ANALOG DEVICES

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MORE THAN YOU EXPECT

SMPS Topologies and Tipps and Tricks

Frederik Dostal
Power Management Expert



analog.com

Agenda

Buck (Step Down)

Boost (Step Up)

Buck-Boost (Step Up and Step Down)

SEPIC (Step Up and Step Down)

Zeta (Inverse SEPIC)

Inverting (Buck-Boost)

CUK (Inverting)

Charge Pump (High Power)

Hybrid Converter

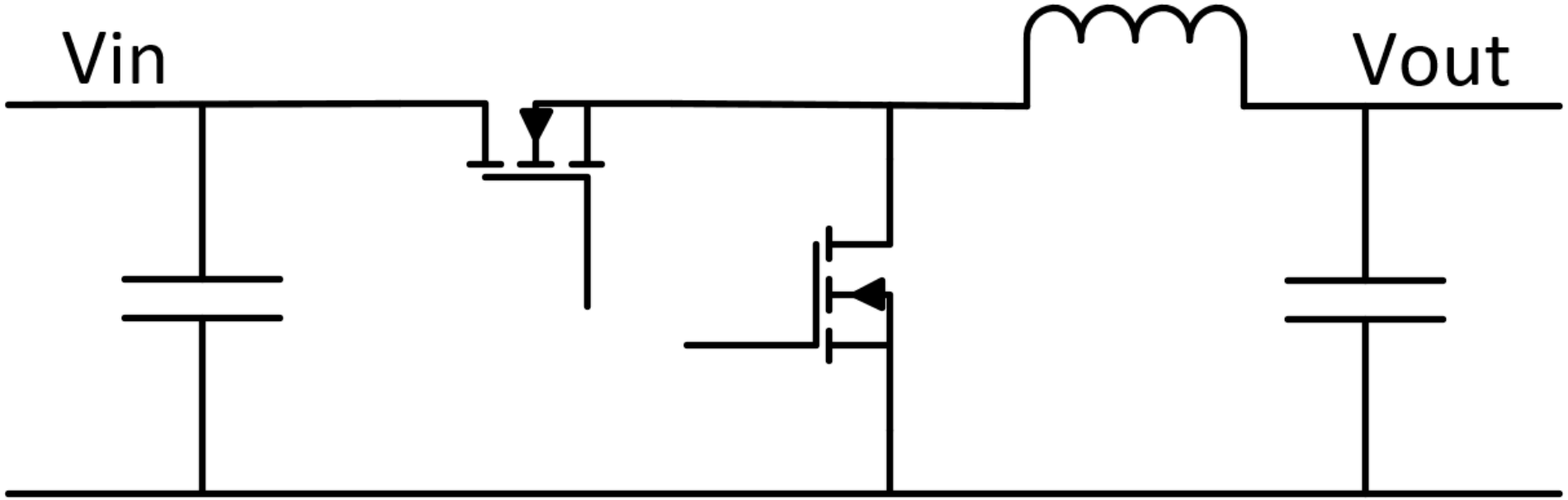
Other combined Topologies (Cascaded)

Isolateded

- Flyback (Isolated)
- Forward (Isolated)
- Push-Pull (Isolated)

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Buck (Step Down)



Synchronous / Non Synchronous / Synchronizable

Monolythic

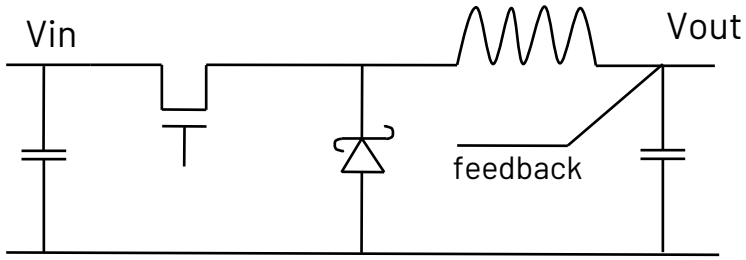
Pulsed Energy Flow on the input side

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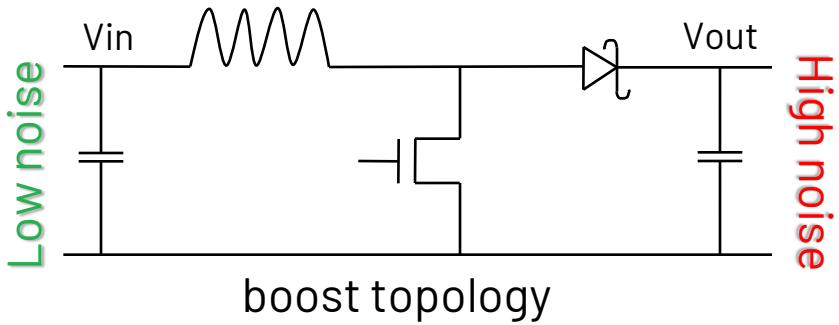
Additional filtering

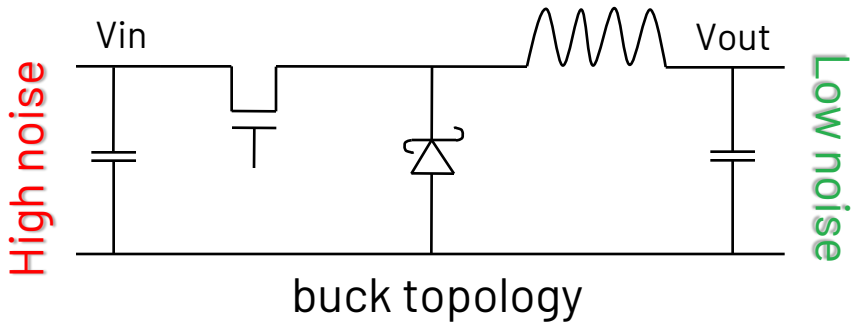
Often input and / or output traces radiate the most

Additional LC filter



Generally trace with inductance in series is less noisy



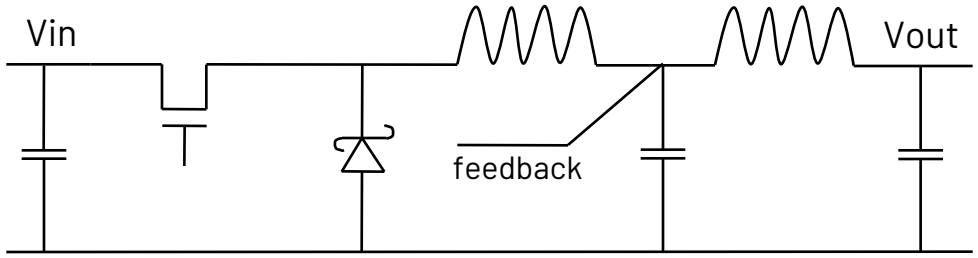


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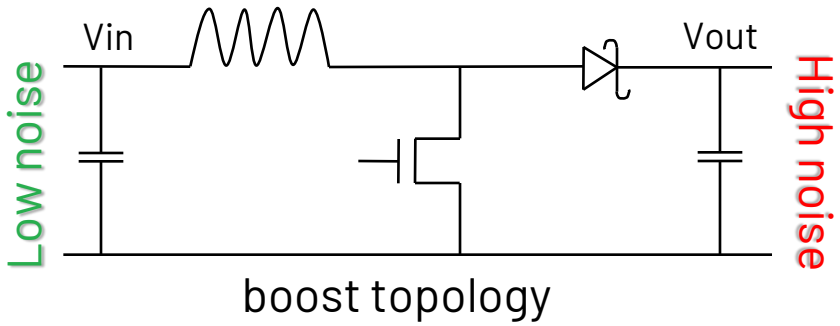
Additional filtering

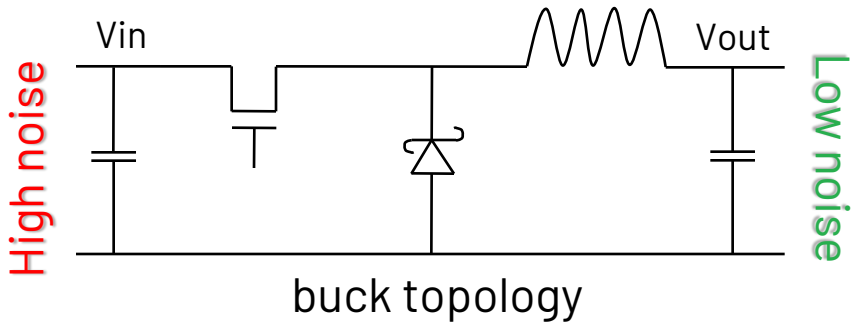
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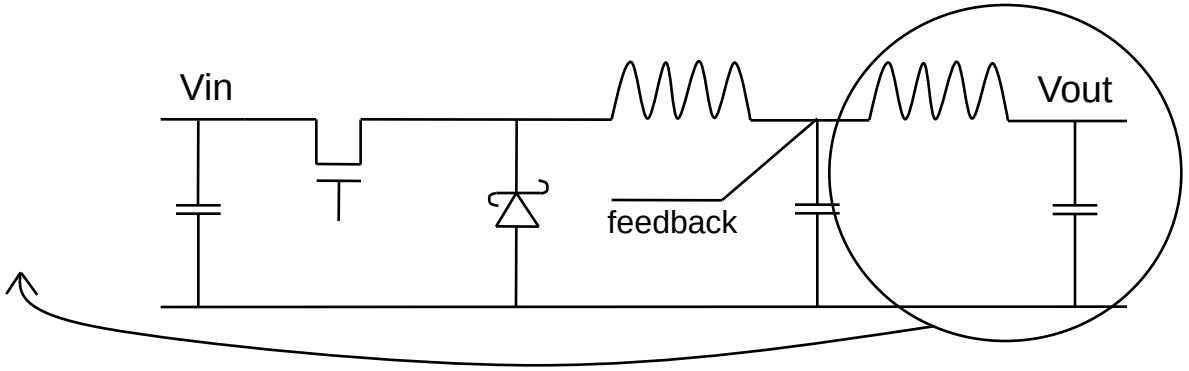


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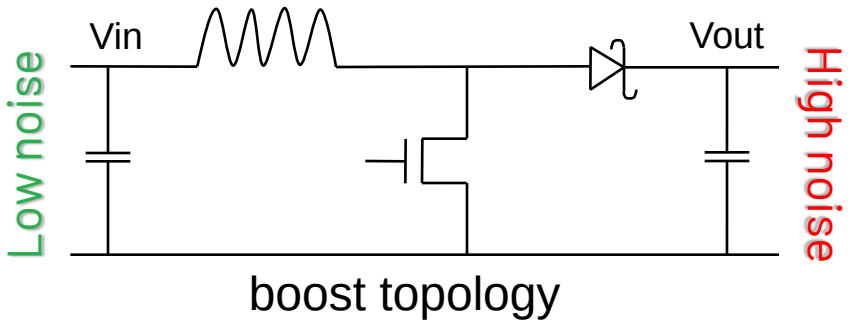
Additional filtering

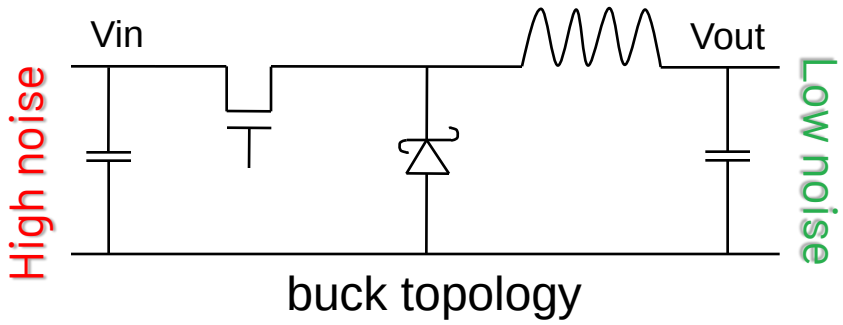
Often input and / or output traces radiate the most

