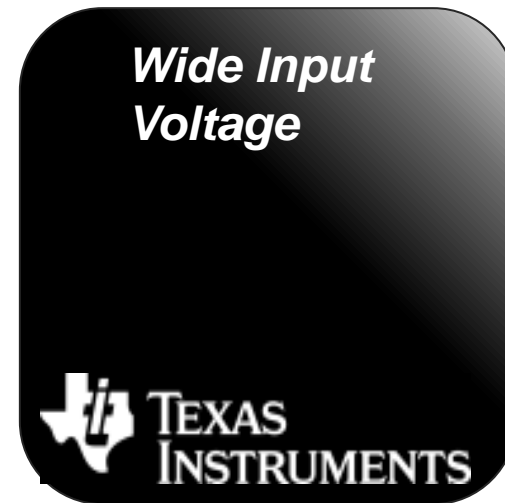


TI 全新一代宽输入降压芯片

New Gen Wide Vin Buck Converter

www.ti.com/widevin

主讲人：黄陆建



AGENDA

- What are wide vin buck converter? 宽输入降压芯片概念介绍
- Why and where use wide vin buck converter? 宽输入降压芯片应用场景详解
- Key features of wide vin buck converter 宽输入降压芯片亮点剖析
- TI New generation wide vin buck converter TI全新一代宽输入降压芯片介绍
- Design know-how of wide vin buck converter 宽输入降压芯片设计指南
- Applications collateral 相关技术文献介绍
- Q&A 问答互动环节

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How to define Wide Vin?



Menu

Search

Home > Power Management > Wide Vin DC/DC Power Solutions

Wide V_{IN} Power Solutions

- Increased protection against input transients
- High power density with large conversion ratios
- Scalability to fit a wide variety of applications

Overview

Wide V_{IN} products

Applications

Tools & software

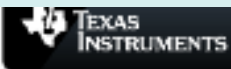
Technical documents

Increased power density and reliability for systems requiring
maximum operating voltages $\geq 30\text{ V}$

最高输入电压 > 30V

Wide V_{IN} Converters

Device	Output Current (A)	Input Voltage Range (V)
Buck Converters		
TPS54062/1	0.05/0.2	4.7 to 60
LM(2)5017/8/9*	0.6/0.3/0.1	9 to 48/100
LM5008A/9A	0.35/0.15	6 to 95
LMR14203/6	0.3/0.6	4.5 to 42

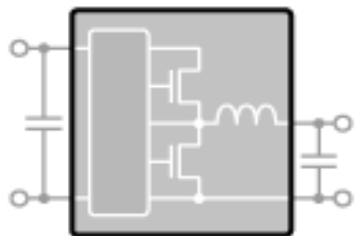


Module/Converter/Controller

Design Made Easy
Power Solutions

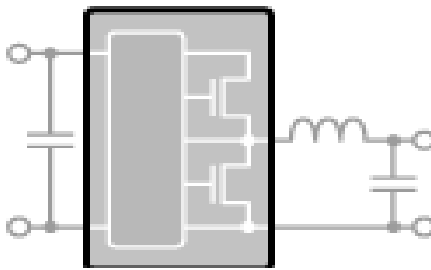
Modules

- **Ultimate Ease of Use with Integrated Inductor**
- **Low EMI, up to 60Vin, 30A Out**



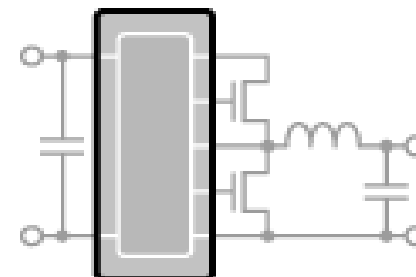
Converters

- **Balance between Ease of Use and flexibility**
- **Up to 100Vin**



Controllers

- **Maximum Flexibility up to 100Vin**
- **WEBENCH® MOSFET Selector Tool enabled**



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Wide VIN DC/DC Converters for Demanding Applications

Automotive 12V/24/48V battery



Battery



Industrial 24V & higher Bus



HAV maintenance services

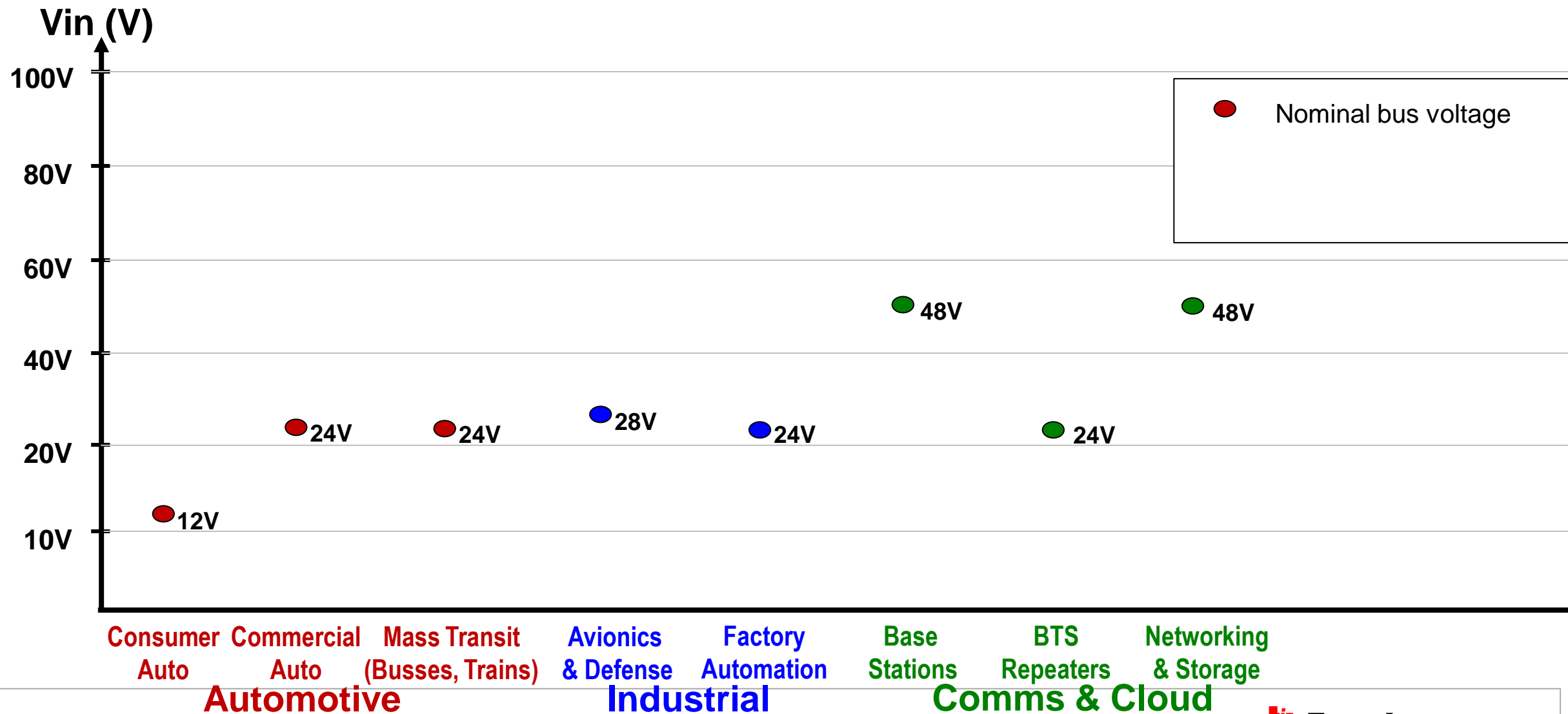


Communications 24V/48V systems



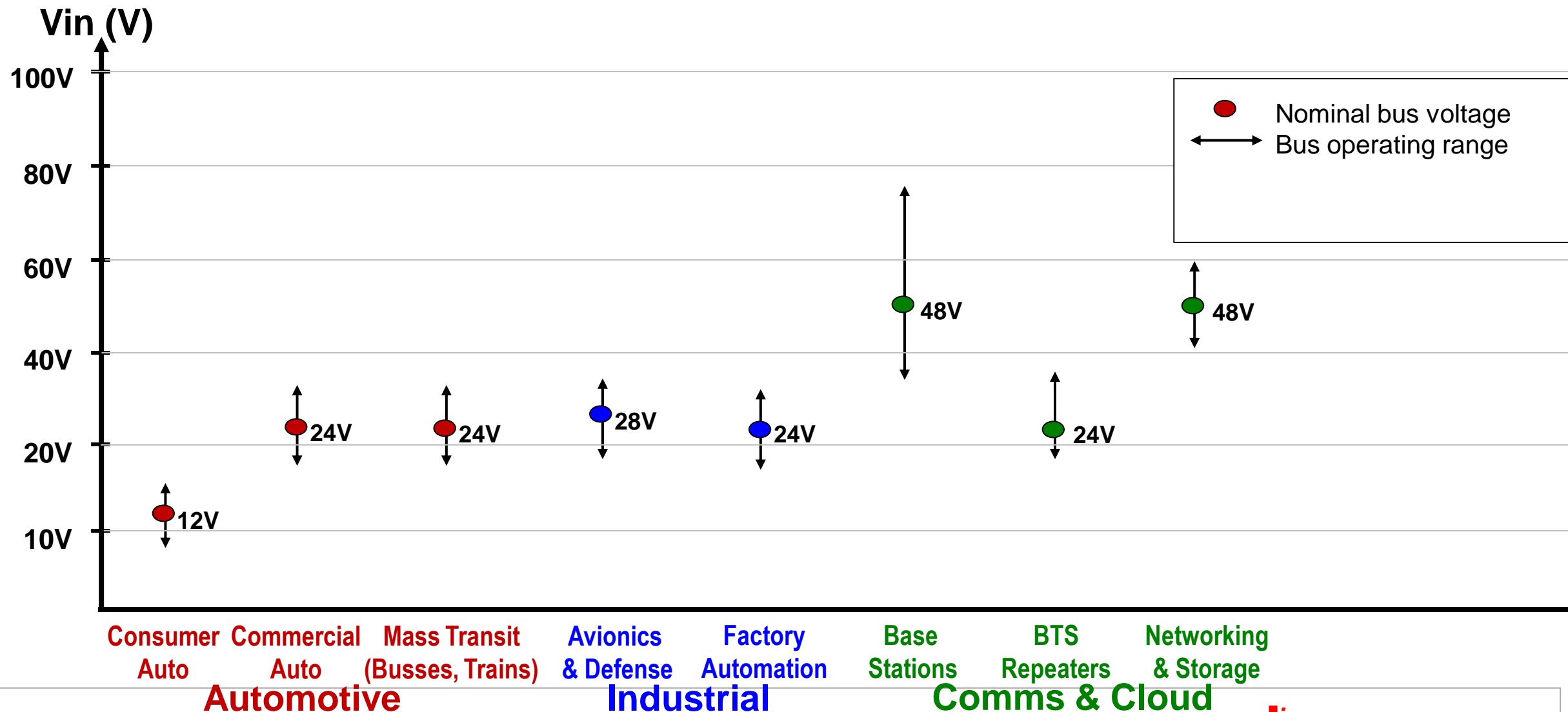
Wide Vin Benefit:

Optimized for Use Across Multiple Markets and Applications



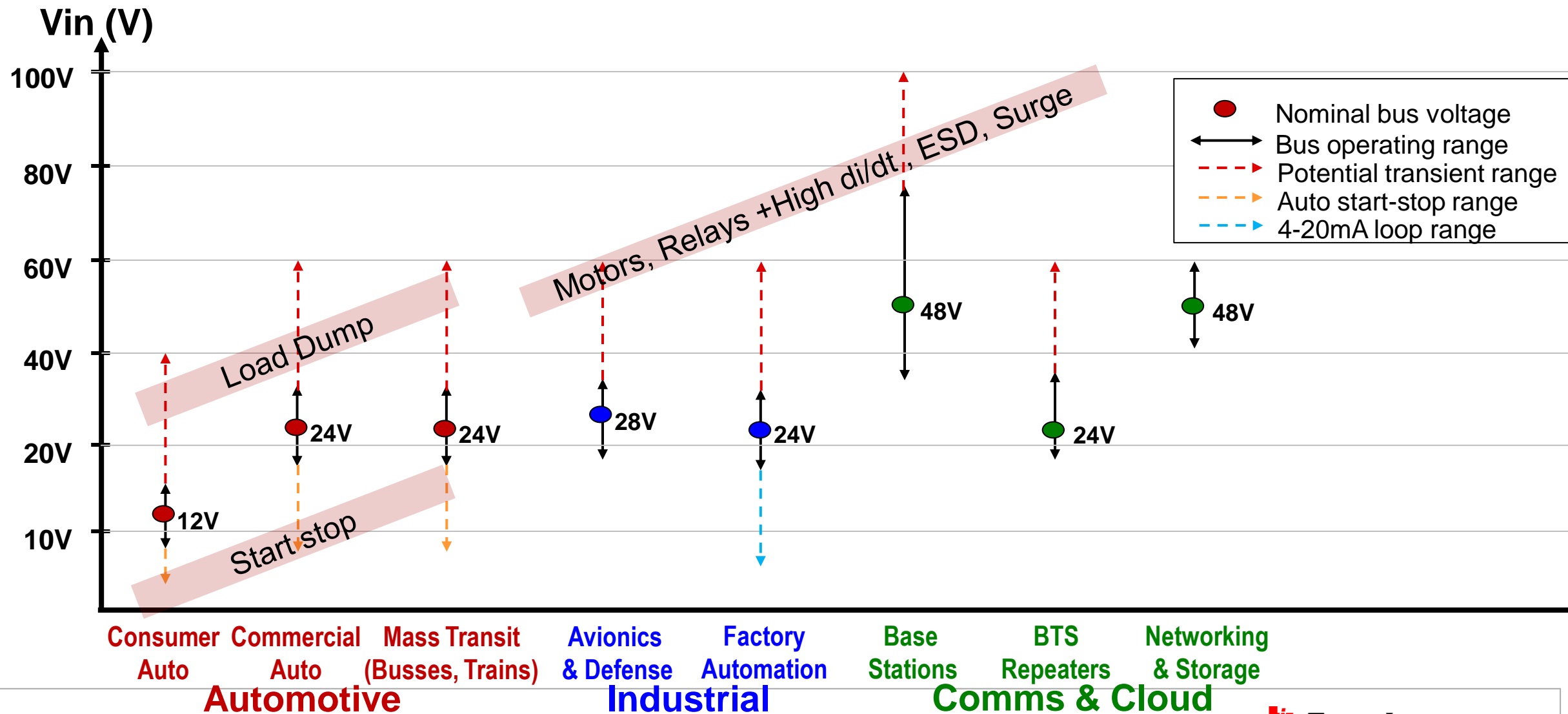
Wide Vin Benefit:

