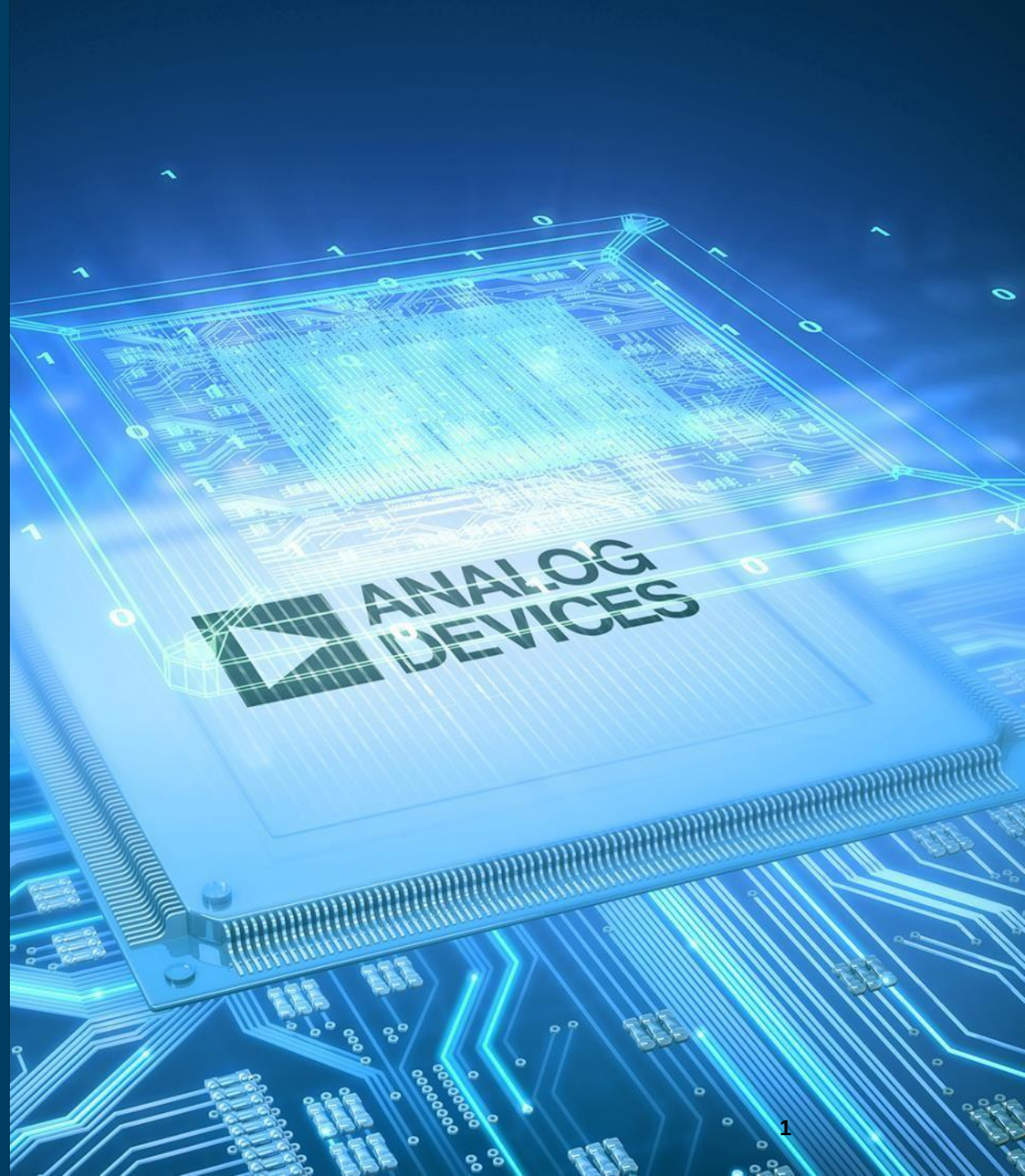
ANALOG DEVICES

AHEAD OF WHAT'S POSSIBLE™

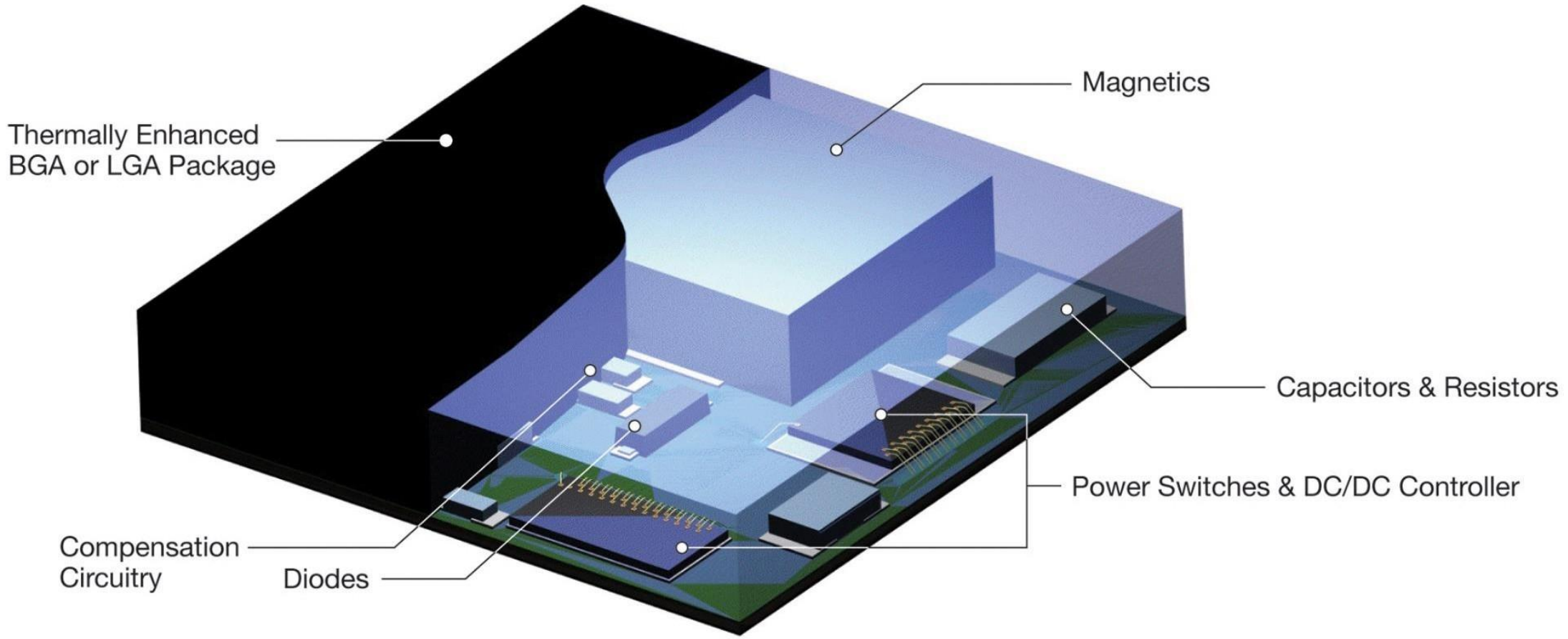
Simplify Power Designs with Micromodule Products



Agenda for Today

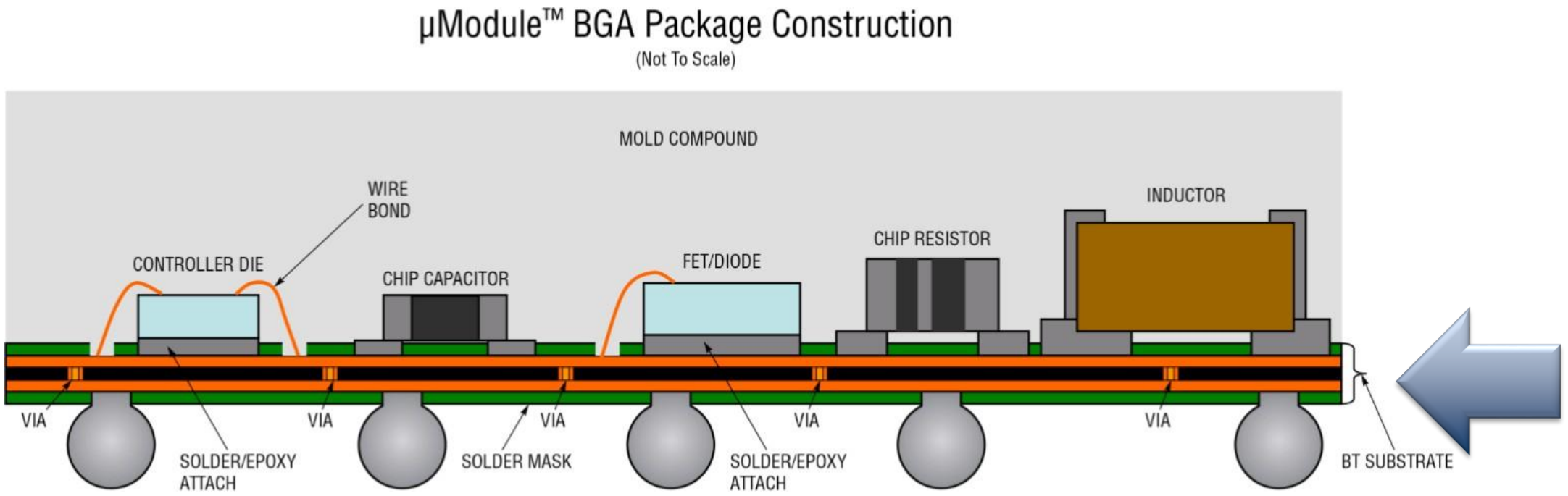
- What are µModule Power Products?
- What Problem are we Solving?
- Quality & Reliability
- µModule Packaging Trends
- Thermal Performance
- Product Portfolio Overview
  - 0 to 15A µModule regulators
  - 25A to 100A+ µModule Regulators
  - UltraThin µModule Regulators
  - Dual, Triple & Quad Output µModules
  - Component on Package (CoP)
- Power VLSI Digital & Reference Designs
- PMBus µModule Regulators

What is a µModule Product?



ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

µModule Architecture Advantage: Multi-Layer Substrate

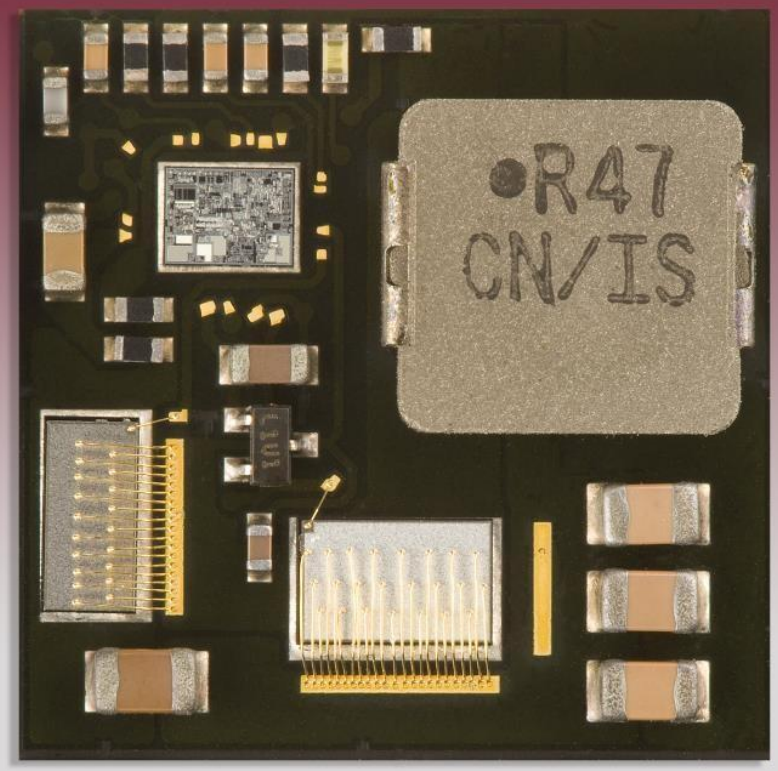


BT is short hand for: Bismaleimide-Triazine

(Pronounced: Biz-mal-ale-ide Tri-a-zine)

What Problem were we Trying to Solve?

