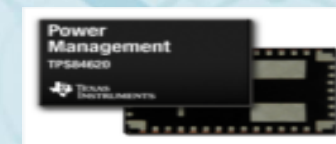
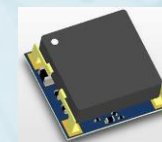
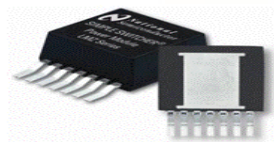


Power Modules

A detailed look at how Power Modules are built and the implications to different applications

Anjana Govil

www.ti.com/powermodules

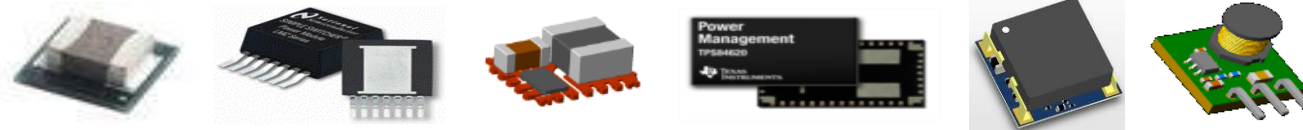
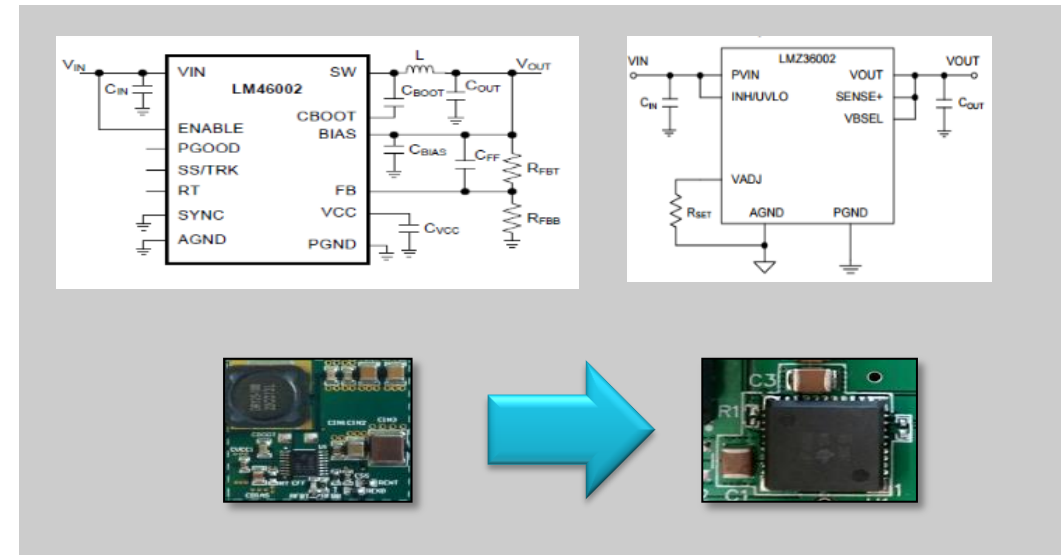


- **Introduction**
- **What are Power Modules?**
- **How are Power Modules made?**
 - Pros/cons of different package types
- **Product portfolio overview**
 - Select product highlights
- **Important collateral**
 - Webench, app notes
- **Q&A**

What are Power Modules?

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

- Simplifying and reducing customer's BOM



TPS62085



65mm²

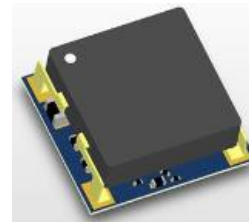
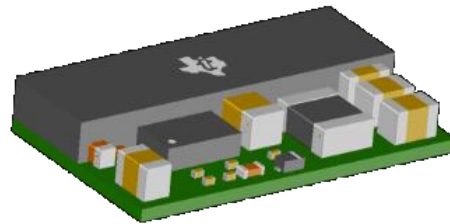
TPS82085



35mm²

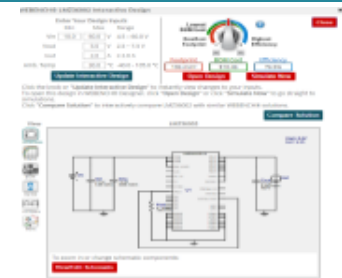
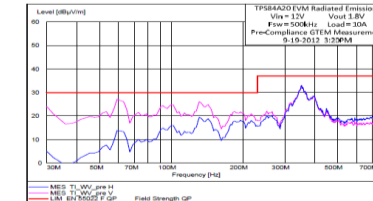
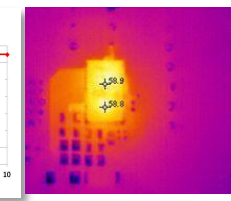
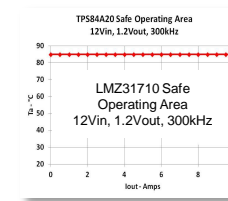
Power Modules Simplify Design

Small solution size



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

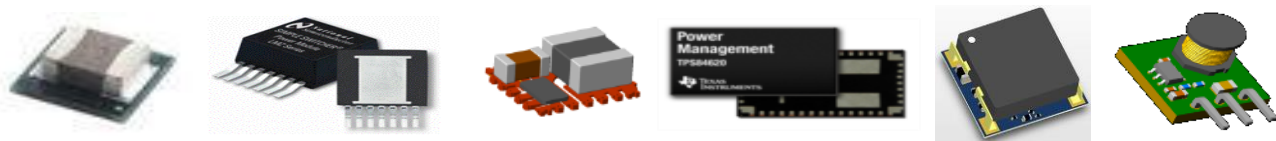
Easy to use



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

TI's Power Modules – A Broad Portfolio

Range of package options



- ✓ Package option 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

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
 - Prices are coming down
- **Modules will be the preferred solution for many engineers in the future**
 - Easy to use. Compelling size. OK price.
 - Quality product

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 Vin, Vout, Fsw, Temp and Cout ranges. Bode Plots
- Switching Frequency: Efficiency/Size trade-off, Inductor and Cout selection.
- Load Transient, Soft Start (Vout 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 Vo 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 Vin, Vout, Iout, Fsw, Cout, 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

Power Modules – Excellent Thermals. SOA Curves

- Excellent thermals
- No airflow required
- 85 ° C ambient

TPS82130

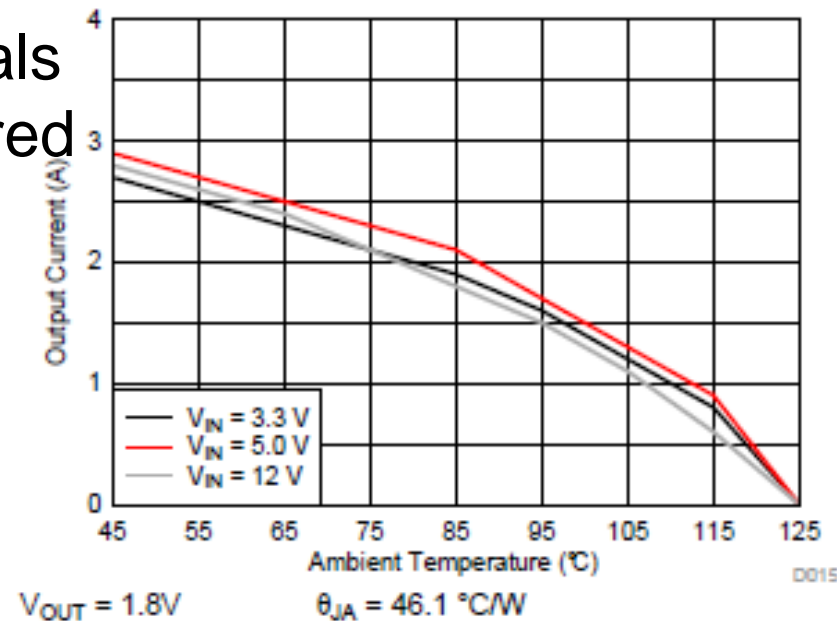
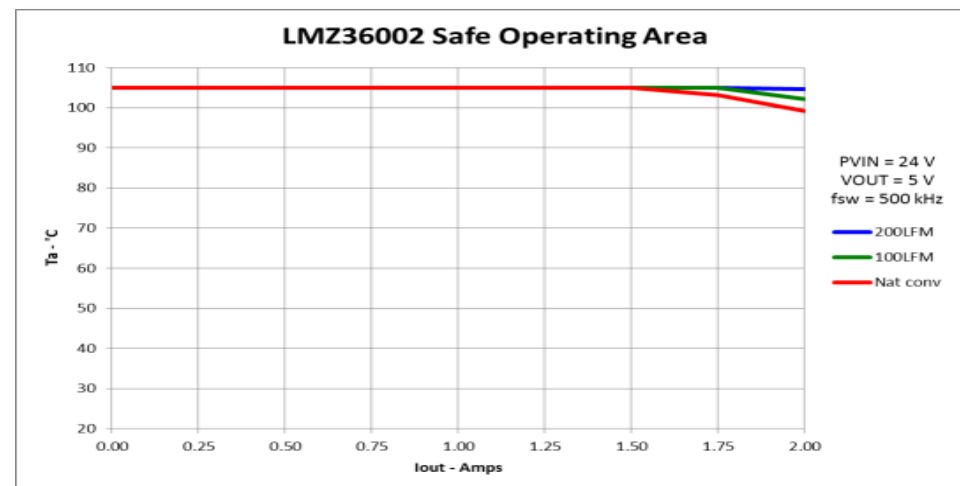
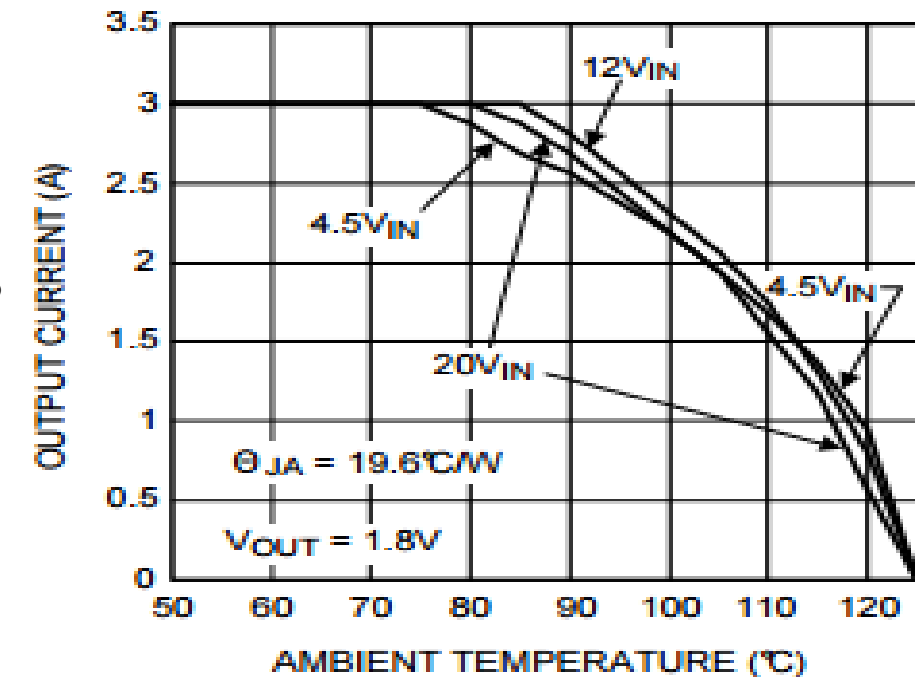


