# Power Module Packaging Technology

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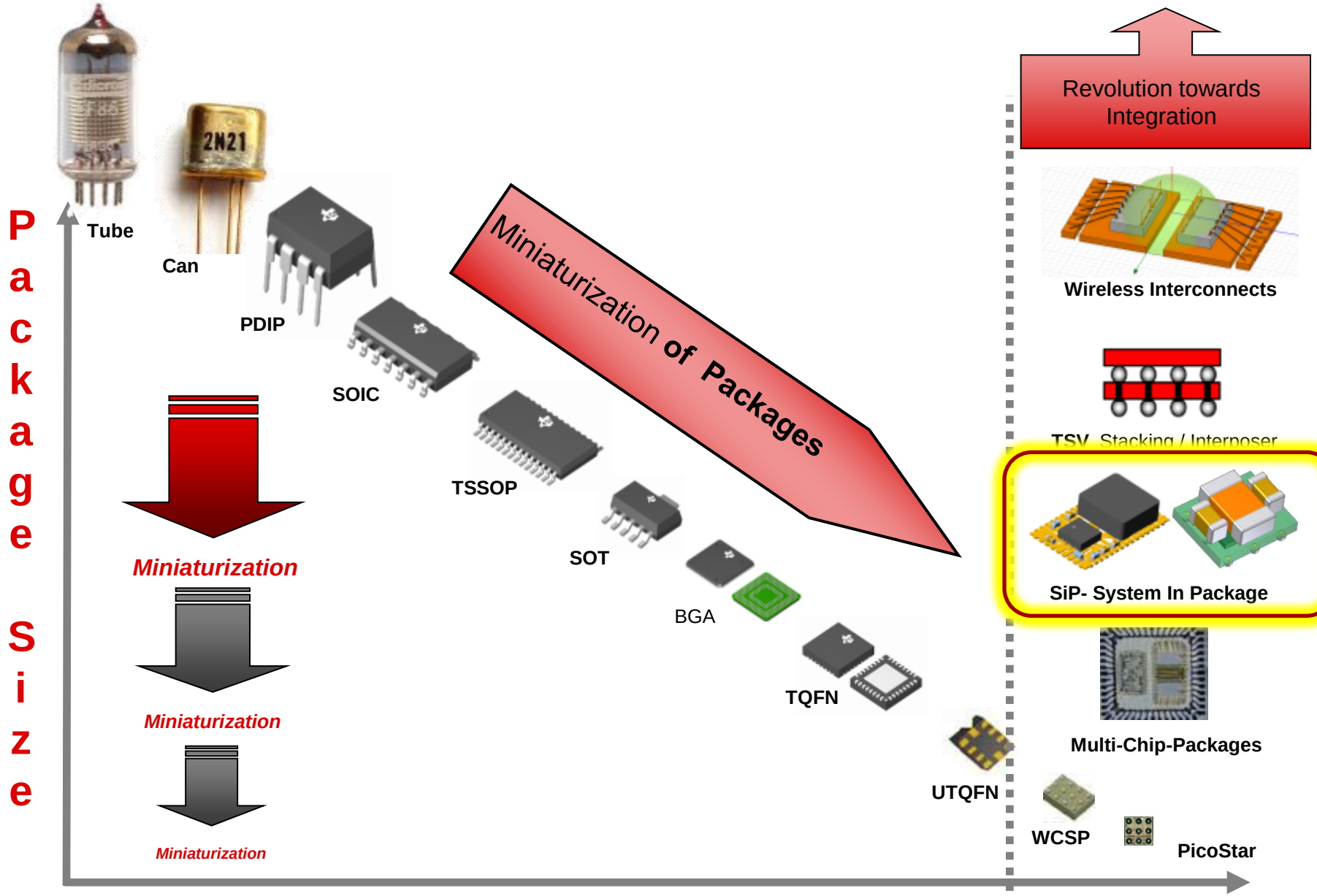
# Power Module Package Technology

- IC Packaging and Inductor Technology Trends

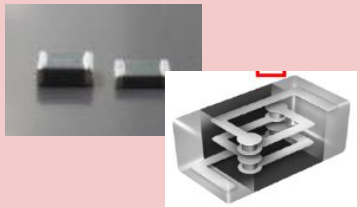
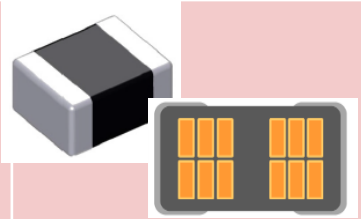
- Power Module Technologies
  - TI modules
    - Molded Leadframe Based
    - MicroSIP embedded die modules
  - Inductor Based modules
  - Industry Modules

- Future Module Direction

# IC Packaging Trends Enabling Disruptive Technologies

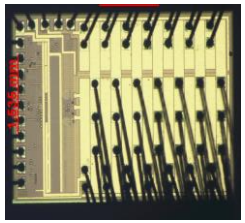


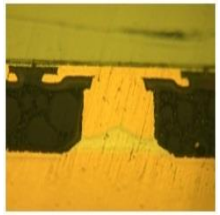
# Inductor Technology Matrix

| | Chip (MultiLayer) | Chip (Molded) | Molded | Assembled |
|---|---|---|---|---|
| **Image** |  |  |  |  |
| **Use** | Low I, <50V<br>Low Cost | Low-Mid I, <20V | 5-50A | Low Cost |
| **Features** | Sintered Ceramic with silver electrode windings | Flat Wire Winding, pressed magnetic powders with organic binders, chip format | Flat Wire Winding w/pressed magnetic powders & organic binders | Sintered or pressed metal cores with wound wire coils. |
| **Efficiency** | | Low DCR, Soft Saturation | Low DCR, Soft Saturation | |
| **Density** | | Compressed | Compressed | |
| **EMI** | Good | Good | Good | Fair/Poor |
| **Cost/other** | | | | Lowest Cost |

# Defining Power Modules

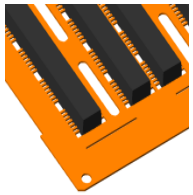
## Combine Silicon..



