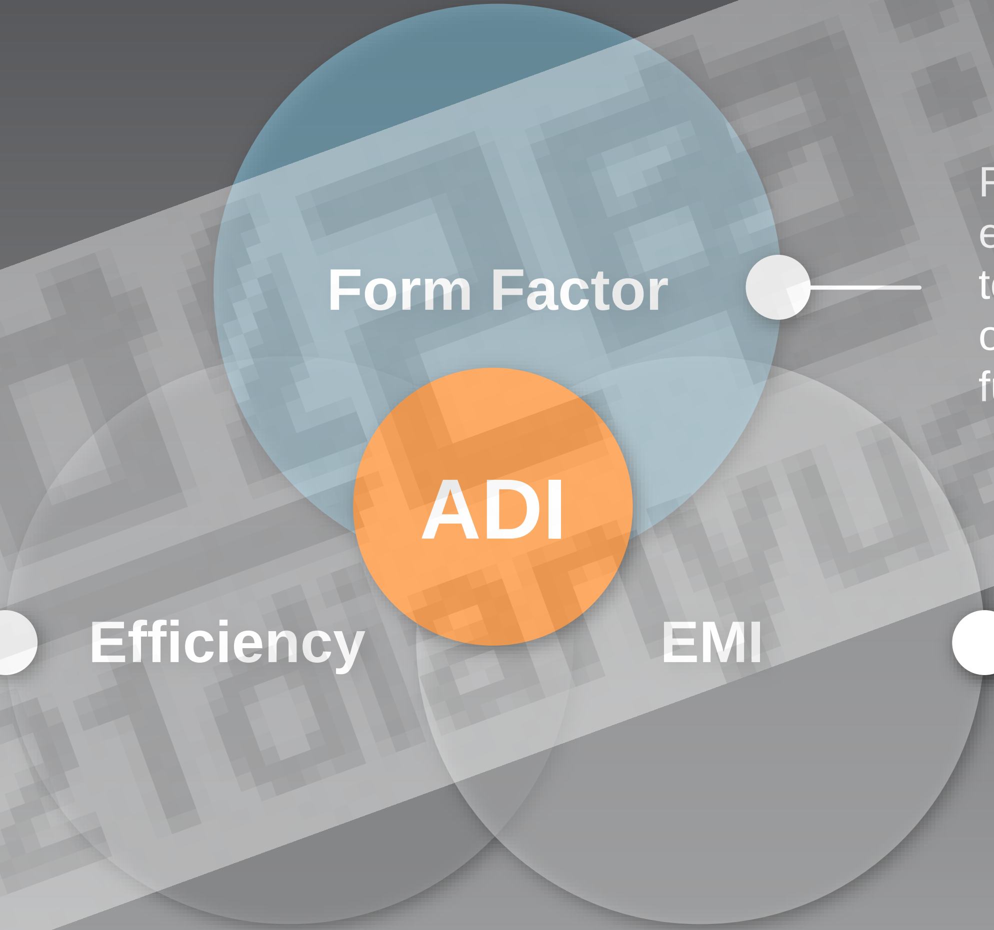
Low EMI power design

ADI Silent Swither products

2019-6-29

We solve *the* Three Key Power Supply
Performance Metrics Form Factor, Efficiency, EMI

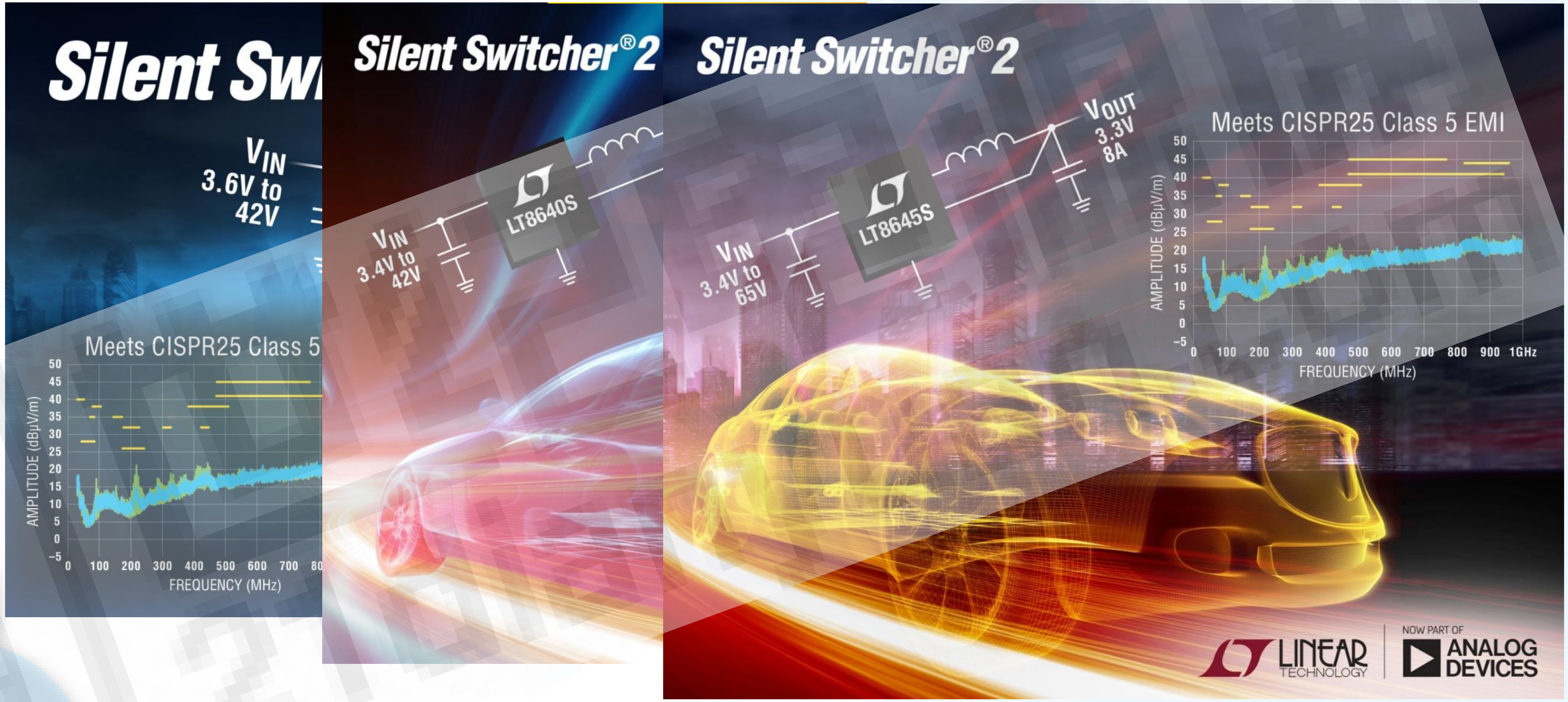


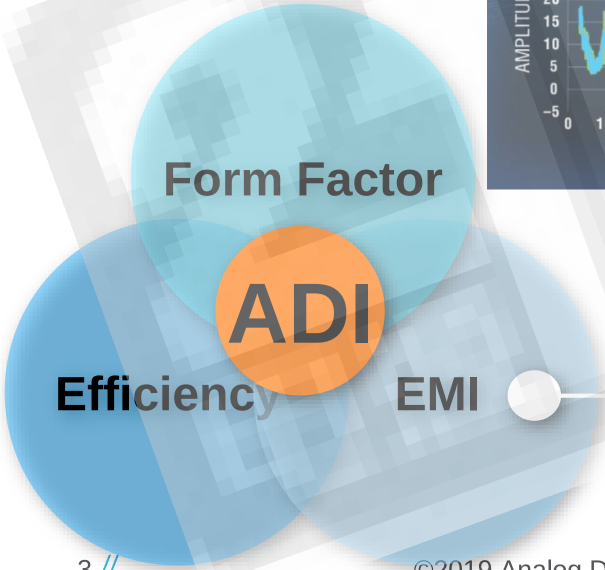
Reduce form factor enabling customers to reduce PCB space or add incremental functionality

Manage heat dissipation in the smallest of form factors

Reduce electromagnetic interference (noise)

Power Innovation Technologies



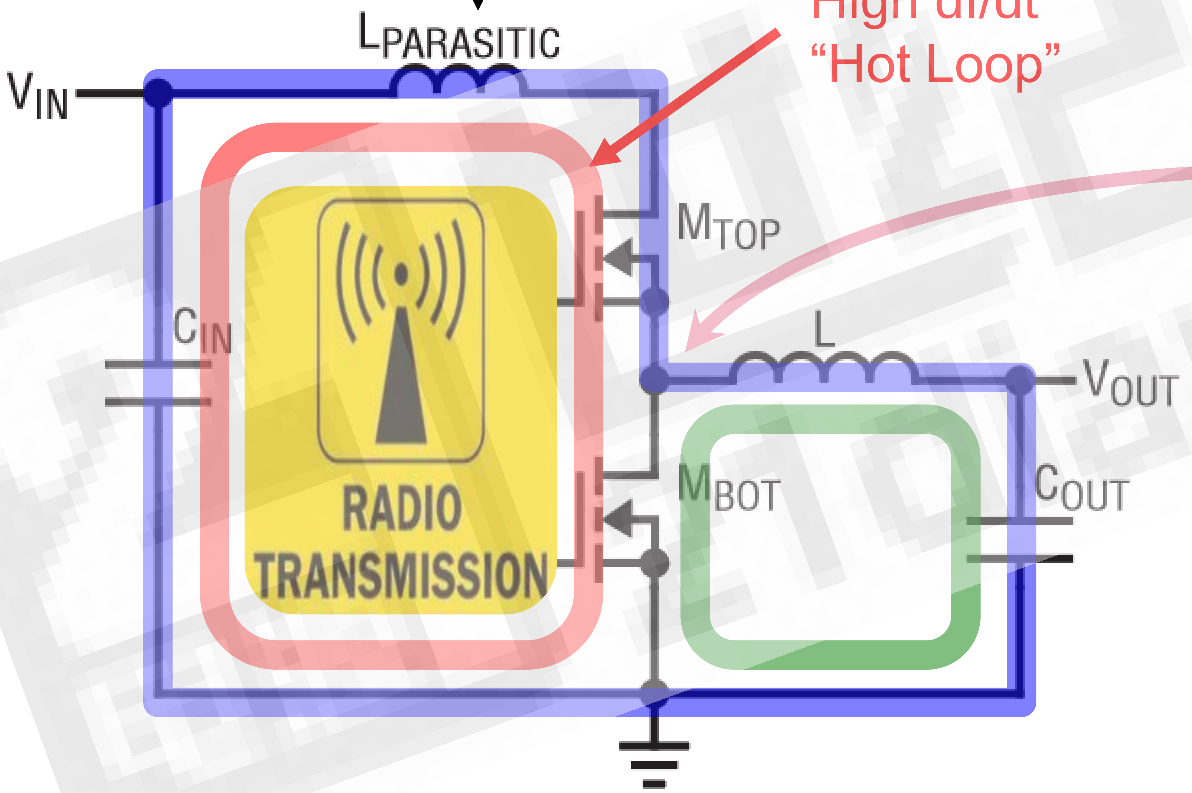


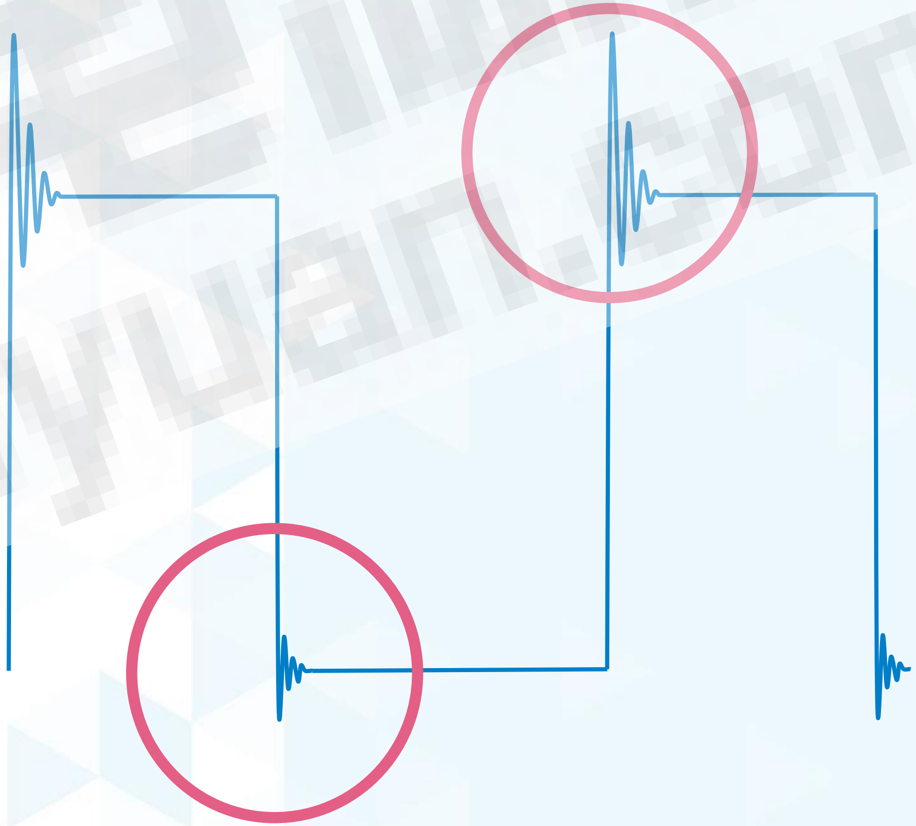
Reduce electromagnetic interference (noise)

The Problem in Traditional Synchronous Buck Converters
High di/dt Currents in SMPS Hot Loops Create EMI

Parasitic inductance due to copper traces, bond wires, ESL of capacitors and FET internal metal