Additional LC filter



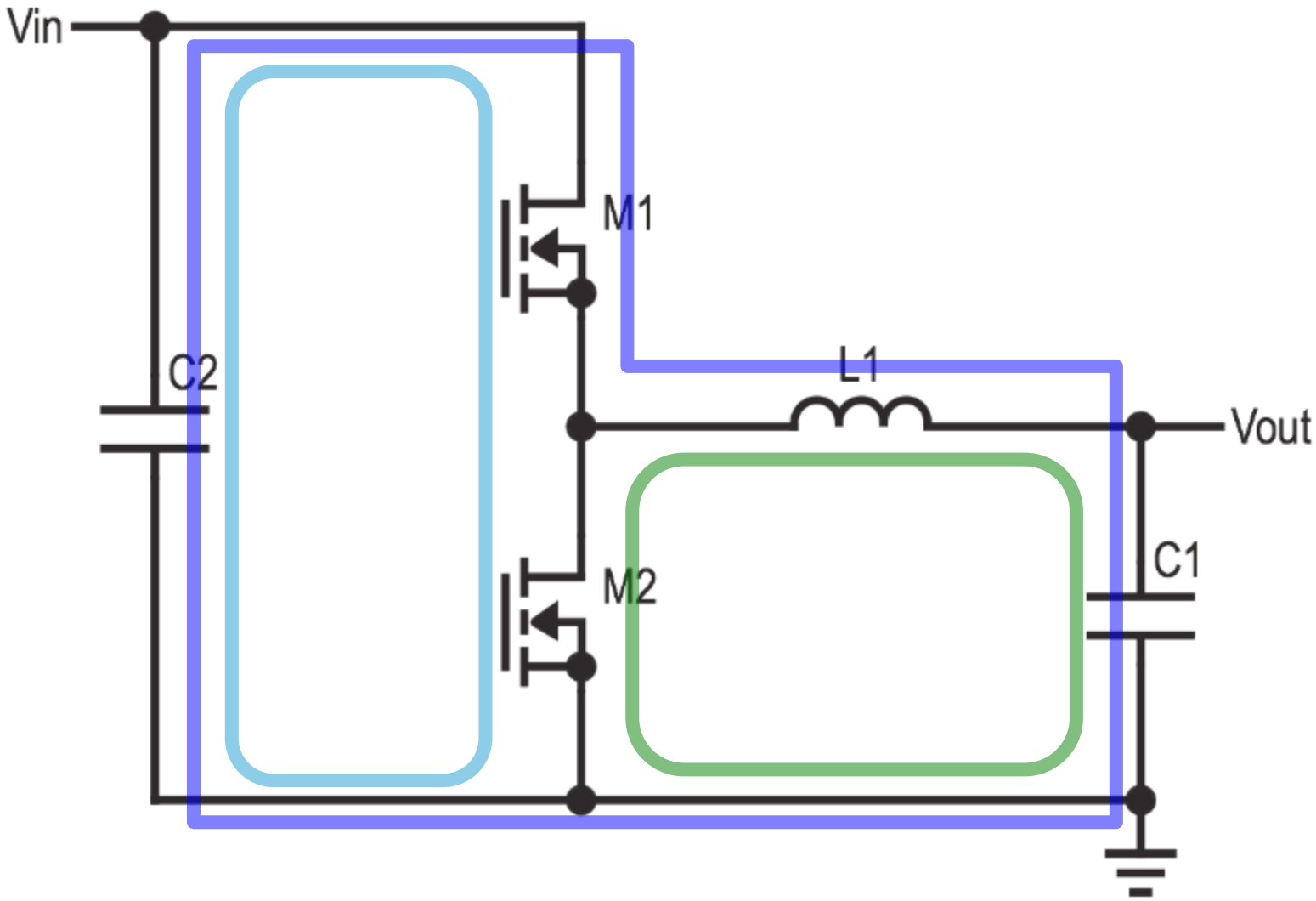
Generally trace with inductance in series is less noisy





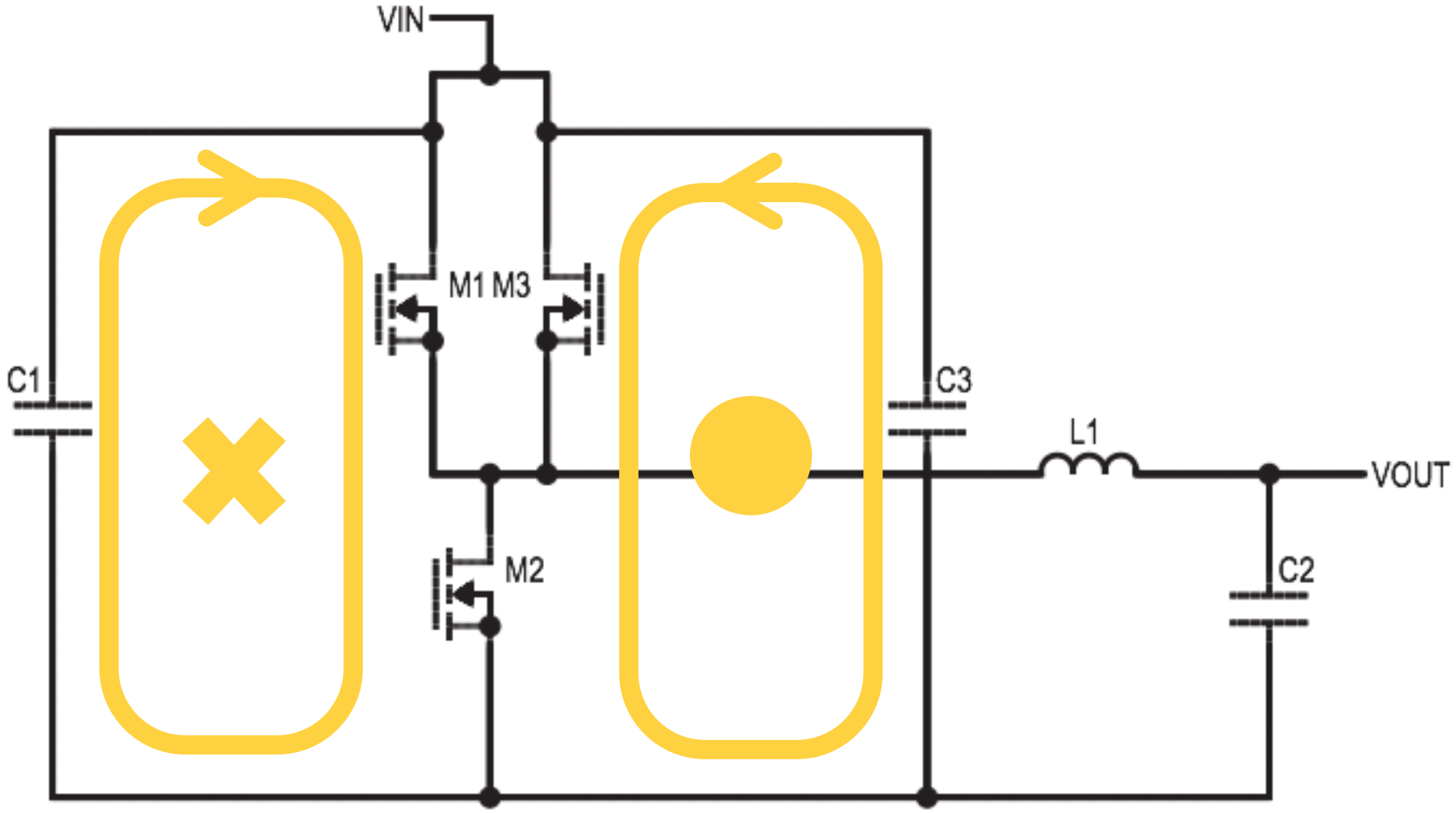
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Buck Hot Loops



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Silent switcher – magnetic field cancellation

