Linear Technology Corporation

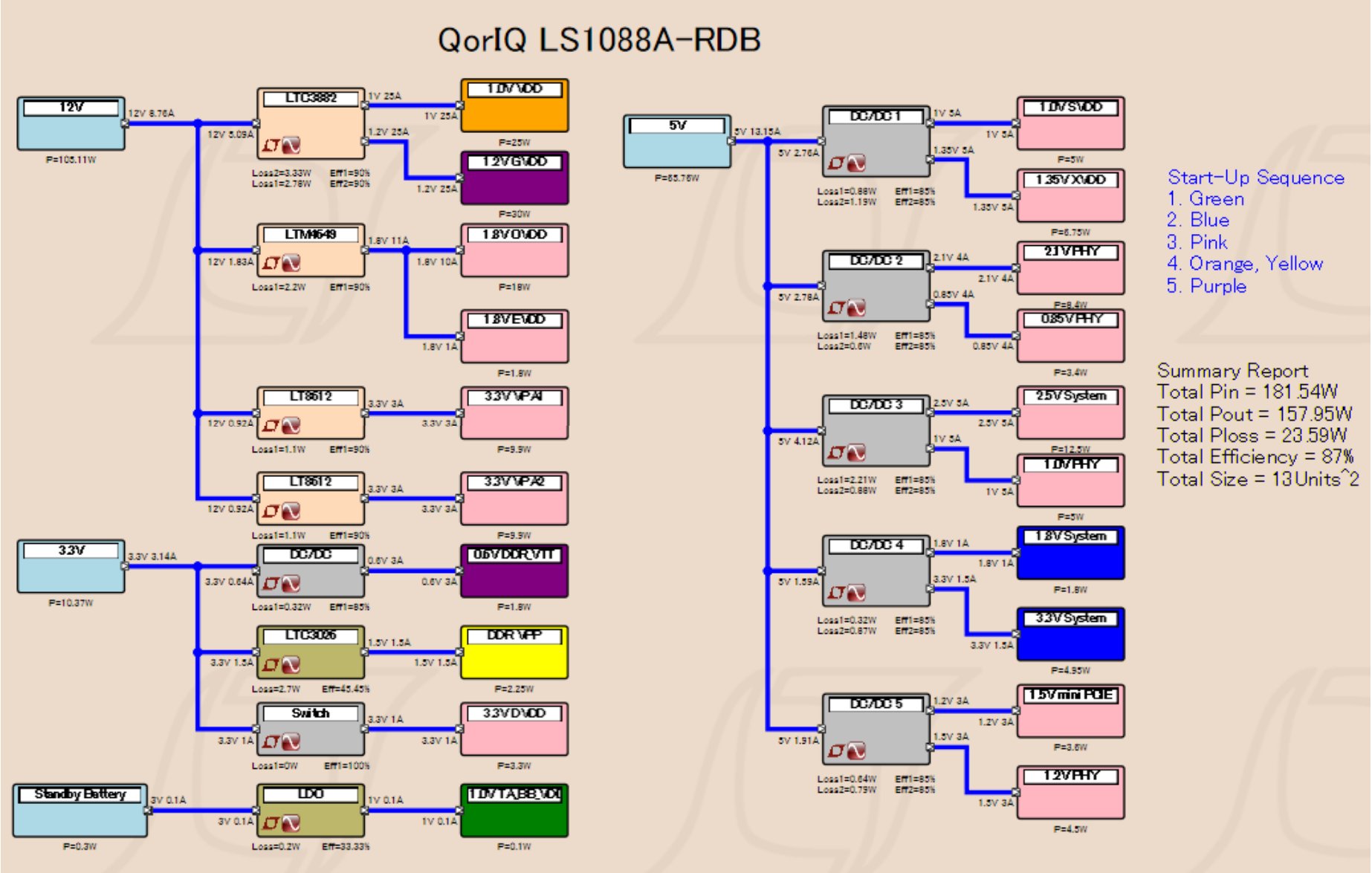
Scalable solutions for latest NXP QorIQ Processors

Power Solutions for QorIQ Processors

- Overview of recent designs for LayerScape Processors
  - LS1088
  - LS1043
  - T1023
- Solutions from Linear Technology
  - PMBus Regulators and Controllers
  - uModules
  - Silent Switchers
- Design Tools
  - Solutions reference website: www.linear.com/nxp
  - LTpowerplanner
  - LTpowerCAD
  - LTpowerplay

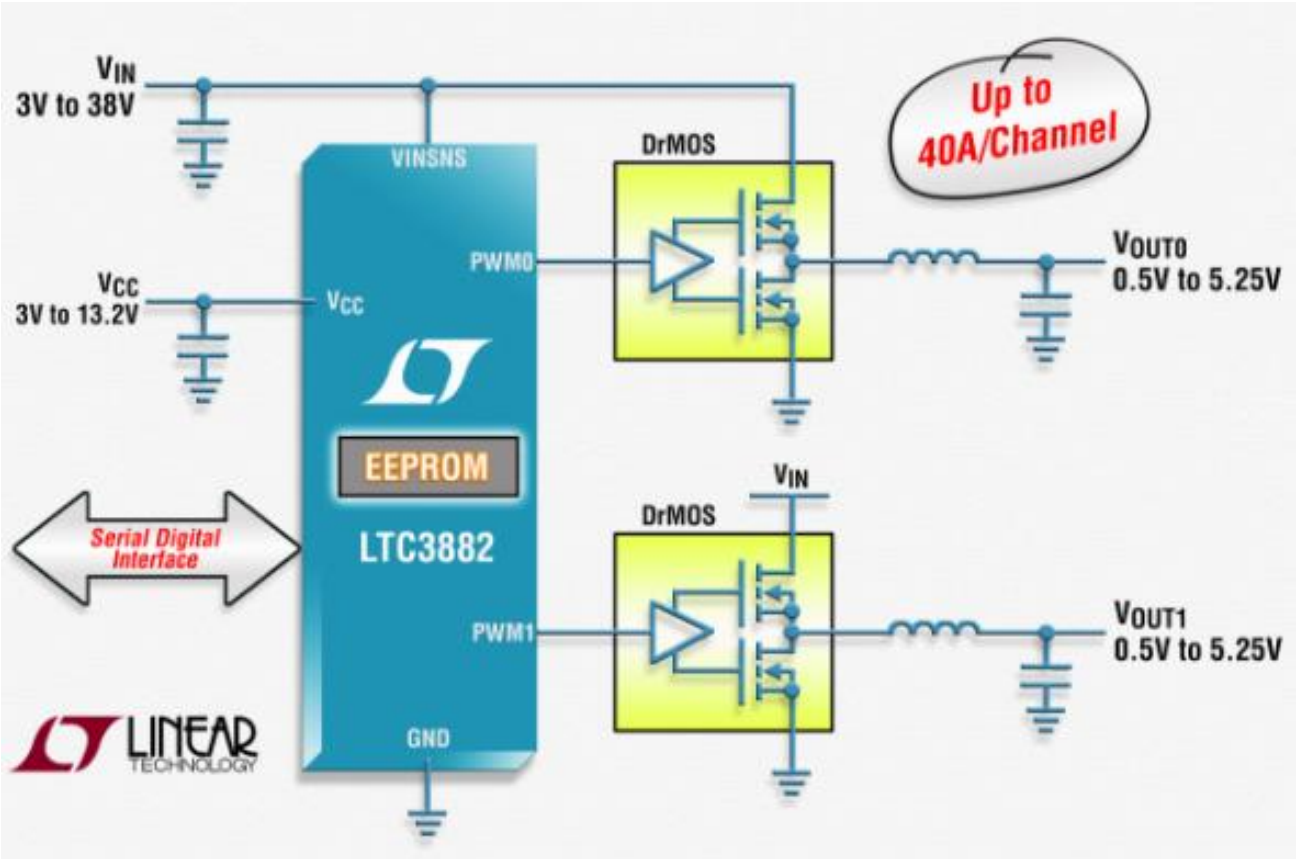
A variety of solutions for NXP QorIQ and T-series processors

LS1088 (QDS and RDB)

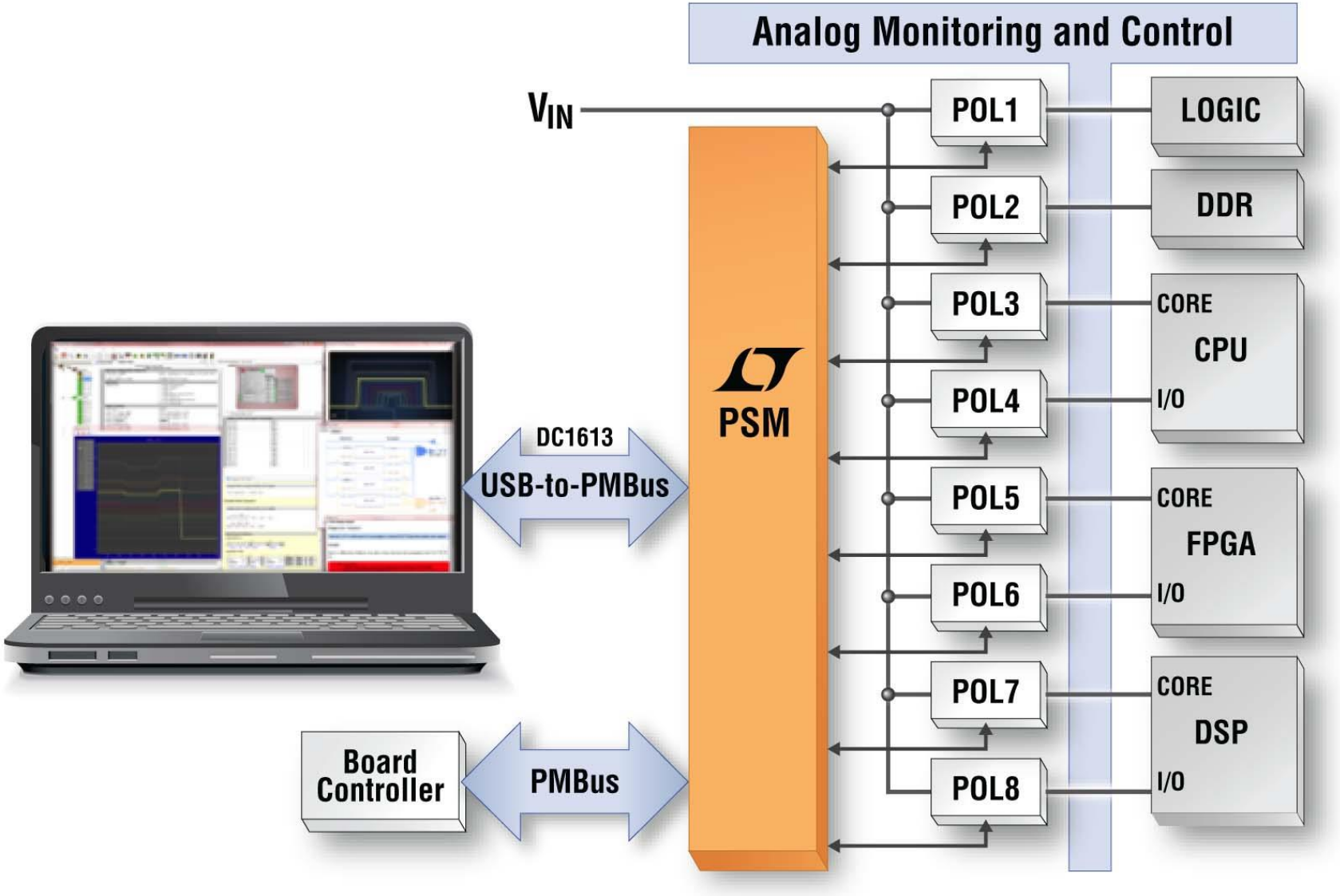


LTC3882: Dual Output PolyPhase Step-Down DC/DC Voltage Mode Controller with Digital Power System Management

- PMBus/I2C Compliant Serial Interface
  - Monitor Voltage, Current, Temperature and Faults
  - Digitally Programmable Voltage, Current Limit, Soft-Start/Stop, Sequencing, Margining, AVP, UV/OV Thresholds
- VIN: 3V - 38V
- VOUT: 0.5V - 5.25V
- ±0.5% Output Voltage Accuracy
- Switching Frequency: 250kHz - 1.25MHz
- Accurate PolyPhase® Current Sharing
- Internal EEPROM with Fault Logging
- Optional Resistor Programming for Key Parameters



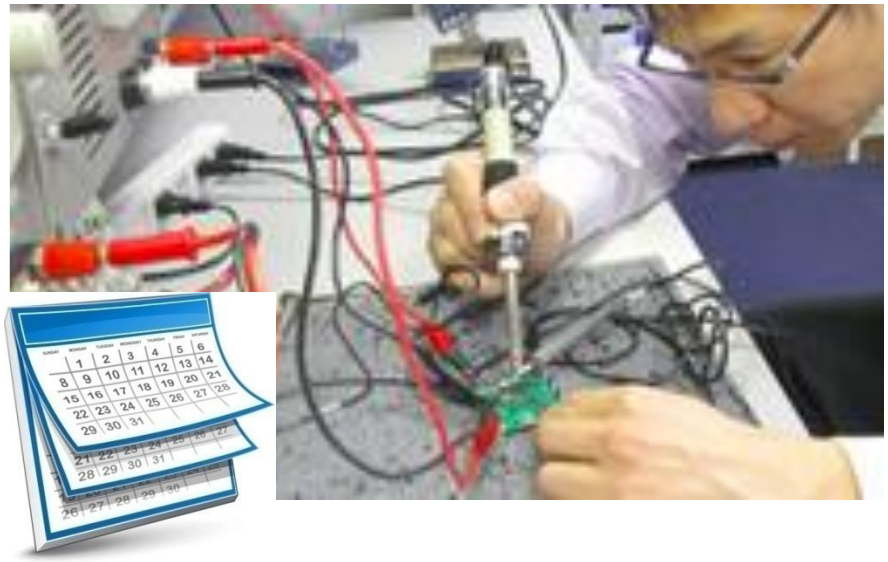
What is Power System Management (PSM)

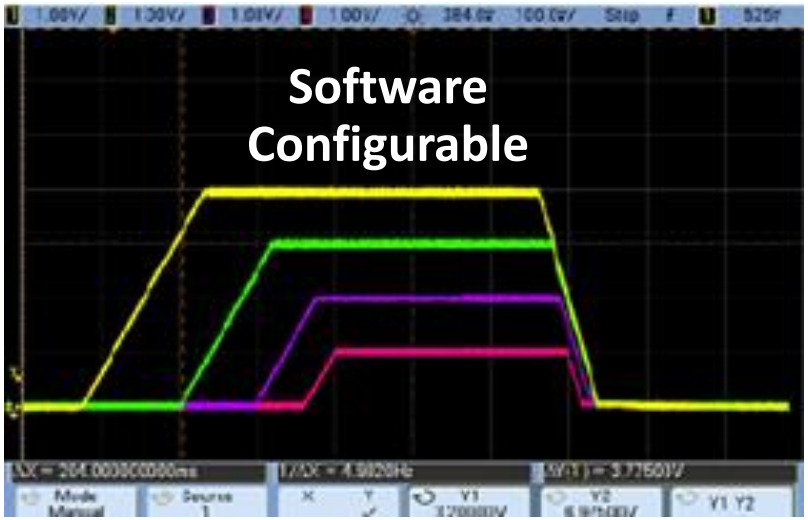


Digital Board Trends & Challenges

- Nanometer Processes: 20nm → 10nm
  - Supplies: 20 to 50, Sub-1V, 100A+, 1% to 3% Tolerance
- Hotter Boards and Chassis – 100ºC
- Shortening Design Cycles and parameters determined emipirically
- Complex & Changing Power-Up/Down Sequencing

