

# 电源模块直播

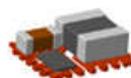
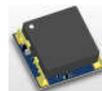
A detailed look at benefits of using modules and how modules are built

[www.ti.com/powermodules](http://www.ti.com/powermodules)

主讲人：郎安东

电源模块系统及应用工程师

德州仪器深圳MCP研发产品线



# Power Modules: The Next “Big Thing”

- **Module market is still relatively “new”**
  - But, it is growing quickly
- **Module technology is making strong advances**
  - Packages are getting smaller
  - Costs are coming down
  - Performance is up
- **Modules will be the preferred solution for many engineers in the future**
  - Easy to use
  - Compelling size
  - EMI tested(电磁干扰测试)

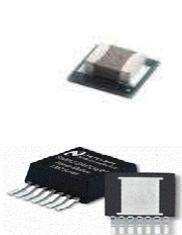
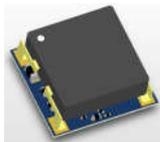
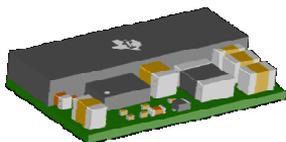
# AGENDA

- **What are Power Modules** 电源模块的概念
- **Why use Power Modules** 电源模块的优势
- **How are Power Modules built** 电源模块的设计与封装
  - Pros/cons of different package types
- **Product portfolio overview** 电源模块产品介绍
  - Select product highlights
- **Important collateral** 电源模块相关技术文献
  - Webench, app notes
- **Q&A** 问答互动环节

# What are Power Modules?

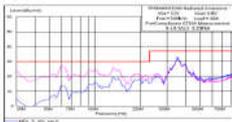
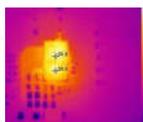
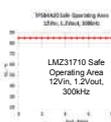
DC/DC Converter that integrates: Controller, FETs and Inductor into single package

## Small solution size



- ✓ Smaller solution size vs discrete
- ✓ Minimal external components
- ✓ Inductors over active components

## Easy to use



- ✓ Simple design
- ✓ Best in class thermals
- ✓ Reliability data
- ✓ Meet EN55022 Class B Emissions
- ✓ Design tools

Up to 36Vin, 1A output



Discrete  
LM53601



Module  
LMZM23601

Up to 17Vin, 8A output



Discrete  
TPS54824



Module  
TPSM84824

# Easy to use--Modules simplify design considerably!

## DISCRETE BUCK CONVERTER DESIGN

### Converter Selection

- Control mode, voltage mode, peak current mode, constant on time, and feature set.

### External Component Selection:

- Inductor: Inductance, DCR, IDC, ISAT, operating frequency, shielded & non-shielded
- Inductor Qual- ISAT vs TA vs IBIAS, HT storage, volt withstand, Curie temp, core cracking
- Capacitors: Type (ceramic, polymer tantalum, electrolytic), amount, layout placement

### Layout and EMI

- Design length and size of current loops, be concerned with high-frequency nodes, and take precautions with ground return paths to both the IC and the input power supply, Parasitics

### Power Supply Design and Characterization

- Output voltage accuracy over line, load, and temperature.
- Compensation: Stability across  $V_{in}$ ,  $V_{out}$ ,  $F_{sw}$ , Temp and  $C_{out}$  ranges. Bode Plots
- Switching Frequency: Efficiency/Size trade-off, Inductor and  $C_{out}$  selection.
- Load Transient, Soft Start ( $V_{out}$  prebias) and Fault (OV, OC, OT) characterization.
- Thermal characterization: Safe Operating Area

### Managing Supply Chain

- Component Vendors (Approved Vendor List)
- Second Sourcing

## MODULE BASED DESIGN

### ✓ You select modules based on key design specs

- We figure out converter selection for best application needs, ease of use, and feature set

### ✓ We do component selection & qualification

- L chosen to optimize efficiency, size, stability, reliability, and cost
- C chosen to optimize  $V_o$  ripple, load transient, solution size and cost

### ✓ We provide optimized layout for EMI and thermals

- DS recommended layout meets thermal and EMI performance
- UL Tested CISPR 11 EMI

### ✓ We provide a fully characterized solution across operating range

- Characterized over  $V_{in}$ ,  $V_{out}$ ,  $I_{out}$ ,  $F_{sw}$ ,  $C_{out}$ , TA, Load Transient, Fault, Thermal and electrical over-stress

### ✓ We work with component vendors to ensure supply continuity

- Module components are 2nd sourced from engineer-selected vendors

# Easy to use--Modules save development cost

## Darnell Group Market Report

### *Ease of Design Comparison for a PSiP/MicroModule/PwrSoC Design Flow Process*

- The DC-DC regulator design flow = much more complex process and with design iterations included ... takes over **2.8 times** as many steps to complete versus module design.
- **Module design** process takes **45.0% less** man hours to complete than a discrete dc-dc regulator “down solution.”
  - 254 vs 464 Man Hours!
- ***Smaller board space and faster time to market***= most common answer for choosing a module

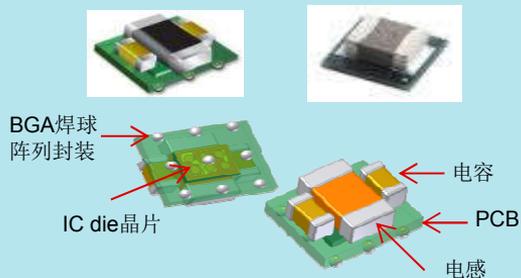
Source: *Ease of Design Comparison for a PSiP/MicroModule/PwrSoC Design Flow Process*  
A Survey by the Darnell Group – April 2012

# How are Power Modules made?

## Pros/cons of different package types

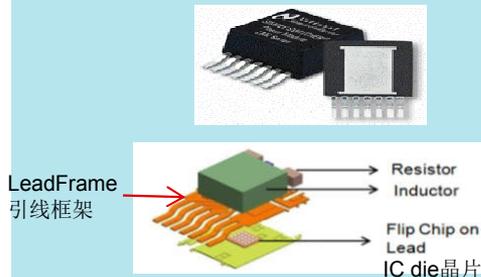
# Broad portfolio of module technologies

## MicroSiP™ 系统级封装 Power Dense



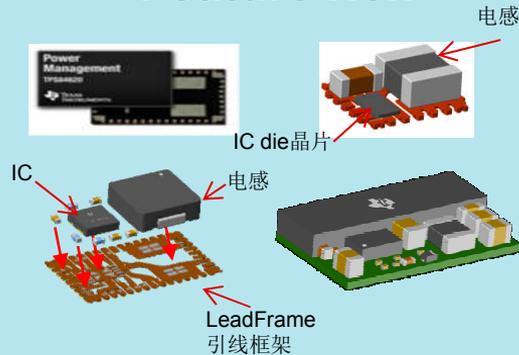
- IC integrated into PCB
- Smallest solution size
  - As small as 2.3x2.9x1.1mm
- Vin up to **36V**
- Iout from 200mA to 3A

## Leaded 有引线封装 Ease of use



- SIMPLE SWITCHER®
- Ease of Prototyping and Manufacturing
- Vin up to 42V
- Iout up to 10A

## QFN 无引线封装 Feature rich



- Standard QFN Package
- Feature Rich and Flexible solutions
- Vin up to 60V
- Iout up to 35A (**70A**)

# MicroSiP® Package Benefits

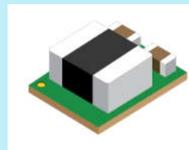
## Process Flow Embed→SMT



3D, low to mid cost assembly  
MSL2/3(潮湿敏感度等级)—  
1year/168hours  
Reflow peak temp(回流焊峰值温度)  
260°C  
0.1A-3A due to thermal limitation