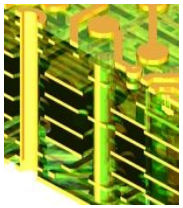


## ...Plus Components...


## ...On a Carrier...



Leadframe

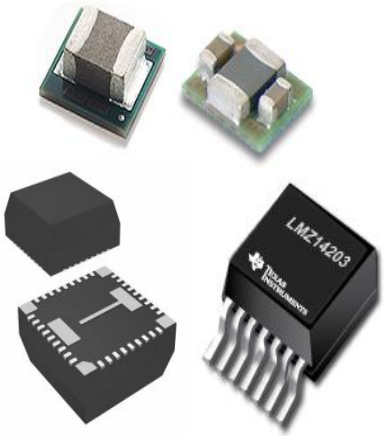


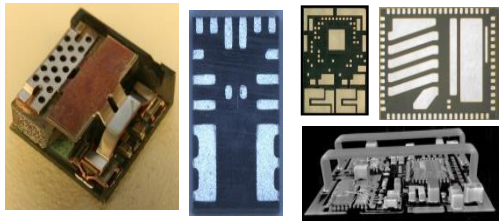
Laminate

## ...to Create a POWER MODULE

**Vin to Vout Conplete**

**System in Package**



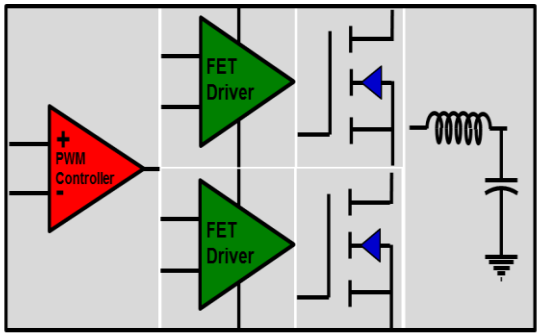



## Focus on POL

**DC / DC**

**Non-Isolated**

**PE, Comms, Industrial, Enterprise**




DC/DC Controller

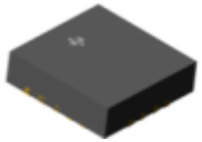
DC/DC Converter

DC/DC Power Module

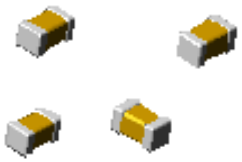
# Leadframe Based Passive Integration

15-mm x 9-mm x 2.8-mm QFN

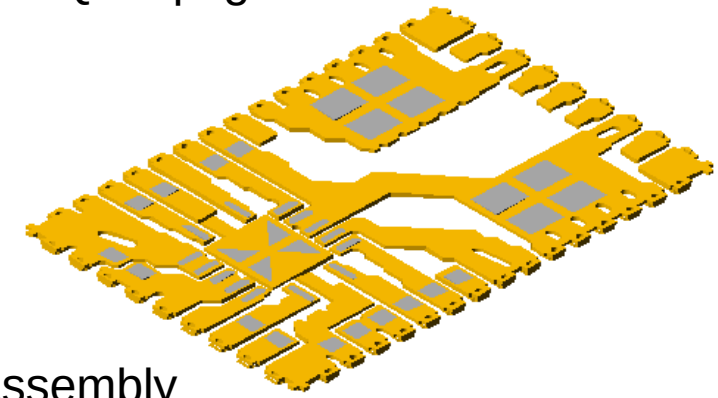
Resistors



Integrated
Controller + FETs
in a QFN pkg

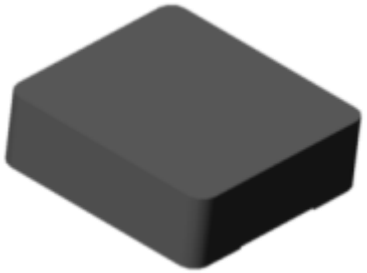


Capacitors



Sub Assembly

TI Leadframe



Inductor

http://www.ti.com/ww/en/analog/tps84620/index-B.shtml?DCMP=hpa_pwr_tps84&HQS=Sample+BA+tps84-bp