Figure 16. Thermal Derating, $V_{OUT} = 1.8\text{ V}$

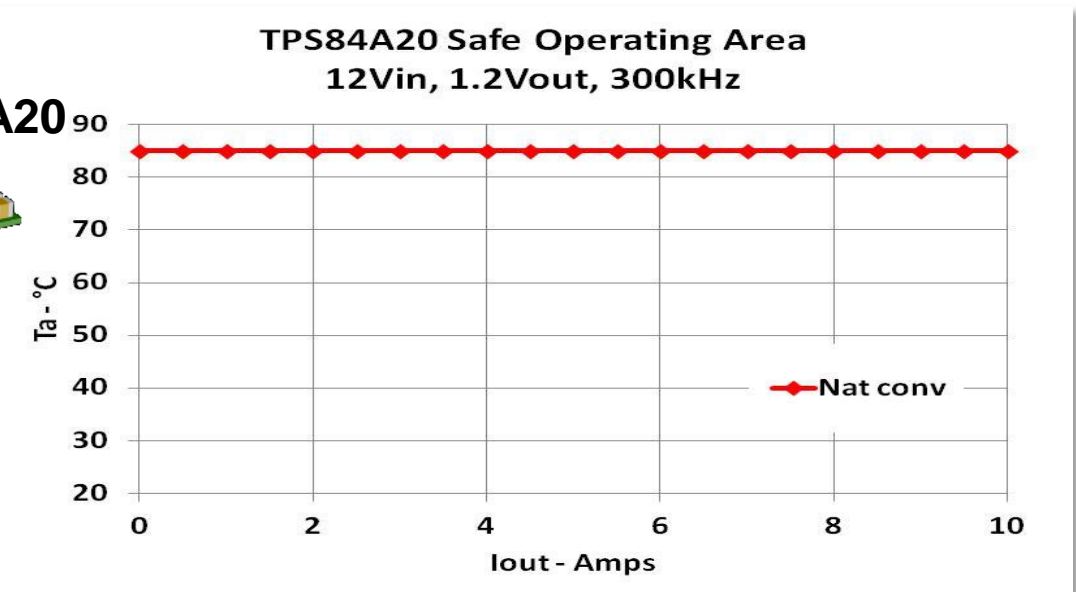
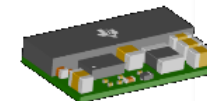
LMZ36002



LMZ12003



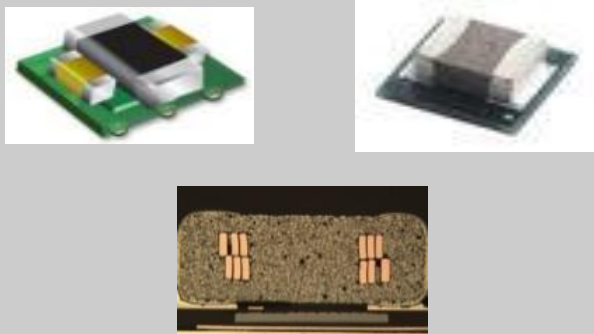
TPSM84A20



Power Modules: Package Technology Overview

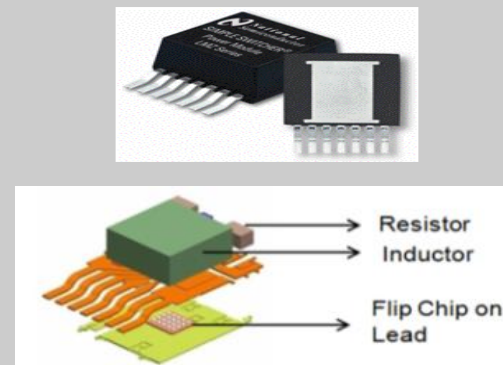
Broad portfolio of module technologies

Embedded solution Density



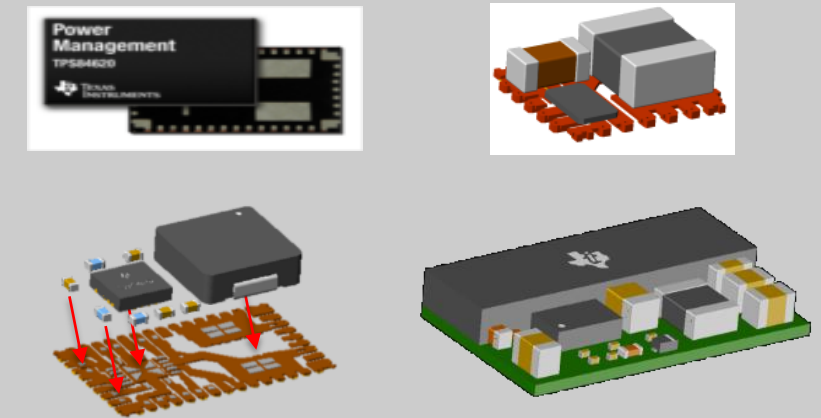
- Buck IC integrated into PCB
- Smallest solution size
 - As small as 2.3x2.9x1.1mm
- Vin up to **36V**
- Iout from 200mA to 3A

Leaded module Ease of use



- SIMPLE SWITCHER products
- Ease of Prototyping and Manufacturing
- Standard Size/Leadpitch
- Vin up to 42V
- Iout up to 10A

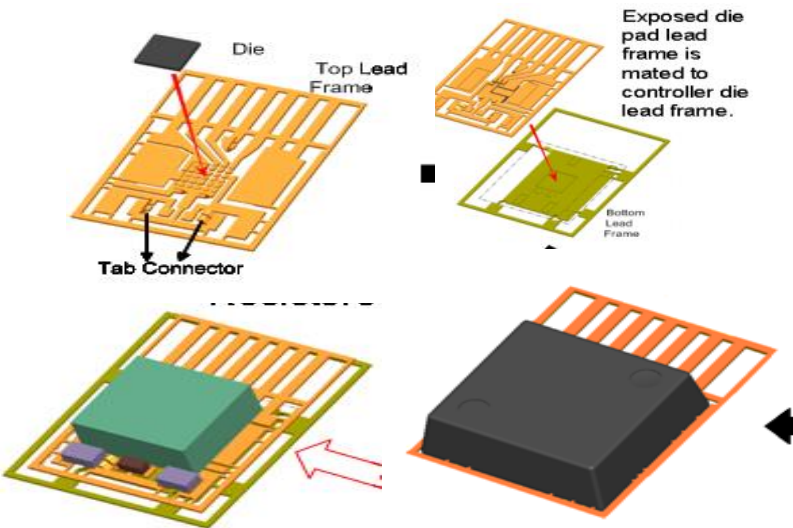
QFN module Feature rich/dense



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

Deep Dive: Leaded

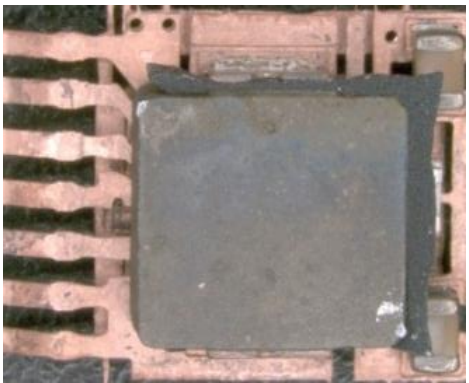
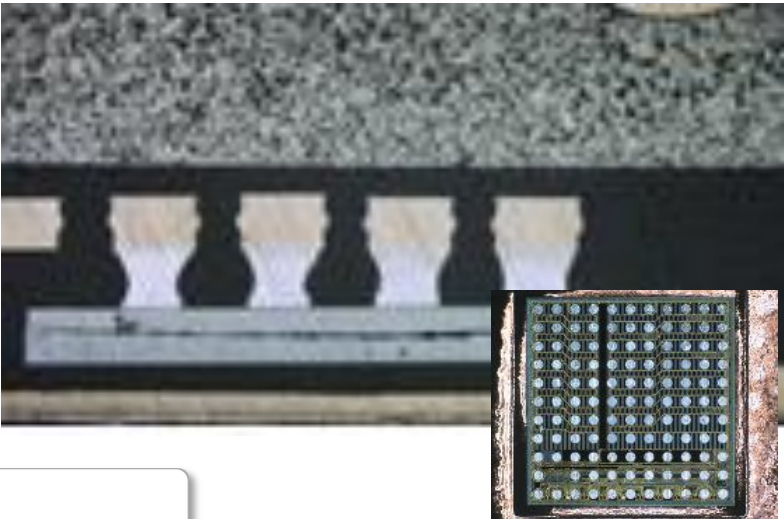
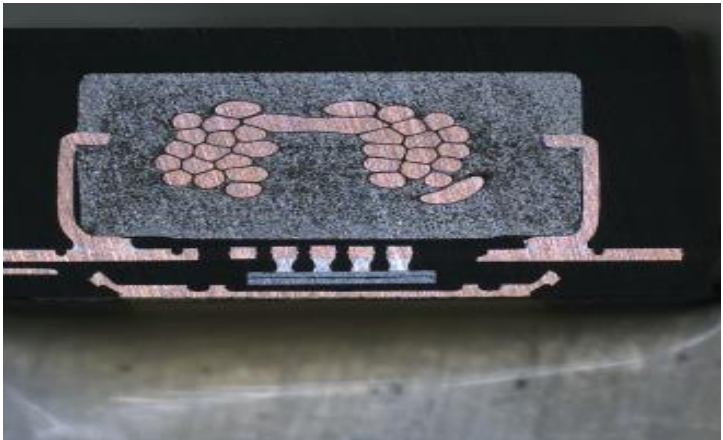
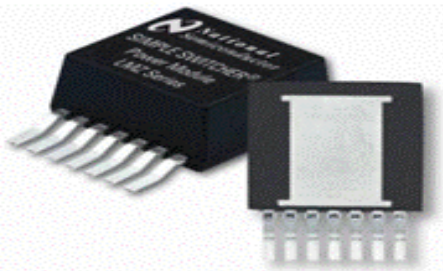
Process Flow
FCOL→LF Bond→SMT→Mold



TECH CHOICE

Overmold 200um dual LF
High flux thermal pad
FCOL between leadframes
SMT components (on top LF)
Molded inductor
1-10A+