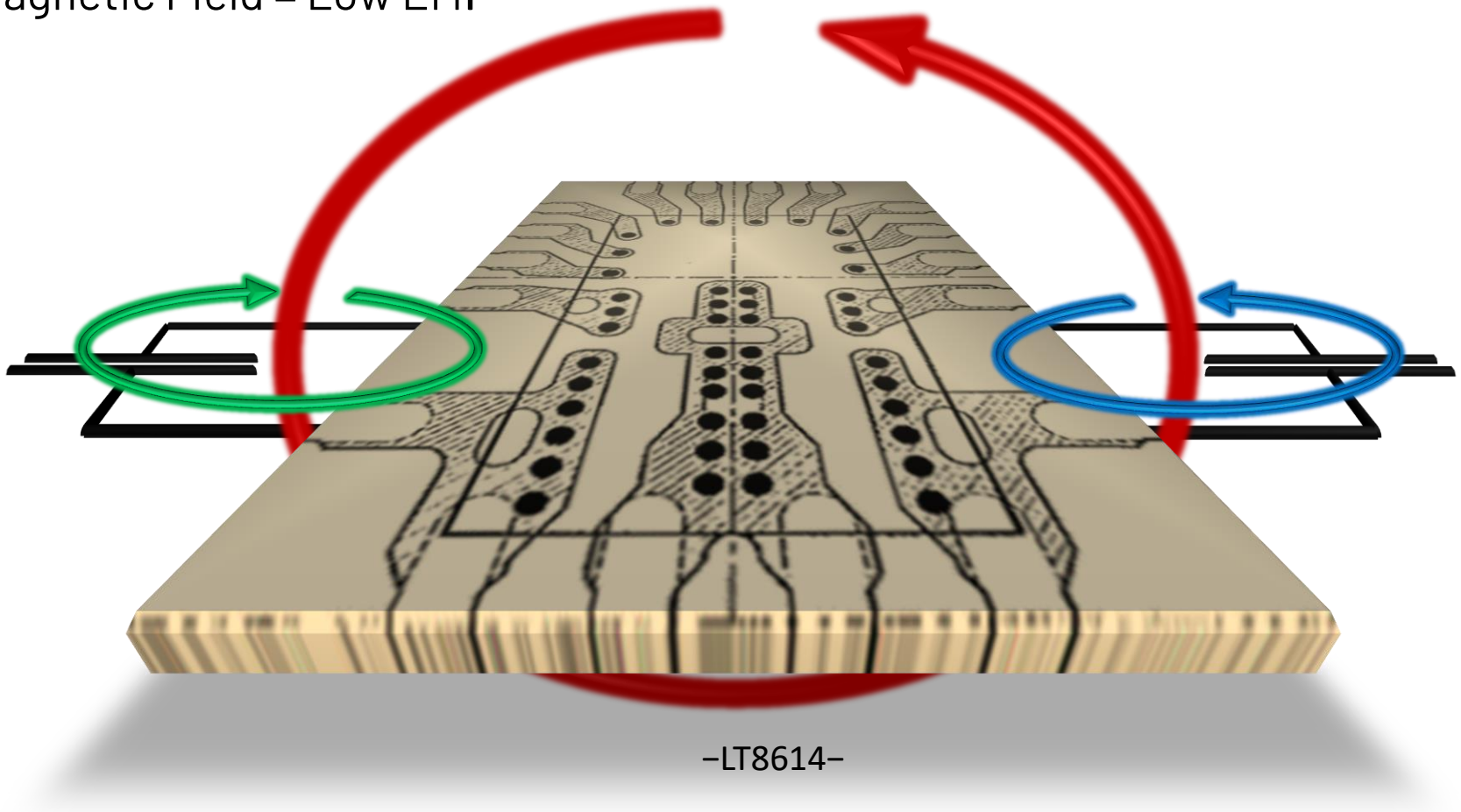


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Cancelling Hot Loops

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

Confined Magnetic Field = Low EMI



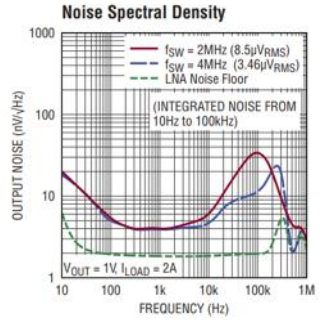
–LT8614–

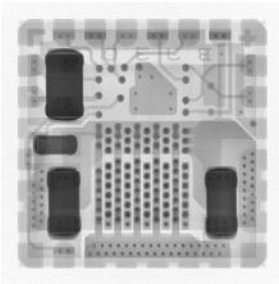
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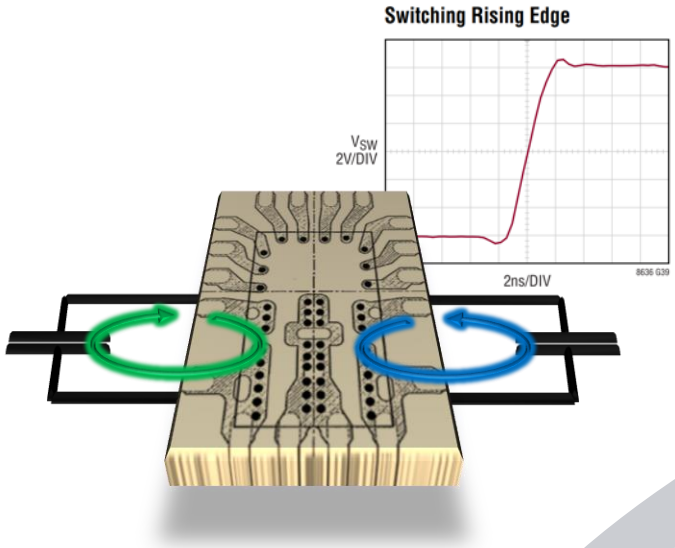
New Silent Switcher 3

- Ultralow EMI Emissions
- High Efficiency at High Switching Frequency
- Integrated Bypass Capacitors
- Eliminates PCB layout sensitivity
- **Ultralow LF Noise (0.1Hz to 100kHz)**
- **Ultrafast Transient Response**









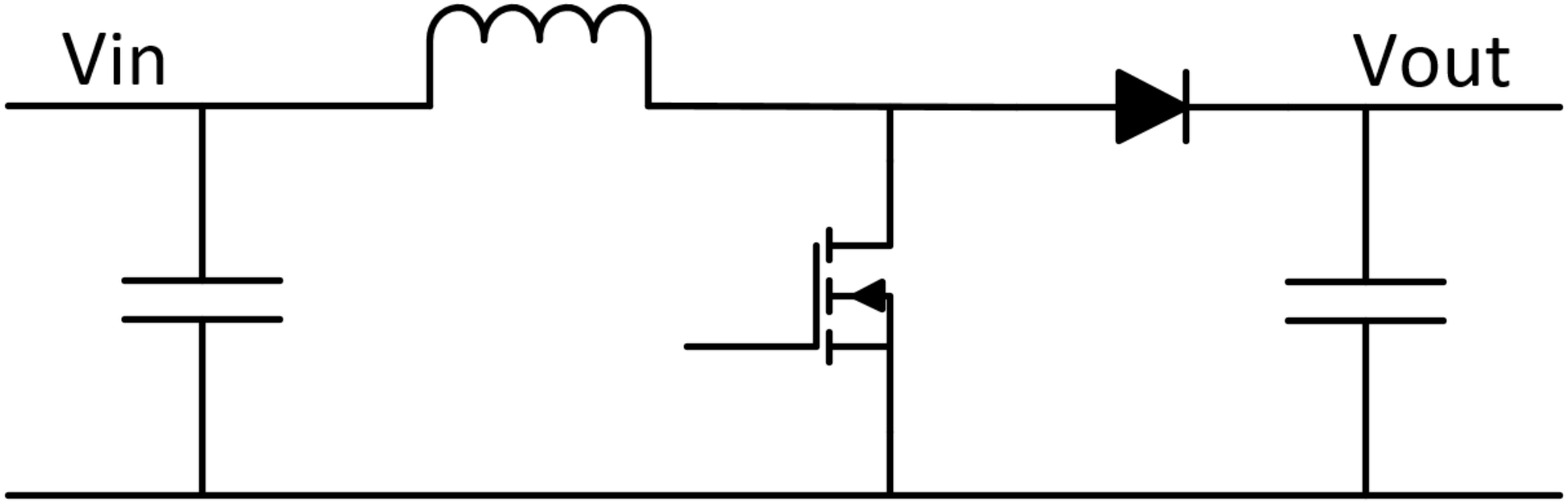
Silent Switcher®1

Silent Switcher®2

Silent Switcher®3

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Boost (Step Up)



Pulsed Energy Flow on the output side

Usually Non Synchronous / Synchronous adds true shutdown

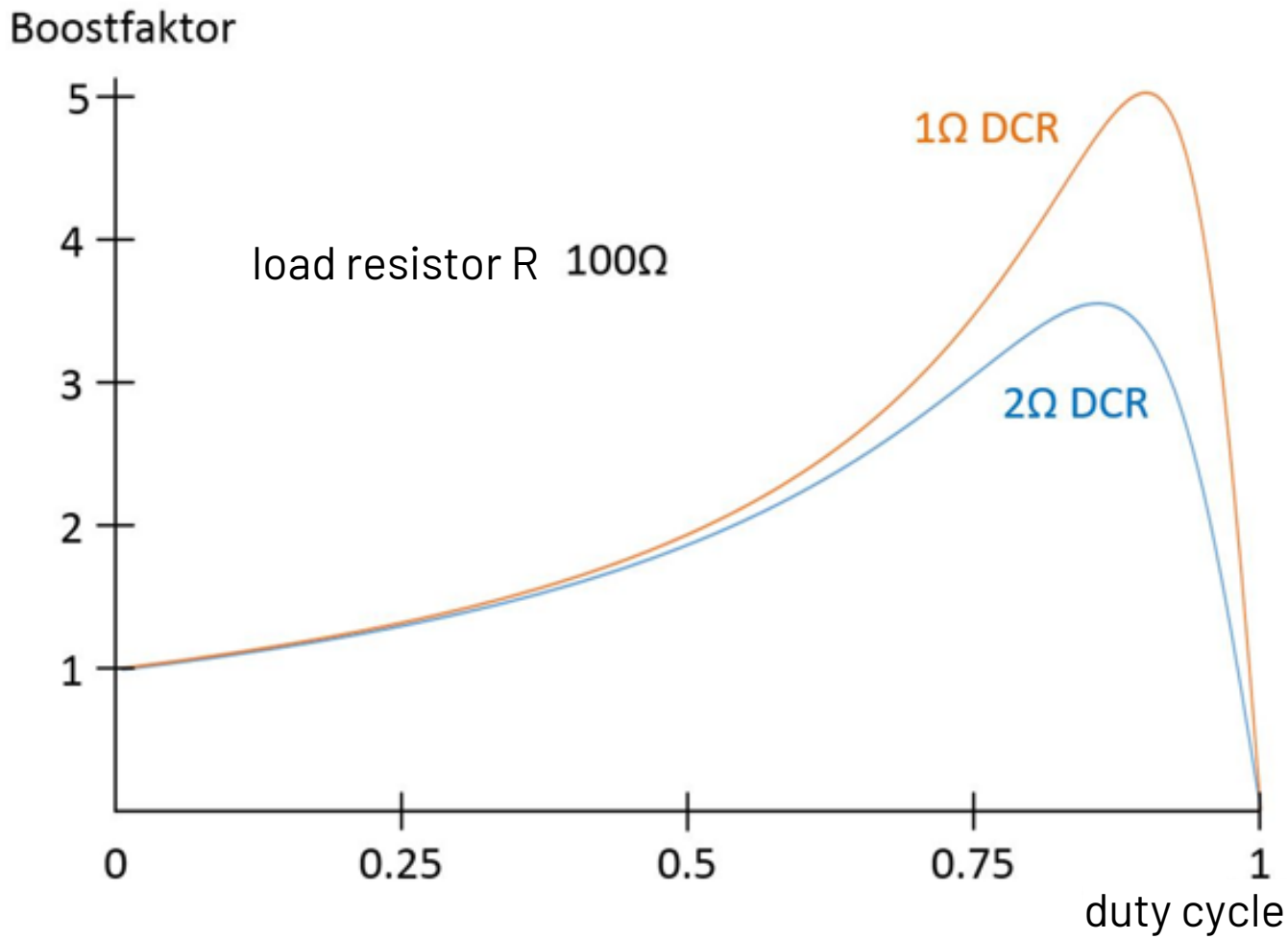
Max boost factor dependent on DCR of inductor and load resistance

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Boost-Factor

There is a limit to how much a boost can boost:

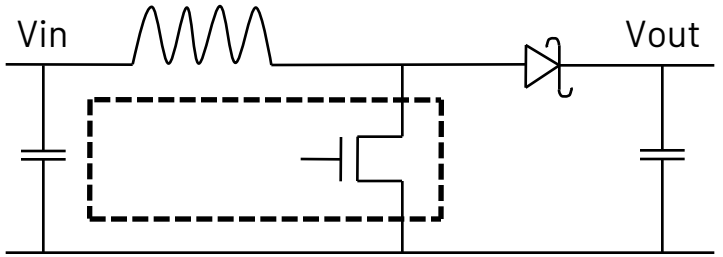
$$BF = \frac{1}{(1-D)} \frac{1}{\left(1+\frac{DCR}{(1-D)^2 * R}\right)}$$



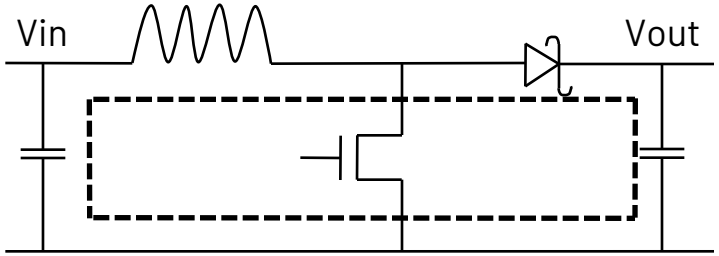
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Hot Loop Boost Regulator

Current flow during on-time:

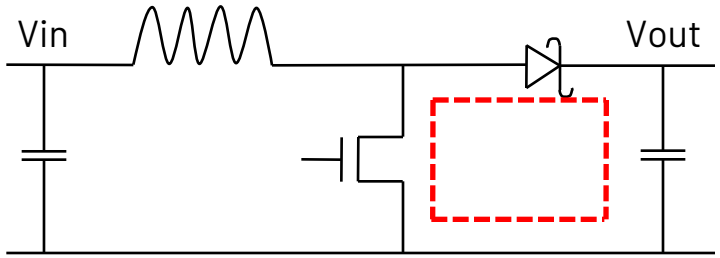


Current flow during off-time:



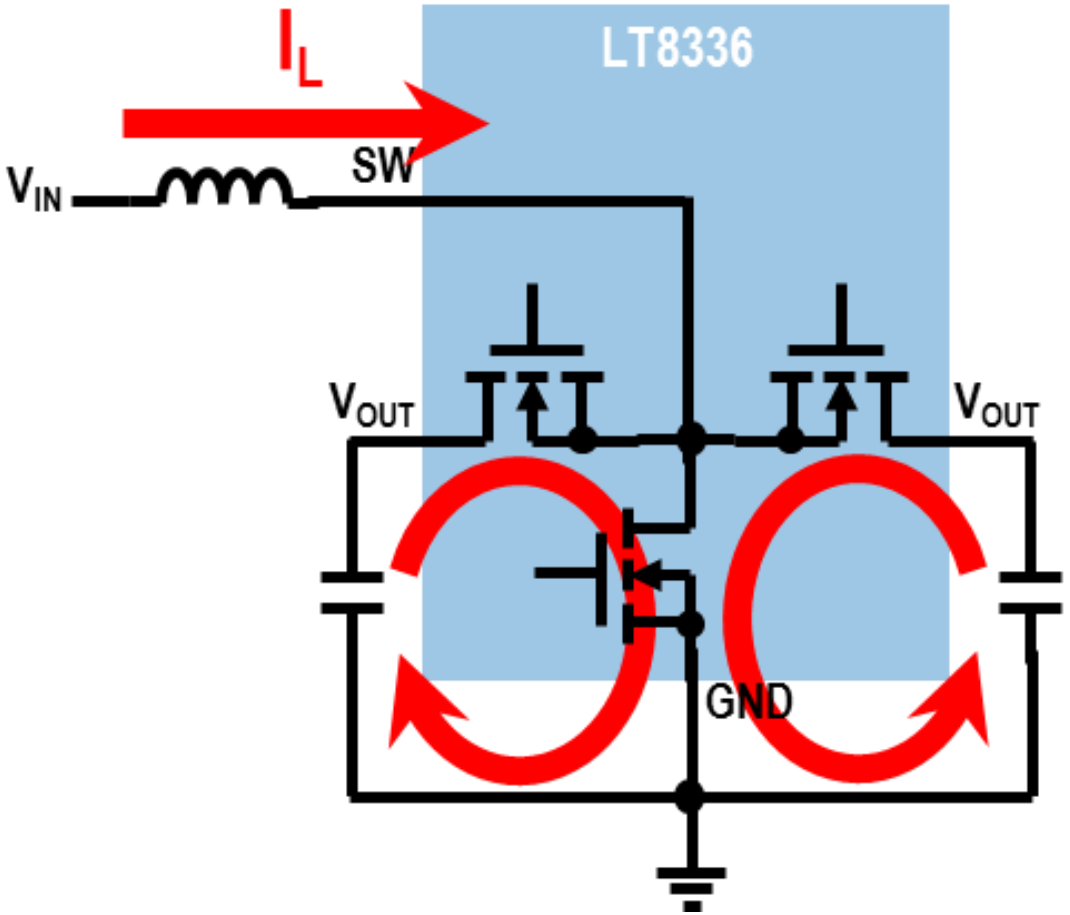
AC traces:

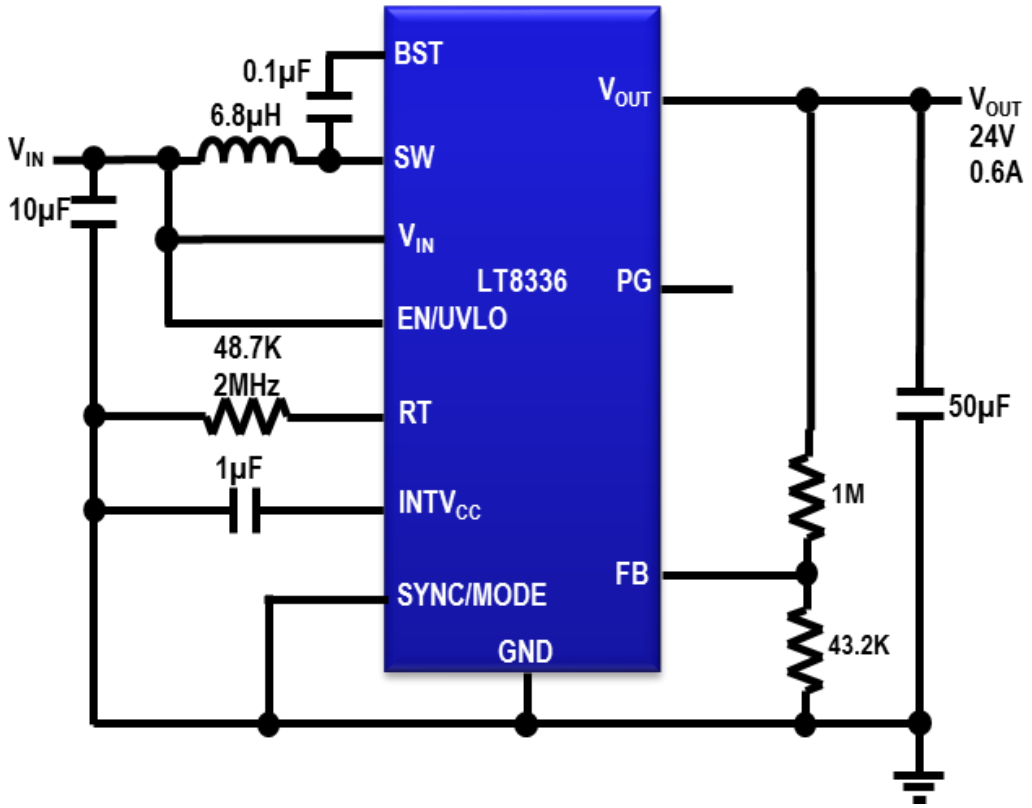
Keep AC traces as short as possible…(ASAP)



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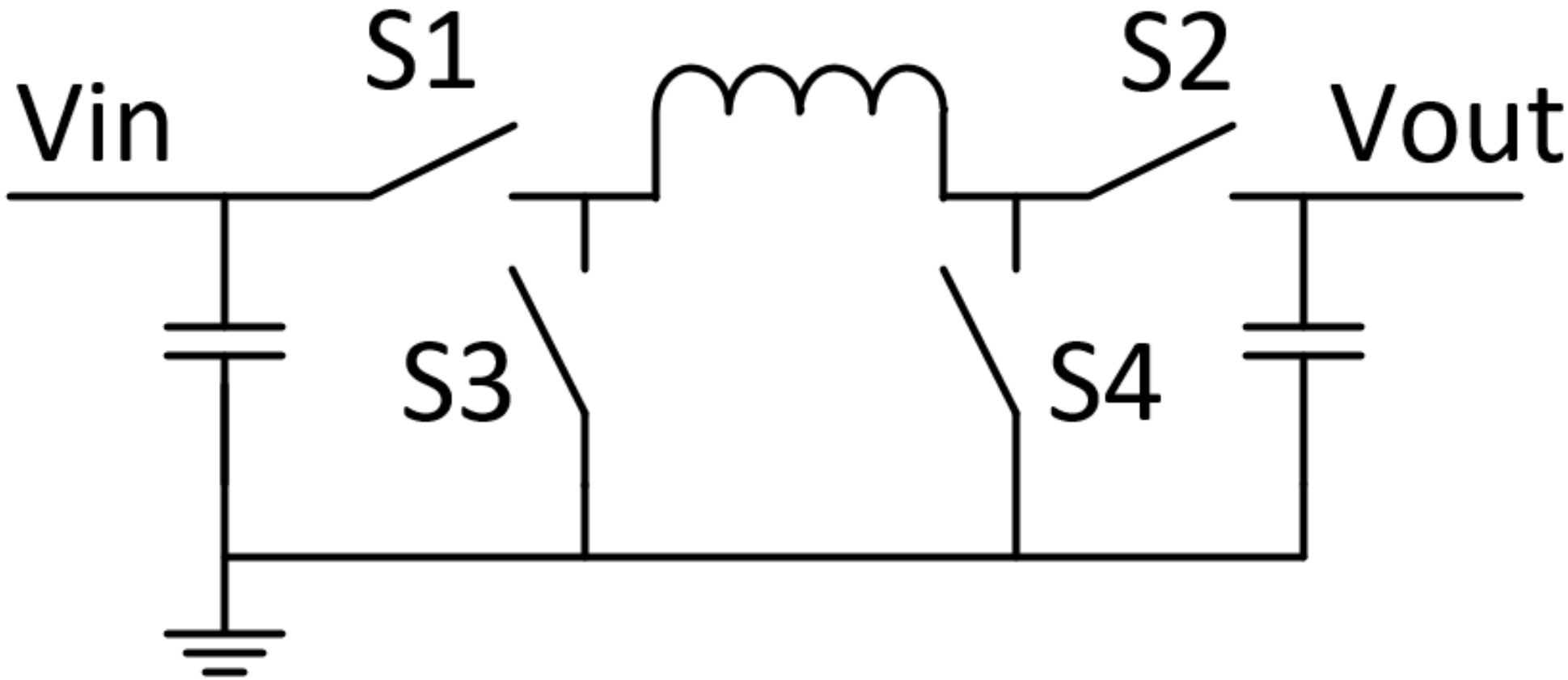
Silent Switcher Boost Converters





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Buck-Boost (Step Up and Step Down)



Very efficient

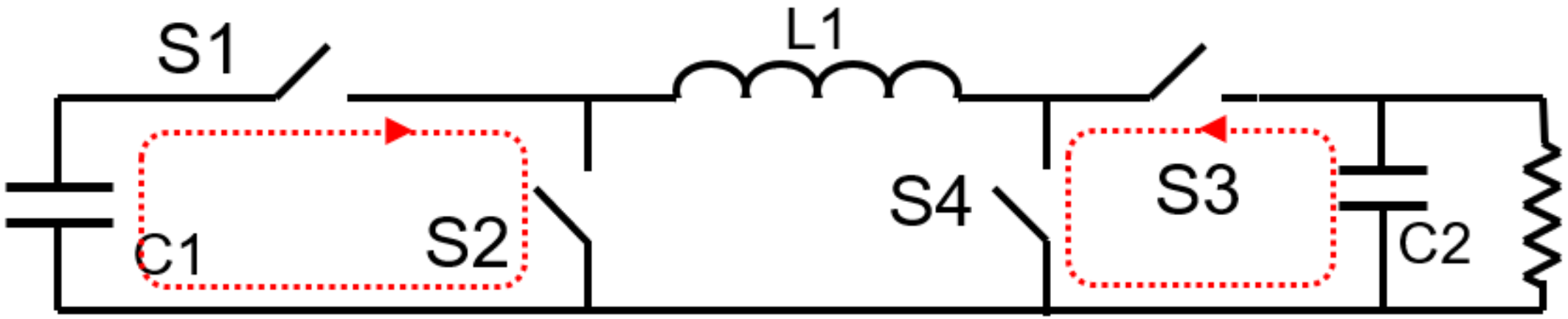
More silicon / fewer passives

Challenge is switch over

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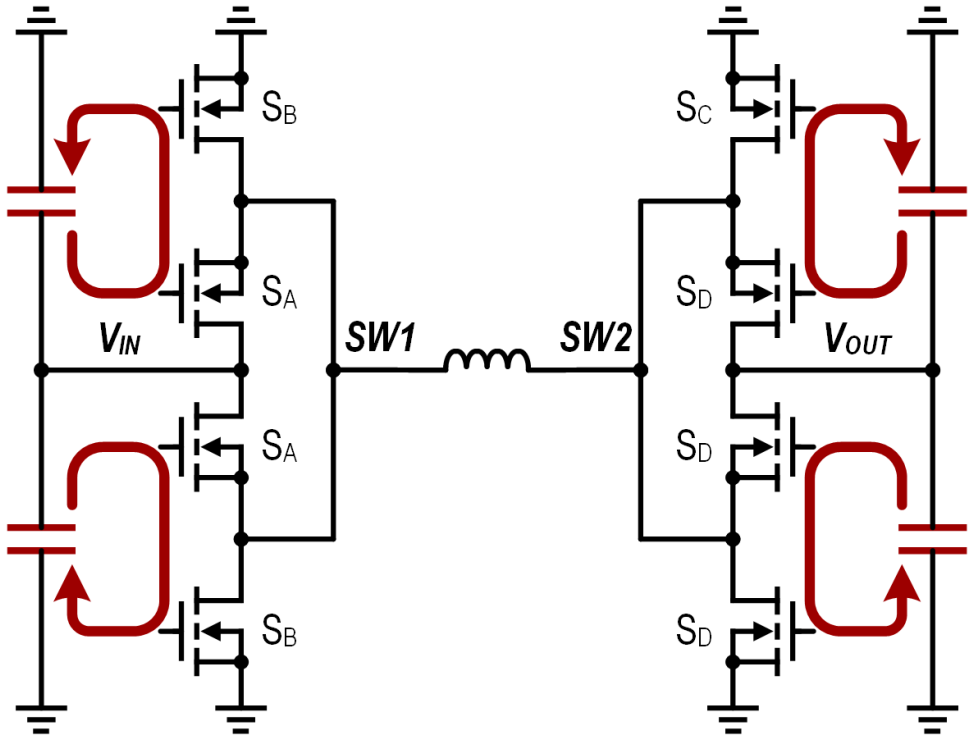
Synchronous Buck-Boost Topology Hot Loops