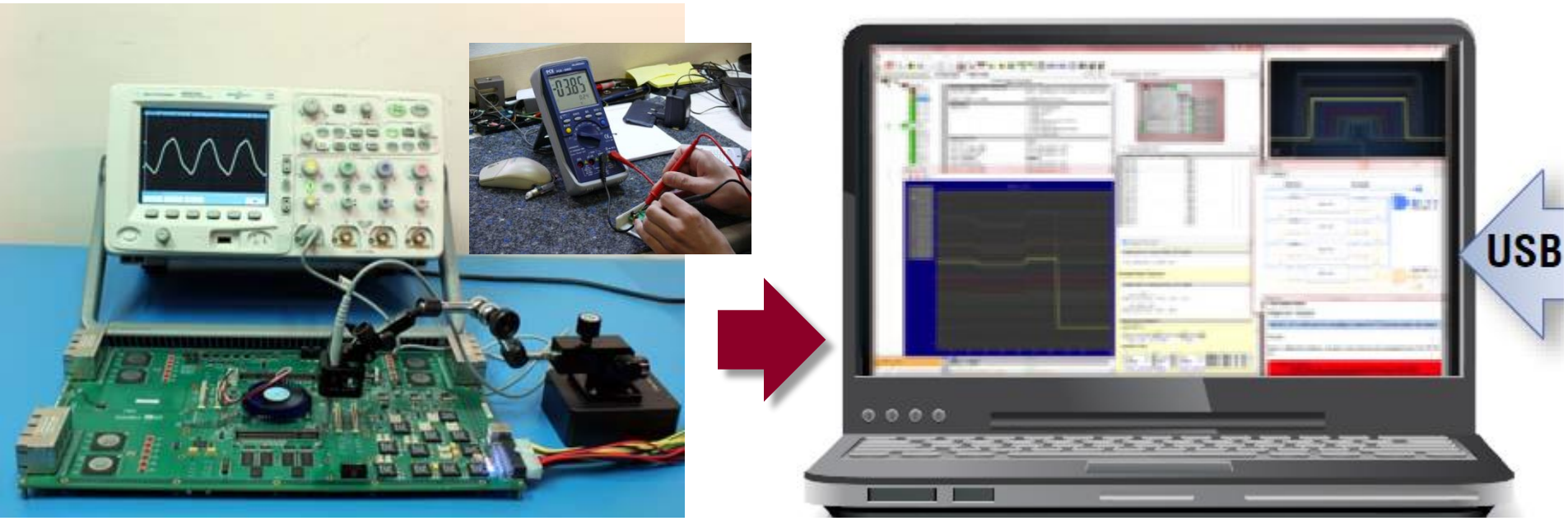
PSM System Benefit: Reduced Time to Market





- Single IC
- PSM Delivers Software Model of Rapid Prototyping to Hardware
- Easy Last-Minute Tweaks Avoid Board Spins & Project Slips
- Field Upgrades Via Firmware

PSM System Benefit: Insight into Power System



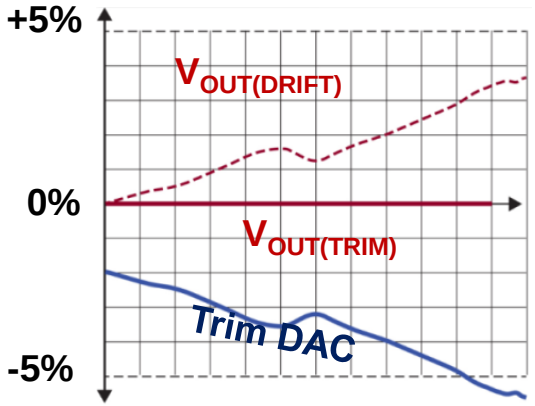
- From Computer Instead of Voltmeters & Oscilloscopes
- Improve Board Reliability
- Correlate Failures to Voltage & Current Patterns
- Monitor and Optimize Energy Consumption

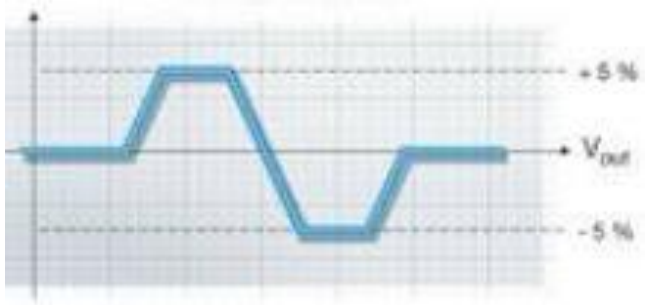
PSM System Benefit: Speed Up Failure Analysis

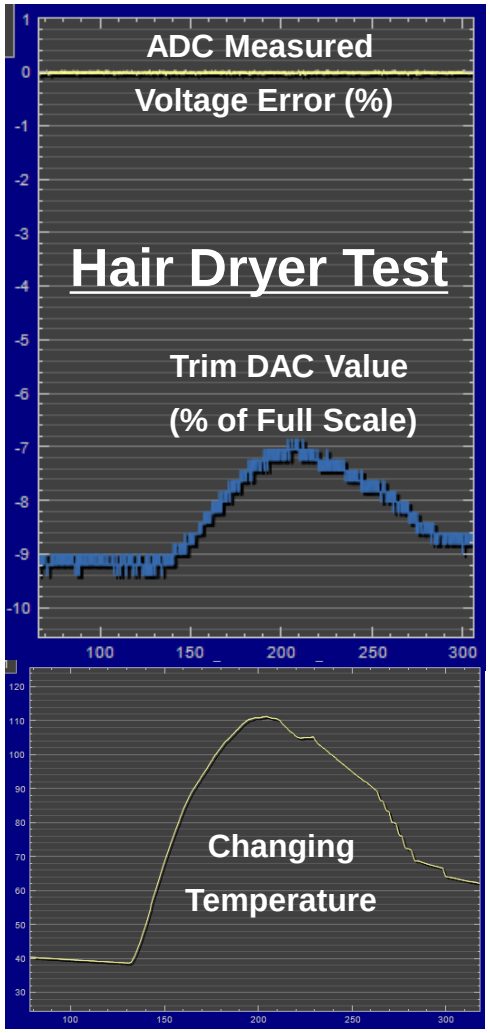
- EEPROM Black Box Recorder (I/V/Temp)
- Remote Debug

PSM Design Benefits

- Trim/Margin/Monitor Supply to **±0.25%** Precision

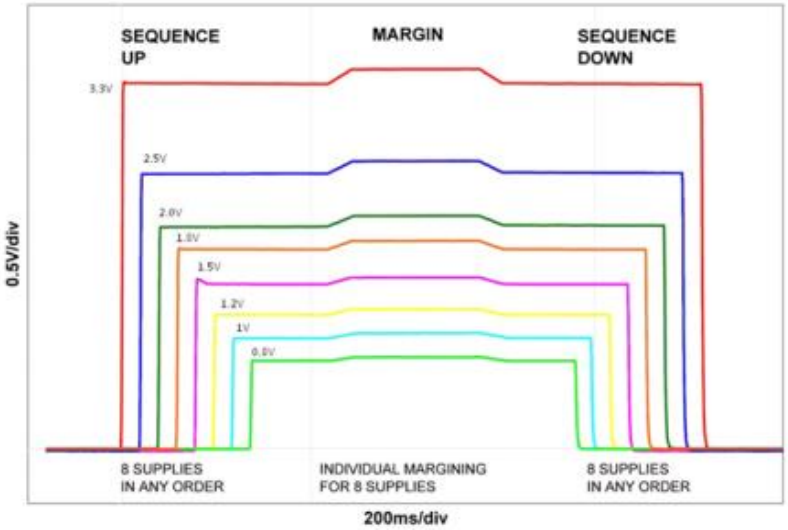




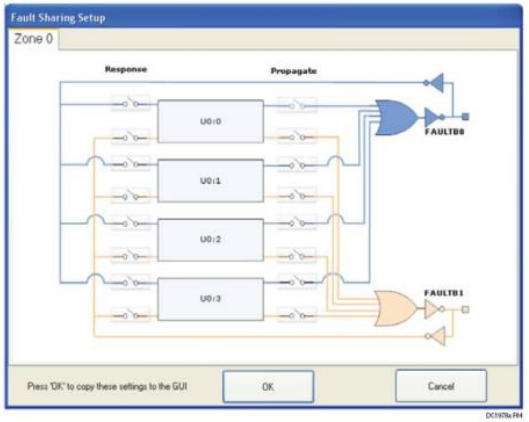


PSM Design Benefits

- Sequence/Track Multiple Rails Easily



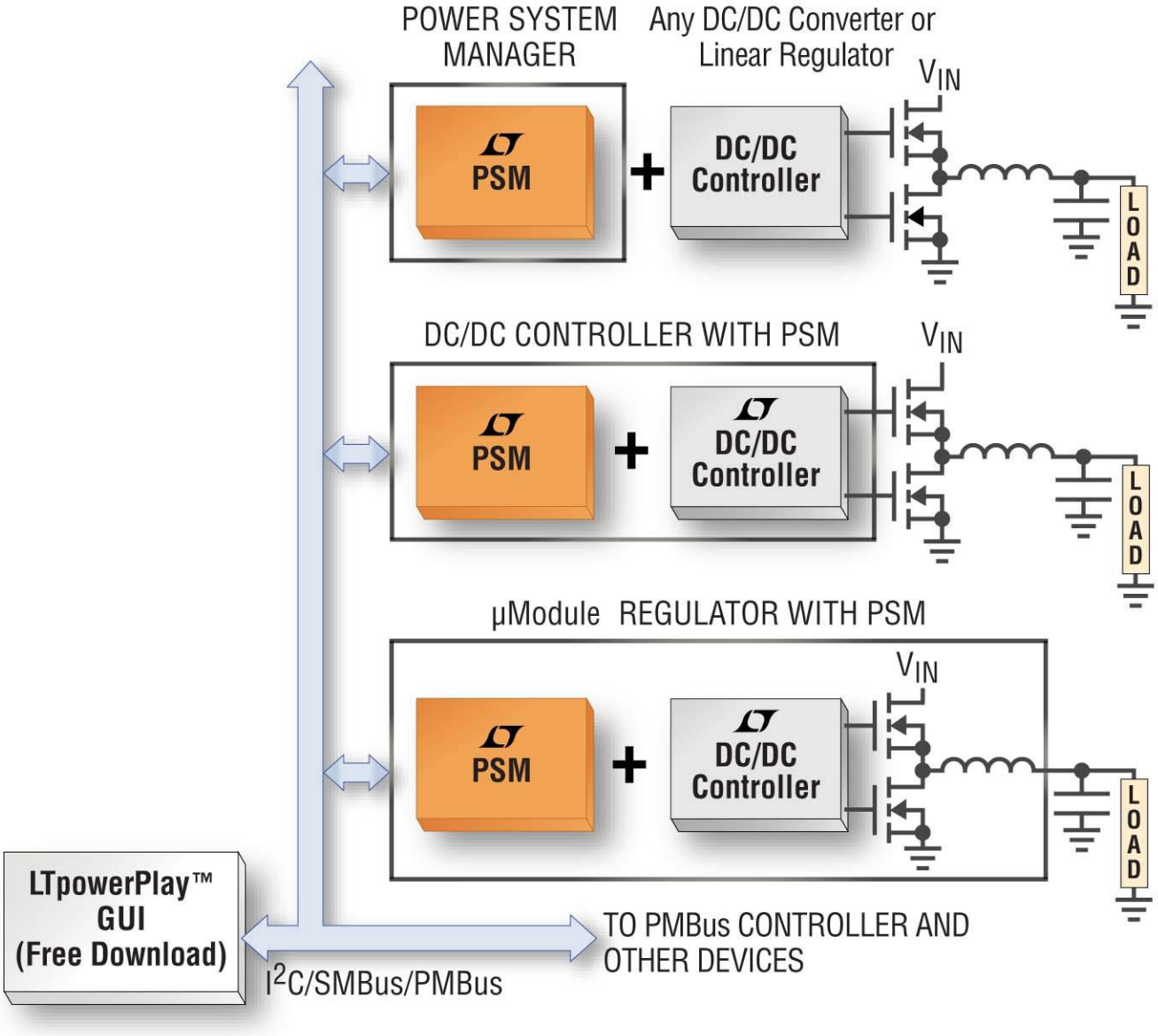
- UV/OV/UC/OC/UT/OT Supervise to Protect Expensive Electronics
- Monitor V_{IN}, I_{IN}, P_{IN}, E_{IN}, V_{OUT}, I_{OUT}, P_{OUT}, Temperature
  - Monitor Board Health, Power Consumption vs Load/Traffic
- Fault Log & Manage
  - Log Faults to EEPROM
  - Response: Ignore, Delayed, Latchoff, Retry 1-6x or ∞
  - Supply Zones for Fault Propagation



LTC PSM Highlights

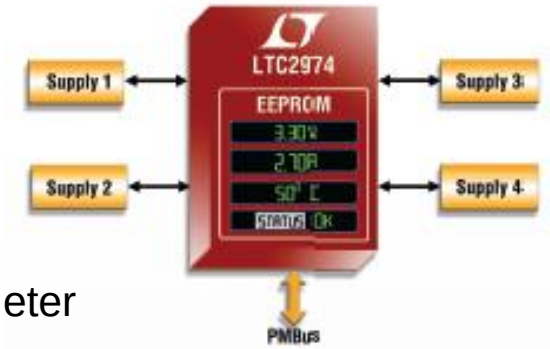
- Best-in-Class ±0.25% Voltage Accuracy
- Interoperable Products
  - Power System Managers
  - DC/DC Controllers with PSM
  - Fully Integrated µModule Regulators
- LTpowerPlay GUI: Engineering-Level Development Environment
- PMBus Compliant Commands Over I^2C/SMBus Digital Interface
- EEPROM for Configuration and Black Box Fault Logging
- Autonomous Operation—No Software Coding Required
- Coordinate Sequencing and Fault Management Across PSM Devices
- Reduced BOM Cost and Validation Effort

LTC PMBus Solutions

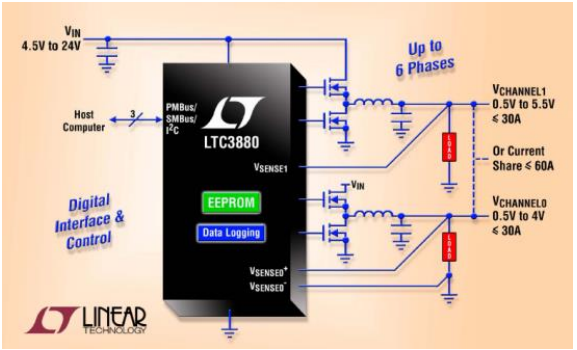


Power System Management (PSM) Lineup

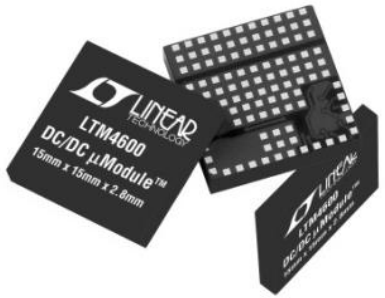
- Power System Manager Companion IC
  - Add Power System Management to any power supply
    - LTC2977: Octal Power System Manager
    - LTC2974: Quad Power System Manager
    - LTC2975: Quad Power System Manager with Input Energy Meter
    - LTC2980: 16 channel Power System Manager
    - LTM2987: 16 Channel Power System Manager with Integrated Filters