LMZ14203
10 x 14 x 4.3 mm
42V, 3A



CUSTOMER IMPACT

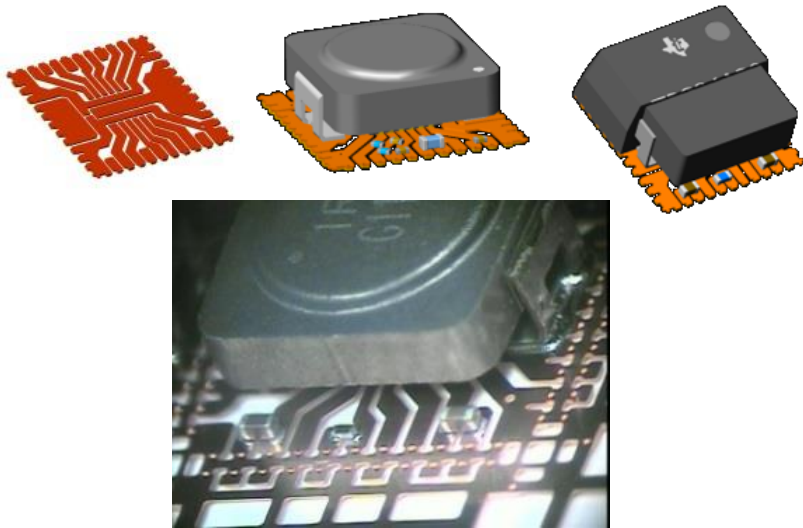
3D, mid-cost assembly
MSL3, 245°C
T-MOD, 1.27mm pitch
 $\theta_{JA} = 19.3^{\circ}\text{C/W}$
46mm²/A, 200mm³/A (wide Vin)

Cost	
Density	
EOU	
Eff	
Thermal	

Extreme High EOU, Density (3D) for low volume Industrial

Deep Dive: QFN

Process Flow
Leadframe→SMT→Mold

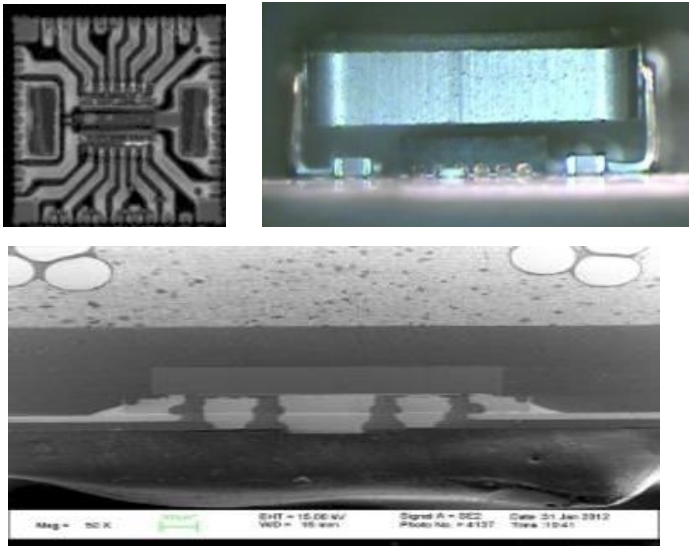


TECH CHOICE

Overmold, 200um LF,
High thermal flux customer pads
Pre-packaged, tested silicon
SMT components
Molded inductor (2D and 3D)
3-30A+

LMZ31710

10 x 10 x 4.3 mm
2.7-17V, 10A

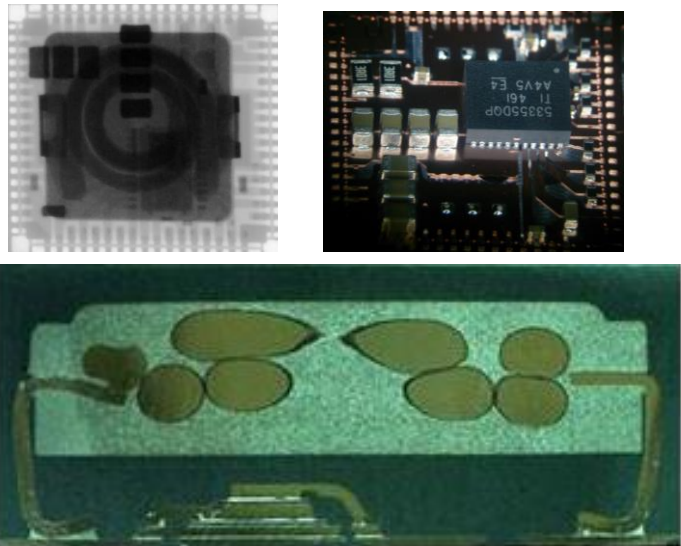


CUSTOMER IMPACT

3D, low cost assembly
MSL3, 245°C
QFN, 0.8mm pitch
 $\theta_{JA} = 13.3^{\circ}\text{C/W}$
10mm²/A, 43mm³/A

LMZ31530

15 x 16 5.8 mm
4.5-15V, 30A



CUSTOMER IMPACT

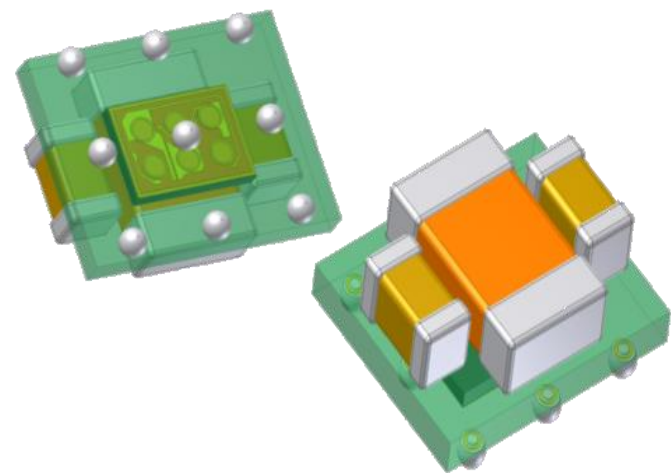
3D, low cost assembly
MSL3, 245°C
QFN, 0.8mm pitch
 $\theta_{JA} = 8.6^{\circ}\text{C/W}$
8mm²/A, 46mm³/A

Cost	
Density	
EOU	
Eff	
Thermal	

High EOU, High Density for low-mid volume Industrial, Enterprise, Communications

Deep Dive: Embedded (uSIP, Nano)

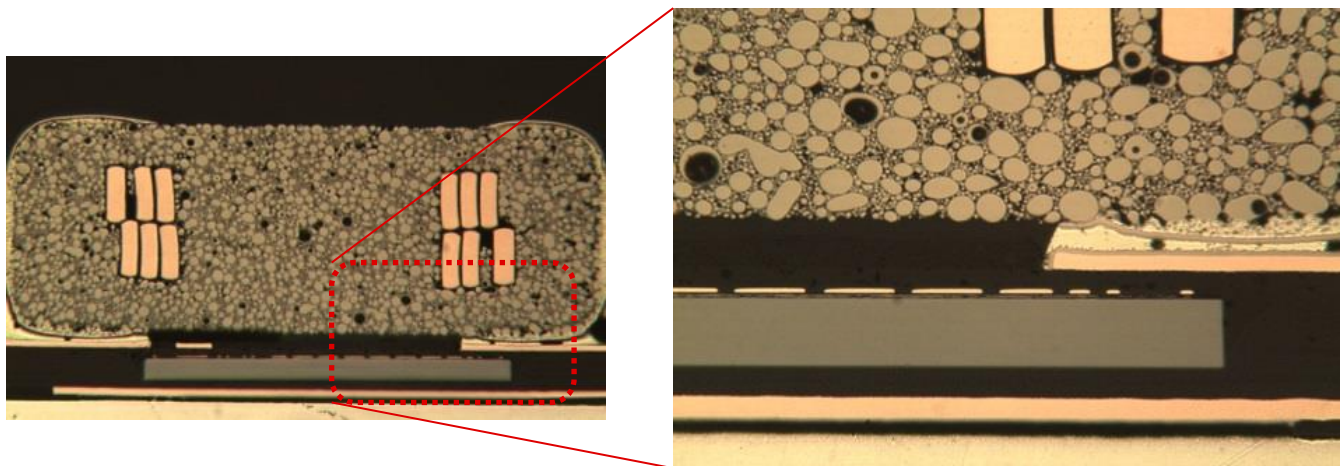
Process Flow
Embed→SMT



TECH CHOICE

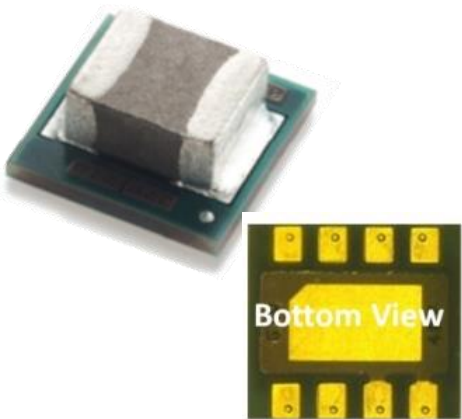
Open Frame, FR Laminate
Embedded, Die up or Die down
SMT components
Multilayer or Molded inductor
0.1-3A (so far...)

TPS82085, TPS82130
2.8 x 3 x 1.3 / 1.5 mm
2.5-6V, 2.7-17V, 3A



CUSTOMER IMPACT

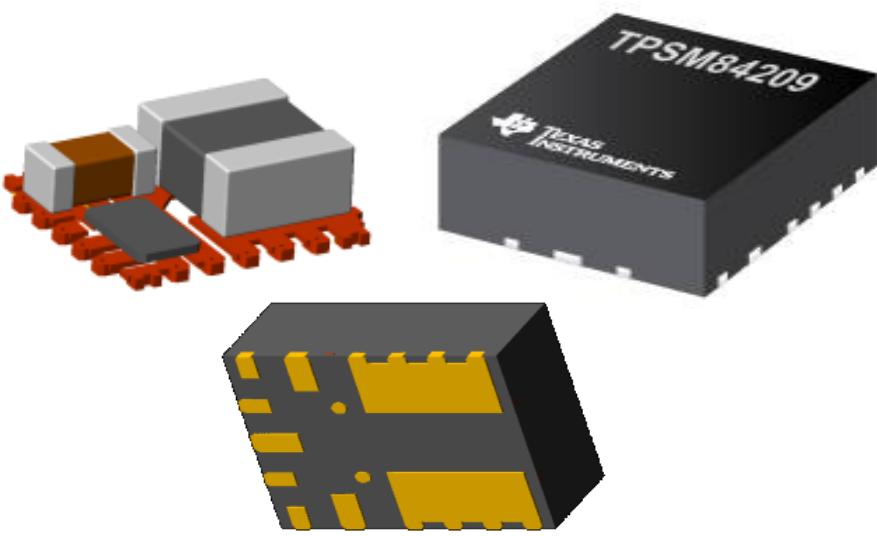
3D, low to mid cost assembly
MSL2/3, 260°C
uSIP LGA, 0.65mm pitch
 $\theta_{JA} = \sim 45^{\circ}\text{C/W}$
2.8mm²/A, 4.2mm³/A



