



AHEAD OF WHAT'S POSSIBLE™

Maximising Power Supply Performance while Minimising EMI

Diarmuid Carey

Senior Applications Engineer – EMEA Power



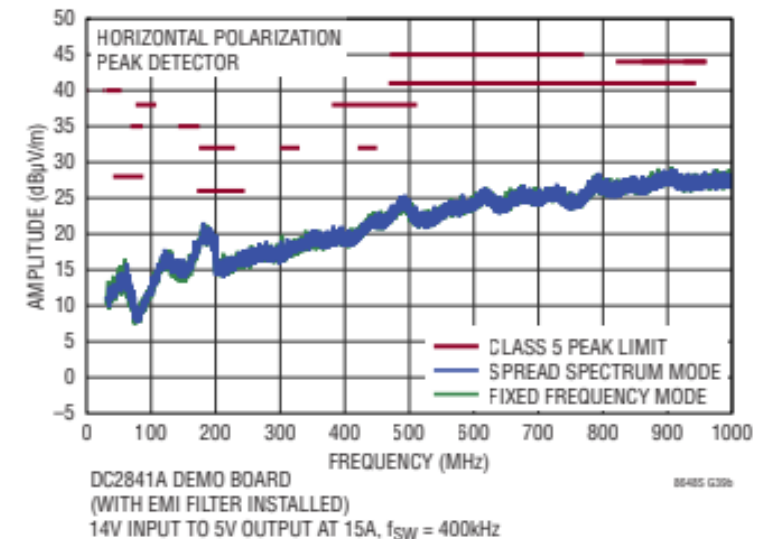
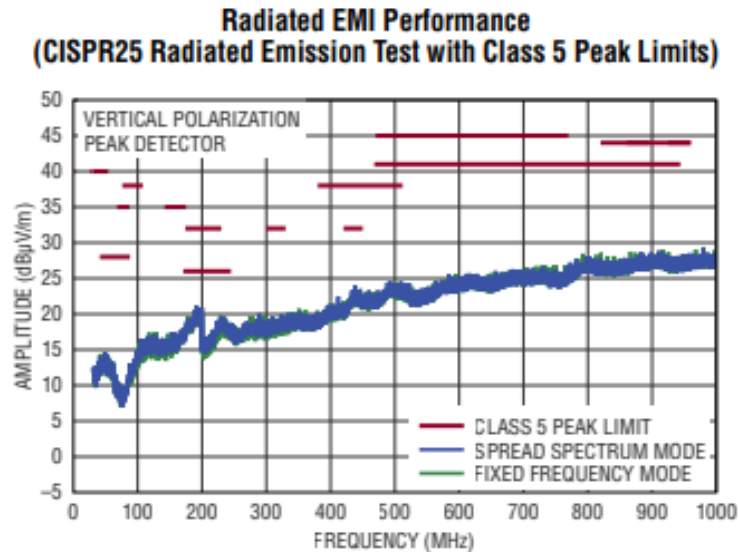
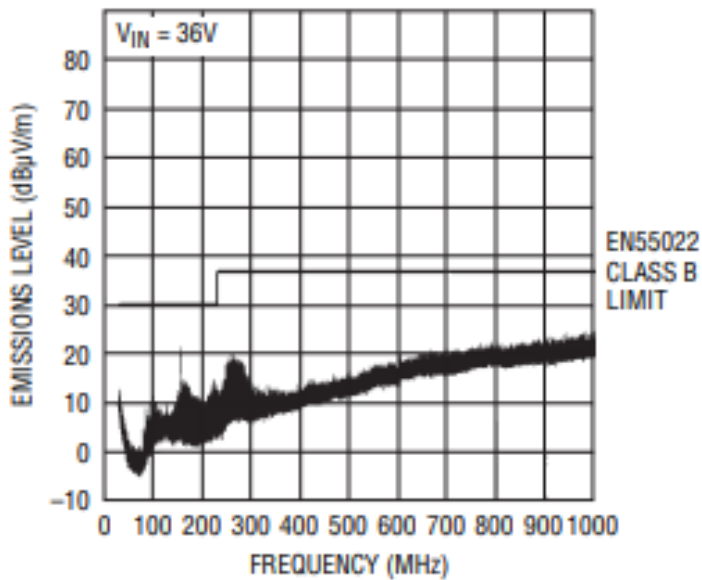
Agenda

- ▶ What is EMC/EMI?
- ▶ EMI Measurements (standards, specs, equipment, measurement equipment)
- ▶ Sources of noise and importance of layout
- ▶ Silent Switcher
- ▶ 4 switch buck boost
- ▶ Demo board layouts

What is EMI/EMC and how is it measured?

Some terminology

- ▶ EMI = Electromagnetic Interference
- ▶ EMC = Electromagnetic Compatibility
- ▶ EN55022B (European EMC Standard for radiated emissions)
- ▶ CISPR25 (International EMC Standard for radiated emissions)



EMI – Conducted vs. Radiated

EMI (Electro Magnetic Interference)

Conducted (<30MHz)

FCC: 450kHz-30MHz

Differential Mode (DM)

Common Mode (CM)

Lower order harmonics are NOT sensitive to supply parasitics and can be estimated with LTpowerCAD.

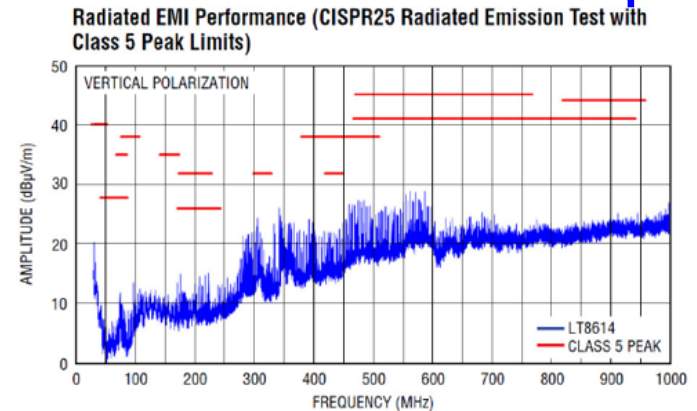
Radiated (>30MHz)

FCC: 30MHz-1GHz

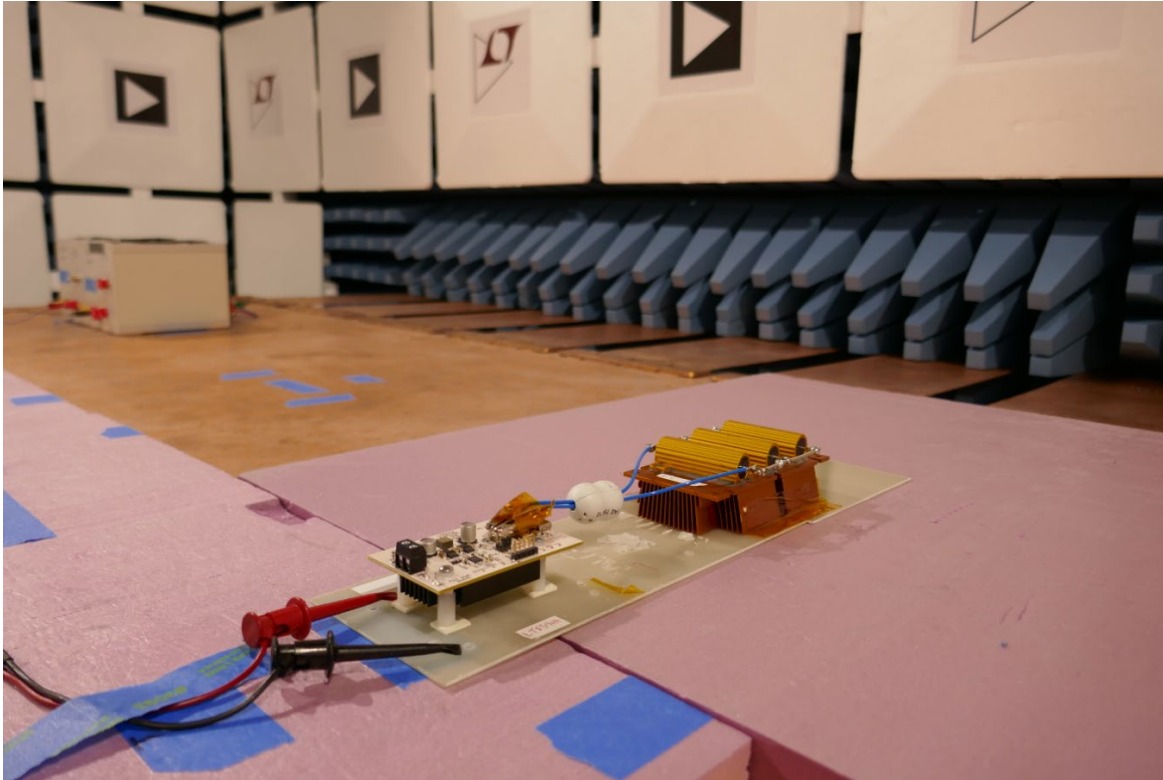
Magnetic

Electric

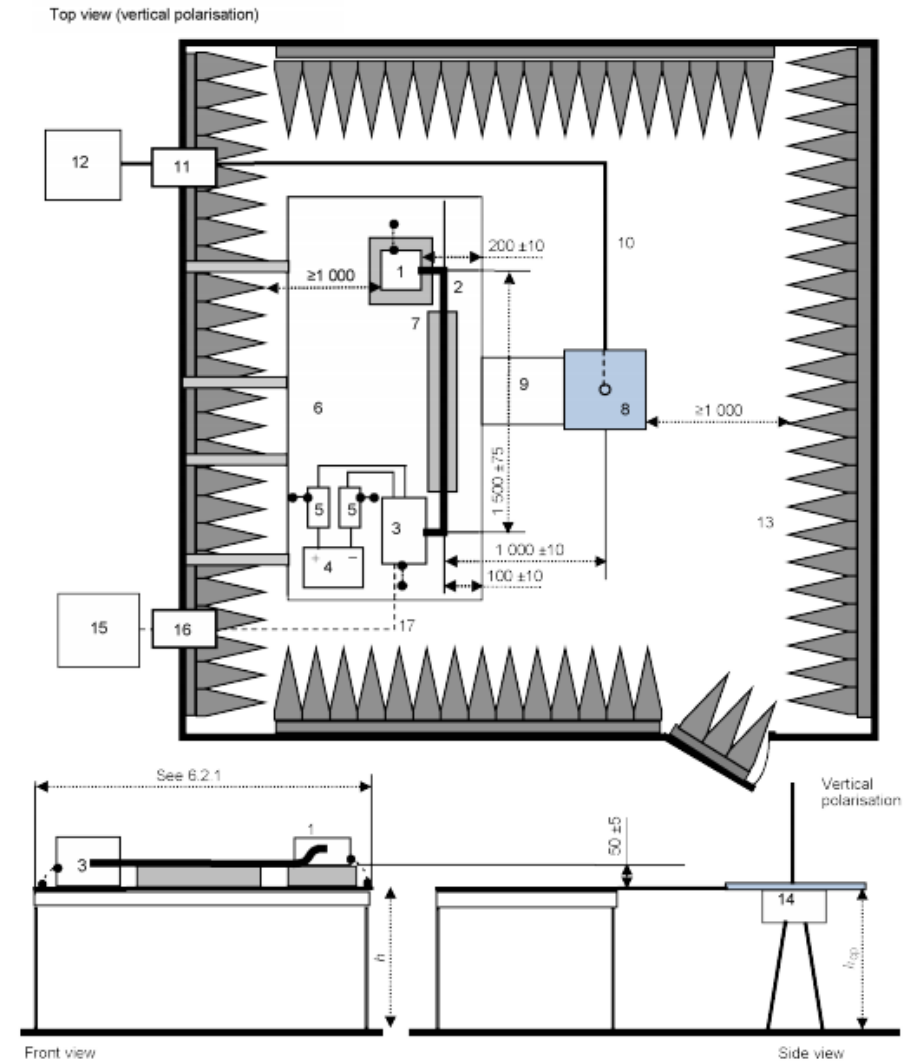
“Silent Switcher” helps!



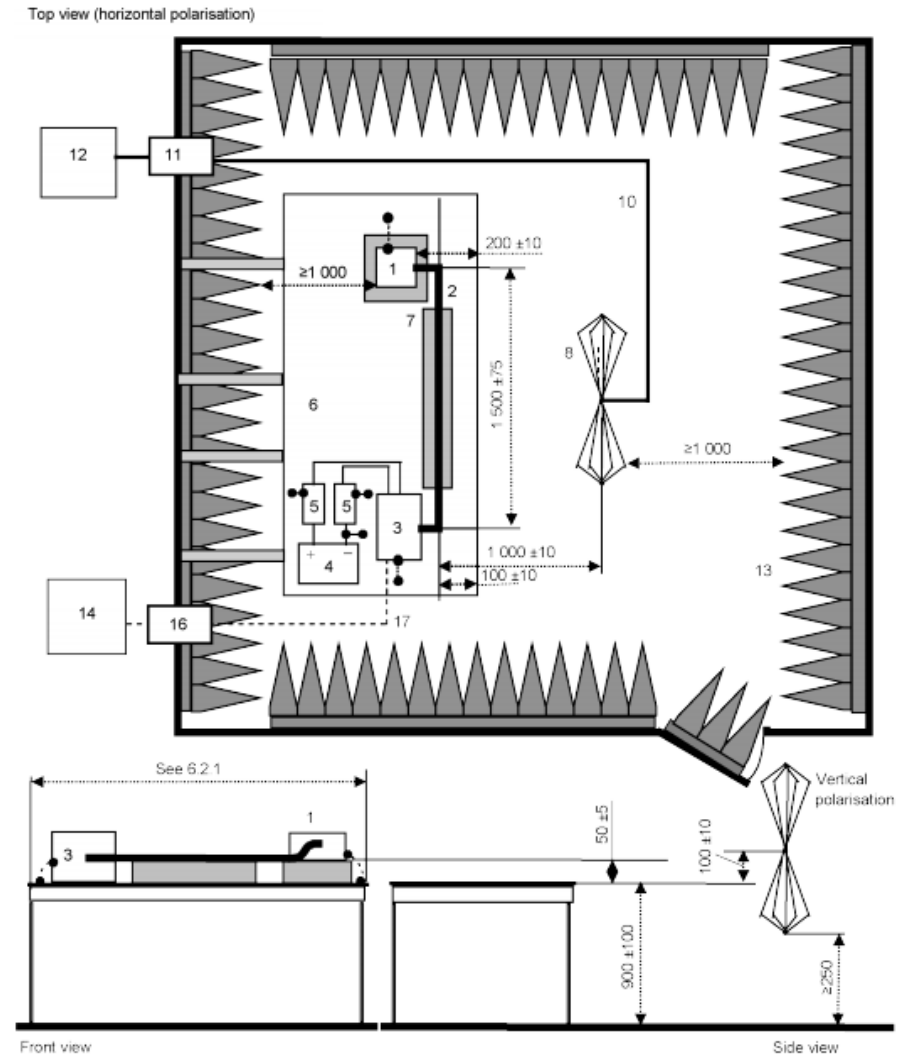
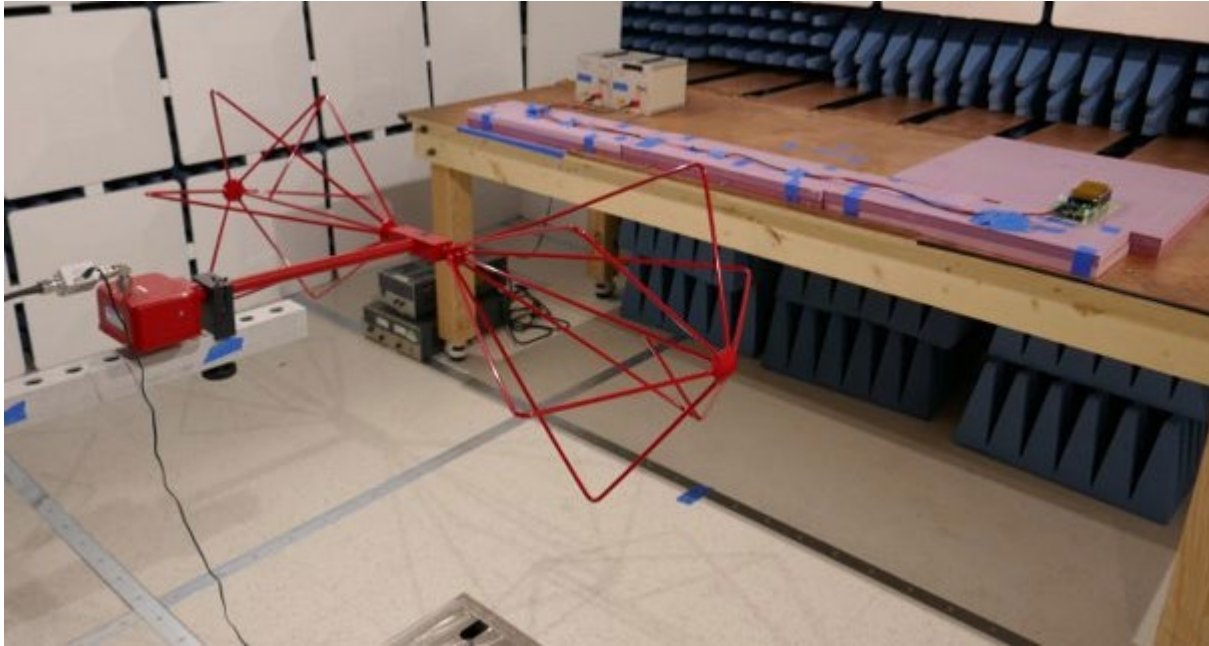
EMI Chamber