- DC/DC Converters with PSM
  - Analog Control Loop plus Power System Management
    - LTC3887: Dual Output Poly-Phase Current Mode DC/DC
    - LTC3883: Poly-Phase Current Mode DC/DC
    - LTC3882: Dual Output Poly-Phase Voltage Mode DC/DC
    - LTC3884: Dual Output Sub-milliohm DCR Current Mode DC/DC

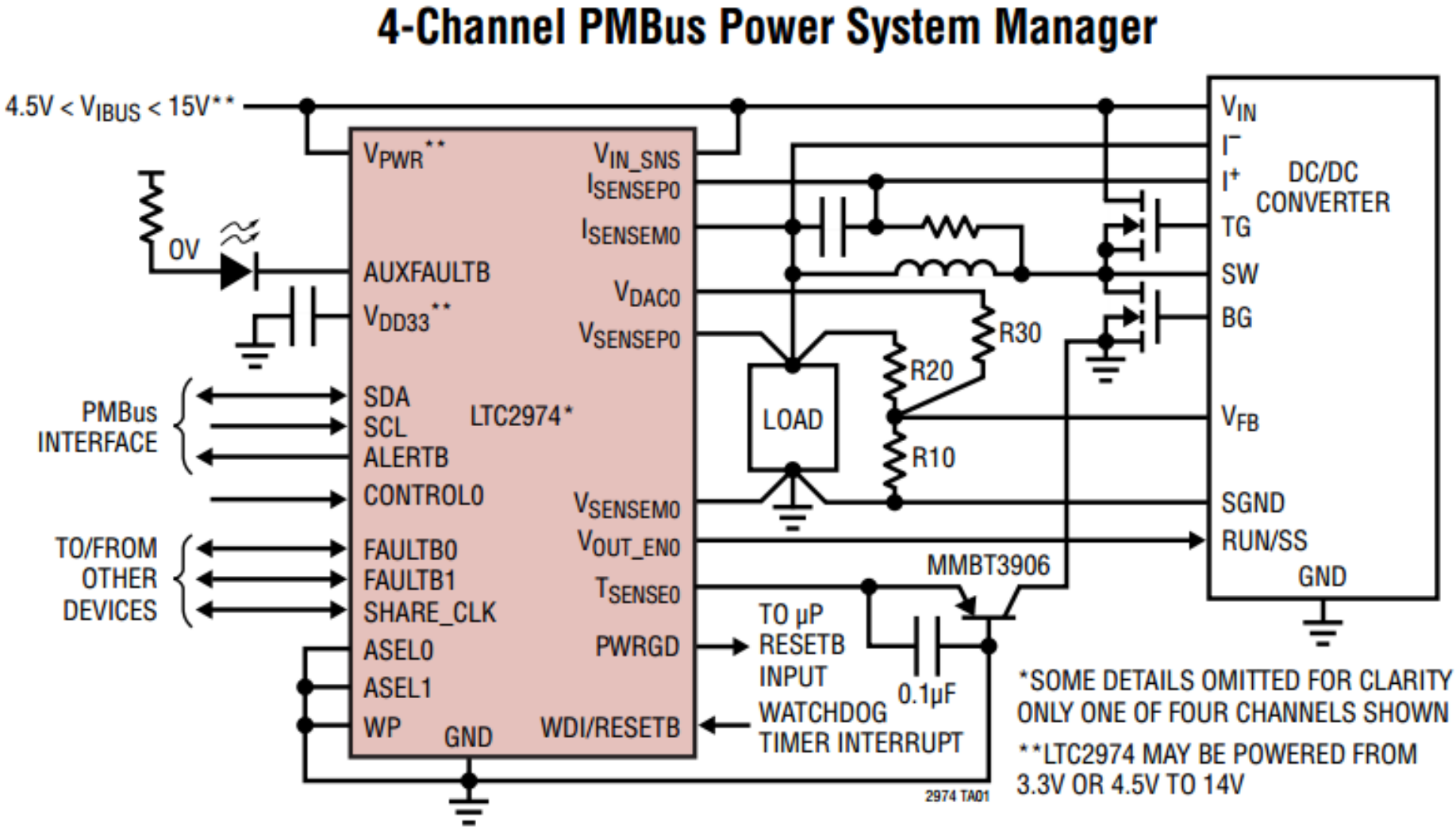


- DC/DC µModules with PSM
  - LTM4675 (Dual 8A Output) in 11.9mmX16mm BGA
  - LTM4676 (Dual 13A Output) in 16mmx16mm BGA
  - LTM4677 (Dual 18A Output) in 16mmX16mm BGA



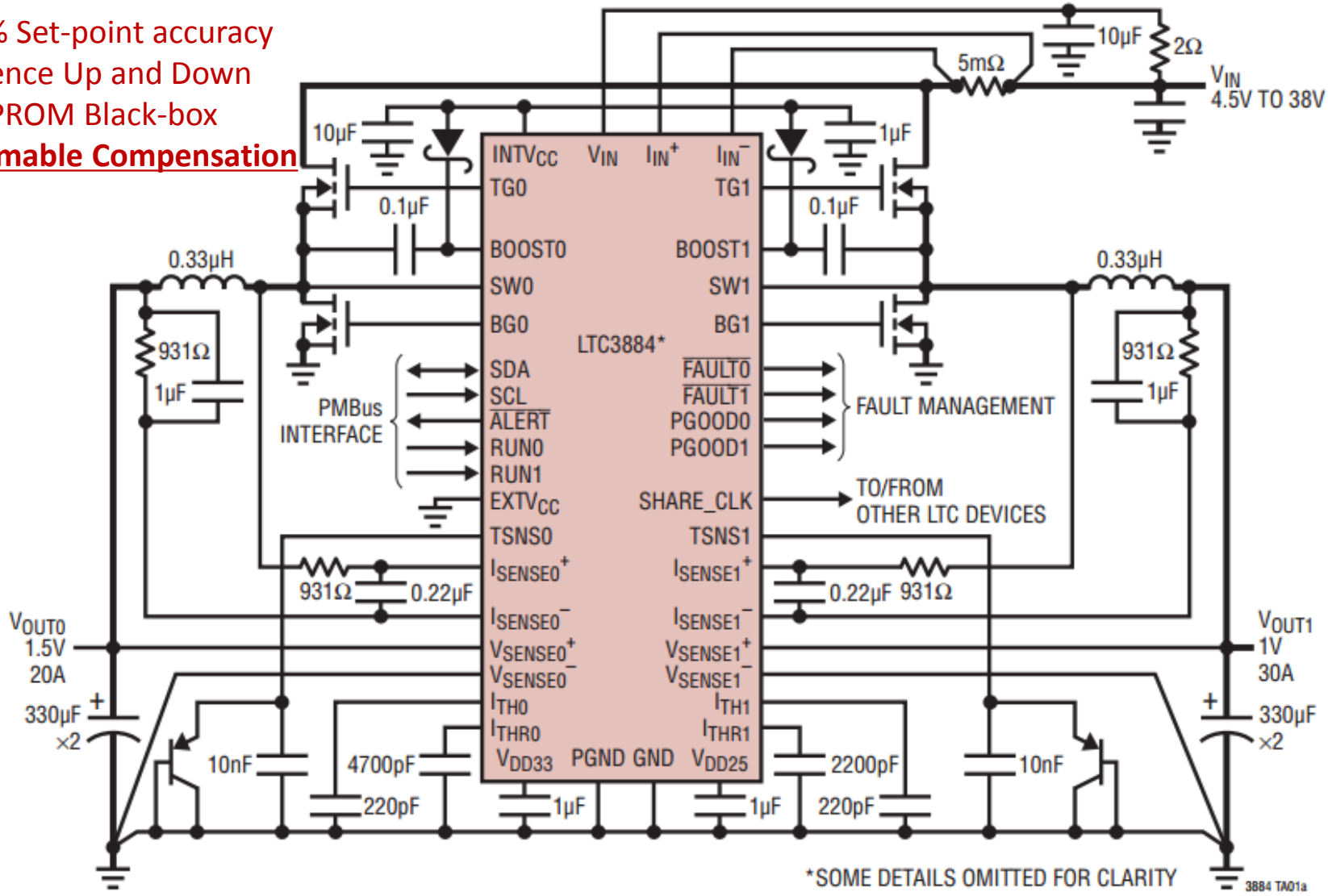
PSM Companion IC

- ± 0.25% Set-point accuracy
- Sequence Up and Down
- EEPROM Black-box

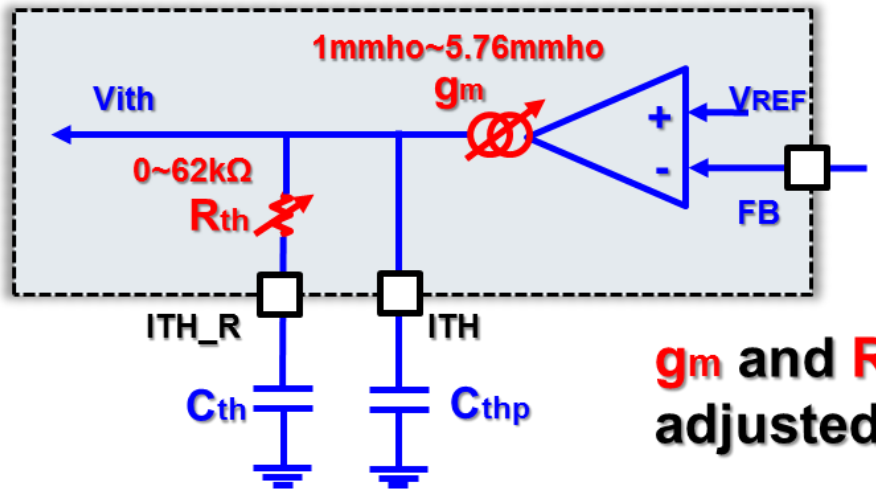


DC/DC Converter with PSM

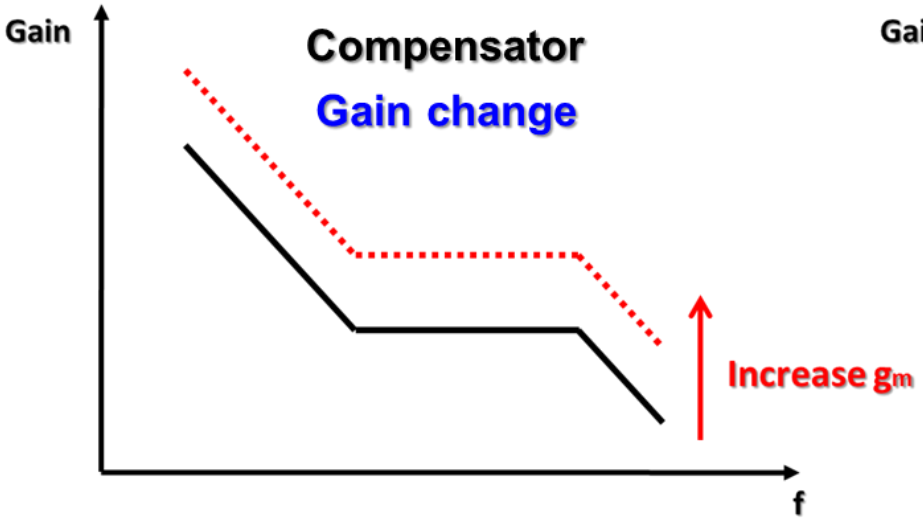
- ± 0.5% Set-point accuracy
- Sequence Up and Down
- EEPROM Black-box
- **Programmable Compensation**