Cost	
Density	
EOU	
Eff	
Thermal	
EMI	
Rel	

Ultra High Density for volume PE, Industrial, Enterprise, Communications

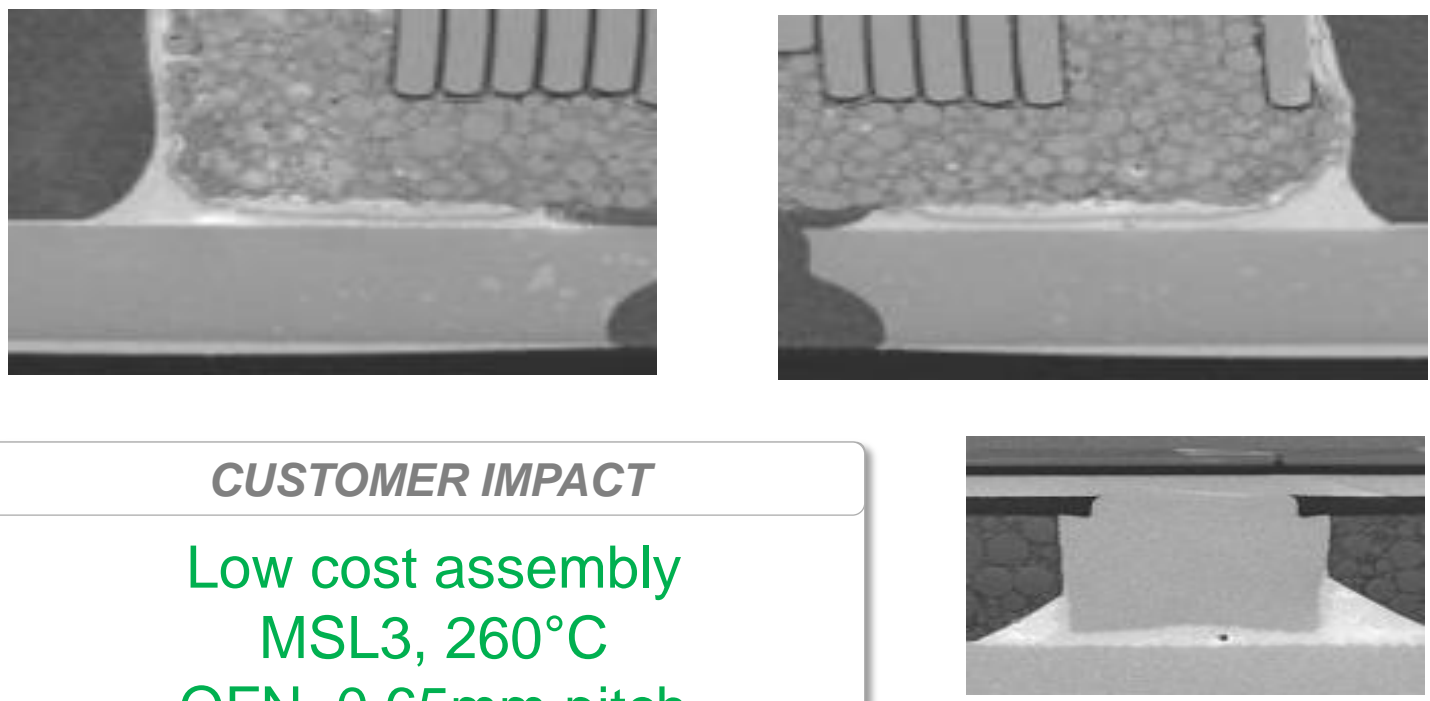
Process Flow
FCOL→SMT→Mold



TECH CHOICE

Overmold, 200um LF
FCOL, direct die
SMT components
Molded inductor
1-4A (so far...)

TPSM84209 (RTM'd)
4 x 4.5 x 2 mm
4.5 - 28V, 2.5A and
Coming soon: TPSM82135 (4.5-17V, 4A)



CUSTOMER IMPACT

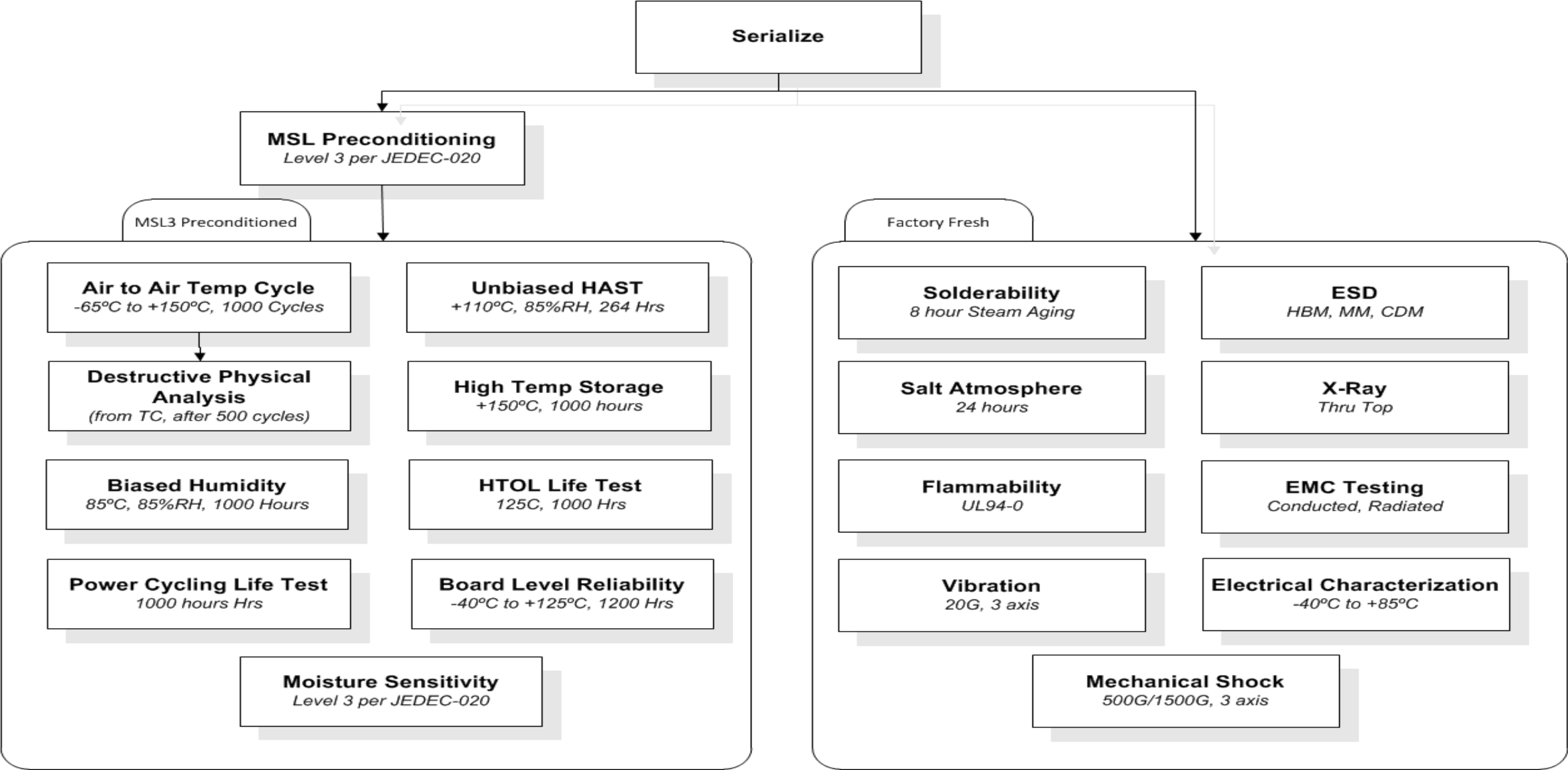
Low cost assembly
MSL3, 260°C
QFN, 0.65mm pitch
 $\theta_{JA} = \sim 30^{\circ}\text{C/W}$
~4mm²/A, 8mm³/A (82135)

Cost	
Density	
EOU	
Eff	

Low Cost, High Density for low-mid current Industrial, Enterprise, Communications

14

Typical module qualification summary



** - MSL 3 Preconditioning

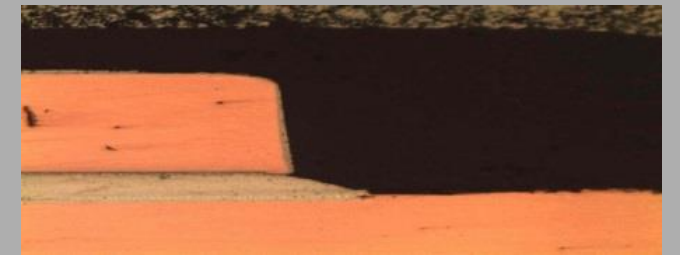
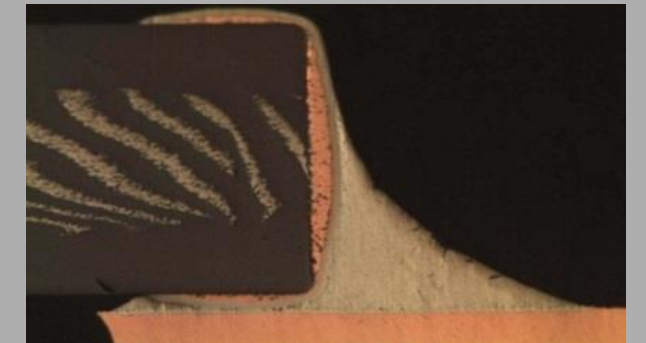
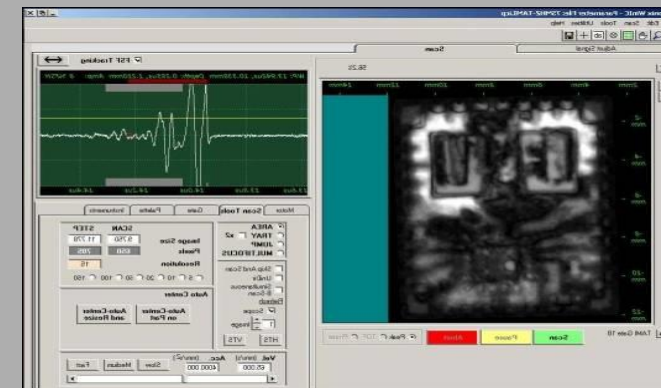
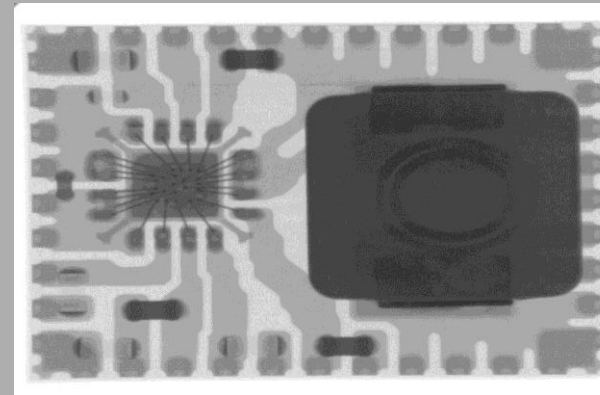
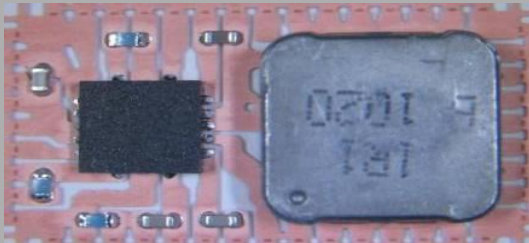
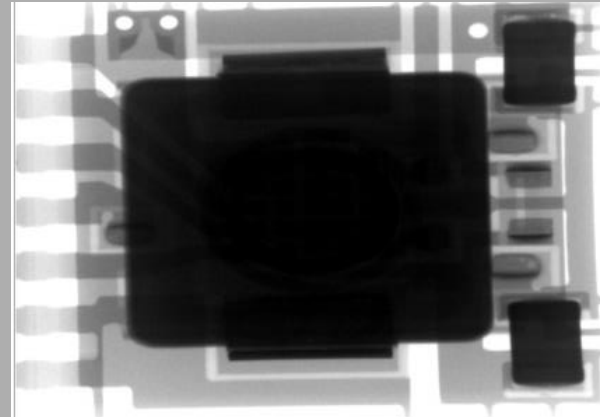
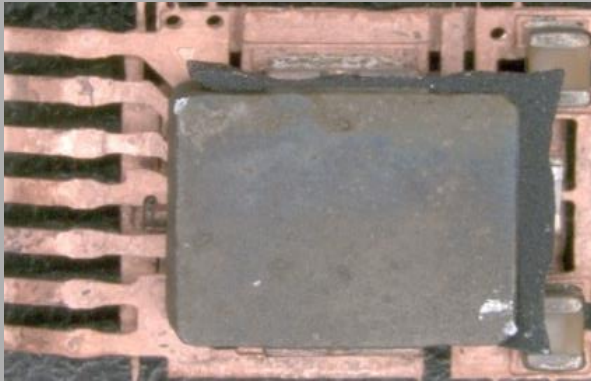
Typical module qualification summary



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

Solder dynamics are reviewed as part of the qualification process



Solder evaluated after assembly

X-rayed after MSL3 / 3x reflow

CSAM/TSAM to review solder integrity

Cross-sections to review solder joints

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)
 - 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
- KOA, Vishay/Dale, Yageo
- Moving to Green status when vendors are ready...