- Switch-mode Power Design Expertise is Declining
- Available PCB area is at a premium
- Thermal Design constraints are be coming more complex as Board D ensities are Increasing for a given amount of Air Flow
- Time-to-Market Pressures are more stringent



LINEAR TECHNOLOGY

LTM4600: 15mm x 15mm x 2.82mm LGA

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

What Problem were we Trying to Solve?

- Switch-mode Power Design Expertise is Declining

- The average age of a Degreed Engineer (BSEE) is 57 years Old across the Globe. [Source: EDN].
- The top 3 Concerns of these Engineers are:

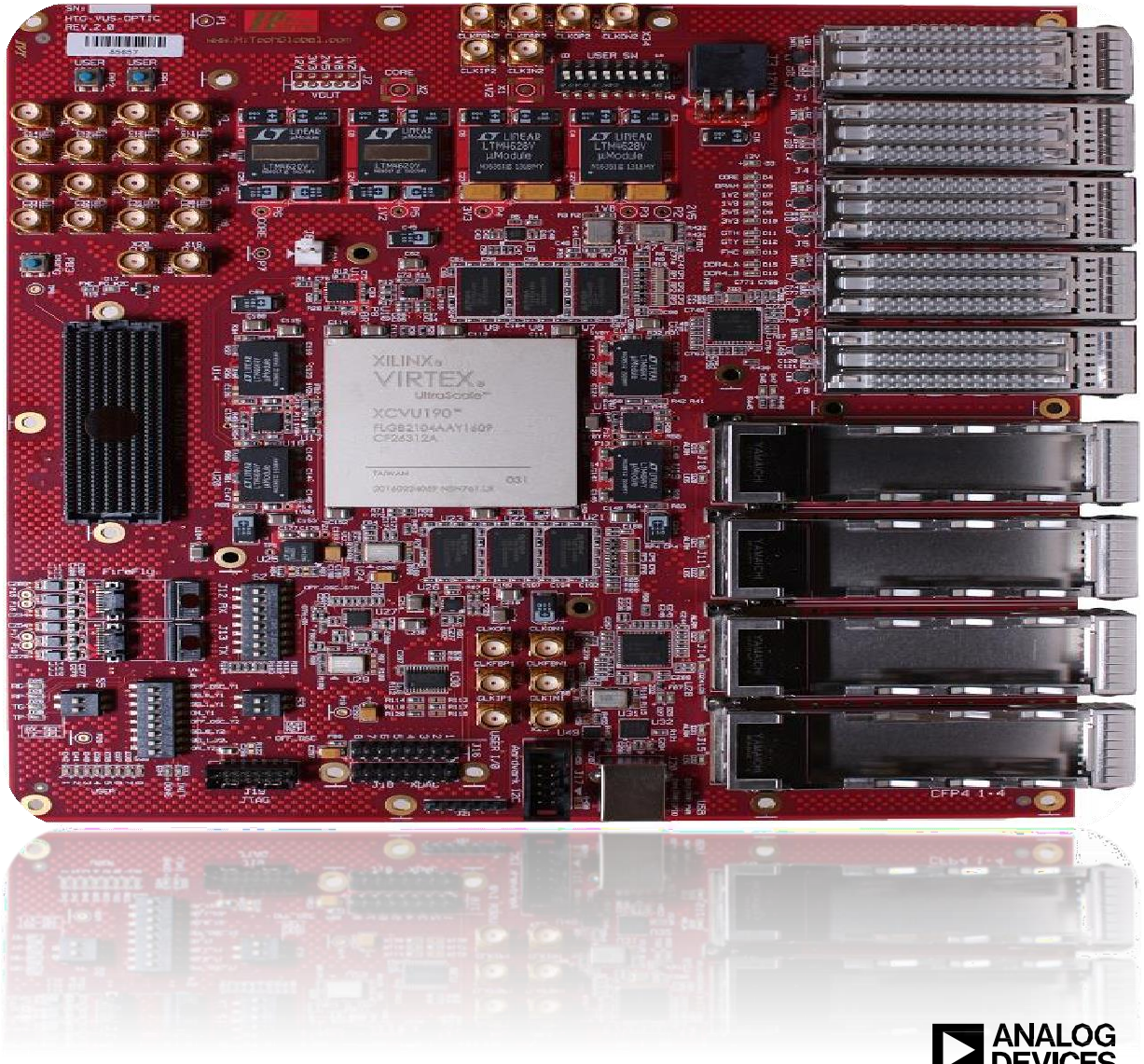
#1: Insufficient People to get the Job Done

#2: Finding the Optimal Component for my Design

#3: Time-to-Market Pressures

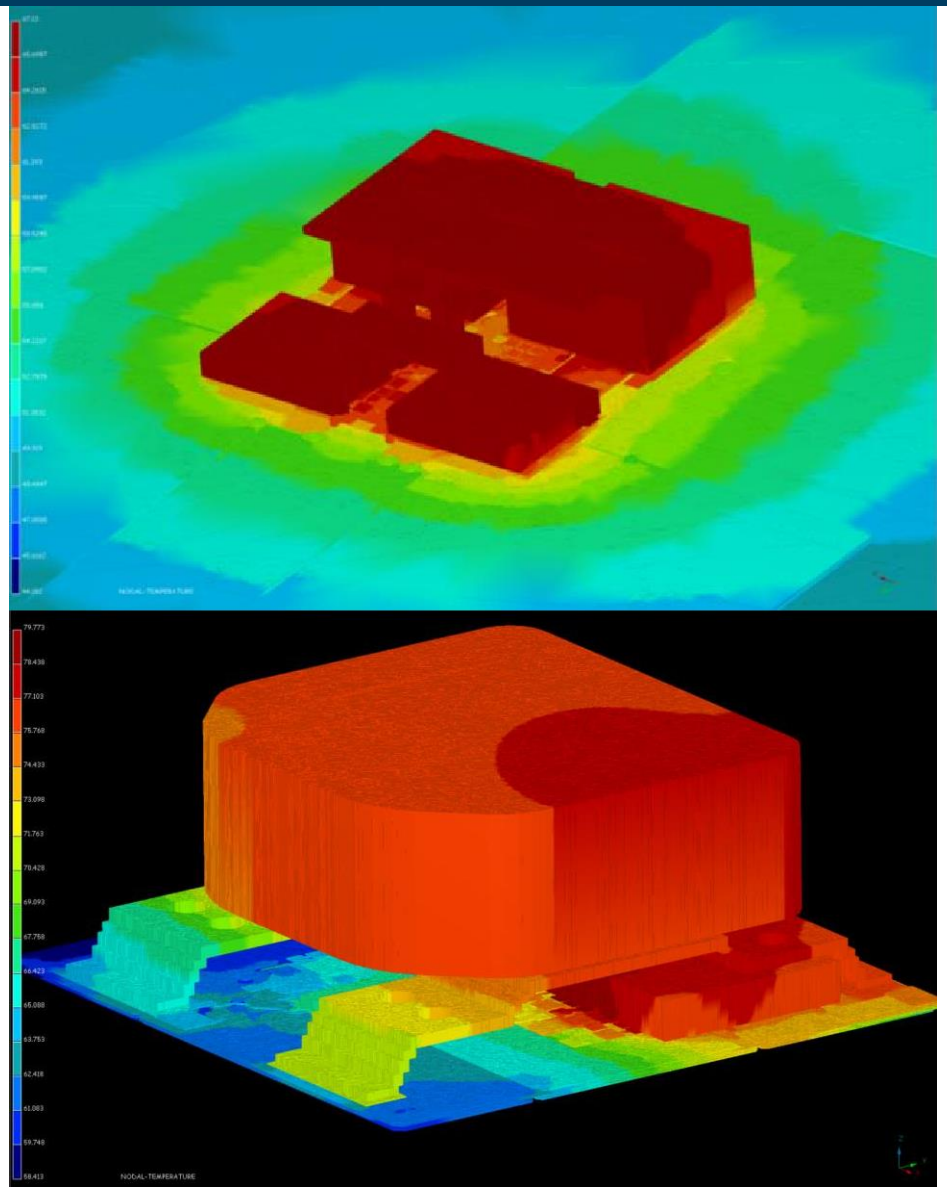
What Problem were we Trying to Solve?

- Available PCB area is at a premium
- System Designers are being asked to increase PCB functionality and density in an ever shrinking form f actor



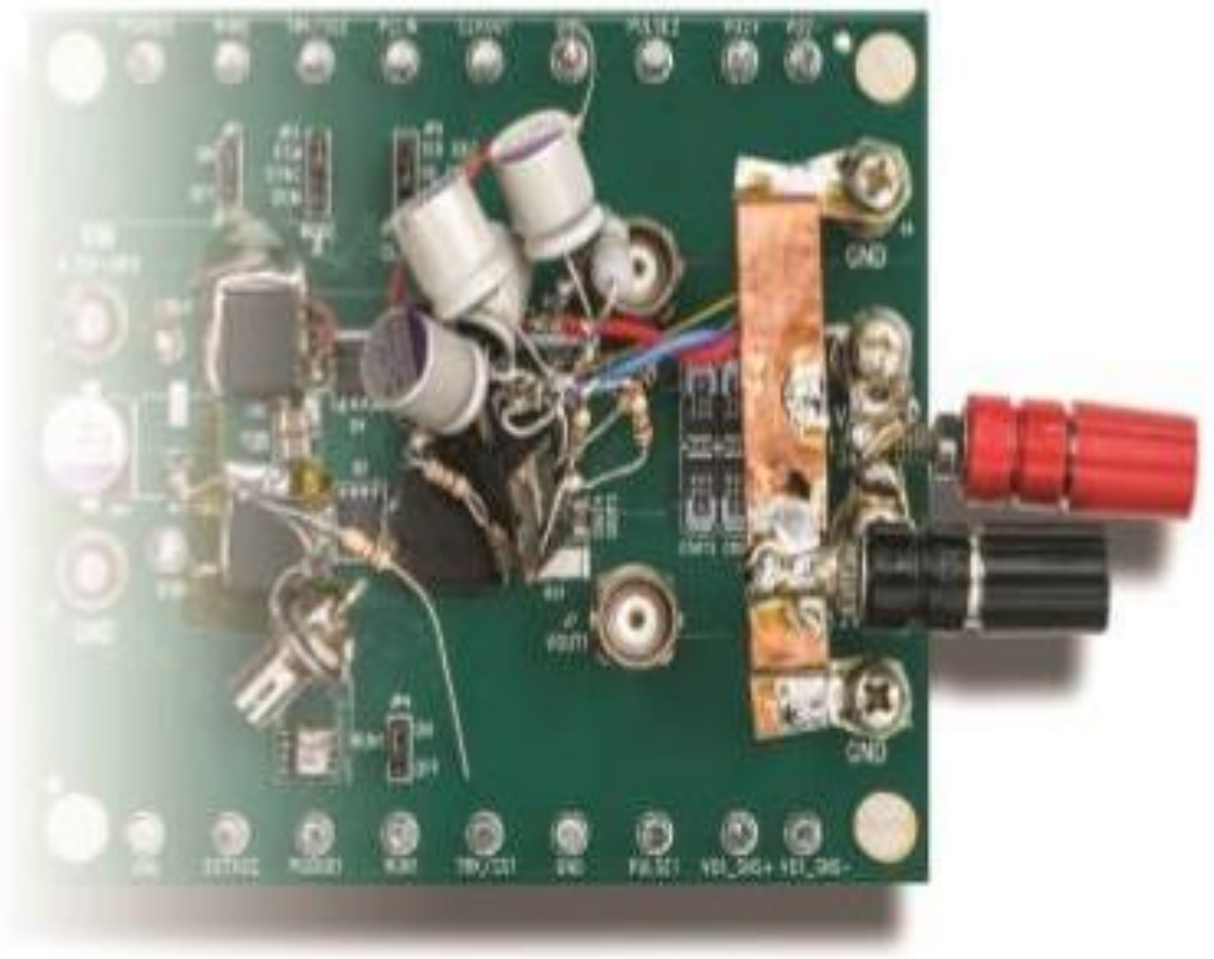
What Problem were we Trying to Solve?