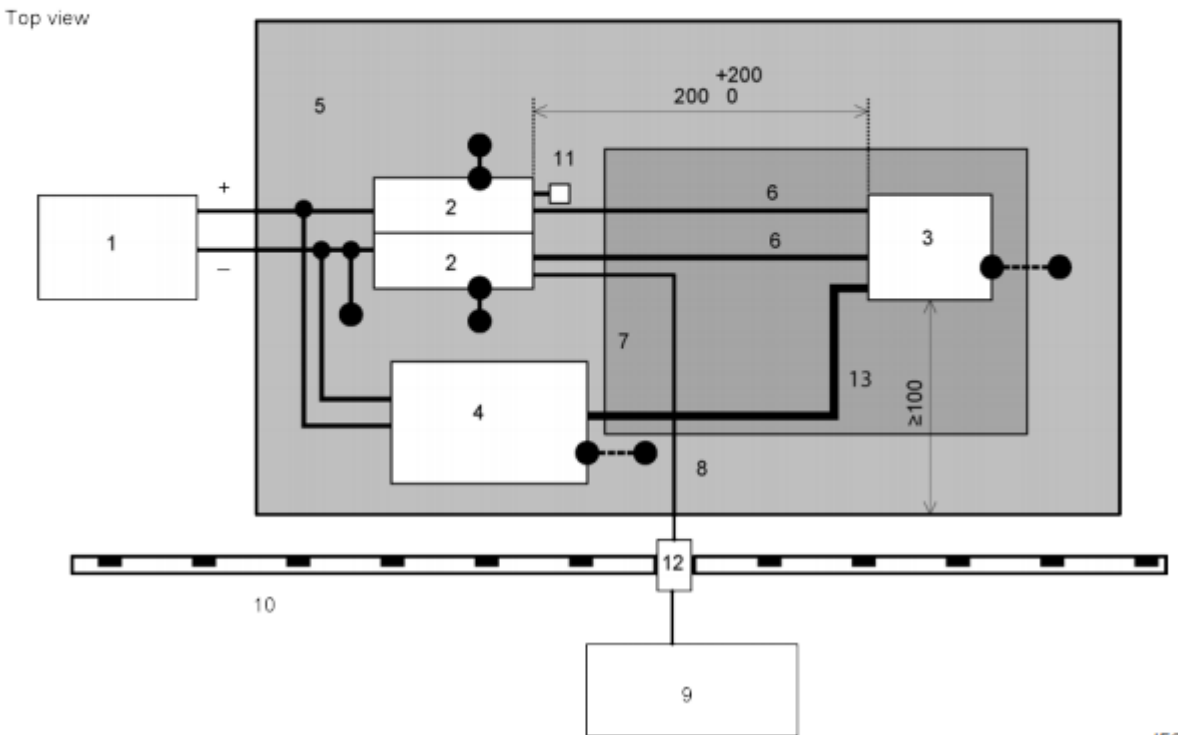
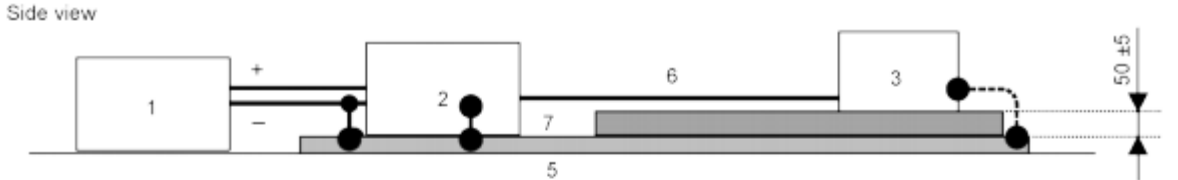
Measurements – Radiated Emissions using Monopole Antenna



Measurements – Radiated Emissions using Biconical Antenna

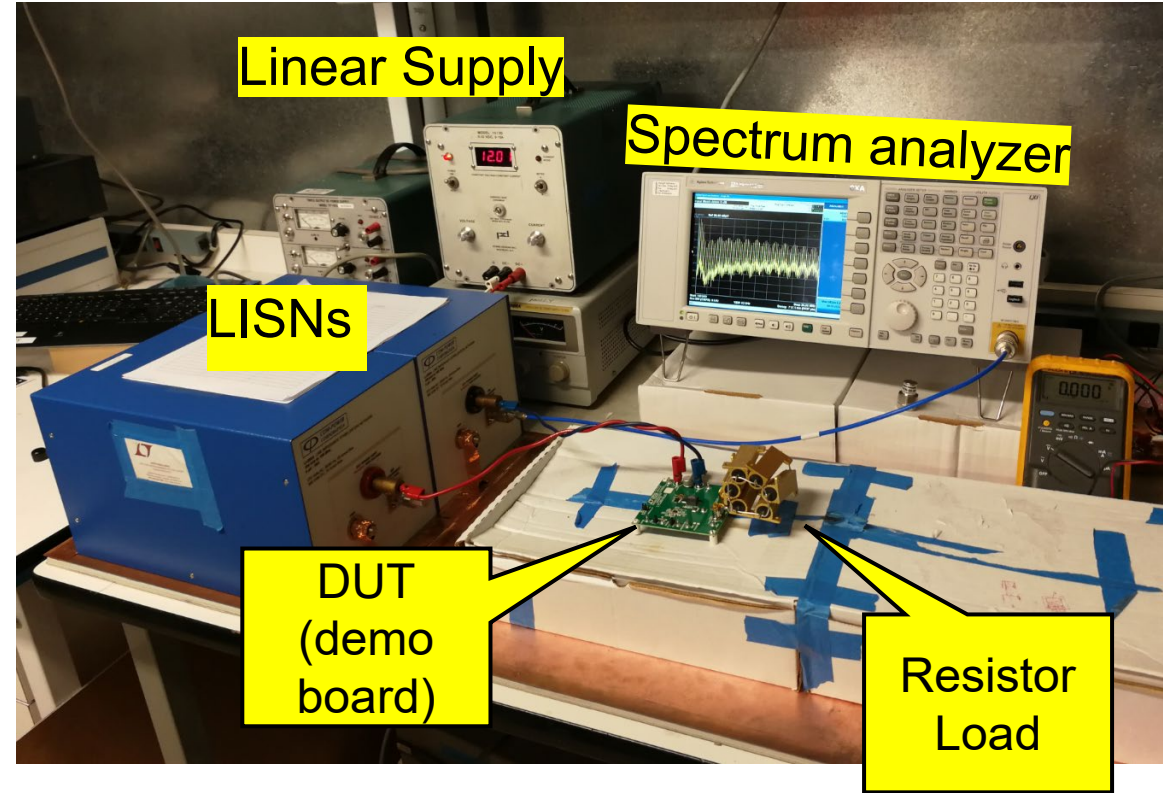
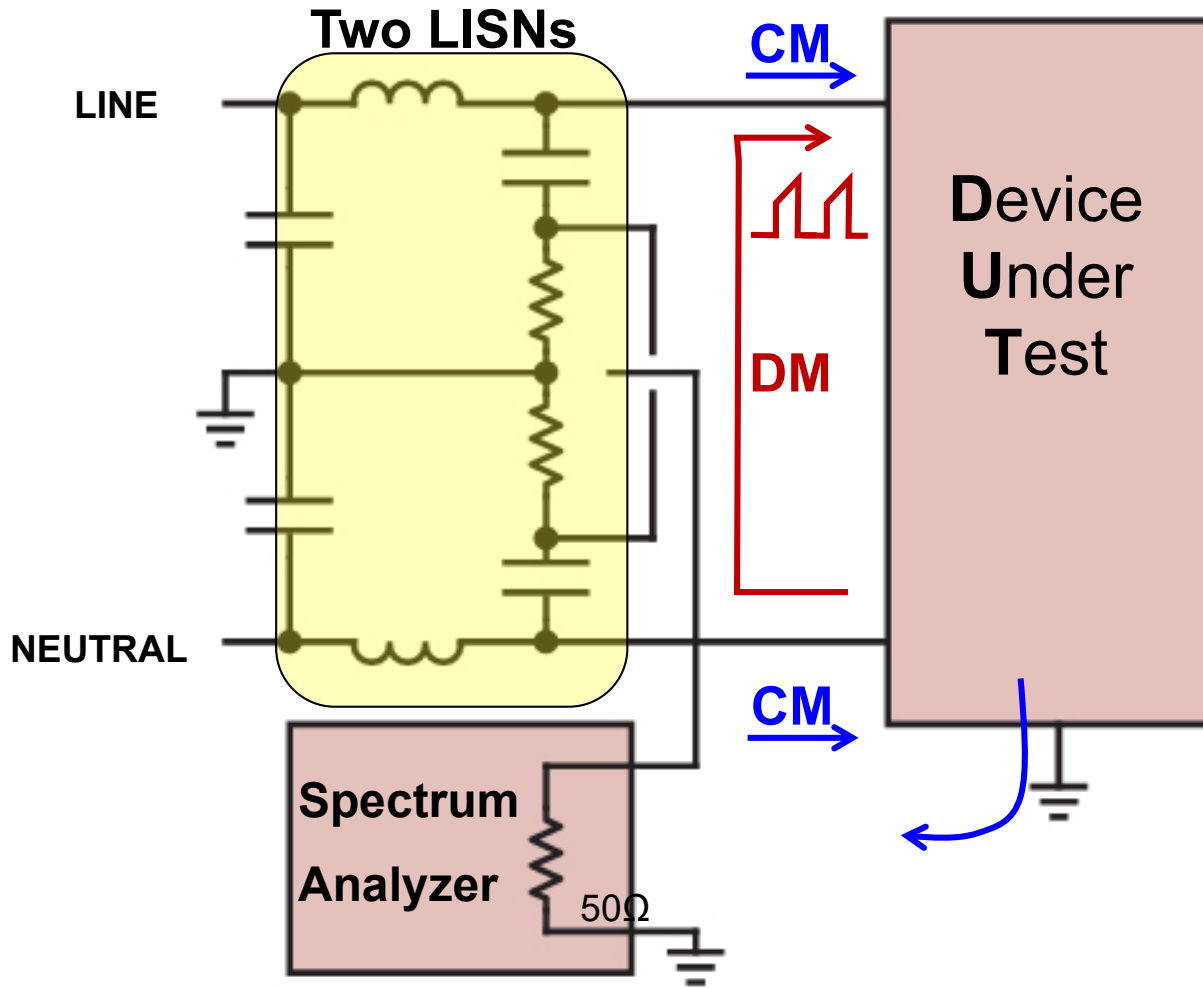


Measurements – Conducted Emissions (voltage measurement)