Optimized for Use Across Multiple Markets and Applications

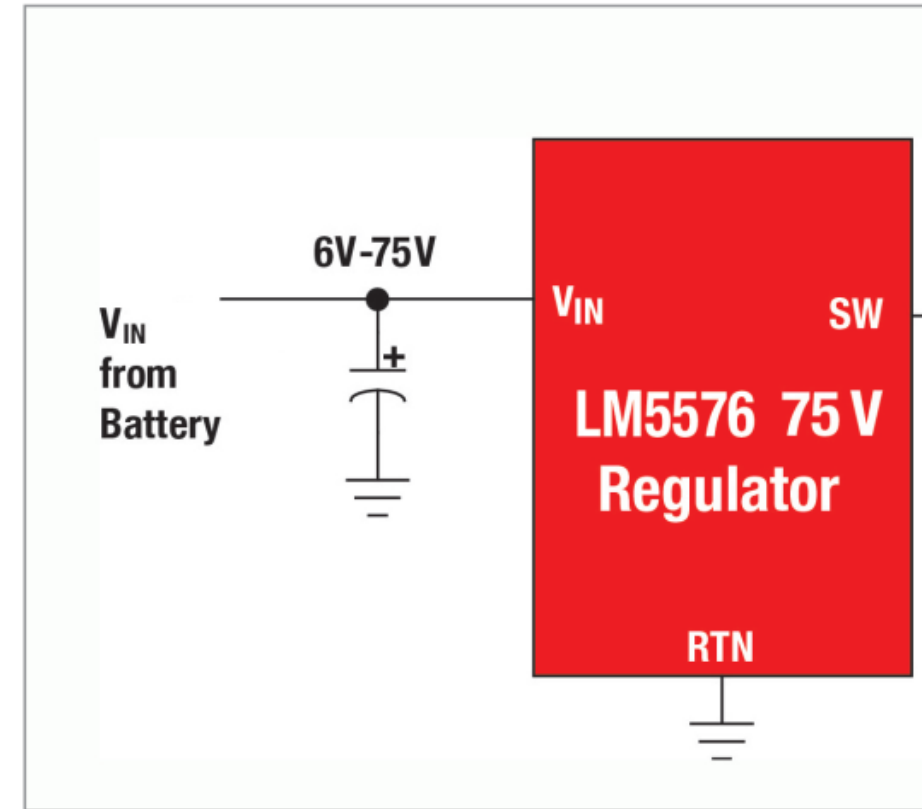
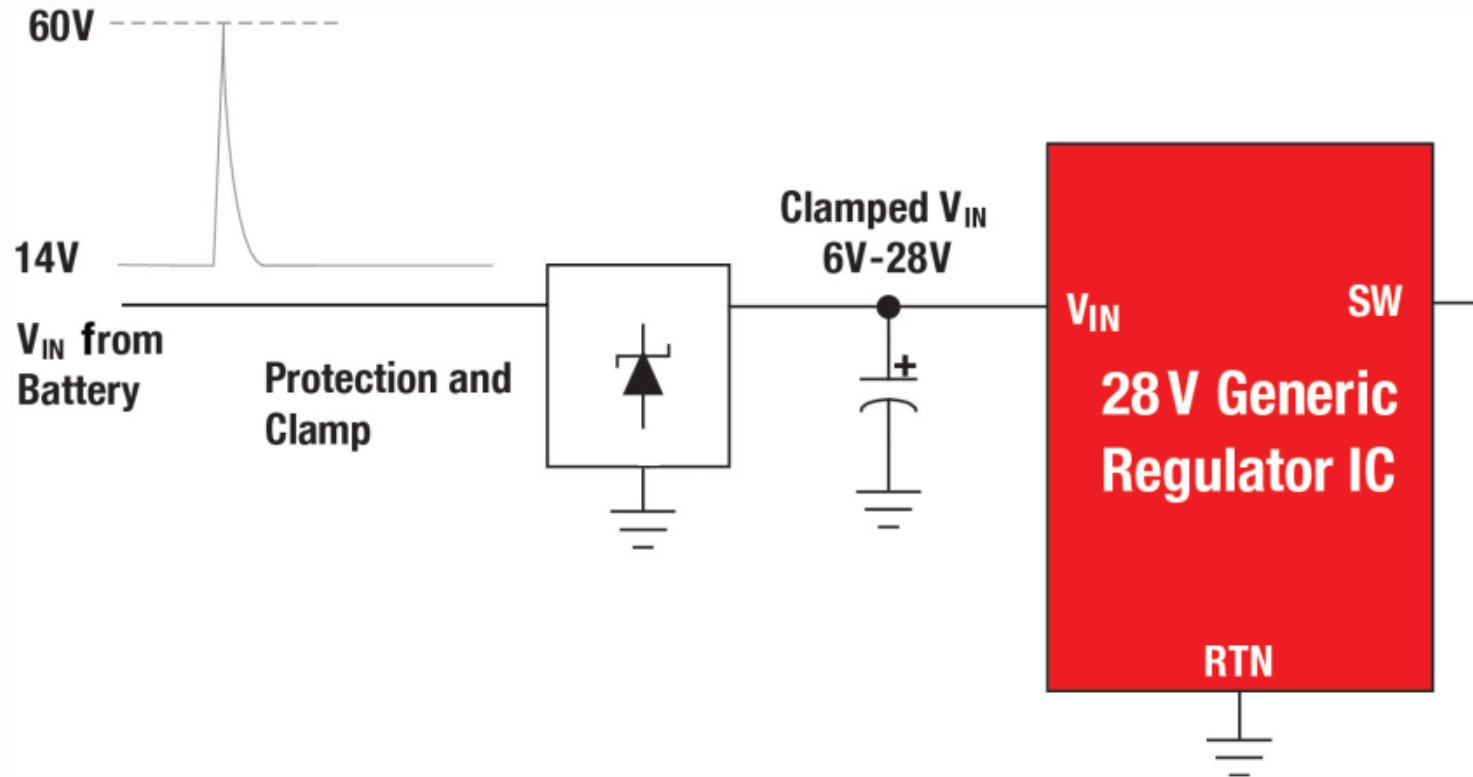


Wide Vin Benefit:

Optimized for Use Across Multiple Markets and Applications

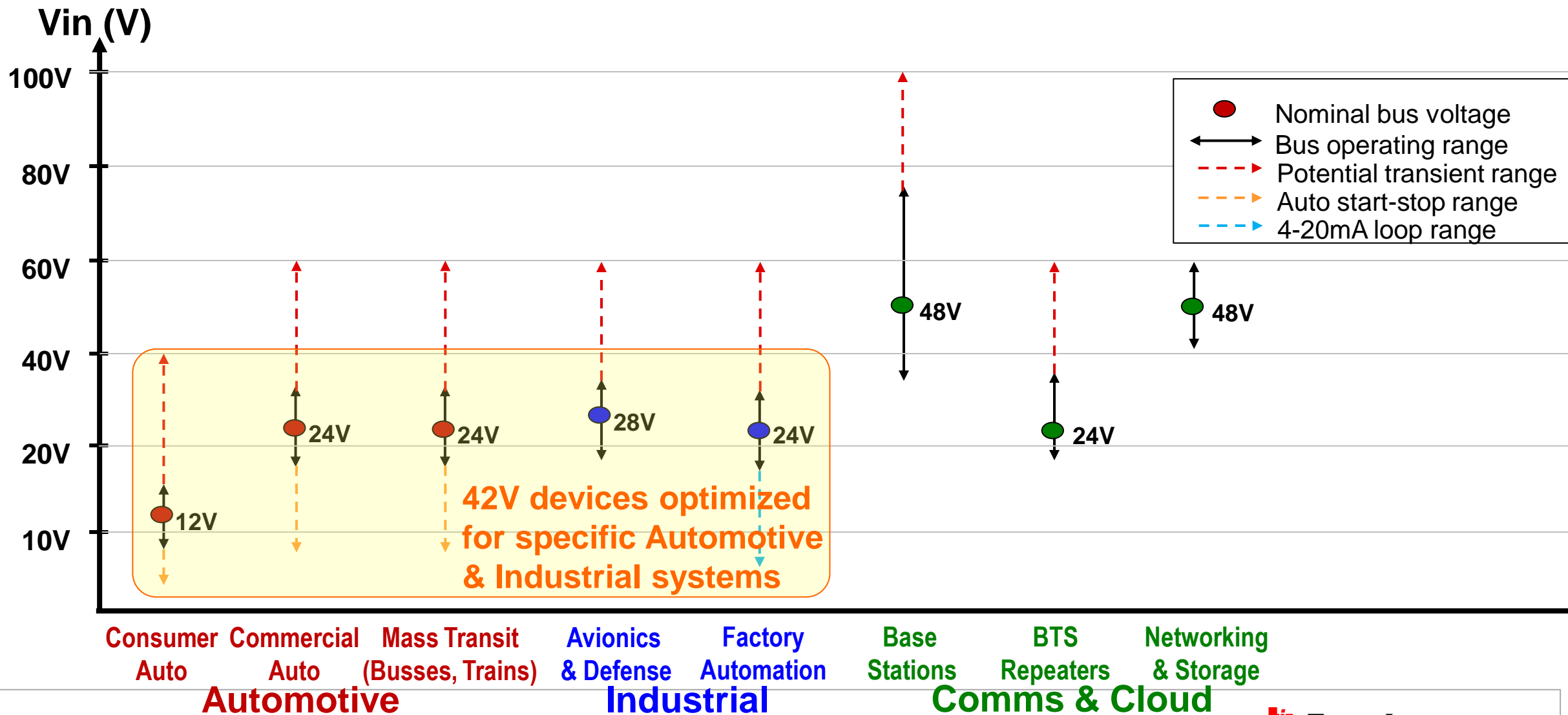


How to suppress the transient Voltage



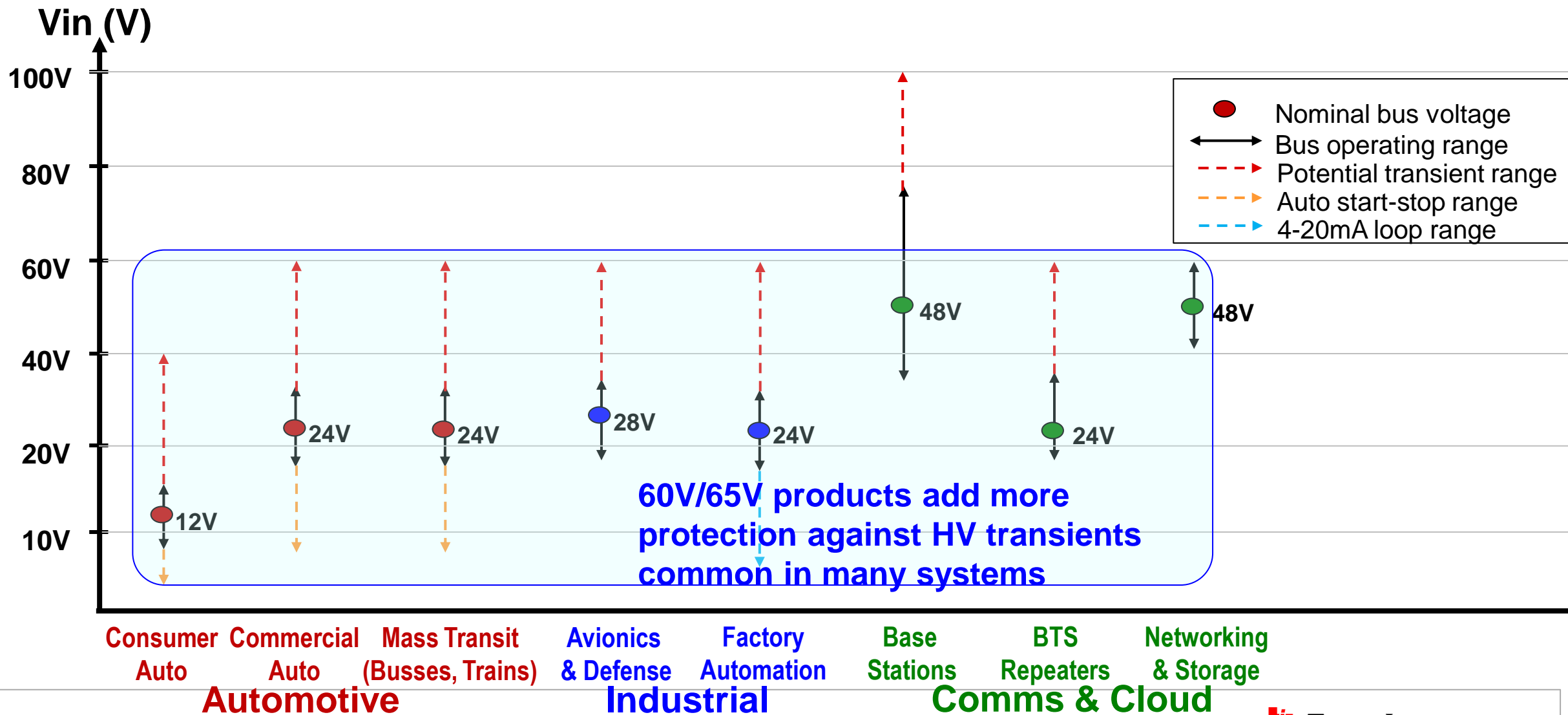
Wide Vin Benefit:

Optimized for Use Across Multiple Markets and Applications



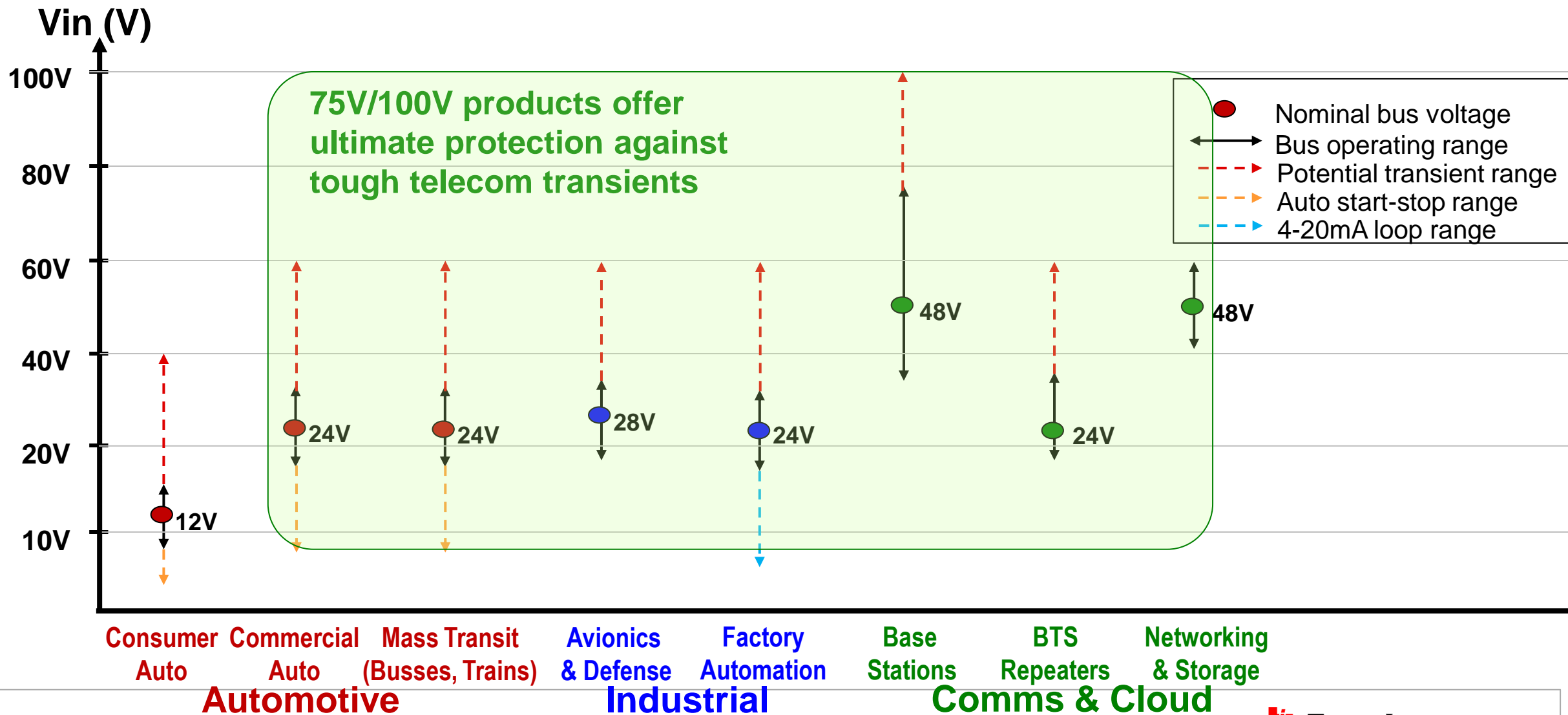
Wide Vin Benefit:

Optimized for Use Across Multiple Markets and Applications



Wide Vin Benefit:

Optimized for Use Across Multiple Markets and Applications



What design challenges is solved by Wide Vin

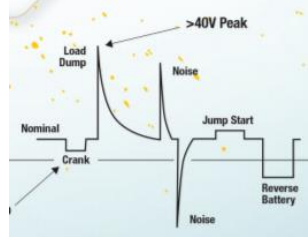
- Surviving line voltage transients
- Eliminate protection circuit
- Save PCB area

AGENDA

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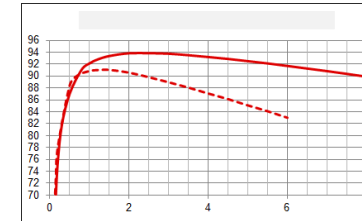
Key DC/DC Converter Features

Wide Input Voltage



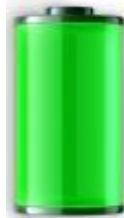
- ✓ Eliminate protection circuit & Save PCB area
- ✓ Endure harsh environments

High Density and Efficiency



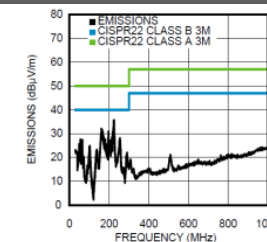
- ✓ Packaging innovations enable small **size**
- ✓ Highly **efficient** converters save power

Low Standby Power



- ✓ Lower **I_q (Quiescent Current)**
- ✓ Longer battery life

Low EMI & Low Noise



- ✓ Solutions enable passing **EMI** tests
- ✓ Noise optimization saves need for LDO

AGENDA

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New Gen Wide Vin DC/DC Converter

LMR33630



3.8V-36V, 3A Sync
Buck Converter

LM73606



3.5V-36V, 6A Sync
Buck Converter

LMR36015



4.2V-60V, 1.5A Sync
Buck Converter

LM76003



3.5V-60V, 3.5A Sync
Buck Converter

LM5164



6V-100V, 1A Sync
Buck Converter

36V

60V

100V

Power Density Evolution -36Vin/3A Iout

1989



TO220
LM2576

10mm x 9mm

Non-Sync

52kHz

2008



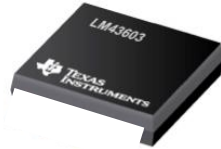
SOIC
LM22676

4mm x 5mm

Non-Sync

Up to 1MHz

2014



WSON
LM43603

4mm x 5mm

Sync

Up to 2.1MHz

Today



QFN
LMR33630

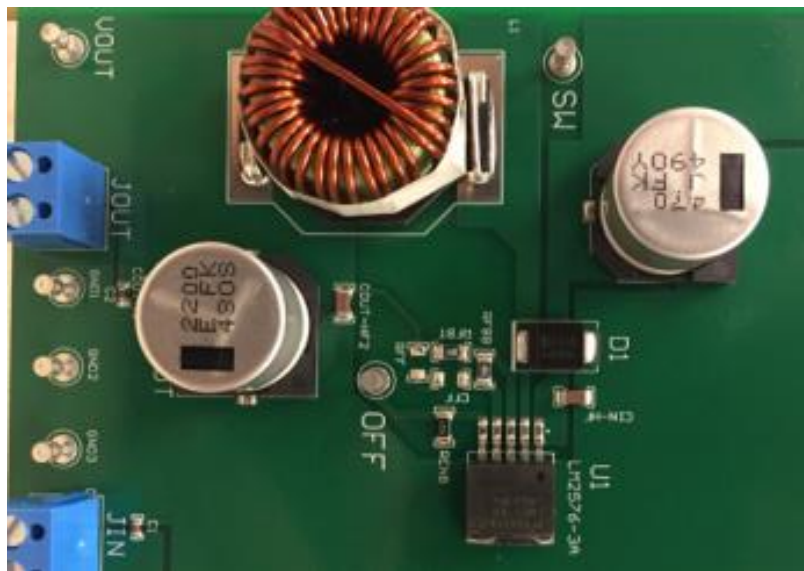
3mm x 2mm

Sync

Up to 2.1MHz

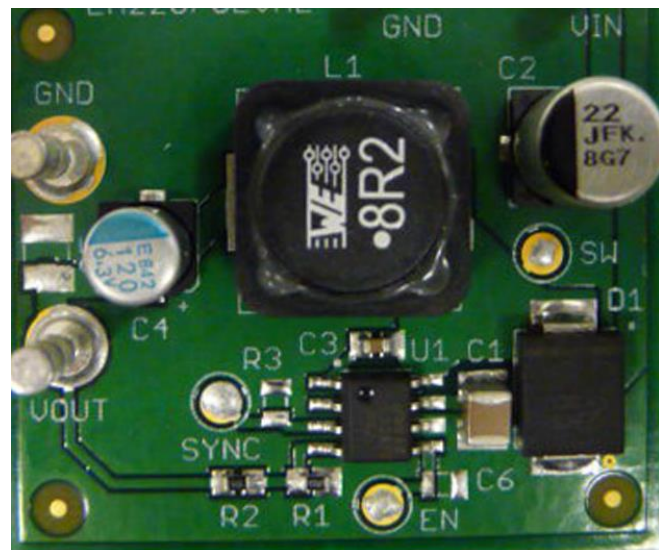
Power Density Evolution -36Vin/3A Iout

1989



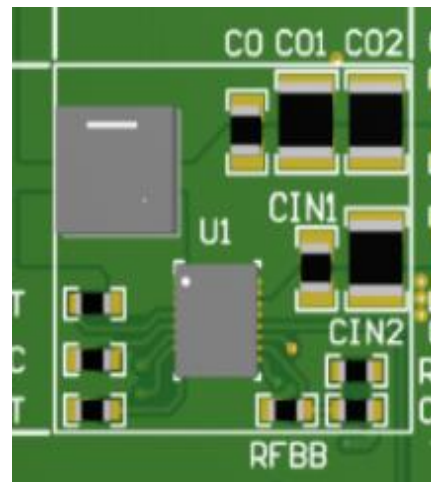
50mm x 50mm

2008



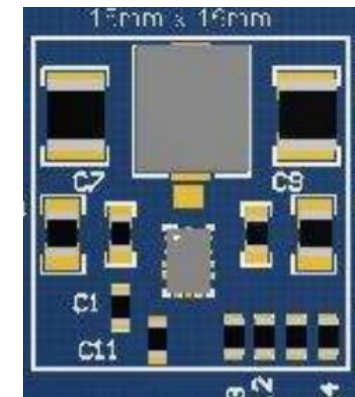
25mm x 20mm

2014



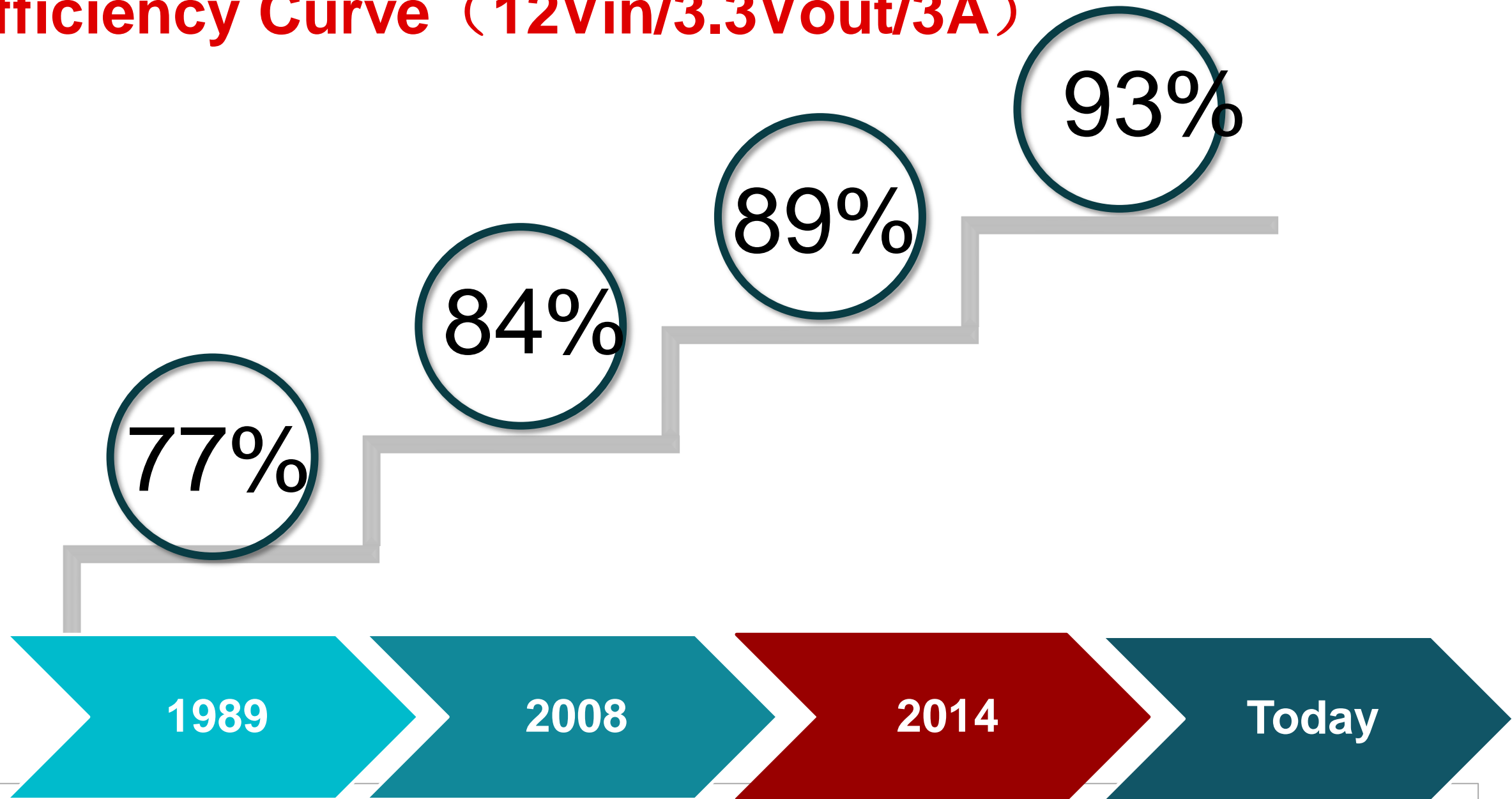
18mm x 17mm

Today



15mm x 16mm

Efficiency Curve (12Vin/3.3Vout/3A)