Power Modules: MSL Ratings

- **Moisture Sensitivity Level (MSL) determines a products Floor Life**
 - The amount of time a device can be removed from Anti-Static, Dry Pack bag before being reflowed
 - If Floor life is exceeded, units must be baked prior to reflow
- **Most TI Power Modules are rated to MSL3 or higher at 30°C and 60% relative Humidity**
 - IPC/JEDEC J-STX-033C provides guidance on Floor Life at different temps and humidity levels
 - See App Note [SLVA840](#) for more info

IPC/JEDEC J-STX-033C is Industry Standard for defining MSL rating vs floor life at 30°C

MSL	Floor Life	Moisture Relative Humidity
1	Unlimited	85% RH
2	1 year	60% RH
2a	4 weeks	
3	168 hours	
4	72 hours	
5	48 hours	
5a	24 hours	
6	Bake before use and reflow within time on label	

Power Modules: Portfolio and Soon To Be Released

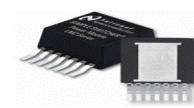
TI's Power Module Portfolio

Advanced Info

TECH DAYS
Texas Instruments



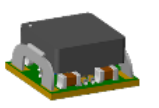
Embedded



Leaded



QFN



OpenFrame

Output Current >4A

PTH04040W
3.3V/5V, 60A

PTH05T210W
5.5V, 30A

PTH08T250W
4.5-14V, 50A

TPSM846C23/C24
15V, 35A, PMBus

NEW!

LMZ31520/30
3-15V, 20A/30

TPSM84A21/2
8-14V, 10A

NEW!

LMZ31707/10
2.95-17V, 7A/10A

LMZ12008/10
6-20V, 8A/10A

LMZ13608/10
6-36V, 8A/10A

LMZ22008/10
20V, 8A/10A

LMZ23608/10
6-36V, 8A/10A

TPSM82480
2.4-5.5V, 6A

NEW!

TPSM84824/624/424
4.5-17V, 8A/ 6A/ 4A

NEW!

LMZ30604/6
6V, 4A/6A

LMZ31506/H
4.5-15V, 6A

LMZ22003/5
4.5-20V, 3A/5A

LMZ23603/5
6-36V, 3A/4A

TPS82085
6V, 3A

TPS82130
3-17V, 3A

LMZ31704
2.95-17V, 4A

LMZ12003
4.5-20V, 3A

LMZ23602/3
36V, 2/3A

LMZ14203/H
6-42V, 3A

TPS82084
6V, 2A

TPS82140
3-17V, 2A

NEW!

LMZ30602
6V, 2A

TPS8268090/105/150
5.5V, 1.6A

TPS82150
3-17V, 1A

NEW!

LMZ20501/02
5.5V, 1A / 2A

LMZ10501
5.5V, 1A

TPS82697/98
4.8V, 800mA

TPS81256
Boost, 400mA*

TPS8267X
4.8V, 600mA*

TPS82695
4.35V, 500mA

LMZ10500
5.5V, 0.65A

LMZ21701/00
3-17V, 650mA / 1A

LMZ12001/2
4.5-20V, 1A/2A

LMZ34002
40V, 2A (Neg)

LMZ14201/2/H
6-42V, 1/2A

LMZ35003
7-50V, 2.5A

TPSM84209
4.5-28V, 2.5A

NEW!

LMZ34202
4.5-42V, 2A

LMZ36002
4.5-60V, 2A

TPSM842xx
28V, 1.5A. T0220

NEW!

LMZM23600/1
4-36V, 0.5A/1A

NEW!

6V

17V

36V

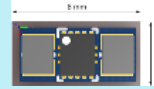
60V



TEXAS INSTRUMENTS

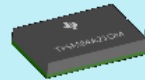
New Power Modules

TPSM82480*:



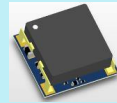
5.5V, 6A in QFN Package (7.9 * 3.6 mm)

TPSM84A21/2:



15V, 10A in QFN Package (9 * 15 mm)

TPSM84824:



17V, 8A in QFN Package (plus 6A, 4A; 7.5 * 7.5 mm)

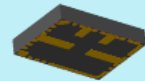
TPSM846C23/C24:



17V, 35A PMBus in QFN Package ('C24 not PMBus; 15 * 16 mm)



TPS82140/50:



17V, 2A/1A MicroSiP Power Modules (3 * 2.8 mm)

TPSM84209*:



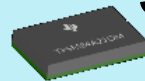
28V, 2.5A in QFN Package (4 * 4.9 mm)

TPSM84203/5/12:



28V, 1.5A TO220 LDO replacement (10 * 15 mm)

LMZM23600/1*:



36V, 0.5A/1A MicroSiP Power Module (3 * 3.8 mm)

LMZM33602/3:



36V, 2A/3A in QFN Package (7 * 9 mm)

* Advanced Information: Samples, EVM and Documentation Available on www.ti.com



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)**
- 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

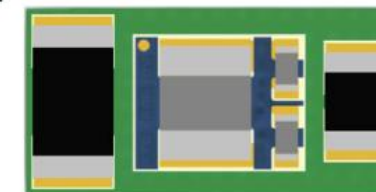
- Factory & Building Automation, Smart Grid & Energy
- Medical
- Defense

TI Confidential – NDA Restrictions

Benefits

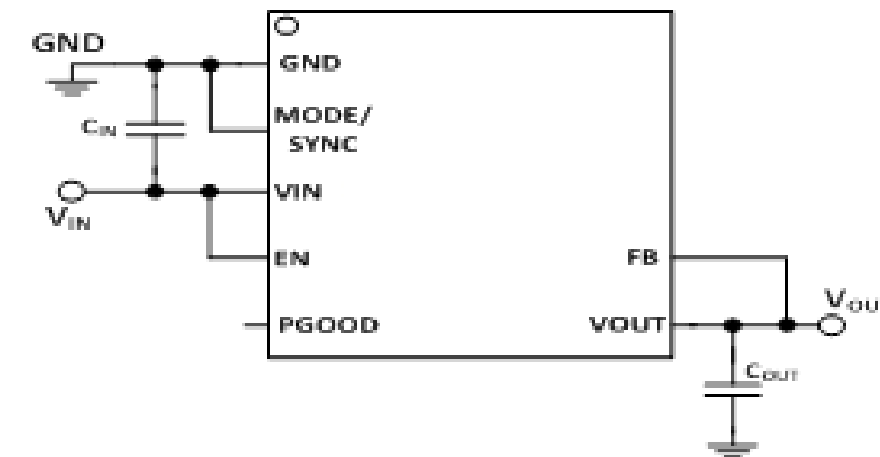
- Supports wide range of application requirements
- Easy to Design: only C_{IN} and C_{OUT} required (Fixed Vout)
- 32mm² solution: 45% smaller than competition; 55% smaller than discrete
- System Flexibility with choice of Fixed Frequency or Light Load Efficiency
- Synchronize to external clock

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



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

Released:
April'18



TPSM82480



6A Step Down Power Module with Integrated Inductors

Features

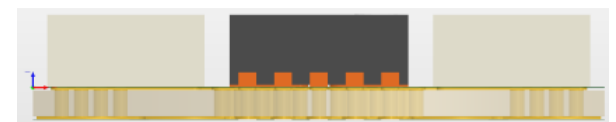
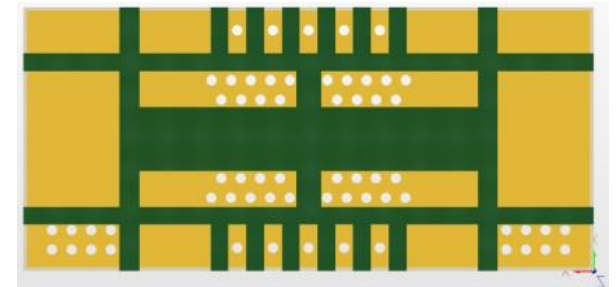
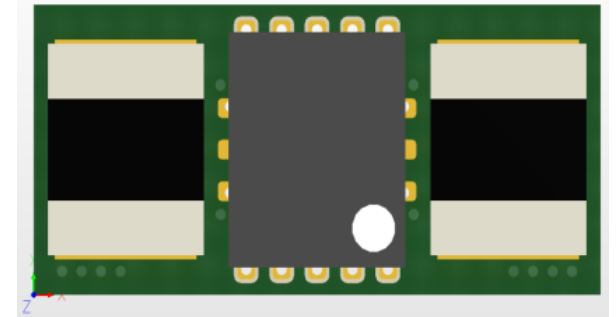
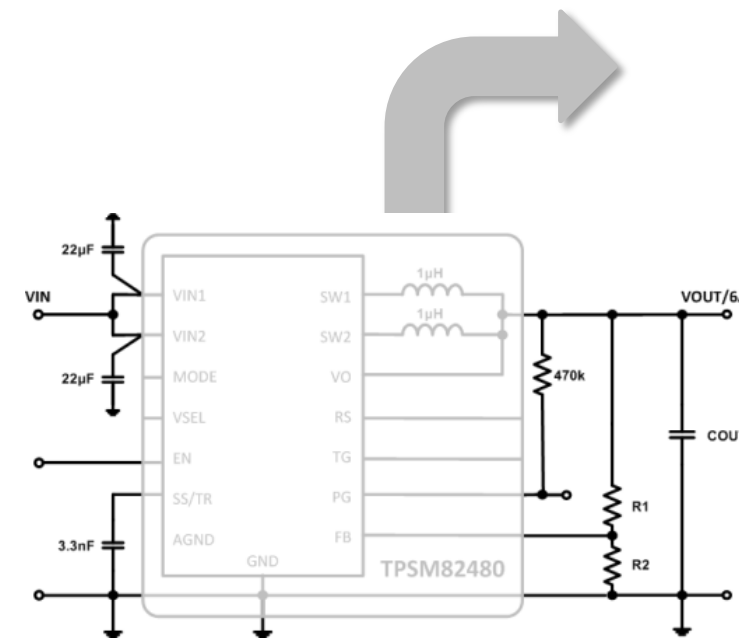
- 2.4/2.6 V to 5.5V Input Voltage Range
- 0.6 V to 5Vout
- 3.6 x 7.9 x 1.5mm Open Frame Package
- Forced PWM Option for Fixed Frequency Operation
- Design Flexibility and Performance
- 23 μ A Quiescent Current
- $\pm 1\%$ Feedback Voltage Accuracy (PWM Mode)
- Power Good & Thermal Good Outputs
- Adjustable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