- Thermal Design constraints are be coming more complex as Board D ensities are Increasing for a given amount of Air Flow and/or heat sin king



What Problem were we Trying to Solve?

- Time-to-Market Pressures are more stringent today
- Who has the time to design and debug their power supply when they are going in to mass produ ction in less than a month?
- µModules provide a “simple and done” proven power conversion solution.
- No late nights in the lab debugging a power supply!



Power µModule Product Quality & Reliability

- 22,175,000 Power Cycles
- 5,071,000 High Temp Operating Life (device hours)
- Board Mount Temp Cycles
  2,118,000 (-40ºC to 125ºC)
  High Temp Bake (device hours)
  43,605,000 at 150ºC
- 25,046,000 Temp Cycle -65ºC to 150ºC
- 16,439,000 Thermal Shock -65ºC to 150ºC
- FIT Rate: < 0.4
- And many more pages of data posted online
  - 2nd Source Assembly & Manufacturing
  - Multi-sourced Substrate and Component Suppliers
  - Die Bank

Reliability Data Report
Report Number: R504
Report generated on: Thu Jan 19 17:03:24 PST 2017

TEMP CYCLE FROM -55 TO 125 DEG C

PACKAGE TYPE	SAMPLE SIZE	OLDEST DATE CODE	NEWEST DATE CODE	K DEVICE CYCLES	No. of FAILURES
BGA 06X06	883	1245	1527	476	0
BGA 09X11	307	1414	1532	349	0
BGA 15X09					
BGA 11X15					
BGA 15X15					
BGA 16X16					
LGA 06X06					
LGA 15X09					
LGA 11X15					
LGA 15X15					
LGA 16X16					
Totals					

TEMP CYCLE FROM

PACKAGE TYPE	SAM
BGA 15X09	
BGA 15X15	
BGA 16X16	
LGA 15X09	
LGA 15X15	
LGA 16X16	
Totals	

THERMAL SHOCK

PACKAGE TYPE	SAM
BGA 06X06	
BGA 09X11	
BGA 15X09	
BGA 11X15	
BGA 15X15	
BGA 16X16	
LGA 06X06	
LGA 15X09	
LGA 11X15	
LGA 15X15	
LGA 16X16	
Totals	

OPERATING LIFE TEST

PACKAGE TYPE	SAMPLE SIZE	OLDEST DATE CODE	NEWEST DATE CODE	K DEVICE HRS (+125°C)[1]	No. of FAILURES[2,3]
BGA 06X06	271	1206	1338	271	0
BGA 15X09	306	1228	1306	306	0
BGA 15X15	911	1141	1428	834	0
BGA 16X16	306	1324	1533	306	0
LGA 06X06	154	1430	1449	154	0
LGA 15X09	788	0634	0843	788	0
LGA 15X15	2448	0452	1223	2297	0
LGA 16X16	153	1233	1247	115	0
Totals	5,337	-	-	5,071	0

HIGHLY ACCELERATED STRESS TEST AT +130 DEG C / 85% RH

PACKAGE TYPE	SAMPLE SIZE	OLDEST DATE CODE	NEWEST DATE CODE	K DEVICE HRS (+85°C)[4]	No. of FAILURES
BGA 06X06	201	1337	1527	771	0
BGA 09X11	305	1414	1532	961	0
BGA 15X09	1149	1306	1525	3998	0
BGA 15X15	958	1235	1530	2563	0
BGA 16X16	1258	1334	1535	3102	0
LGA 06X06	689	1338	1524	2497	0
LGA 15X09	77	1502	1502	147	0
LGA 15X15	3591	0645	1544	10130	0
LGA 16X16	434	1248	1447	913	0
Totals	8,662	-	-	25,082	0

PRESSURE COOKER TEST AT 15 PSIG , +121 DEG C

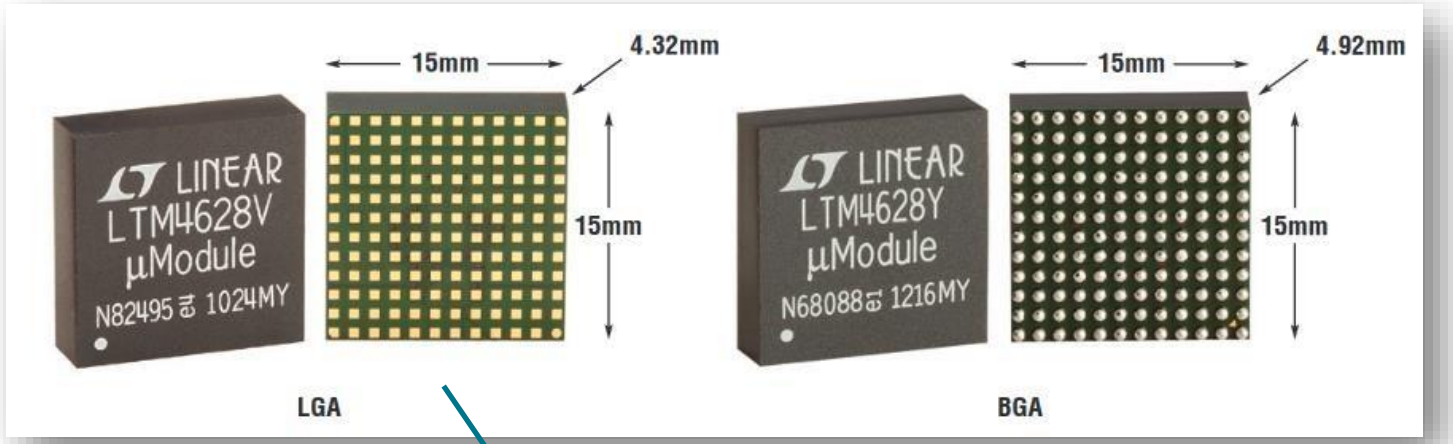
PACKAGE TYPE	SAMPLE SIZE	OLDEST DATE CODE	NEWEST DATE CODE	K DEVICE HRS	No. of FAILURES
LGA 15X09	50	1505	1505	1	0
Totals	50	-	-	1	0

TEMP CYCLE FROM -40 TO 125 DEG C

PACKAGE TYPE	SAMPLE SIZE	OLDEST DATE CODE	NEWEST DATE CODE	K DEVICE CYCLES	No. of FAILURES
LGA 15X09	76	0710	0710	76	0
LGA 15X15	230	0632	0642	230	0
Totals	306	-	-	306	0

(1) Assumes Activation Energy = 1.0 Electron Volts
(2) Failure Rate Equivalent to +55 °C, 60% Confidence Level =0.36 FITS
(3) Mean Time Between Failure in Years = 315776.72
(4) Assumes 20X Acceleration from 85 °C to +130 °C
Note 1: 1 FIT = 1 Failure in One Billion Hours.
Note 2: HAST, Temp Cycle & Thermal Shock are subjected to J-STD-020 MSL Preconditioning

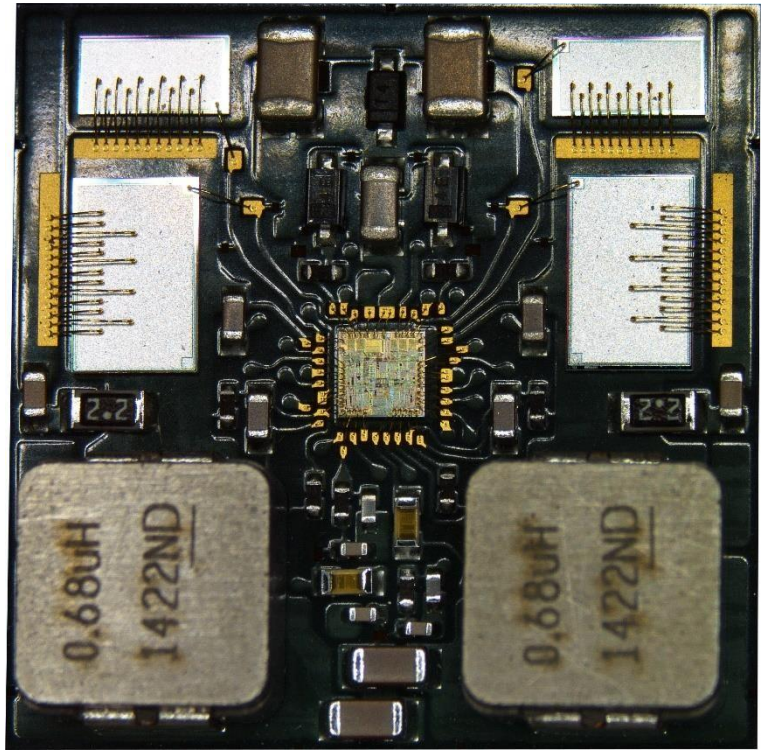
Packaging Trends: LGA & BGA Package Options



Uniformly Spaced, Equal Size Pads (BGA or LGA):