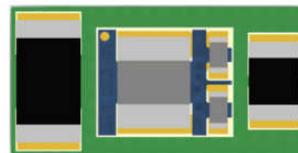
## Smallest solution size

### LMZM23601 4-36Vin, 1A output



Module  
3.8\*3mm

Complete 24 V to 5 V 1000 mA DC/DC Converter



8 mm x 4 mm Solution Size  
(1206 Cin, LMZM23601V5, 0805 Cout)

Discrete  
LM53601



142mm<sup>2</sup>



Module  
LMZM23601

32mm<sup>2</sup>

Save **77%** board area

# Leaded Package Benefits

## Ease of Prototyping&Manufacturing

- **Simple mounting**
  - Easier to mount than BGA, etc.
  - **Single DAP** allows easy prototyping in lab with a single soldering iron and superior thermal performance
- **Standard size and lead pitch**
  - Same pick and place manufacturing as TO-263 package

## Superior Thermal Performance



7-pin  
10.16 x 13.77 x 4.57 mm  
 $\theta_{J/C}=1.9^{\circ} \text{ C/W}$   
 $\theta_{J/A}=12^{\circ} \text{ C/W}$  (热阻)

3.5" x 3.5" four-layer board



11-pin  
15 x 17.8 x 5.9 mm  
 $\theta_{J/C}=1.0^{\circ} \text{ C/W}$   
 $\theta_{J/A}=9.9^{\circ} \text{ C/W}$

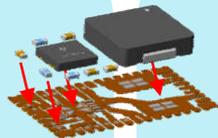
3.5" x 3" four-layer board

Thermal performance measured with [no airflow or heatsink!](#)

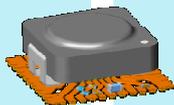
# QFN Package Benefits

## Feature Rich & Flexible

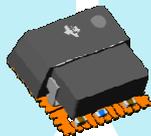
- **Adjustable Switching Frequency**
  - Low-Vin: 500kHz – 2MHz
  - Mid-Vin: 250kHz – 780kHz
  - High-Vin: 400kHz – 1MHz
- **Adjustable UVLO**
- **Adjustable Slow-start (SS)**
- **Sync to Ext Clock** to avoid beat noise
- **Tracking (TR)** pin for sequencing
- **Remote sense (SENSE+)**  
improves regulation at desired load
- **Powergood (PG)** and **Inhibit (INH)**



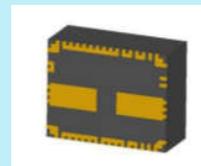
**2D**



**3D**



## Great Power Density



LMZM33603 4-36Vin, 3A Buck Module 7\*9\*4mm

**MSL3-168 Hours**

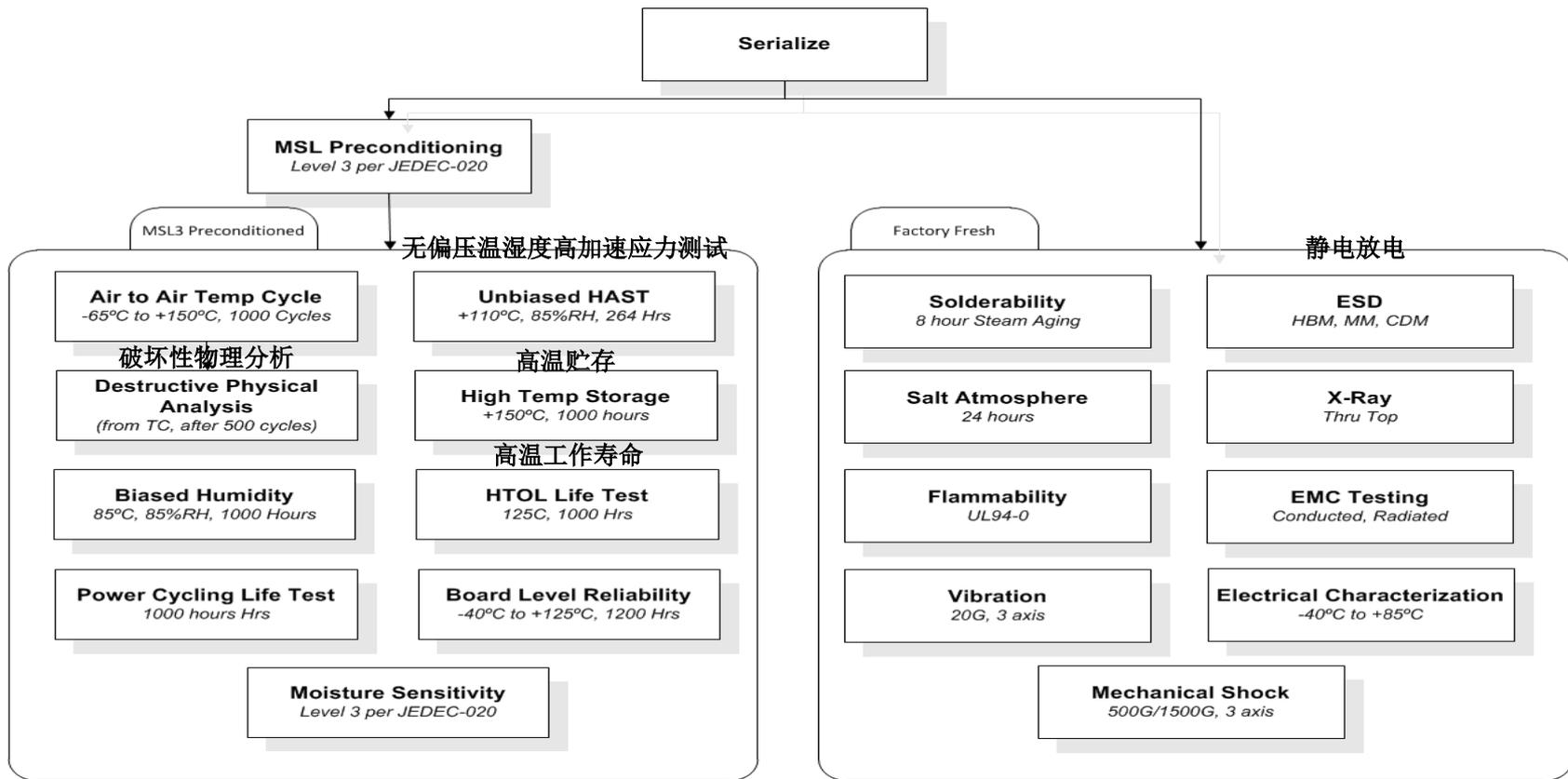
**3x Reflow**

**Reflow spec conforms to JEDEC**

Table 4-2 Pb-Free Process - Classification Temperatures (T<sub>c</sub>)

Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> 350 - 2000	Volume mm <sup>3</sup> >2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm - 2.5 mm	260 °C	250 °C	245 °C
>2.5 mm	250 °C	245 °C	245 °C