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15-mm x 9-mm x 2.8-mm QFN

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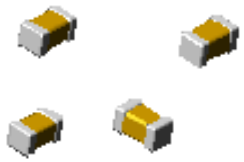
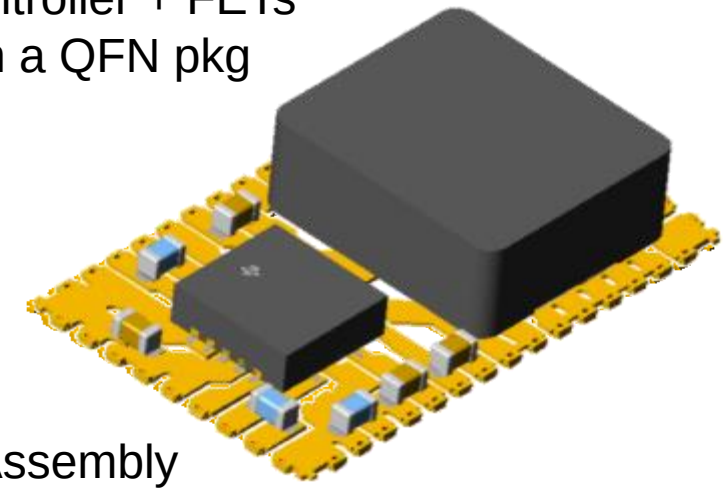
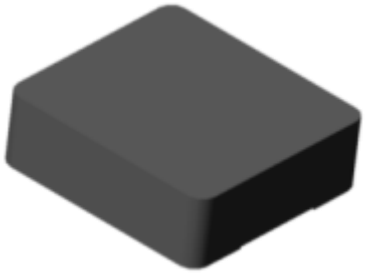


Capacitors



Sub Assembly

TI Leadframe



Inductor

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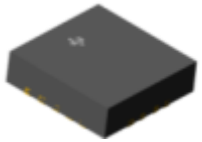

Integrated
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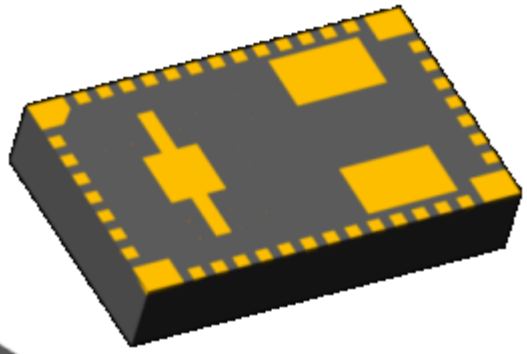
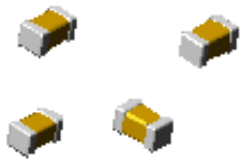
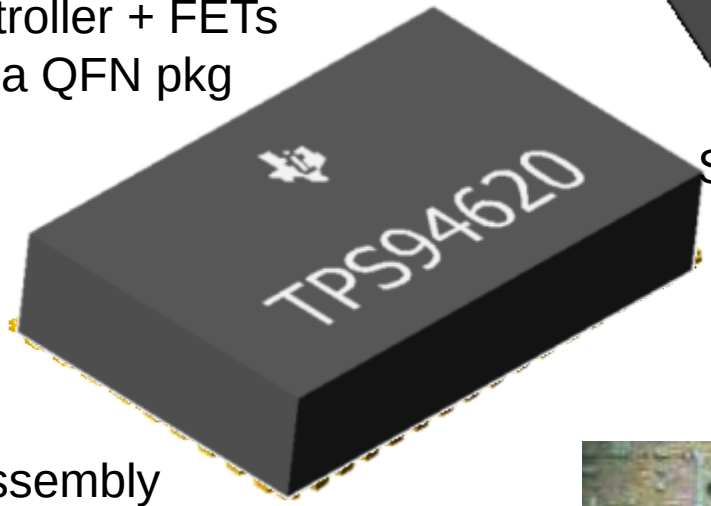