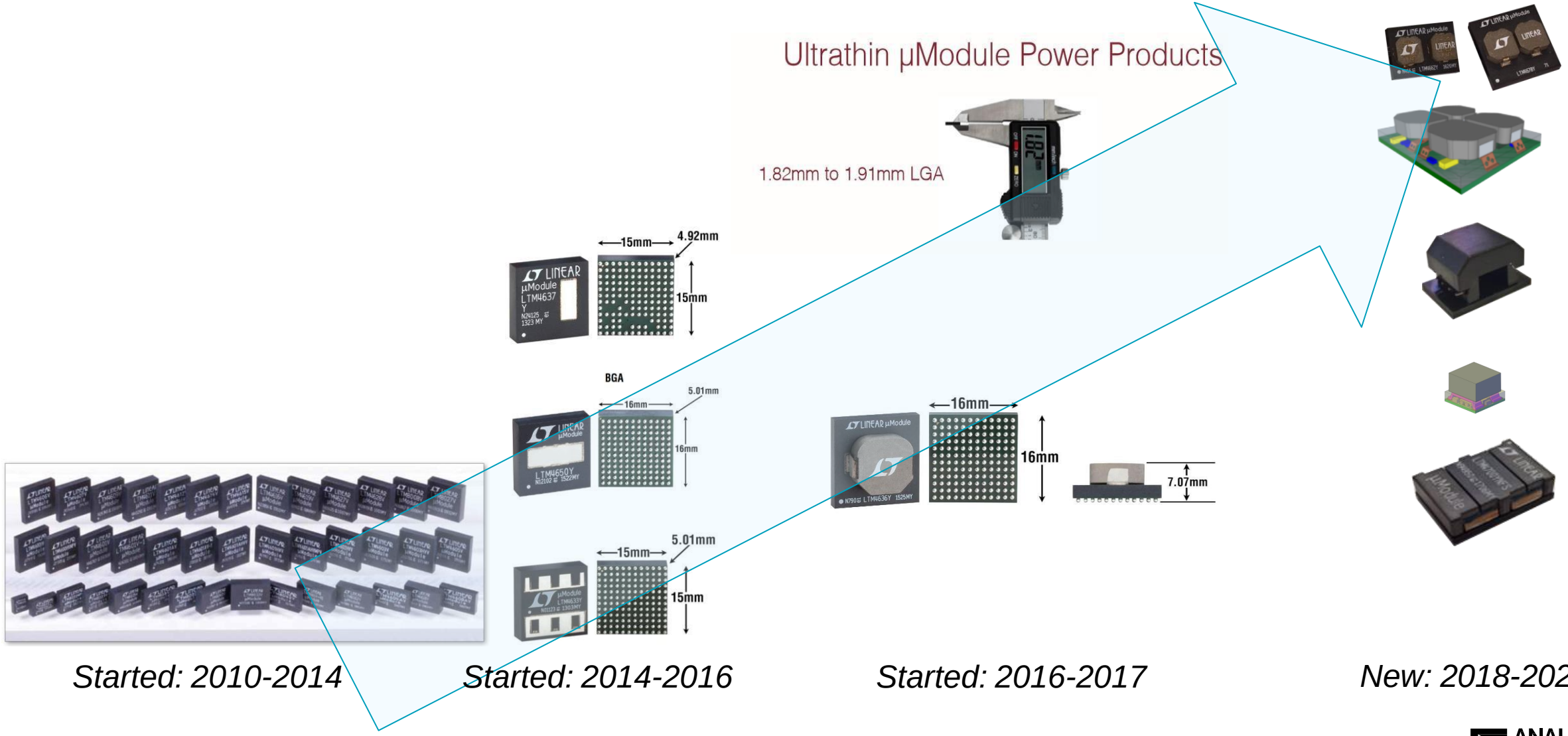
For simpler, quicker and Error-Free PCB Layout

(symbols and footprints available on-line)



ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

µModule Packaging Trend Evolution

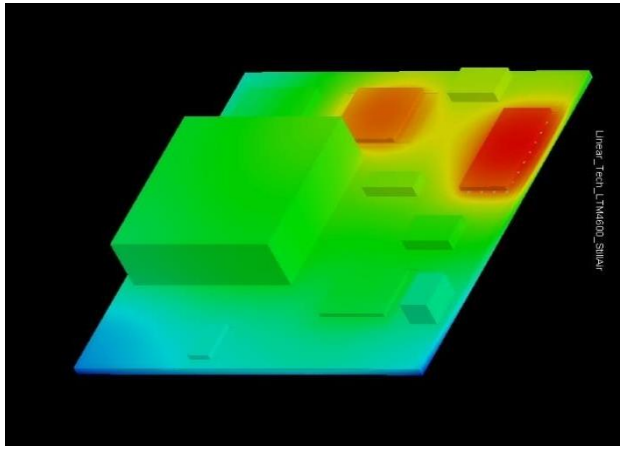


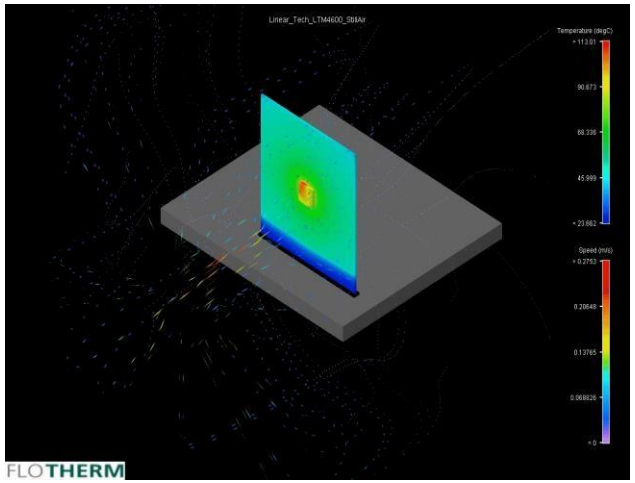
Started: 2010-2014 *Started: 2014-2016* *Started: 2016-2017* *New: 2018-2021*

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

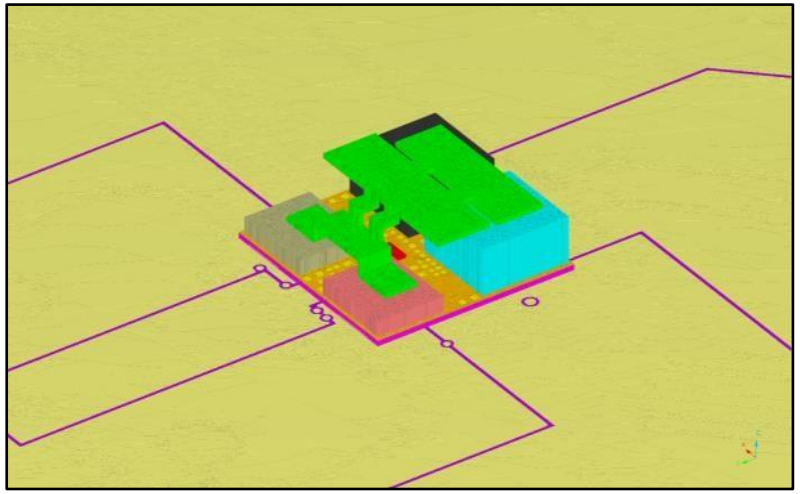
Thermal Performance

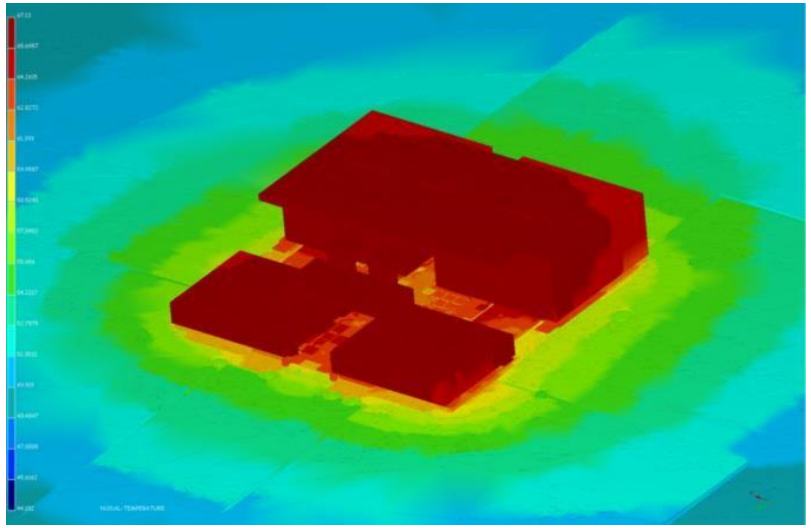
- Early Lower Power µModule Regulators



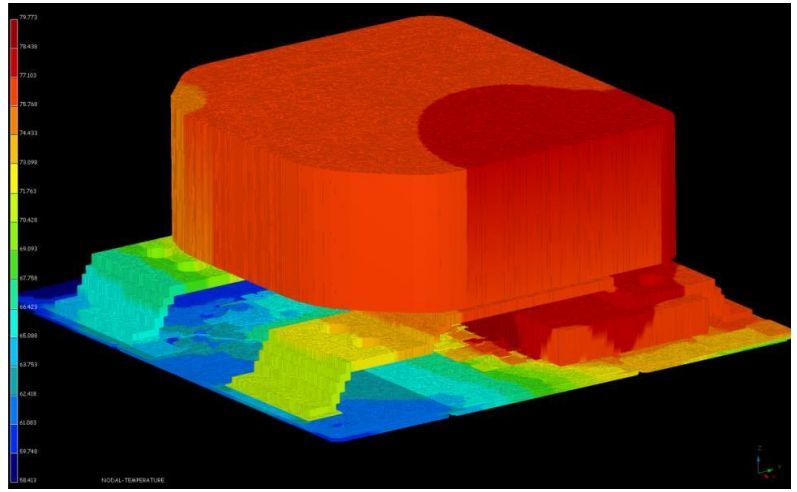


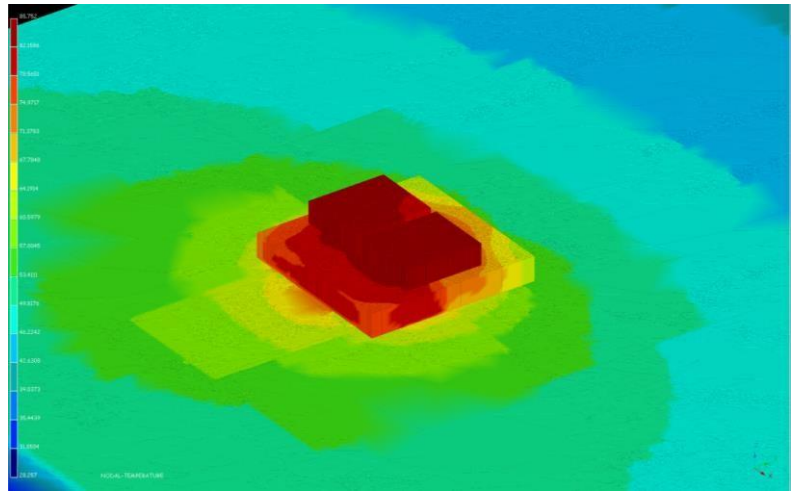
- Heat Sink Power µModule Regulators





- Component on Top µModule Regulators



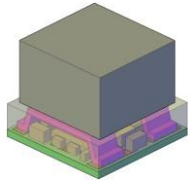


ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

15A Output µModules

LTM4638

(June-July 2018)



6.25mm x 6.25mm x 5.02mm BGA

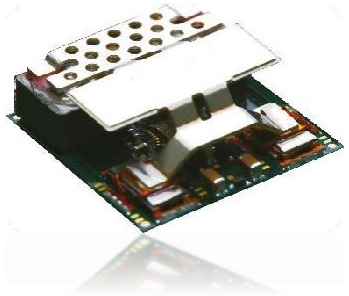
LTM4627

(4 years ago)

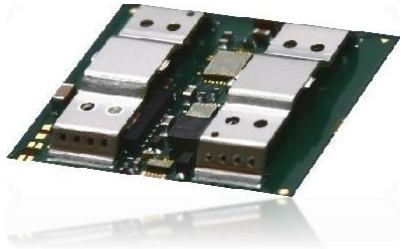
15mm x 15mm x 4.92mm BGA

25A to 100A+ Output µModules

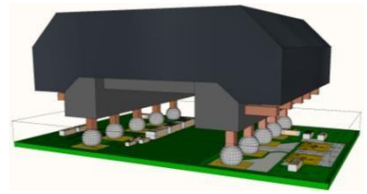
26A-50A
2013-2016

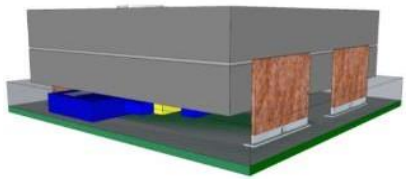


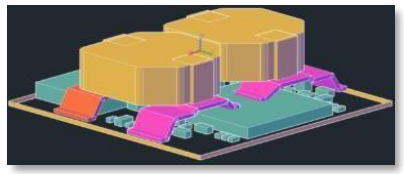
40A+ with 88%-89% Efficiency
2016 Onwards



80A-100A+ with High Voltage & Feature Rich
2018 Onwards







ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

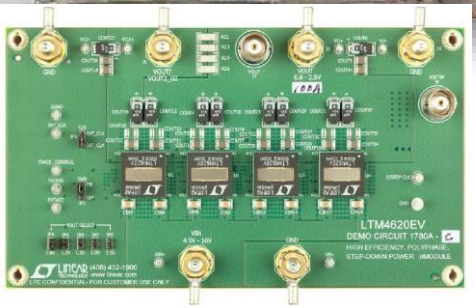
The Road to a 100A µModule : How did we get there?