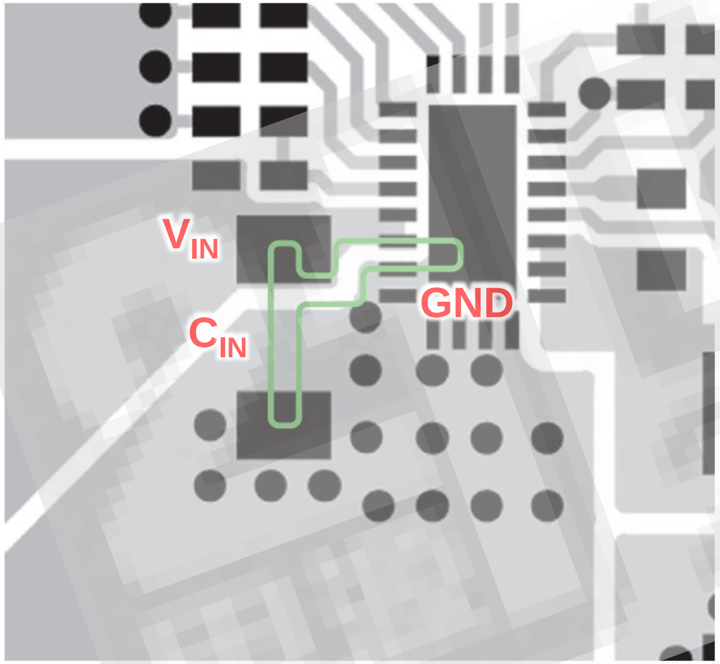
Excessive rings at the switching edges cause conductive noise and radiation





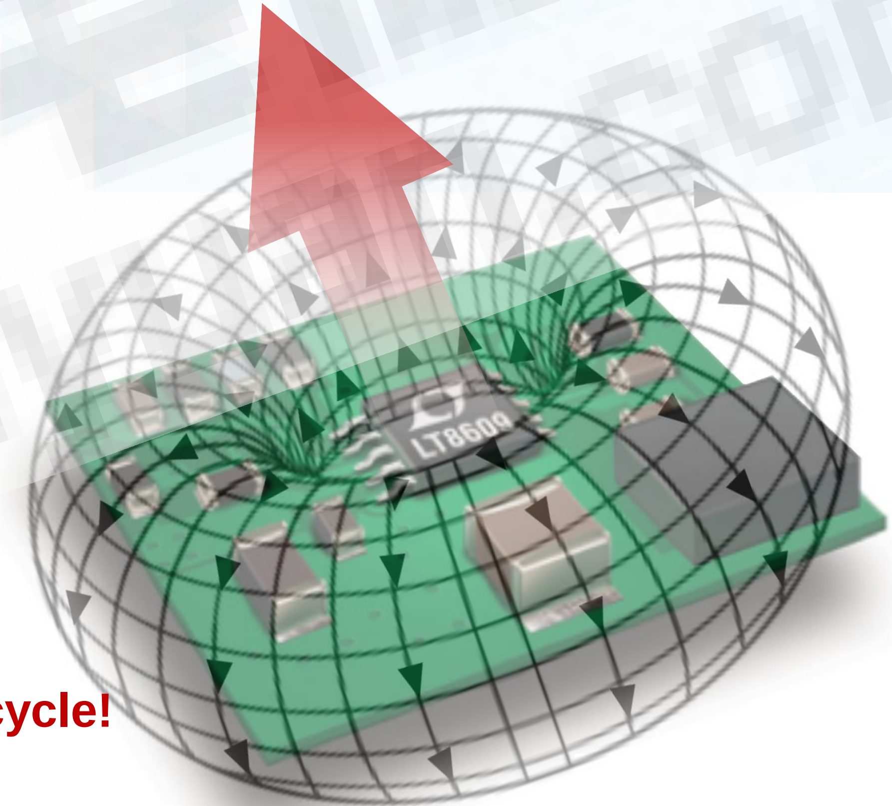
Minimizing Hot Loop

- With monolithic switcher, the best way is to place the low ESL input capacitor as close to the V_{IN} and GND as possible
- A solid GND plane with minimum distance to the hot loop is one of the most effective ways to reduce EMI



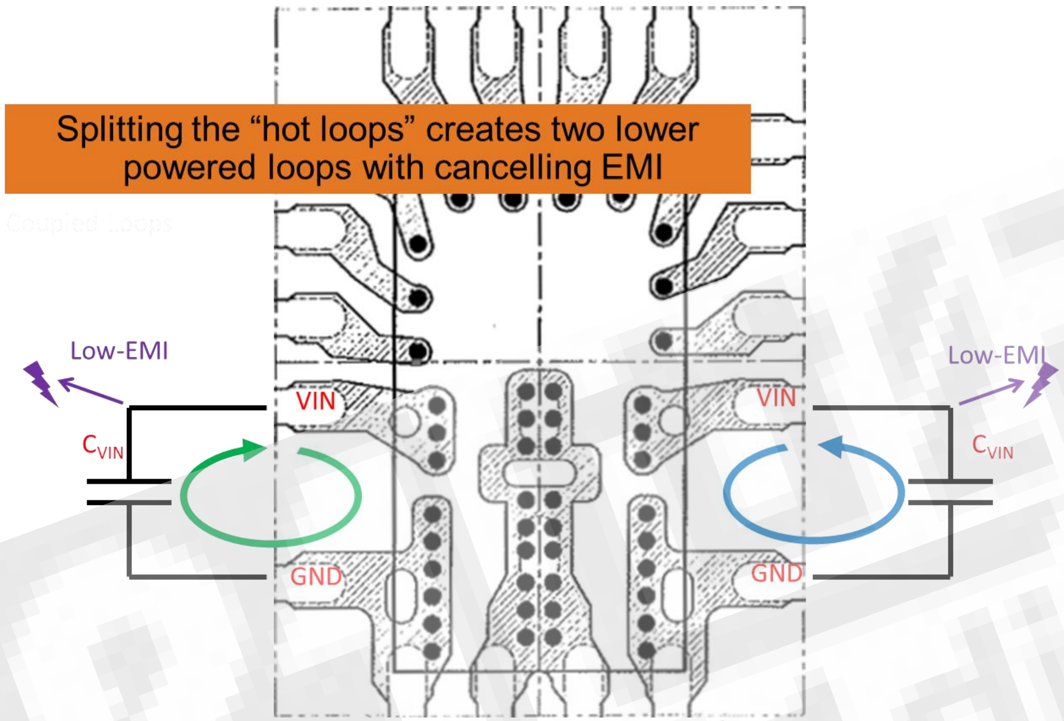
LARGE EMI BURST!

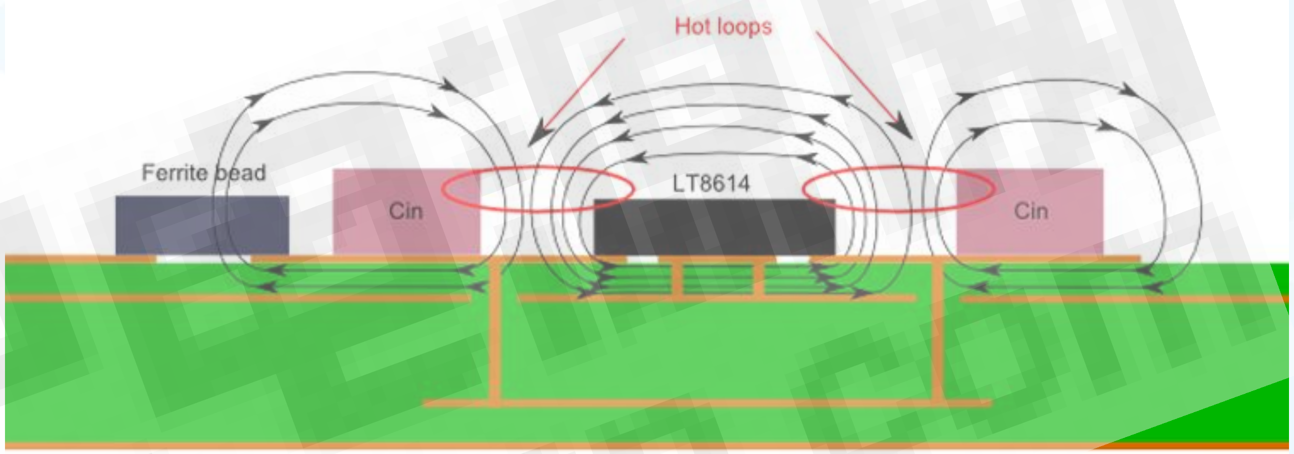
Occurs every switching cycle!

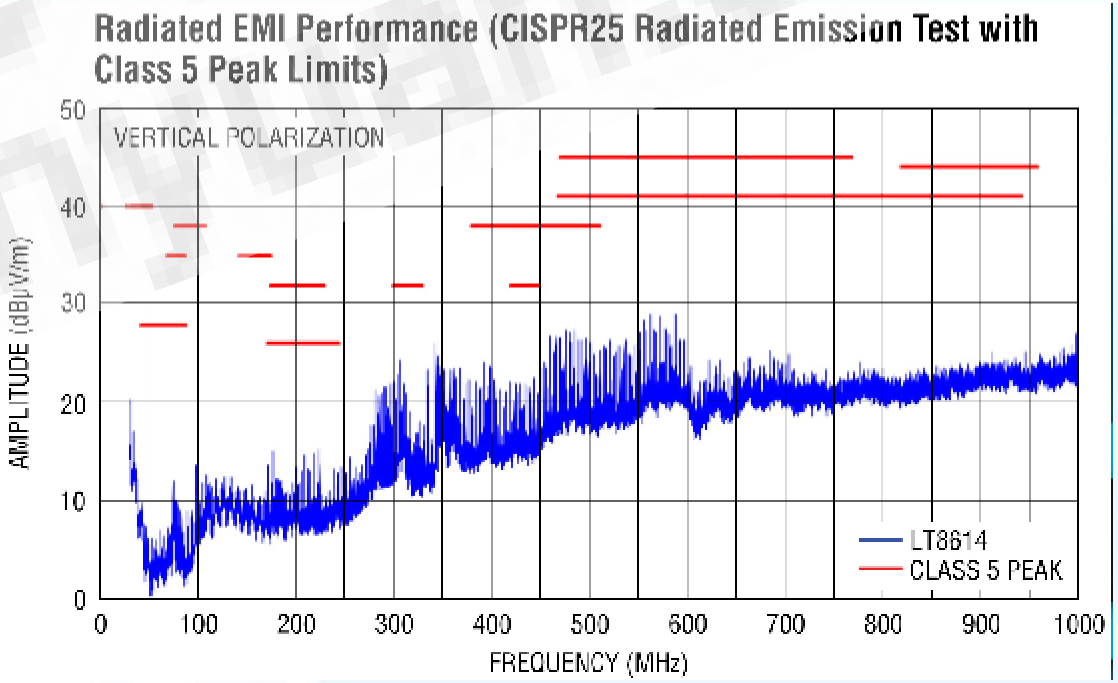


Silent Swither 1

Innovation - Silent Switcher



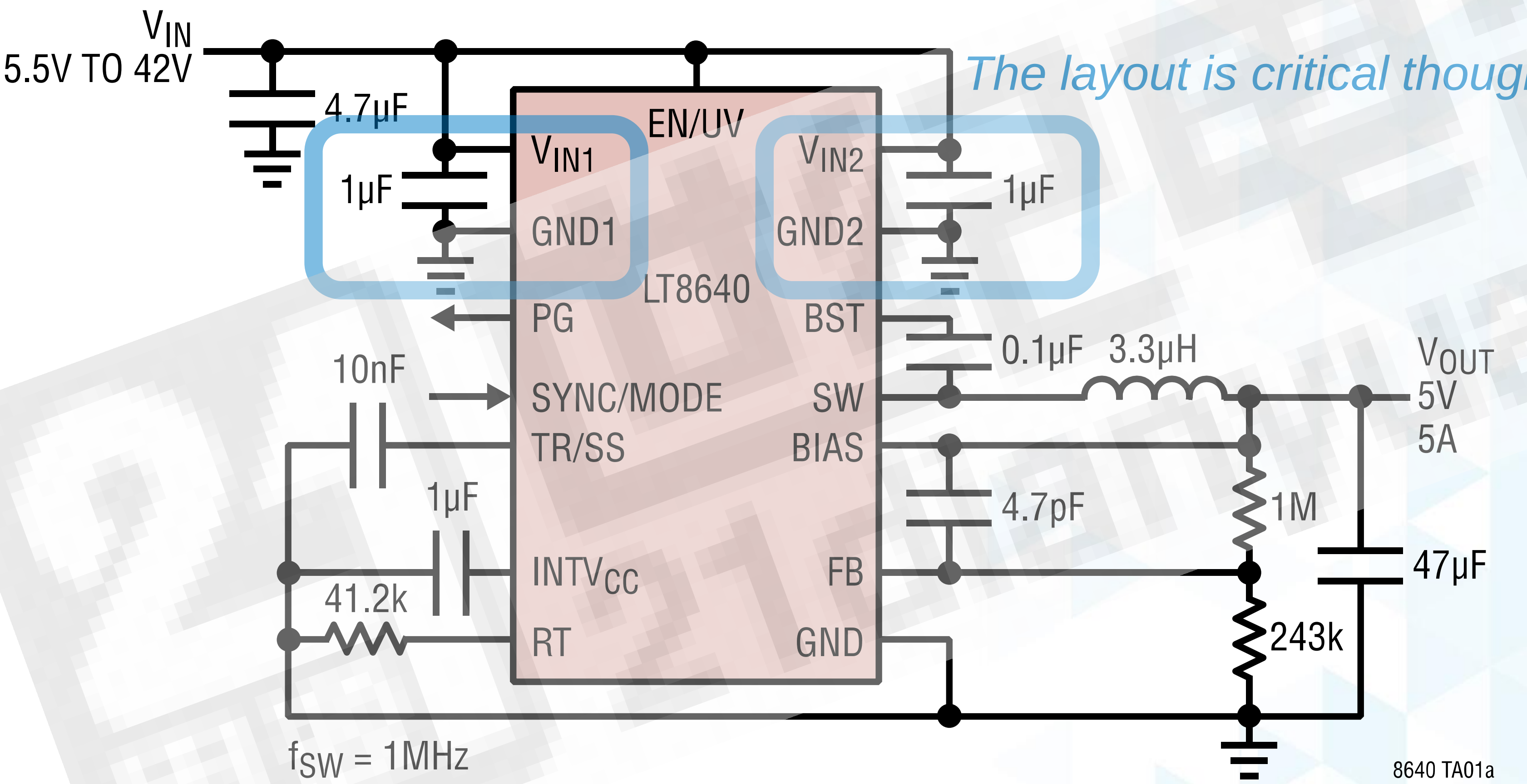




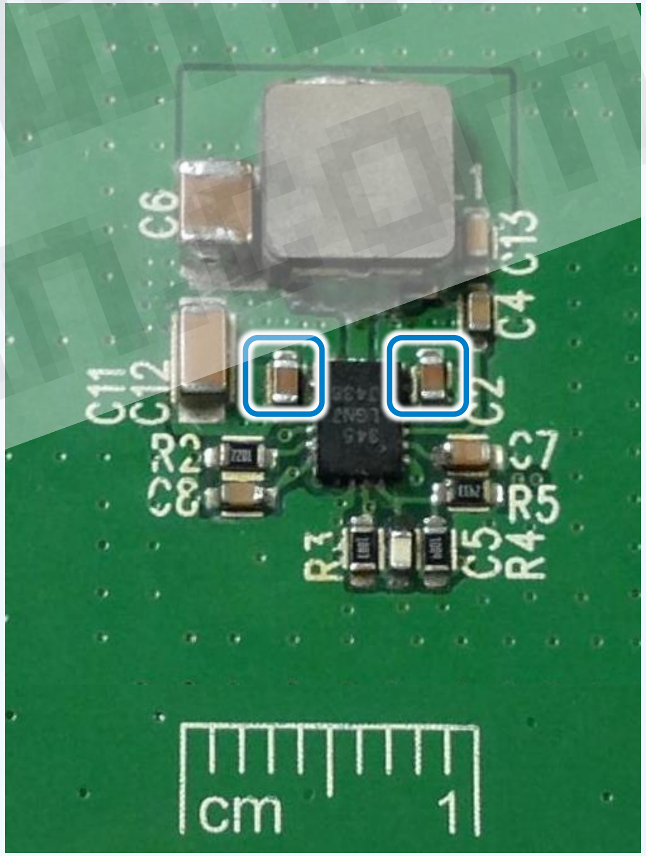
- The two high current loops cancel each others magnetic field, almost like enclosing the circuit in a metal box