# Typical module qualification summary(可靠性测试)



\*\* - MSL 3 Preconditioning

# Typical module qualification summary

Test Type	Condition/Duration	QTY Lots/Pieces	Results
Moisture Sensitivity	Level 3 as per Jedec-020	27	Pass
**Temp cycling -65C/150°C	-65C/+150°C (500, 1000* Cyc)	3/77	Pass
**Unbiased HAST	110C/85%RH/17.7 psia (96, 264* hours)	3/77	Pass
**Biased Temp. Humidity	85C/85%RH (500, 1000 hours)	1/77	Pass
BLR - Temp Cycle, -40/125°C	-40/125°C (1200 cycles)	1/42	Pass
**High Temp. Storage Bake	150°C (500 hours)	1/75	Pass
**High Temp. Storage Bake	170°C (168, 420 hours)	2/77	Pass
**Steady-State Life Test	125°C (500, 1000 hours)	2/77	Pass
**Power Cycling	15 Minute Duty Cycle 1000 hours	3/40	Pass
Vibration	MIL-STD-883D, METHOD 2007.2 - Pass 20g	1/9	Pass
Mechanical Shock	MIL-STD-883D, METHOD 2002.3 - pass 1500g	1/3	Pass
Flammability	Method A - UL94-0	3/5	Pass
Solderability	Steam age, 8 hours	3/22	Pass
Salt Atmosphere	24 hours	3/22	Pass
ESD HBM	+/-100V	1/3	Pass
ESD MM	+/-100V	1/3	Pass
ESD CDM	+/-500V	1/3	Pass
Radiated Emissions	Pass - Class B EN55022 Regulations	1/3	Pass
Conducted Emissions	Data Provided, Passed Class B EN55022	1/3	Pass

\*\* - MSL 3 Preconditioning

# Component selection for modules

- **Inductors**

- Preferred Types: Molded Powdered Iron, Ferrite Staple Core (40A+)
- Pre Qualification:
  - Inductance vs. DC current vs. Temperature (saturation)
  - High Temperature Storage (6 wks @ 150°C or greater), monitor L, DCR, Q @ 1MHz
  - 3x Reflow, monitor change in L and DCR

- **Capacitors**

- Preferred Types: X7R, X7S
- Pre Qualification:
  - Capacitance vs. DC bias
  - Insulation resistance
  - 3x Reflow, monitor change in C and IR

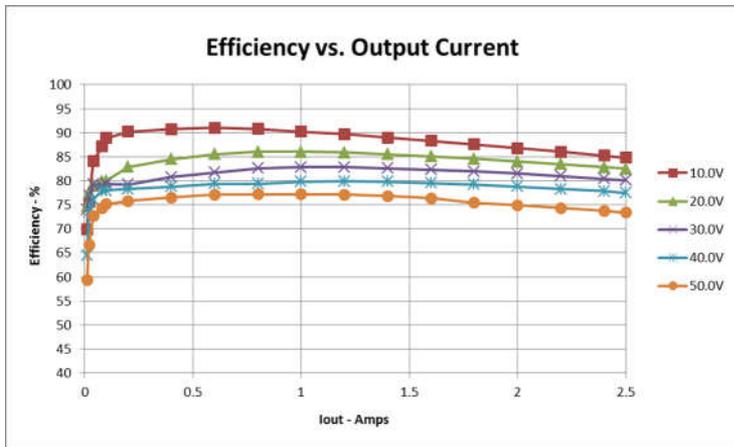
- **Resistors**

- Thick Film, 1% or better, TC = 100-200 PPM
- Yageo, Vishay/Dale, KOA
- Moving to Green status when vendors are ready...

# Example of Poor inductor HTS(高温贮存):

## Before & After – Impact on Efficiency

Pre HTS

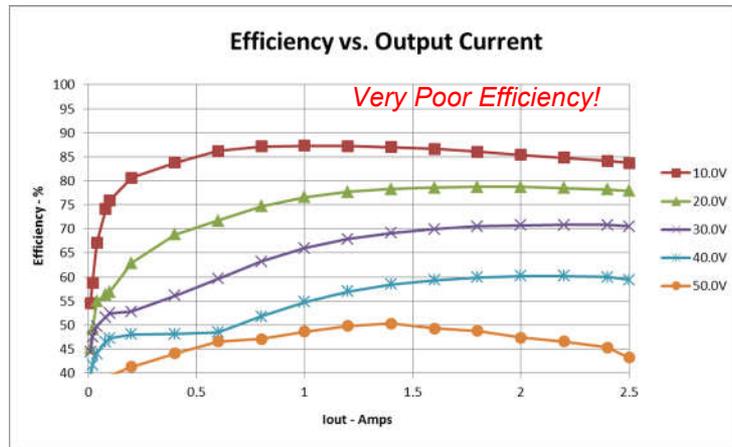


V<sub>in</sub> Range: 10V to 50V

V<sub>out</sub>: 5V

F<sub>sw</sub>: 800kHz

Post HTS



Efficiency Delta @ 2.5A

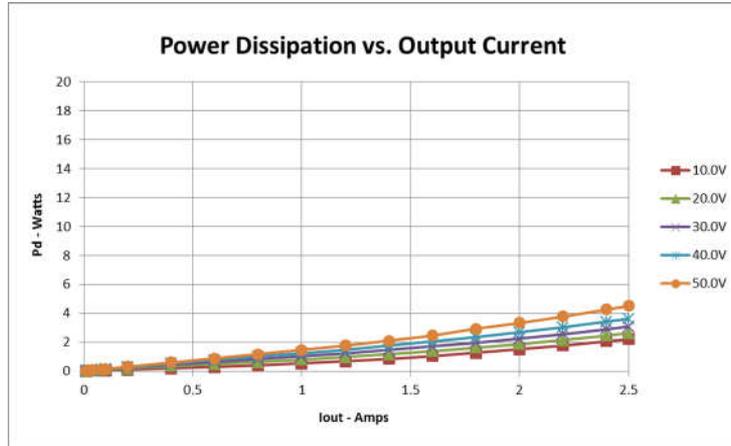
At 10V<sub>IN</sub>: -1.1%

At 50V<sub>IN</sub>: -30.2%

# Example of Poor inductor HTS:

## Before & After – Impact on power dissipation

### Pre HTS

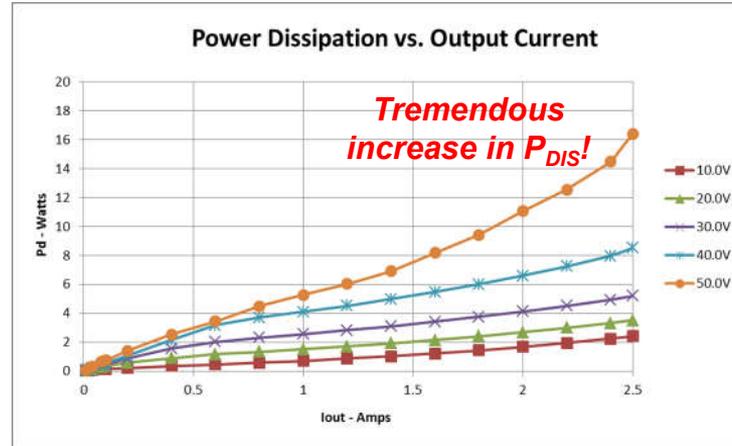


V<sub>in</sub> Range: 10V to 50V

V<sub>out</sub>: 5V

F<sub>sw</sub>: 800kHz

### Post HTS



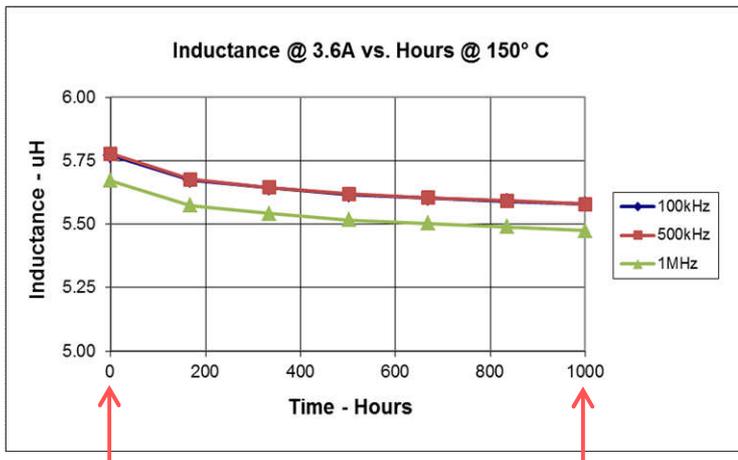
Power Dissipation  $\Delta$  @ 2.5A

At 10V<sub>IN</sub>: 200mW

At 50V<sub>IN</sub>: 11.9W! ← All dissipated in the inductor!

