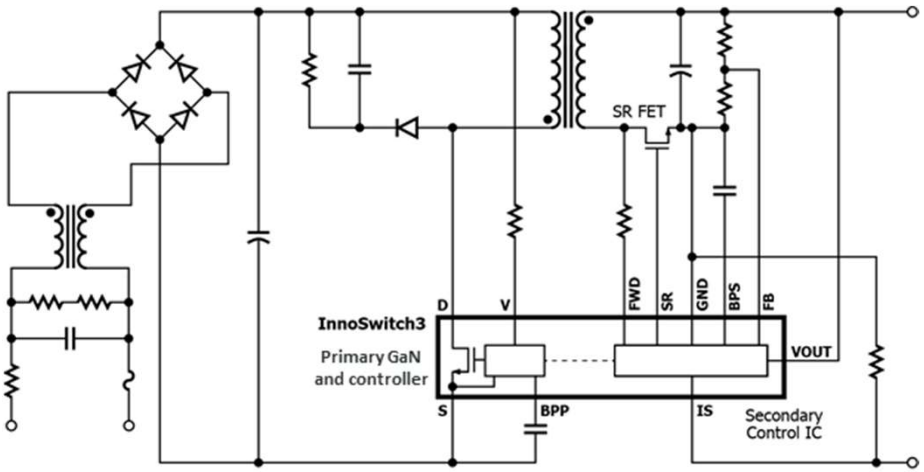




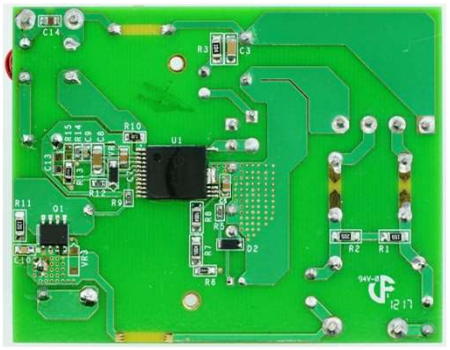
Low-line DCM Turn-on Comparison (100 V_{DC})

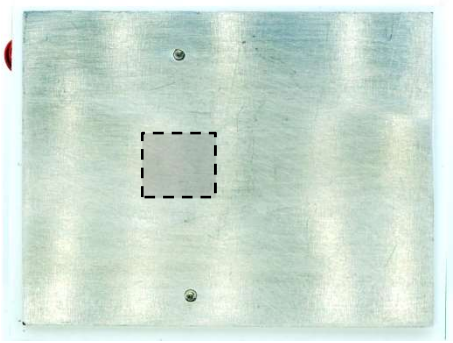
Integrated PowiGaN Device provides superior management of Rapid Switching

- **Driver matched to GaN switch**
  - Controls slew rate and di/dt
- **Allows integrated current limit**
  - Extremely fast control
  - No false triggering
- **Reduces parasitic components**
  - Less trace inductance
  - Reduced voltage transient spikes

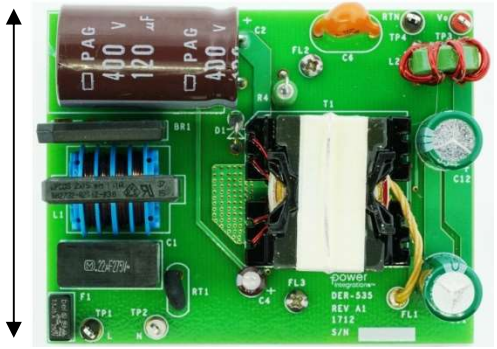


PowiGaN Technology Makes for Better Products





InnoSwitch3-CP
Size 8 MOSFET



DER-535
65 W 20 V / 3.25A

InnoSwitch3-CP
Size 8 PowiGaN

DER-747
65 W 20 V / 3.25A

PowiGaN is Winning in the Market

- **More GaN power devices shipped than anyone else**
  - Proprietary PI technology developed for power switching
- **Easy to use**
  - Integrated protection, drive and control eliminates challenges of discrete GaN
  - Looks like a conventional part – easy to change between designs
  - Very high reliability – More than 6 million shipped with no field failures
- **Provides major benefits across markets**
  - Smaller lighter power supplies
  - Simplifies meeting existing and emerging energy standards
  - Ideal for adapters, USB PD, industrial, and appliance

No heatsinks makes open frame /embedded power more mechanically stable

power integrations™

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