Silent Switcher 1

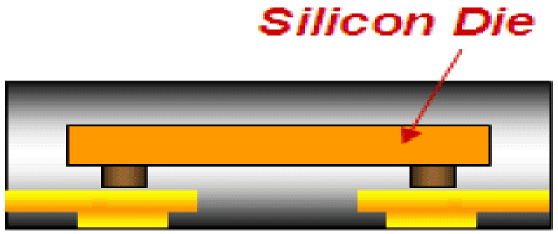
5V 5A Step-Down Converter

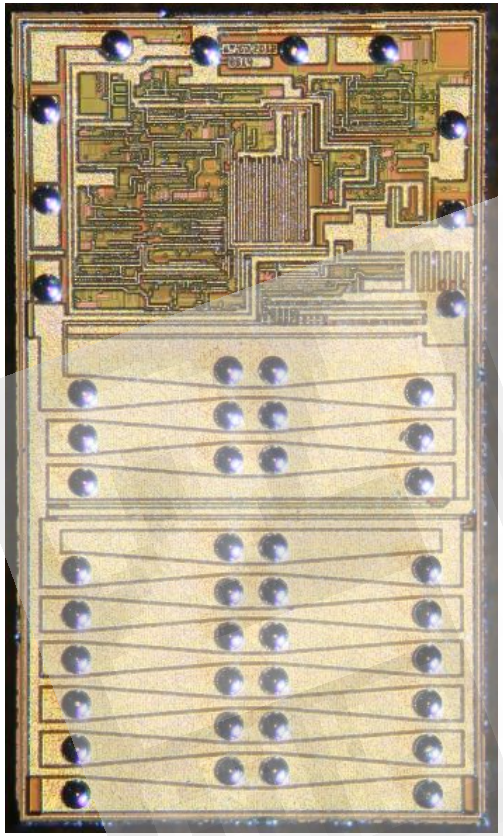


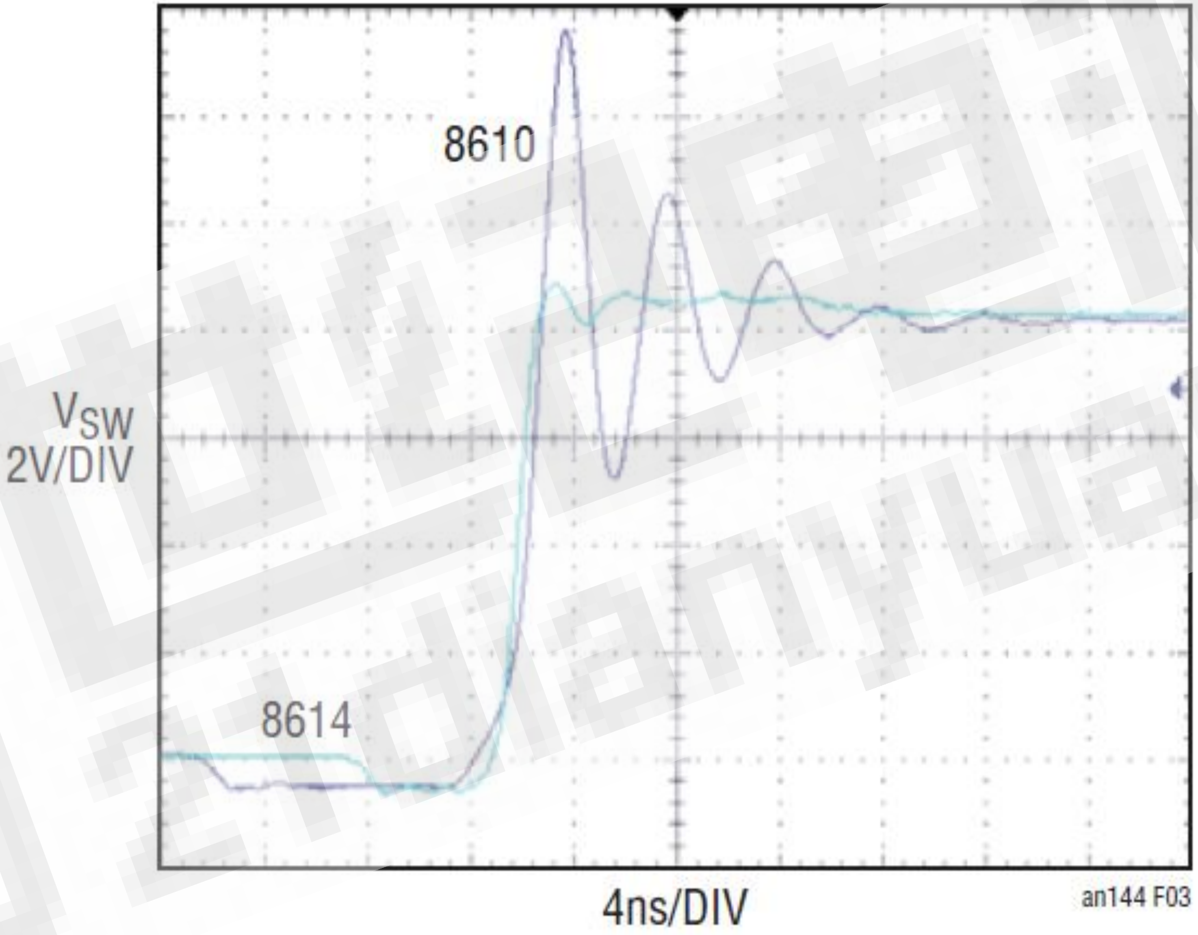
The layout is critical though!



Silent Switcher Eliminates Switch Ringing







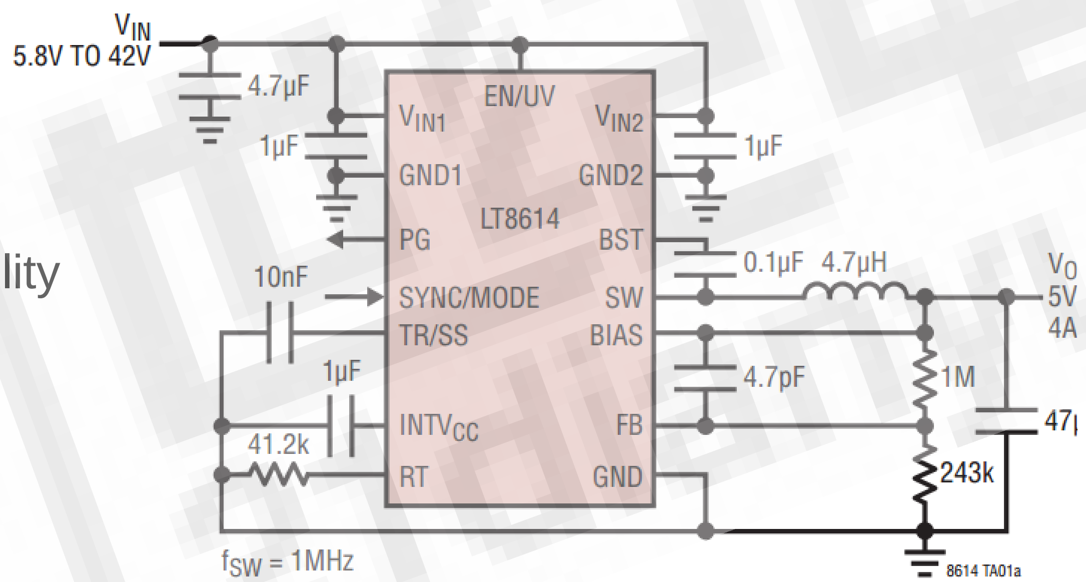
LT8610: Wirebonded in MS16E

LT8614: Silent Switcher 1: Magnetic cancellation + CuPillar Flip-Chip

Silent Switcher Platform – Innovations To Deal with Hot Loop

- Buck regulator platform
  - 20dB EMI improvement – No compromise in efficiency and size!
- Offers customers:
  - High frequency
  - High efficiency
  - High current
  - Low EMI noise
  - Solder joint reliability
- Technologies
  - Circuits
  - Process/devices
  - Package
  - In-package passive

5V 4A Step-Down Converter



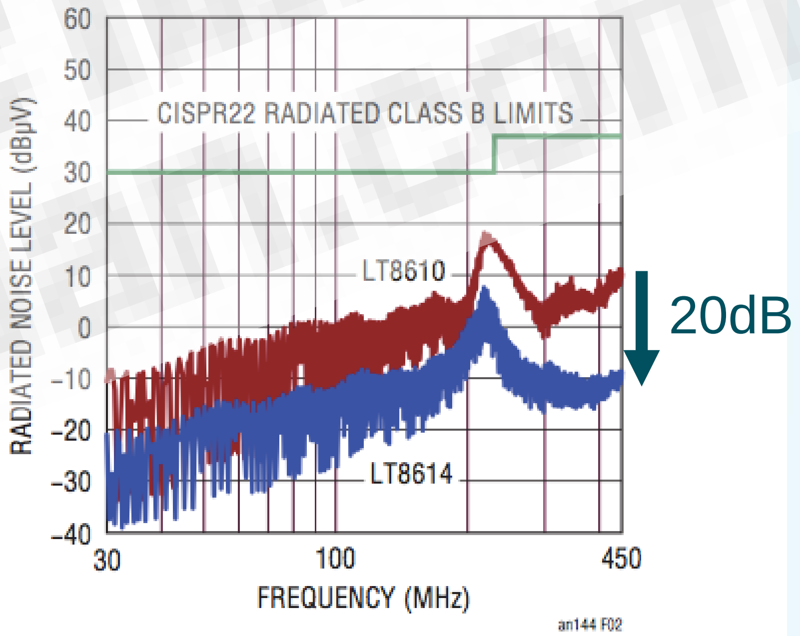
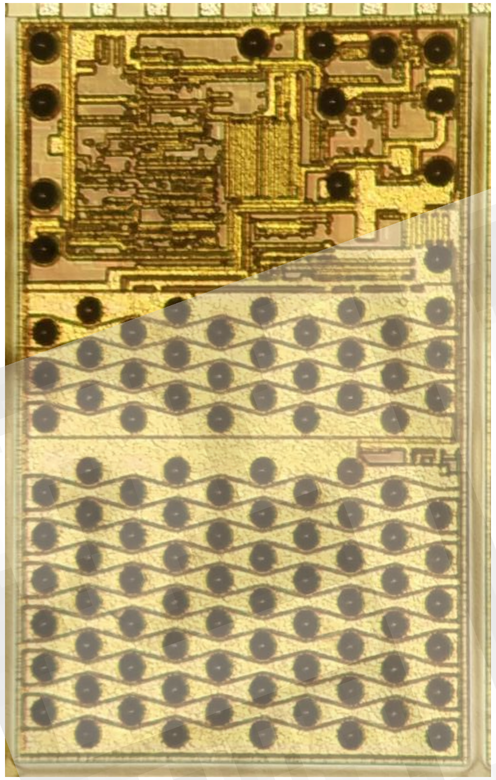
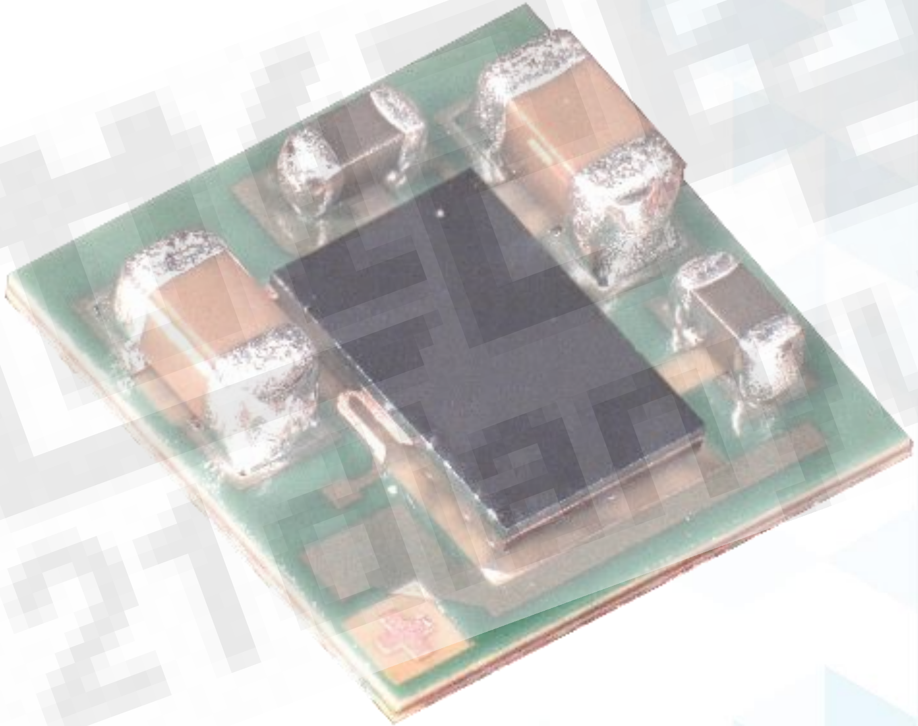
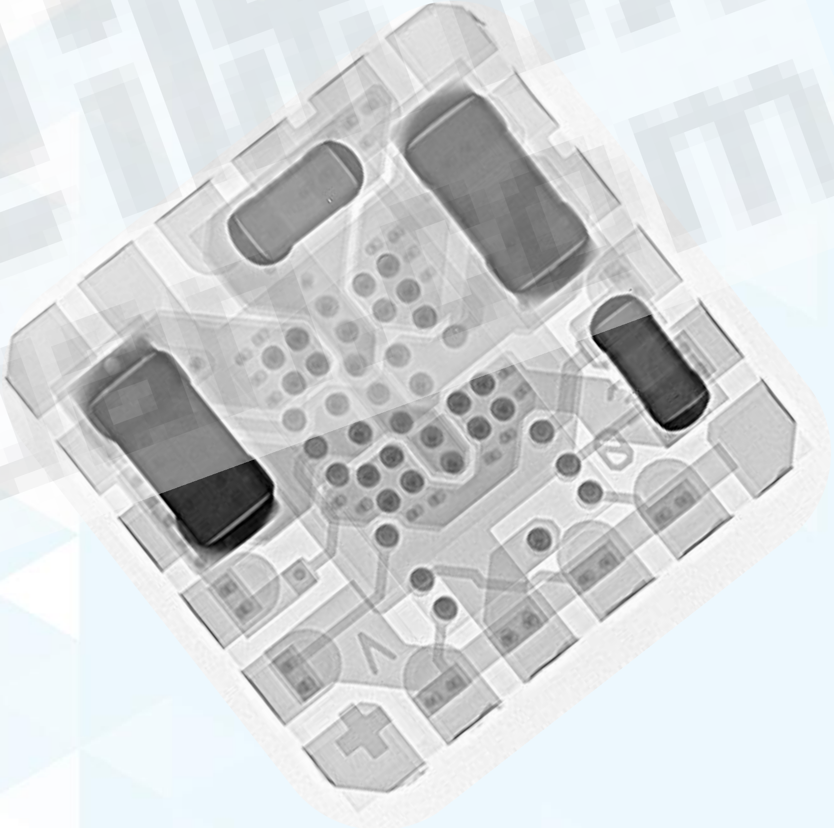