# HTS: What Changes?

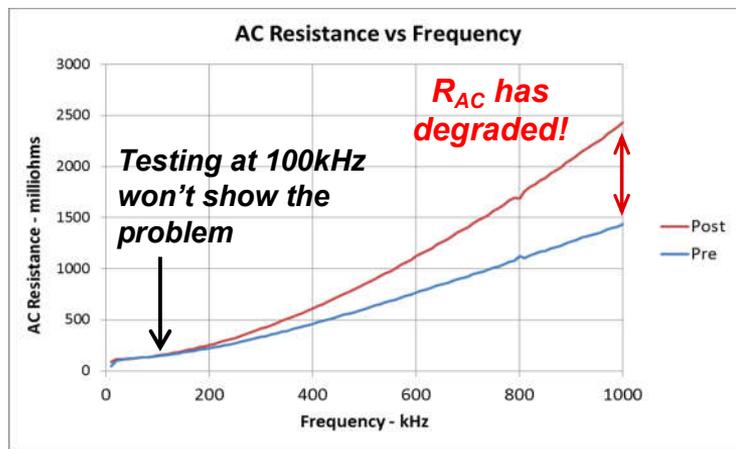
*L and DCR do not change.  $R_{AC}$  changes.*



**Very slight change in inductance:  
< 200nH**

**As the core ages, the permeability (L)  
does not change!**

Data from a different example..



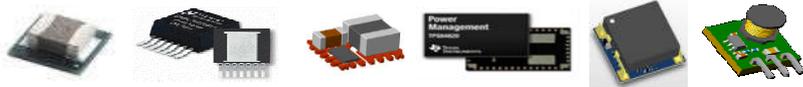
DC Resistance (DCR) does not change.  
AC Resistance diverges with increasing frequency.

**The coil windings do not change, so  
DCR does not change!**

# **Power Modules:** **Portfolio and Soon To Be Released**

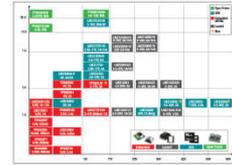
# TI's Power Modules – A Broad Portfolio

## Range of package options



- ✓ Package options matched to IC and application
- ✓ Range of surface mount, leaded and through-hole options
- ✓ Pin-Pin compatible options

## Broad portfolio



- ✓ Input voltages from 2.2V up to 60V
- ✓ Output currents up to 70A
- ✓ Stackable options for reduced noise and high lout
- ✓ EMI Tested



# New Power Modules



- |                                        |                                                                                   |                                                                                                 |
|----------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| <u><a href="#">TPSM82480:</a></u>      |  | <u><a href="#">5.5V, 6A in QFN Package (7.9 * 3.6 * 1.5 mm<sup>3</sup>)</a></u>                 |
| <u><a href="#">TPSM84824:</a></u>      |  | <u><a href="#">17V, 8A in QFN Package (plus 6A, 4A; 7.5*7.5*5.3 mm<sup>3</sup>)</a></u>         |
| <u><a href="#">TPSM846C23:</a></u>     |  | <u><a href="#">17V, 35A PMBus in QFN Package ('C24 not PMBus; 15*16*6.4 mm<sup>3</sup>)</a></u> |
| <u><a href="#">TPS82130/40/50:</a></u> |  | <u><a href="#">17V, 3A/2A/1A MicroSiP Power Modules (3*2.8*1.5 mm<sup>3</sup>)</a></u>          |
| <u><a href="#">TPSM84209:</a></u>      |  | <u><a href="#">28V, 2.5A in QFN Package (4*4.5*2 mm<sup>3</sup>)</a></u>                        |
| <u><a href="#">TPSM84203/5/12:</a></u> |  | <u><a href="#">28V, 1.5A TO220 LDO replacement (10*15 mm)</a></u>                               |
| <u><a href="#">LMZM23600/1:</a></u>    |  | <u><a href="#">36V, 0.5A/1A MicroSiP Power Module (3*3.8*1.6 mm<sup>3</sup>)</a></u>            |
| <u><a href="#">LMZM33602/3:</a></u>    |  | <u><a href="#">36V, 2A/3A in QFN Package (7*9*4 mm<sup>3</sup>)</a></u>                         |
| <u><a href="#">LMZM33606*:</a></u>     |  | <u><a href="#">36V, 6A in QFN Package (10*16*4 mm<sup>3</sup>)</a></u>                          |

\*APL

# TPSM82480



## 6A Step Down Power Module with Integrated Inductors

### Features

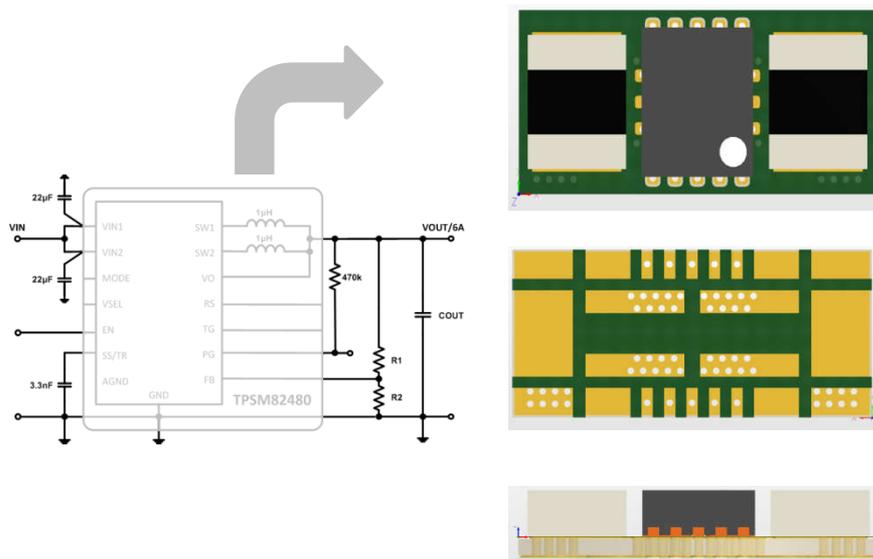
- 2.4/2.6 V to 5.5V Input Voltage Range
- 0.6 V to 5Vout
- 3.6 x 7.9 x 1.5mm Open Frame Package
- Forced PWM Option for Fixed Frequency Operation
- Design Flexibility and Performance
  - 23 $\mu$ A Quiescent Current
  - $\pm$ 1% Feedback Voltage Accuracy (PWM Mode)
  - Power Good & Thermal Good Outputs
  - Adjustable Soft Startup
- -40°C to 125°C operating temperature range

### Applications

- Low profile POL Supply
- Communications Equipment / Infrastructure
- Solid State Drive
- Portable/Embedded/Tablet PC