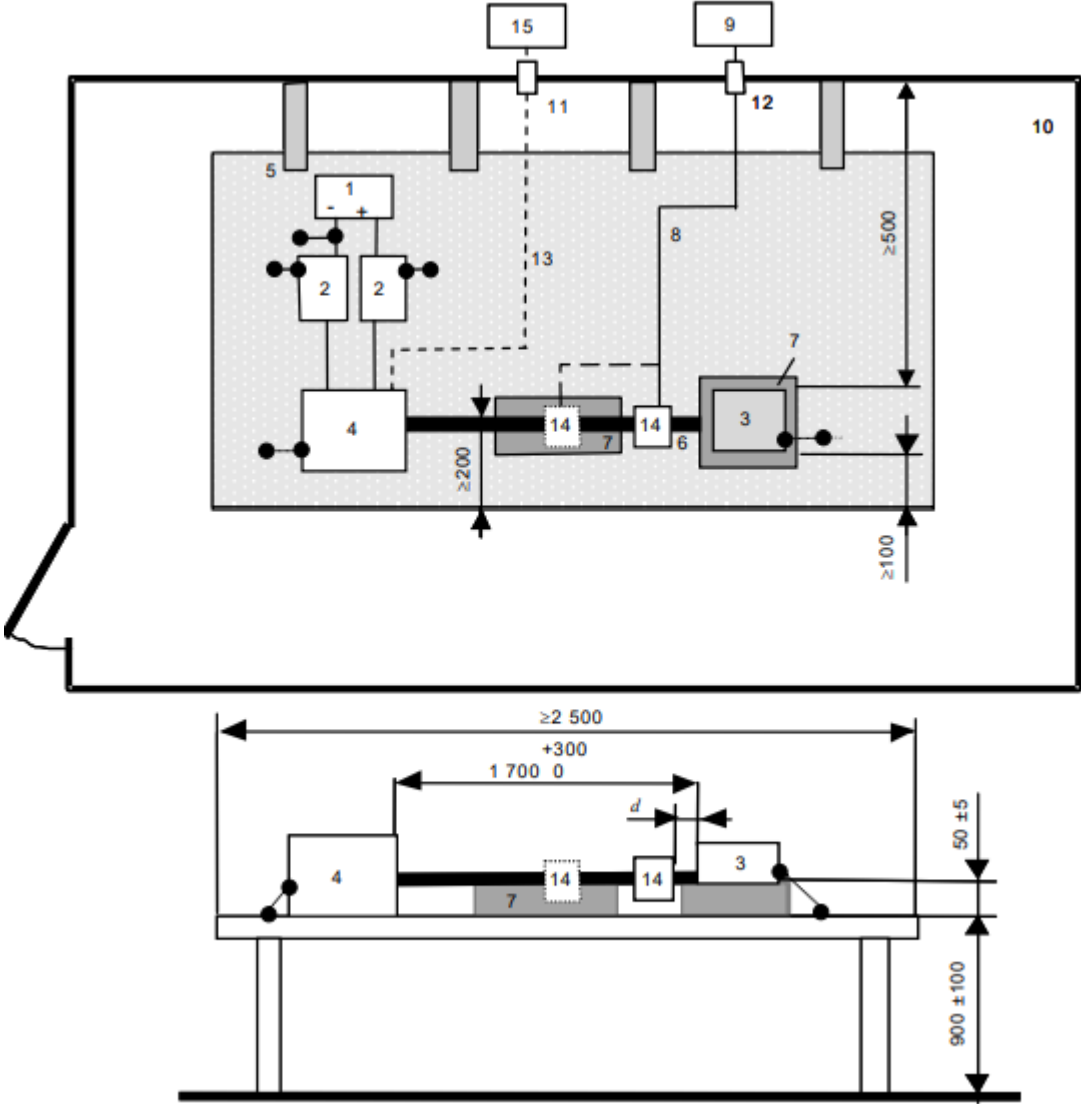
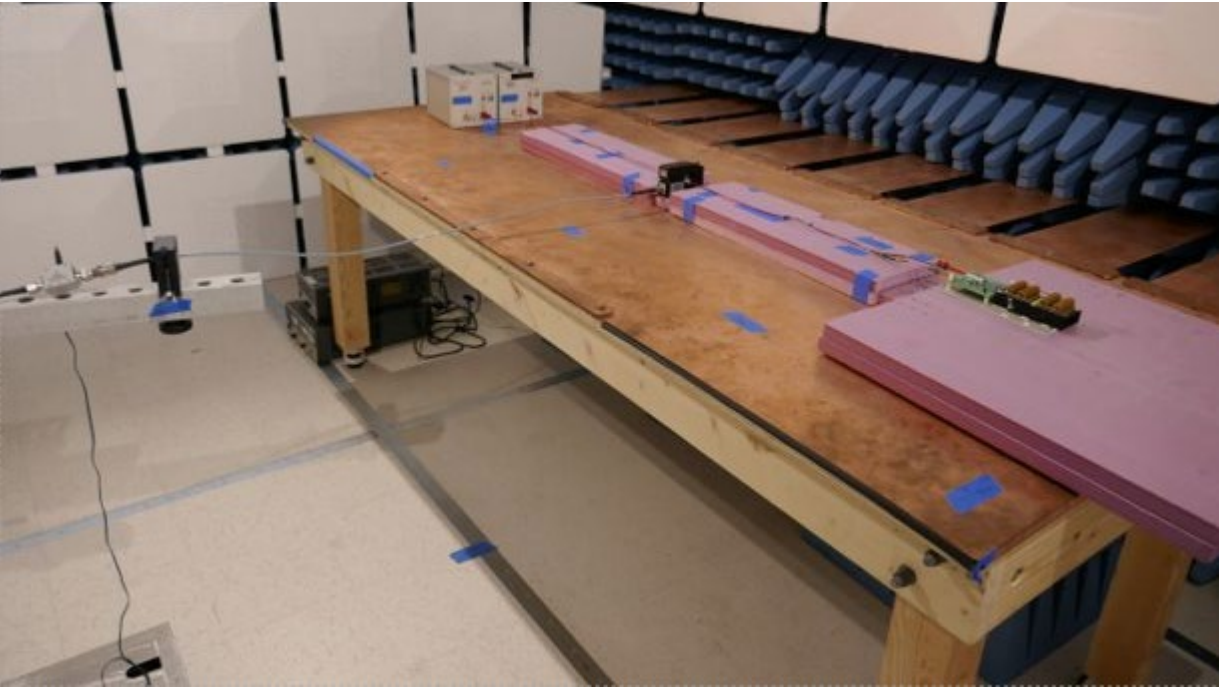


IEC

Conducted EMI – equipment

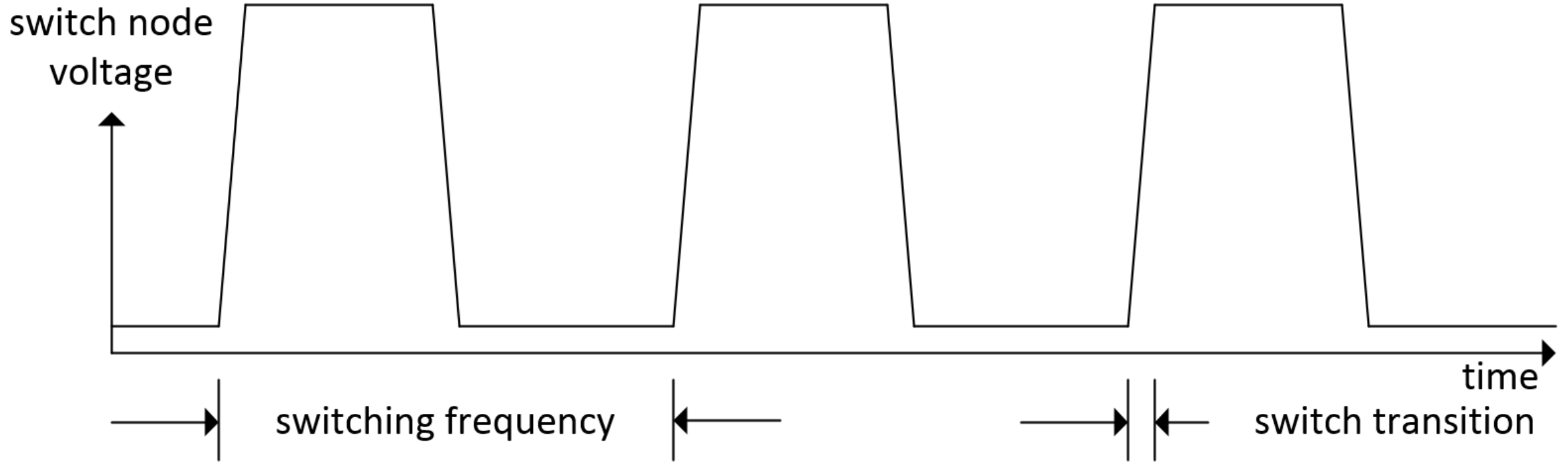


Measurements – Conducted Emissions (current measurement)



Sources of noise in a DC/DC converter

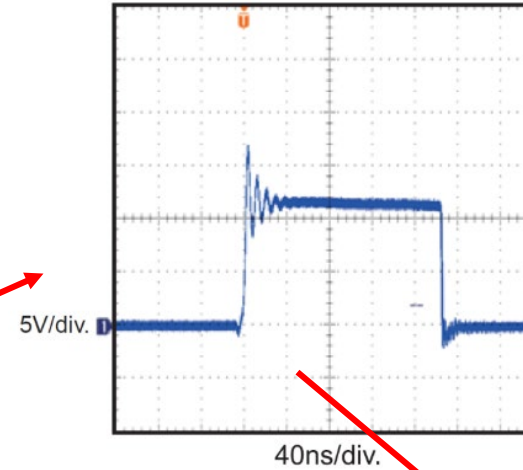
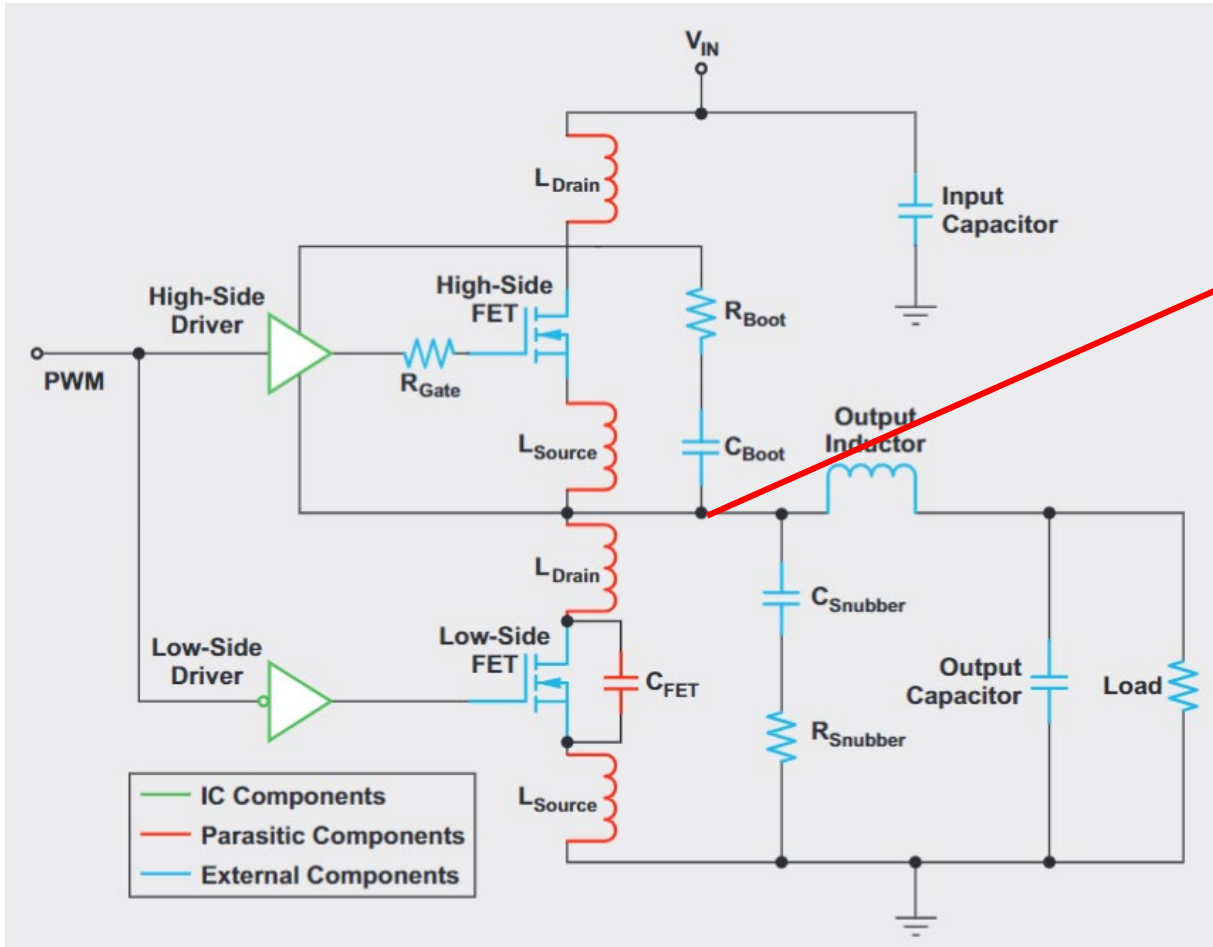
Noise generated by a switch mode power supply



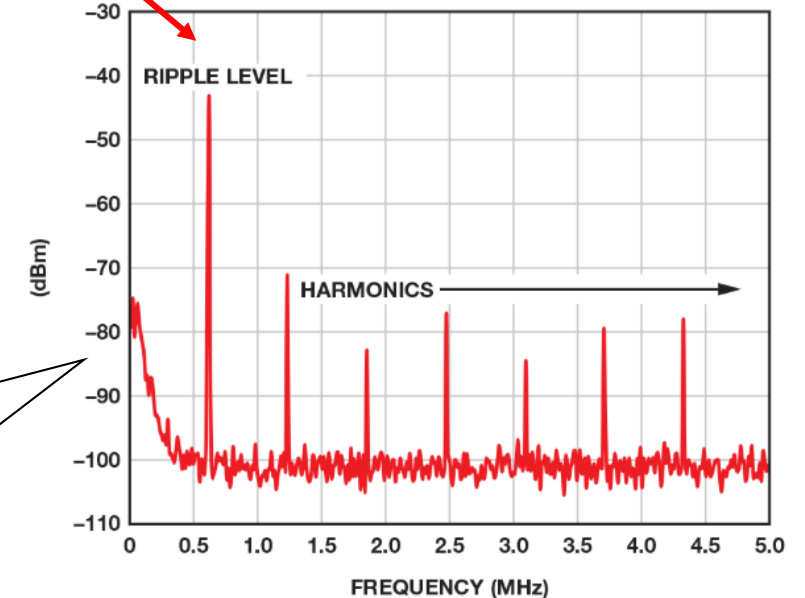
Switching frequency typically **500kHz** to **3MHz**

Switching transition typically **10MHz** to **200MHz** (100ns to 5ns)

Where does high frequency noise come from?



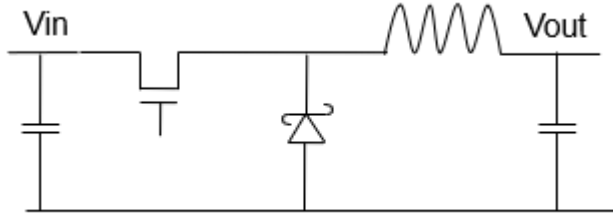
In the time domain, we see ringing on the SW node



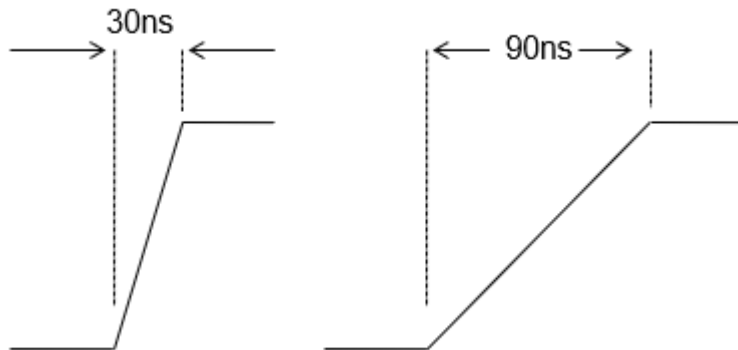
In the frequency domain, we see high frequency harmonics

Layout, a very important 'external' component

Basic buck topology



Switch Transition



Voltage offset resulting from switch transitions

- ▶ Every one inch (2.5cm) of PCB trace has about 20nH of trace inductance

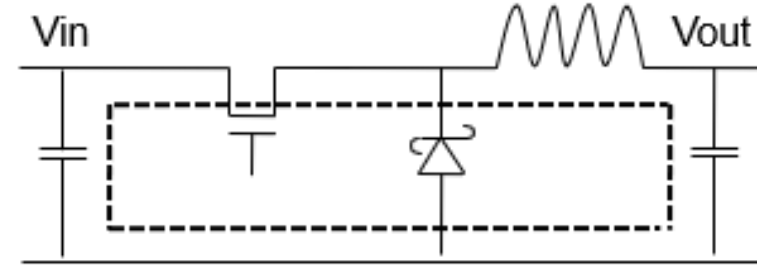
- ▶ $V = L (di/dt)$

- ▶ With switch transitions of 30ns, 1 inch of board trace length and 5A of current:

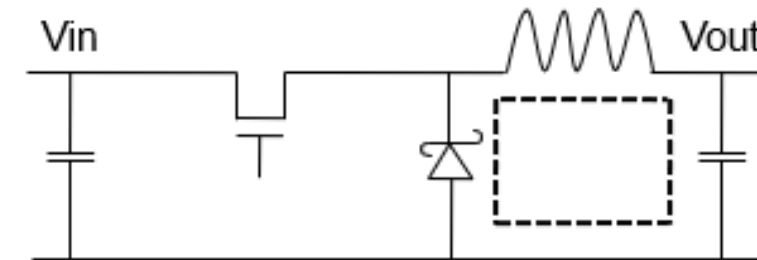
- ▶ $V = 20\text{nH} (5\text{A}/30\text{ns}) = 3.33\text{V}$

What are AC traces?