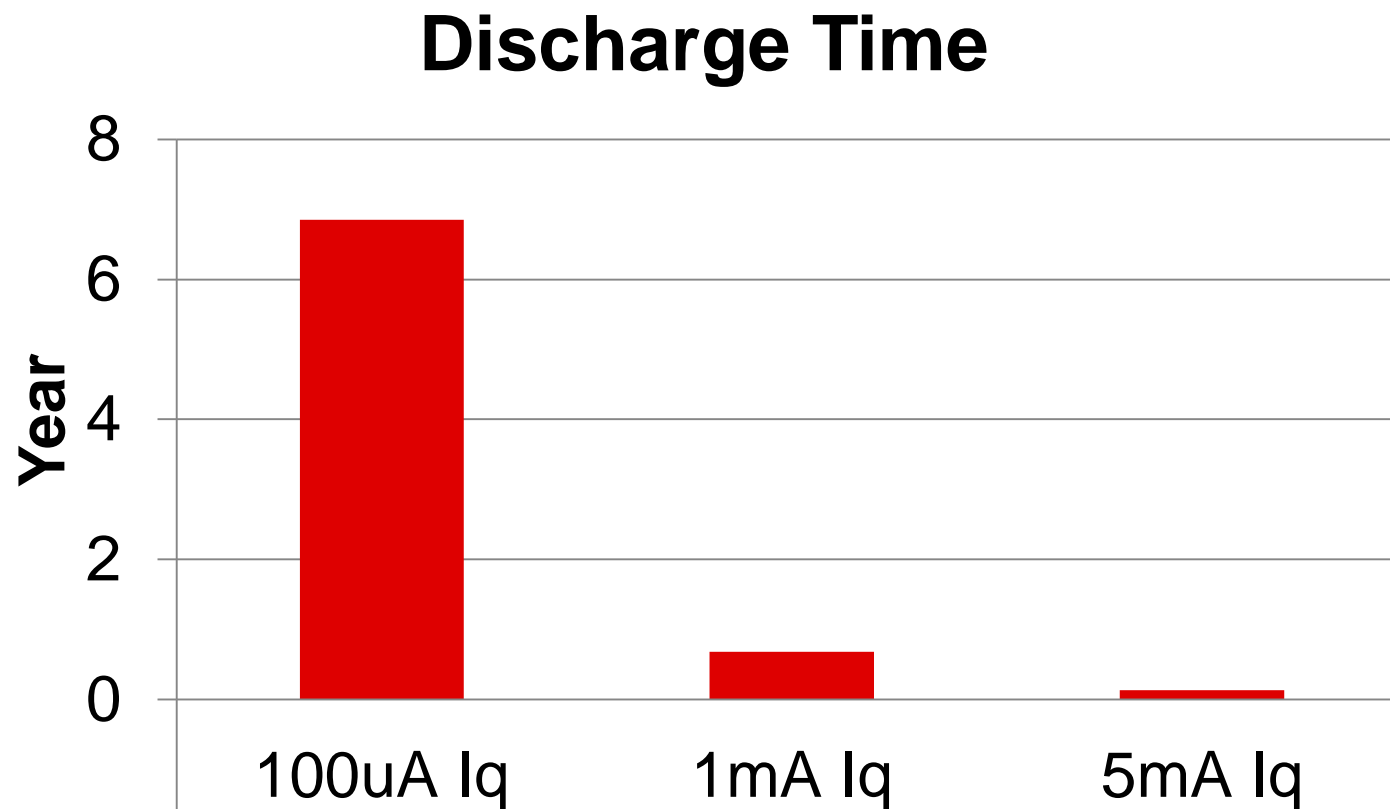
Quiescent Current Benefit



Always On



Extend battery life



LMR33630

36V, 3A, Ultra-Small SIMPLE SWITCHER® Synchronous Converter

Features

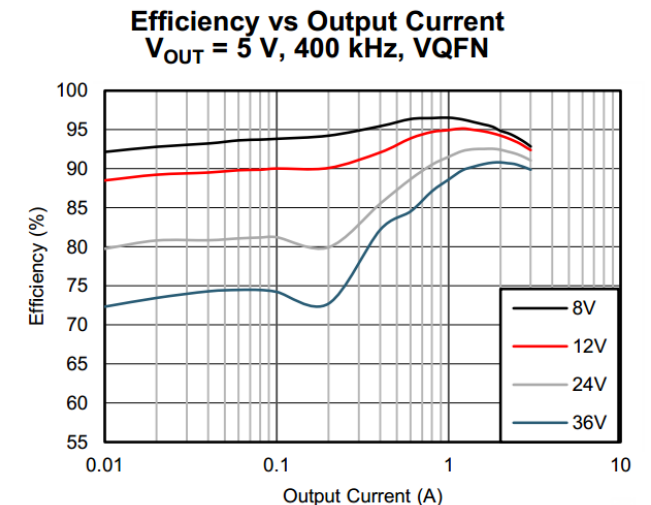
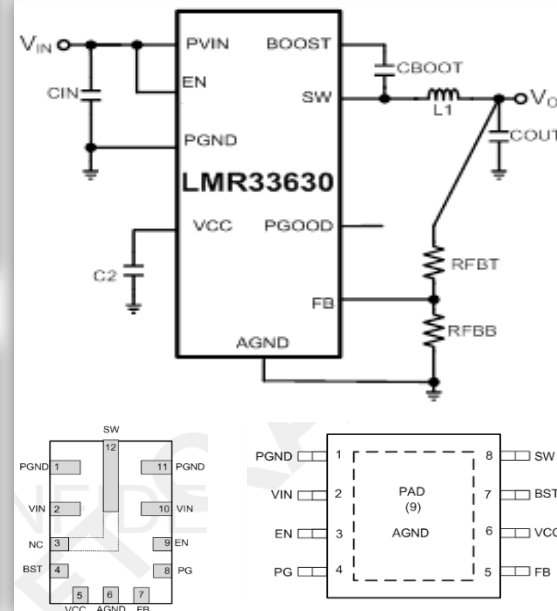
- Low 85/55 mOhm Internal HS & LS Rdson
- 50ns min ON time, 75ns min OFF-time
- <25µA quiescent current at no load
- Vin range 3.8V - 36V; Vout Range 1.0V to 95%Vin
- Switching frequency = 410 kHz, 1.4MHz, 2.1 MHz +/-15%
- Soft-start time = 5 ms; Starts into pre-biased load
- Cycle by cycle current limit & Hiccup Short Circuit Protection
- Internal Compensation
- HSOIC-8 and QFN-12 3x2mm package
- P2P compatible with 60V LMR36006/15

Applications

- Industrial distributed power applications
- Space constrained industrial applications
- Space constrained automotive applications
- Automotive Body Control Modules

Benefits

- High frequency and tight current limit to lower inductor size
- Wide vin operation to accommodate industrial and automotive line variation
- High efficiency with good thermal performance to withstand high ambient temperatures found in automotive electronics
- Compact solution size with high switching frequency



LMR36015

60V, 1.5A SIMPLE SWITCHER® Synchronous Converter

Features

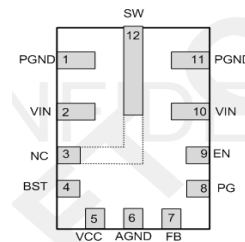
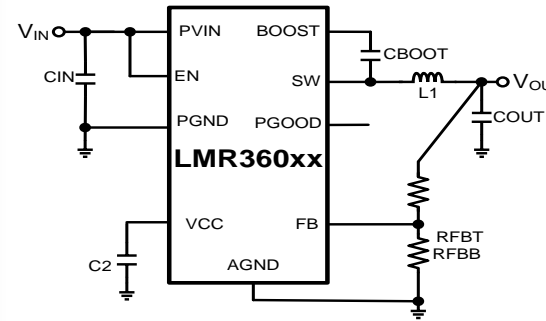
- Vin range 4.2V - 60V (65V Transients)
- 225/150mOhm Internal HS&LS RDS_{on}
- 50 ns minimum on time (typical)
- <25µA quiescent current at no load
- Vout Range 1.0V to 95%Vin
- Switching frequency = 410 kHz, 1MHz, 2.1MHz +-15%
- Minimum Off -Time = 75ns (typ)
- Vfb =1V +-2% over temperature
- Soft-start time = 4.5 ms
- Soft starts into pre-biased load
- Cycle by cycle current limiting
- Hiccup Short Circuit Protection
- Internal Compensation
- QFN-12 3x2mm package
- P2P compatible with 36V versions

Applications

- Industrial distributed power applications
- Space constrained automotive applications
- Body control

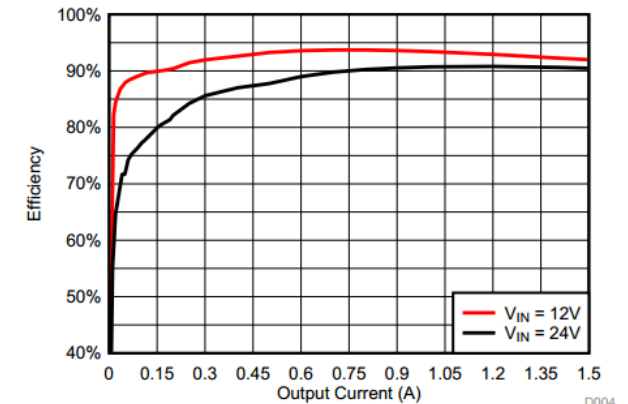
Benefits

- High frequency and tight current limit to lower inductor size
- Wide vin operation to accommodate industrial and automotive line variation
- High efficiency with good thermal performance to withstand high ambient temperatures found in automotive electronics
- Compact solution size with high switching frequency



QFN-12

Efficiency vs Output Current
V_{OUT} = 5 V, 400 kHz



LM73606

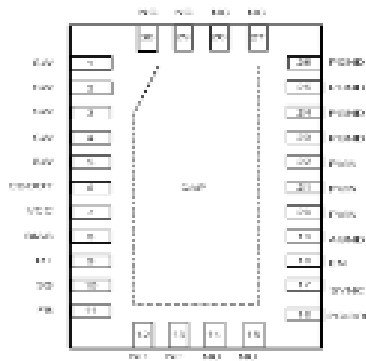
36V, 6A Low Iq, High Efficiency Synchronous Buck Converter

Features

- Wide Vin range 3.5V - 36V, Vout range 1.0V to 95%Vin
- **Min ON time = 60ns (typ), min OFF time = 80 ns (typ)**
- **Fully Synchronous Rectifier**
- Internal Compensation
- Default operation when feature pins floating
- **Wettable Flank QFN 4x6mm package**
- **51/30 mOhm Internal HS&LS Rdson**
- **15 μ A standby current**, PFM operation at light load
- External bias input to improve efficiency
- Adjustable / synchronizable switching frequency range 350kHz – 2.2MHz (default 500kHz when RT pin floating)
- Pin selectable **FPWM or Auto mode**
- Internal soft start / Prebias SS / extendable SS time / Tracking
- **Wettable Flank QFN 4x6mm package**
- Cycle by cycle current limiting
- Hiccup Short Circuit Protection

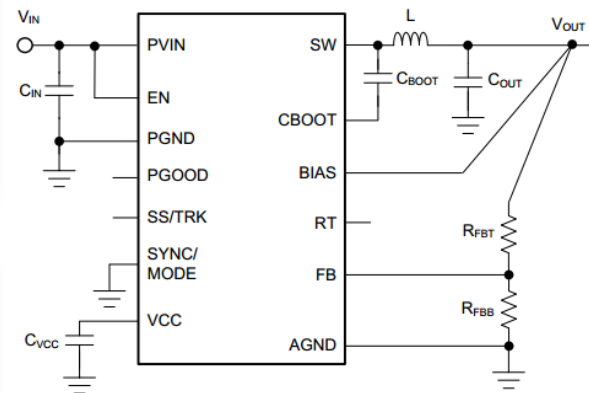
Applications

- Industrial distributed power application
- Automotive systems
- Telecommunications Systems
- General Purpose Wide VIN Regulation

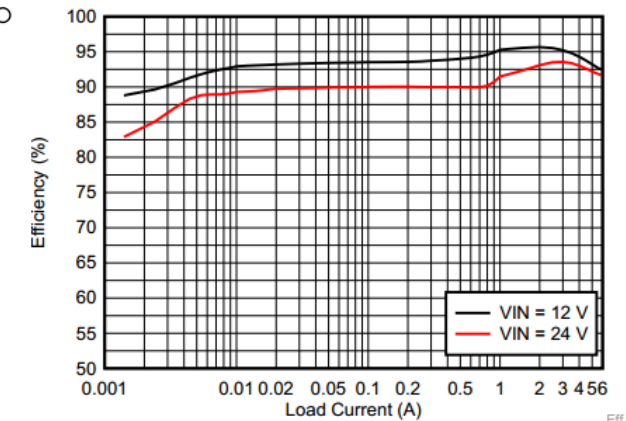


Benefits

- **Easy to use:** no external power diode, minimum BOM count, visual inspection, small solution size → save design time, save board space / cost, visual inspection
- **High Performance:** high efficiency at heavy load and light load, good thermal, long standby time
- **Wide Range** of Vin/Vout/fsw: easy system optimization, current scaling, easy reuse, and single stage step down from high Vin
- **Flexible** system optimization options, monitoring and protections features



Efficiency vs Load Current
 $V_{OUT} = 5\text{ V}$, $f_{sw} = 500\text{ kHz}$, Auto Mode



LM76003

60V, 3.5A Low Iq, High Efficiency Synchronous Converter

Features

- Wide Vin range 3.5V - 60V, Vout range 1.0V to 95%Vin
- 100/60 mOhm Internal HS&LS Rdson
- 15 μ A standby current, PFM operation at light load
- Synchronous Rectification
- Internal Compensation
- Default operation when feature pins floating
- External bias input to improve efficiency
- Min ON time = 60ns (typ), min OFF time = 80 ns (typ)
- Adjustable switching frequency range 350kHz – 2.2MHz (default 500kHz when RT pin floating)
- Pin selectable FPWM or Auto mode
- Internal soft start / Prebias SS / extendable SS time / Tracking
- Wettable Flank QFN 4x6mm package
- Cycle by cycle current limiting
- Hiccup Short Circuit Protection

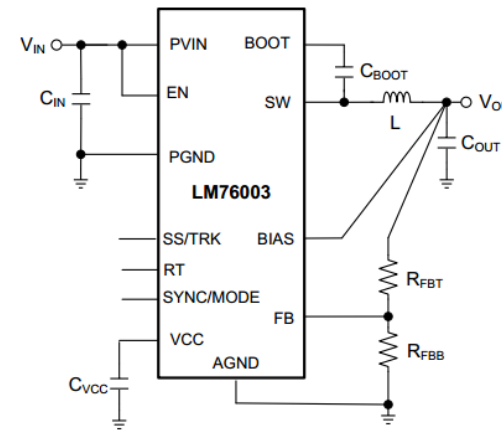
Applications

- Industrial distributed power application
- Automotive systems
- Telecommunications Systems
- General Purpose Wide VIN Regulation

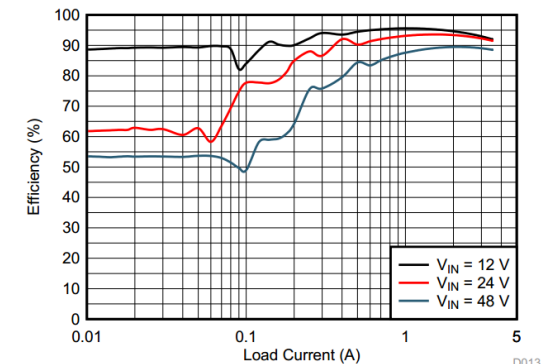
Benefits

- **Easy to use:** no external power diode, minimum BOM count, visual inspection, small solution size → save design time, save board space / cost, visual inspection
- **High Performance:** high efficiency at heavy load and light load, good thermal, long standby time
- **Wide Range** of Vin/Vout/fsw: easy system optimization, current scaling, easy reuse, and single stage step down from high Vin
- **Flexible** system optimization options, monitoring and protections features

Simplified Schematic



Efficiency vs Output Current (VOUT = 5 V, fsw = 500 kHz, Auto Mode)



100V, 1A Low I_Q Synchronous Buck Converter

Features

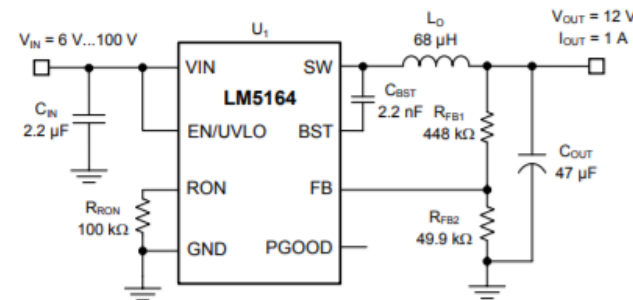
- Wide input voltage range from 6V to 100V
- Low quiescent current
 - 3 μ A Shutdown I_Q minimizes battery drain
 - 10 μ A Sleep I_Q extends battery life when idle
- Integrated low on-resistance FETs
 - HS: 0.75 Ω , LS: 0.33 Ω
- Near constant frequency adjustable to 1MHz
- Low minimum Ton and Toff of 50ns
- Peak & valley current limit prevents excessive heat
- Power Good output
- Internal soft-start and bootstrap diode
- Precision Enable / UVLO
- Thermal shutdown
- SOIC-8 package with PowerPAD™

Applications

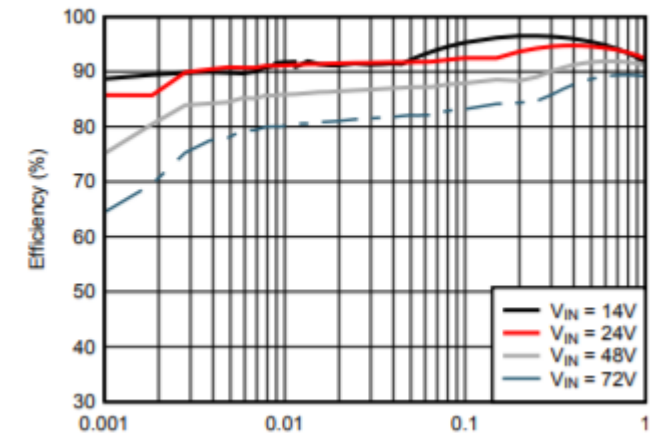
- Appliances, power/garden tools, multi-cell battery packs
- Motor drives, e-bikes, drones, telecom