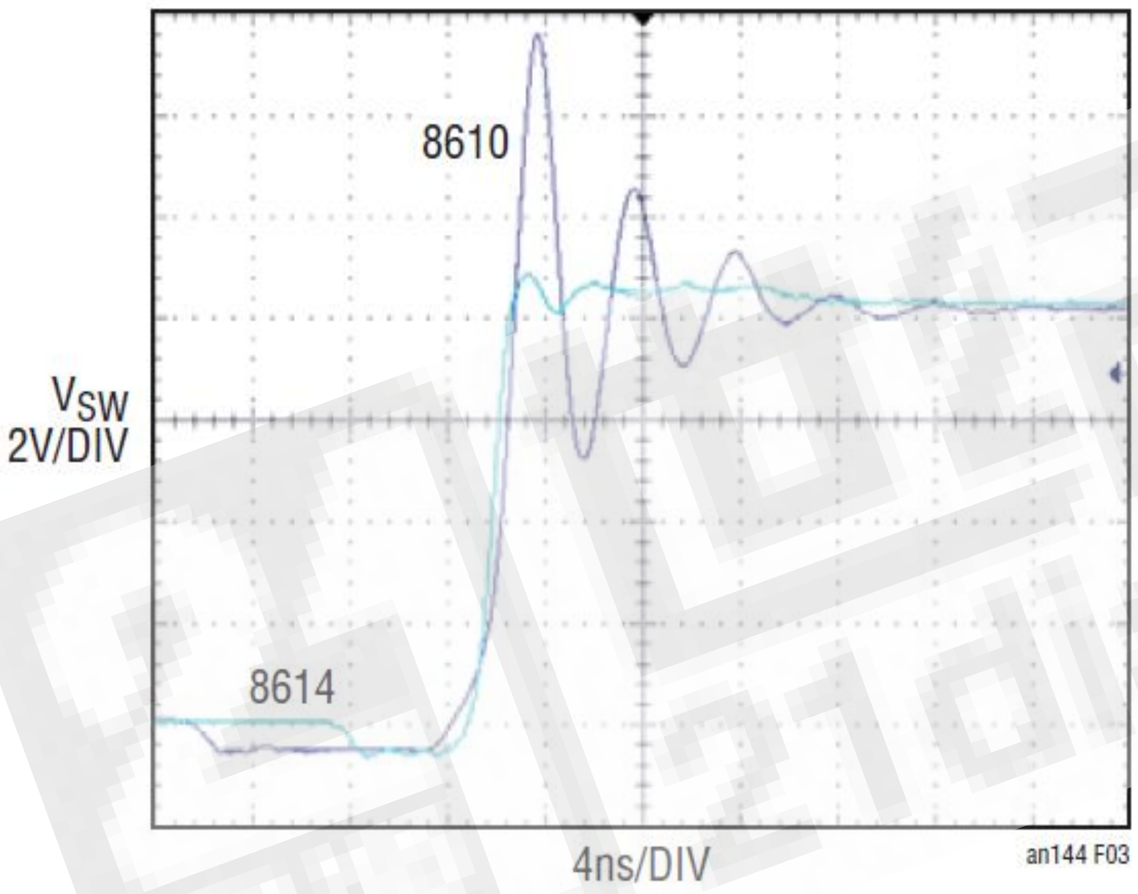
Figure 2. LT8610 and LT8614 700kHz 14V to 3.3V 2A Radiated EMI in GTEM Corrected for OATS