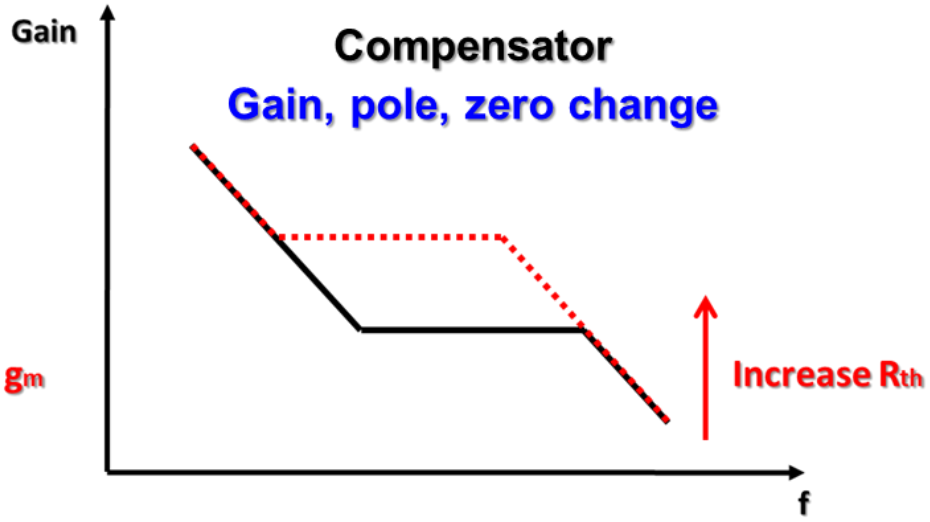


LTC3884: Programmable Compensation

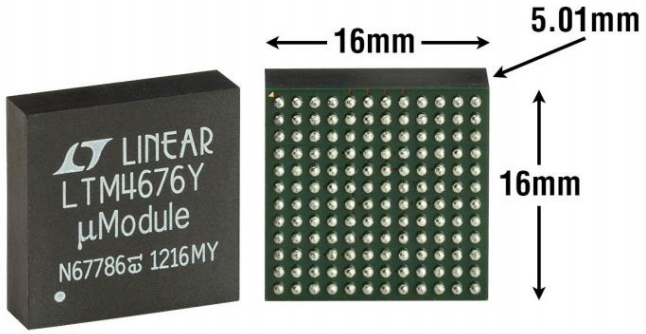


gm and Rth can be adjusted through PMBus

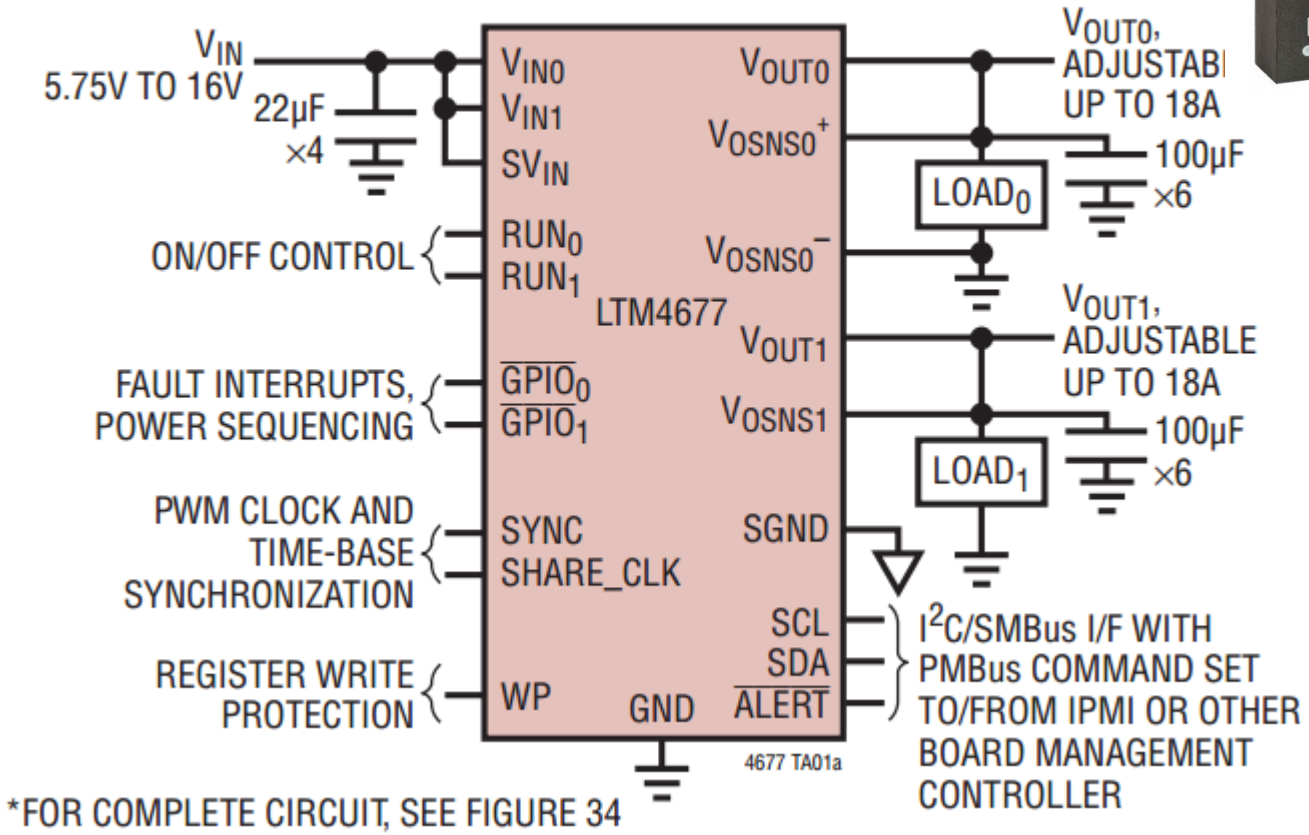




DC/DC Integrated uModule with PSM

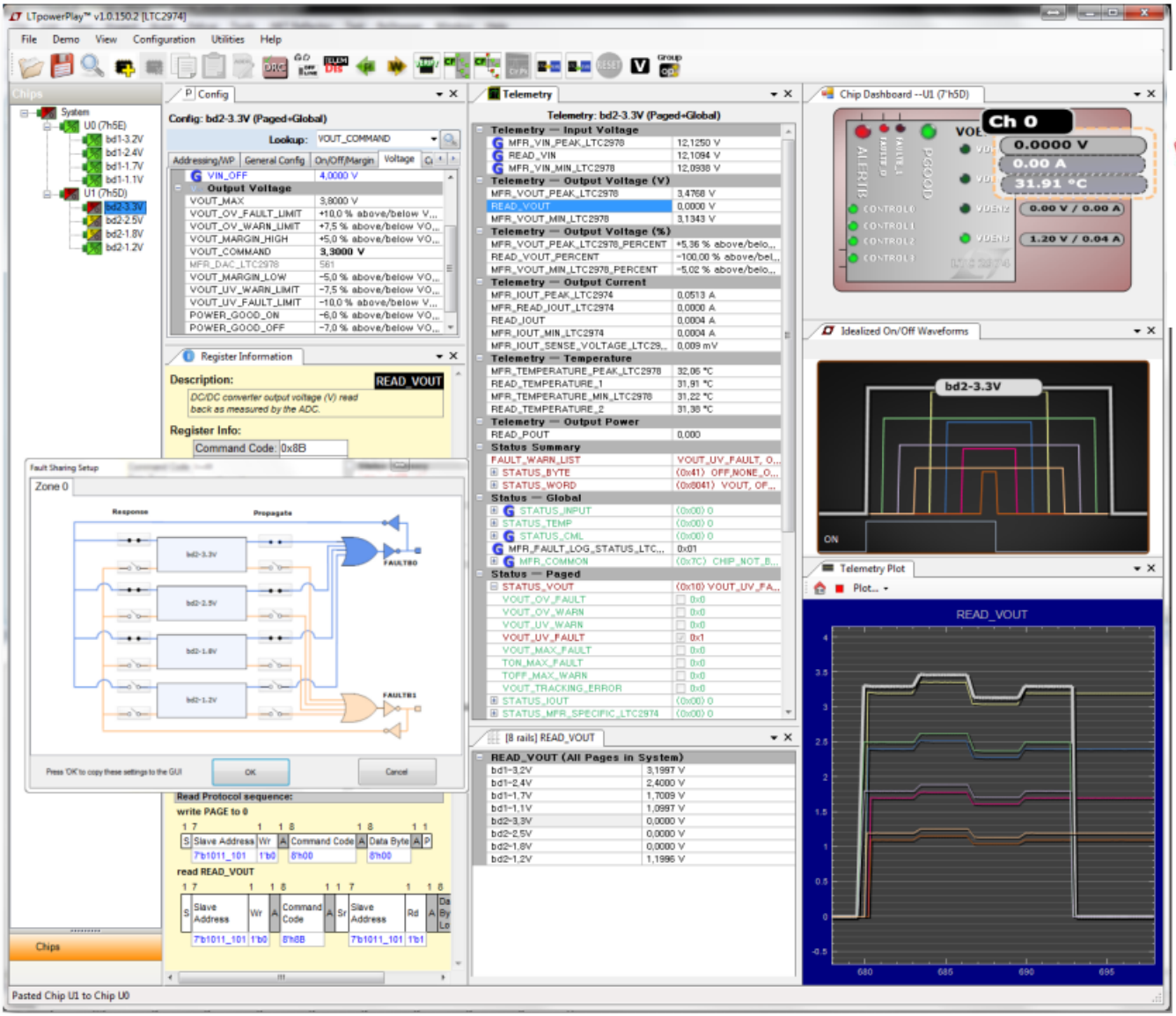


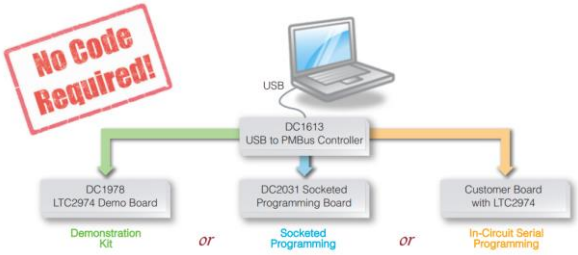
Dual 18A µModule Regulator with Digital Interface for Control and Monitoring*



*FOR COMPLETE CIRCUIT, SEE FIGURE 34

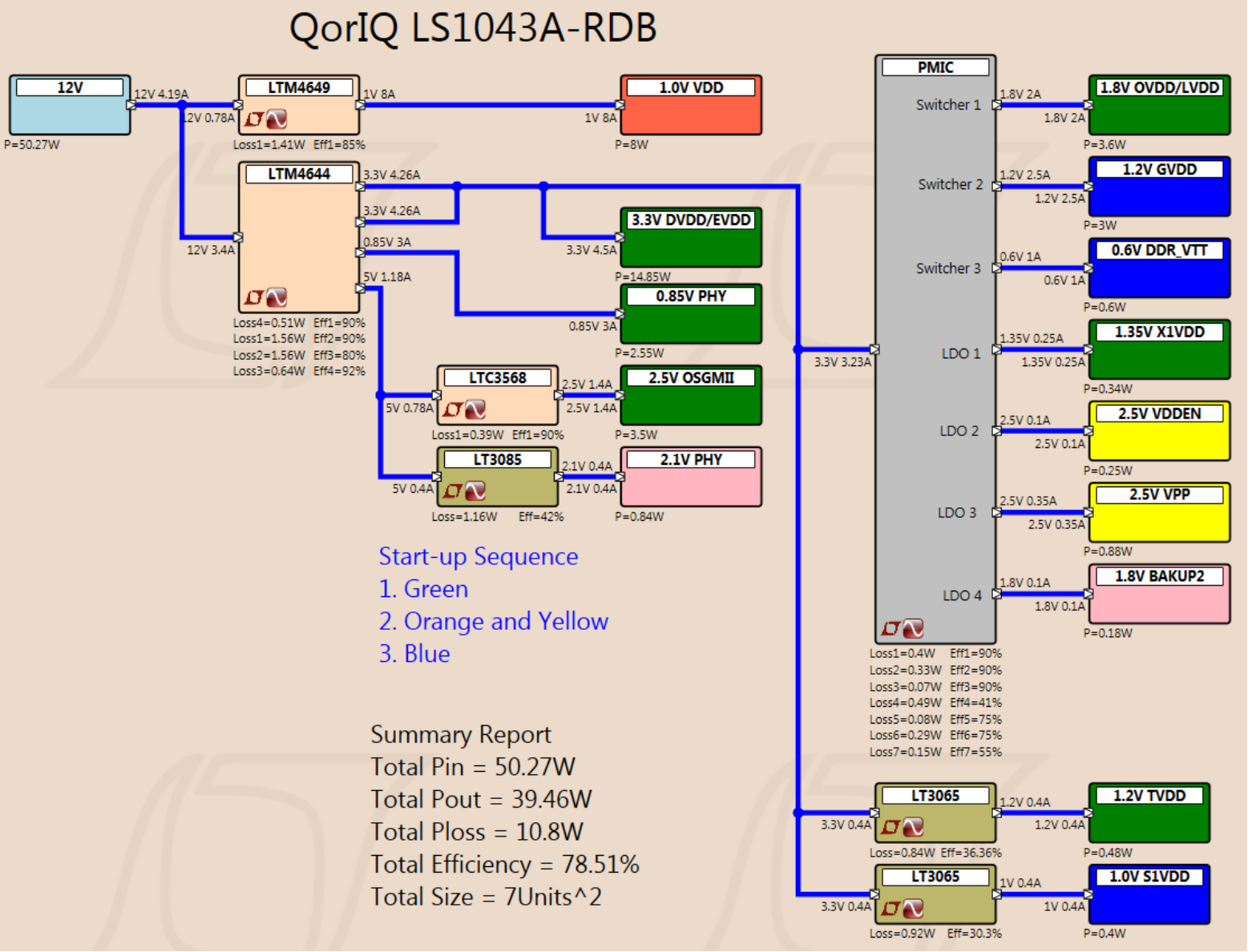
One GUI to rule them all…





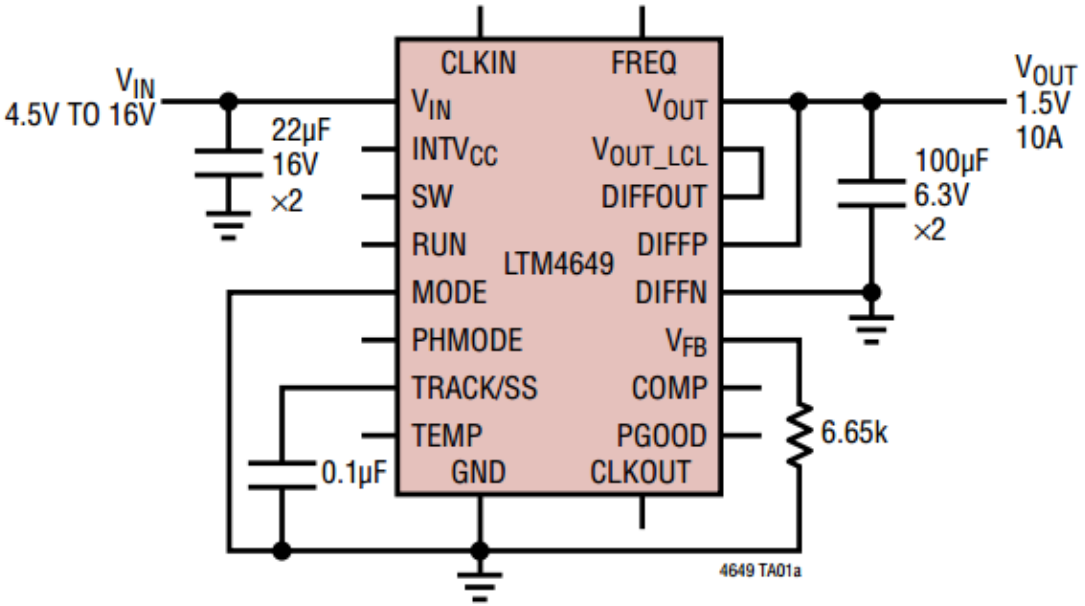
- View and change registers for board bring up
- Data log the system for long term testing
- Test sample code and functionality
- **Remote Debugging**

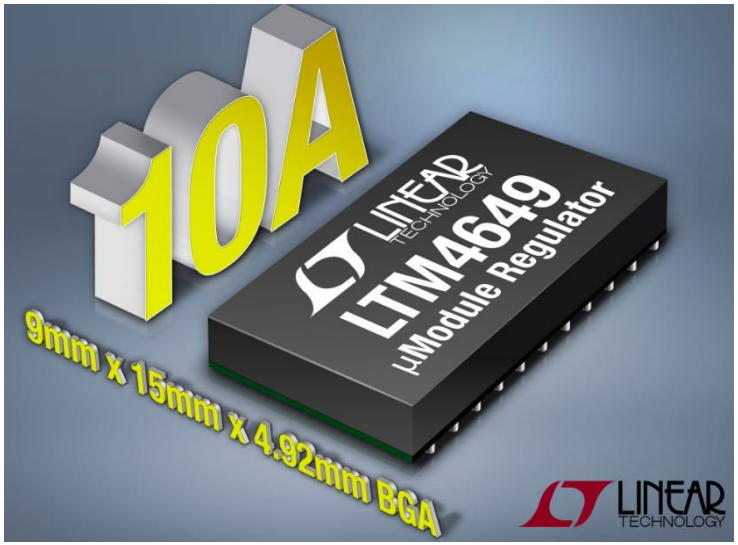
LS1043



LTM4649: 10A Step-Down DC/DC µModule Regulator

- 10A DC Output Current
- VIN: 4.5V - 16V
- VOUT: 0.6V - 3.3V
- No Heat Sink or Current Derating Up to 85°C Ambient Temperature
- ±1.5% Total DC Voltage Output Error
- Multiphase Operation with Current Sharing
- Remote Sense Amplifier