System-In-Package

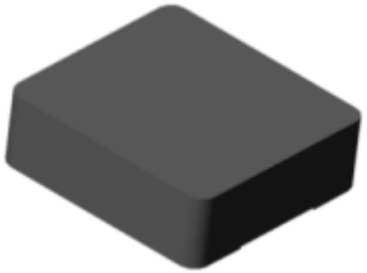


Capacitors

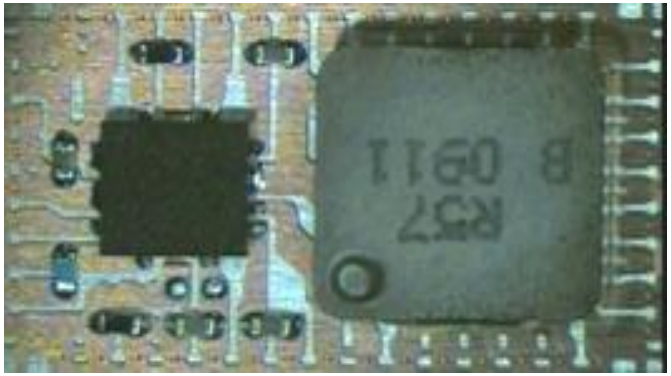



Sub Assembly

TI Leadframe



Inductor



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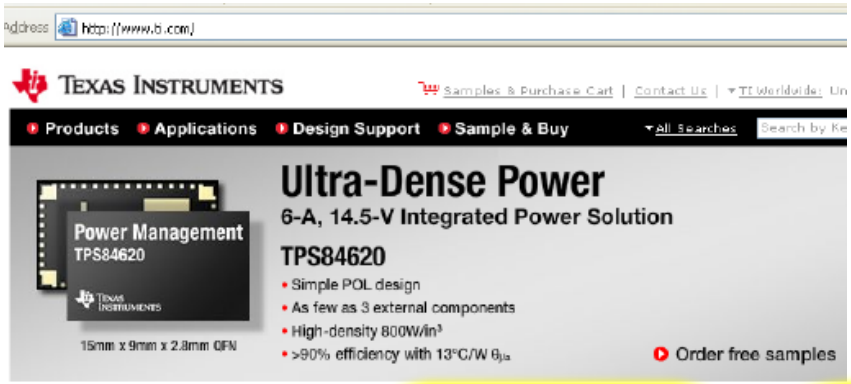
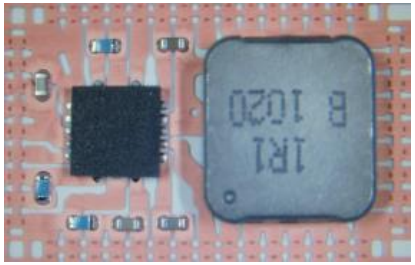
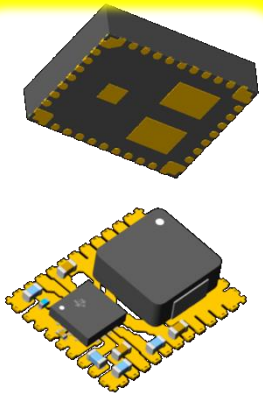
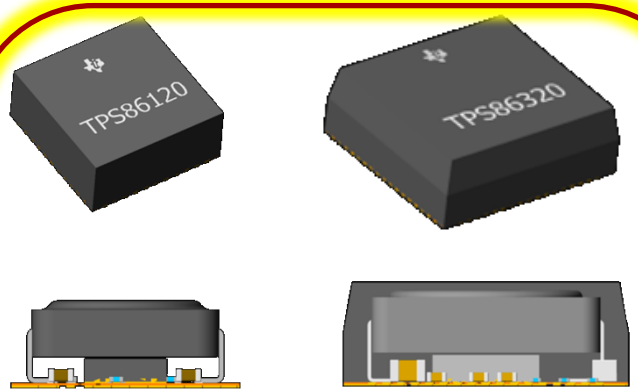
# Integrated Power Module Integration Trend



2D
Side by Side






2.5D
Stacked
Inductor

| | | | |
|---|---|---|---|
| **Pkg X & Y** | **11x9mm, 15x9mm** | **10x10mm** | **16x15mm** |
| **Pkg Height** | **2.8mmt** | **4.3mmt** | **5.8mmt** |
| **Current** | **2A-6A** | **10A, 6A, 4A** | **30A, 20A, 15A** |
| **Availability** | **Released** | **Released** | **Released** |