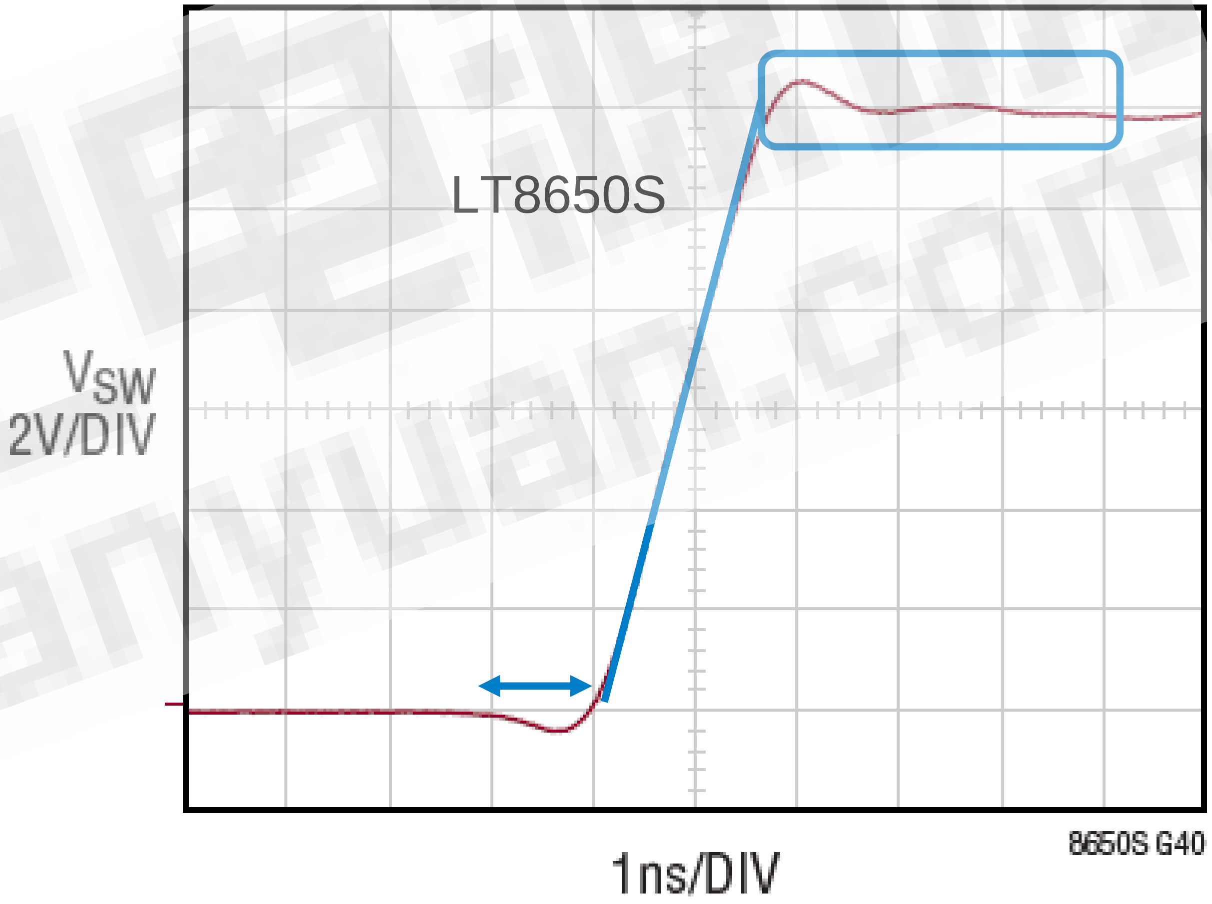
Silent Swither 2

Silent Switcher 2:
Flip chip on laminate (FCOL) and Cap-In-Package

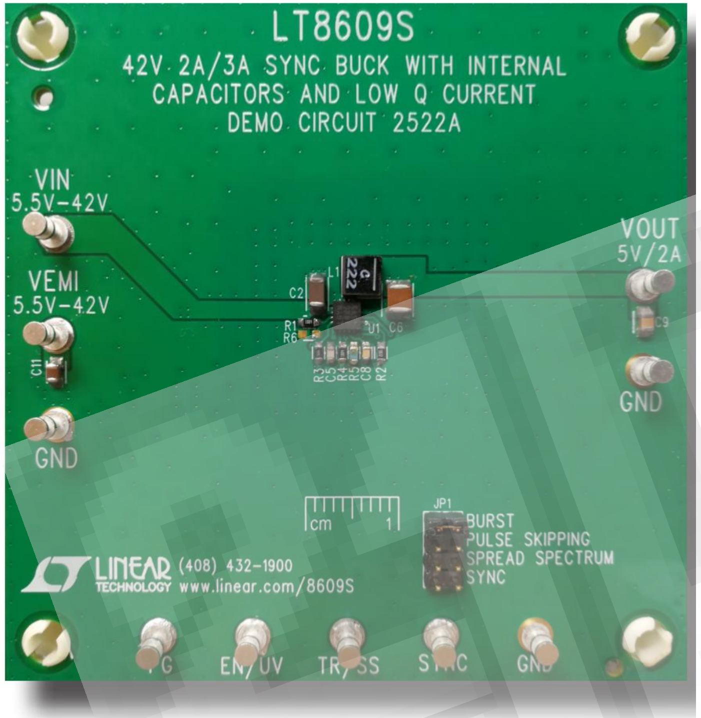




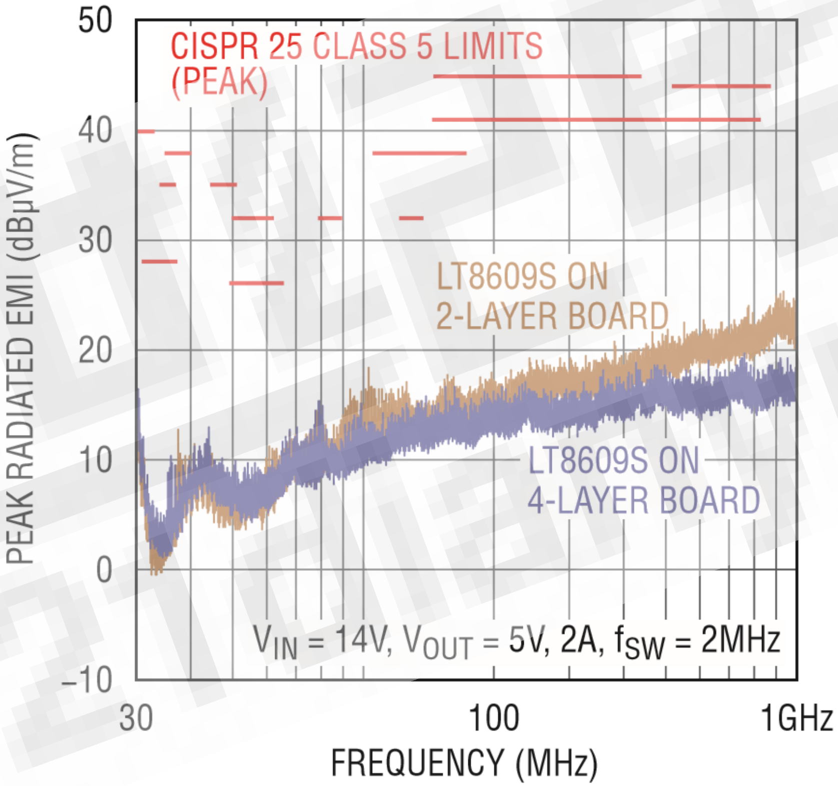
Imporve Performance

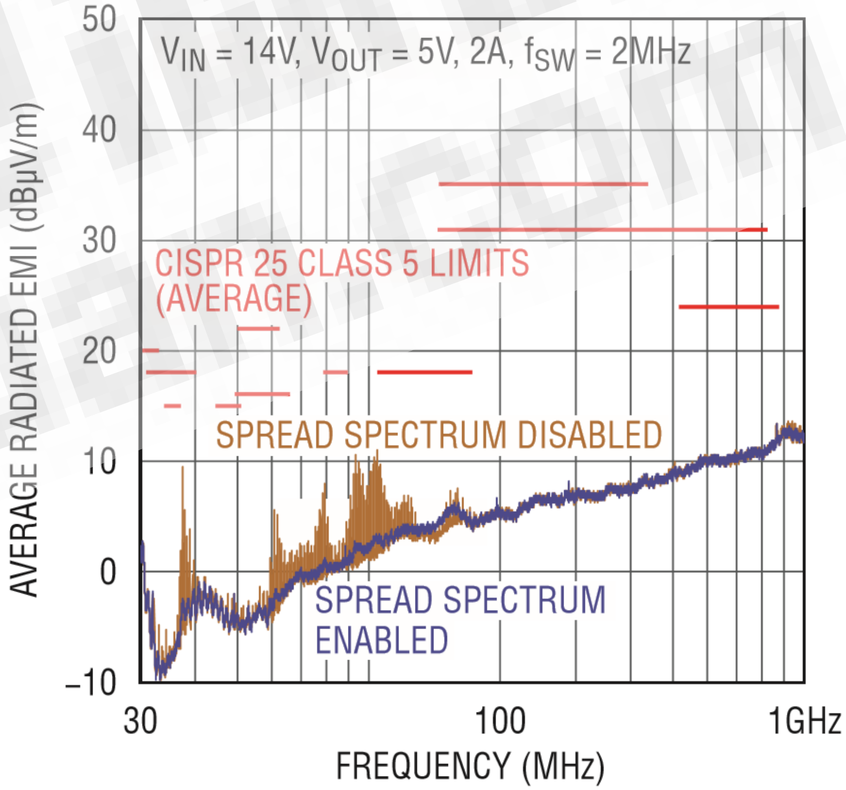




Silent Switcher 2 Example
Excellent EMI Test Results

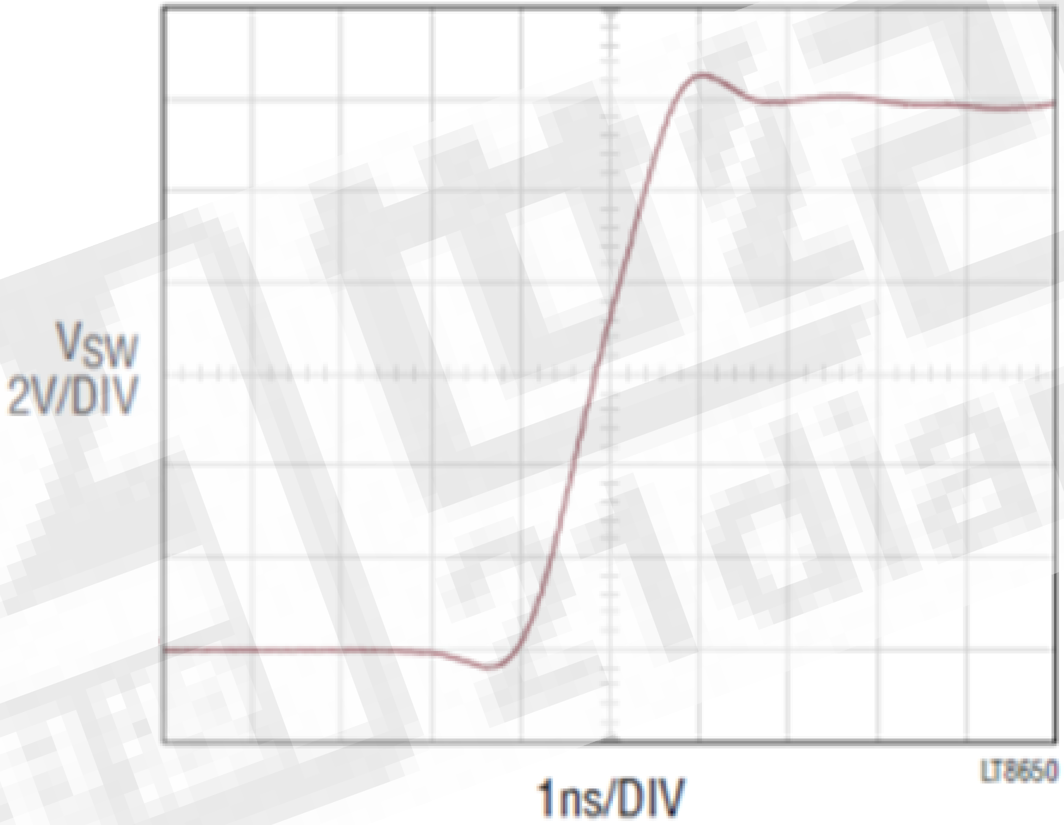






A Paradigm Shift
Fast Switching Enables Ultralow EMI and High Efficiency

No slew rate limit on switching node necessary to achieve low EMI !

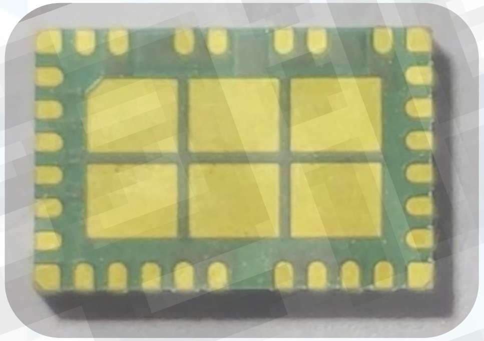


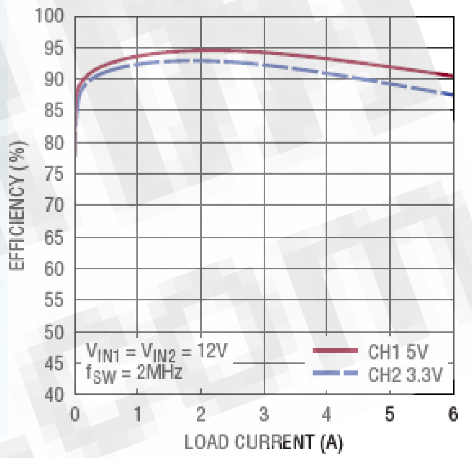
- Hot loop area and inductance virtually zero
- Extremely fast switching
- Neglectable overshoot and no parasitic oscillation on switching node
- Dead time only 1ns

Unmatched switching performance !

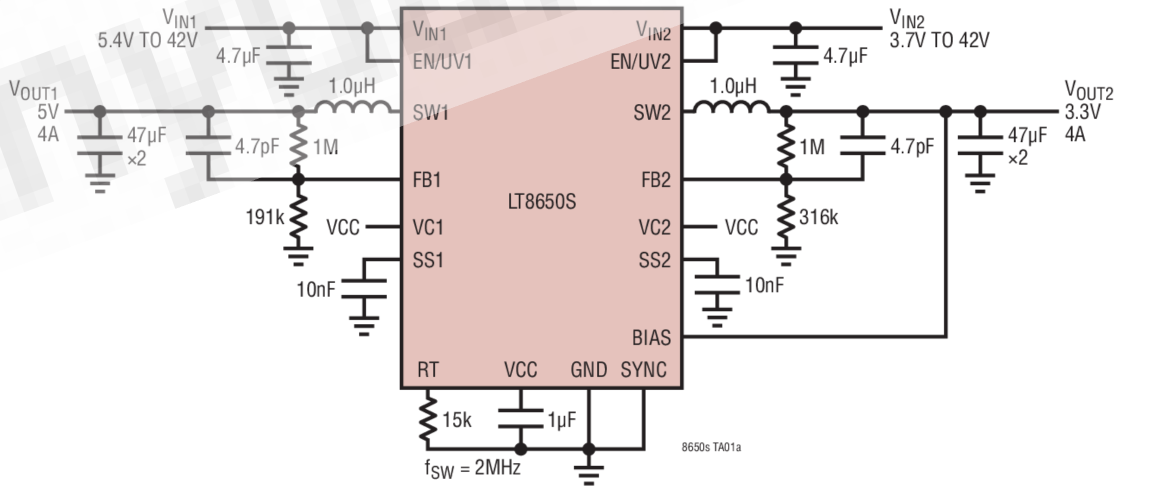
LT8650S Dual Channel 4A, 42V, Silent Switcher 2 Synchronous Buck

- Silent Switcher®2 architecture
  - Internal bypass capacitors reduce radiated EMI
  - Optional spread spectrum modulation
  - Ultralow EMI on any PCB, eliminate PCB layout sensitivity
- Wide input range: 3.0V to 42V
- High output dual capability:
  - 4A DC for each channel simultaneously
  - Up to 6A on either channel (limited by thermal)
- Ultralow quiescent current Burst Mode® operation
  - 6.2µA I_Q regulating $12V_{IN}$ to $5V_{OUT1}$ and $3.3V_{OUT2}$
  - Output ripple <$10mV_{P-P}$
- Fast minimum switch-on time: 40ns
- Adjustable and synchronizable: 300kHz to 3MHz
- Small 4mm x 6mm 32-pin LQFN package



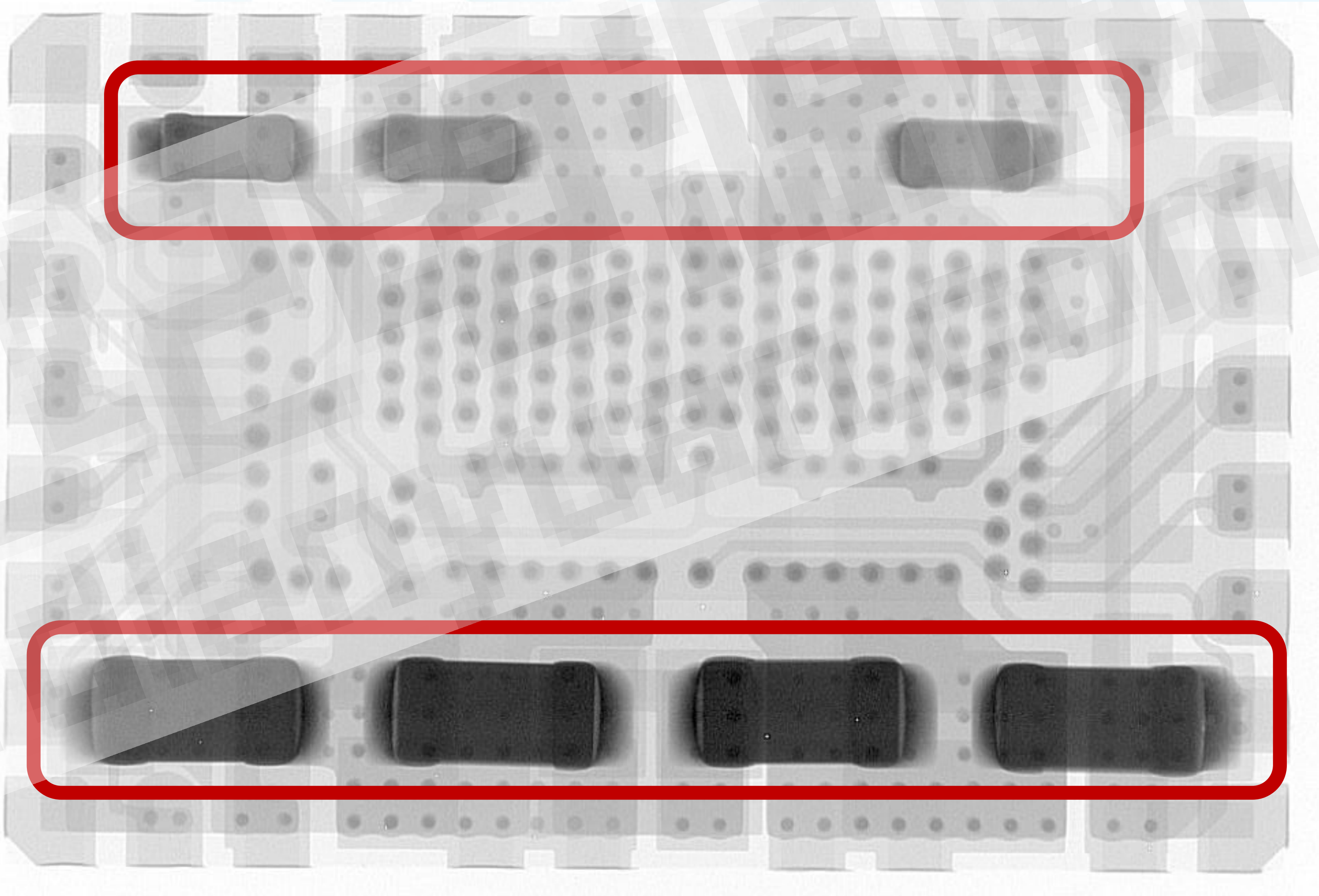


5V/4A, 3.3V/4A 2MHz Step-Down Converter



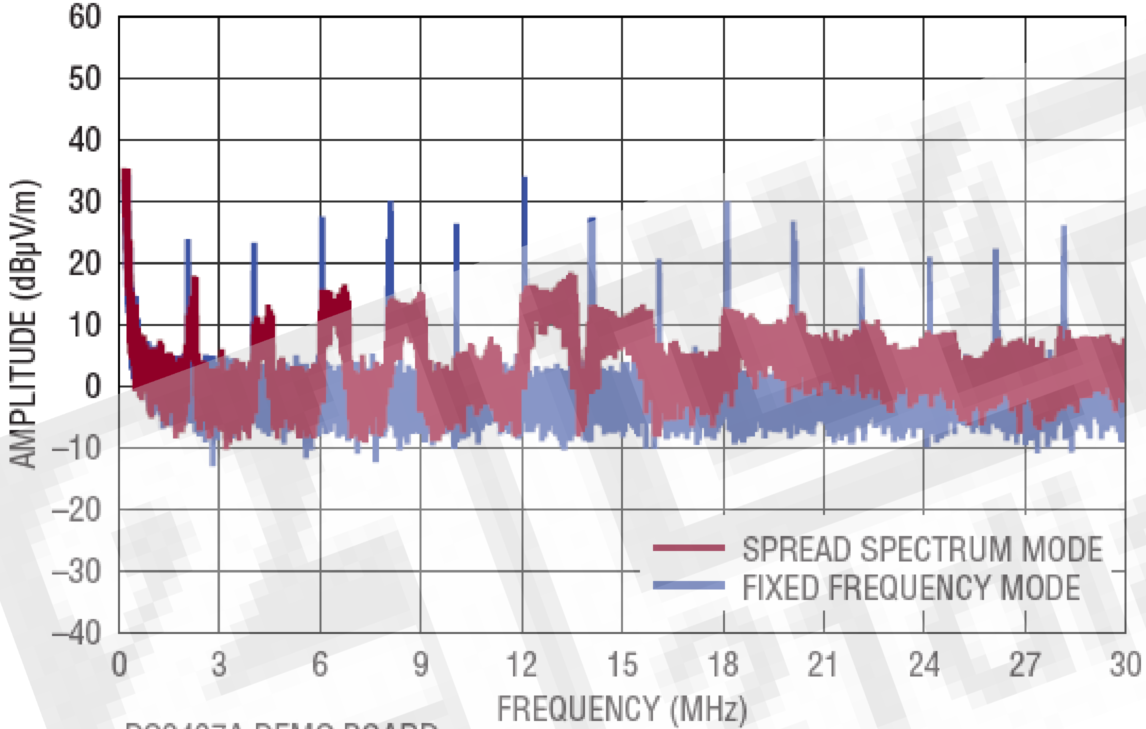
Silent Switcher 2 Platform

- Buck Regulator Platform
- Offers to the customer:
  - High Frequency
  - High Efficiency
  - High Current
  - Low EMI Noise
  - Solder Joint Reliability
- Tech:
  - Circuits
  - Process/Devices
  - Package
  - In-Package Passives