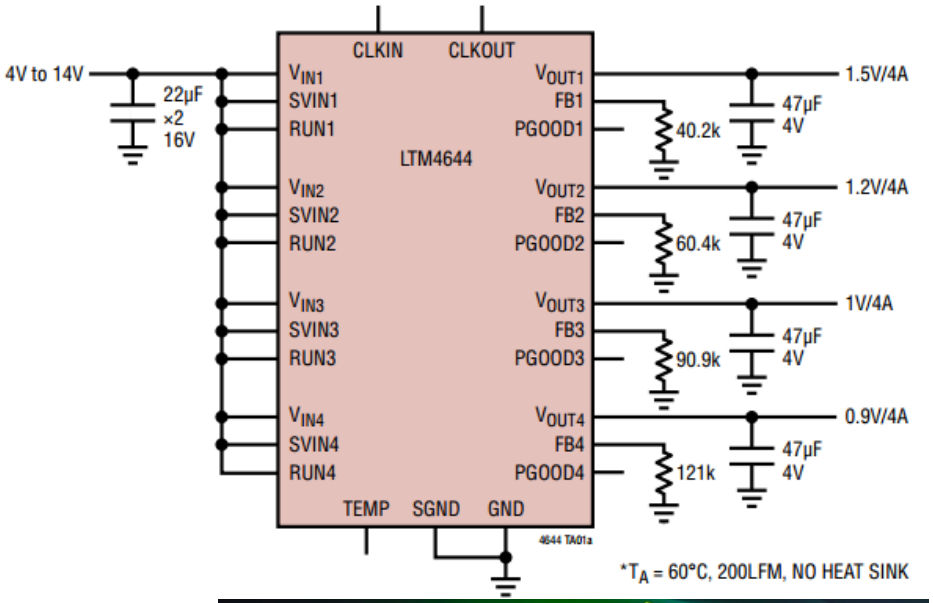


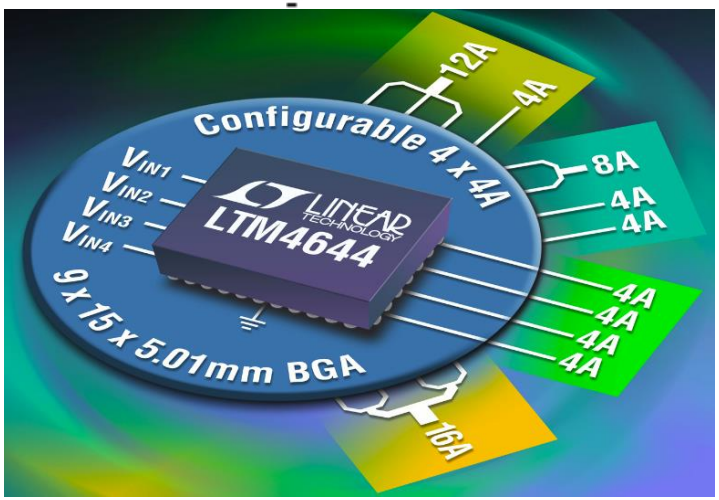


LTM4644: Quad 4A Step-Down DC/DC µModule Regulator

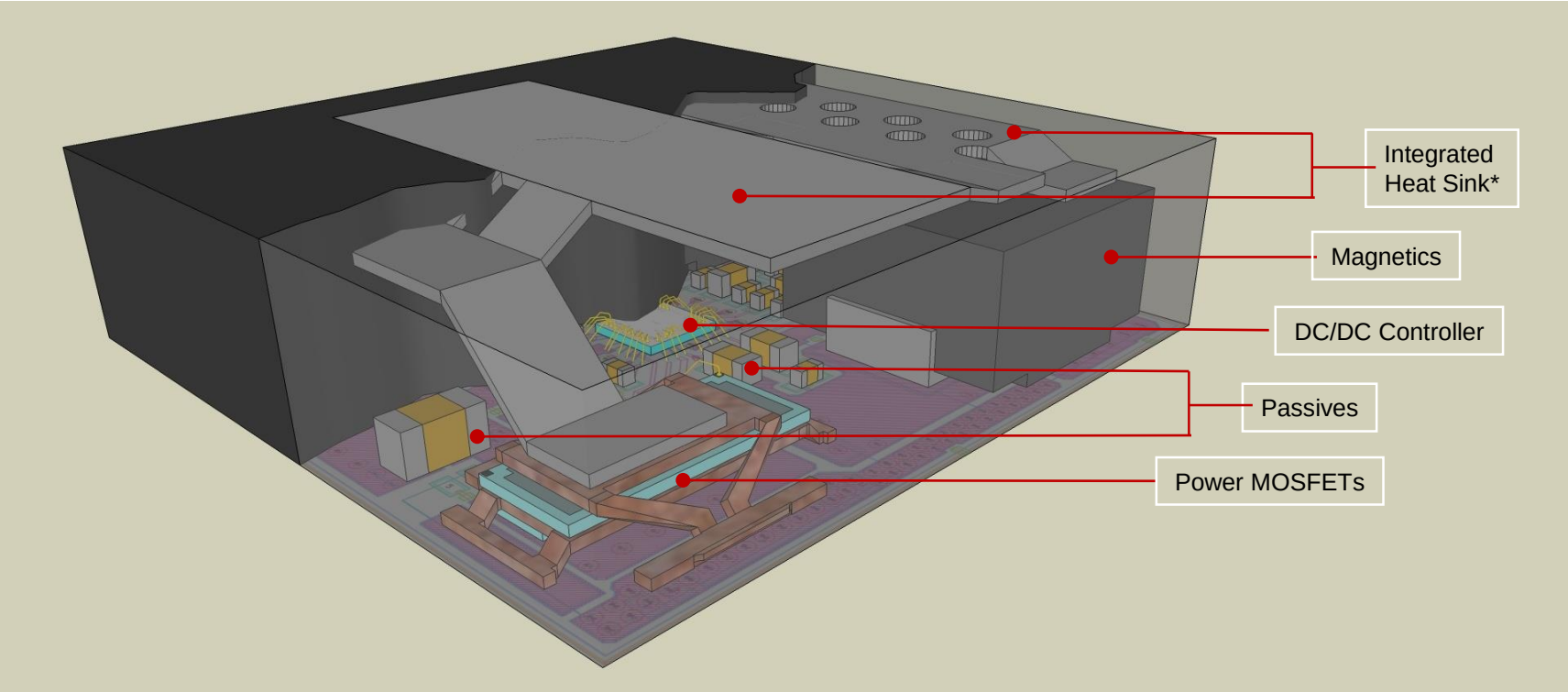
- Quad 4A DC Output Current
- VIN: 4V - 14V
- VOUT: 0.6V – 5.5V
- Up to 5.5W Power Dissipation
- ±1.5% Total DC Voltage Output Error
- Multiphase Operation with Current Sharing

4V to 14V Input, Quad 0.9V, 1V, 1.2V and 1.5V Output DC/DC µModule Regulator*





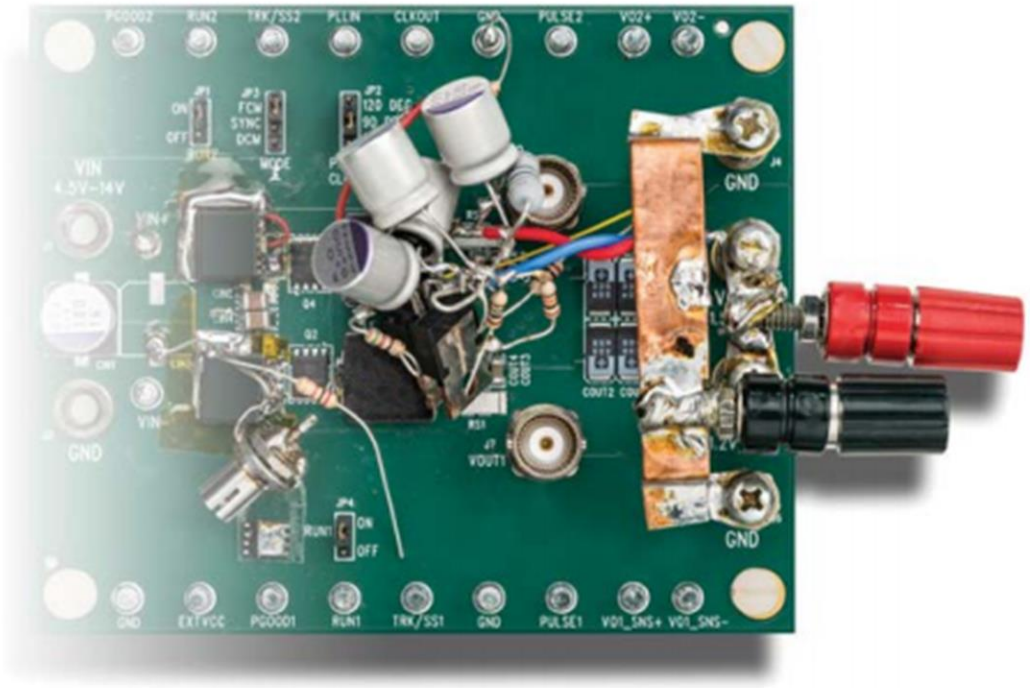
What is a µModule Power Product?

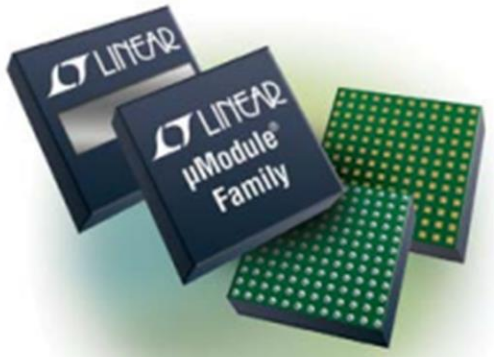


A µModule® Power Product Simplifies Implementation, Verification, and Manufacturing of Complex Power Circuits by Integrating the Power Function in a Compact Molded Plastic Package

* Example: LTM4620, LTM4620A, & LTM4637 step-down µModule regulators

Time to market





Complete Power System-in-a-Package

Reliability

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 15X09	75	1228	1228	75	0
BGA 15X15	529	1141	1227	452	0
LGA 15X09	941	0634	1247	903	0
LGA 15X15	2448	0452	1223	2259	0
Totals	3,993	-	-	3,727	0

HIGHLY ACCELERATED STRESS TEST AT +131 DEG C /85% RH					
PACKAGE TYPE	SAMPLE SIZE	OLDEST DATE CODE	NEWEST DATE CODE	K DEVICE HRS (+85°C)[4]	No. of FAILURES
BGA 15X09	304	1213	1330	1839	0
BGA 15X15	304	1235	1316	1927	0
LGA 15X15	1621	0645	1237	10680	0
Totals	2,229	-	-	14,455	0

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	154	1245	1306	192	0
BGA 15X09	533	1150	1306	568	0
BGA 11X15	77	1304	1304	77	0
BGA 15X15	1892	1148	1320	1651	0
LGA 15X09	983	0634	1317	1166	0
LGA 11X15	153	1304	1304	153	0
LGA 15X15	9413	0643	1319	11099	0
Totals	13,205	-	-	14,906	0

TEMP CYCLE FROM -65 TO 150 DEG C					
PACKAGE TYPE	SAMPLE SIZE	OLDEST DATE CODE	NEWEST DATE CODE	K DEVICE CYCLES	No. of FAILURES
BGA 15X09	149	1213	1228	259	0
BGA 15X15	1871	1141	1235	1520	0
LGA 06X06	100	0646	0749	55	0
LGA 15X09	5243	0634	1309	2706	0
LGA 15X15	31797	0513	1320	15756	0
Totals	39,160	-	-	20,296	0

THERMAL SHOCK FROM -65 TO 150 DEG C					
PACKAGE TYPE	SAMPLE SIZE	OLDEST DATE CODE	NEWEST DATE CODE	K DEVICE CYCLES	No. of FAILURES
BGA 15X09	228	1213	1306	266	0
BGA 15X15	1434	1141	1235	1068	0
LGA 15X09	4861	0634	1309	2332	0
LGA 15X15	25552	0332	1320	11509	0
Totals	32,075	-	-	15,175	0

- FIT Rate = 0.49
- MTBF = 232k years

- 3.7M Operating Life Device Hours
- 22.2M Power Cycles
- 35.2M Temperature Cycles
- 3.1M Board Mount Temp Cycles
- 29.8M Thermal Shock Cycles
- 43.1M Hours of High Temp Bake
- 14.5M Hours HAST

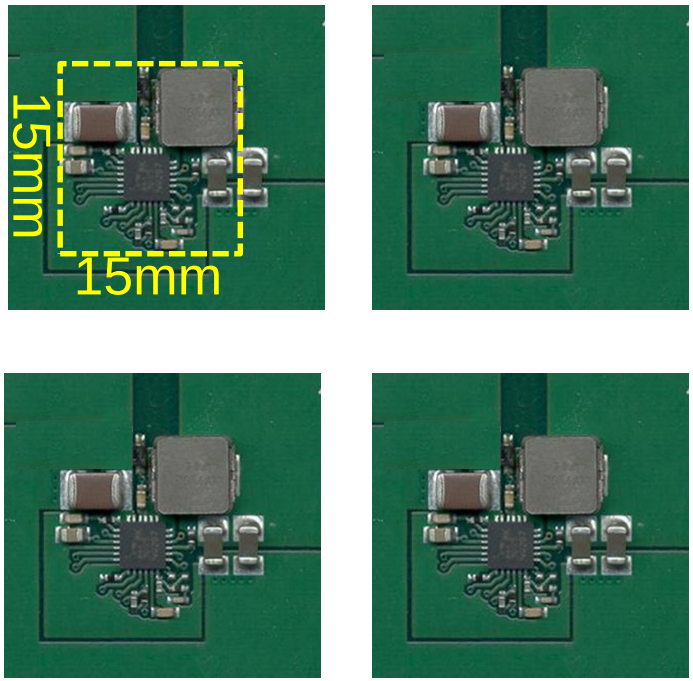
http://www.linear.com/designtools/packaging/umodule.php#rel

POWER CYCLE FROM 50 TO 100 DEG C					
PACKAGE TYPE	SAMPLE SIZE	OLDEST DATE CODE	NEWEST DATE CODE	K DEVICE CYCLES	No. of FAILURES
LGA 15X09	117	0712	0730	5850	0
LGA 15X15	347	0513	1048	16325	0
Totals	464	-	-	22,175	0

Board Space

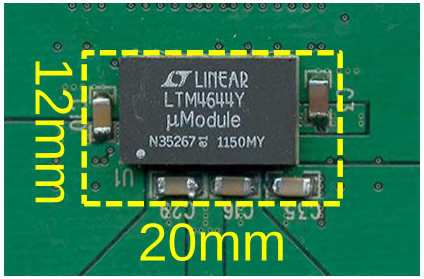
LTC3605 x 4

5A Monolithic Converters



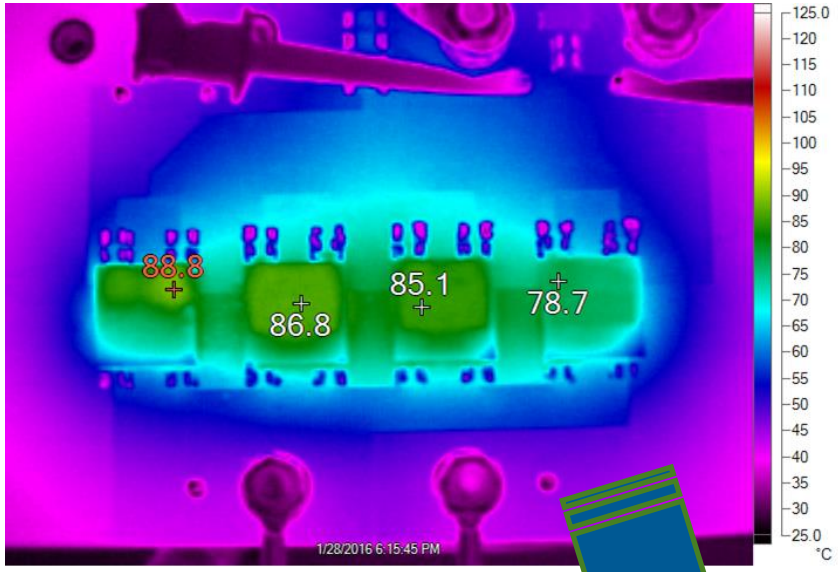
LTM4644

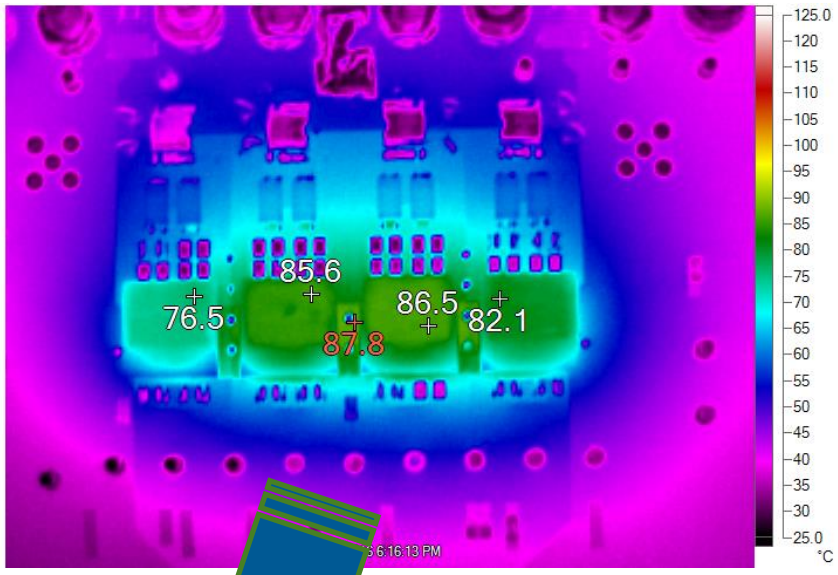
Quad 4A (5A Peak) DC/DC Module



- **900 mm² vs. 240mm² = 73% reduction**

Scalable (386A Design Below)