# Package Thickness Progression enabling embedded solutions

SOIC
*1.75 mm*

TSSOP
*1.2 mm*

MicroStar
*1 mm*

QFN
*1 mm*

Thin QFN
*0.8 mm*

WCSP (NanoStar)
*0.6/0.5 mm*

U*CSP
*0.4mm*

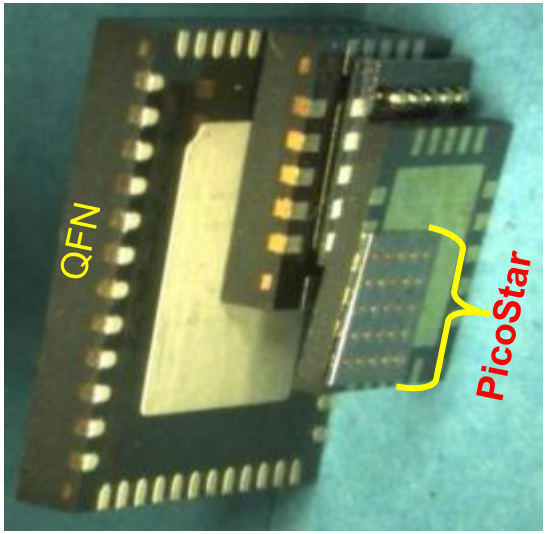
X-QFN
*0.4 mm*

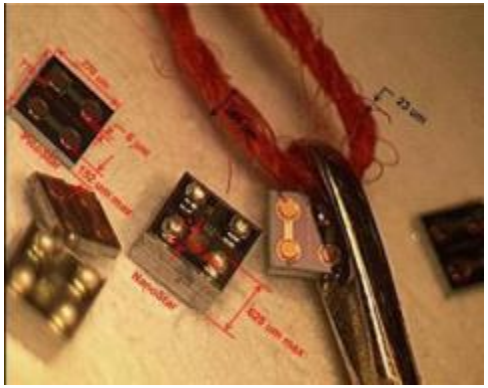
TWCSP
*0.4/0.3 mm*

PicoStar
*0.15/0.1 mm*

PicoStar-2G
*0.075mm*

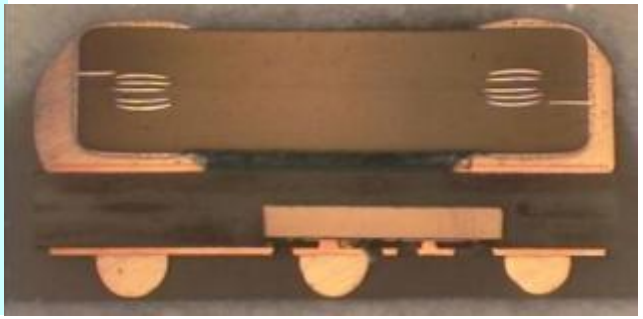
Invisible to naked eye
*~0.04 mm*

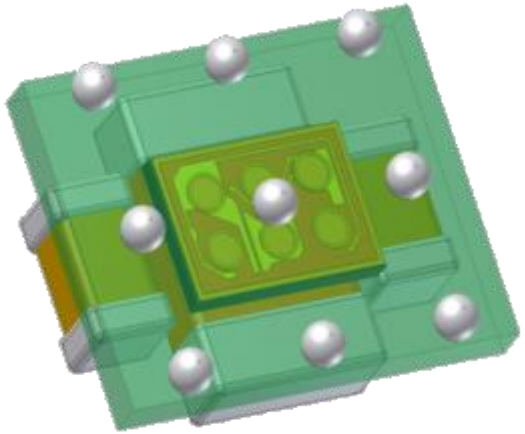


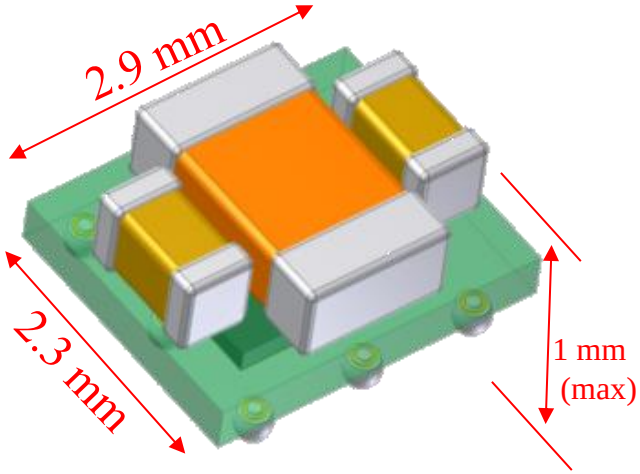



# MicroSiP™ DC/DC Converter

- PCB (substrate)
- Embedded PicoStar™ DC/DC converter
- Integrated passives (L, $C_{IN}$, $C_{OUT}$)
- Released to market



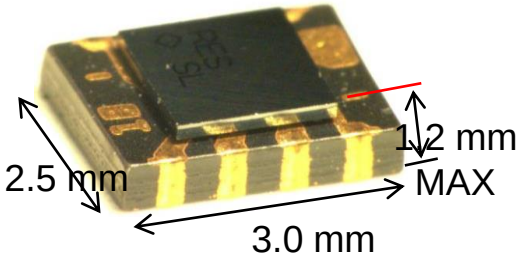




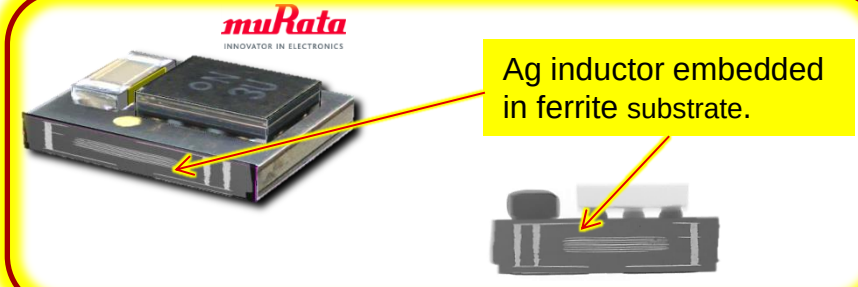

http://www.ti.com/ww/en/analog/tps82671/index.shtml?DCMP=hpa_pwr_tps82&HQS=Sample+BA+tps82-bp

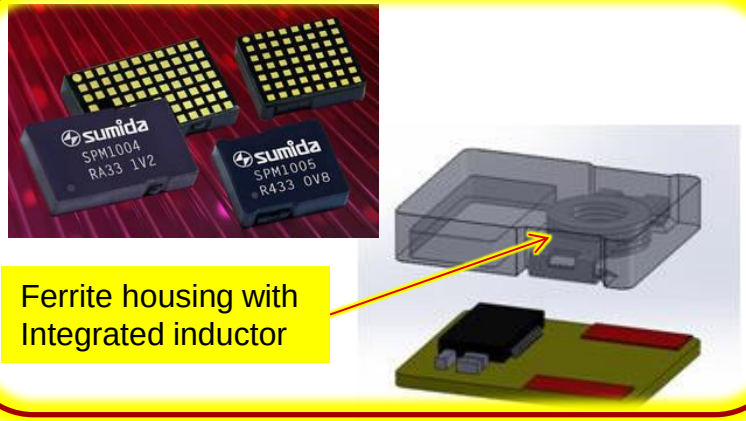
0402 Caps, 2012 Inductor

# Inductor based modules




National Semiconductor Nano-module 2011

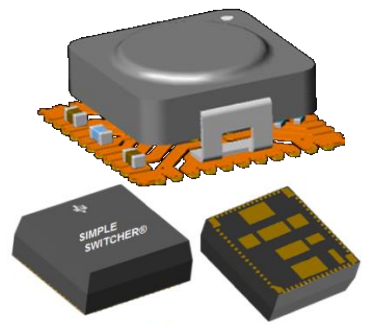


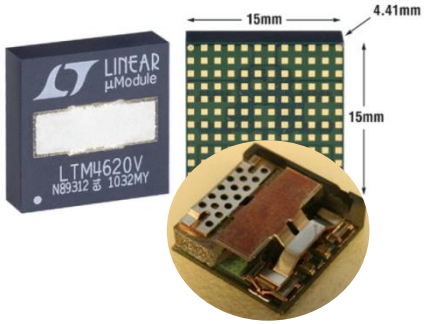
# Industry Landscape & Construction Examples