2010 :

12x LTM4601

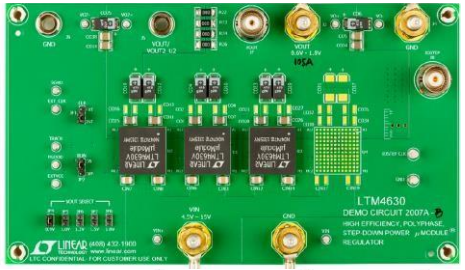
2012 :

4x LTM4620



2014 :

3x LTM4630



2016 :

2x LTM4650

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

Single 100A µModule

1 x LTM4700 with
Digital Telemetry

(July-August 2018)

12 x LTM4601

(8 years ago)

LTM4700: 100A µModule Regulator Summary

- LTM4700: Single 100A Output or Dual 50A Output
- Close to 90% Efficient from 12V to 1V at 100A Output with 200LFM
- Footprint is 15mm x 22mm x 7.82mm
- Release date is July 2018

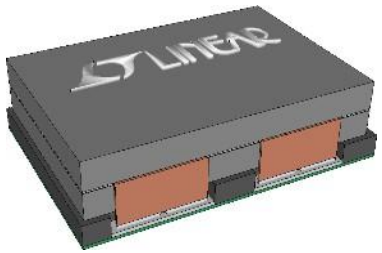
LTM4700 1st 100A µModule (89.6% efficiency)

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

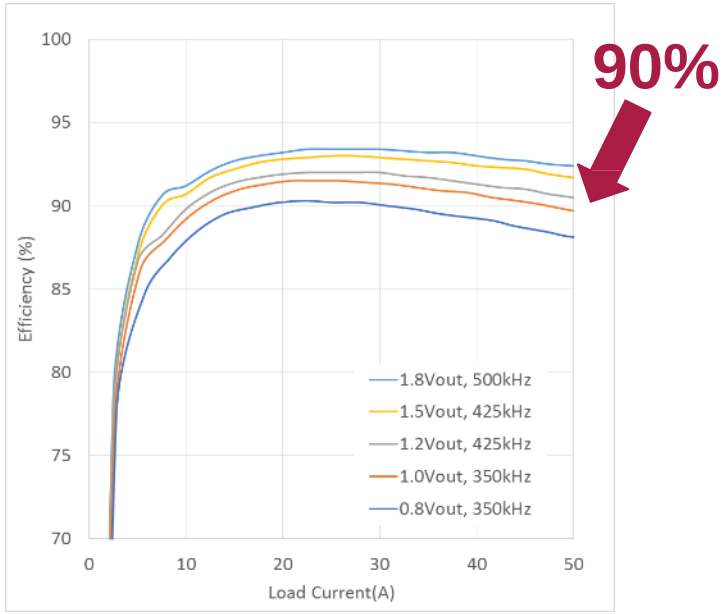
LTM4700: Single 100A / Dual 50A µModule Regulator with Digital PSM

FEATURES

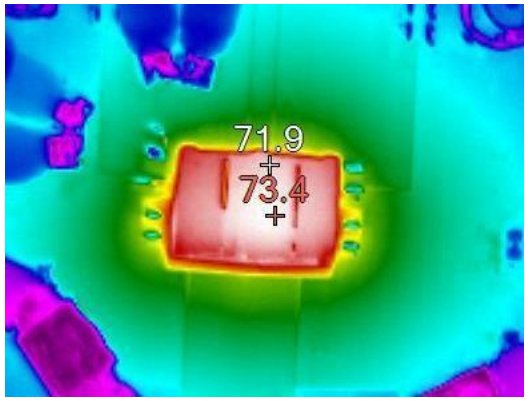
- Dual 50A Digitally Adjustable Outputs with Digital Interface for Control, Compensation and Monitoring
- Wide Input Voltage : 4.5V to 16V
- Output Voltage Range: 0.5V to 1.8V
- ±0.5% Maximum DC Output Error Over Temperature
- ±2.5% Current Readback Accuracy
- Integrated Input Current Sense Amplifier
- 400kHz PMBus-Compliant I^2C Serial Interface
- Supports Telemetry Polling Rates Up to 125Hz
- Integrated 16-Bit ΔΣ ADC
- Constant Frequency Current Mode Control
- Parallel and Current Share Multiple Modules
- 15mm × 22mm × 7.82mm BGA Package



12V Input Efficiency



12V to 1V at 100A, 200LFM Airflow



ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

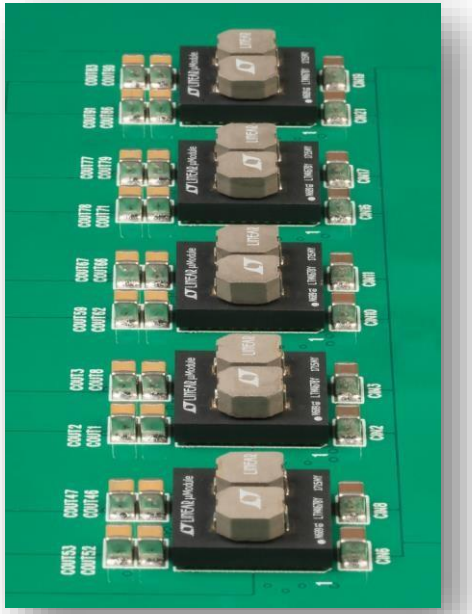
Higher Power Scaling: From 50A to 500A+

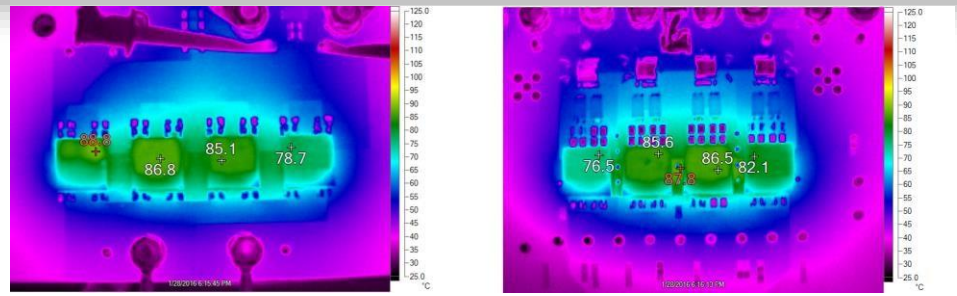
Ex: 5 x 50A =250A with I2C Digital Telemetry

Ex: 36A + 7 x 50A = 386A with I2C Digital Telemetry

µModule Solution Advantage:

- Precise sharing of total output current among each µModule regulator
- Heat is uniformly distributed too.
- High reliability: no thermal stress on one device



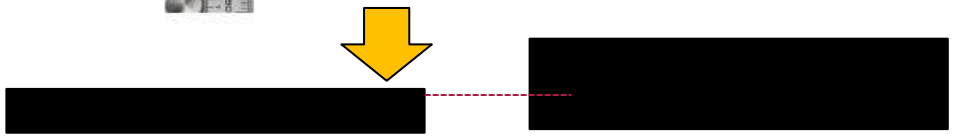


ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

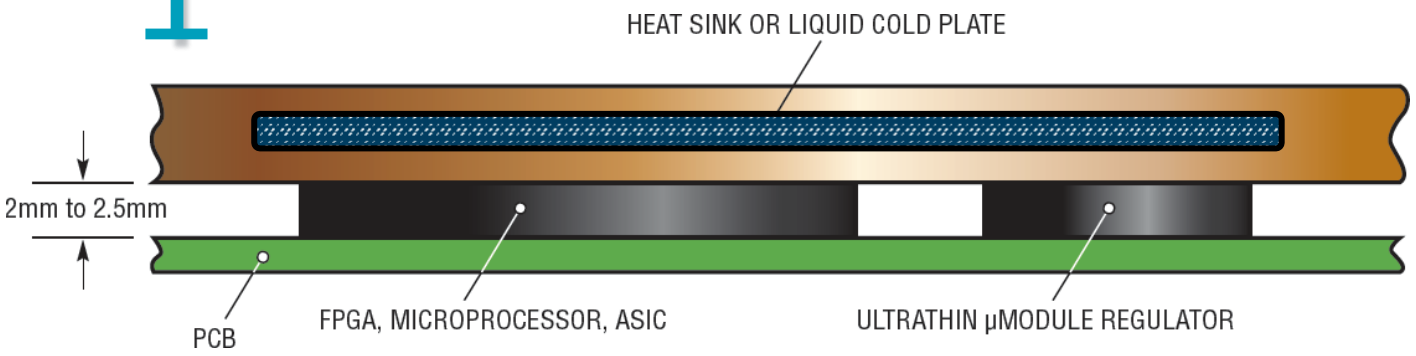
Ultrathin Packages have 2 Benefits: Use Existing Heat sink or utilize the underside of the PCB