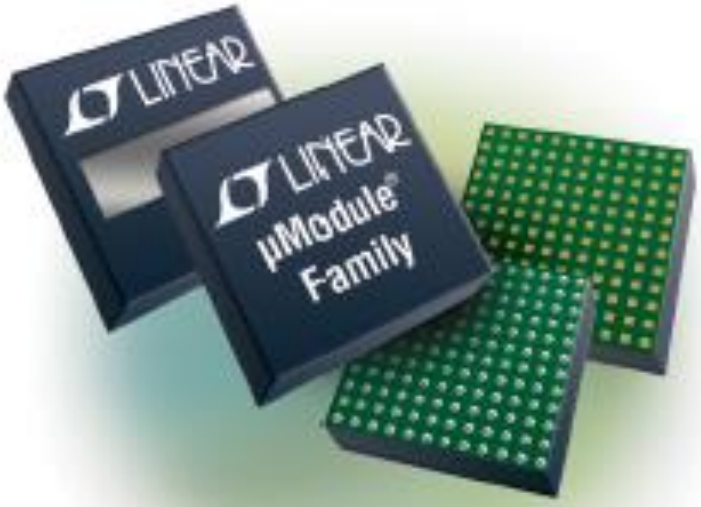




Test Conditions:

- 386A = 7 x LTM4650 50A + LTM4677 36A digital brain
- 12Vin
- 1Vout
- 425kHz switch frequency
- 400-450 LFM
- T_A = 25° C

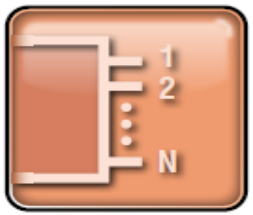
(top of devices are painted white for better quality thermal imaging)



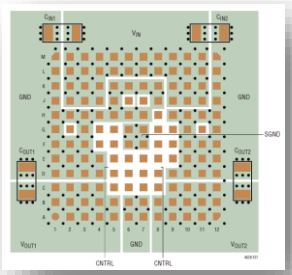
15 Product Families 100 µModule Power Products 30 Package Options

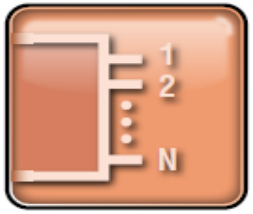
First uModule Introduced in 2004!!

Recommended Solutions for QorIQ Processors

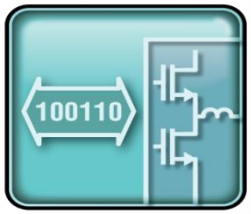


Multiple Output

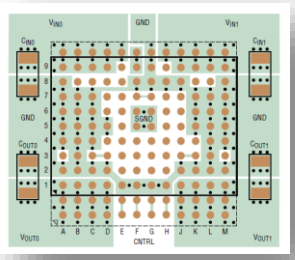




Multiple Output



Digital Power System Management



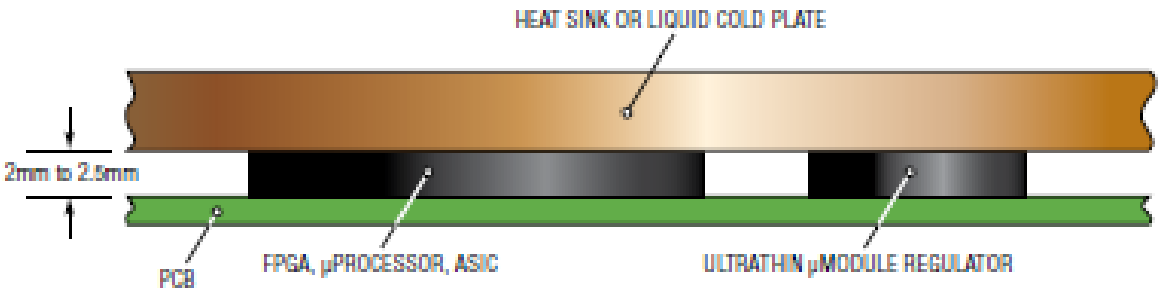
Non PMBus	Output	Size		PMBus	Output	Size
LTM4628	Dual 8A, Single 16A	15x15		LTM4675	Dual 9A, Single 18A	16x11.9
LTM4620(A)	Dual 13A, Single 26A	15x15		LTM4676(A)	Dual 13A, Single 26A	16x16
LTM4630(A), LTM4630-1	Dual 18A, Single 36A	16x16		LTM4677	Dual 18A, Single 36A	16x16
LTM4650, LTM4650-1	Dual 25A, Single 50A	16x16		LTM467x (2016/2017)	Dual 25A+, Single 50A+	TBD
Pin Compatible, package sizes may vary				Pin Compatible, package sizes may vary		

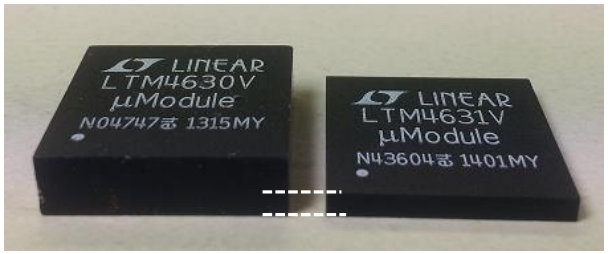
Ultrathin uModules

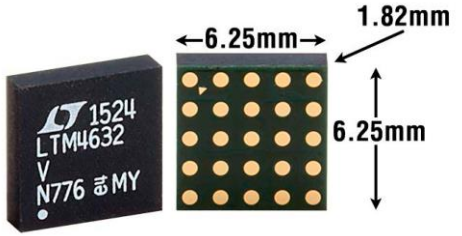
Ultrathin 1.82mm, 20V_{IN} µModule Regulators

	LTM4622	LTM4623	LTM463x**	LTM4632
	Dual Step-Down	Single Step-Down	Dual Step-Down	For DDQ/QDR
Vin Range	3.6V* to 20V	4V to 20V	4.5V to 15V	3.6V* to 15V
Vout Range	0.6V to 5.5V	0.6V to 5.5V	0.6V to 1.8V	0.6V to 2.5V
Iout	2.5A x 2	3A	10A x 2	±3A x 2 (V_{DDQ}, V_{TT}) 10mA (V_{REF})
Package Type	LGA (BGA available)	LGA (BGA available)	LGA	LGA
Package Size (mm)	6.25 x 6.25 x 1.82	6.25 x 6.25 x 1.82	16 x 16 x 1.82	6.25 x 6.25 x 1.82

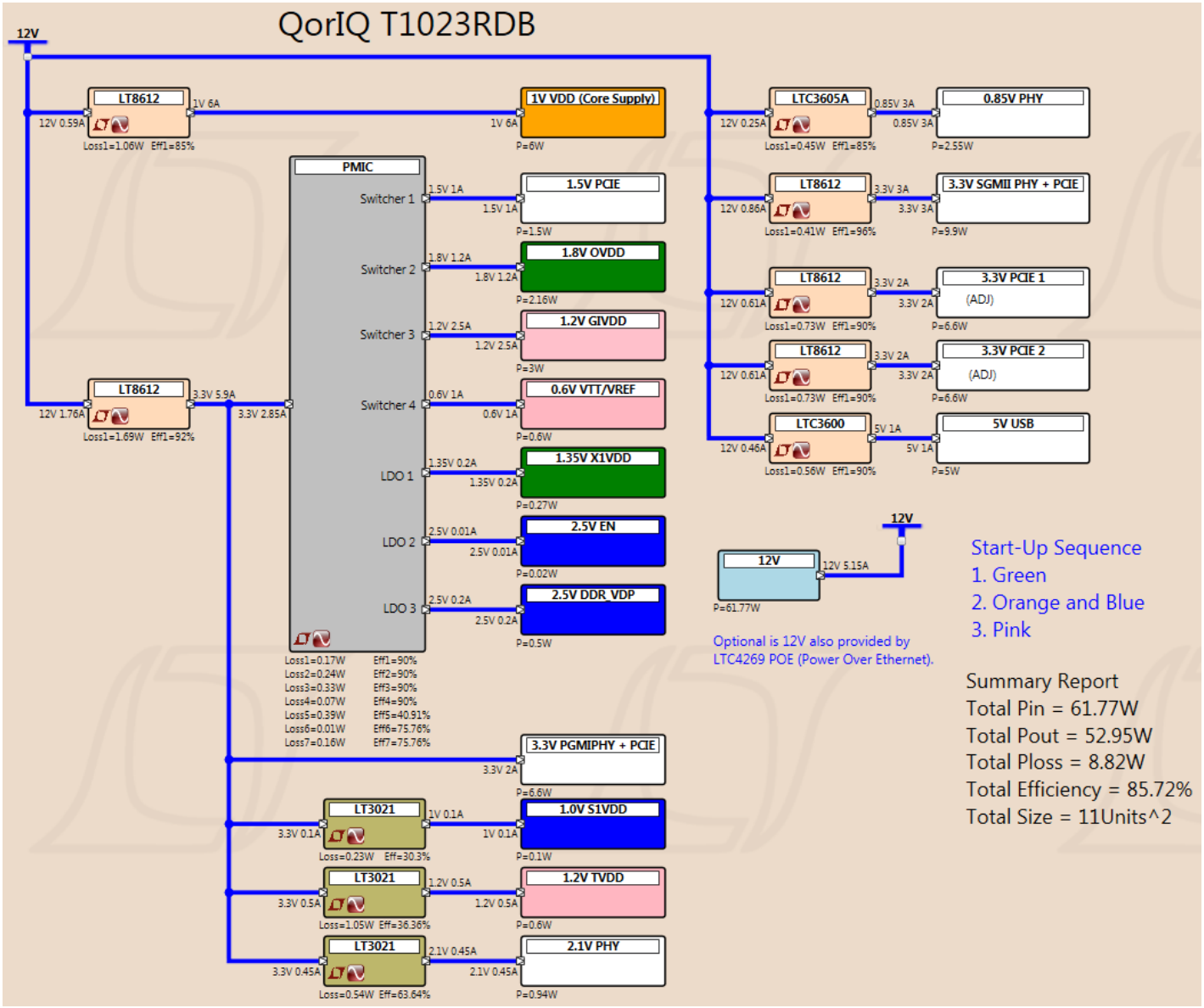
Ultrathin µModule Regulators Fit Under the FPGA Heat Sink





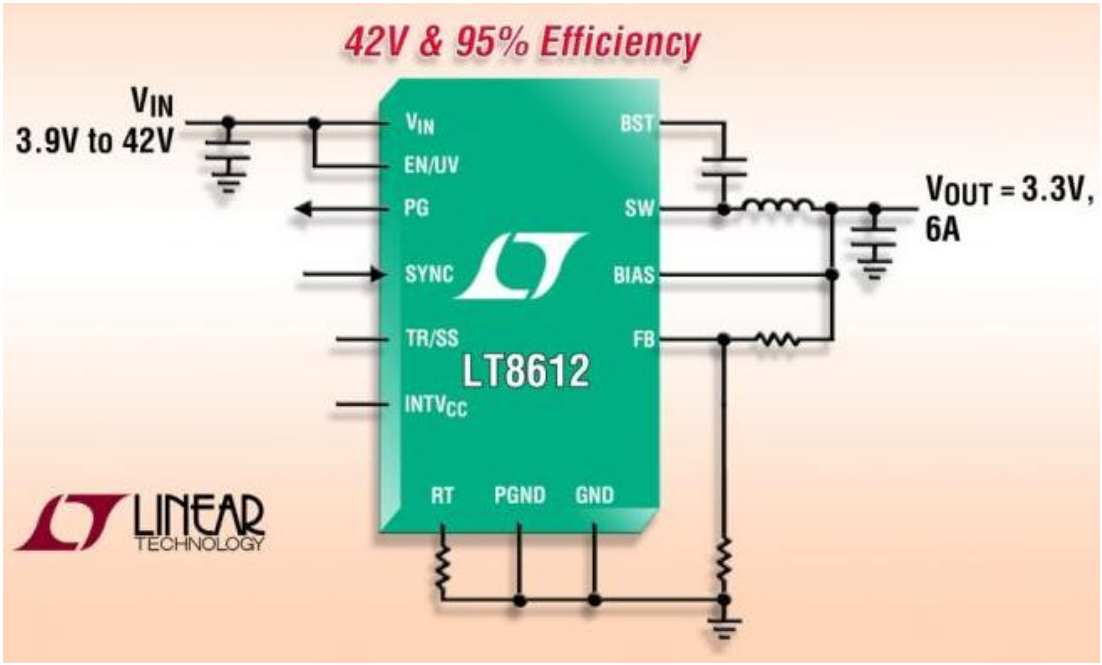


T1023

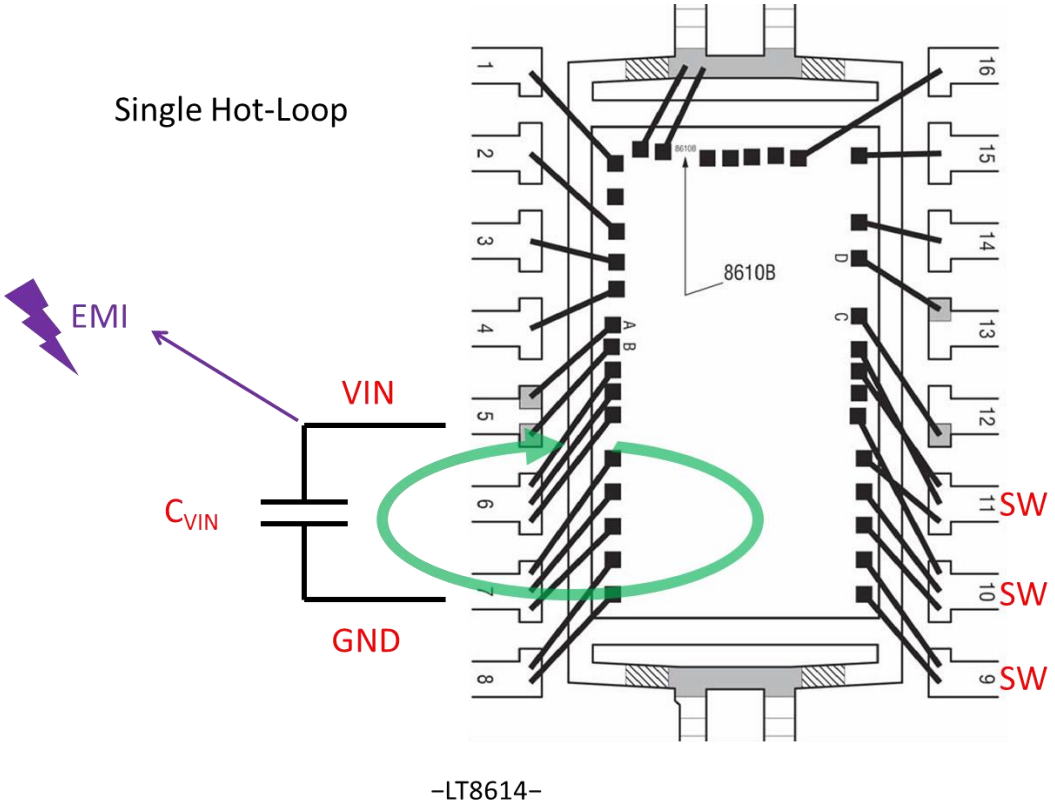


LT8612: 6A Synchronous Monolithic Switching Regulator

- VIN: 3.4V to 42V
- 3µA Burst Mode® operation quiescent current with low <10mVp-p output ripple
- Fast 40ns on-time
- Frequency: 200kHz-2.2MHz
- Low dropout under all conditions: 250mV at 3A
- Soft-start and output voltage tracking
- Internal compensation