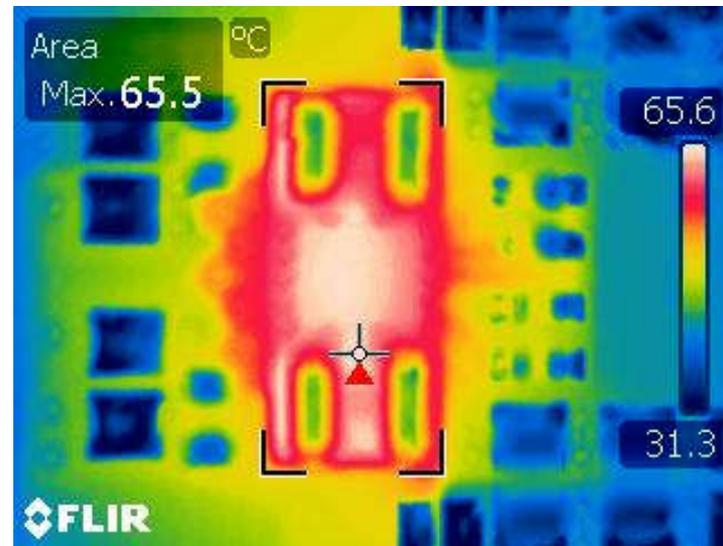
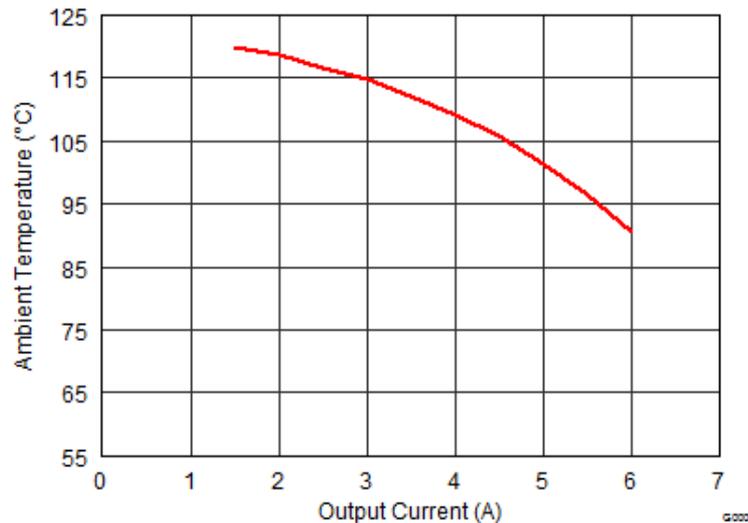
### Benefits

- Small solution size with **ultra low profile height**
- Easy to use by simplified layout
- Symmetrical structure with equal height of components



# TPSM82480, Maximum Ambient Temperature

$V_{IN}=5V$ ,  $V_{OUT}=3.3V$ ,  $I_{OUT}=6A$



Full output current rating at  $T_A=85^{\circ}C$ .

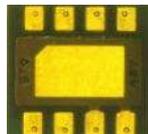
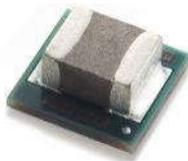
# TPS82130 / TPS82140 / TPS82150

## 17V 1-A to 3-A Step Down Converter Module with Integrated Inductor



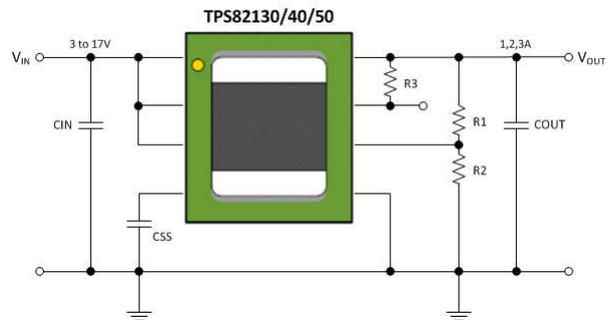
### FEATURES

- MicroSiP™ package with integrated inductor  
3.0mm x 2.8mm x 1.5mm
- 3V to 17V Input Voltage Range
- DCS-Control™ Topology
- Power Save Mode for Light Load Efficiency
- 100% Duty Cycle
- 20μA Quiescent Current
- Power Good Output plus Capacitor Discharge
- Adjustable Output Voltage
- Programmable Soft Startup
- -40°C to 125°C operating temperature range



### BENEFITS

- Small, low profile solution
- Saves >50% PCB area (TPS82130), compared to discrete solution
- Easy to use



### APPLICATIONS

- General Purpose POL
- Data cards, Network Switcher, Line Cards
- Storage: Server, Motherboards
- Telecom Infrastructure: Optical Modules (Inverter)

Device Name	Output Current
TPS82130SIL	3-A
TPS82140SIL	2-A
TPS82150SIL	1-A



# TPSM84A21/2

## 8-14Vin, 10A, 0.55 – 2.05V Vout Compact Power Module



### Features

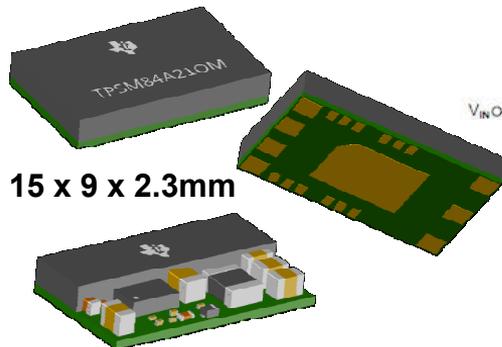
- Integrated input and output capacitors
- Adjustable output voltage using VADJ pin with a single resistor
- Fast transient response with less than 3% total  $V_{OUT}$  deviation
- Fixed frequency steady-state operation
- Low EMI & external SYNC capability
- 15 x 9 x 2.3mm power module size

### Applications

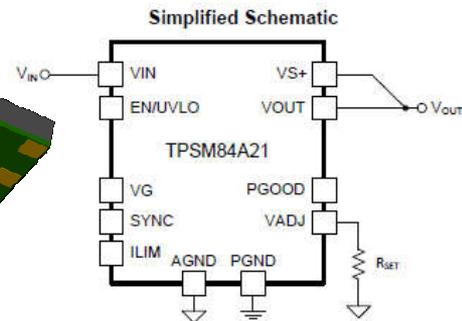
- Backside board mounting (<2.3mm height)
- Telecom base station and communications infrastructure equipment
- Storage, SSD, DDR memory, switches, hubs, routers & other networking equipment

### Benefits

- High power density
- Easy to Use: Only One External Component
- Low profile supports backside board mounting
- Meets Class B EN55022 Emissions

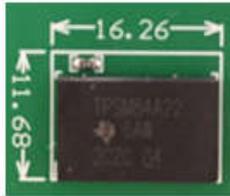
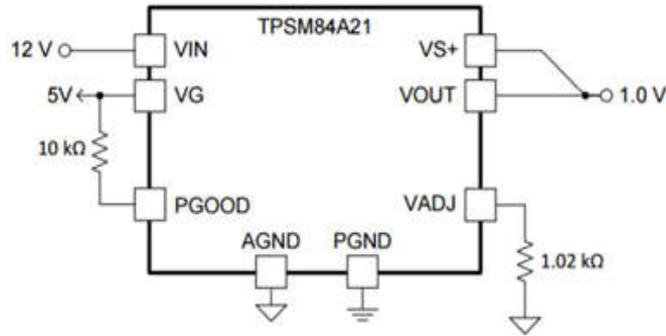


15 x 9 x 2.3mm

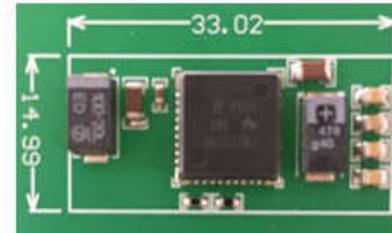
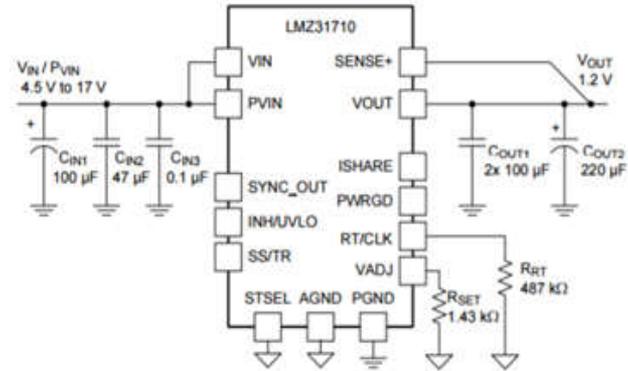