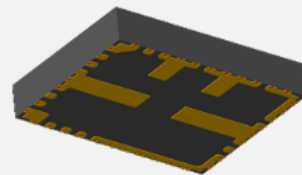
LMZM33602/3



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)
- **Tested to CISPR11/EN55011, Radiated EMI**
- **PG, Pre-Biased Start Up and Prog UVLO**

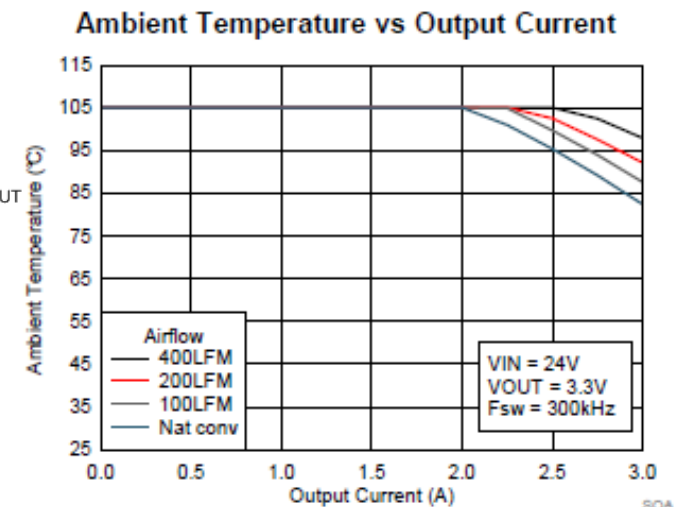
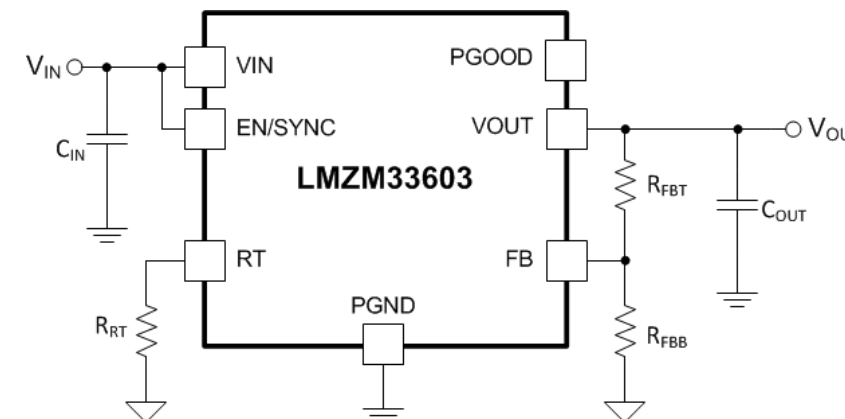


Applications

- Factory & Building Automation, Smart Grid & Energy
- Medical
- Defense

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 (105°C T_A, Wider Vout Range, Higher current)



TPS82140/TPS82150



17-Vin 2-A / 1-A Step Down Converter with Integrated Inductor

Features

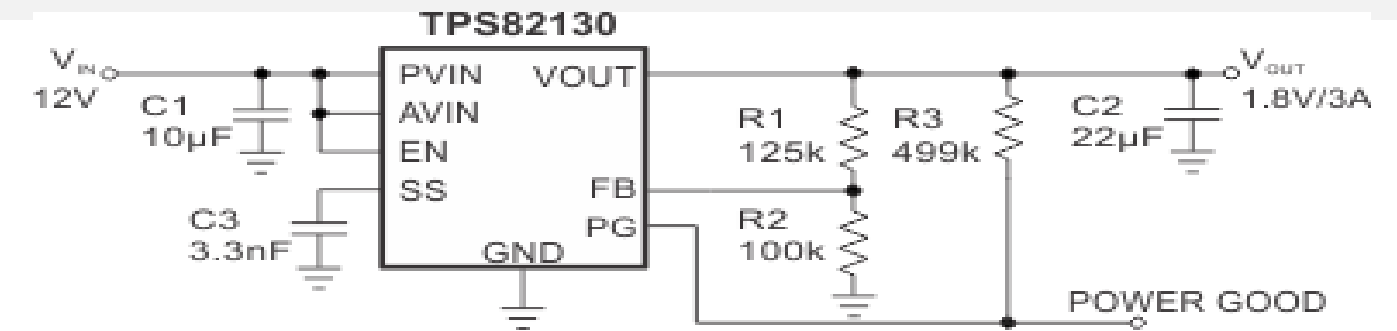
- **3V to 17V Input Voltage Range**
 - TPS82140 = 2A, TPS82150 = 1A
- **Adjustable Output Voltage**
- **Programmable Soft Startup**
- Power Save Mode for Light Load Efficiency
- Power Good Output plus Capacitor Discharge
- -40°C to 125°C operating temperature range
- **3.0 x 2.8 x 1.5mm SIL module**

Applications

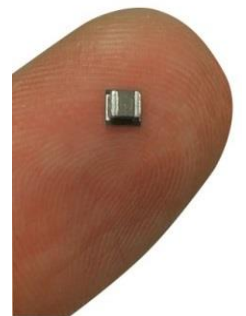
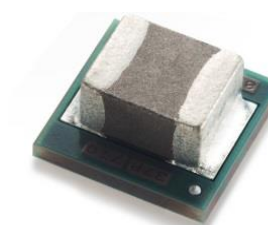
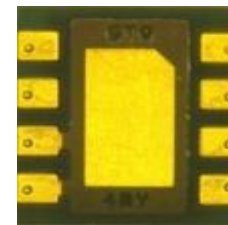
- Data Card, Network Switcher
- Optical Modules (voltage inverter)
- Test & Measurement
- SSD storage
- Portable industrial/ medical

Benefits

- Small, low profile solution
- Save >40% PCB area, comparing with discrete solution
- Easy to use



Solution total size: 42 mm²



Saves 40 mm² (>40%) versus discrete TPS62130

TPSM84824/624/424



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

Features

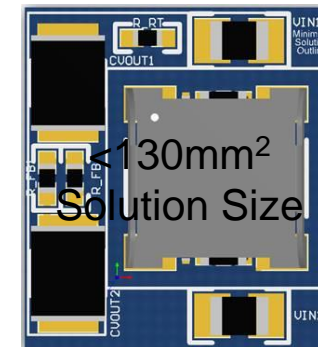
- **Vout from 0.6V to 10V, w/ 1% Reference**
- **TurboTrans™ feature for excellent transient response over whole Vout range**
- **7.5 x 7.5 mm footprint (<130mm² Minimum Solution Size)**
- **200kHz to 1.6MHz fixed frequency operation with ability to sync to an external clock**
- **Low BOM Cost with few Ceramic Caps**
- **Pin-Pin Family: 8A, 6A and 4A Options**
- **Soft Start, PG and Pre-Biased Start Up. Peak Current Mode Control**

Applications

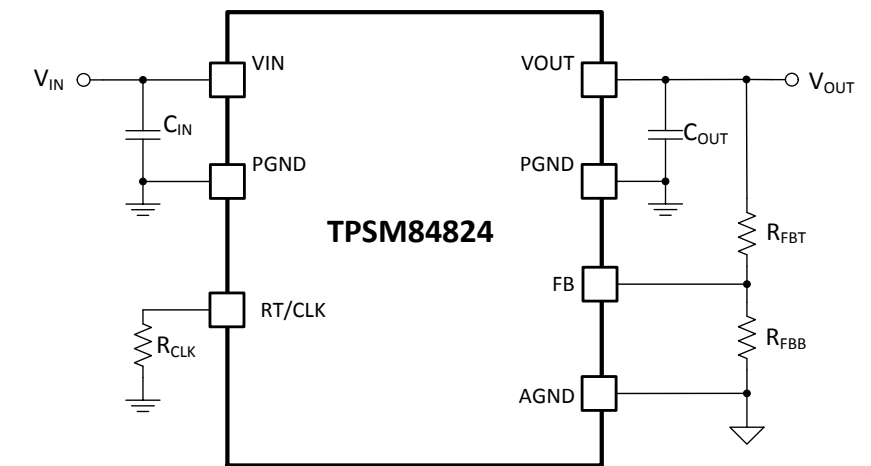
- Telecom base station and communications infrastructure equipment
- Storage, SSD, switches, hubs, routers and other networking equipment
- Power for performance DSPs, FPGAs and ASIC

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 comp required for 0.6Vout



7.5x7.5x5.4mm



TPSM84A21/2

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



Features

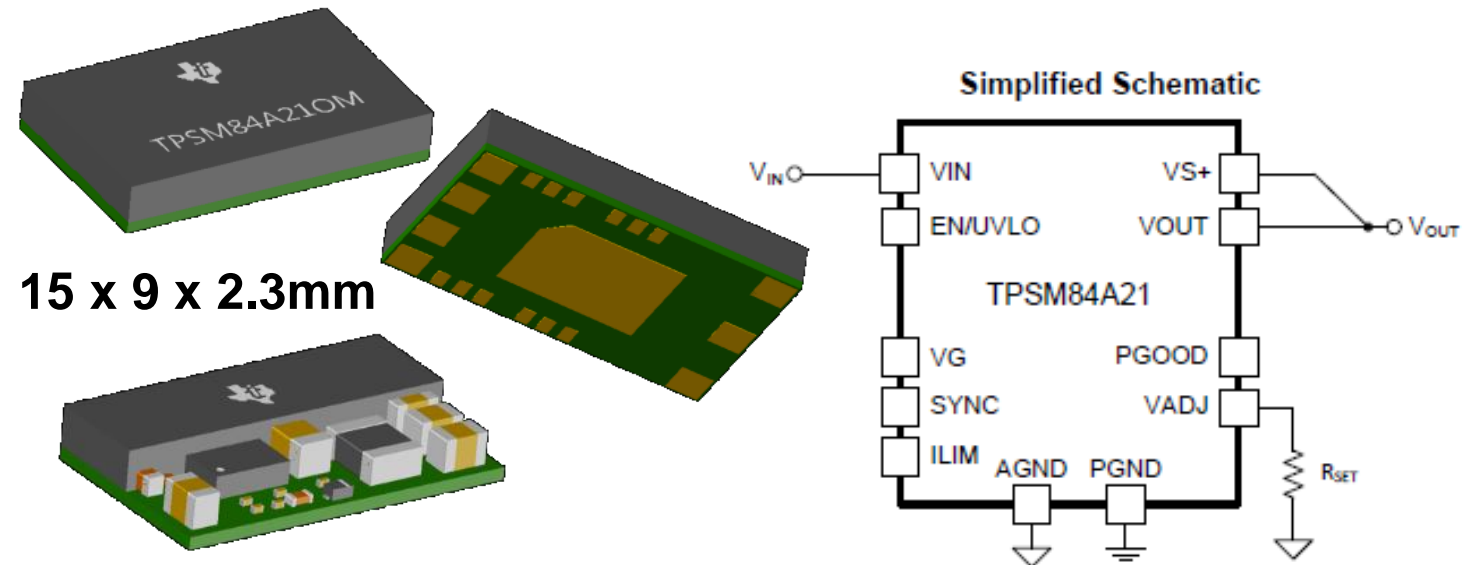
- Integrated Input and output capacitors
- Adjustable output voltage using VADJ pin with a single resistor
- Fast transient response with less than 3% total V_{OUT} deviation
- Fixed frequency steady-state operation
- Low EMI & external SYNC capability
- 15 x 9 x 2.3mm power module size