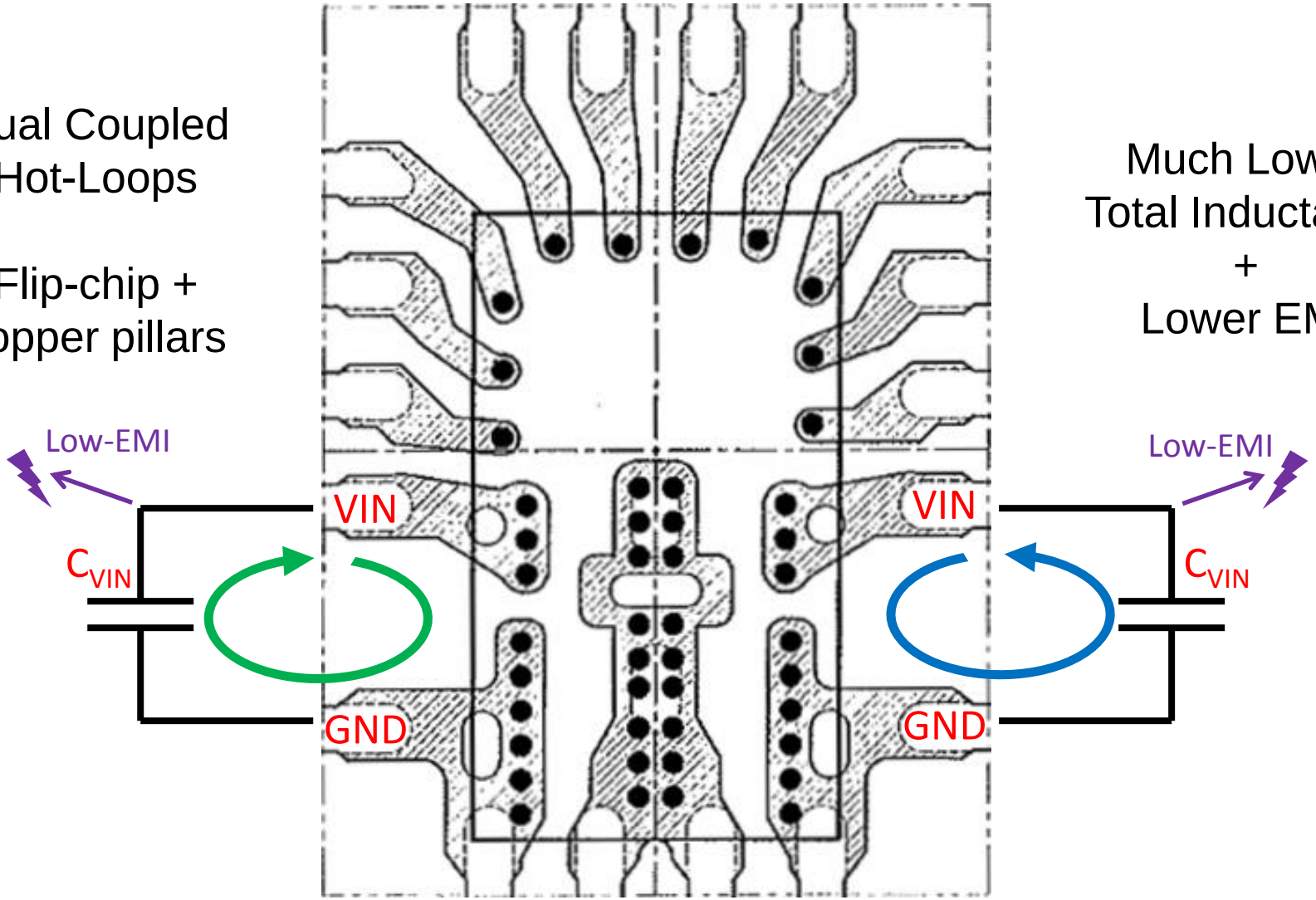
Traditional Monolithic: LT8610



Silent Switcher Monolithic

Dual Coupled
Hot-Loops

Flip-chip +
copper pillars



Much Lower
Total Inductance
+
Lower EMI

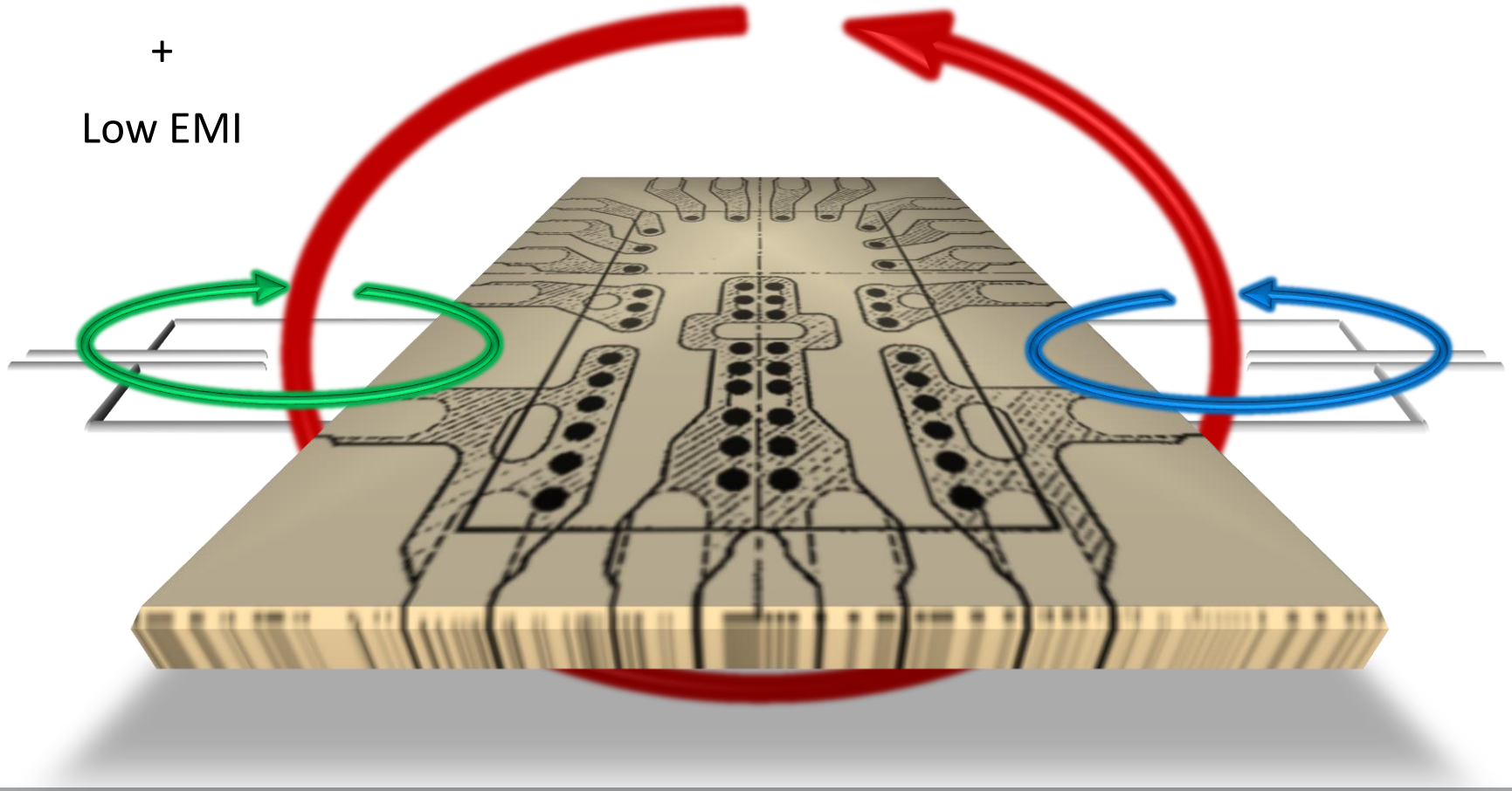
Silent Switcher Technology

Confined

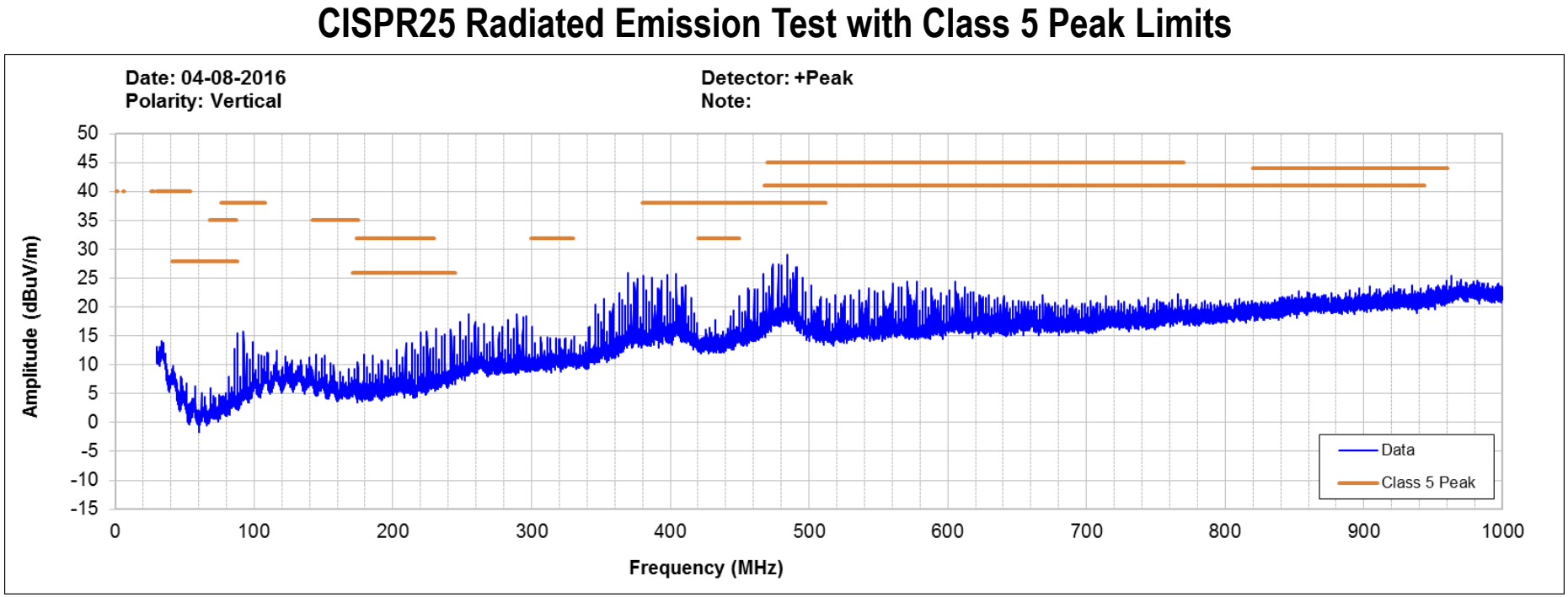
Magnetic Field

+

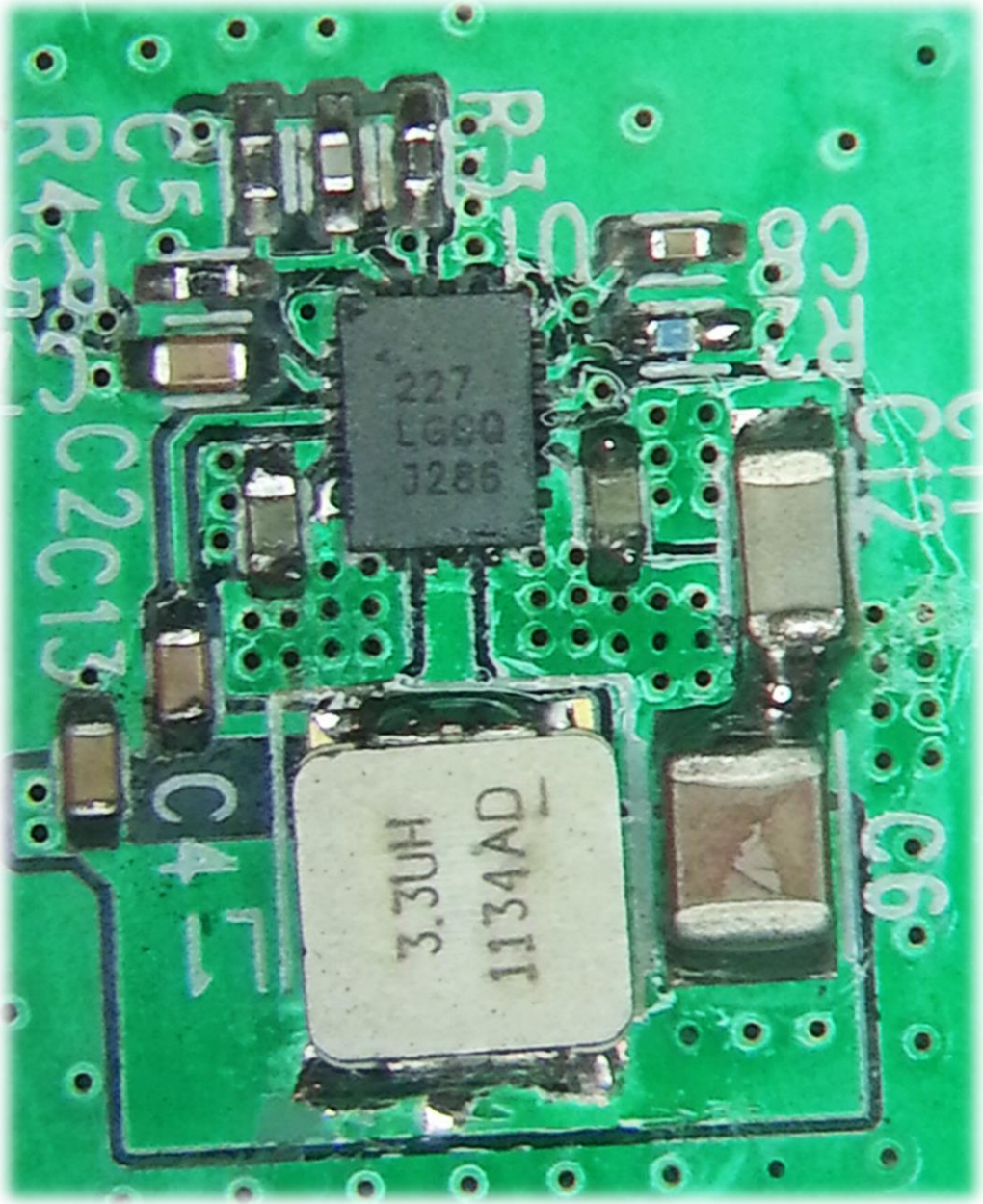
Low EMI



Low noise switching regulators



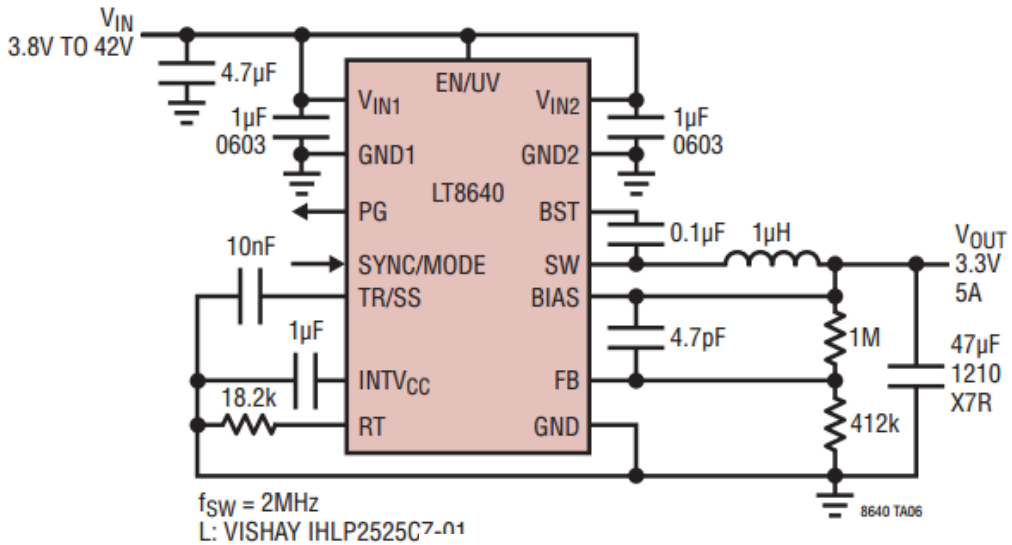
3mmx4mm



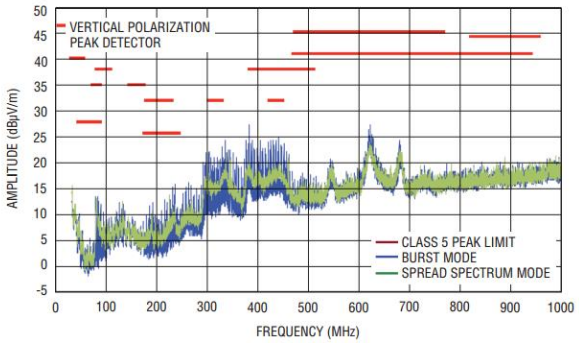
LT8640: 5A Synchronous Step-Down Silent Switcher

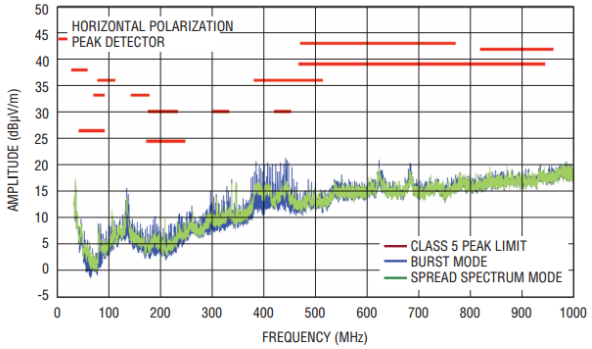
- Input: 3.4V to 42V
- Output: 5A, 7A Peak
- **Output Ripple**: < $10mV_{P-P}$
- Fast Minimum Switch-On Time: 40ns

2MHz 3.3V, 5A Step-Down Converter



Radiated EMI Performance
(CISPR25 Radiated Emission Test with Class 5 Peak Limits)

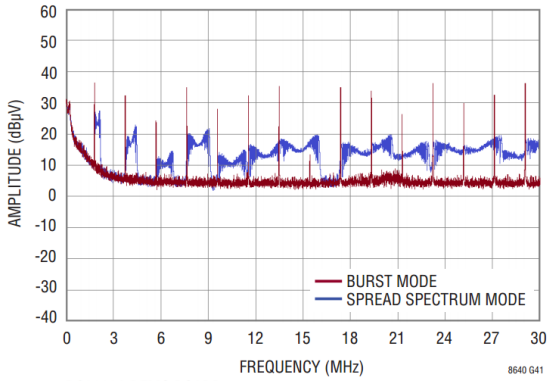




DC2202A DEMO BOARD
(WITH EMI FILTER INSTALLED)
14V INPUT TO 5V OUTPUT AT 4A, f_{SW} = 2MHz

8640 G42

Conducted EMI Performance



DC2202A DEMO BOARD
(WITH EMI FILTER INSTALLED)
14V INPUT TO 5V OUTPUT AT 4A, f_{SW} = 2MHz

Released Silent Switcher – Stay Tuned!