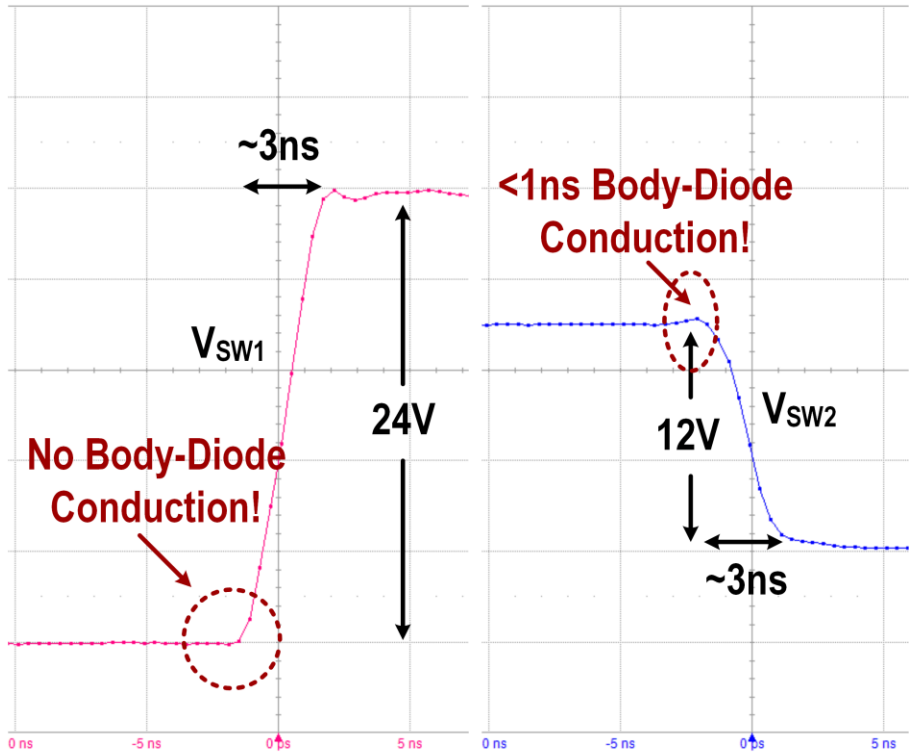
Input **and** Output capacitor has to deliver, depending on operation mode



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LT8350S – New Generation Silent Switcher 2



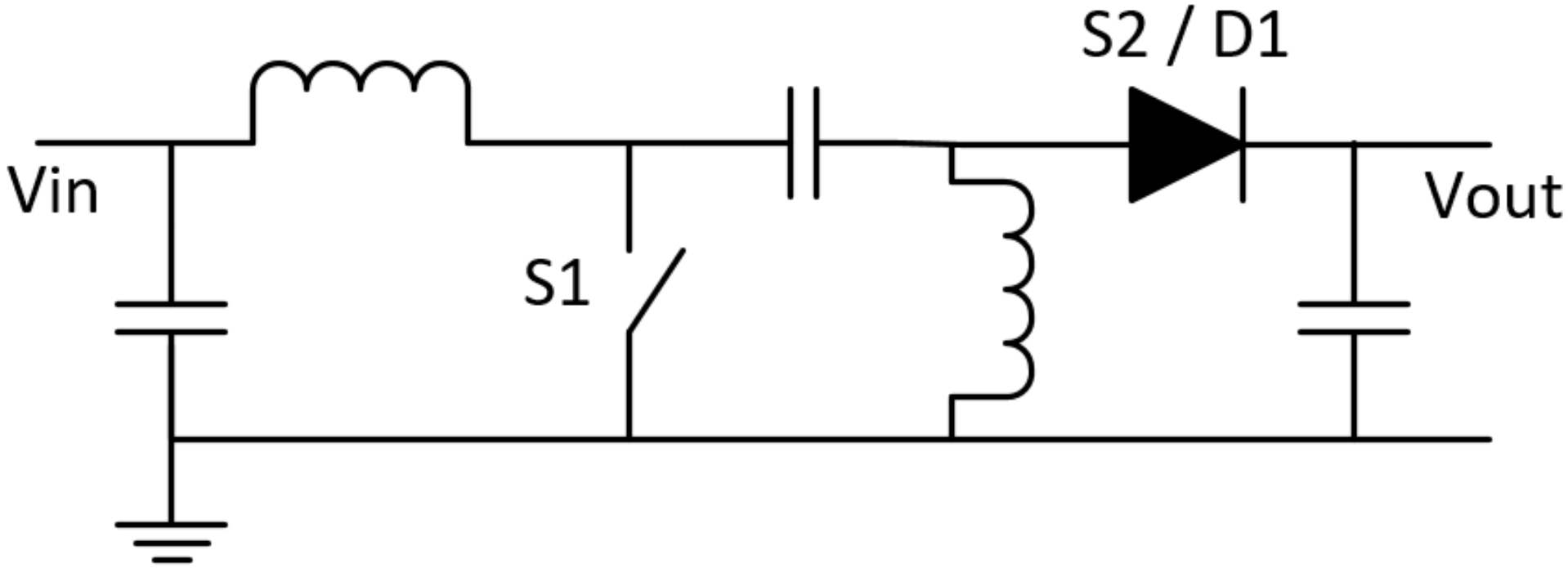


- Silent Switcher 2 Architecture
  - Symmetrical hot loops
  - Internal hot loop caps
  - Cu pillars instead of bond wire
- Safe zero-deadtime

For Good EMI, Good Efficiency, Simple PCB

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SEPIC (Step Up and Step Down)



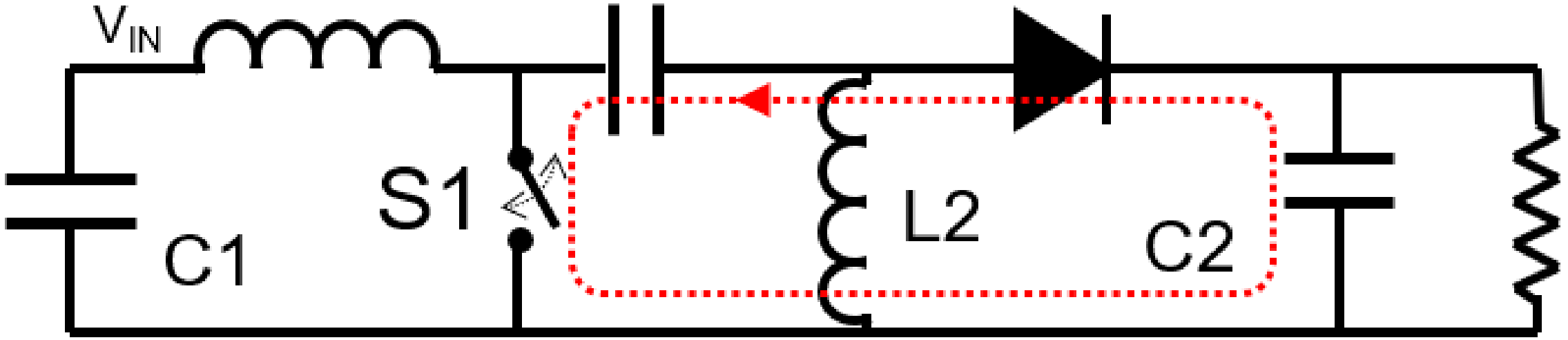
Coupled inductors / coupling capacitor

RHP Zero

Lower efficiency compared to buck-boost

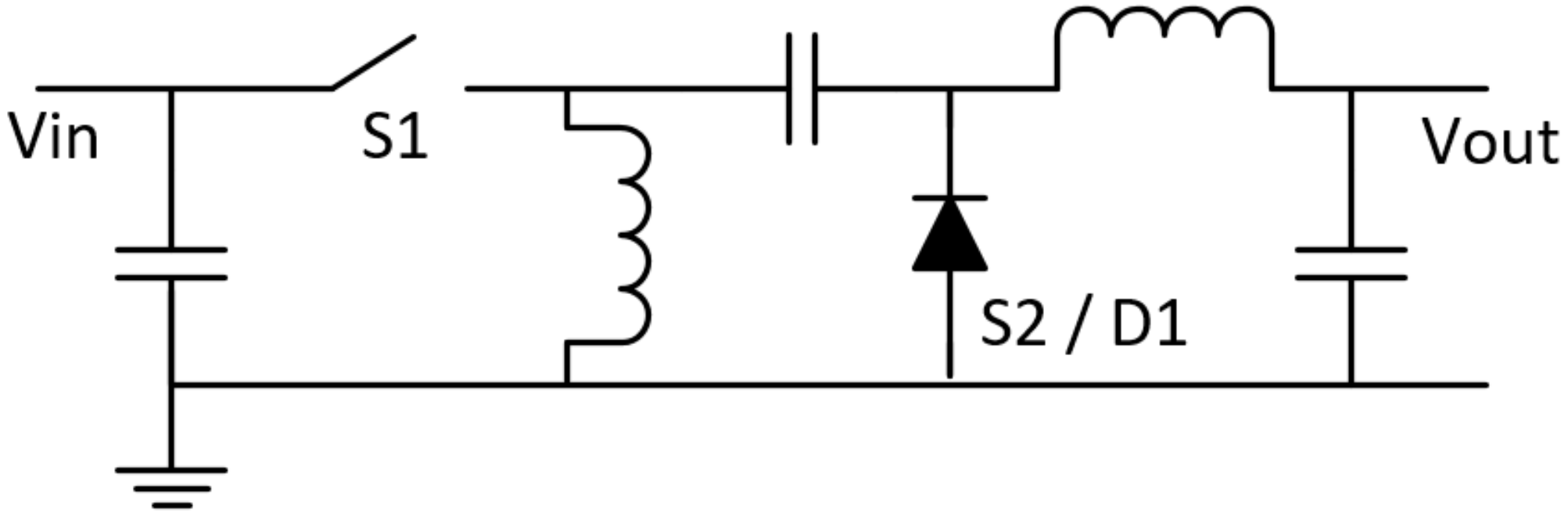
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SEPIC Topology Hot Loop



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Zeta (Inverse SEPIC)