Benefits

- Small solution size with low external component count
- Easy to use, fast transient response with no external compensation using Constant On Time (COT) control
- High efficiency due to low I_Q and low Rds-on
- High step-down conversion and up to 99% duty cycle due to low minimum Ton & Toff

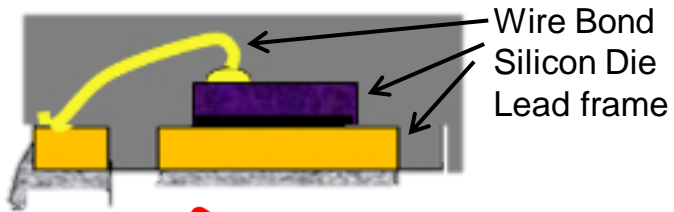


Typical Application Efficiency, $V_{OUT} = 12V$

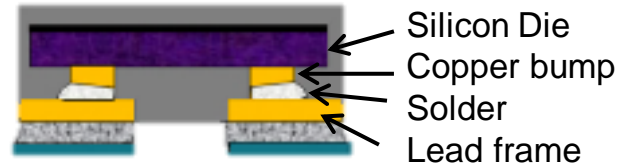


Innovation for Packaging

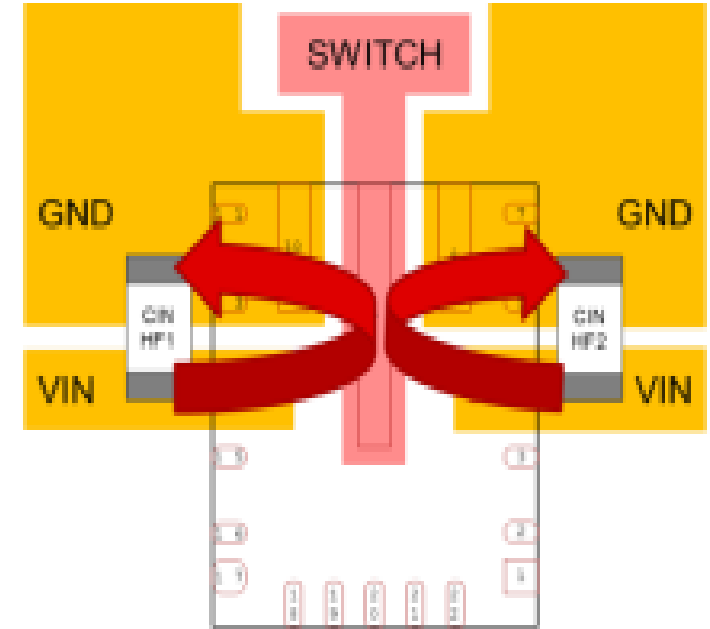
Standard wire bond QFN package



'Hotrod' flip chip on lead frame QFN



Die is flipped and placed directly onto the lead frame



Eliminates switching ring and reduces EMI with lower ESL



Improves efficiency with lower ESR

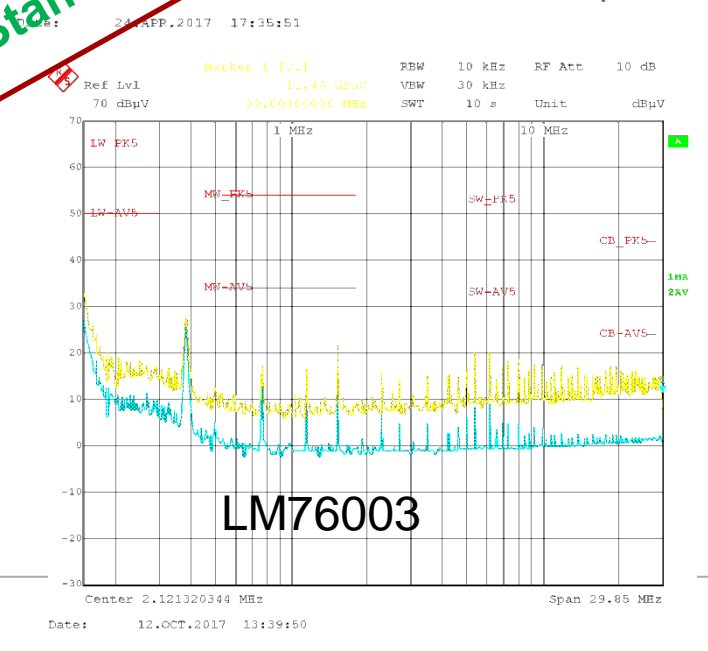
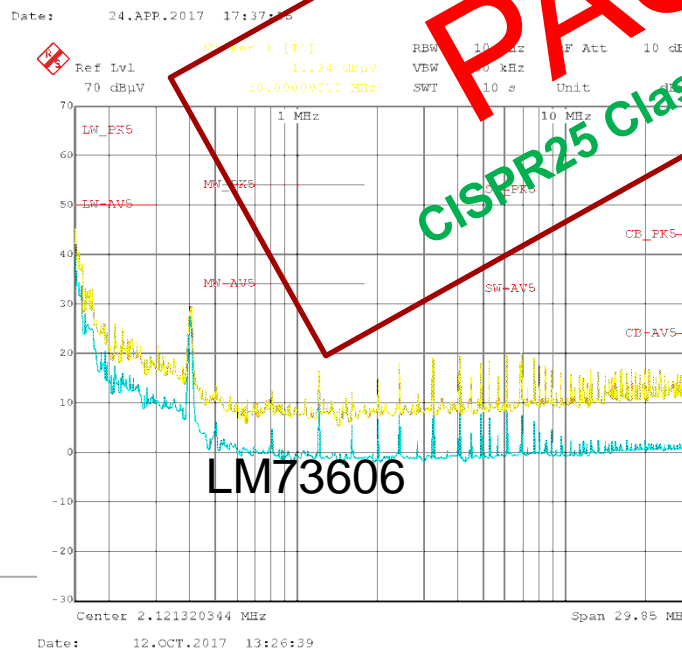
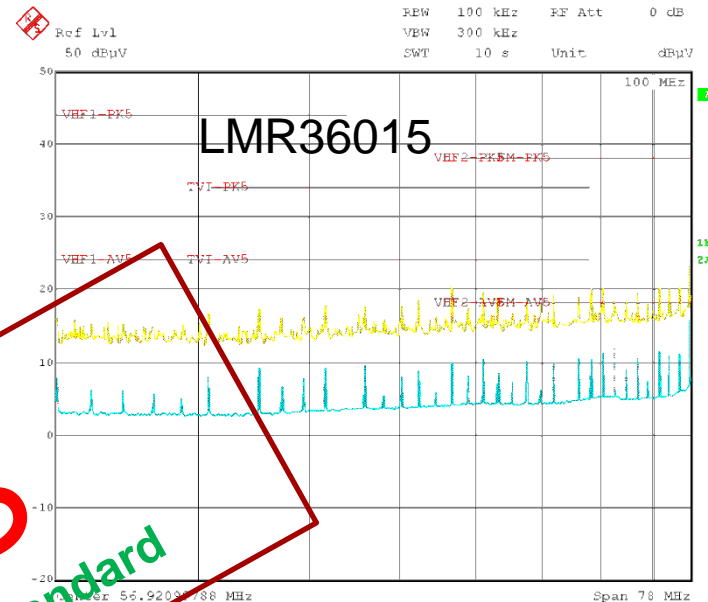
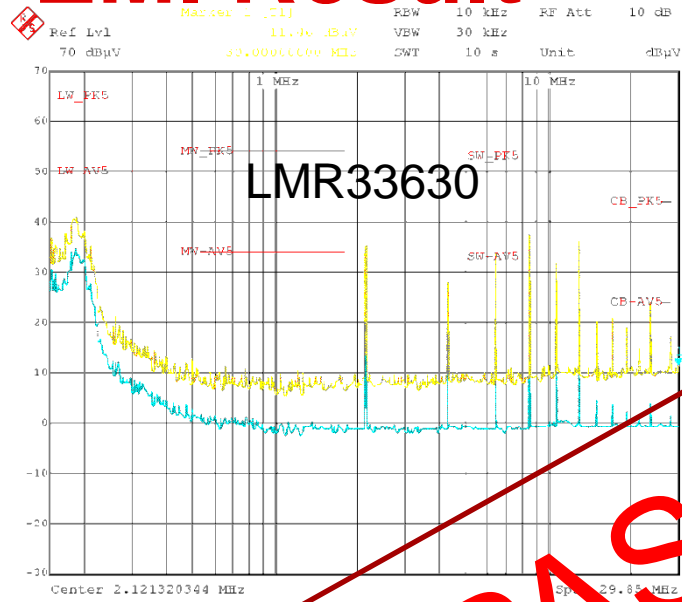