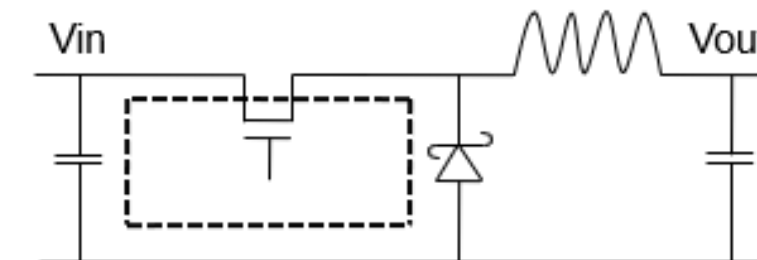
Current flow during on-time:



Current flow during off-time:



AC Traces:

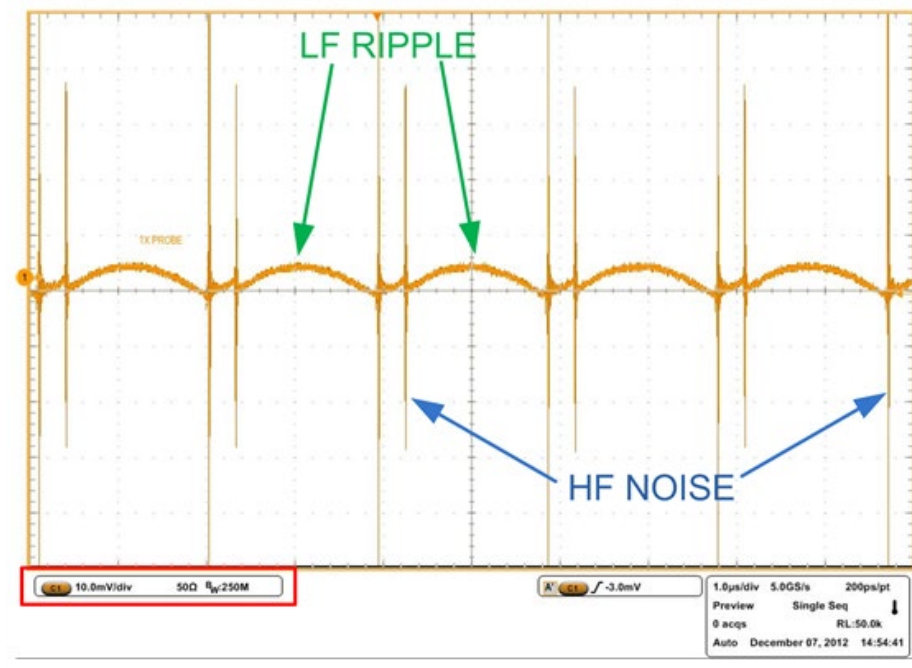
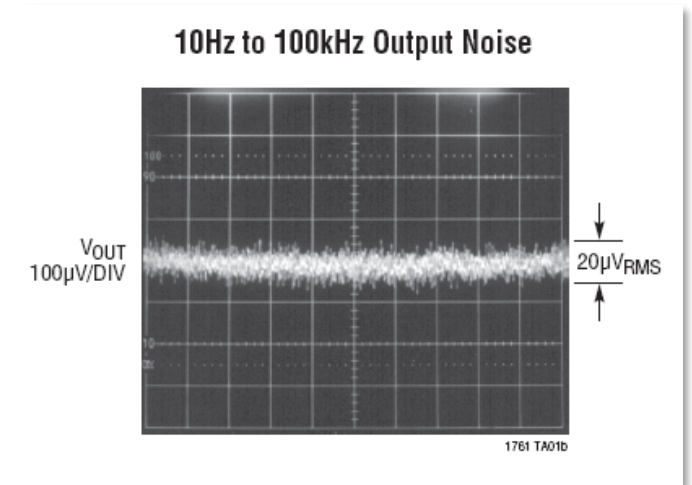


Keep AC traces as short as possible....

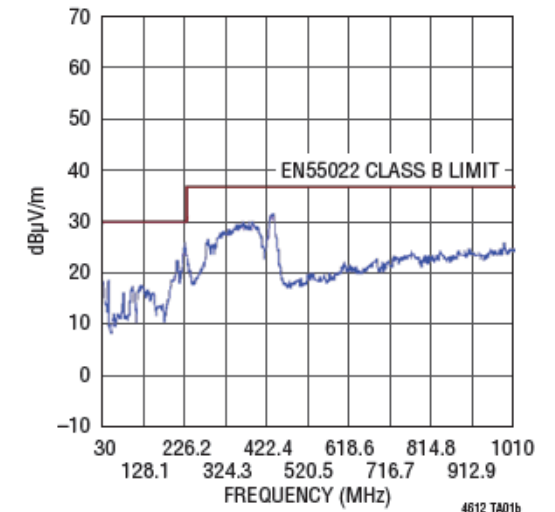
How can Analog Devices help?

How ADI Products Help Customer Reduce Noise

- ▶ Control the slew rate of switches
- ▶ Spread spectrum frequency modulation
- ▶ Modules with internal filtering and shielding
- ▶ Silent Switcher

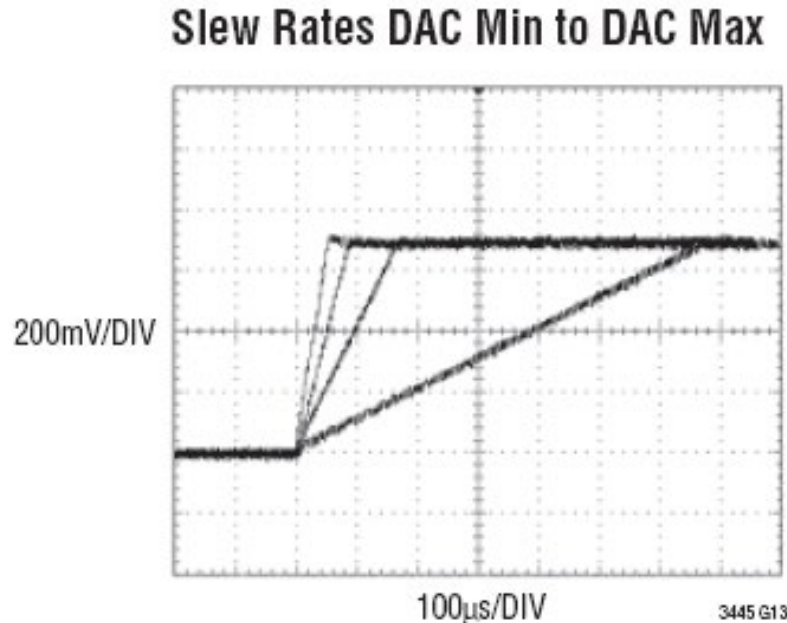


Radiated Emission Scan at 24V_{IN}, 5V_{OUT}/5A



Controlling Switch Transitions To Reduce Noise

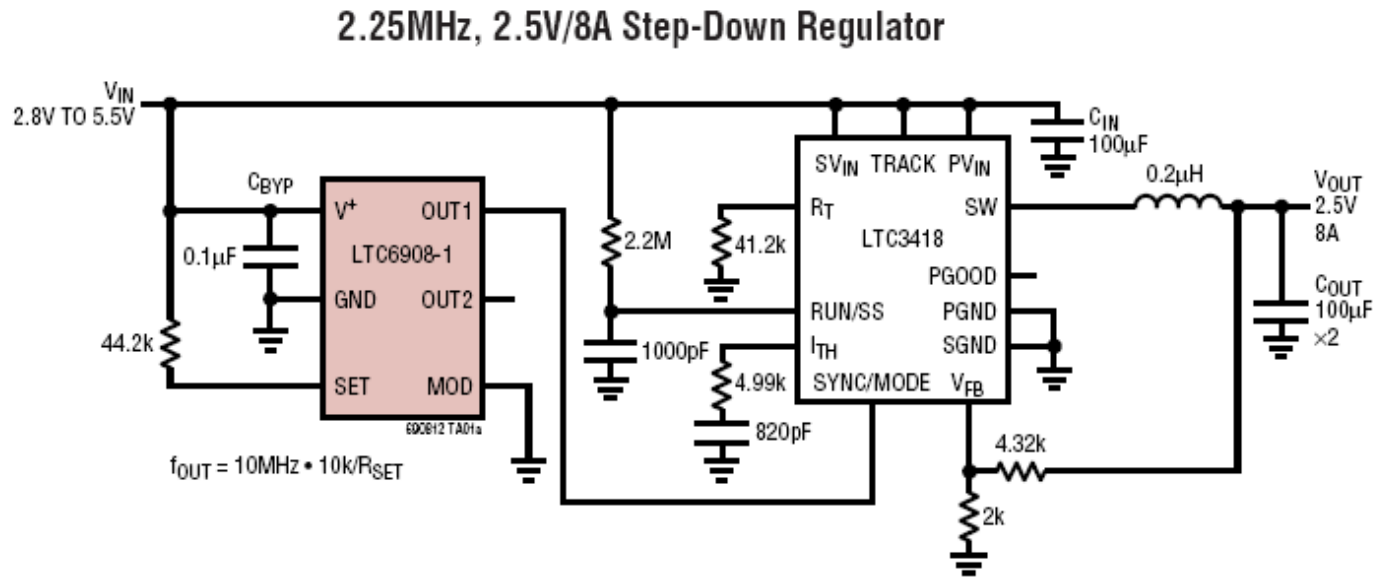
- ▶ Other parts with switch slew rate control for lower EMI



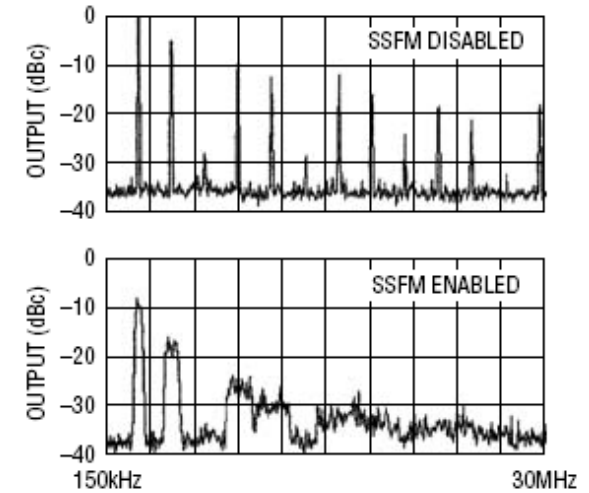
	Description
LTC3445	I ² C Controllable Buck Regulator with Two LDOs in a 4mm × 4mm QFN
LTC3562	I2C Quad Synchronous Step-Down DC/DC Regulator 2 x 600mA, 2 x 400mA
LTC3589	8-Output Regulator with Sequencing and I2C
LTC3670	Monolithic 400mA Buck Regulator with Dual 150mA LDOs in 3mm × 2mm DFN
LTC3672B	Monolithic Fixed-Output 400mA Buck Regulator with Dual 150mA LDOs in 2mm x 2mm DFN
LTC3675/6	7-Channel Configurable High Power PMIC
LTC3816	Single-Phase Wide VIN Range DC/DC Controller for Intel IMVP-6/IMVP-6.5 CPUs

Spread Spectrum Frequency Modulation

- ▶ SSFM decreases the peak electromagnetic radiation level and improve EMC (electro-magnetic compatibility). We can add SSFM with an external LTC6908...



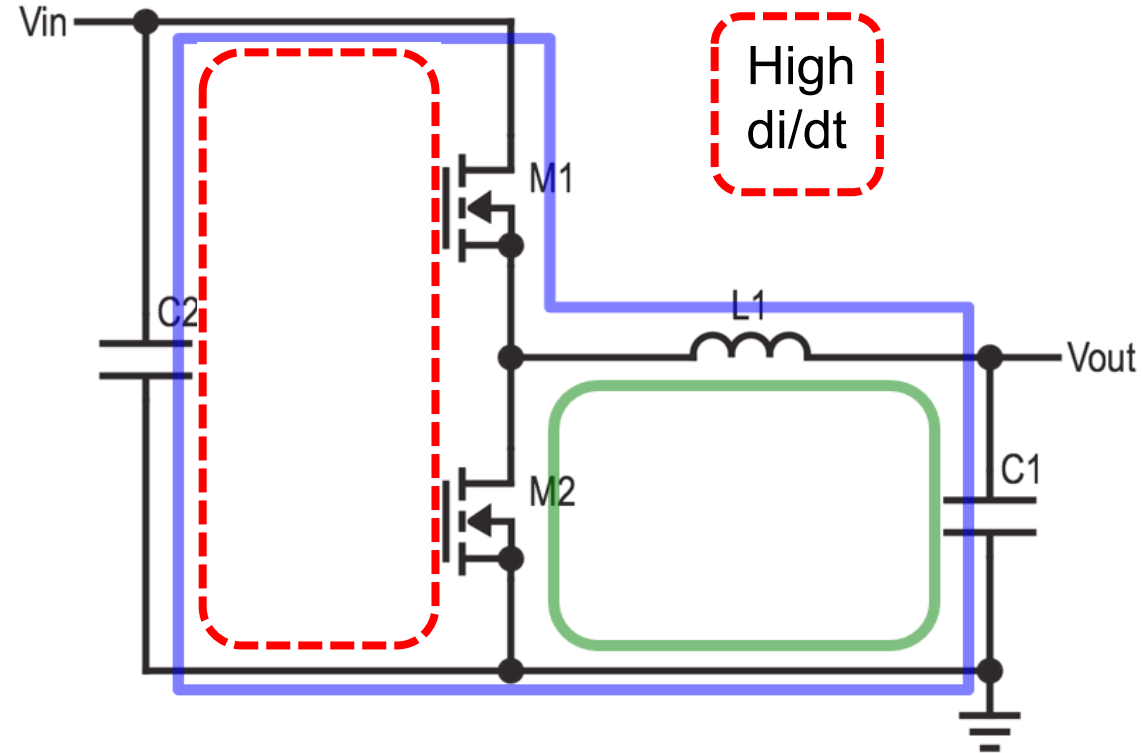
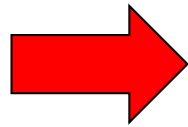
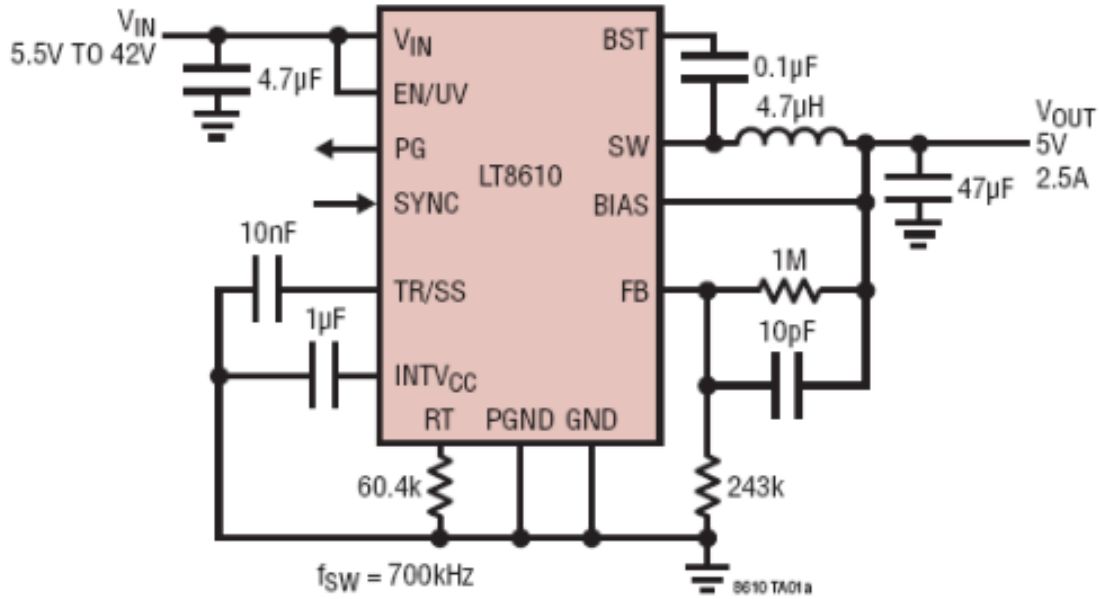
150kHz to 30MHz Output Frequency Spectrum (9kHz Res BW)