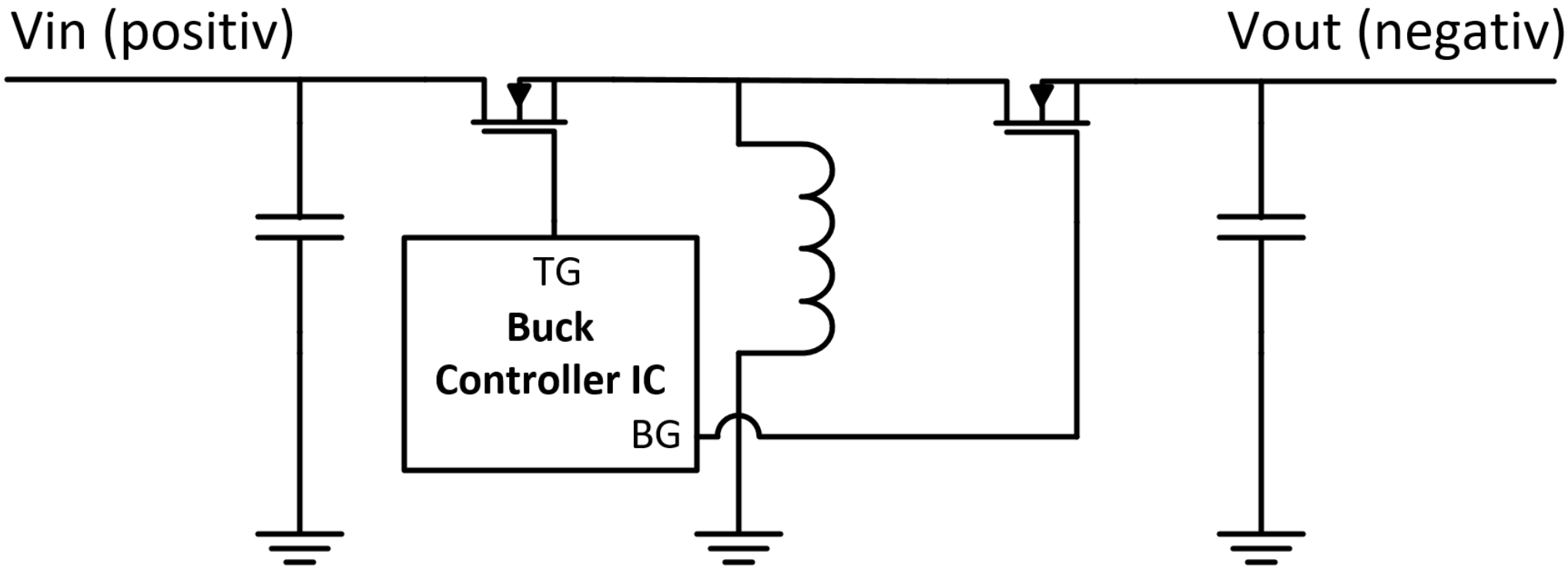


No right half plane zero

Active high side switch needed (buck converter type)

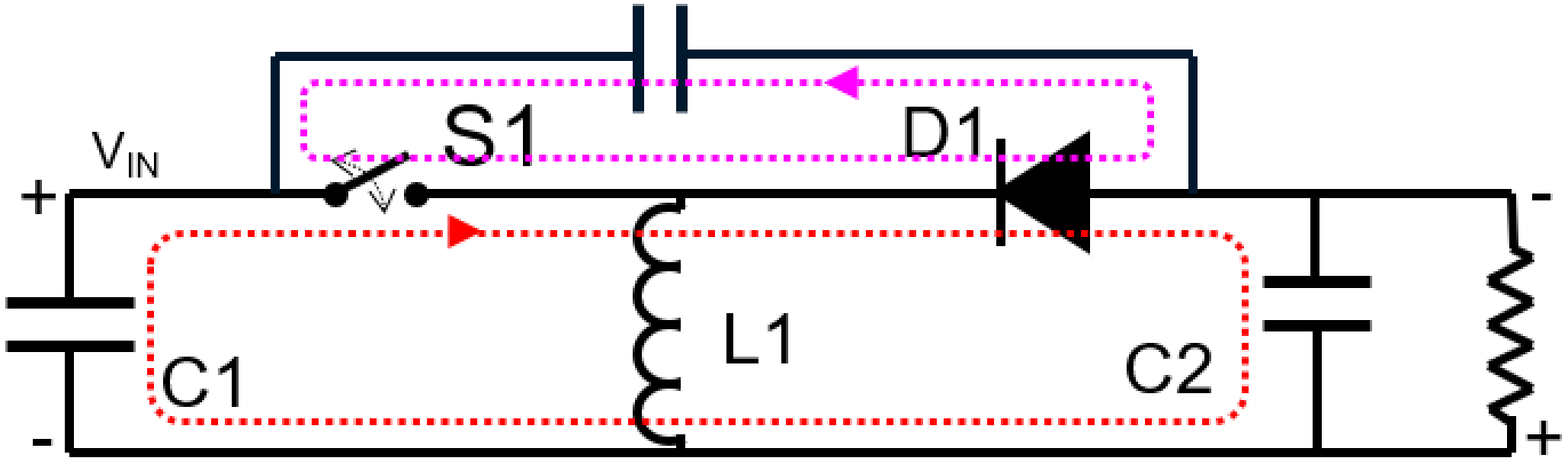
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Inverting (Buck-Boost)



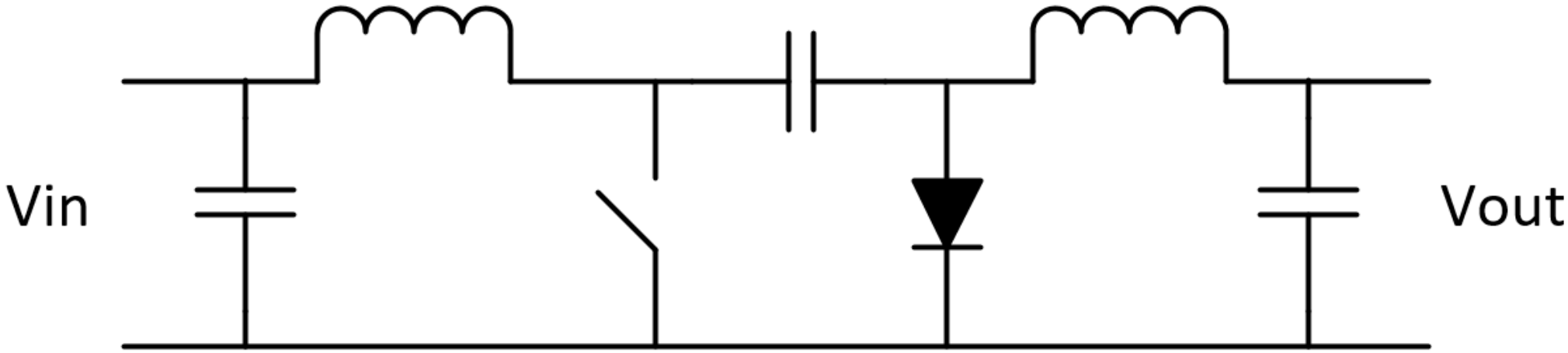
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Inverting (Buck-Boost) Topology Hot Loop



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CUK (Inverting) (Ćuk)



Continuous power flow on Vin and Vout

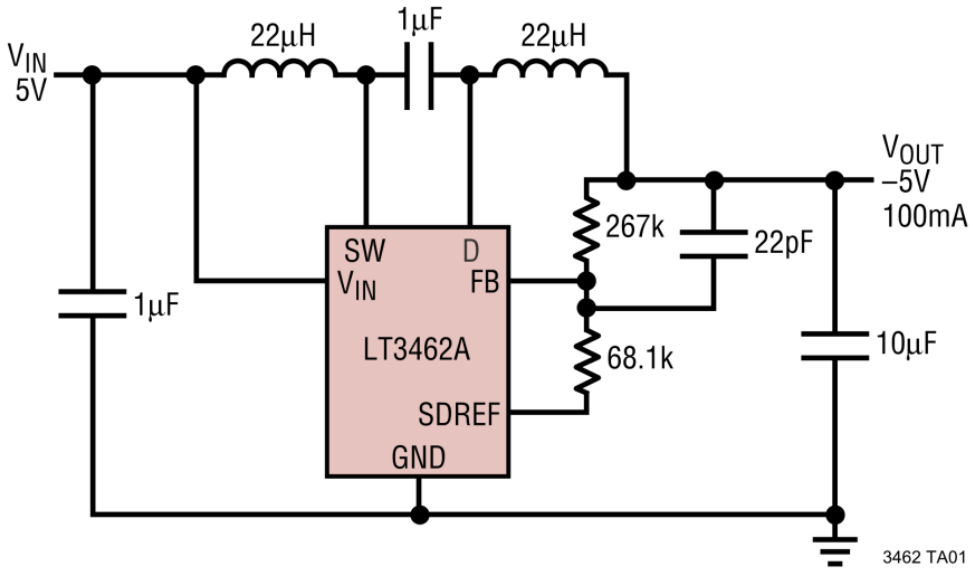
Low noise

Special converter needed

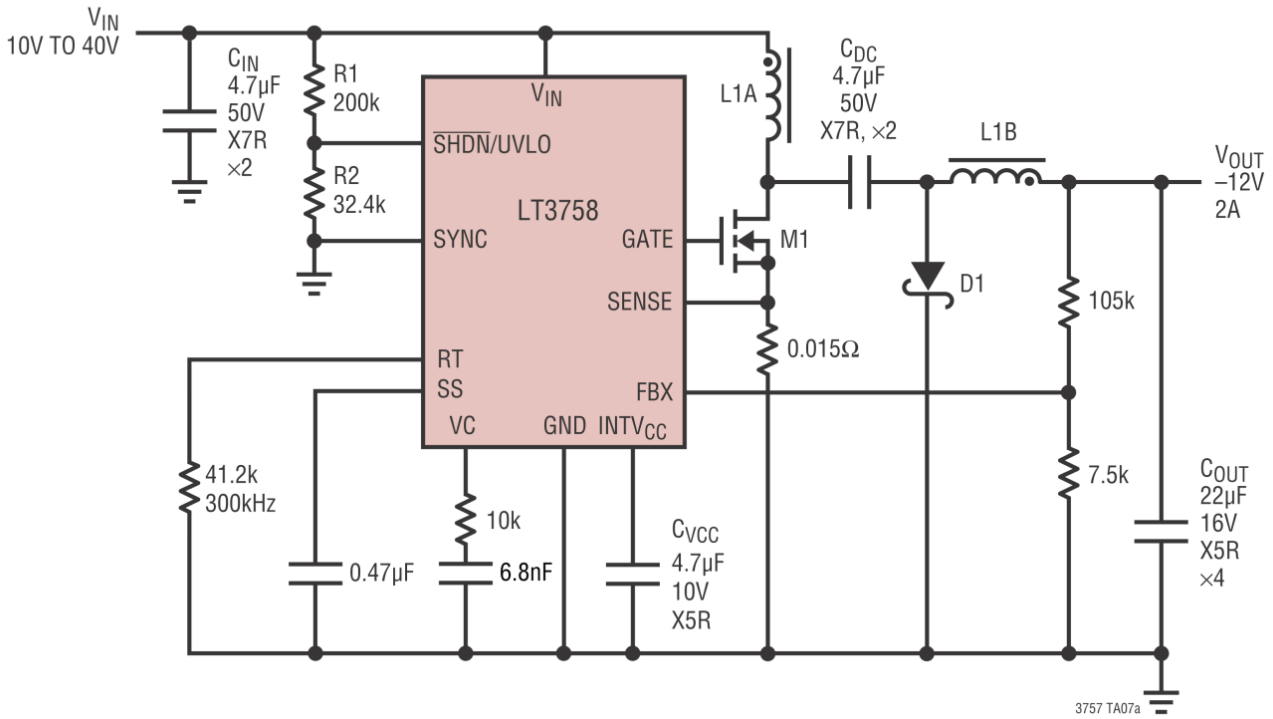
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Ćuk Converter Examples