Applications

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

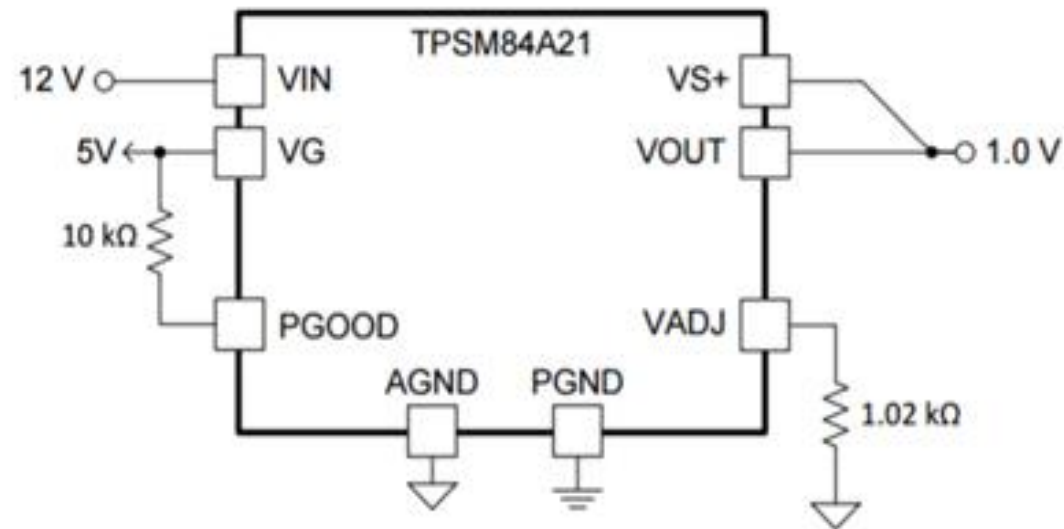
Benefits

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

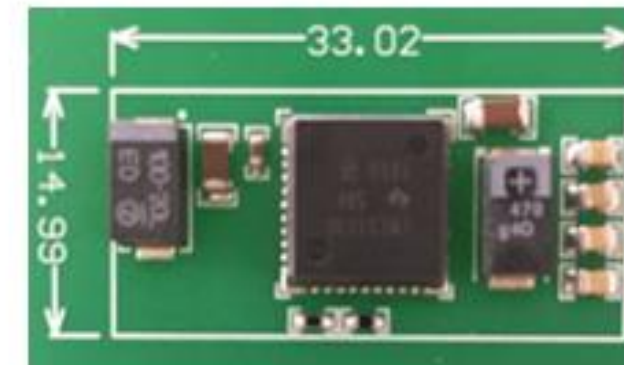
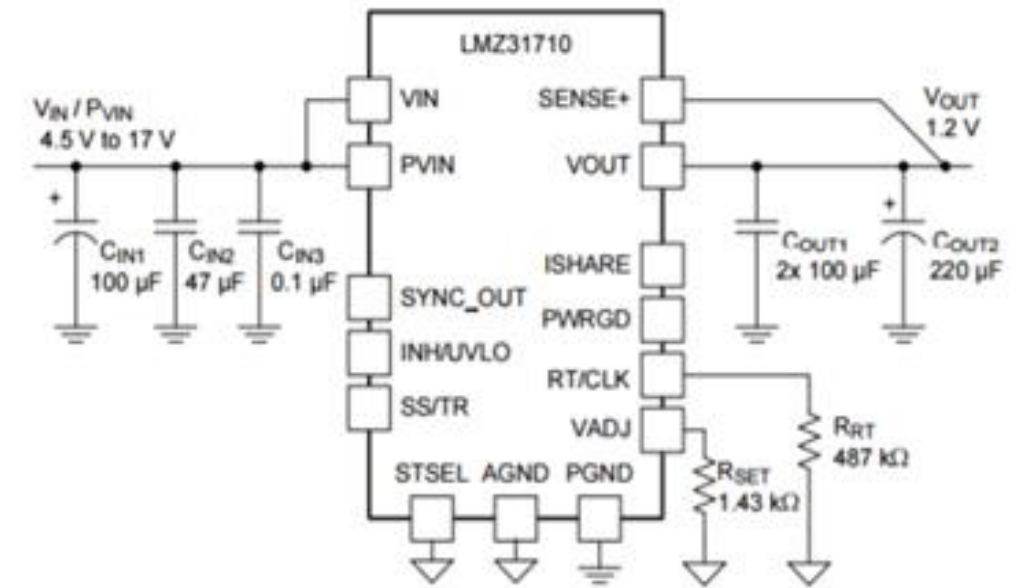


P/N	Adj. V_{OUT} Range
TPSM84A21	0.55 – 1.35V
TPSM84A22	1.2 – 2.05V

TPSM84A21/2 vs LMZ31710



Solution size = 190mm², 2.3mm height
Transient response = +/-1% overshoot



Solution size = 495mm², 4.3mm height
Transient response = +/-3% overshoot

TPSM84203/5/12: TO220 Module



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

Features

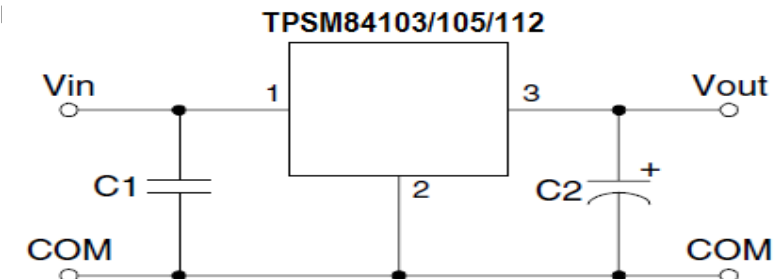
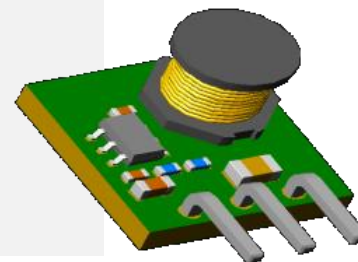
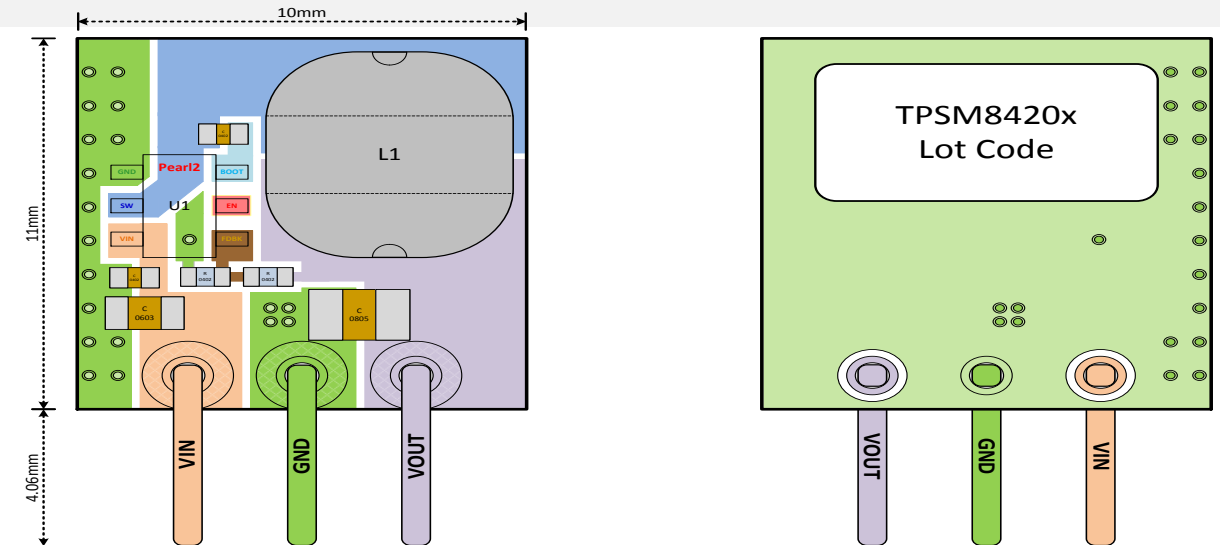
- **Maximum 28V Input Voltage**
- **Fixed 3.3V/5.0V/12V Output Voltage**
- **1.5A Maximum Continuous Output current**
- +/- 3% Vout Accuracy (25 °C, max)
- Ultra Low Quiescent Current for Higher Light Load Efficiency
- Frequency Spread Spectrum to Reduce EMI
- Fixed Soft-Start:4mS
- **780x pin-2-pin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



TPSM846C23/C24



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

Features

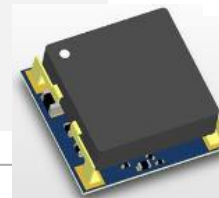
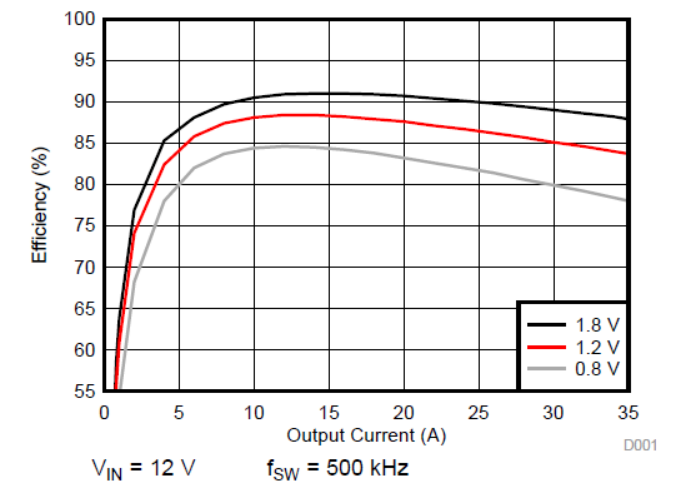
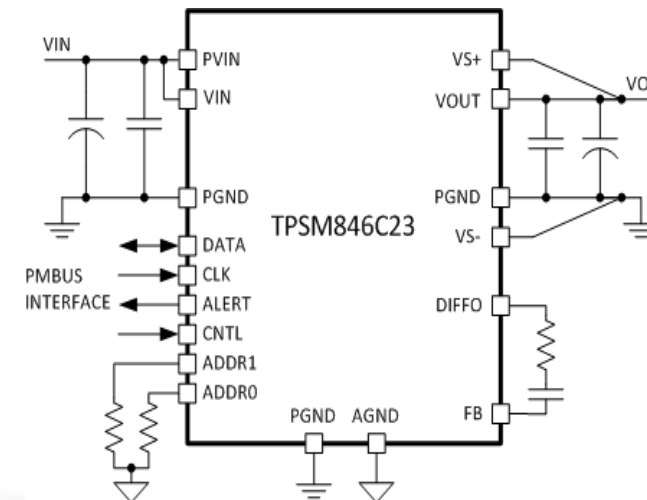
- Output Voltage Range 0.35V to 2V, **0.5% Vref (0 to 85C)**
- **Stack 2 x 35A, for Single 70A Output**
- Fully differential remote voltage sense
- FPWM with Fsync In/Out from 300KHz to 1MHz
- **PMBus v1.3 Command Set with Telemetry**
- **Tested to CISPR22 Class A Radiated EMI**
- **Compact 15 x 16 x 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 (+/-5 C), 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