Smaller size smaller package using hotrod



Symmetrical pin out optimizes EMI performance Cancelling current loops

Super EMI Result



PASS
CISPR25 Class 5 Standard

New Gen Wide Vin DC/DC Converter Features Summary

LMR33630

2x3
mm

93%

24uA

**3.8V-36V, 3A Sync
Buck Converter**

LMR36015

2x3
mm

93%

24uA

**4.2V-60V, 1.5A Sync
Buck Converter**

LM73606

4x6
mm

95%

15uA

**3.5V-36V, 6A Sync
Buck Converter**

LM76003

4x6
mm

95%

15uA

**3.5V-60V, 3.5A Sync
Buck Converter**

LM5164

4x5
mm

92%

10uA

**6V-100V, 1A Sync
Buck Converter**

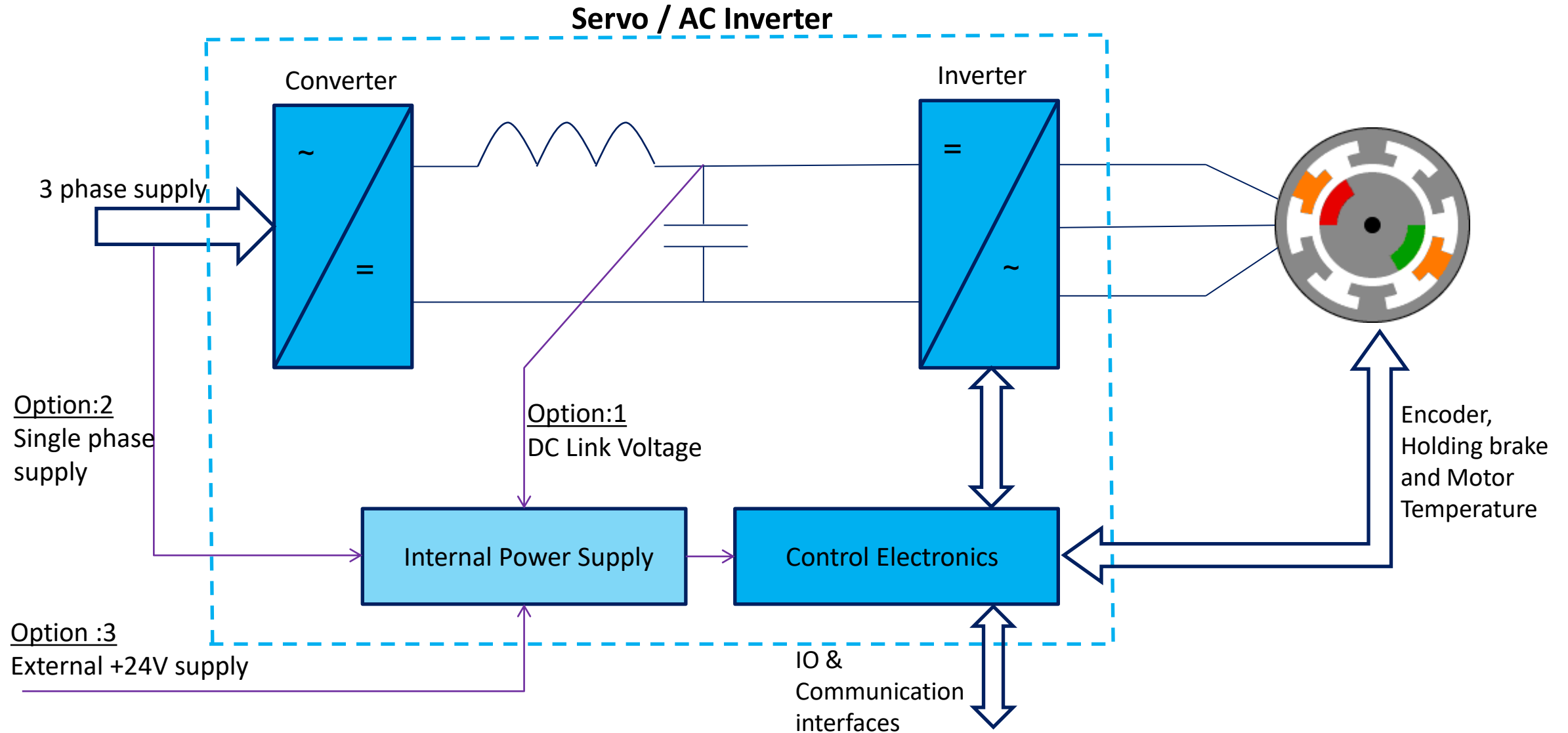
Product family

P2P compatible and easy to re-use

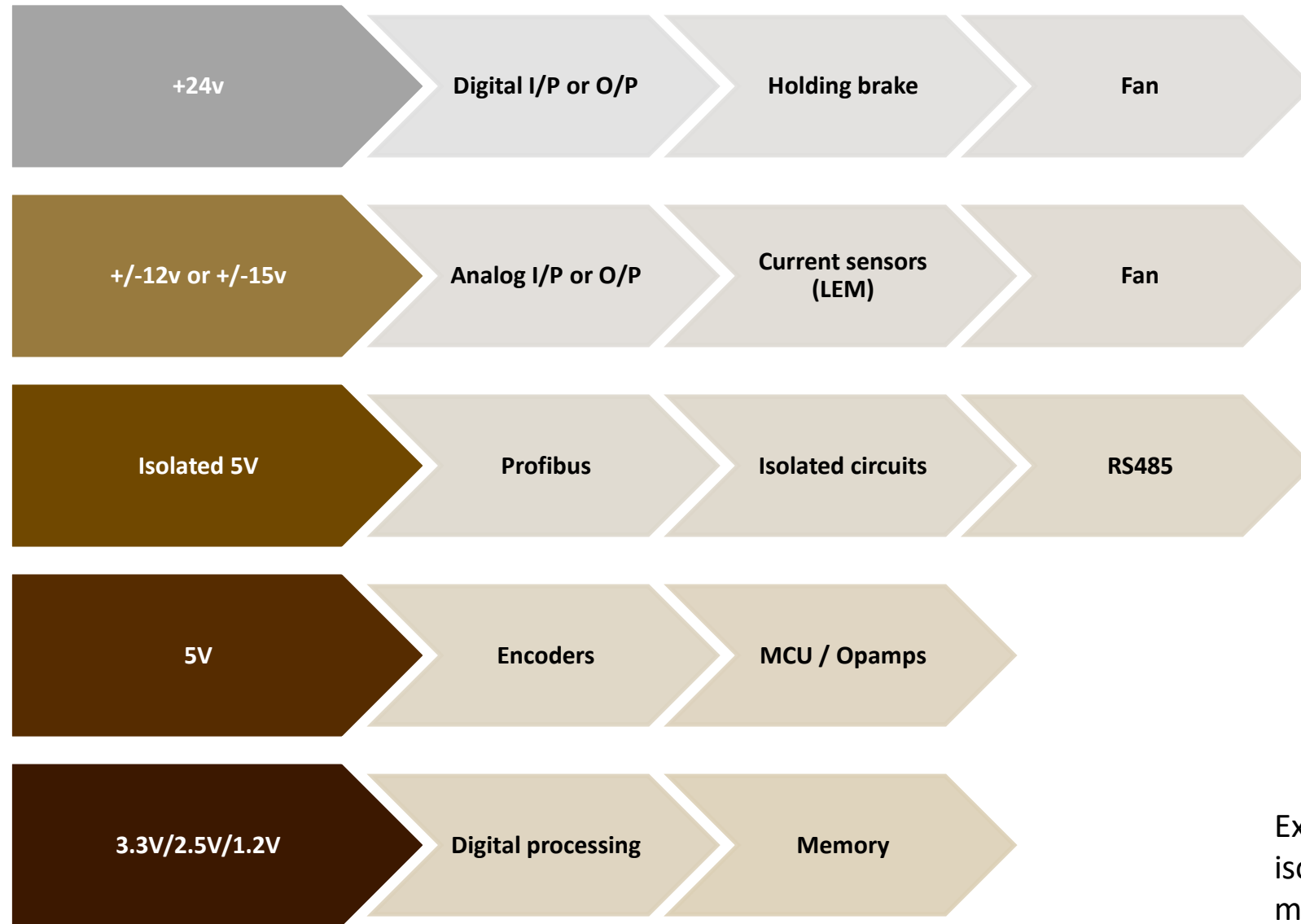
LMR33630	LMR36015	LM73606	LM76003
3.8V-36V, 3A Sync Buck Converter	4.2V-60V, 1.5A Sync Buck Converter	3.5V-36V, 6A Sync Buck Converter	3.5V-36V, 3.5A Sync Buck Converter
LMR33620	LMR36006	LM73605	LM76002
3.8V-36V, 2A Sync Buck Converter	4.2V-60V, 0.6A Sync Buck Converter	3.5V-36V, 5A Sync Buck Converter	3.5V-36V, 2A Sync Buck Converter

Typical Power Tree in Servo drive

Drives power supply architectures (Stand alone)

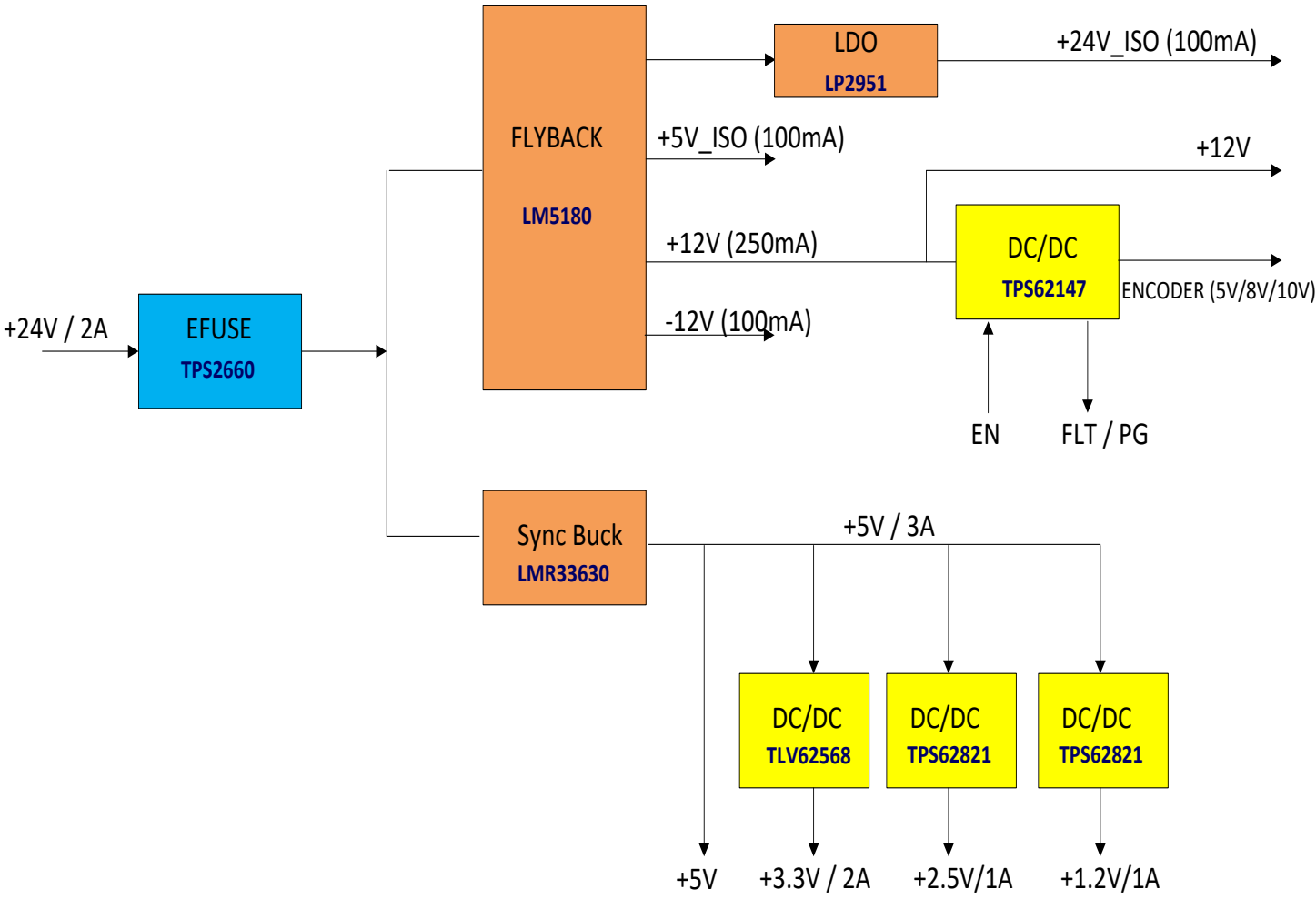
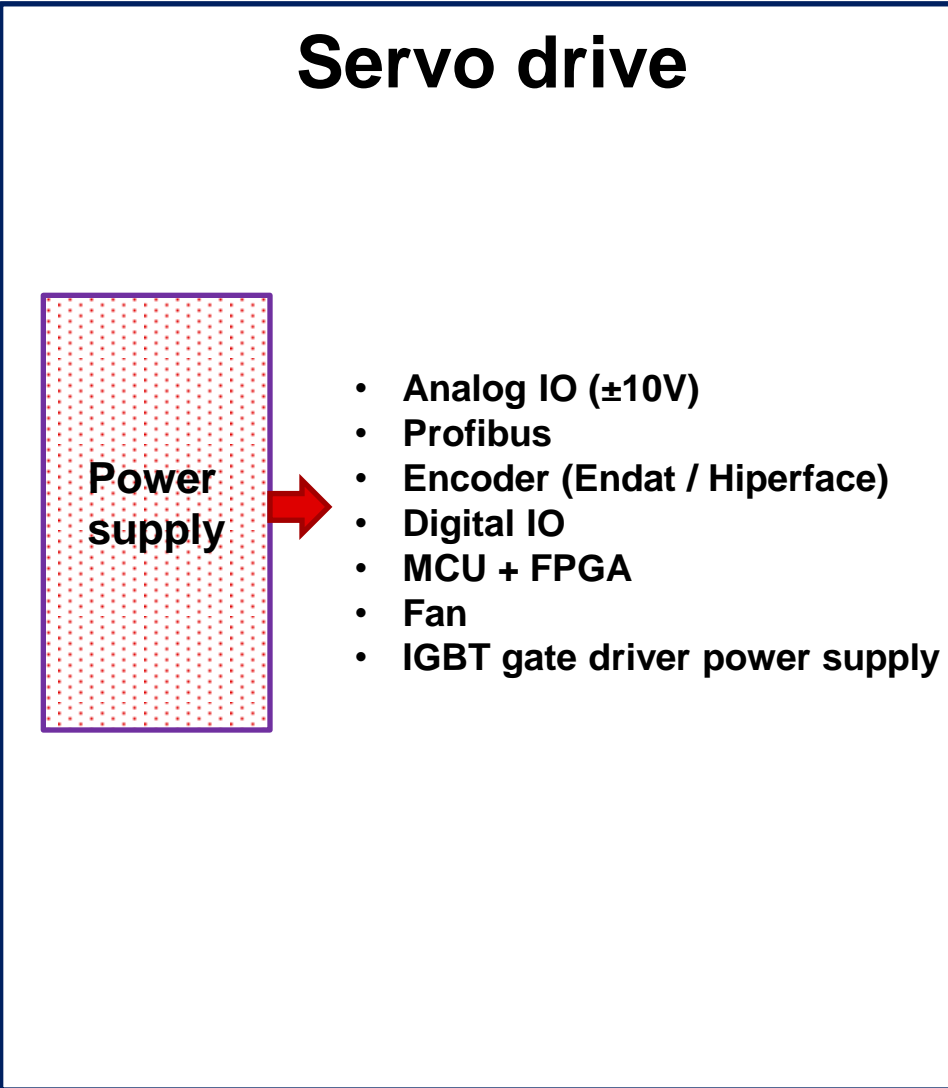


Voltage rails in AC Servo / Inverters



Excluded gate drivers and isolated amplifiers / modulators

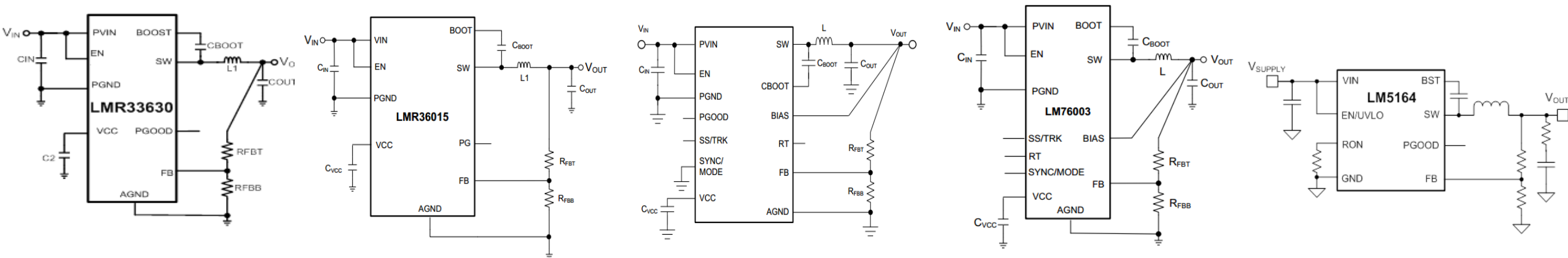
Power tree of +24v Aux powered drives (Option-1)



AGENDA

- What are wide vin buck converter? 宽输入降压芯片概念介绍
- Why and where use wide vin buck converter? 宽输入降压芯片应用场景详解
- Key features of wide vin buck converter 宽输入降压芯片亮点剖析
- TI New generation wide vin buck converter TI全新一代宽输入降压芯片介绍
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Design know-how of wide vin buck 宽输入降压芯片设计指南



		Cin	Cout	L	RFB	Cboot	RT	Vcc
	外围元器件数量	输入电容	输出电容	功率电感	反馈电阻	自举电容	调频电阻	
LMR33630	7	Y	Y	Y	Y	Y	N	Y
LM73605	7	Y	Y	Y	Y	Y	N	Y
LMR36015	7	Y	Y	Y	Y	Y	N	Y
LM76003	7	Y	Y	Y	Y	Y	N	Y
LM5164	7	Y	Y	Y	Y	Y	Y	N