Ultrathin µModule Power Products

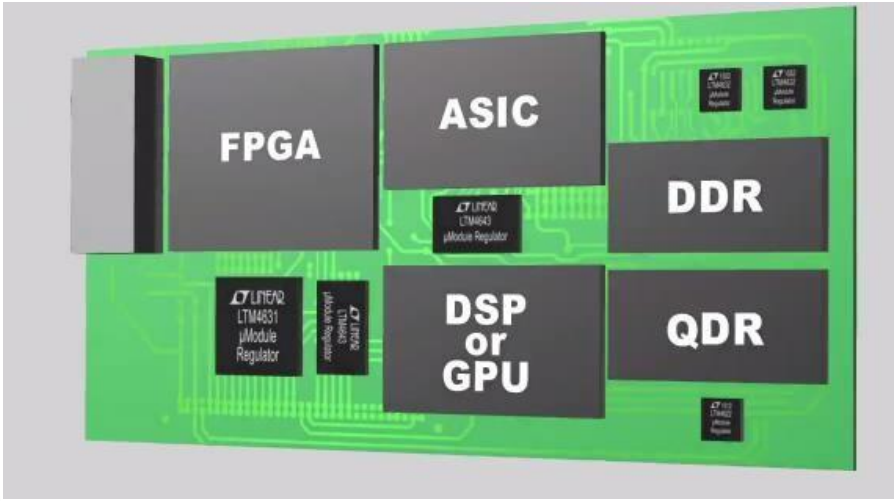
1.82mm to 1.91mm LGA

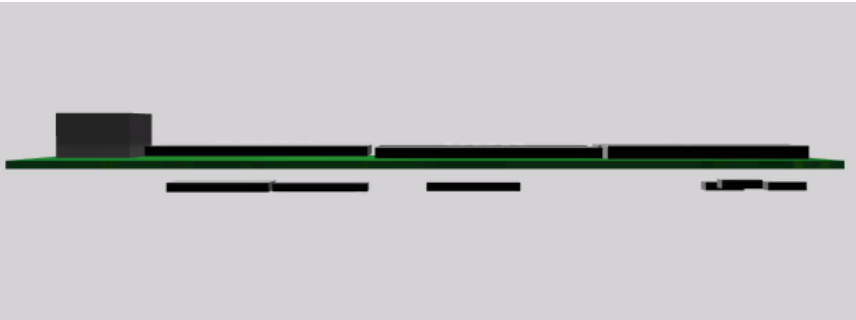


1



2

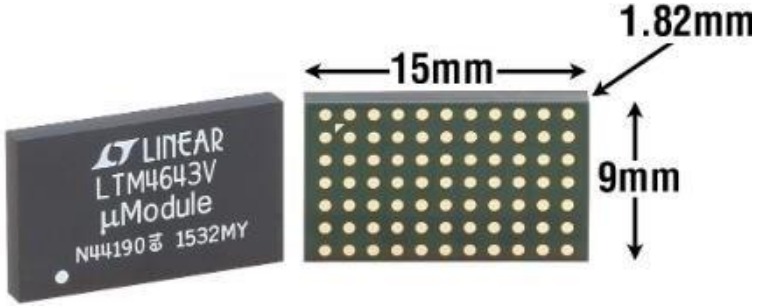


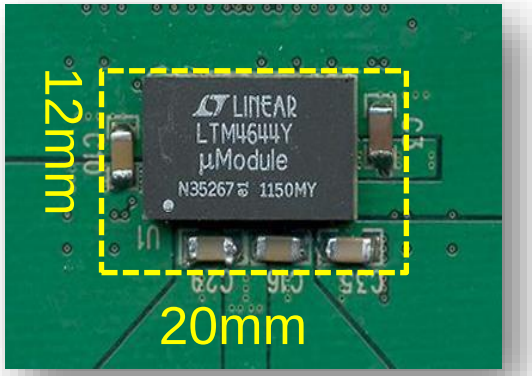


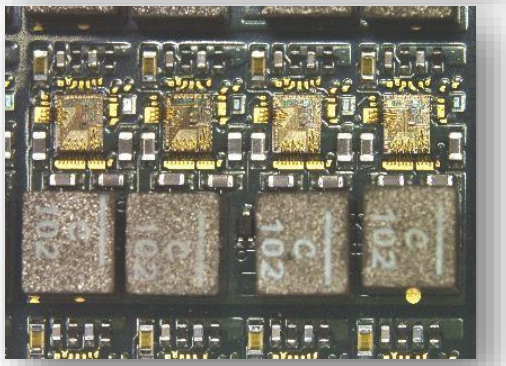
ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

Ultrathin Quad 3A µModule – LTM4643

- 4 x 3A Outputs
- Footprint is 15mm x 9 mm x 1.82mm
- Input Voltage Range: 4V to 20V (Down to 2.475 with external bias supply)
- Output Voltage Range: 0.6V to 3.3V
- ±1.5% Total Output Voltage Regulation
- Outputs can current share for Configuration Flexibility:
- 1 Output of 12A
- 2 Outputs of 6A each or 3A & 9A
- 3 Outputs of 6A, 3A & 3A
- 4 Outputs of 3A, 3A, 3A & 3A



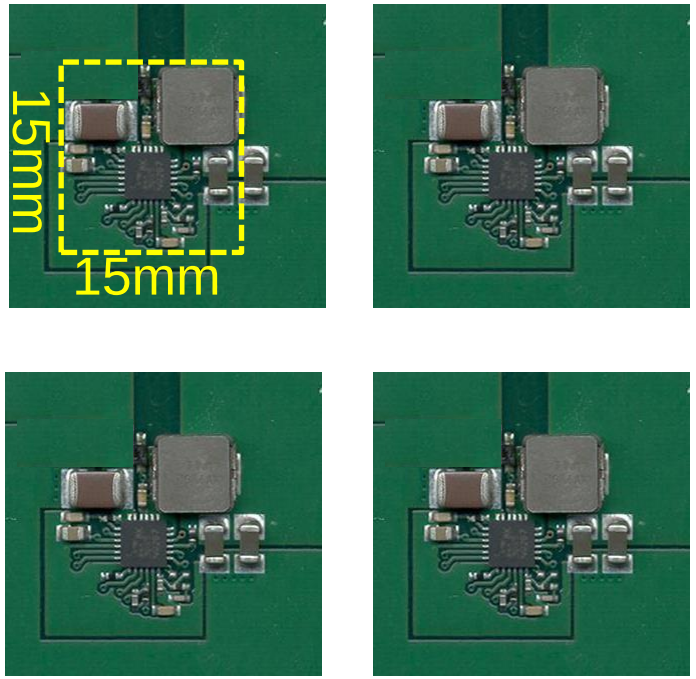




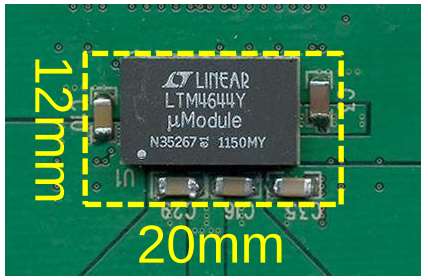
ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

LTM4644: Quad 4A µModule Regulator

LTC3605
4 x 4A Monolithic Regulators



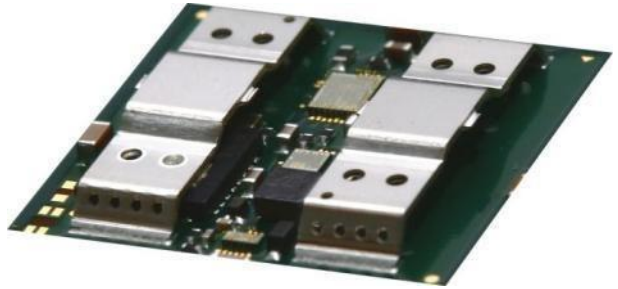
LTM4644
Quad 4A µModule Regulator



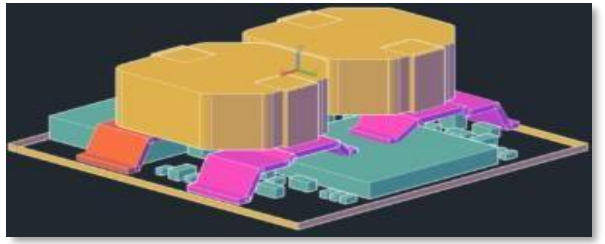
- 900 mm^2 vs. 240mm^2 = 73% reduction

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

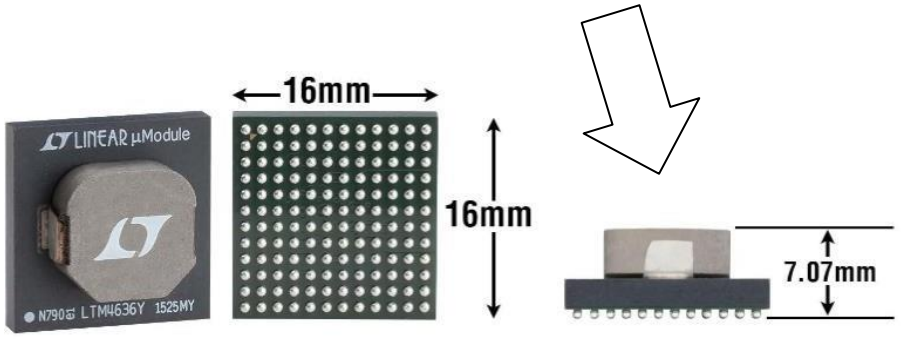
CoP: Component-on-Package

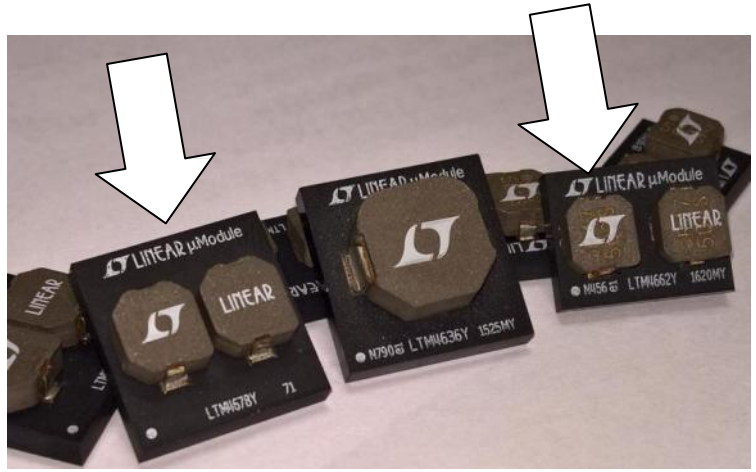


LTM4636 CoP unmolded



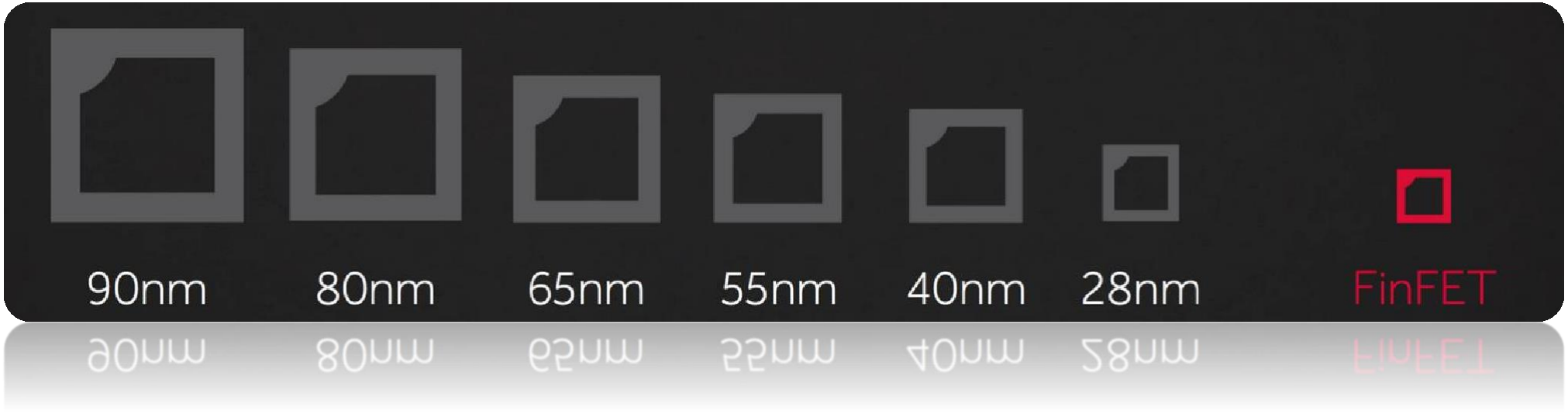
LTM4678 mCoP 3D design
(Jan. 2018 release)