(FUNDAMENTAL AND HARMONICS SHOWN)

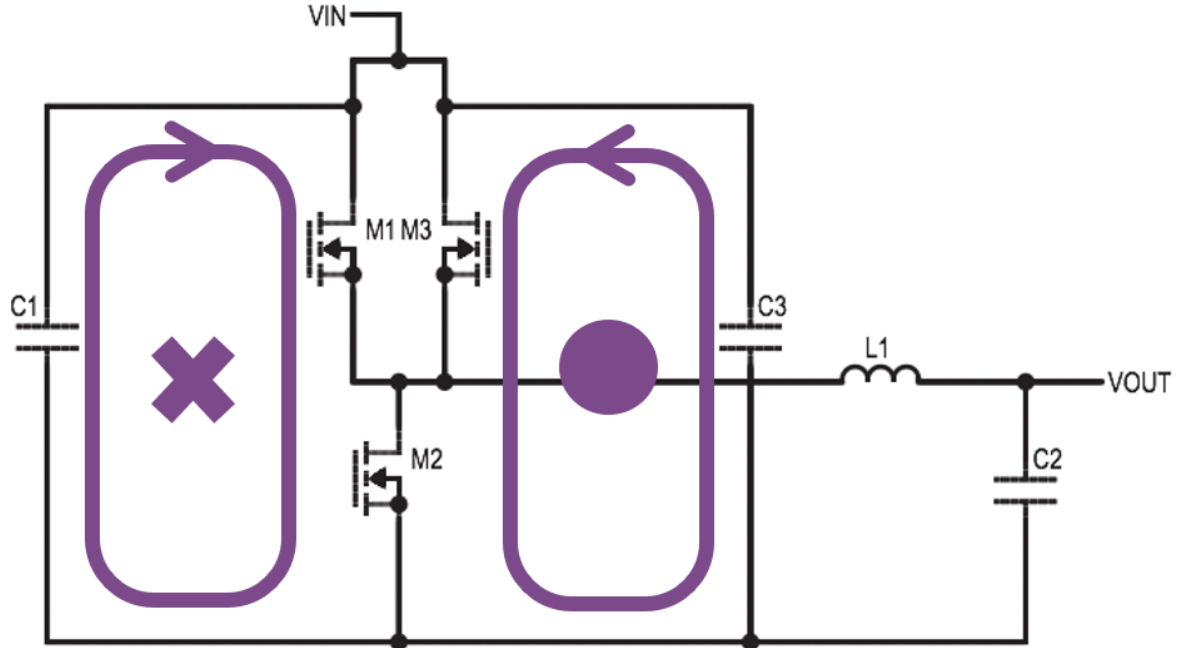
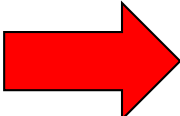
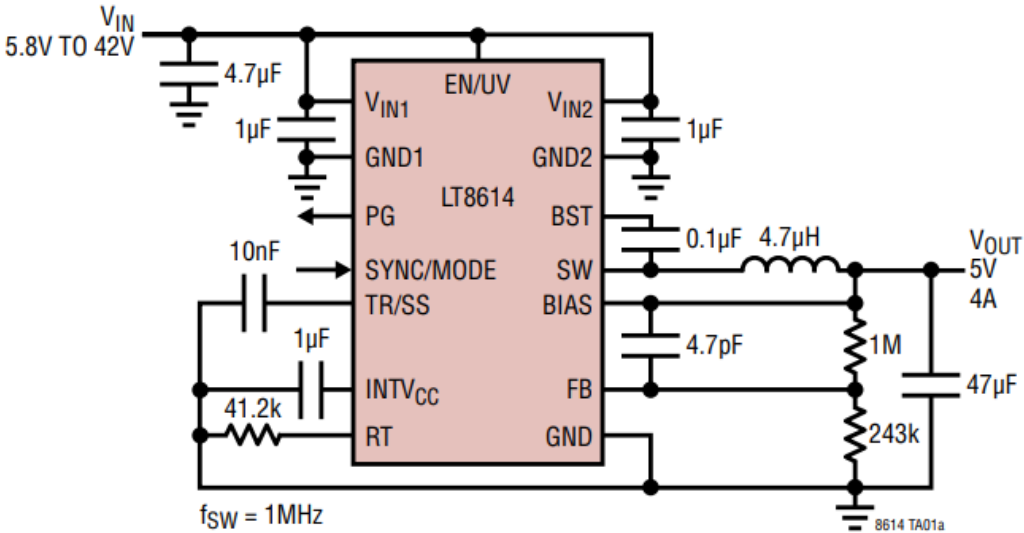
Hot loops in a switcher

5V 2.5A Step-Down Converter

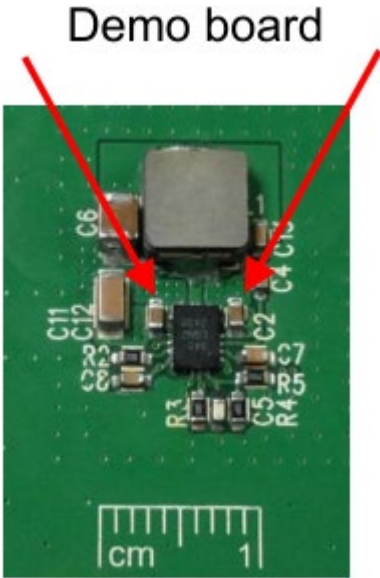
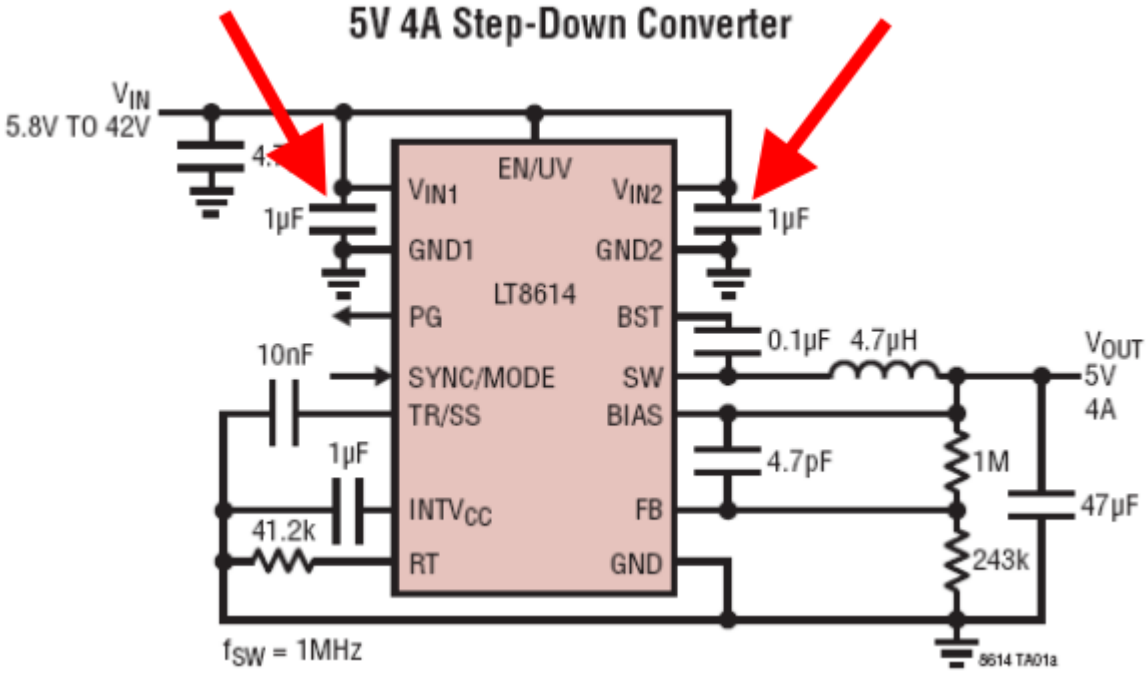