	LT8641	LT8614	LT8640/-1
V_{IN}	3V to 65V	3.4V – 42V	3.4V to 42V
V_{REF}	0.8V	0.97	0.97
I_{OUT}	3.5A	4A	5A
I_{OUT} (Peak)	5A		7A
Fsw	3MHz	3MHz	3MHz
Iq	2.5µA	2.5µA	2.5µA
Ton min	35ns	30ns	30ns
Note	Silent Switcher! SSFM!	Silent Switcher!	Silent Switcher! SSFM!
Pack	3x4 QFN-18	3x4 QFN-18	3x4 QFN-28

Upcoming:

18V, 10A

18V, Dual 7.5A

20V, 20A

Tools from LTC

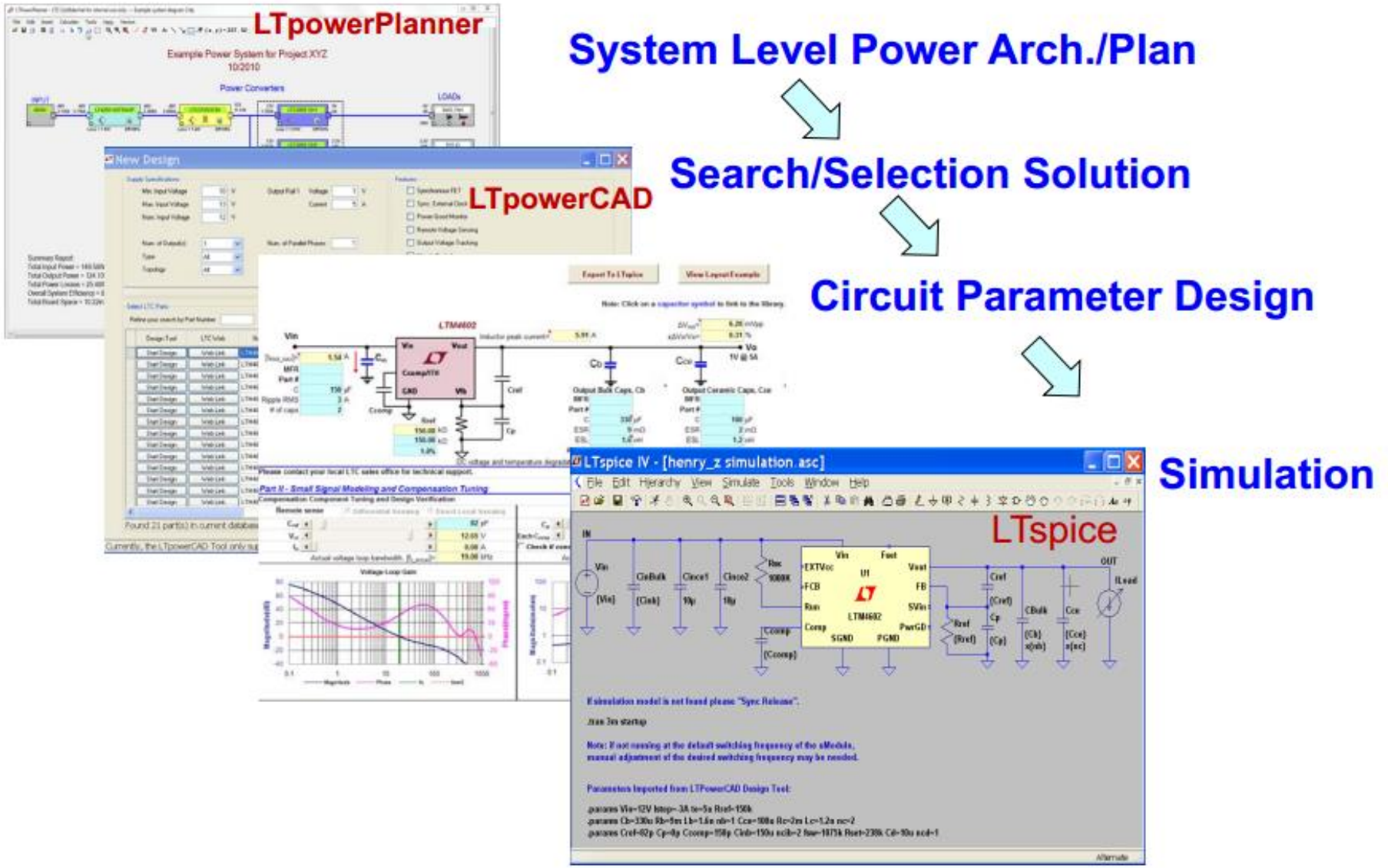
- Website: www.linear.com/nxp
- Design Tools:
  - LTpowerPlanner
  - LTpowerCAD
  - LTpowerPlay
  - LTspice

www.linear.com/nxp

QorIQ		
LayerScape		
Product Name	Power	
	Core	I/O
NXP (Freesscale) QorIQ LS1043A-RDB	LTM4649 - 1V @ 8A	2.5V @ 0.1A 2.5V @ 0.35A
NXP (Freescale) QorIQ LS1088A -RDB	LTC3882 - 1V @ 25A	LTC3026 - 2.5V @ 1.5A
T Series		
NXP (Freescale) QorIQ T1023RDB	LT8612 - 1V @ 6A	LT3021 - 2.1V @ 0.45A

i.MX		
i.MX 7		
Product Name	Power	
	Core	I/O
NXP (Freescale) i.MX7 96Board	LTC3589-2 - 1.1V @ 0.5A	LTC3589-2 - 1.8V @ 0.2A

System Planning to Simulation



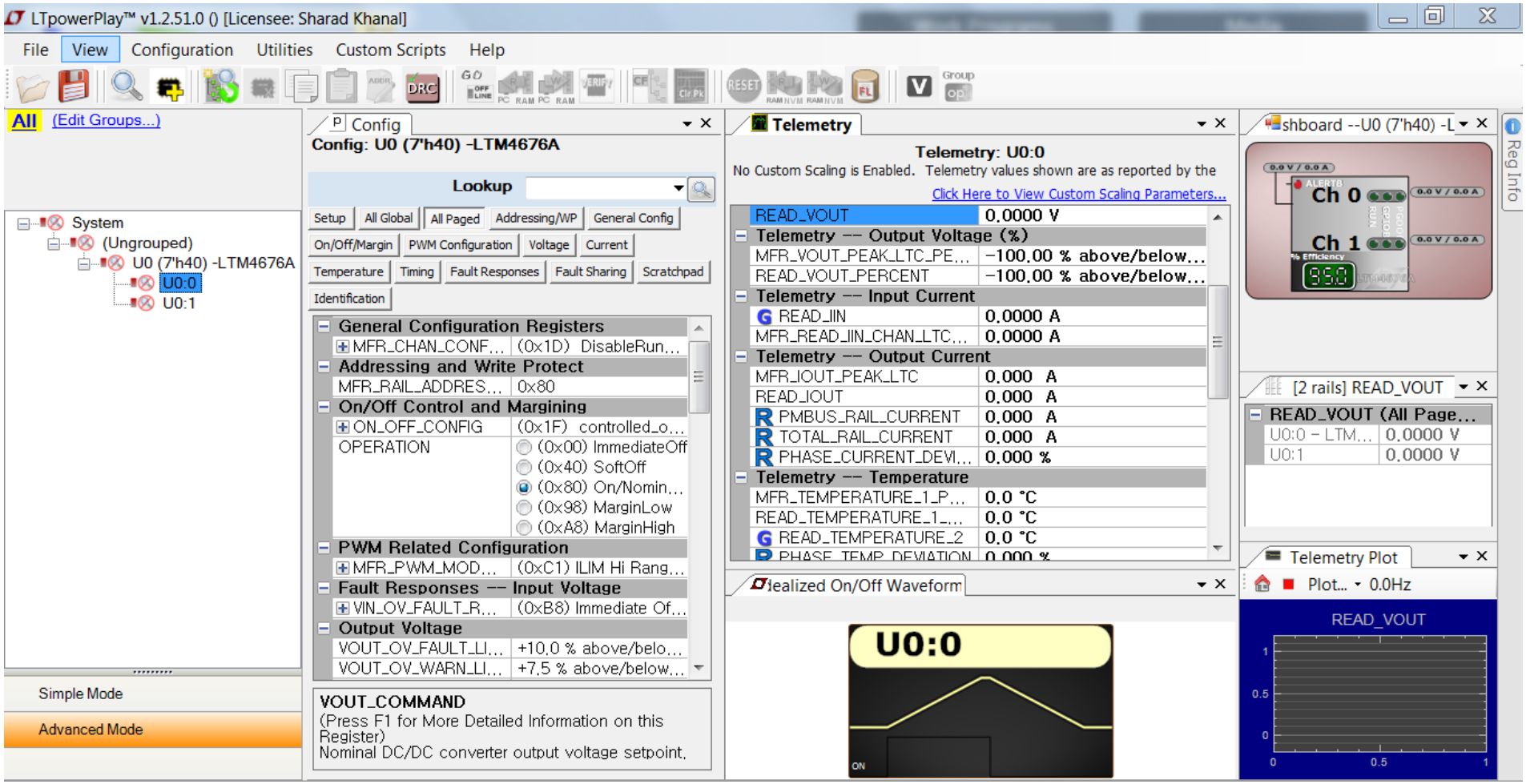
System Level Power Arch./Plan

Search/Selection Solution

Circuit Parameter Design

Simulation

Working with PMBus Devices - LTpowerPlay



Questions?