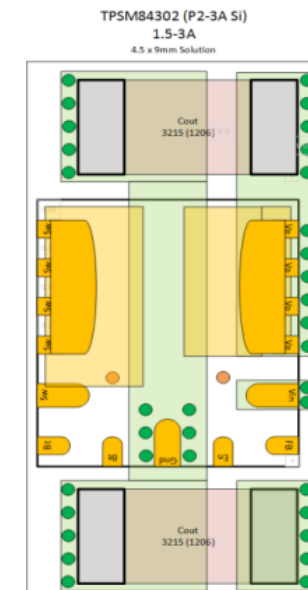
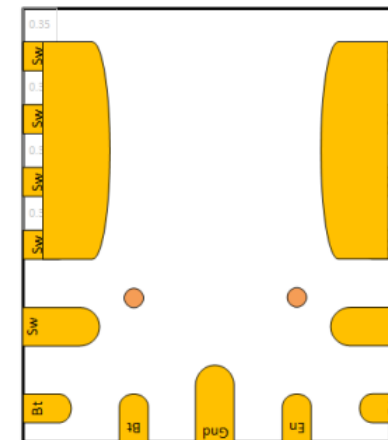
- **Maximum 28V Input Voltage**
- Adjustable Output Voltage down to 1.2V
- **2.5A Continuous Output current.**
- +/- 3% Vout Accuracy
- **Ultra Low Quiescent Current and Pulse Skip for High Light Load Efficiency**
- Fixed Soft-Start: 5mS
- **Small QFN Style Leadframe: 4 x 4.5 x 2mm**

Applications

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

Benefits

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



Power Modules: Save development cost...

Darnell Group Market Report

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

- **Module design** process takes **45.0% less** man hours to complete than a discrete dc-dc regulator “down solution.”
 - 254 vs 464 Man Hours!
- 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.
- *Board space requirements and density issues* = most common answer for choosing a module
- Both DCDC-regulator and PSIP users concerned about potential design issues: *noise, parasitics, load change, stability and EMI*
- 5A DCDC discrete vs module example

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

Power Modules: important collateral

Design	Description	Application/Market	Device
PMP10630	Xilinx Kintex XCKU040 Ultrascale Reference Design. Optimized for 6W output power.	FPGA Power	LMZ21700
PMP10600	Xilinx Zynq 7000 Power Reference Design. Optimized for 5W output power.	FPGA Power	LMZ31503
PMP10601	Xilinx Zynq 7000 Power Reference Design. Optimized for 8W output power.	FPGA Power	LMZ31503, LMZ31506
PMP10613	Xilinx Zynq 7000 Series (XC7Z045) 20W Reference Design	FPGA Power	LMZ31503, LMZ31520
PMP7804	Xilinx Kintex 7 Reference Design. Optimized for 12V input using LMZ1 series leaded modules and regulators.	FPGA Power	LMZ22010
PMP7975	Analog Solution for Zynq	FPGA Power	LMZ12002
PMP7976	Analog Solution for Virtex7	FPGA Power	LMZ12002
PMP7977	Xilinx Artix 7 AC701 EVM	FPGA Power	TPS84320, TPS84621
PMP7978	Xilinx Kintex 7 KC705 EVM	FPGA Power	LMZ12002
PMP8571	Altera Cyclone V Power Reference Design	FPGA Power	TPS84320, TPS84621
PMP8610	Arria V Power Reference Design	FPGA Power	LMZ31503, LMZ31710
PMP9335	Multi-output Multi-buck 20W Power Supply for Xilinx Zynq	FPGA Power	TPS84320, TPS84A20
PMP9353	Altera Cyclone V Power Reference Design	FPGA Power	LMZ31503/6
PMP9365	Altera Stratix V Power Reference Design	FPGA Power	LMZ31503, LMZ31520
PMP9444	Xilinx Kintex Ultrascale Power Reference Design. Optimized for 12V Input.	FPGA Power	LMZ31503, LMZ31506
PMP10595	Minature (30mm ²) 2A Power Supply with LMZ20502 Nano Module	Buildiing Block	LMZ20502
PMP10618	15V to 60V Wide Input Four-Output SIMPLE SWITCHER® Reference Design Using LM46002 and LMZ21701	Buildiing Block	LMZ21701
PMP10638	Inverting Buck Boost Power Module Reference Design (3.1V-3.3V to -5.2V 4A)	Buildiing Block	LMZ31710
PMP10651	2.2MHz Switching, Synchronous Split Supply Reference Design for 12V Battery with all Protections	Buildiing Block	LMZ21700
PMP10743	7V to 40V Wide Input, 3-Output SIMPLE SWITCHER® Reference Design Using LMR14050 and LMZ20502	Buildiing Block	LMZ20502
PMP8372	40V Dual 1A Module w/Low Noise LDOs Split-Rail (±5V) Output Voltages Reference Design	Buildiing Block	TPS84250, TPS84259
PMP9464	LMZ31530 with PMBUS control via LM25056 and output voltage margining	Buildiing Block	LMZ31530
PMP9483	7V to 36V in, 5Vout @ 2A , 1.8V@1A and 2.5V@1A. 15W Total Output Power.	Buildiing Block	LMZ10501
TIDA-00582	100-A Current Source Reference Design Using Two Power Modules in Parallel	Buildiing Block	PTH08T250W
TIDA-00783	Space Optimized Wide Vin Triple-Output Power Module	Buildiing Block	LMZ20502, LMZ36002
TIDA-00808	Space-optimized DC/DC Inverting Power Module	Buildiing Block	LMZ36002
TIDA-01405	Inverting O/P using TPS82130	Buildiing Block	TPS82130
TIDA-01457	Inverting O/P using TPS82130	Buildiing Block	TPS82130
TIDA-00172	Reference Design for an Interface to a Position Encoder with EnDat 2.2	Factory AutoMation	LMZ14201
TIDA-00175	Interface to a 5V BiSS Position Encoder Reference Design	Factory AutoMation	LMZ14201
TIDA-01461	EtherCAT P® One Cable for Power and EtherCAT® Reference Design	Factory AutoMation	LMZ35003
TIDA-01352	400-W Continuous, Scalable, ±2.5- to ±150-V, Programmable Ultrasound Power Supply Reference Design	Medical/Ultrasound	LMZ34002
TIDA- 01050	Optimized Analog Front End DAQ System Reference Design for 18 bit SAR Data Converters	T&M	LMZ14201/3/5
TIDA-01051	Reference Design Optimizing FPGA Utilization and Data Throughput for Automatic Test Equipment	T&M	TPS82084
TIDA-01052	ADC Driver Reference Design Improving Full Scale THD Using Negative Supply	T&M	LMZ14201/3/5
TIDA-01054	Multi-Rail Power Reference Design for Eliminating EMI Effects in High Performance DAQ Systems	T&M	LMZ14201/3/5
TIDA-01022	Flexible 3.2 GSPS Multi-Channel AFE Reference Design for DSOs, RADAR, and 5G Wireless Test Systems	T&M, Radar, Software Defined Radio	TPS82130



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

Innovative DC/DC Power Modules



Overview

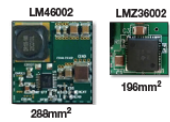
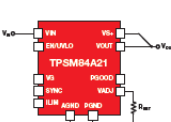
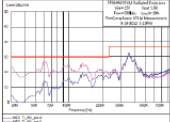
TI's broad range of DC/DC power modules are designed specifically to help designers get to market faster with validated, high performance solutions. In a single package, these power modules integrate inductors, FETs, compensation, and other passive components to reduce development time for design and verification, and speed up time to market with proven reliability.

To browse the entire portfolio and learn more on the latest products, visit: ti.com/powermodules

Featured Products

TPSM846C23  <ul style="list-style-type: none">• 4.5V to 15V_{IN}• 35A Output; Parallel for 70A• PMBus v1.3 Command Set• 15 x 16 x 6.5mm• TPSM846C24 for Non-PMBus	TPS82130/40/60  <ul style="list-style-type: none">• 5V to 17V_{IN}• 1, 2 and 3A Output Current Options• 0.9 to 5V_{OUT}• Tiny 2.8 x 3.0 x 1.5mm Package• Light Load Efficient
TPSM84203/05/12  <ul style="list-style-type: none">• 4.5 to 28V_{IN}• Fixed 3.3V, 5V and 12V Outputs• 1.5A Output Current• Low EMI with Spread Spectrum• Pin-Pin With TO-220 Package	TPSM82480  <ul style="list-style-type: none">• 2.4 to 5.5V_{IN}• Tiny 3.6 x 7.9 x 1.5mm Package• 0.6 to 5.0V_{OUT} at 6A• Light Load Efficiency or Fixed Freq.
LMZM33602/03  <ul style="list-style-type: none">• 4V to 36V_{IN}• 2.4 to 18V_{OUT}• 2A/3A Output Current• 7 x 9 x 3.8mm Package• Forced PWM and Low EMI	LMZM23600/1  <ul style="list-style-type: none">• 4V to 36V_{IN}• 1A and 0.5A Output Current Options• Fixed 5V, 3.3V and Adj V_{OUT} to 15V• Tiny 3.6 x 3.0 x 1.8mm Package
TPSM84A21/2  <ul style="list-style-type: none">• 8V to 14V_{IN}• 10A Output Current• 0.55 to 2.05V_{OUT}• Only One External Component• 15 x 9 x 2.3mm Package	TPSM84824/624/424  <ul style="list-style-type: none">• 4.5 to 17V_{IN}• 8A, 6A and 4A Output Current• 0.6V to 10V_{OUT}• 7.5 x 7.5 x 5.3mm Package• TurboTrans™ Fast Transient Response

Why Power Modules?

Smaller Size	Simple Solutions	Low EMI
 <p>LM46002 LMZ38002 288mm² 196mm²</p> <ul style="list-style-type: none">• Module smaller vs discrete	 <p>TPSM84A21</p> <ul style="list-style-type: none">• Minimal components	 <ul style="list-style-type: none">• Tested EMI performance

SLYT685C

Questions?

Thank you!



TI Webinar Series

www.ti.com/webinarseries