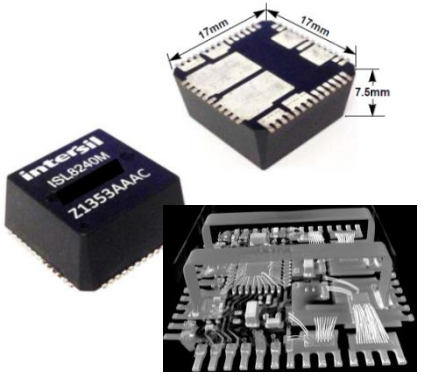
| | LMZ31530<br>SIMPLE SWITCHER® Power Module | LTM4620<br>DC/DC µModule Regulator | ISL8240M<br>Step-Down Power Module | MPM3686<br>DC/DC Step-Down Power Module |
|---|---|---|---|---|
| Manufacturer | TI | Linear Technology | Intersil | MPS |
| Iout (A) | 30 | 26 | 40 | 20 |
| Vin (V) | 3 ~ 14.5 | 4.5 ~ 16 | 4.5 ~ 20 | 2.5 ~ 18 |
| Vout (V) | 0.6 ~ 3.6 | 0.6 ~ 2.5 | 0.6 ~ 2.5 | 0.65 ~ 5 |
| Sizes (mm) | 15 x 16 x 5.8 | 15 x 15 x 4.4 | 17 x 17 x 7.5 | 12 x 15 x 4 |
| Regulated output | 1 | 2 | 2 | 1 |
| Cost | $17 (per 1000) | $29.99 (per 1000) | $32 | $11.00 (per 1000) |
| Efficiency | >95% | 83% | 94% | >92% |
| Frequency (max) | 850kHz | 750kHz | 700kHz | 600kHz |
| Substrate | Leadframe | Multilayer laminate | Multilayer laminate /leadframe hybrid | Leadframe |
| Exposed heatsink | No | Yes | No | No |
| Inductor | 1<br>Cylindrical ferrite core | 2<br>Cylindrical ferrite cores | 1<br>Flat ferrite core | 1<br>Cylindrical ferrite core |

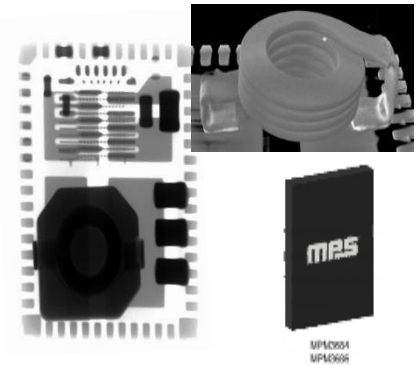
- **Pros**
  - Ease of use
  - Performance
  - Reliability
  - Reduced footprint
- **Cons**
  - Complex Development
    - Power dissipation
    - Routable substrate