Two hot loops – magnetic fields cancel

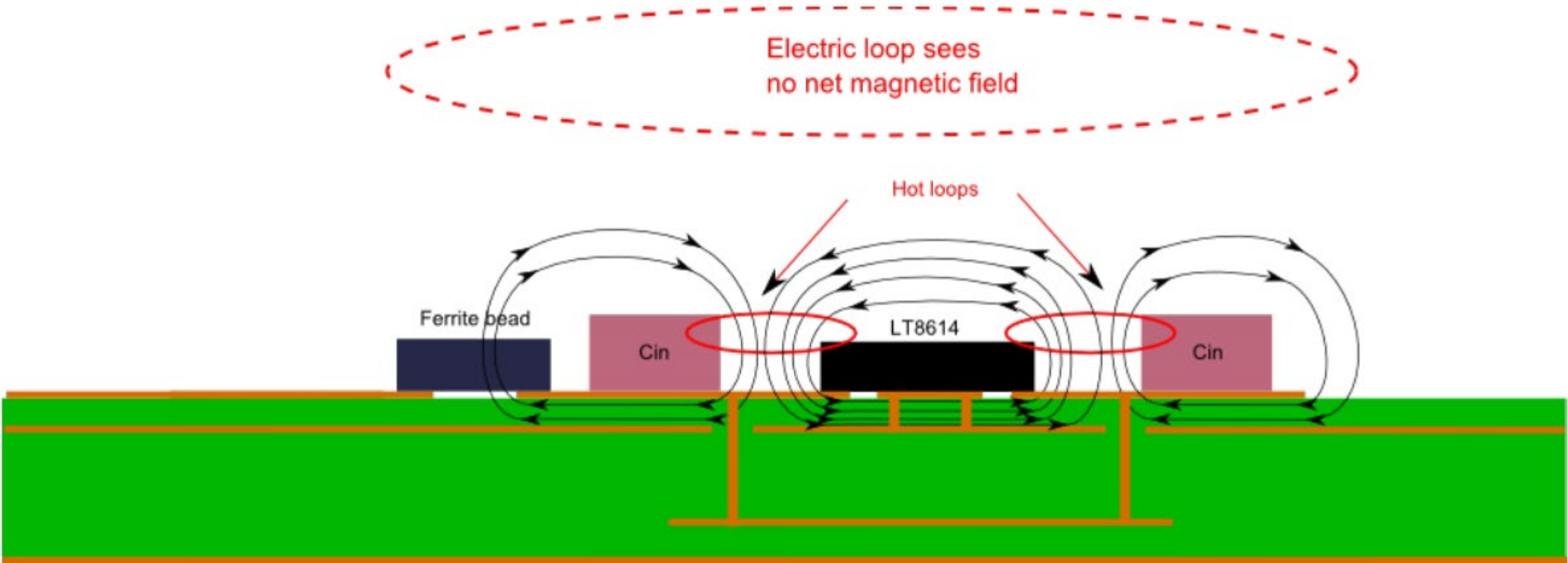
5V 4A Step-Down Converter



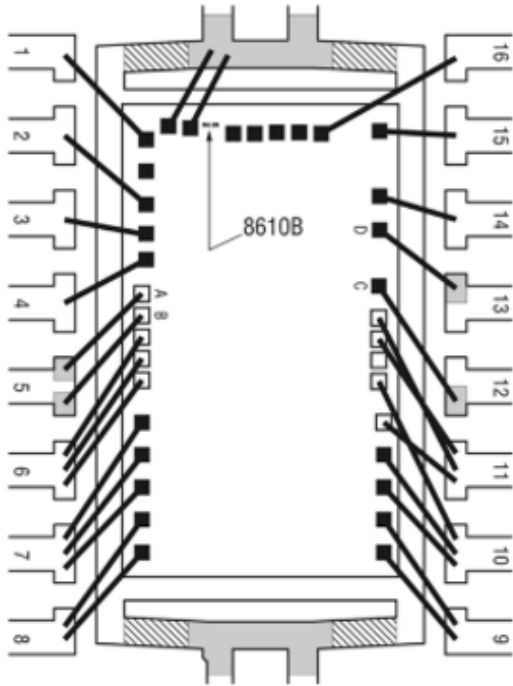
Silent Switcher 1 Innovation



Cancelling Hot Loops

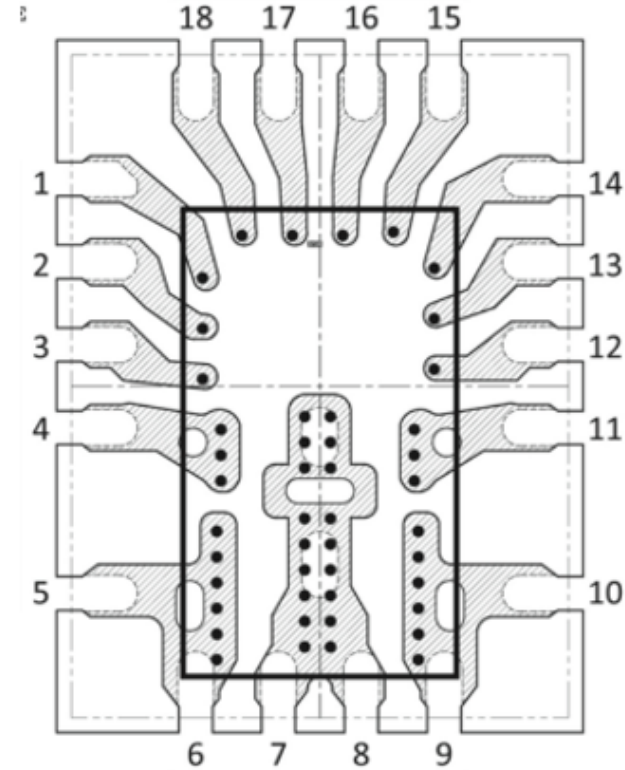


Assembly improvements also help



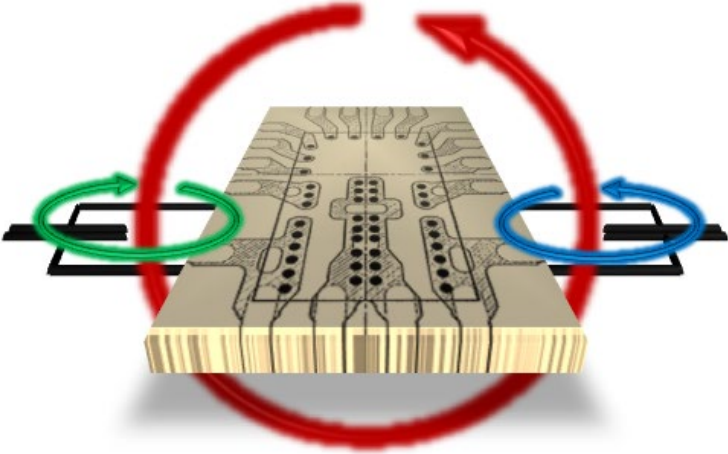
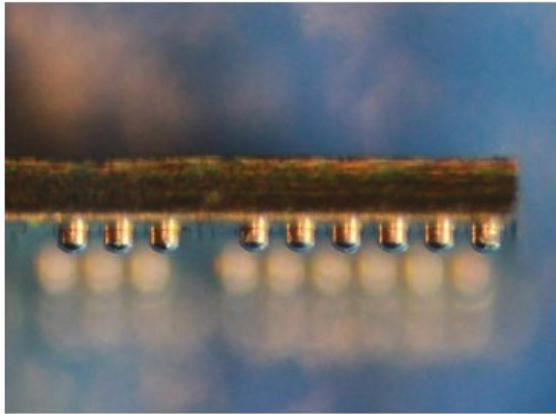
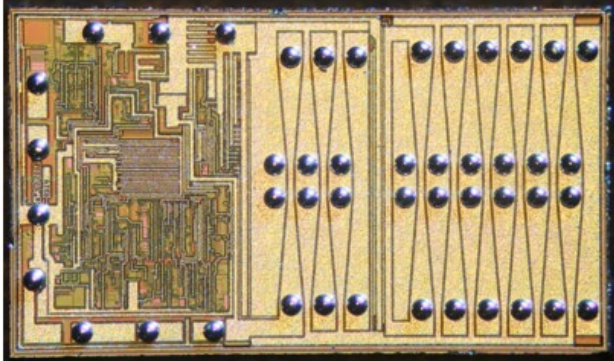
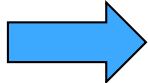
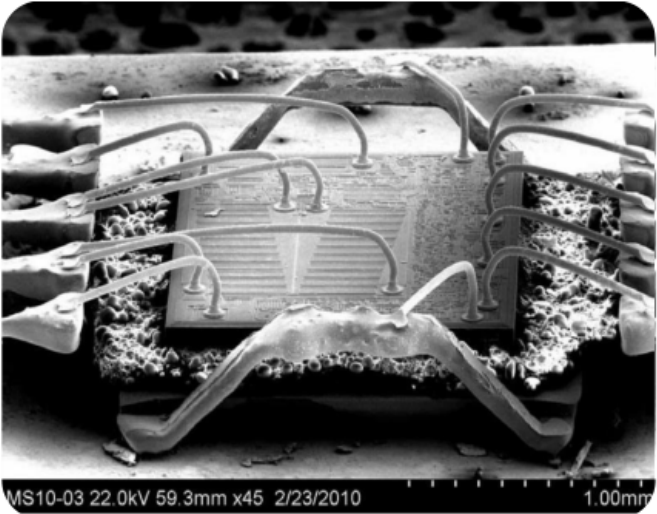
LT8610
MSOP-16E
Body 3 x 4 mm

Die size is identical,
But....



LT8640
QFN
Body 3 x 4 mm

Confined Magnetic Field = Low EMI



-LT8640-

20dB improvement

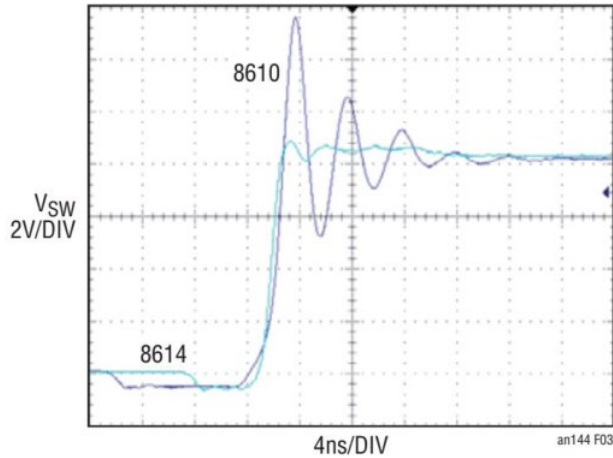


Figure 3. LT8610 and the LT8614, Switch Node Rising Edge Both at $8.4V_{IN}$, $3.3V_{OUT}$ at 2.2A

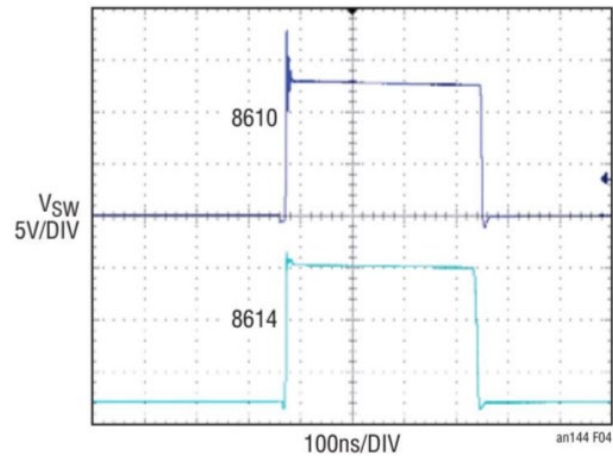


Figure 4. LT8610 and the LT8614, Both at $13.2V_{IN}$, $3.3V$ 2.2A out

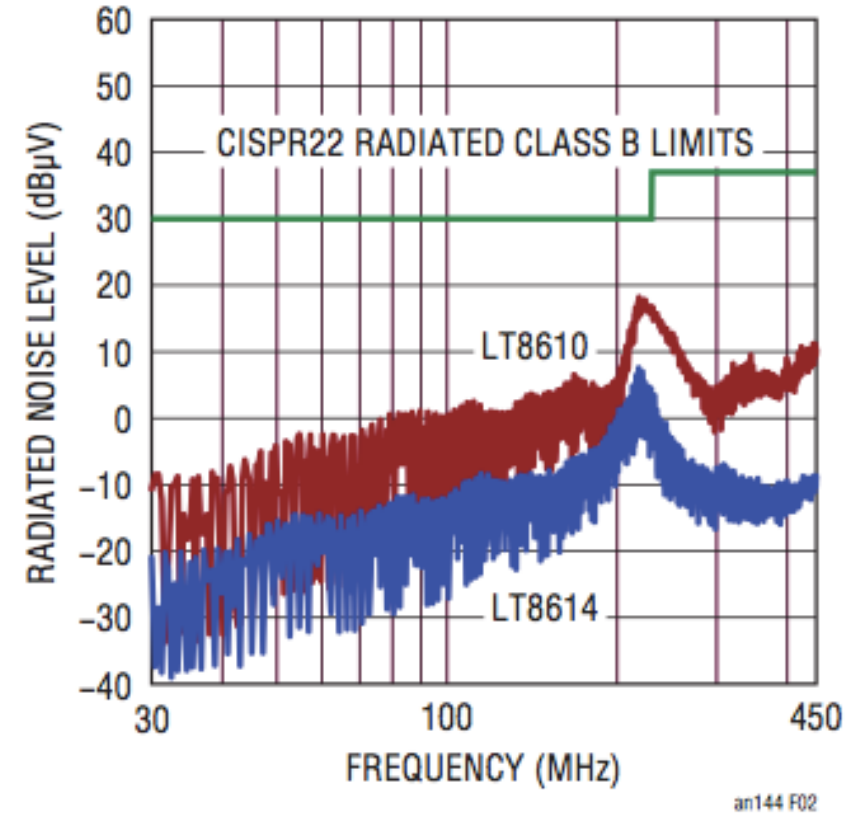
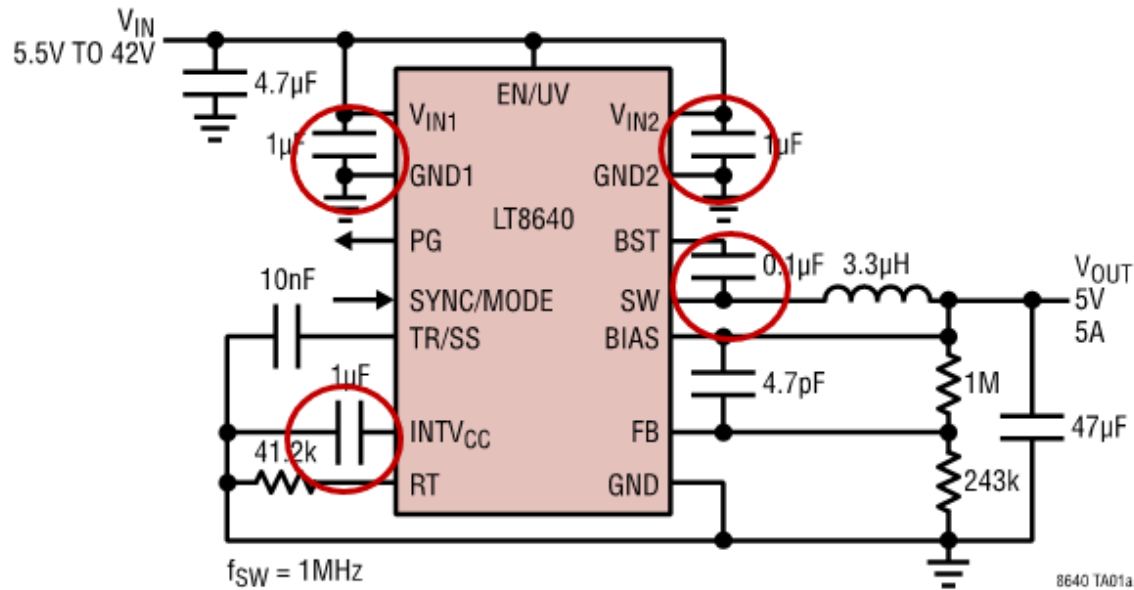


Figure 2. LT8610 and LT8614 700kHz 14V to 3.3V 2A Radiated EMI in GTEM Corrected for OATS

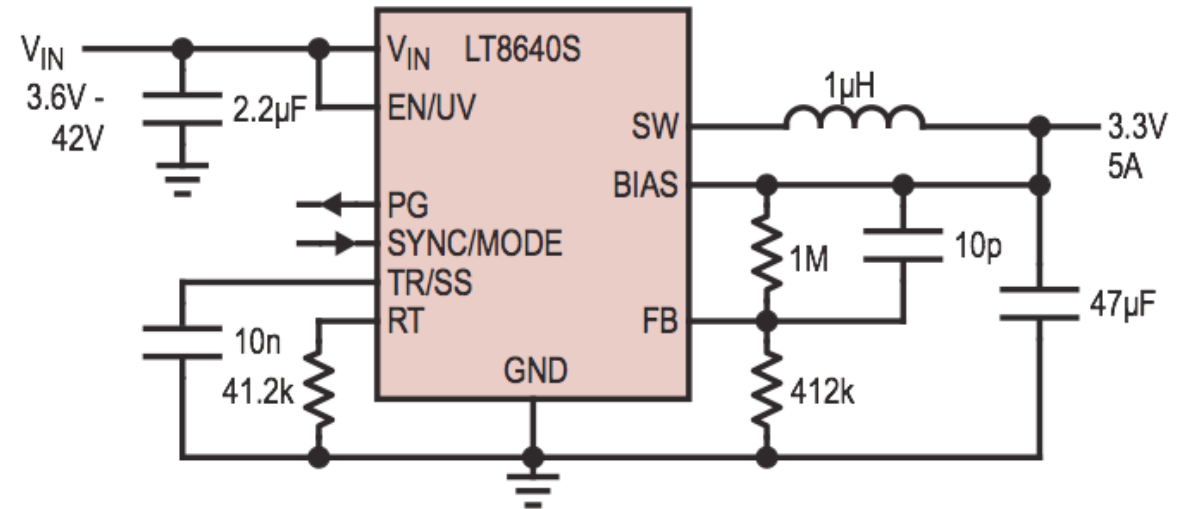
Silent Switcher 2

From this:
Silent Switcher 1

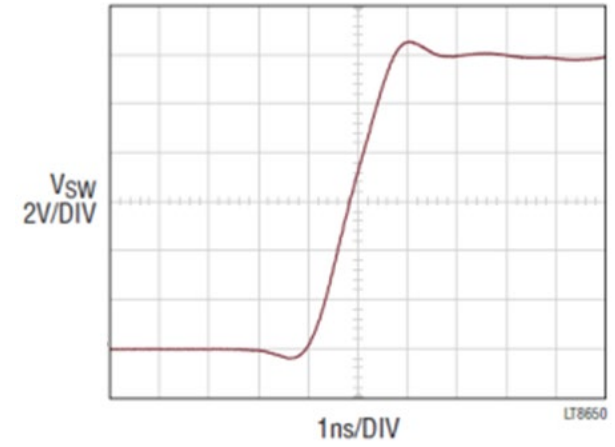
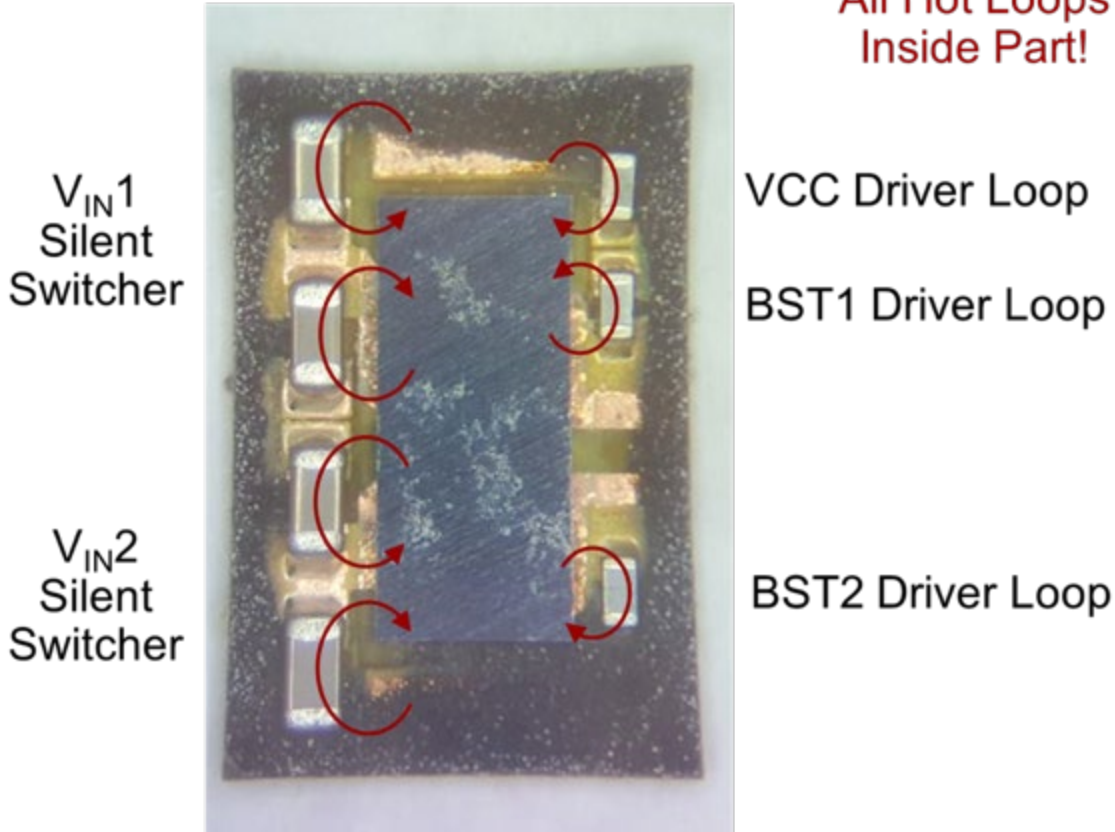
5V 5A Step-Down Converter