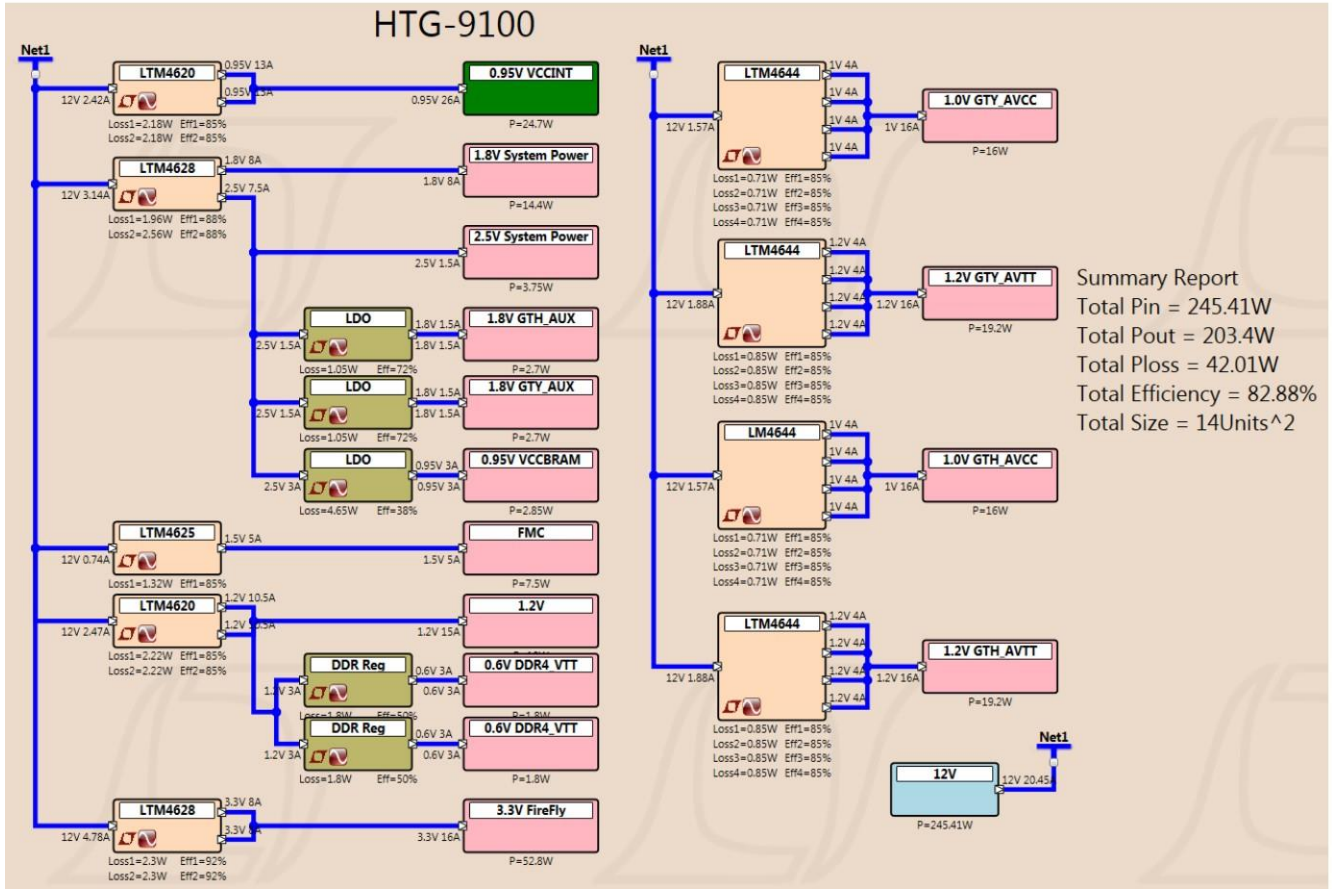
ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

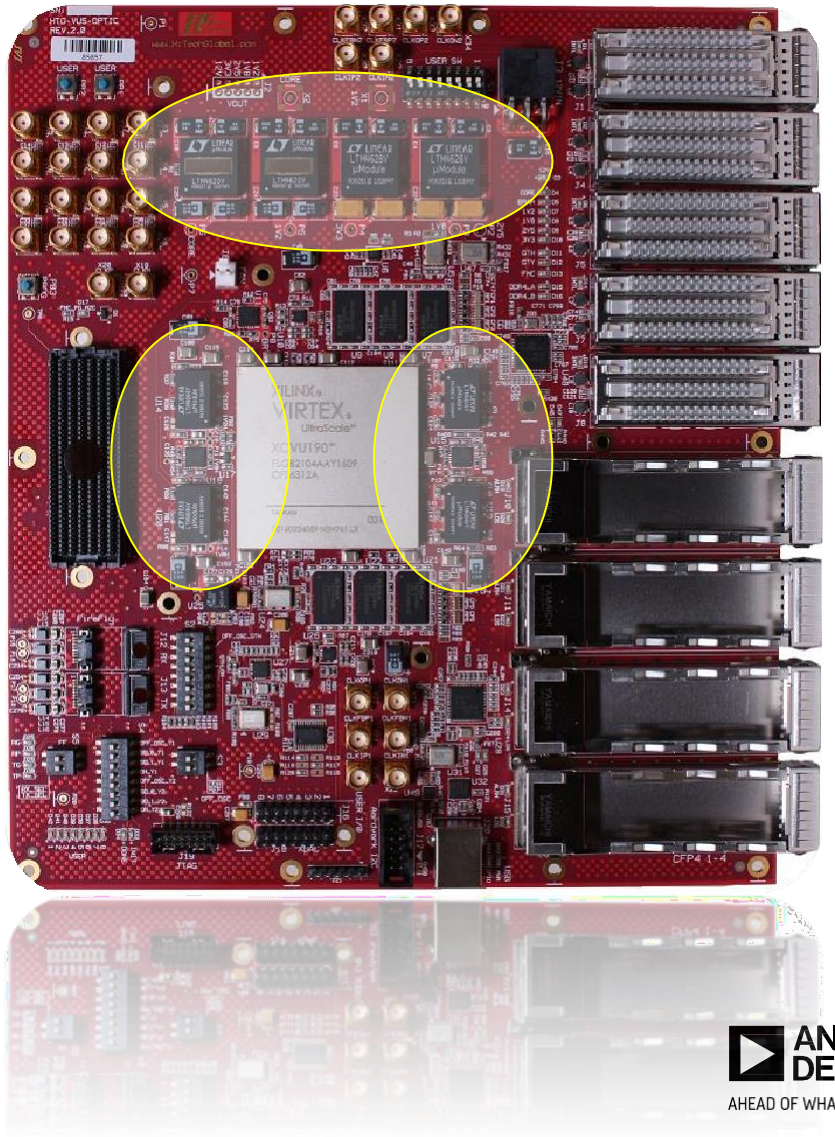
VLSI Digital Ics: We Are Ready To Power Them



Leader in Providing Power Management for 40nm… sub-10nm-Based Systems Since 2009

Solve The Larger Puzzle ▶ Cheaper, Smaller, Better

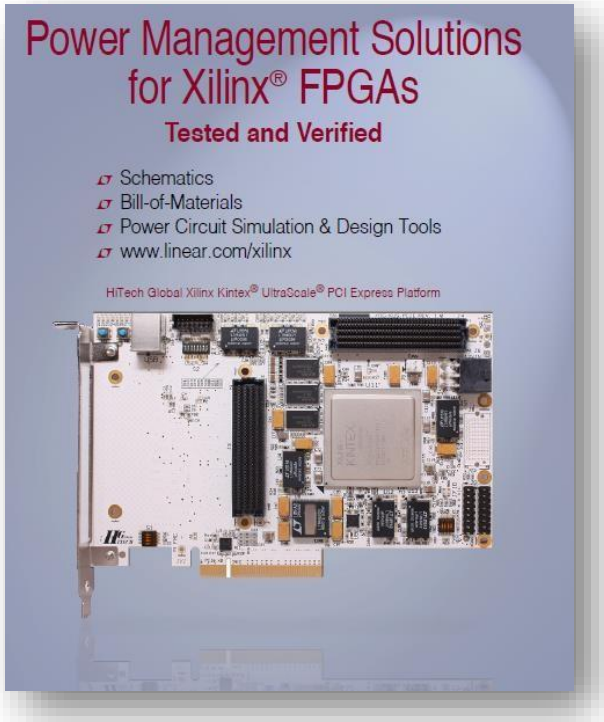


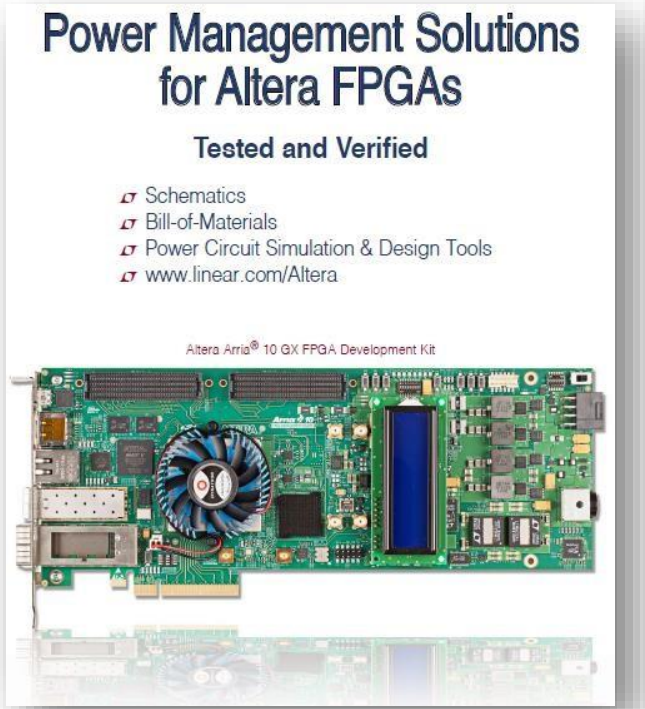


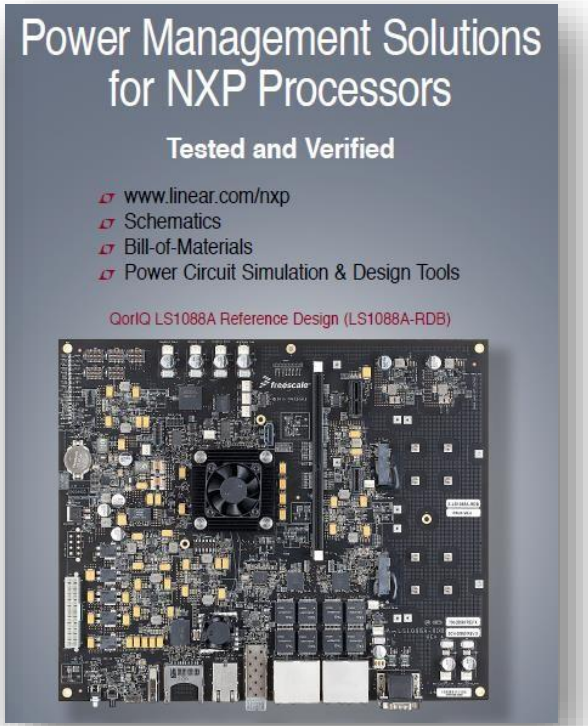
ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