P/N	Adj. $V_{OUT}$ Range
TPSM84A21	0.55 – 1.35V
TPSM84A22	1.2 – 2.05V

# TPSM84A21/2 vs LMZ31710



Solution size = 190mm<sup>2</sup>, 2.3mm height  
Transient response = +/-1% overshoot



Solution size = 495mm<sup>2</sup>, 4.3mm height  
Transient response = +/-3% overshoot

# TPSM84824/624/424

## 4.5V - 17V, 8A/6A/4A Synchronous Step-Down Module



7.5x7.5x5.4mm

Released

### Features

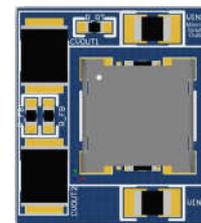
- Vout from 0.6V to 10V, w/ 1% Reference
- TurboTrans™ feature for excellent transient response over whole Vout range
- 7.5 x 7.5 mm footprint (<math><130\text{mm}^2</math> Minimum Solution Size)
- 200kHz to 1.6MHz fixed frequency operation with ability to sync to an external clock
- Low BOM Cost with few Ceramic Caps
- Pin-Pin Family: 8A, 6A and 4A Options
  
- Soft Start, PG and Pre-Biased Start Up. Peak Current Mode Control

### Applications

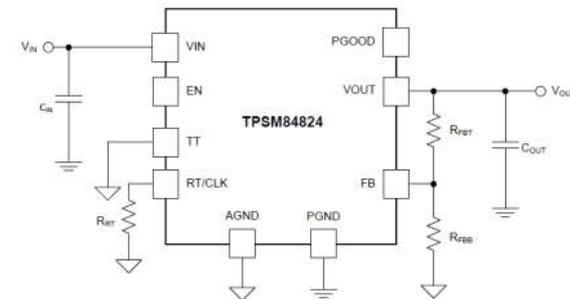
- Telecom base station and communications infrastructure equipment
- Storage, SSD, switches, hubs, routers and other networking equipment
- Power for performance DSPs, FPGAs and ASIC

### Benefits

- Suitable for wide range of Digital and Analog loads
- Excellent Transient response with minimal Output Capacitance (60mV deviation @ 50% load step; 1A/us; w/ 200uF Cout)
- Smaller than popular competitive solution
- Syncing to external clock simplifies noise reduction in many systems
- Easy to use: Only 3 external components required for 0.6Vout



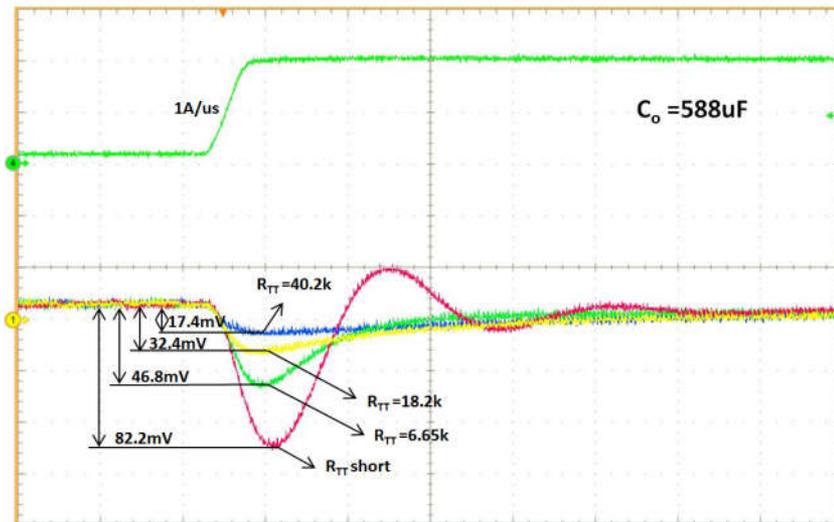
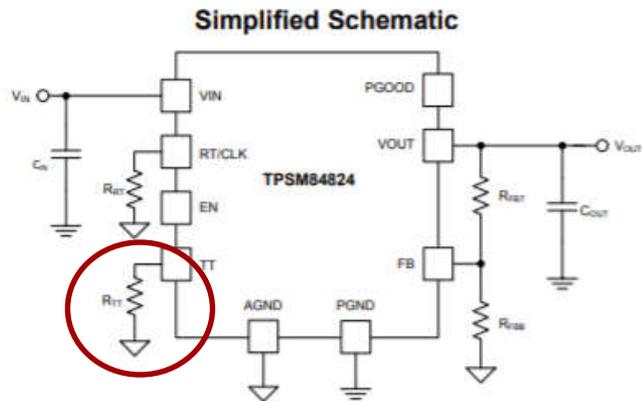
<math><130\text{mm}^2</math>  
Solution Size



# TPSM84824/624/424

4.5V - 17V, 8A/6A/4A Synchronous Step-Down Module

TurboTrans™: One resistor to improve transient response



[To learn more, click to check out this blog](#)

Transient response with  $R_{TT}$

# TPSM846C23/C24

4.5V-15Vin, 35A Stackable Power Module with/without PMBus™



## Features

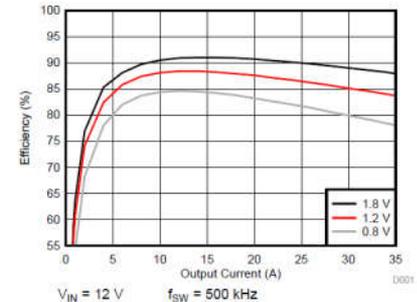
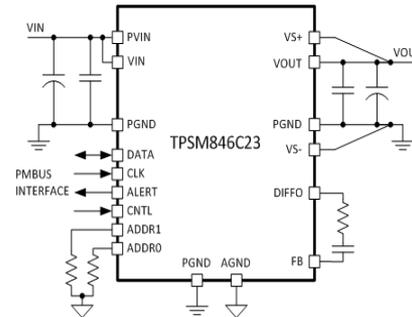
- Output Voltage Range 0.35V to 2V, **0.5% Vref (0 to 85C)**
- **Stack 2x for 70A**
- Fully differential remote voltage sense
- FPWM with Fsync In/Out from 300KHz to 1MHz
- **PMBus v1.3 Command Set with Telemetry**
- **Tested to CISPR22 Class A Radiated EMI**
- **Compact 15 x 16 x 6.4mm package footprint**
- P2P Analog Version (TPSM846C24)

## Applications

- Telecommunication & Networking Equipment
- Industrial, Test & Measurement
- Enterprise Storage and Video Broadcasting
- ASIC, FPGA and DSP Attach

## Benefits

- High design flexibility
- **Outstanding** load regulation (100uV deviation 0 to 35A)
- Fixed frequency, 180° out-of-phase sync out when stacking
- Die temp monitoring (+/-5C), Accurate lout telemetry (+/-15% lout), Set Vout with 2mV resolution
- Smaller than discrete with over-the-IC inductor



# TPSM84209



## 4.5 to 28V/2A, Adjustable Power Module with Integrated Inductor

### Features

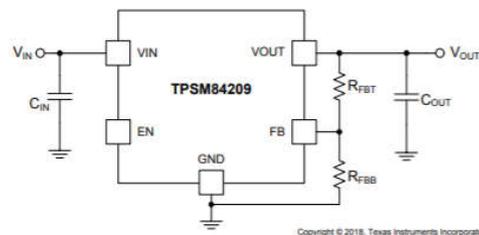
- **Maximum 28V Input Voltage**
- Adjustable Output Voltage down to 1.2V
- **2.5A Continuous Output current.**
- +/- 3% Vout Accuracy
- **Ultra Low Quiescent Current and Pulse Skip for High Light Load Efficiency**
- Fixed Soft-Start: 5mS
- **Small QFN Style Leadframe: 4 x 4.5 x 2mm**