5V to –5V, 100mA Inverting DC/DC Converter



10V to 40V Input, –12V Output Inverting Converter

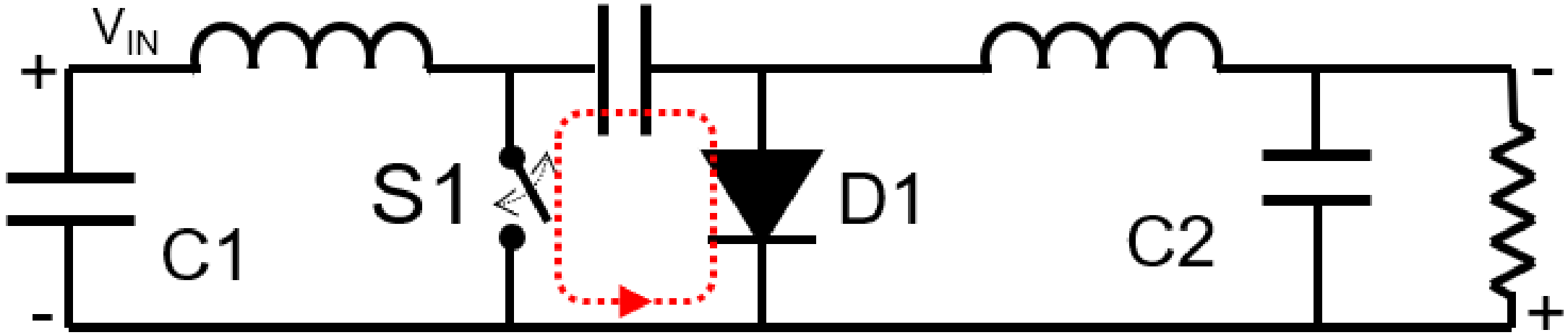


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Ćuk Topology Hot Loop

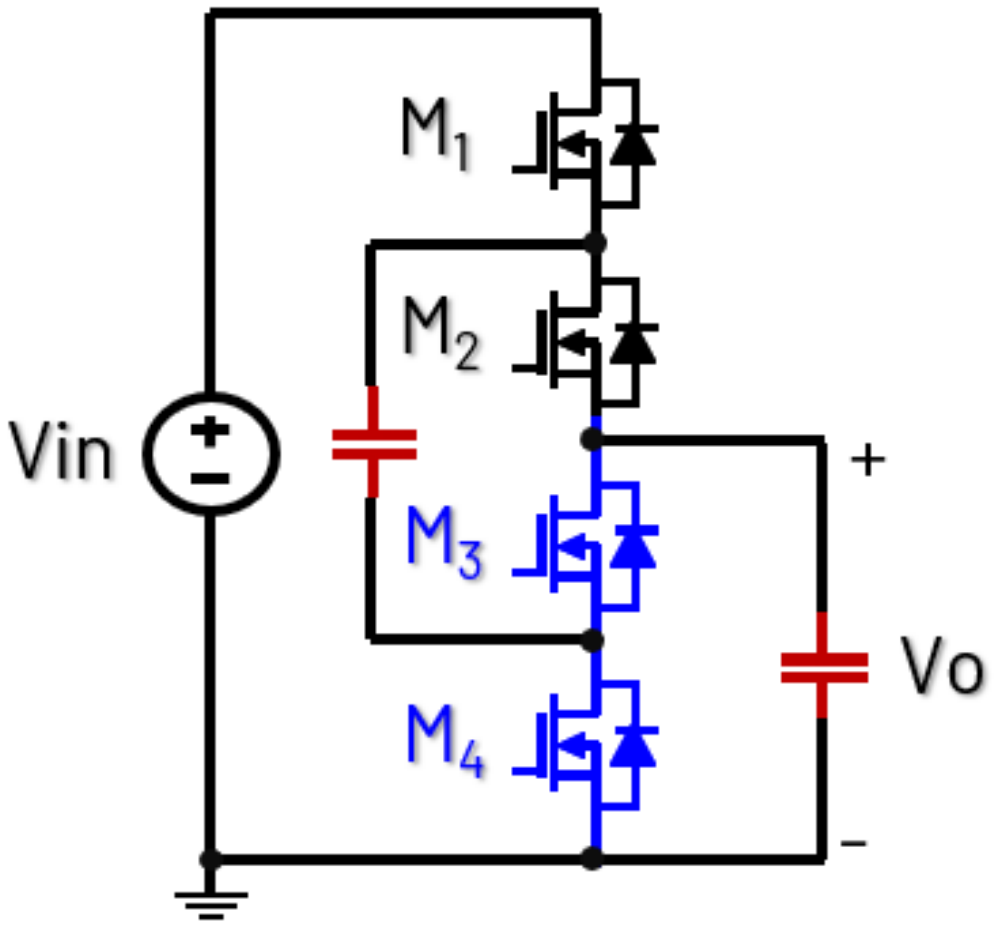
Parasitic junction capacitance has to be charged in ns range

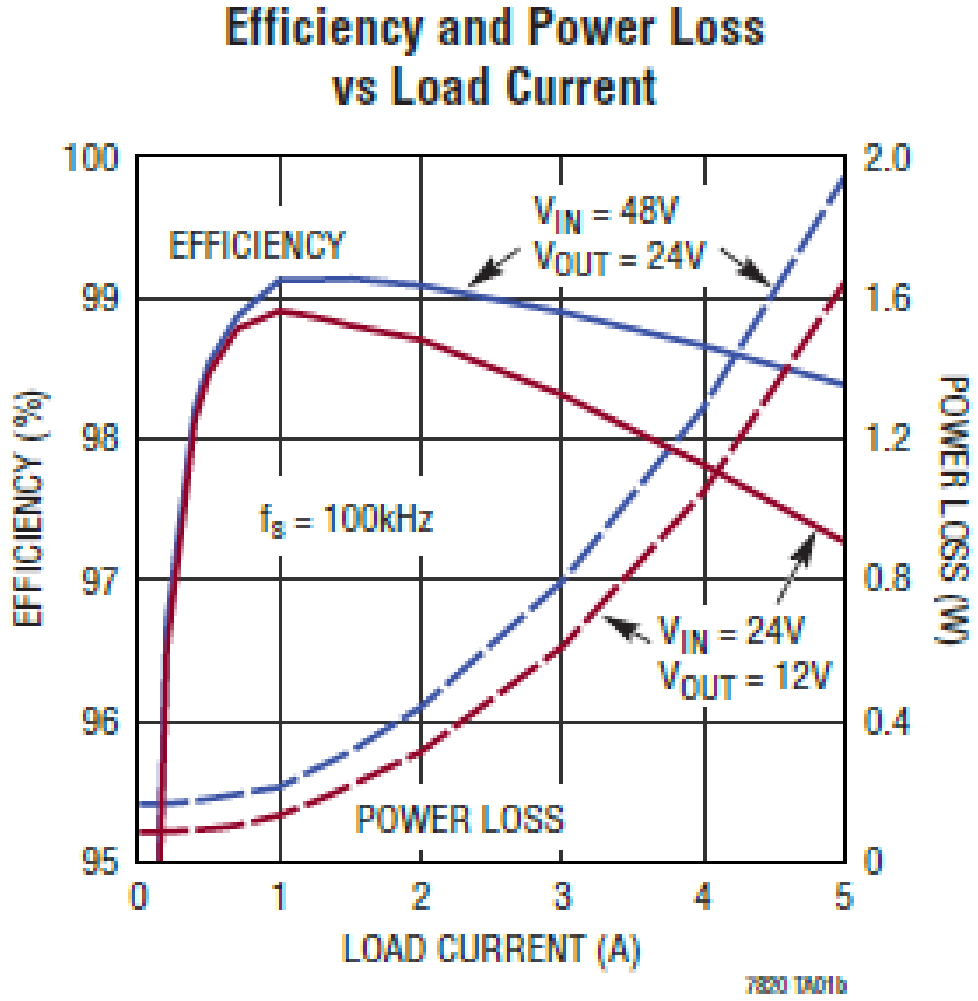
This topology produces the smallest interferences in comparison to all other DC/DC topologies



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Charge Pump (High Power)





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Hybrid Converter

Low FET voltage stress (Vin/2)

Low switching loss

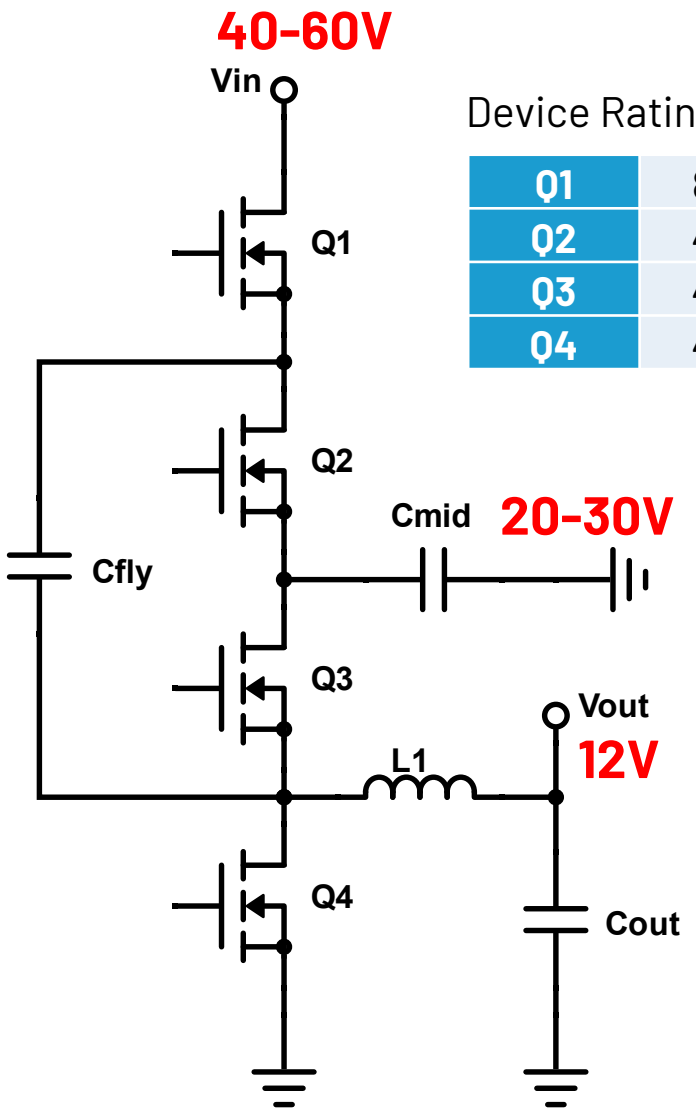
High switching frequency

Small inductor

Vo = ½Vin*D, tightly regulated

Current Mode control

Current Sharing (Scalable)

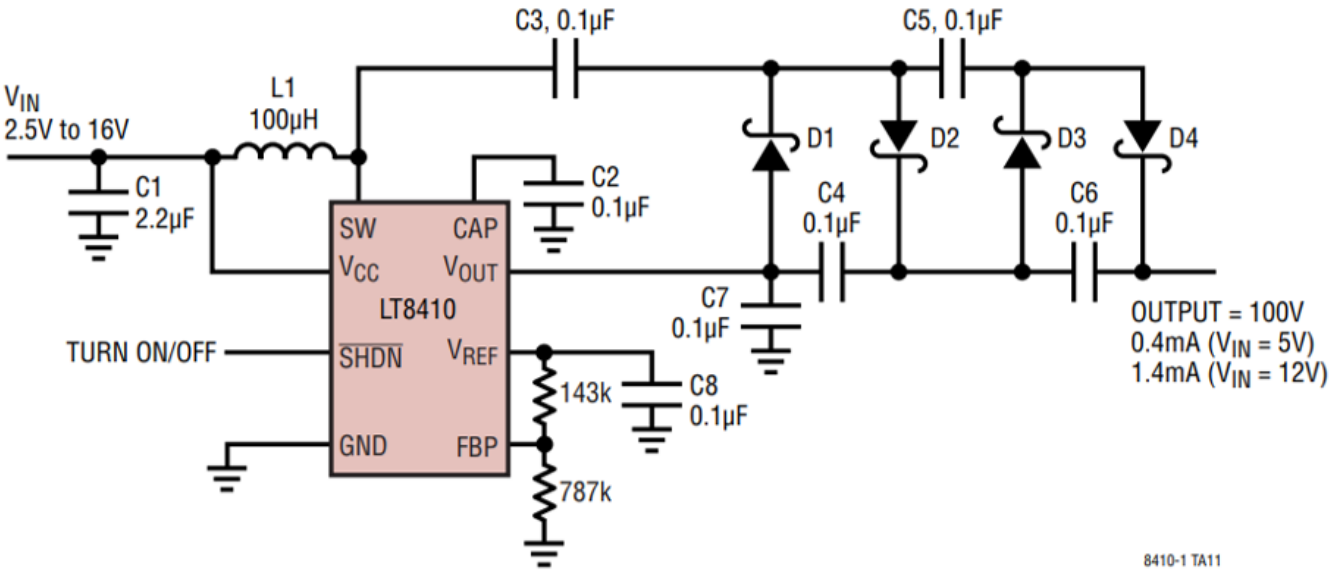


Device Rating:

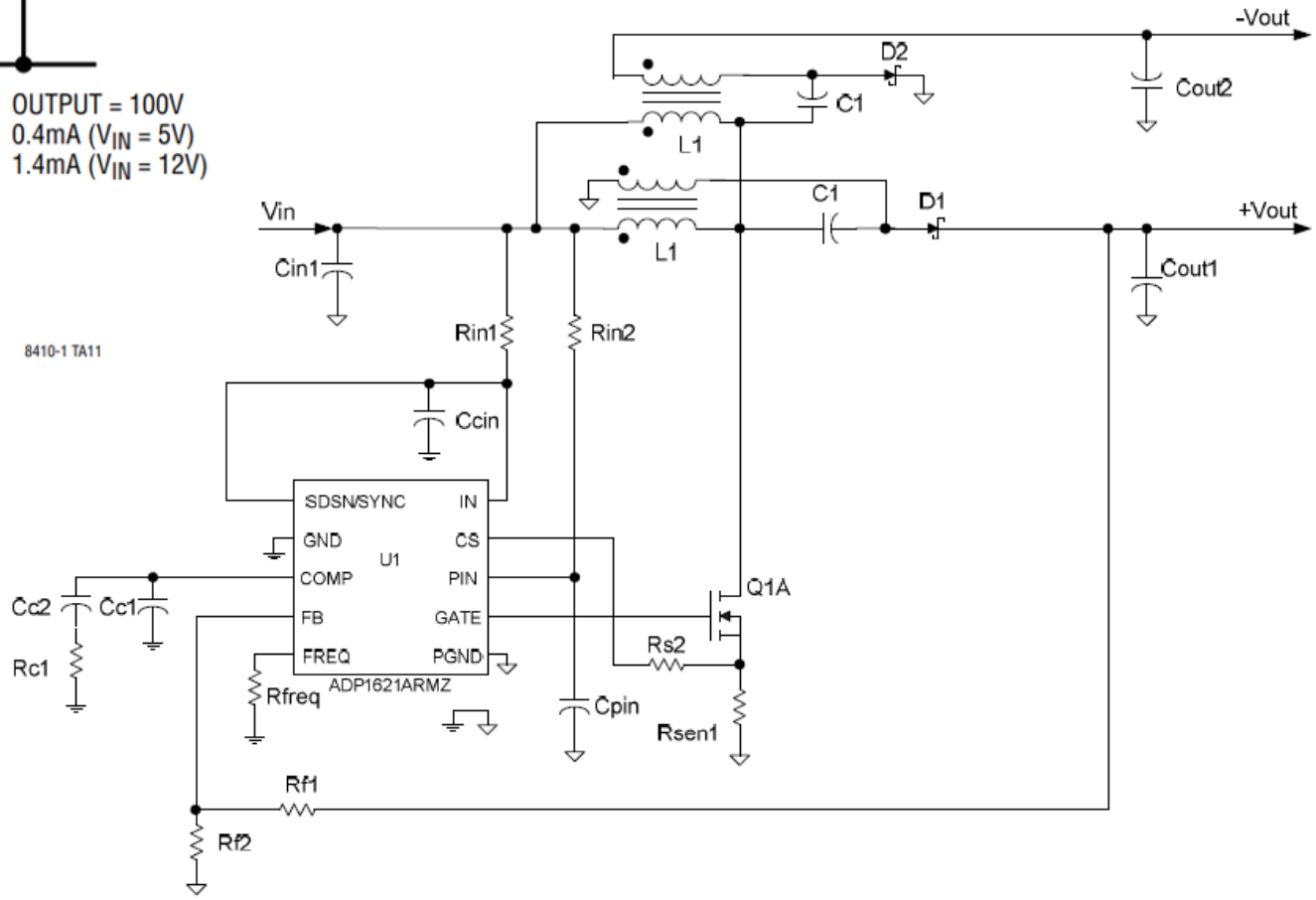
Q1	80V
Q2	40V
Q3	40V
Q4	40V

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Other combined Topologies (Cascaded)



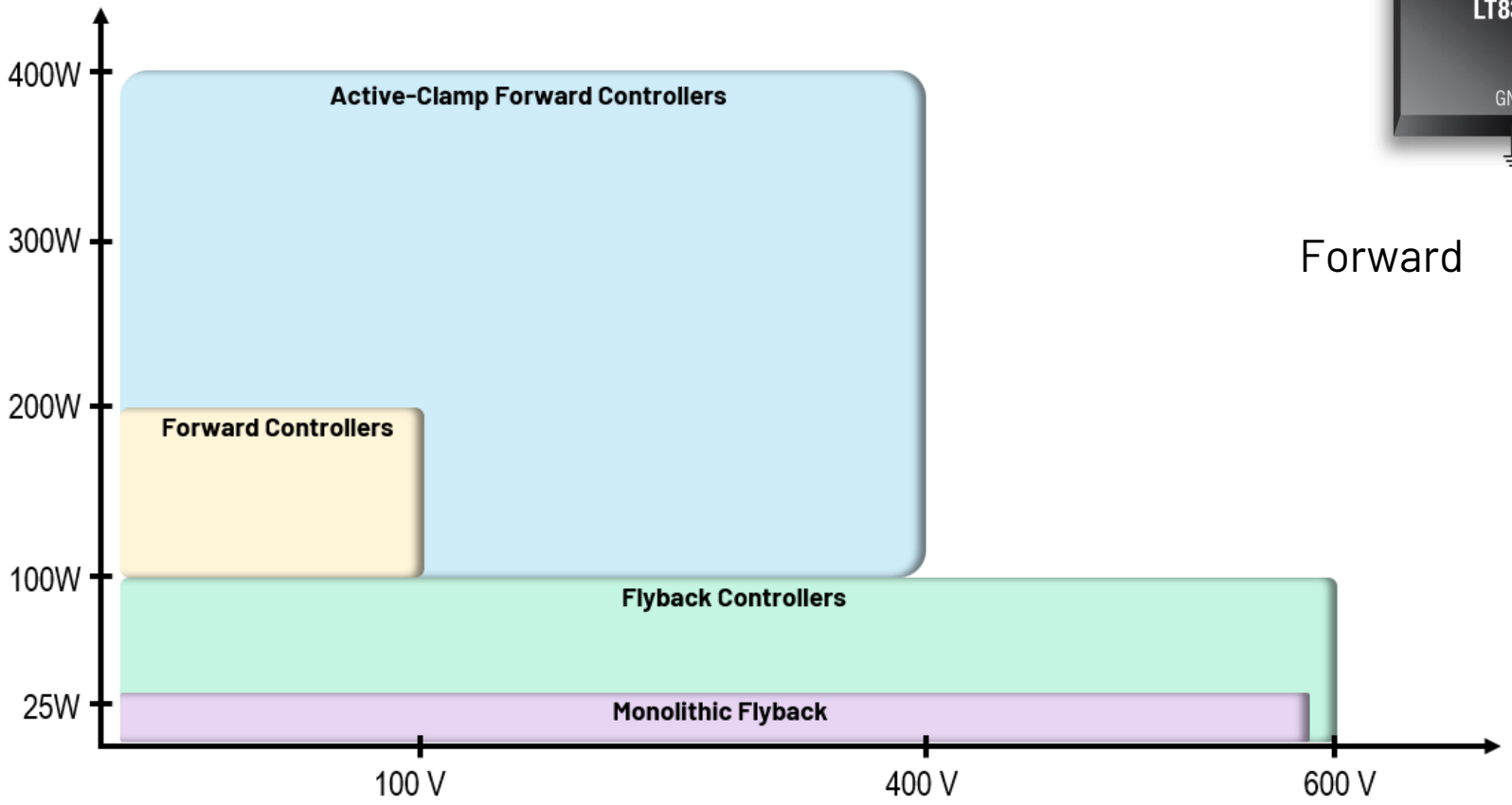
Boost and Charge Pump (voltage doublers)



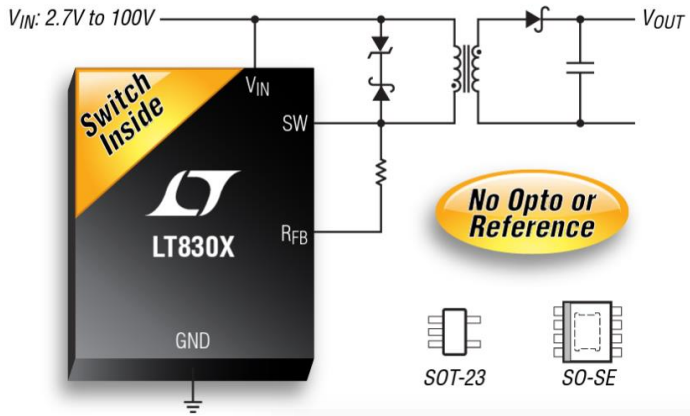
Coupled SEPIC - CUK

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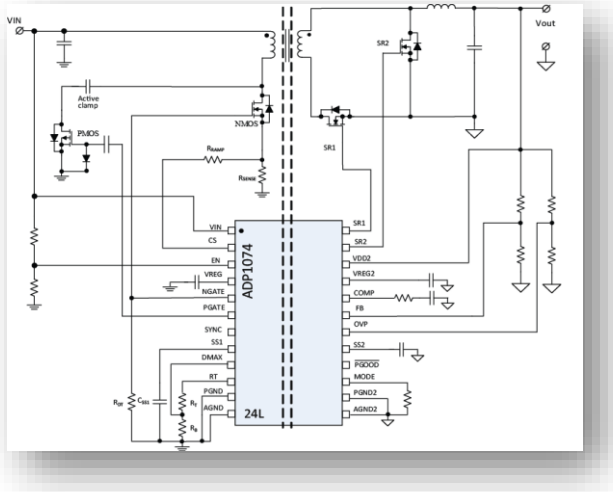
Isolated Topologies



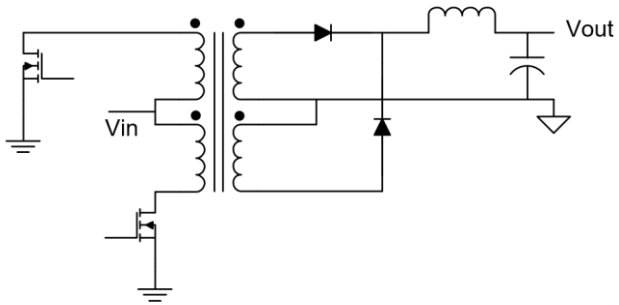
Flyback



Forward



Push-Pull



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AHEAD OF WHAT'S POSSIBLE

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