Power for FPGA, Processors & Rest of System - Reference Designs

The examples of actual application board “Tested and Verified” by the board suppliers

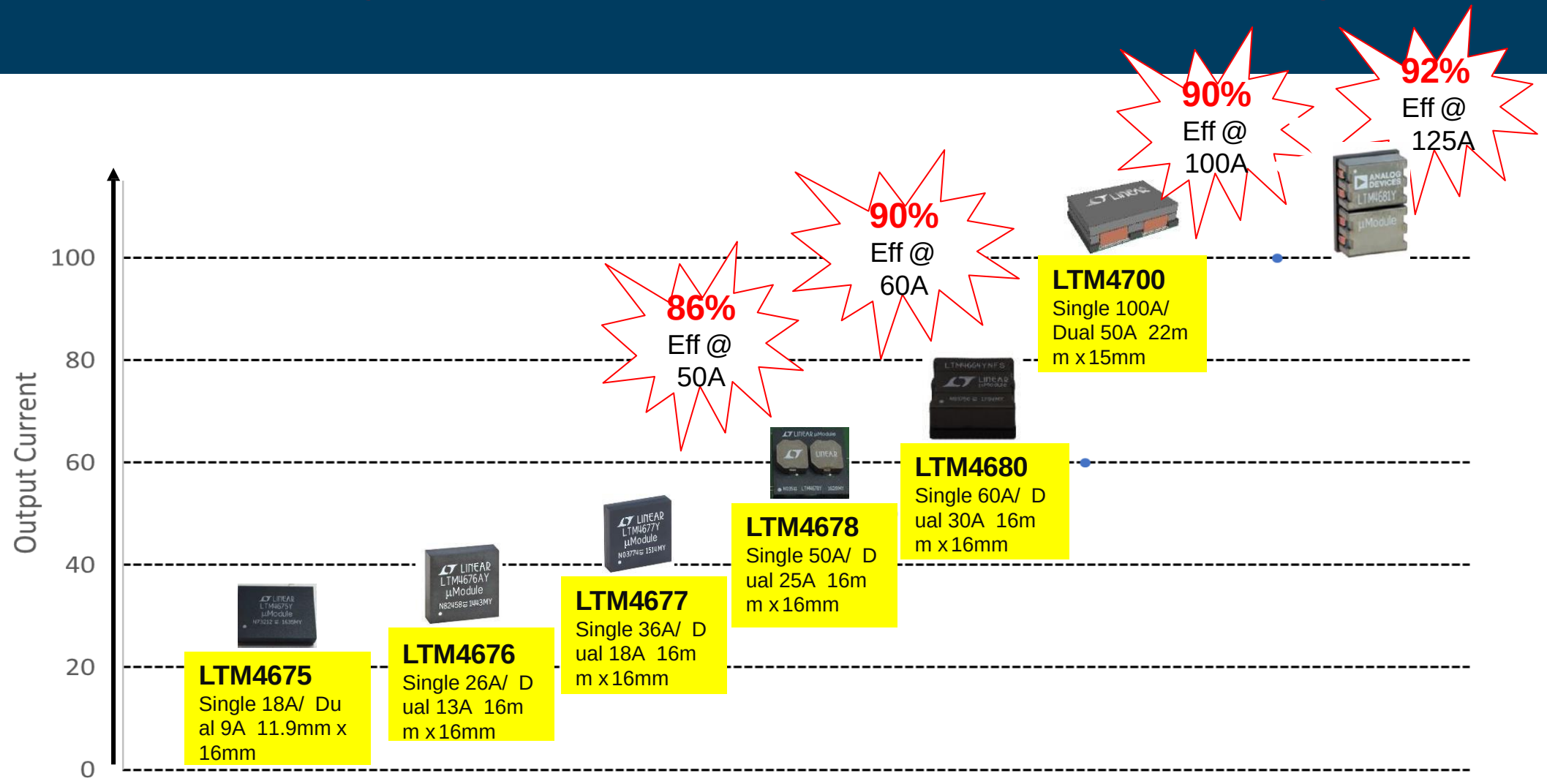






ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

High Current µModule Regulator Roadmap with Power System Management (PSM)

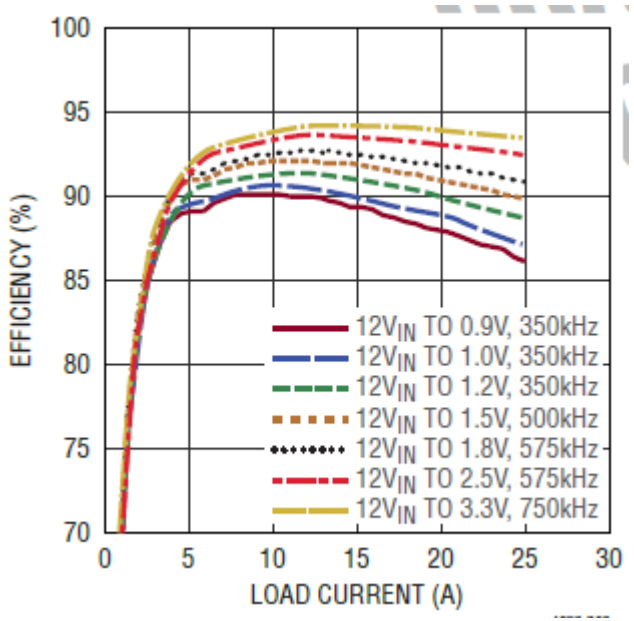


ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

LTM4678 Dual 25A or Single 50A µModule Regulator with Digital PSM

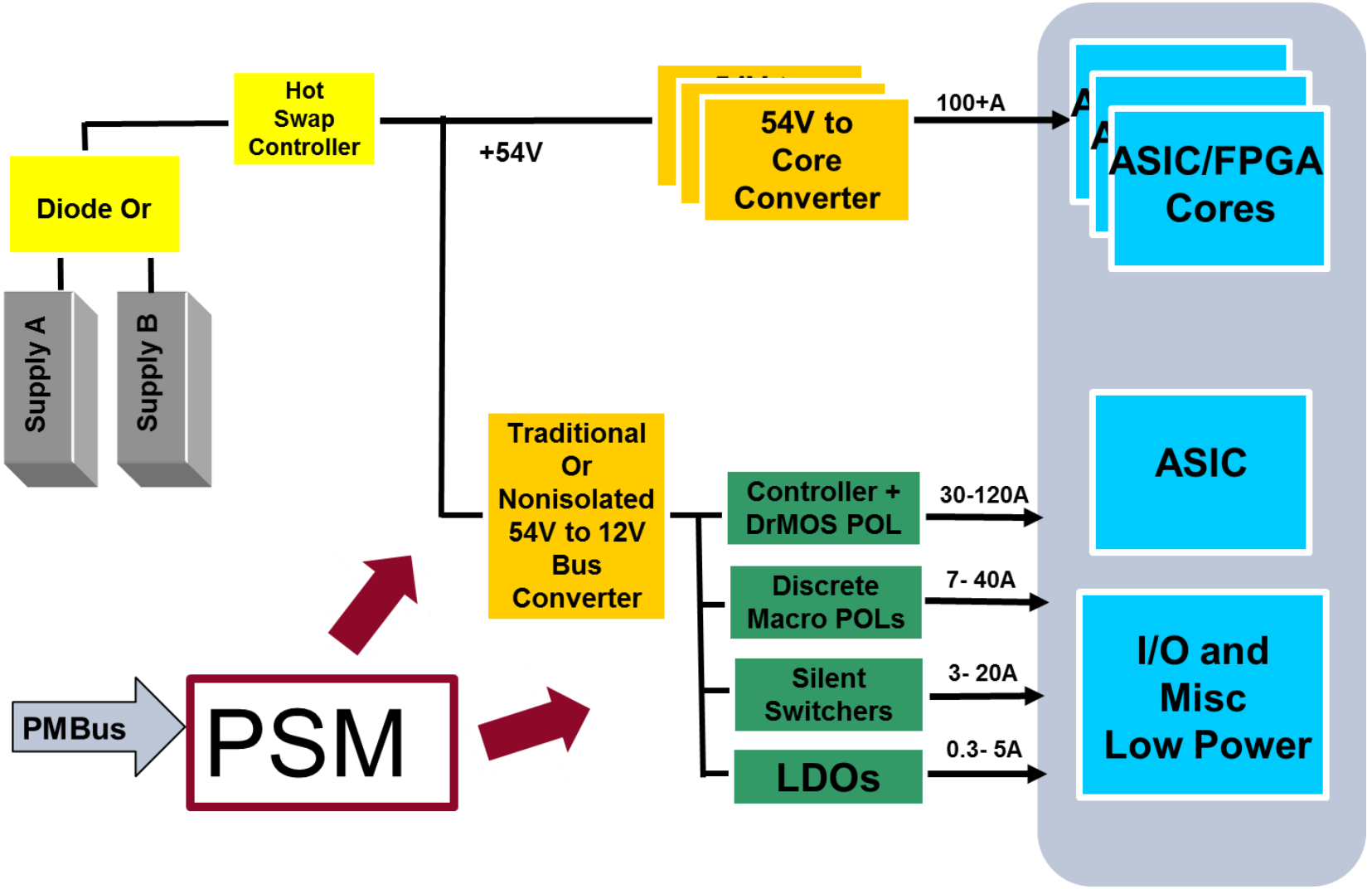
FEATURES

- Dual Digitally Adjustable Analog Loops with Digital Interface for Control and Monitoring
- Wide Input Voltage Range: 4.5V to 16V
- Output Voltage Range: 0.5V to 1.8V
- ±0.5% Maximum DC Output Error Over Temperature
- ±2.5% Current Readback Accuracy
- Sub-Milliohm DCR Current Sensing
- Integrated Input Current Sense Amplifier
- 400kHz PMBus-Compliant I^2C Serial Interface
- Supports Telemetry Polling Rates up to 125Hz
- Integrated 16-Bit ΔΣ ADC
- Constant Frequency Current Mode Control
- Parallel and Current Share Multiple Modules
- 16mm × 16mm × 5.74mm BGA Package



ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

Next Generation Telecom 48V Bus Power Architecture



LTM4664 54V To Core Voltage Single 50A/Dual 25A µModule with Digital PSM

- Vin range: 30V to 58V
- Vout range: 0.5V to 1.5V
- Dual outputs at 25A each or two phase single output at 50A (75W)
- Efficiency = 89% for 54Vin to 1Vout at 50A
- ±0.5% Vout Accuracy Over Line, Load and Temperature
  - Dual differential remote sense amplifiers
- PMBus/I2C Compliant Serial Interface for Core Voltage Outputs
- Digitally Adjustable Loop Compensation
- Programmable Voltage, Current Limit, Digital Soft-Start/Stop, Sequencing, Margining, OV, UV, OC
- 16 Bit Telemetry Read Back Includes V_{IN} and I_{IN}, V_{OUT} and I_{OUT}, Temperature and Faults with non-volatile logging
- Current Mode Control / Fast Transient Response
- 16mm x 16mm x 7.72mm BGA Package

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

Thank You For Watching!

Analog Devices Homepage : www.analog.com

Ask Questions on EngineerZone

https://ez.analog.com/

아나로그월드 (제품 구매, 기술문의)

홈페이지 : www.awc.co.kr

E-Mail : marketing@awc.co.kr

Tel. 031-783-0599

Fax. 031-783-0598

경기도 성남시 분당구 황새울로258번길 19, 7층 (수내동, 한원빌딩)

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™