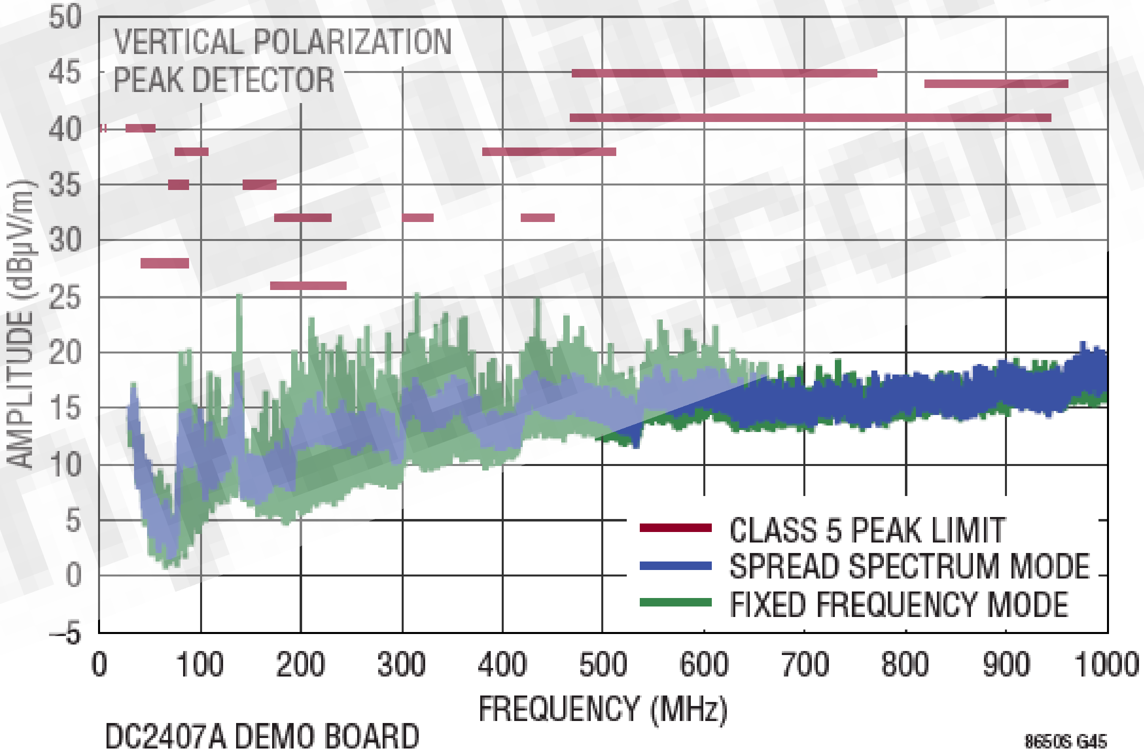
LT8650S Passes EMI Tests

Conducted EMI Performance



DC2407A DEMO BOARD
(WITH EMI FILTER INSTALLED)
12V INPUT TO 5V OUTPUT1 AT 4A AND 3.3V OUTPUT2 AT 4A, f_{SW} = 2MHz

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



DC2407A DEMO BOARD
(WITH EMI FILTER INSTALLED)
12V INPUT TO 5V OUTPUT1 AT 4A AND 3.3V OUTPUT2 AT 4A, f_{SW} = 2MHz

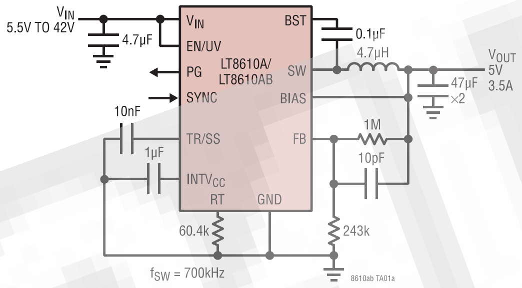
Silent Switcher Family

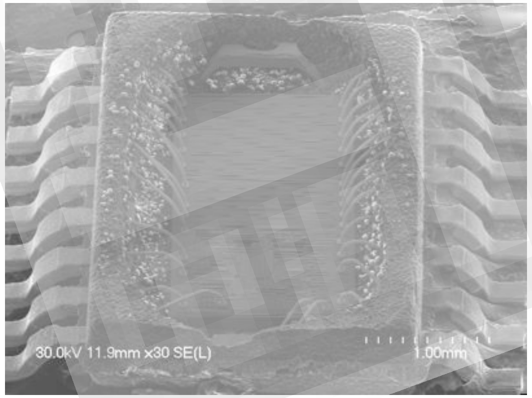
DEVICE	# OF OUTPUTS	V_{IN} RANGE	OUTPUT CURRENT	PEAK EFFICEINCY AT 2MHz, 12V TO 5V	I_Q	FEATURES	PACKAGES
LT8650S	**2**	3V – 42V	4A + 4A on both channels or 6A on either channel	94.60%	6.2µA	Silent Switcher 2	6mm x 4mm x 0.95mm LQFN
LT8645S	1	3.4V – 65V	**8A**	94%	2.5µA	Silent Switcher 2	6mm x 4mm x 0.95mm LQFN
LT8643S	1	3.4V – 42V	6A continuous 7A peak	95%	120µA	Silent Switcher 2, external compensation	4mm x 4mm x 0.94mm LQFN
LT8640S	1	3.4V – 42V	6A continuous 7A peak	95%	2.5µA	Silent Switcher 2	4mm x 4mm x 0.94mm LQFN
LT8609S	1	3V – 42V	2A continuous 3A peak	93%	2.5µA	Silent Switcher 2	3mm x 3mm x 0.94mm LQFN
LT8640 LT8640-1	1	3.4V – 42V	5A continuous 7A peak	95%	2.5µA	Silent Switcher, LT8640 pulse skipping, LT8640-1 forced continuous	3mm x 4mm QFN-18
LT8641	1	3V – 65V	3.5A continuous 5A peak	94%	2.5µA	Silent Switcher	3mm x 4mm QFN-18
LT8614	1	3.4V – 42V	4A	94%	2.5µA	Silent Switcher. Low ripple Burst Mode operation	3mm x 4mm QFN-18

Package technology improves performance, options for customer

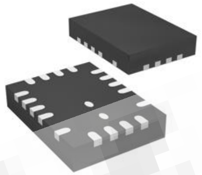
LT8610 MSOP-16

5V 3.5A Step-Down Converter

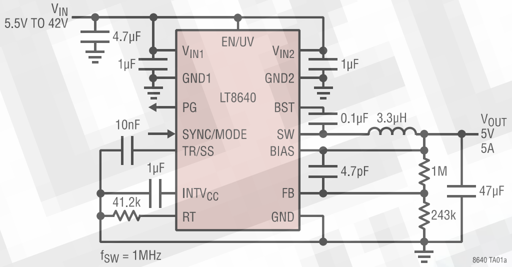


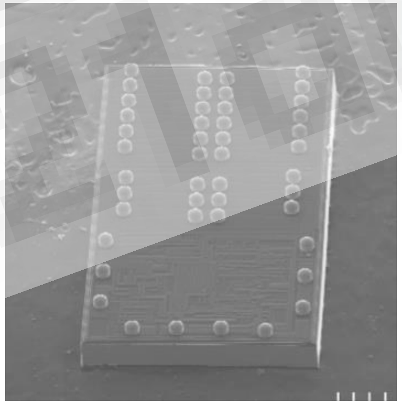


LT8640 MSOP-16

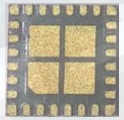


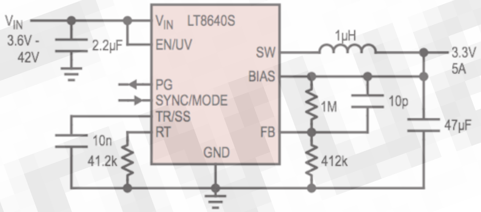
5V 5A Step-Down Converter

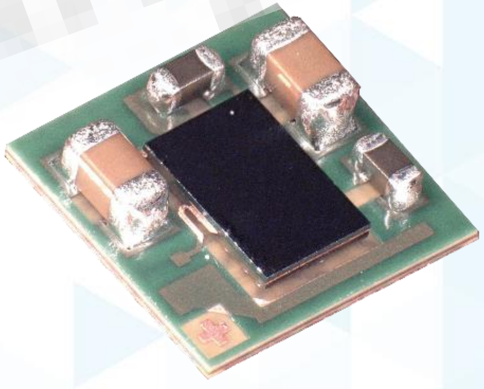




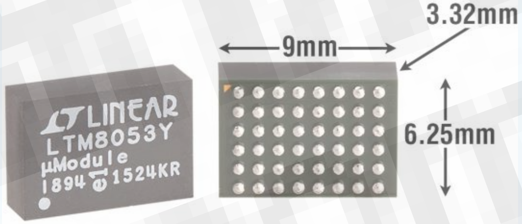
LT8640S MSOP-16 (BT laminate LGA)

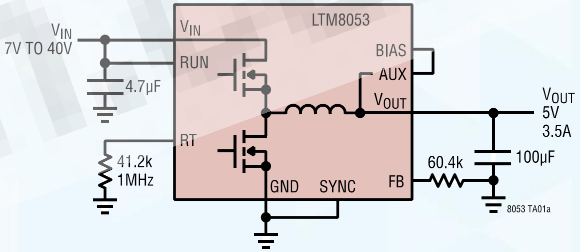






LTM8053 6x9 BGA





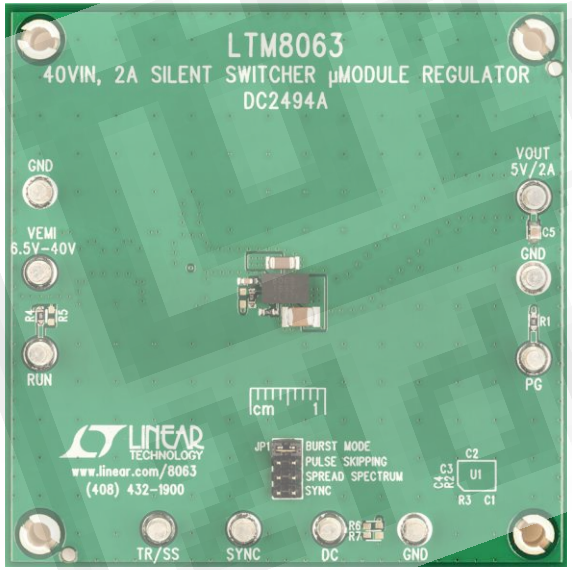
40Vin Step-Down µModule Regulator Size Comparison

LTM8074 (1.2A)

4mm x 4mm

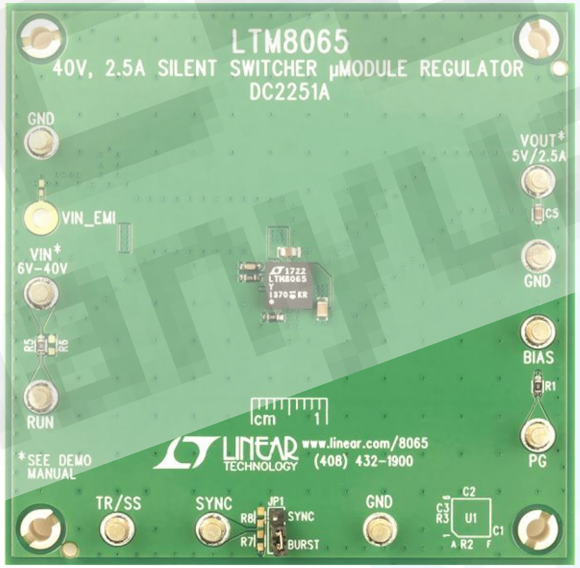
LTM8063 (2A)

4mm x 6.25mm



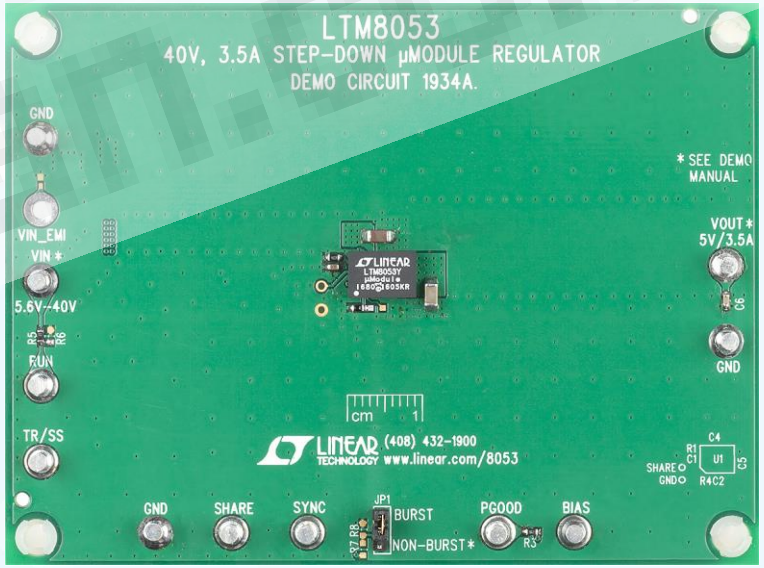
LTM8065 (2.5A)

6.25mm x 6.25mm



LTM8053 (3.5A)