### Applications

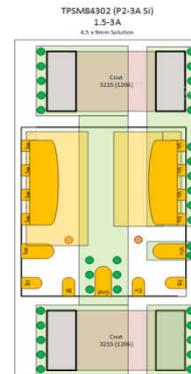
- 12-V, 24-V Distributed Power-Bus Supply
- Industrial Controls
- Communications Equipment
- LDO Replacement

### Benefits

- High light load efficiency( $V_{IN}=12V, V_{OUT}=5V$   
>88%@10mA)
- Simple Layout
- Lowest external component count to optimize board space, and less cost
- Meets Class B EN55022 Emissions with Reduced Noise

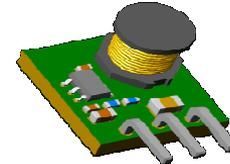


Copyright © 2018, Texas Instruments Incorporated



# TPSM84203/5/12: TO220 Module

4.5 to 28V Input , High Efficiency, Low EMI 1.5A Module



## Features

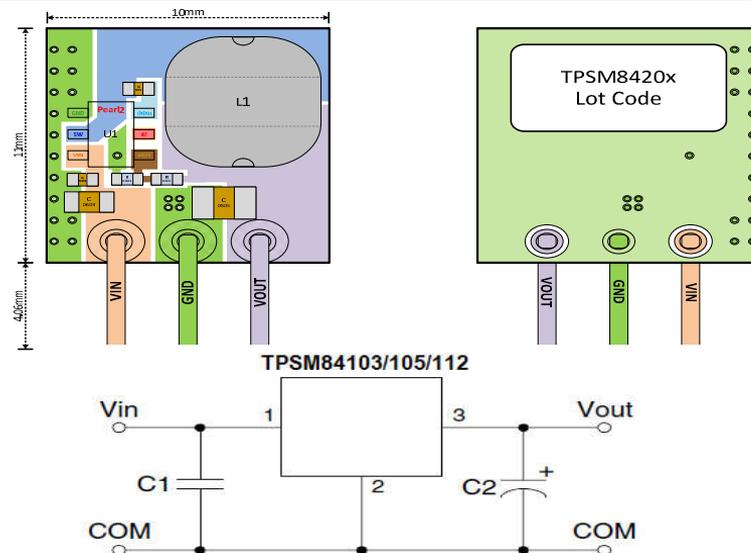
- **Maximum 28V Input Voltage**
- **Fixed 3.3V/5.0V/12V Output Voltage**
- **1.5A Maximum Continuous Output current**
- +/- 3% Vout Accuracy (25C, max)
- Ultra Low Quiescent Current for Higher Light Load Efficiency
- Frequency Spread Spectrum to Reduce EMI
- Fixed Soft-Start:4mS
- **780x pin-2-pin compatible.** Low External Comp Count

## Applications

- 12-V, 24-V Distributed Power-Bus Supplies
- Linear Regulator Replacement in Industrial Applications
- White Goods

## Benefits

- High light load efficiency(VIN=12V,VOUT=5V, >88%@10mA)
- Simple Layout
- Lowest ext. component count optimize board space, cost
- Meets Class B EN55022 Emissions with Reduced Noise



# LMZM23600/1

## Industry's smallest 36V Input 0.5A/1A Step-Down DC/DC Module



### Features

- 4 to 36V Input Voltage Range, Transient to 42V
- 0.5A and 1A Output Current Options
- Fixed 3.3V, 5V & Adj. (2.5V – 15V) Output Voltage Range
- Miniature 3 x 3.8 x 1.6mm Package (0.6mm Pitch)
- Low EMI: Tested to CISPR11 Class B Radiated EMI
- Mode Pin
  - Forced PWM Mode w/ Freq Sync
  - Auto PFM Mode option for Light Load Efficiency
- -40 °C to 125 °C Operating Junction Temperature
- Built in Compensation, Soft Start, Current Limit, Thermal Shutdown, Power Good, and Input UVLO

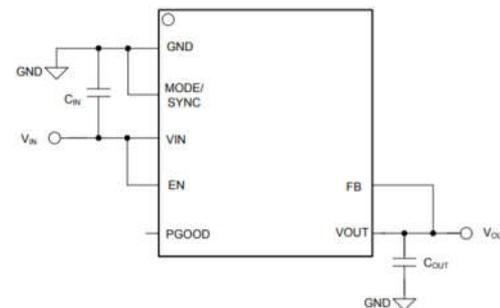
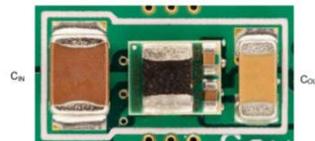
### Applications

- Factory & Building Automation
- Medical Equipment
- Smart Grid & Energy
- Defense Equipment
- [Inverting Output – Application Note](#)

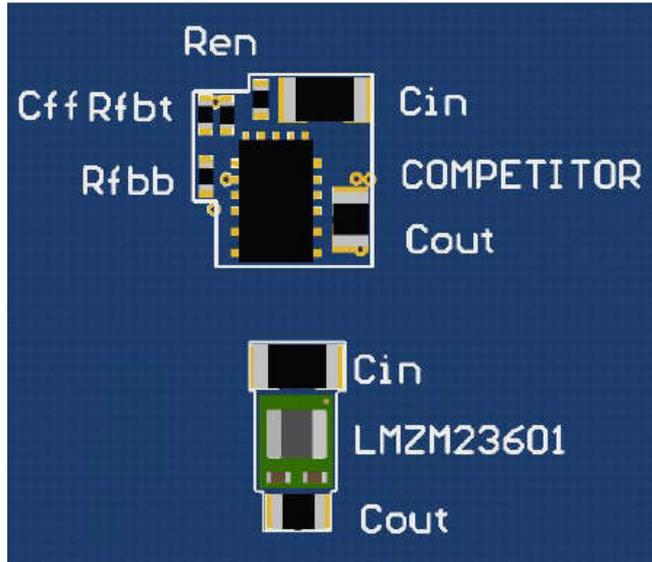
### Benefits

- Supports wide range of application requirements
- Easy to Design: only  $C_{IN}$  and  $C_{OUT}$  required (Fixed  $V_{out}$ )
- 27mm<sup>2</sup> solution: 45% smaller than competition; 55% smaller than discrete
- System Flexibility with choice of Fixed Frequency or Light Load Efficiency
- Synchronize to external clock

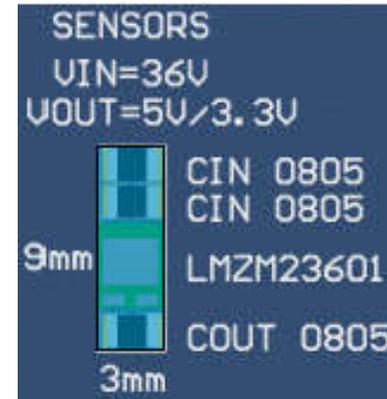
Single-Sided Layout Solution Size  
24-V to 5-V, 0.5-A DC-DC Converter  
3.8 mm x 3.0 mm package



# LMZM23600/1 solution size comparison



30mm<sup>2</sup> vs 58mm<sup>2</sup>  
(using same size external components)