15mm x 16mm x 5.8mm

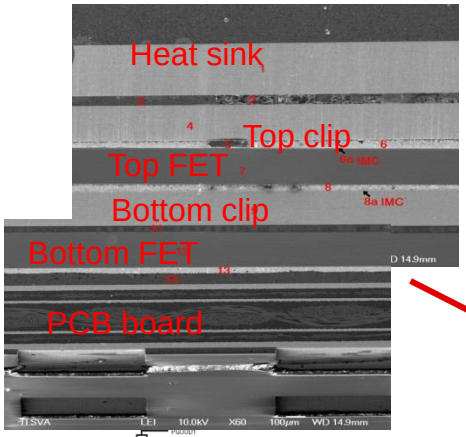


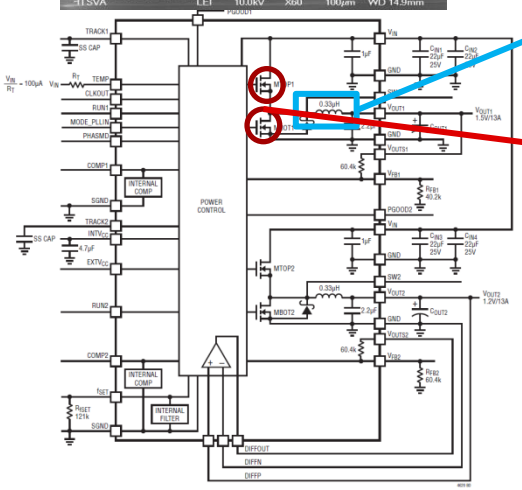



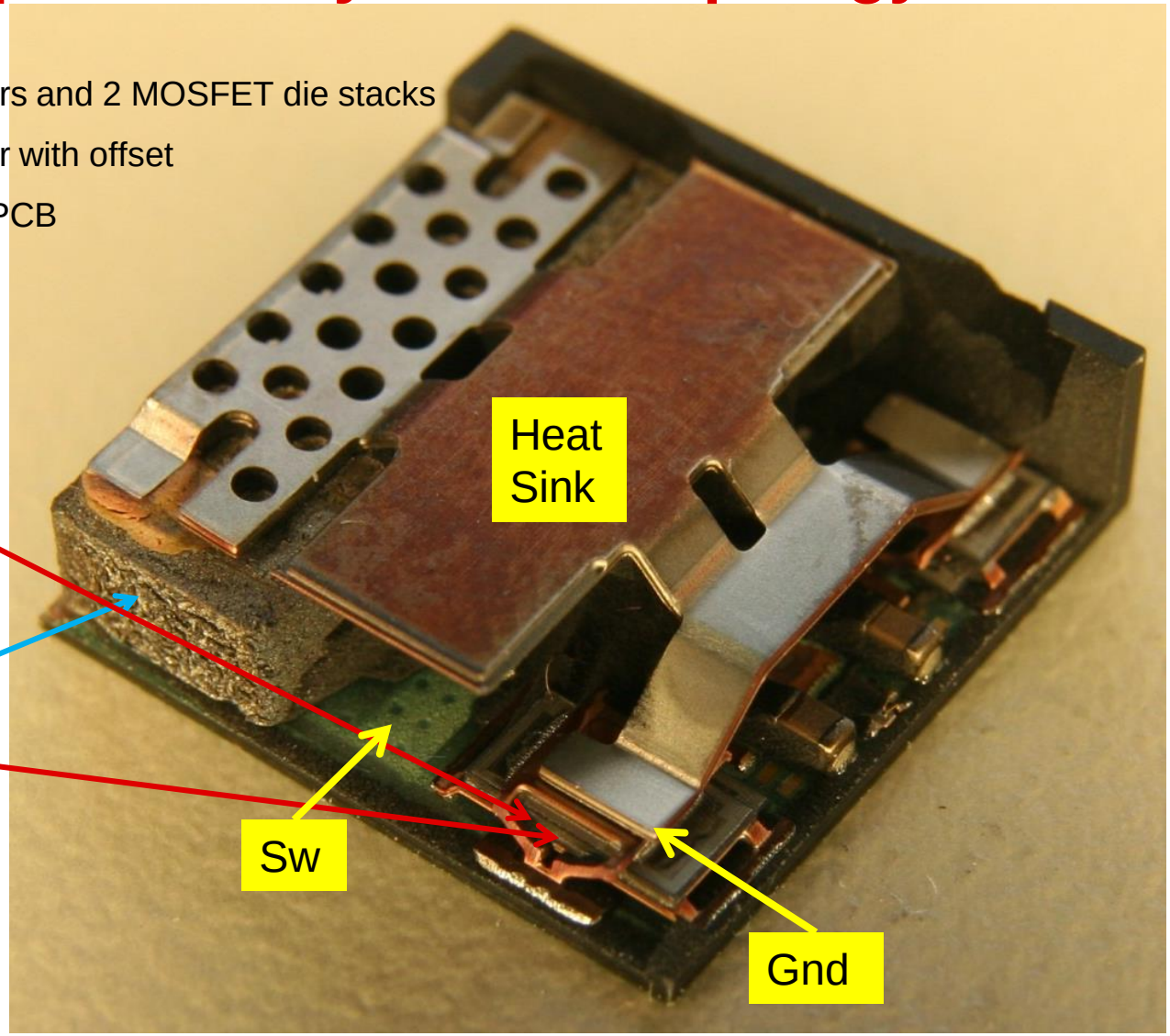



# LTM 4620 Components layout and topology

- Cu clip heat sink
- Heat sink attached to 2 inductors and 2 MOSFET die stacks
- MOSFETs are stacked together with offset
- Switch node is embedded the PCB