6.25mm x 9mm



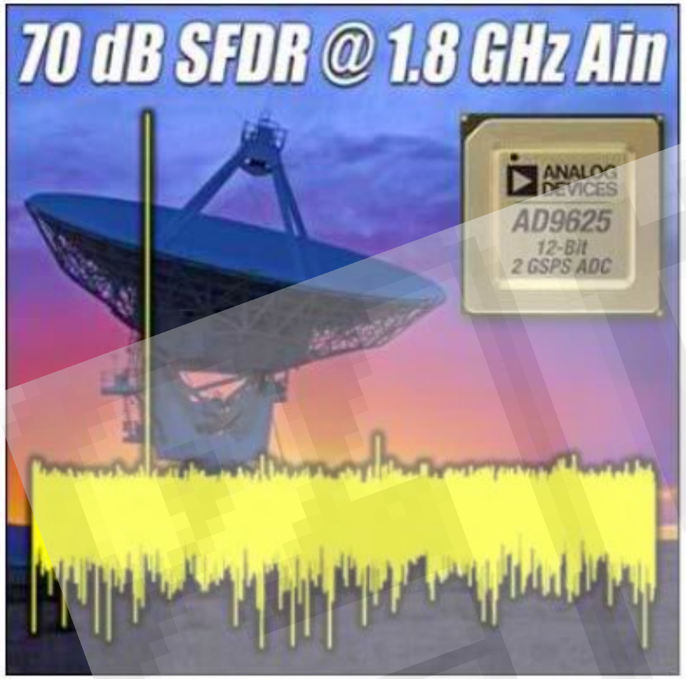
40Vin Silent Switcher µModule Regulators

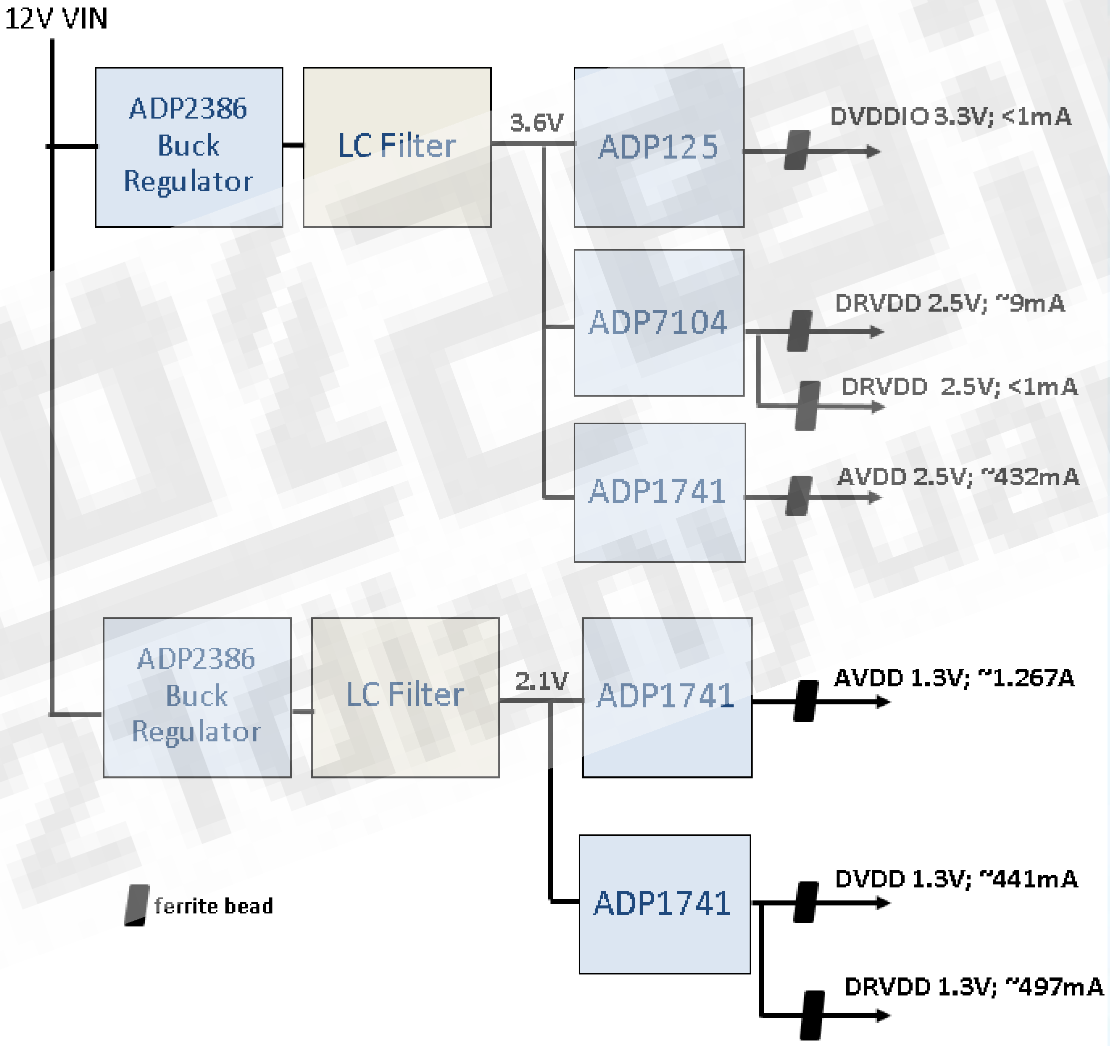
	LTM8074	LTM8063	LTM8065	LTM8053
Silent Switcher	Yes			
CISPR22 Class B Compliant	Yes			
Vin Range	3.2V to 40V	3.2V to 40V	3.4V to 40V	3.4V to 40V
Vout Range	0.8V to 12V	0.8V to 15V	0.97V to 15V	0.97V to 15V
Iout	1.2A (Continuous) 1.75A (Peak)	2A (Continuous) 2.5A (Peak)	2.5A (Continuous) 3.5A (Peak)	3.5A (Continuous) 6A (Peak)
Switching Frequency		200kHz to 2.2MHz	200kHz to 3MHz	200kHz to 3MHz
Package Size (mm)	4 x 4 x 2.22	4 x 6.25 x 2.22	6.25 x 6.25 x 2.32	6.25 x 9 x 3.32
Package Type	BGA	BGA	BGA	BGA
RPL Schedule	Q3 CY2018	Released		

Application

Improve System performance

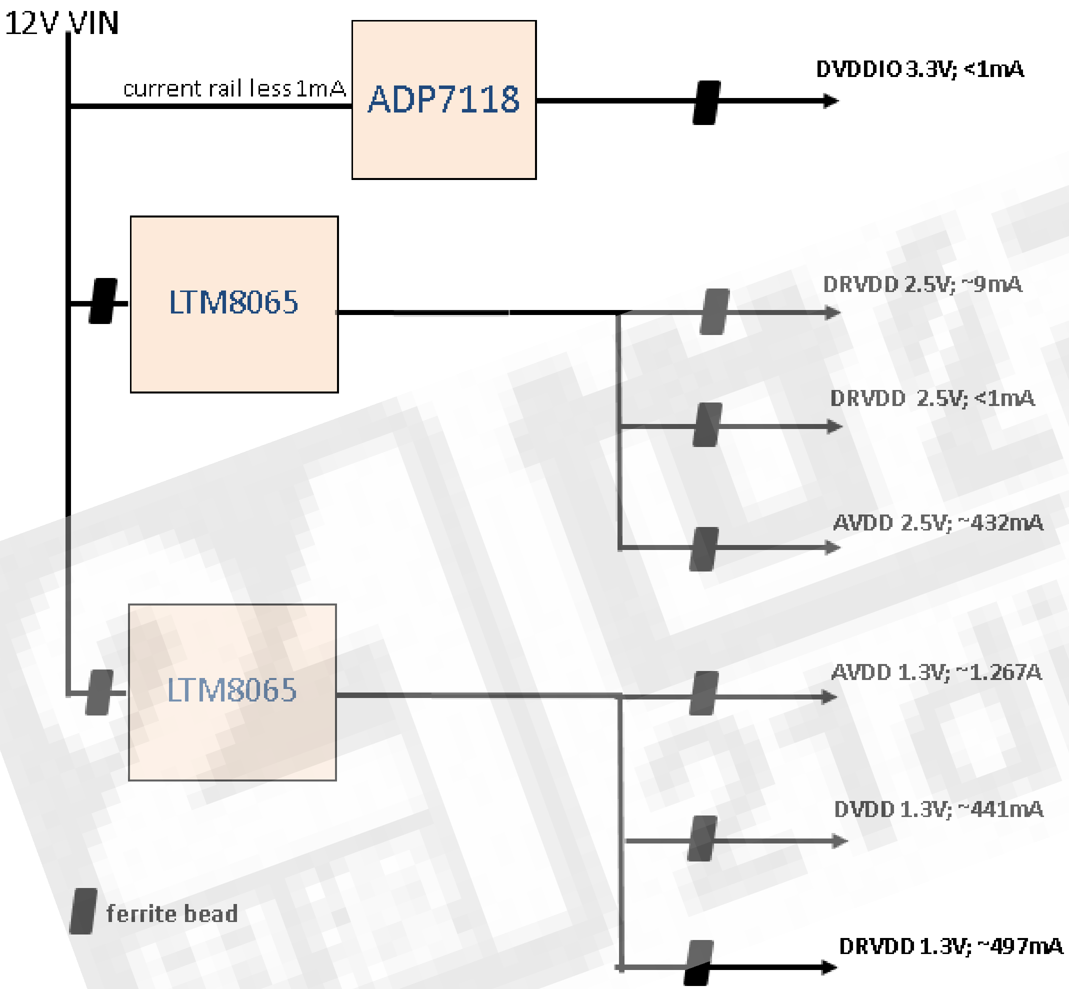
Silent Switcher Application

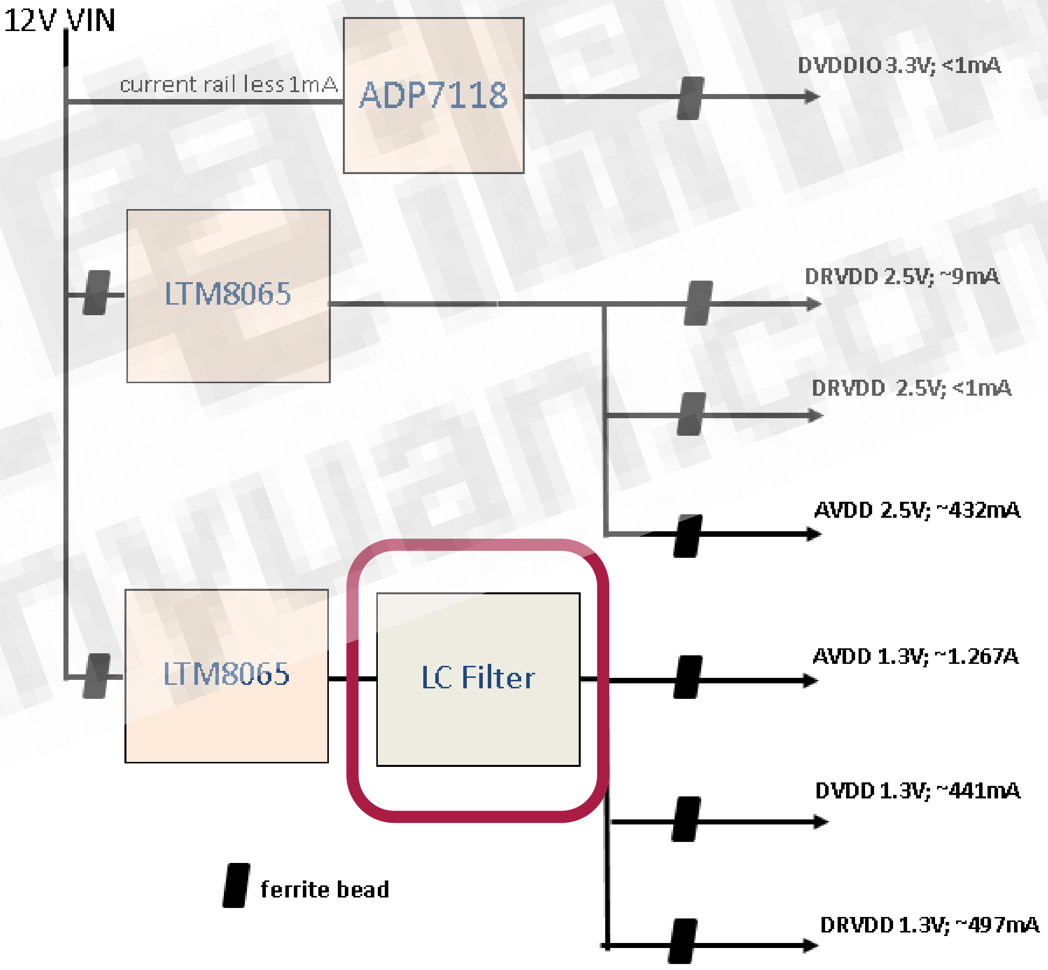




- Good Performance
- 48% efficiency
- Thermal issue
- Big power size

Silent Switcher Application



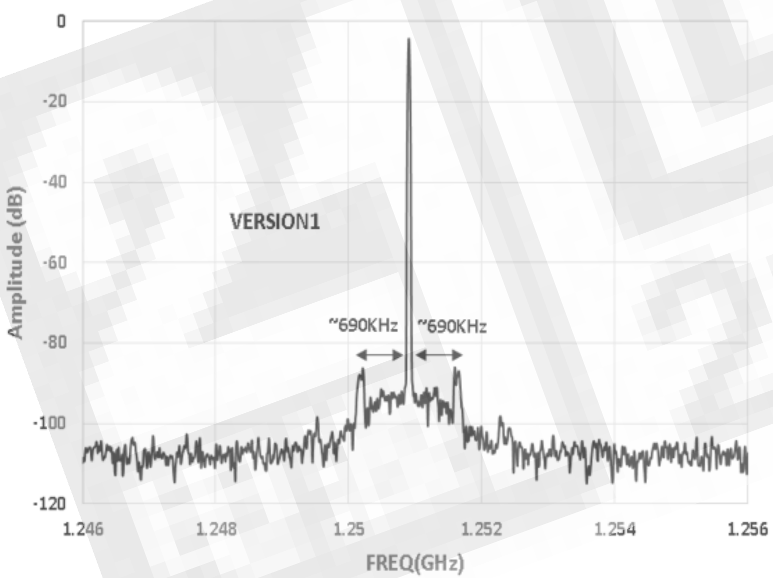


Silent Switcher Application

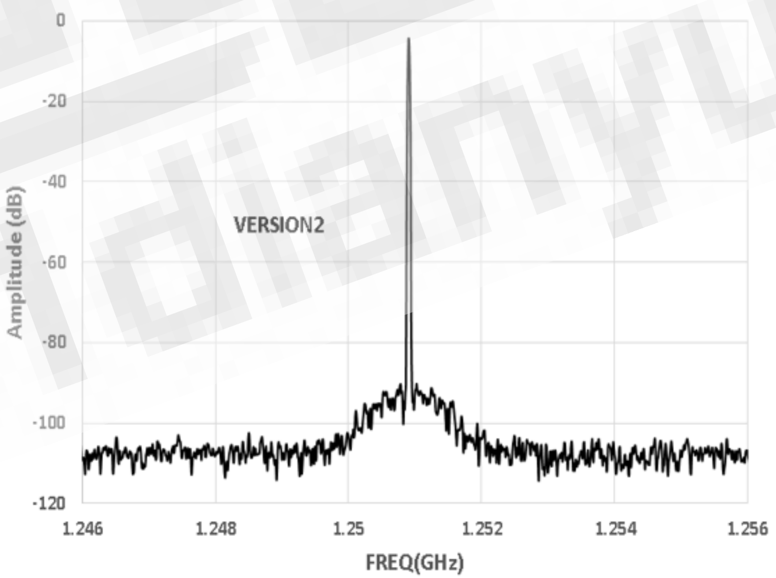
AD9625-2.6 GHz Dynamic Performance						
Input Frequency (MHz)	SNRFS (db)			SFDR (dbc)		
	Baseline Power Supply	LTM8065 Version1	LTM8065 Version 2	Baseline Power Supply	LTM8065 Version1	LTM8065 Version 2
729	57.01	57.03	57.01	79.87	79.72	80.11
1349	56.53	56.49	56.54	78.41	80.06	80.77