To this:
Silent Switcher 2



Bypass Caps integrated



Allows for faster switching

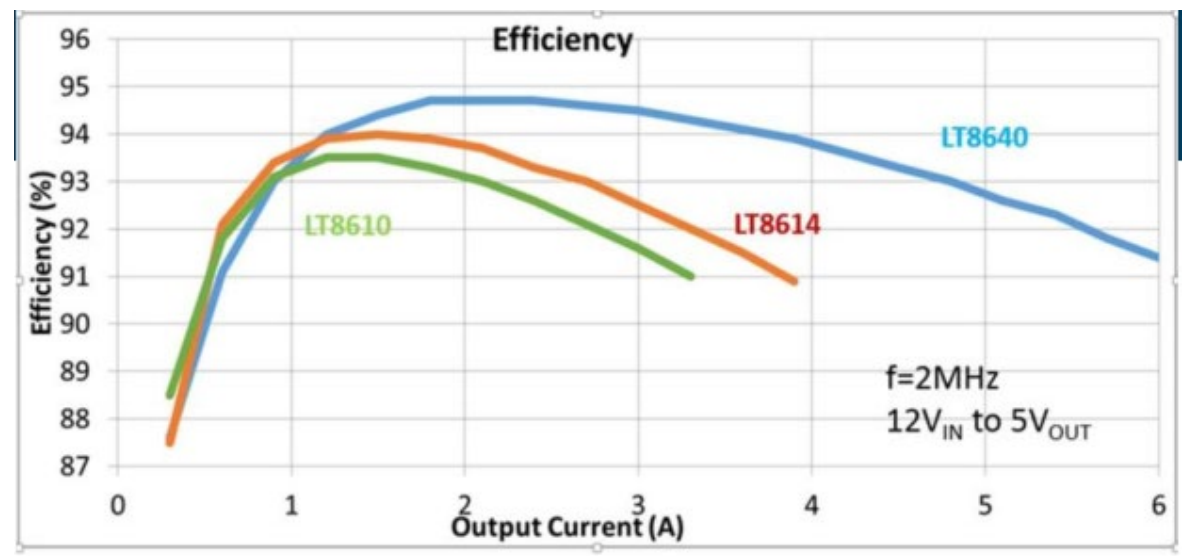
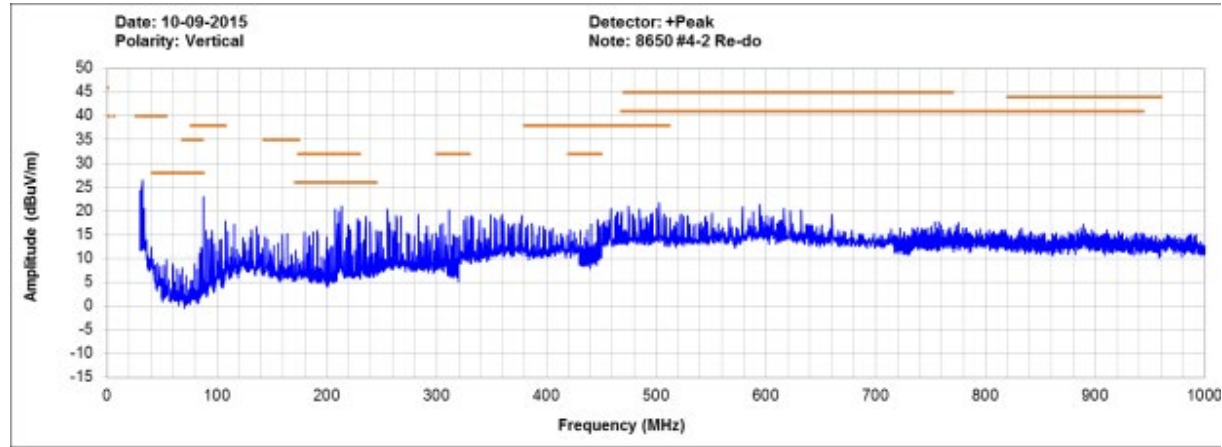
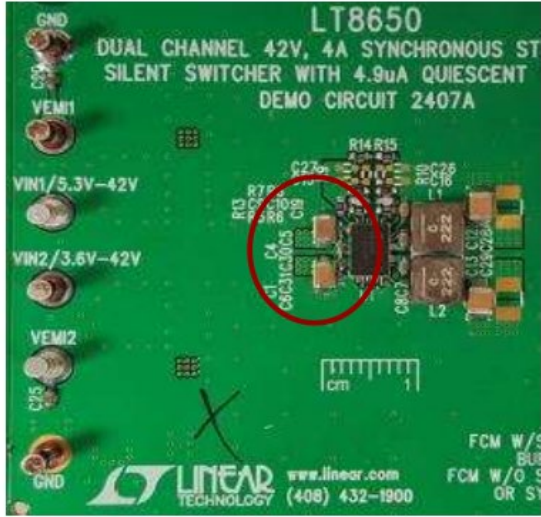
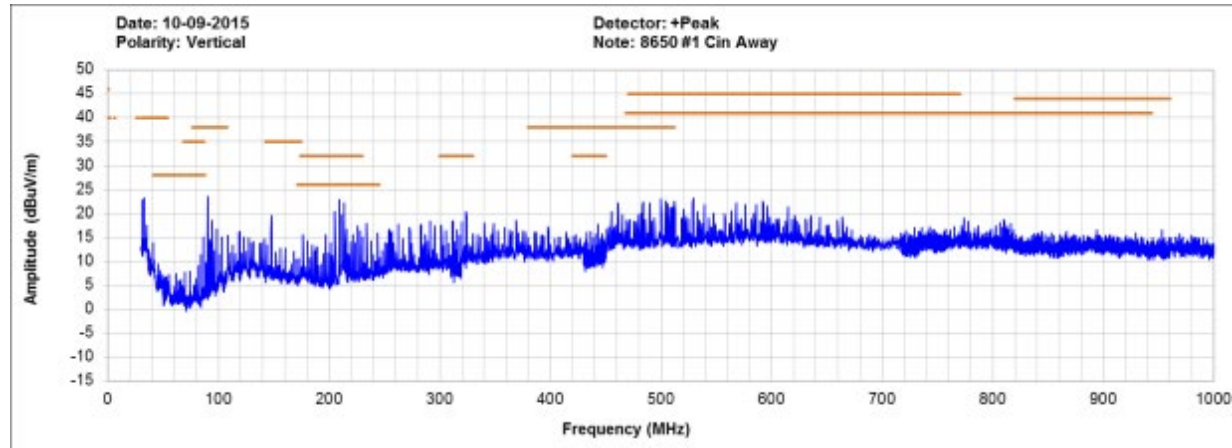


Figure 1. Efficiency Comparison with $f_{sw}=2\text{MHz}$

Robust layout



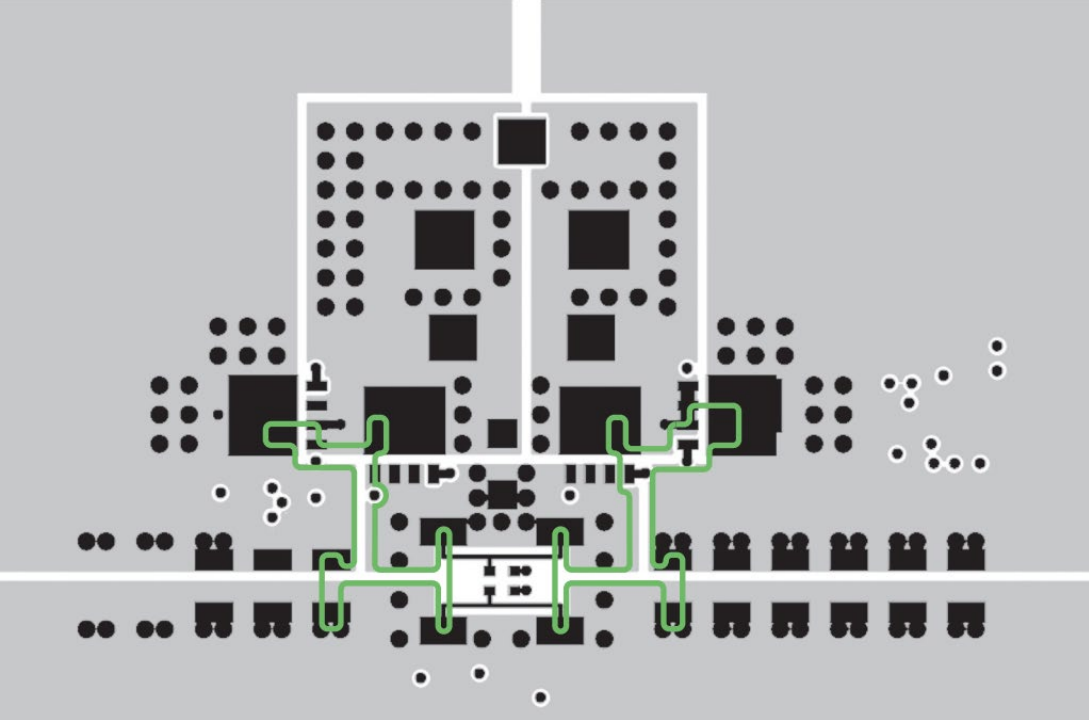
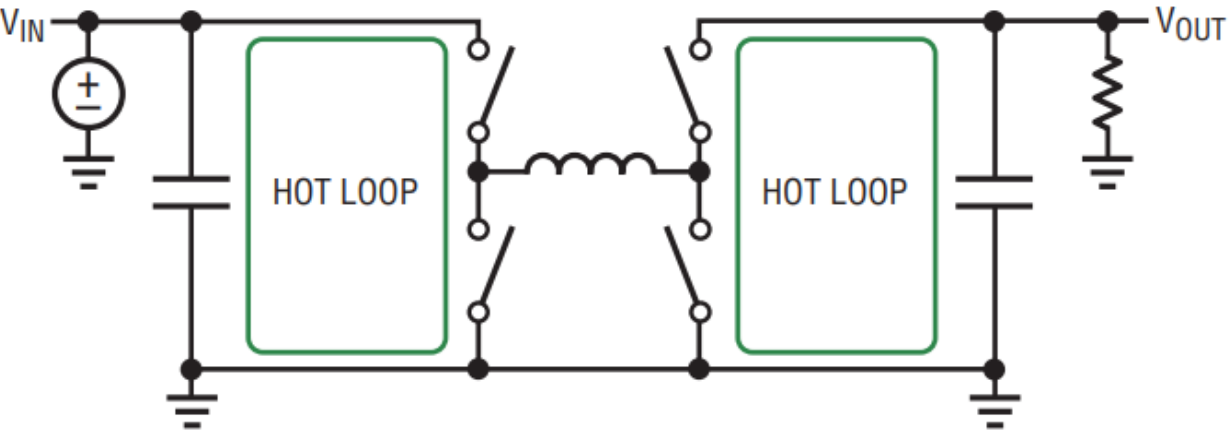
Demoboard with External V_{IN} caps



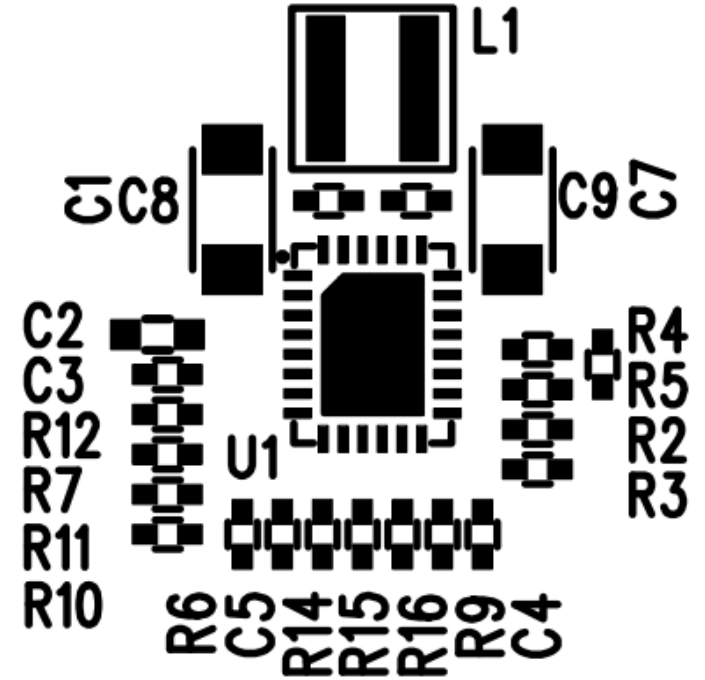
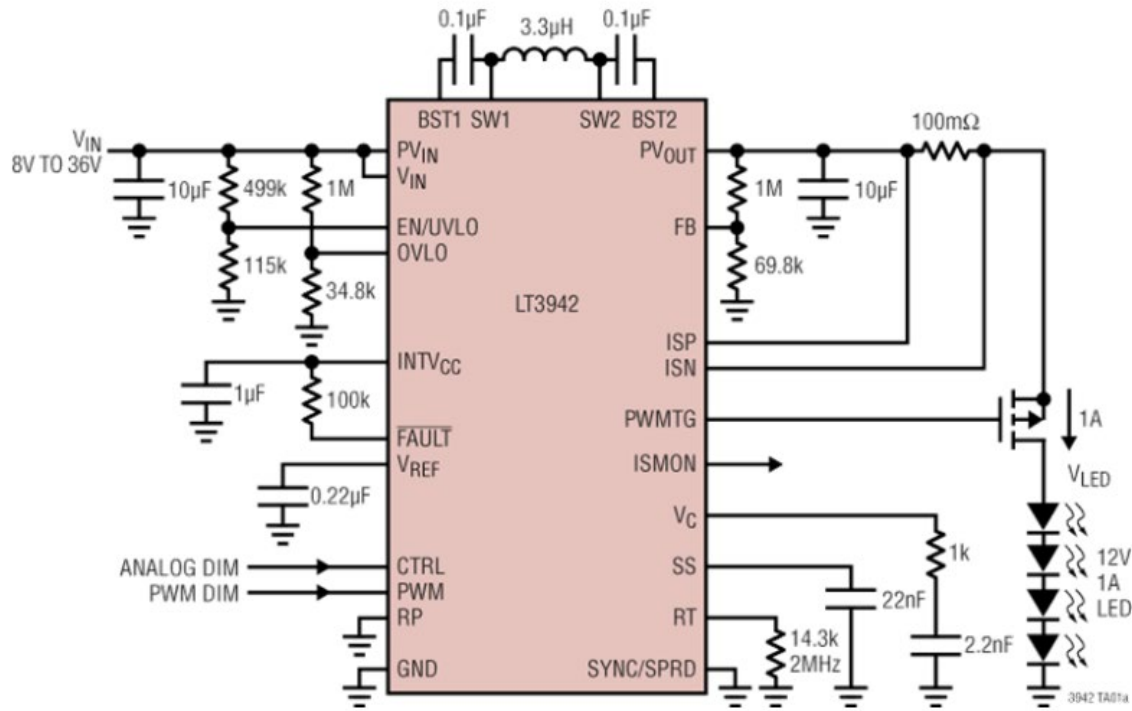
Demoboard with V_{IN} Caps 3cm Away!