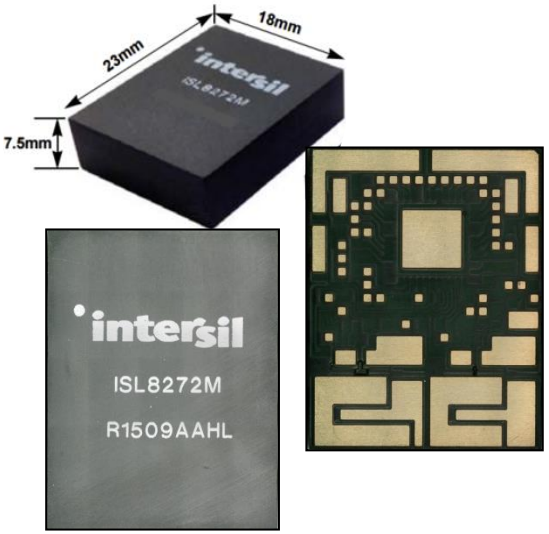


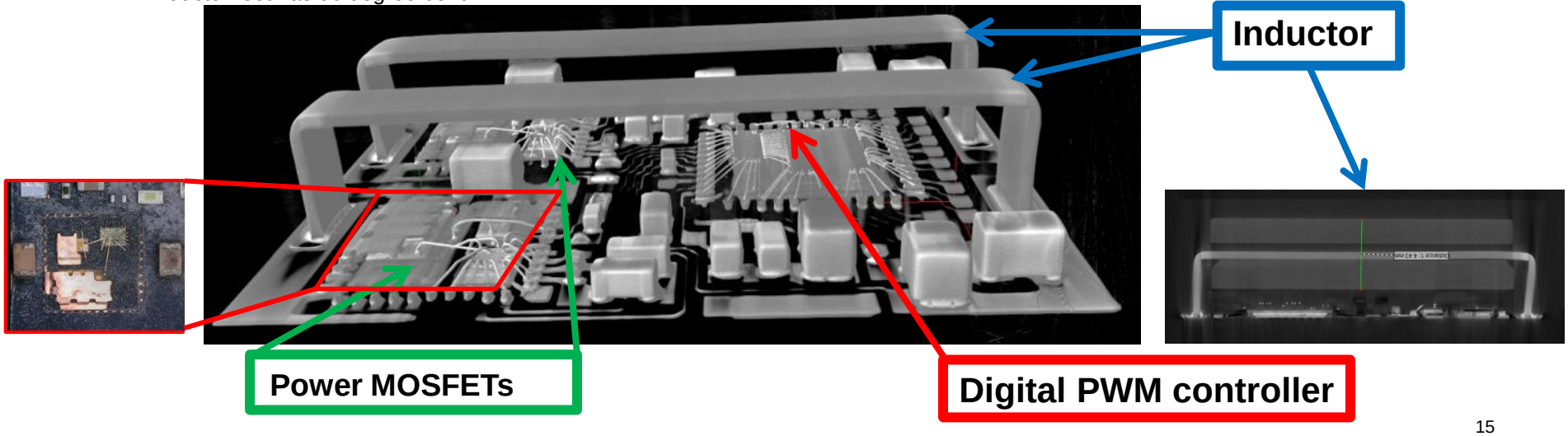





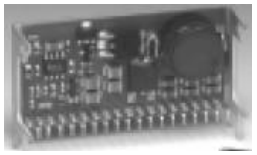
# ISL8272M Key packaging features

- **External**
  - 7.5 mm thick sawn-type QFN package
  - Over mold without exposed top heatsink
- **Internal**
  - Package in package
  - Power MOSFETs have Cu clips and their own controllers
  - Two dies are found in the high performance digital PWM controller
- **Substrate**
  - Leadframe
  - Routing using top half etch
  - Solder resist for insulation
- **Inductors**
  - Two clips passing through flat rectangular-shaped ferrite
  - Inductor feet has 90 degree bend



# POL Module—Continued Integration Over Time

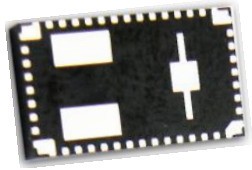


**PT6725**
**62x31x10.6mm**

**Inductor = 11% volume**
**18x15x8.4mm**
350kHz, 10mΩ, 2.2uH
Ferrite Drum, Round Wire Self Term

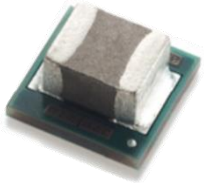
**PTH12050**
**22 x 13 x 8.5 mm**

**Inductor = 11% volume**
**7x7x5mm**
350kHz, 6mΩ, 1.5uH
Powder Iron EI, Edge Wound Wire Self Term



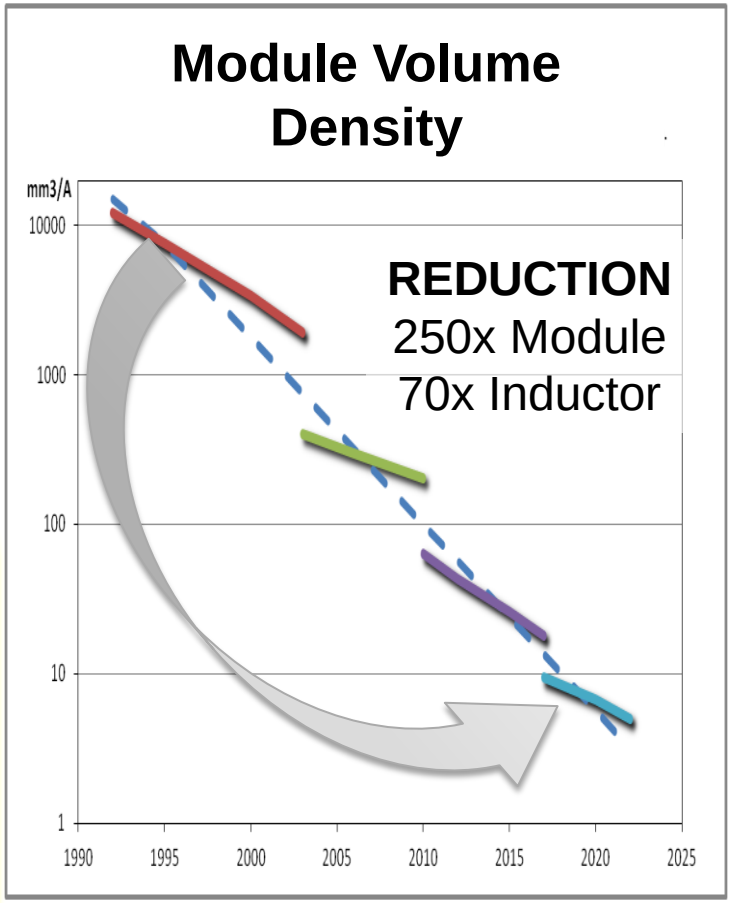
**LMZ31506**
**15 x 9 x 2.8 mm**

**Inductor = 25% volume**
**7x6.5x2.1mm**
500kHz, 13mΩ, 1.1uH
Powder Iron Molded, Round Wire Weld on LF



**TPS82130**
**2.8 x 3 x 1.5 mm**

**Inductor = 45% volume**
**2.5 x 2.0 x 1.2 mm**
1MHz, 10mΩ, 0.6uH
Powder Iron, Edge Wound Flat Wire Plated Termination




***INTEGRATION*** ***FREQUENCY*** ***MAGNETICS*** ***PACKAGING***

# THANK YOU