Baseline Power Supply		Voltage (V)	Current (A)	Power (W)
PIN		11.729	0.676	7.929
POUT	AVDD_1.3V	1.268	1.222	1.549
	DRVDD_1.3V	1.301	0.521	0.678
	DVDD_1.3V	1.305	0.406	0.530
	AVDD_2.5V	2.589	0.408	1.056
	DRVDD_2.5V	2.590	0.0047	0.012
	DVDD_2.5V	2.590	0.0001	0.0003
	DVDDIO_3.3V	3.301	0.0004	0.0013
			POUT TOTAL:	3.827
			Efficiency (%):	**48.26**

AD9625 FFT using LTM8065 (AIN = 1349MHz)



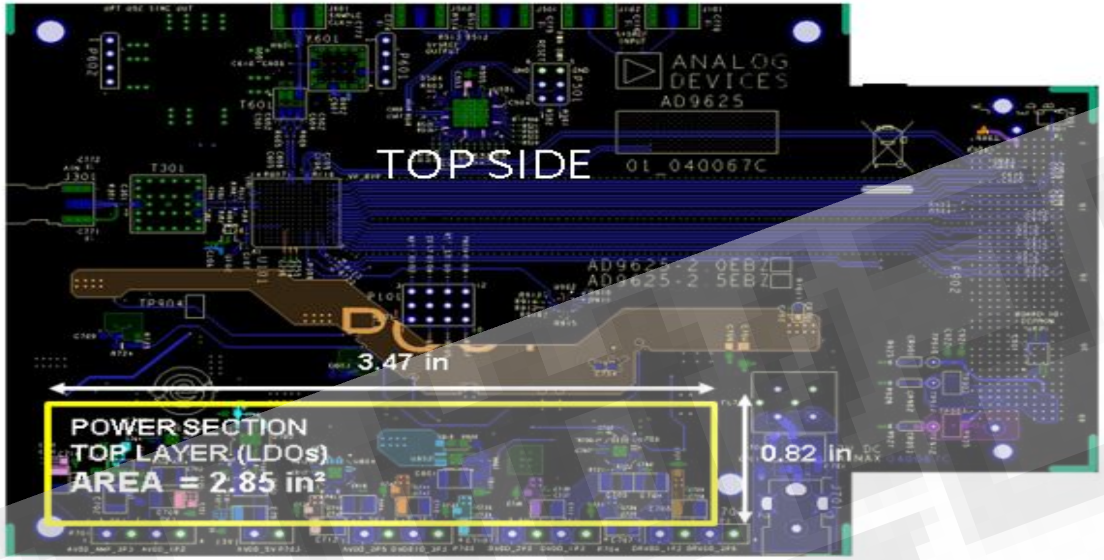
AD9625 FFT using LTM8065 + LC Filter (AIN = 1349MHz)

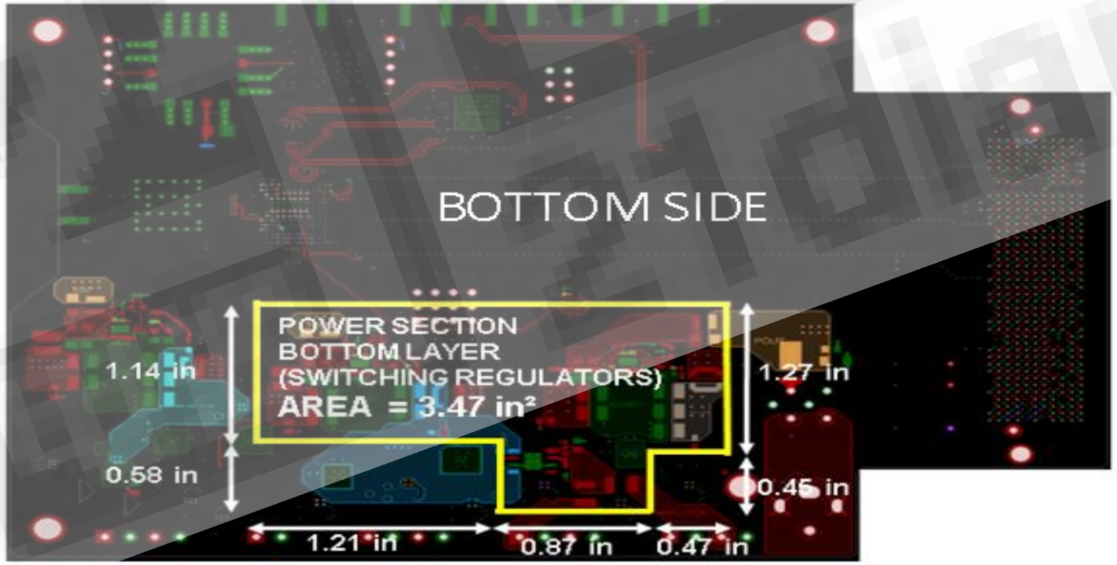


LTM8065 Version 2		Voltage (V)	Current (A)	Power (W)
PIN		11.885	0.442	5.256
POUT	AVDD_1.3V	1.303	1.308	1.704324
	DRVDD_1.3V	1.302	0.531	0.691
	DVDD_1.3V	1.305	0.459	0.599
	AVDD_2.5V	2.486	0.440	1.094
	DRVDD_2.5V	2.494	0.005	0.012
	DVDD_2.5V	2.496	0.0001	0.0002
	DVDDIO_3.3V	3.301	0.0004	0.0013
			POUT TOTAL:	4.102
			Efficiency (%):	**78.05**

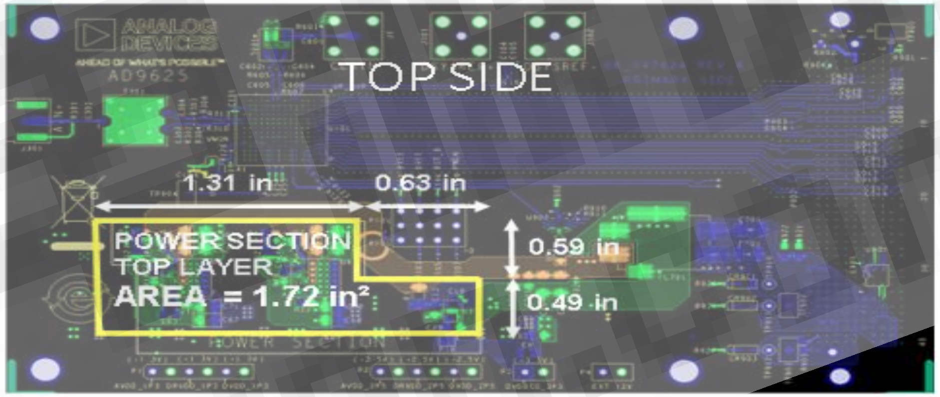
Silent Switcher Application

EVAL-AD9625 Evaluation Board





REVISED Evaluation Board USING LTM8065 POWER SOLUTION



Test Guaranteed VS Design Guaranteed

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

Features

- Low 20μA Quiescent Current
- +3.5V to +30V Wide Input Voltage Range, +45V Tolerant
- Operates Through Cold-Crank Conditions
- Low-Dropout Voltage of 280mV at 200mA
- Up to 200mA Output Current Capability
- Stable Operation with Tiny 4.7μF Output Capacitor
- User-
  - +3.
  - +1.
  - Re
- Open
- Fixed
- High-
- Therm
- Opera
- Auton

LTC3803

ELECTRICAL CHARACTERISTICS The ● denotes the specifications which apply over the full operating junction temperature range, otherwise specifications are at T_A = 25°C. V_{CC} = 8V, unless otherwise noted. (Note 2)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
$V_{CLAMP1mA}$	V_{CC} Shunt Regulator Voltage at 1mA	I_{CC} = 1mA, $V_{ITH/RUN}$ = 0V					
		LTC3803E	●	8.3	9.4	10.3	V
		LTC3803H, LTC3803I	●	8.3	9.4	10.5	V
		LTC3803MP	●	8	9.4	10.5	V
$V_{CLAMP25mA}$	V_{CC} Shunt Regulator Voltage at 25mA	I_{CC} = 25mA, $V_{ITH/RUN}$ = 0V					
		LTC3803E	●	8.4	9.5	10.5	V
		LTC3803H, LTC3803I	●	8.4	9.5	10.7	V
		LTC3803MP	●	8.1	9.5	10.7	V
V_{MARGIN}	$V_{CLAMP1mA} - V_{TURNON}$ Margin	LTC3803E	●	0.05	0.6		V
		LTC3803H, LTC3803I, LTC3803MP	●	0.03	0.6		V

200mA, Automotive Quiescent Current,

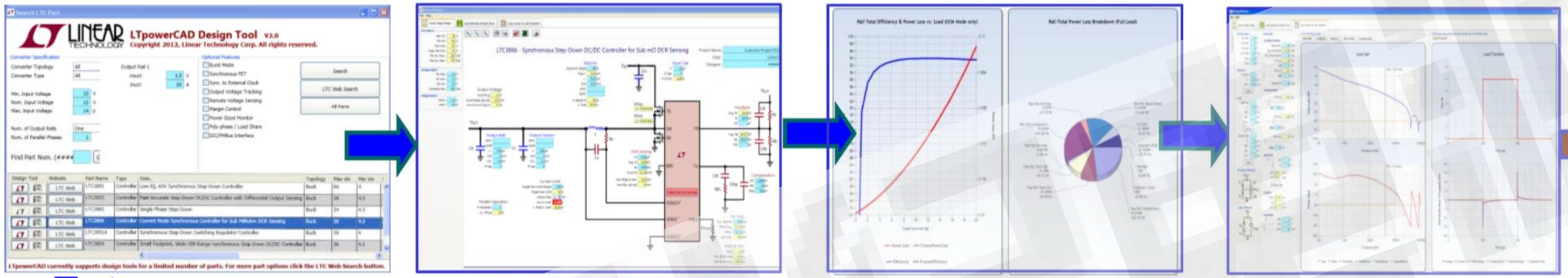
ELECTRICAL CHARACTERISTICS (

(V_{IN} = V_{ENABLE} = +14V, $C_{TIMEOUT}$ = open, C_{IN} = 1μ … otherwise noted. Typical values are T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SETOV INPUT (TRI-MODE)						
SETOV Input Leakage Current		SET = HIGH, V_{SETOV} = 5V or SET = GND, V_{SETOV} = 5V		1		μA
SETOV Low-Level Input Voltage	$V_{ILSETOV}$	SET = GND, V_{SETOV} < $V_{ILSETOV}$ or places device in +3.3V fixed output-voltage mode			0.4	V
SETOV High-Level Input Voltage	$V_{IHSETOV}$	SET = GND, V_{SETOV} > $V_{IHSETOV}$ or places device in +5V fixed output-voltage mode	V_{OUT} - 0.4			V

Note 2: Production tested at T_A = +25°C. Overtemperature limits are guaranteed by design.

Design Tools: Step-by-Step Power Supply Design



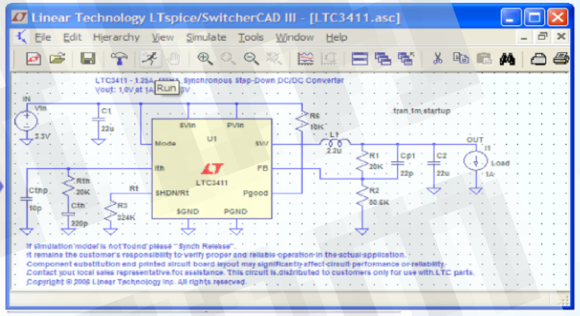
Enter specs, search solution.

Power Supply Schematic.

Efficiency & Power Loss

Loop Stability & Transient

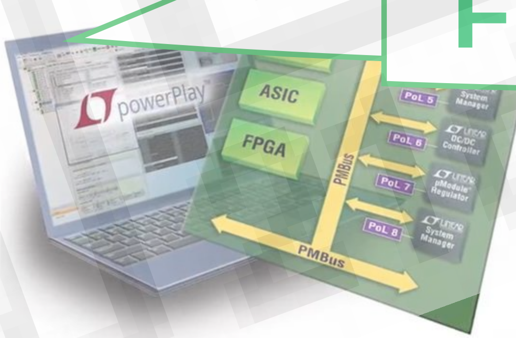
LTpowerCAD



LTspice™ Simulation

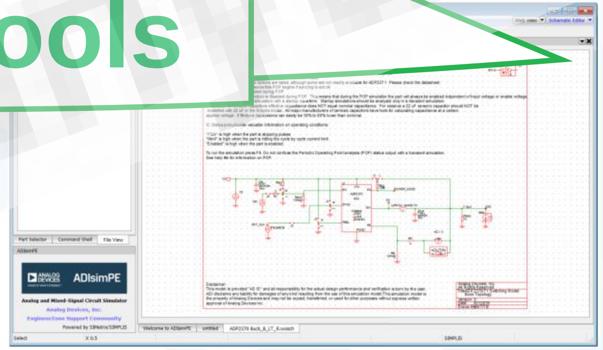
LTspice

Free Tools



Develop tools for PSM

LTpowerPlay



ADI power Simulation

ADIsimPE

Thanks

Analog Device