9x3 mm solution size for width  
sensitive applications like sensors

# LMZM33602/3

4V to 36V, 3A Step-Down Power Module in Compact 7x9x4mm QFN Package



## Features

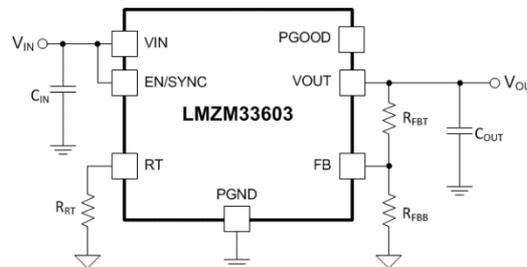
- 4 to 36V Input Voltage Range
- 2A and 3A Output Current Options:
- 1V to 18V Vout w/ 2A Iout
- 1V to 13.5V Vout w/ 3A Iout
- 7 x 9 x 4.0mm QFN Package
- All pins accessible from perimeter of package
- FPWM with Frequency Sync from 200KHz to 1.2MHz
- -40 °C - 105 °C Operating Temp Range (125 °C Junction)
- Low EMI: Tested to CISPR11/EN55011 Radiated EMI
- PG, Pre-Biased Start Up and Prog UVLO

## Applications

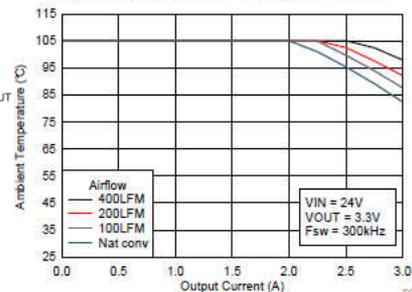
- Factory & Building Automation, Smart Grid & Energy
- Medical
- Defense
- [Inverting Output – Application Note](#)

## Benefits

- Ideally suited for 24V, 12V and 5V Bus Systems
- Provides wide output voltages for a broad range of digital and analog loads
- Low design effort – highly integrated, small solution
- Fixed Freq + Sync to reduce system noise
- Wide Temperature range allows wide SOA performance
- Next generation module offers improved performance vs LMZ35003 (105C T<sub>A</sub>, Wider Vout Range, Higher current)



Ambient Temperature vs Output Current



# LMZM33604/6



In-Development  
Sample: Now

## High Efficiency 36V Input 6A Module in Compact 10x16x4mm QFN Package

### Features

- **3.5 to 36V** Input Voltage Range
- **4A and 6A** Output Current Options
- Adjustable 1.0 to 18V  $V_{out}$
- **10 x 16 x 4.0mm QFN Package**
- **FPWM with Frequency Sync from 200KHz to 1.2MHz**
- **-40 °C to 105 °C Operating Temp Range** (125 °C Junction)
- **Tested to CISPR11/EN55011, Class B Radiated EMI**
- PG, Pre-Biased Start Up and Prog UVLO

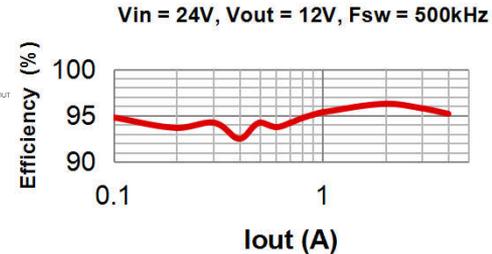
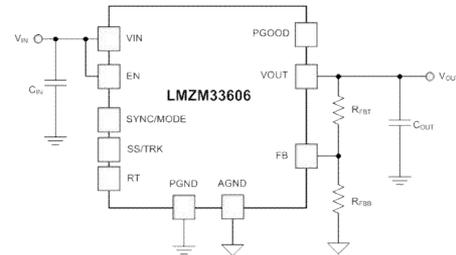


### Applications

- Automated Test and Measurement
- Medical & Imaging
- Industrial and Motor Control

### Benefits

- Ideally suited for 24V, 12V and 5V Bus Systems
- Low design effort – highly integrated, small solution
- Fixed Freq + Sync to reduce system noise
- Wide Temperature range allows wide SOA performance
- Next generation module offers improved performance vs LMZ23605



# Applications collateral

## • Application Notes and Blogs

### – EMI and Noise Reduction

- [Simple Success With Conducted EMI From DCDC Converters](#)
- [Simplify low EMI design with power modules](#)
- [Understanding, measuring, and reducing output voltage ripple](#)
- [Design a second-stage filter for noise sensitive applications](#)
- PCB layout techniques for low noise power designs (in progress)

### – Inverting Applications

- [Inverting application for the LMZ14203 SIMPLE SWITCHER® Power Module](#)
- [Inverting application for the LMZM33603](#)
- [Inverting application for the TPS82130](#)
- Inverting supply for space constrained systems with the LMZM23601 (in progress)

### – Thermal Design

- [PCB design and thermal performance of SIMPLE SWITCHER® Power Modules](#)
- [Improving the Thermal Performance of MicroSiP Power Modules](#)
- Thermal design made easy with TI Power Modules (in progress)

### – Transient Performance

- [TurboTrans technology: transient performance and reduced solution size](#)

## • Webench

### – A priority for all Power Modules

[www.ti.com/powermodules](http://www.ti.com/powermodules)

## Innovative DC/DC Power Modules



**Overview**  
The broad range of DC/DC power modules are designed specifically to help designers get to market faster with robust, high performance solutions. In a single package, these power modules integrate inductors, FETs, capacitors, and other passive components to reduce development time for design and verification, and speed up time to market with proven reliability. To browse the entire portfolio and learn more on the latest products, visit [www.ti.com/powermodules](http://www.ti.com/powermodules).

Product	Key Features
<b>TPS82130</b>	• 4.5V to 18V In • 30A Output (Rated for 75A) • PFM/DCM (2:1 Conversion Ratio) • 1% to 10% Load Regulation • 2.5mm x 2.5mm Package
<b>LMZ14203</b>	• 4.2 to 28V In • PFM/DCM (2:1 Conversion Ratio) • 1.5A Output Current • Low EMI with Spread Spectrum • 5-Pin, 10-Lead Package
<b>LMZ14201</b>	• 4.2 to 28V In • 2.4-A Output Current • 240mA Output Current • 7-Pin, 8-Lead Package • PFM/DCM and Low EMI
<b>LMZ14202</b>	• 2.5V to 28V In • 1.5A Output Current • 0.05% to 0.5% Load Regulation • Only One External Component • 1% to 10% Load Regulation
<b>TPS82130</b>	• 4.5V to 18V In • 1.2 and 3A Output Current Options • 0.05% DRG • 75A to 3.0A to 1.5A Load Package • 2.5mm x 2.5mm Package
<b>LMZ14203</b>	• 2.4 to 28V In • 1.5A Output Current • 240mA Output Current • 7-Pin, 8-Lead Package
<b>LMZ14201</b>	• 4.2 to 28V In • 1.5A and 3A Output Current Options • PFM/DCM, 3.3V and 4.5V to 18V In • 7-Pin, 8-Lead Package
<b>TPS82130</b>	• 4.5V to 18V In • 1.2 and 3A Output Current • 0.05% DRG • 75A to 3.0A to 1.5A Load Package • 2.5mm x 2.5mm Package

### Why Power Modules?

Smaller Size	Simple Solutions	Low EMI
• Multiple smaller vs. discrete	• Internal components	• Tuned EMI performance

**SLYT685C**

# Questions?

Thank you!



# TI Webinar Series

[www.ti.com/webinarseries](http://www.ti.com/webinarseries)

# TI Webench design tool



## Create a new DC/DC power design

WEBENCH® Power Designer creates customized power supply circuits based on your requirements. The environment gives you end-to-end power supply design capabilities that save you time during all phases of the design process. [Learn more](#)

🔍 Part Number

### Input

Supply type is

DC  AC

Vin Min \*

14 V  
(0 - 1000)

Vin Max \*

22 V  
(0 - 1000)

Advanced



### Output

Vout \*

3.3 V  
(-80 - 500)

Iout Max \*

2 A  
(0 - 180)

Isolated Output

Advanced