1. 芯片集成度越来越高，外围元器件越来越少。
2. 器件参数值，根据规格书中的公司或Webench仿真即可
3. 关键点是PCB布板设计

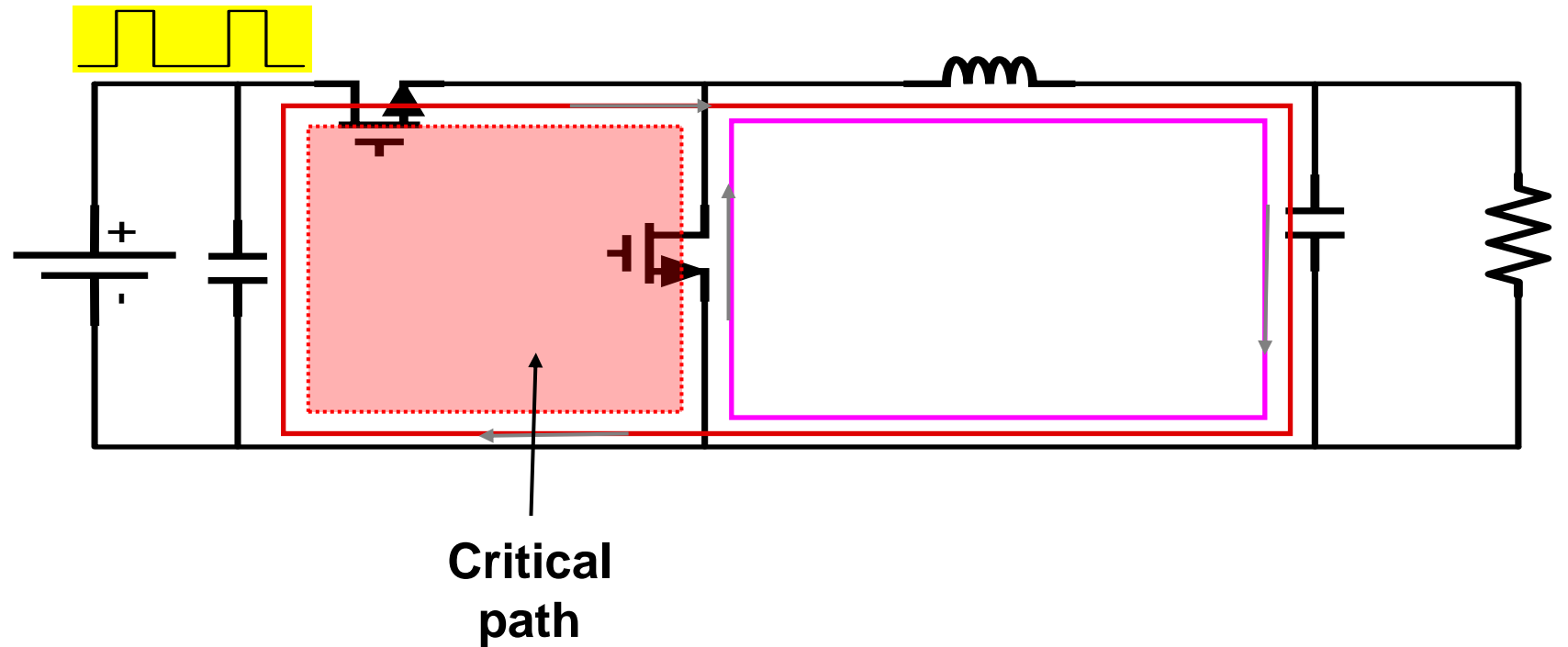
Identify Critical Path

Buck Converter

Boost Converter

Buck-Boost Converter

Switching Current exist in the input side



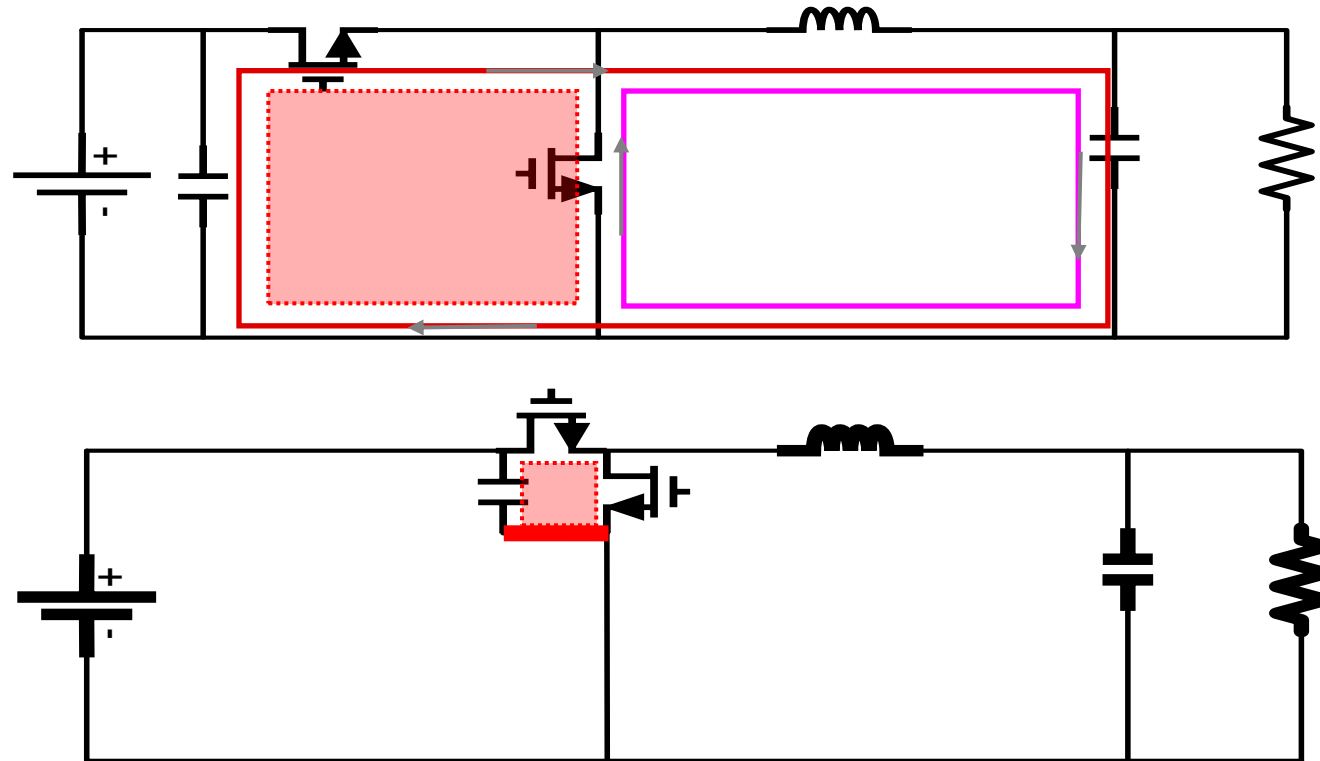
What Can We Do In PCB Layout?

--Buck example

Buck Converter

Boost Converter

Buck-Boost
Converters



- Minimize critical path area (环路面积越小越好)
- Separate noisy ground path from quiet ground

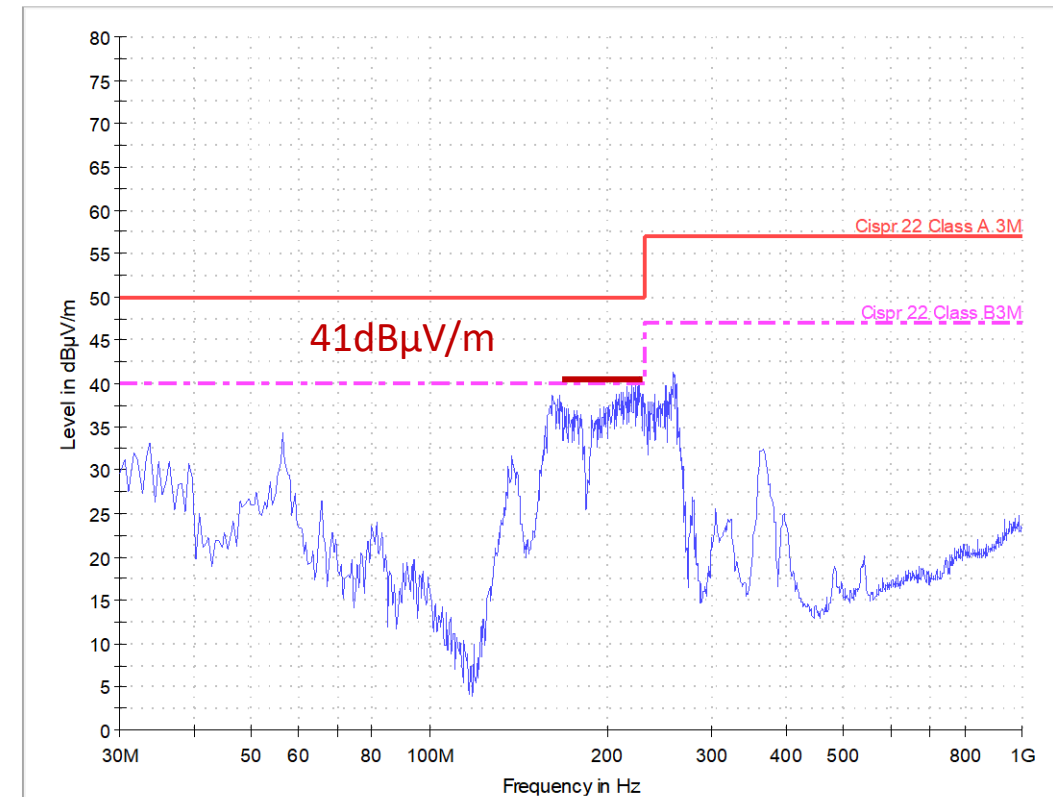
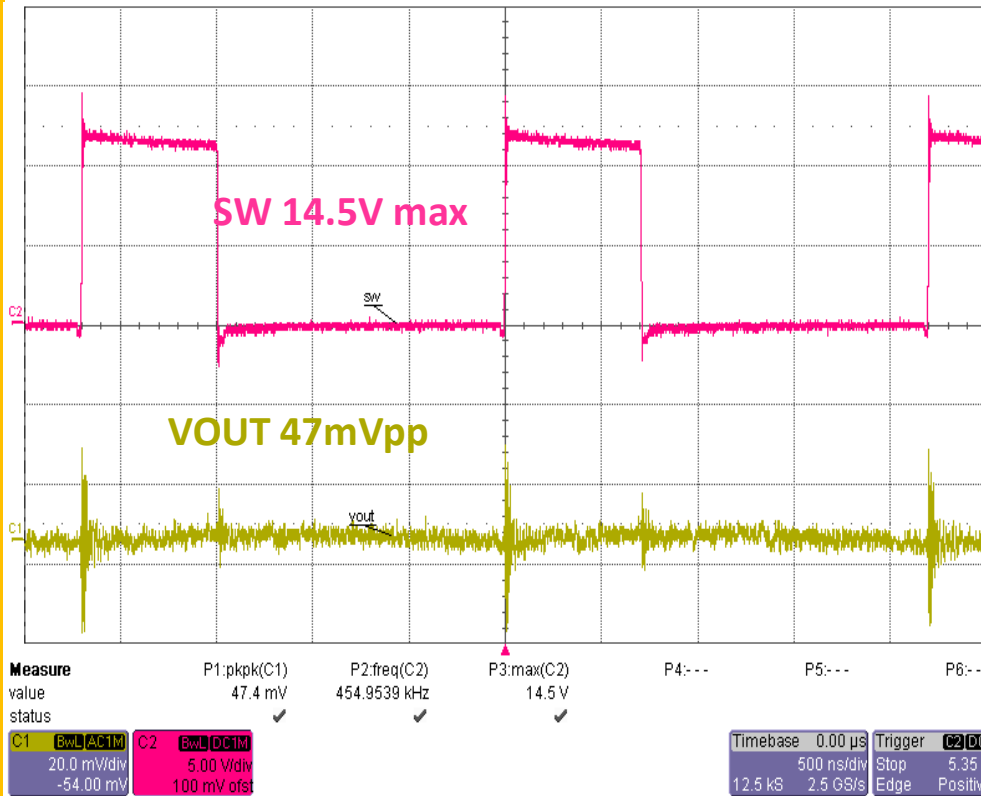
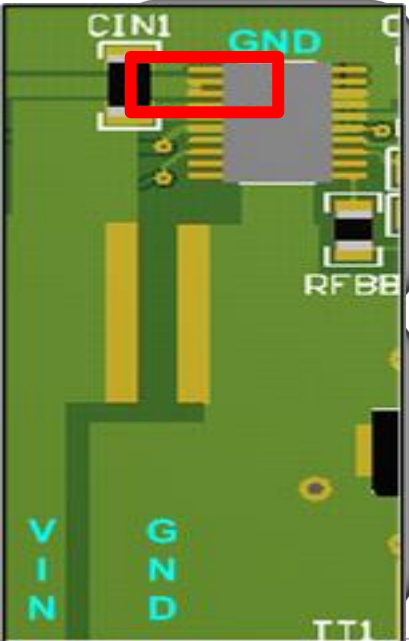
Critical Path Area Comparison

Critical Path Area Reduction

Grounding

High di/dt Caps

- Buck Regulator Comparison with Cin location (single Cin, smaller loop area)



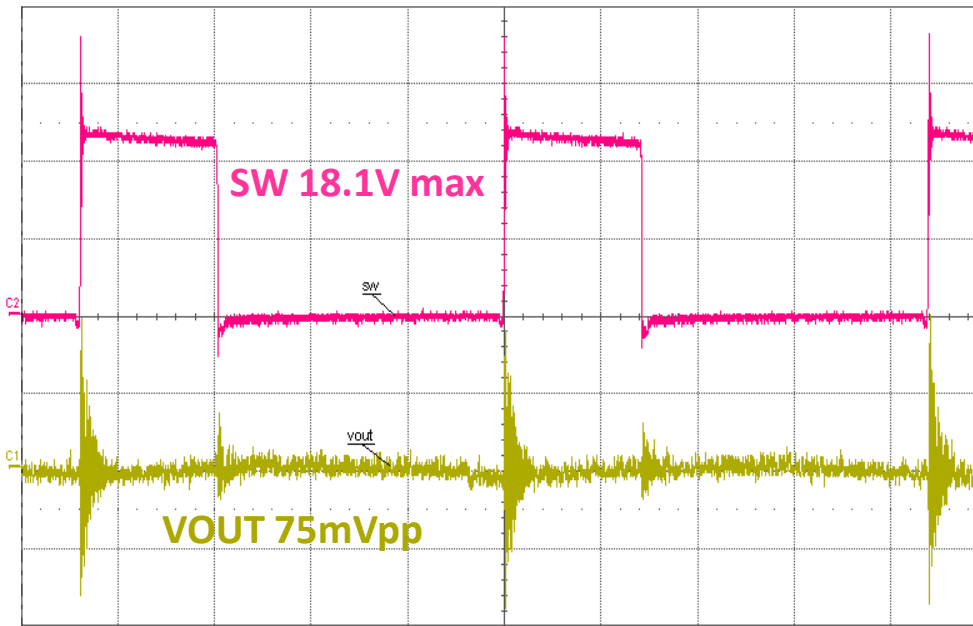
Critical Path Area Comparison

Critical Path Area Reduction

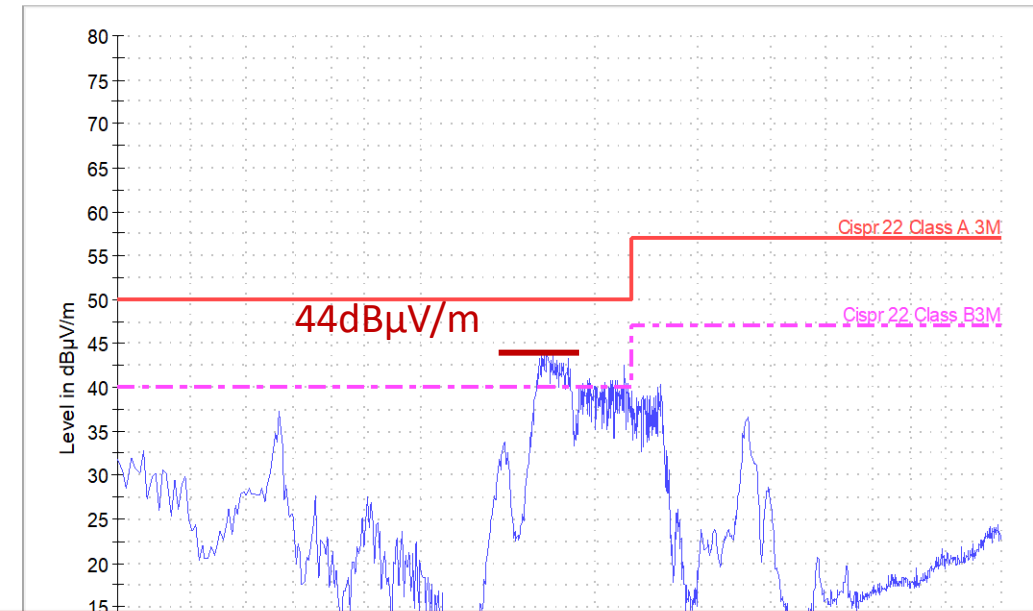
Grounding

High di/dt Caps

- Buck Regulator comparison with Cin location (single Cin, 2.5 times larger area)



Measure	value	status
C1	20.0 mV/div	BWL ActM
C2	-39.00 mV	BWL



Comparison	SW max (V)	Vout p2p (mV)	EMI peak (dBuV/m)
Smaller Area	14.5	47	41
Larger Area	18.1	75	44

EMI Mitigation by slowing rise-time

Critical Path Loop Reduction

Grounding

High di/dt
Caps

SW Node

FETs &
Driver

Contradiction on SW node transition rate:

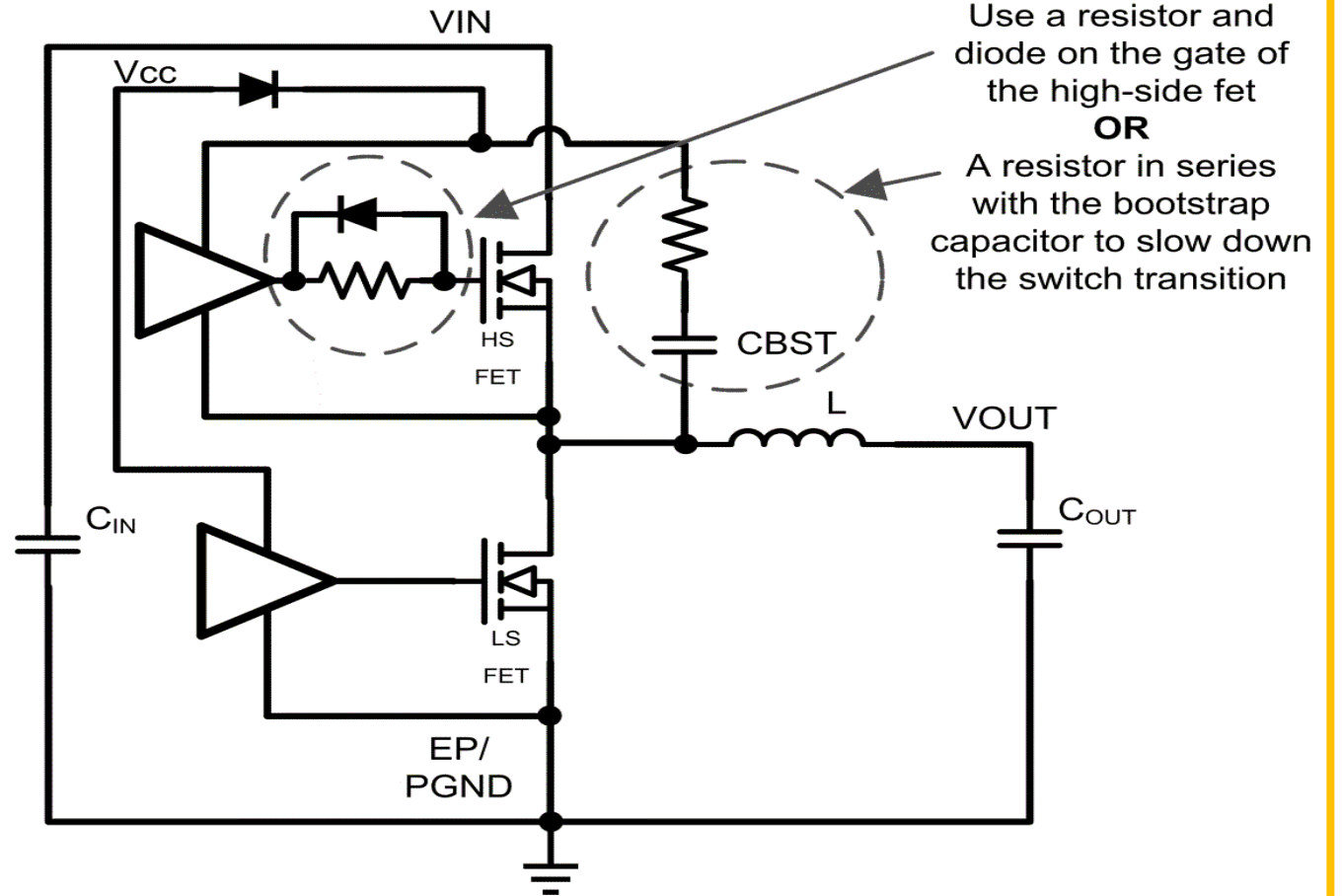
Faster Rising and Falling Times

= Less Losses

= Higher EMI

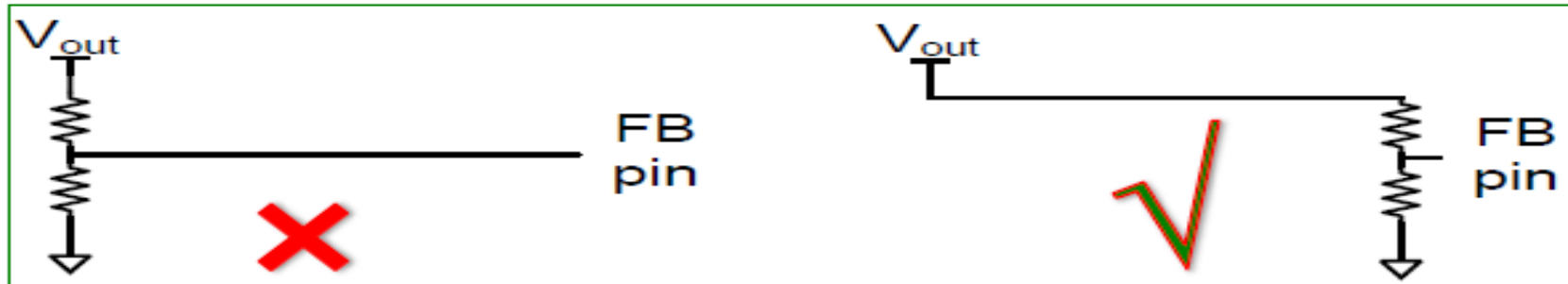
Resistor Value:

Start with 1-10 ohms and adjust from there



Protect EMI Sensitive Nodes – Cont.

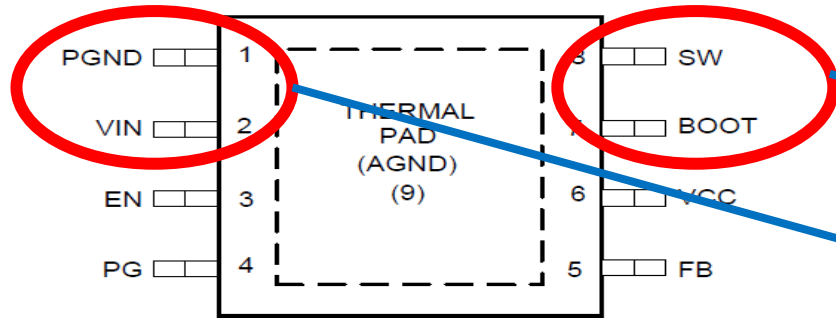
- Make long runs to low impedance nodes, short runs to high impedance nodes.
- Place output voltage divider close to the FB node (high impedance)



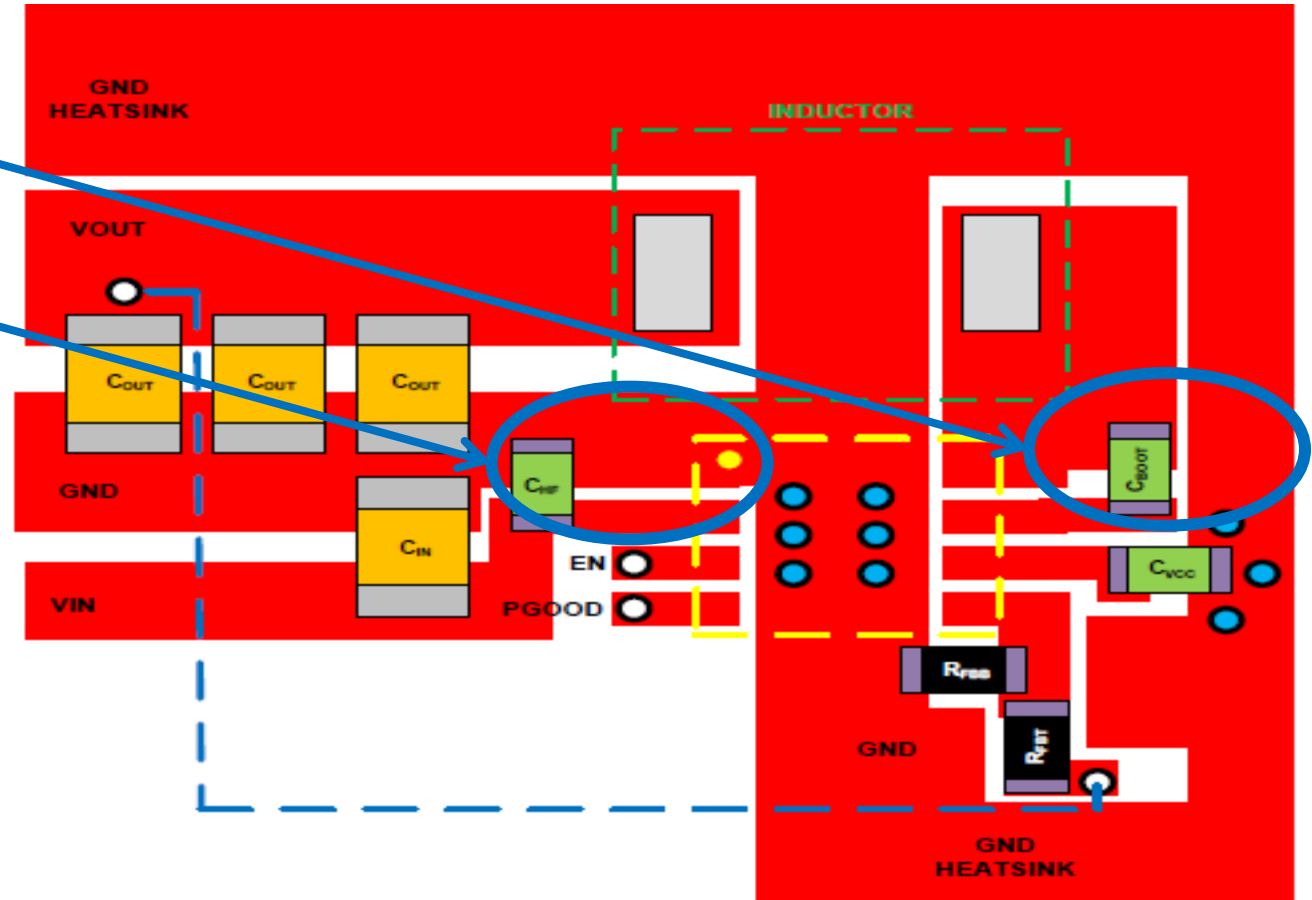
- Route Sense+/Sense- traces parallel to one another – minimize differential-mode noise pickup.
- Keep sensitive small signal traces thin and further away from surrounding signals – lower capacitance coupling

PIN OUT Designed With Performance In Mind

Compact, Low EMI, Good Thermal Performance



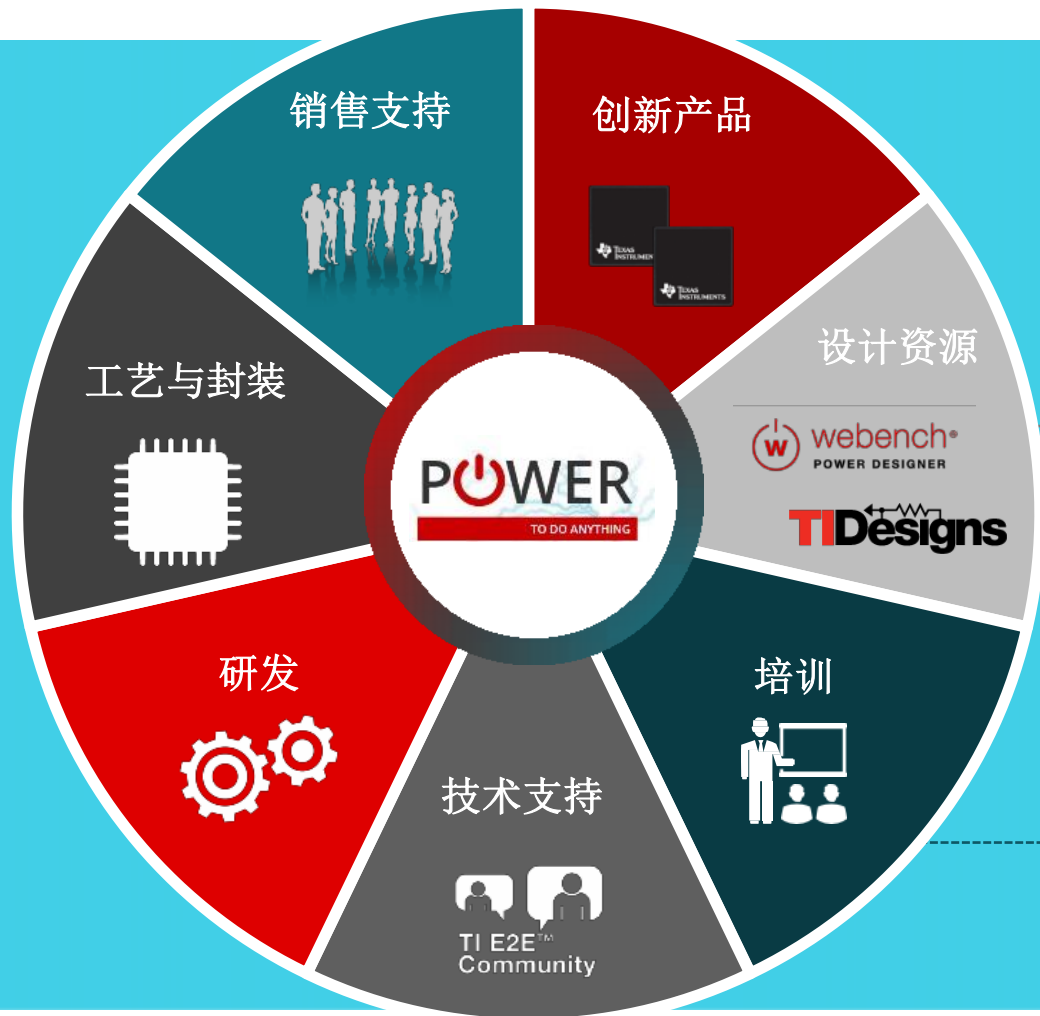
LMR33630



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Applications collateral

Application Notes

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Blogs

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[A review of EMI standards, part 2 – radiated emissions](#)

[Effects of IC package on EMI performance](#)

[Design a second-stage filter for sensitive applications](#)

[Designing USB into challenging automotive applications](#)

[HEV/EV battery management systems explained simply](#)

[How to overcome size, EMI and thermal challenges of automotive LED lighting](#)

[Vary the output voltage in an inverting buck-boost topology](#)

TI Designs

[10kW 3-Phase 3-Level Grid Tie Inverter Reference Design for Solar String Inverter](#)

[Automotive Dual Port USB Type-C™ DFP 5V 3A Charger Reference Design](#)

[Automotive USB Type-C™ DFP 5V 3A + USB Type-A 5V 2.4A Charger Reference Design](#)

[Automotive Wide-VIN to Point-of-Load Power Supply with Front-End Circuit Protection Reference Design](#)

[Dual USB Car Charger Reference Design with Port Power Management](#)

[Integrated Power Front End and Multi-Phase Processor Supply Automotive Reference Design](#)

[Inverting Buck-Boost Converter With Variable Output Voltage Reference Design](#)

[Low-Noise Fixed Drop-Out \$\pm 2.5\$ to \$\pm 12\$ -VOUT 3A Power Supply Reference Design for Ultrasound CW Pulser](#)

[Two-Stage Power Supply Reference Design for Field Transmitters](#)

[Wide Vin Power Supply Reference Design for Space-Constrained Industrial Sensors](#)

Questions?

Thank you!

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