4 Switch Buck-Boost

Hot loops in a 4 Switch Buck-Boost



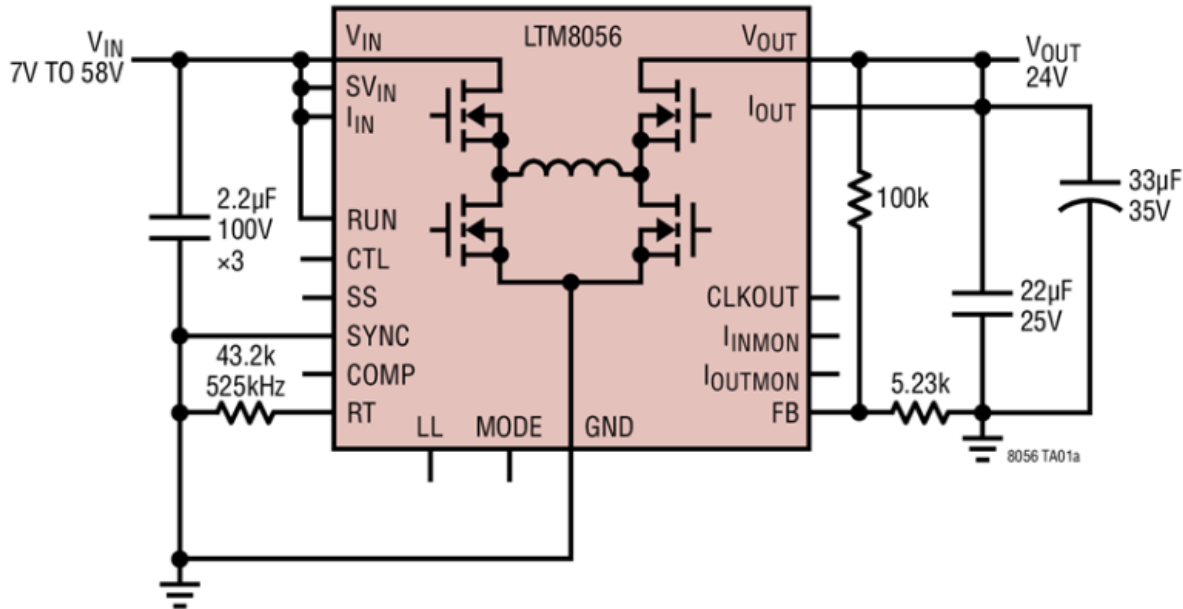
Integrated FETs



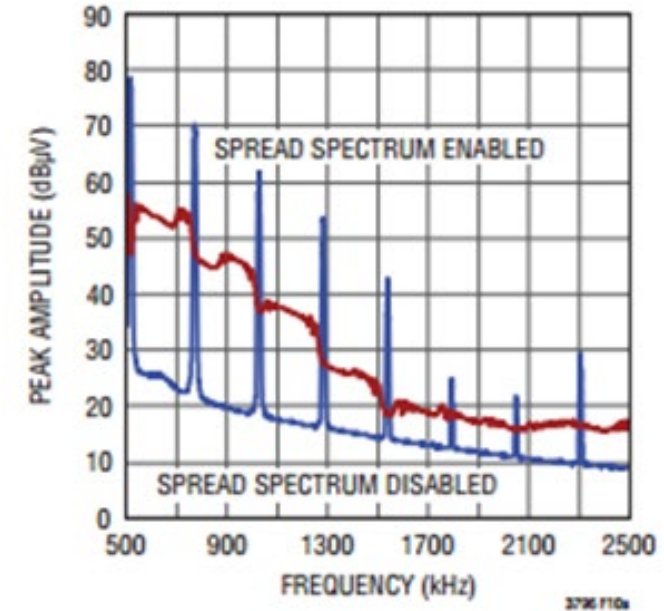
Further Integration

µModule 4 SW Buck-Boost

24V_{OUT} from 7V_{IN} to 58V_{IN} Buck-Boost Regulator



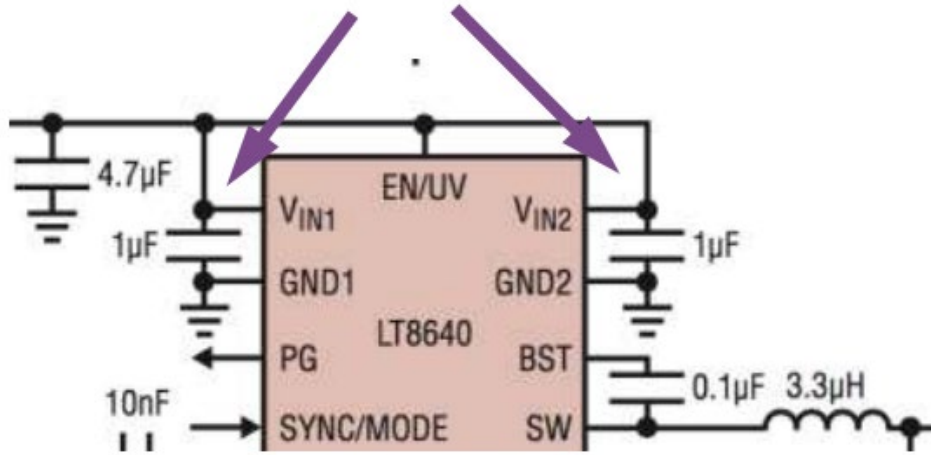
Spread Spectrum Frequency Modulation (SSFM)



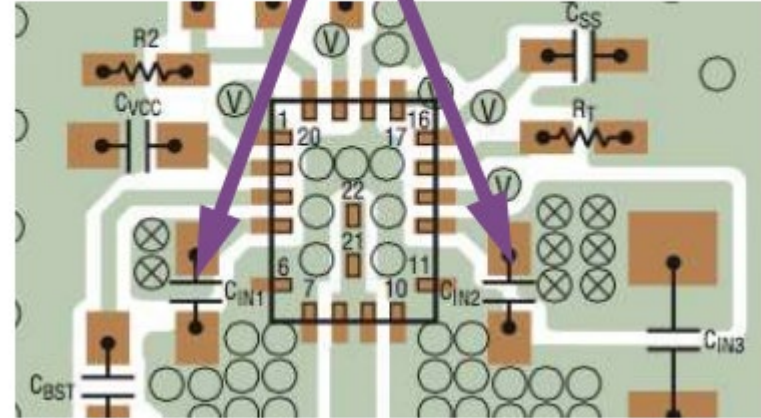
Resources Available

Layout

Schematic



Recommended layout



Demoboard



#&*@\$?!!



Actual Designed Board



Demo boards, layout + gerbers available

LT8614 | 42V, 4A Synchronous Step-Down Silent Switcher with 2.5µA Quiescent Current | [Data Sheet Rev. E](#) | Production

Overview | **Evaluation Kits** | Documentation | Tools & Simulations | Product Recommendations | Reference Materials | Design Resources | Support & Discussions | Sample & Buy

Evaluation Kits (1)

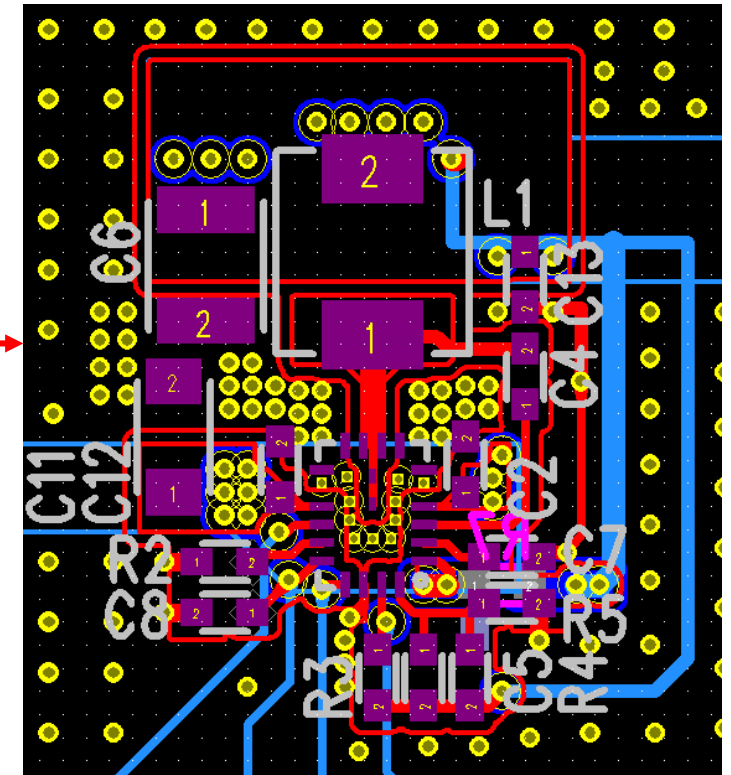
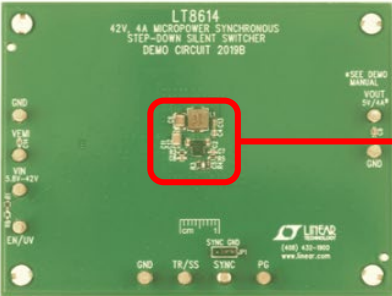
DC2019B
[View Detailed Evaluation Kit Information](#)

Demonstration circuit 2019B is a 42V, 4A micropower synchronous step-down Silent Switcher™ featuring the LT8614. The demo board is designed for 5V output from a 5.8V to 42V input. The wide input range allows a variety of input sources, such as automotive batteries and industrial supplies. The LT8614 is a compact, ultralow emission, high efficiency and high speed synchronous monolithic step-down switching regulator. The integrated power switches and inclusion of all necessary circuitry reduce the components count and solution size. Special Silent Switcher architecture minimizes EMI/EMC emissions. Ultralow 2.5µA quiescent current in Burst Mode® operation achieves high efficiency at very light loads. Fast minimum on-time of 30ns enables high V_{IN} to low V_{OUT} conversion at high

Resources

- [DC2019B - Schematic](#)
- [DC2019B - Design Files](#)
- [DC2019B - Demo Manual](#)

- archive.log
- DC2019B-3.DSN
- DC2019B-3.PCB
- DC2019B-3.XLS
- DC2019B-3-CF.XLS
- DC2019B-3-GBR.ZIP
- DC2019B-3-LAYOUT-ASC.ASC
- DC2019B-3-PDF.ZIP
- DC2019B-3-SCH.PDF



Utilising Analog.com to filter based on features

Choose Parameters All Reset Table Maximize Filters Sort by Newest Save to myAnalog Download to Excel Share

Part Number	Features	Number of Outputs	Vin min V	Vin max V
1 Values Selected				
HIDE				
<input type="checkbox"/> LTM8078 (dual output) NEW	Adjustable Slew Rate, Adjustable Switching Frequency, Dual Input, External Synchronization, Power Good, Resistor Set Frequency, Silent Switcher Architecture, Soft Start, Spread Spectrum, Tracking	2	3	40
<input type="checkbox"/> LTM8078 (single output) NEW	Adjustable Slew Rate, Adjustable Switching Frequency, Dual Input, External Synchronization, Power Good, Resistor Set Frequency, Silent Switcher Architecture, Soft Start, Spread Spectrum, Tracking	1	3	40
<input type="checkbox"/> LT1533	Adjustable Slew Rate, External Synchronization, Low EMI	1	2.55	42
<input type="checkbox"/> LT1534	Adjustable Slew Rate, External Synchronization, Low EMI	1	2.7	42
<input type="checkbox"/> LT1534-1	Adjustable Slew Rate, External Synchronization, Low EMI	1	2.7	42
<input type="checkbox"/> LT3439	Adjustable Slew Rate, External Synchronization, Low EMI, Resistor Set Frequency	1	2.8	42
<input type="checkbox"/> LT1683				

Just filter for "Spread Spectrum" in the features column

Choose Parameters All Reset Table Maximize Filters Sort by Newest Save to myAnalog Download to Excel Share

Part Number	Features	Number of Outputs	Vin min V	Vin max V
1 Values Selected				
HIDE				
<input type="checkbox"/> LT8648S NEW	Burst Mode, External Synchronization, Power Good, Resistor Set Frequency, Silent Switcher 2 Architecture, Soft Start, Spread Spectrum, Tracking	1	2.45	42
<input type="checkbox"/> LT8653S NEW	Power Good, Sequencing, Silent Switcher 2 Architecture, Soft Start, Spread Spectrum, Tracking	2	2.6	42
<input type="checkbox"/> LTM8078 (dual output) NEW	Adjustable Slew Rate, Adjustable Switching Frequency, Dual Input, External Synchronization, Power Good, Resistor Set Frequency, Silent Switcher Architecture, Soft Start, Spread Spectrum, Tracking	2	3	40
<input type="checkbox"/> LTM8078 (single output) NEW	Adjustable Slew Rate, Adjustable Switching Frequency, Dual Input, External Synchronization, Power Good, Resistor Set Frequency, Silent Switcher Architecture, Soft Start, Spread Spectrum, Tracking	1	3	40
<input type="checkbox"/> LT8646S	Burst Mode, External Synchronization, Resistor Set Frequency, Silent Switcher 2 Architecture, Spread Spectrum	1	3.4	65
<input type="checkbox"/> LT8609S	Burst Mode, External Synchronization, Internal Bypass Caps, Power Good, Resistor Set Frequency, Silent	1	3	42

Just filter for "Adjustable Slew Rate" in the features column

Thank you

