# Agenda

| | | |
|---|---|---|
| ***08:30 – 09:00*** | | *Arrival / Registration / Coffee* |
| ***09:00 – 09:50*** | | SMPS Topologies, tips and tricks (Analog Devices) |
| ***09:50 – 10:45*** | | Filtering Considerations for DC/DC Converters (Wurth Electronics) |
| ***10:45 – 11:10*** | | *Coffee Break & Networking Opportunity* |
| ***11:10 – 12:00*** | | The Art of Loop Compensation (Wurth Electronics) |
| ***12:00 – 13:00*** | | *Lunch* |
| ***13:00 – 13:50*** | | LTspice Examples (Analog Devices) |
| ***13:50 – 14:45*** | | Smart Selection of Inductors and Capacitors (Wurth Electronics) |
| ***14:45 – 15:10*** | | *Coffee Break & Networking Opportunity* |
| ***15:10 – 16:00*** | | PCB Board Layout Optimisation (Analog Devices) |

ANALOG DEVICES

WÜRTH ELEKTRONIK
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)

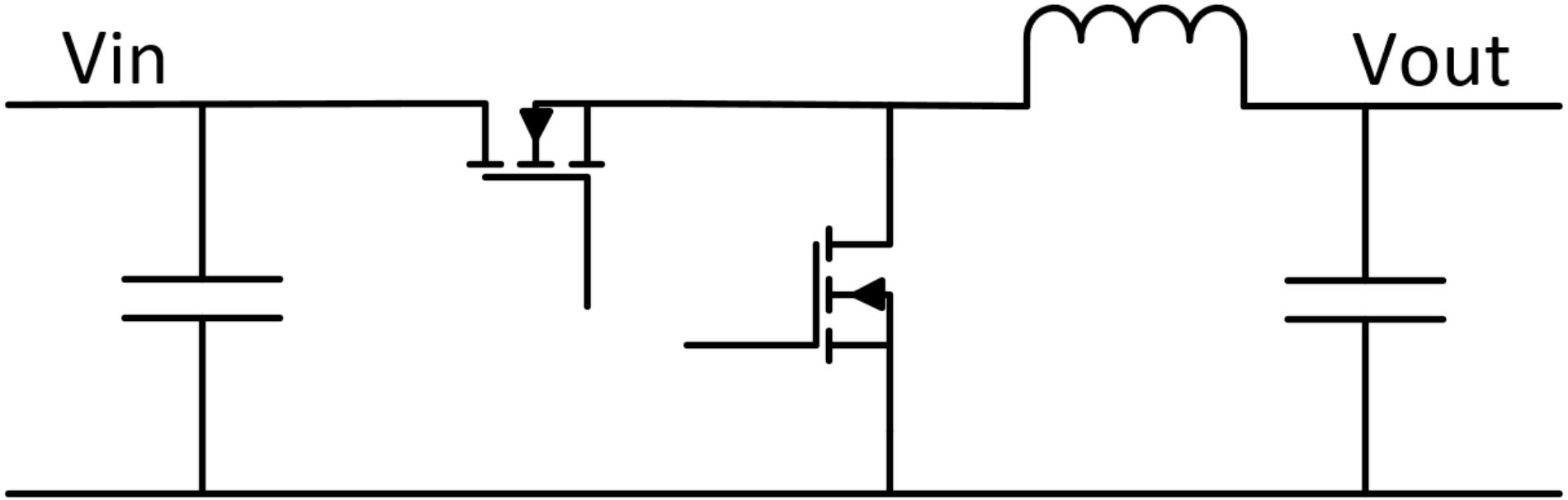
Hybrid Converter

Other combined Topologies (Cascaded)

Isolateded

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

# Buck (Step Down)




Synchronous / Non Synchronous / Synchronizable

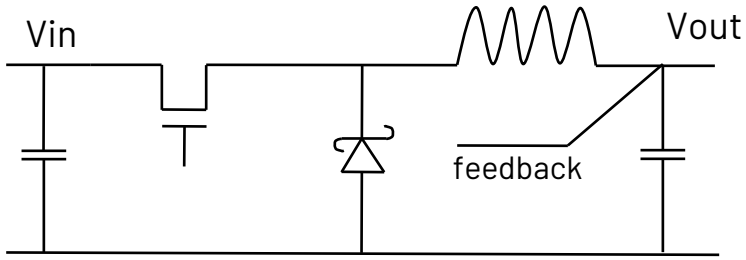
Monolythic

Pulsed Energy Flow on the input side

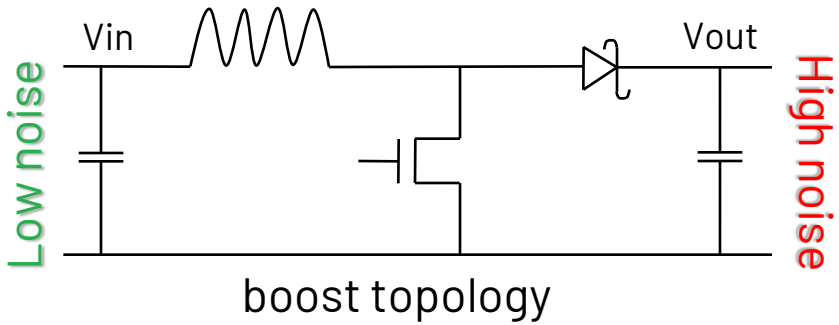
# Additional filtering

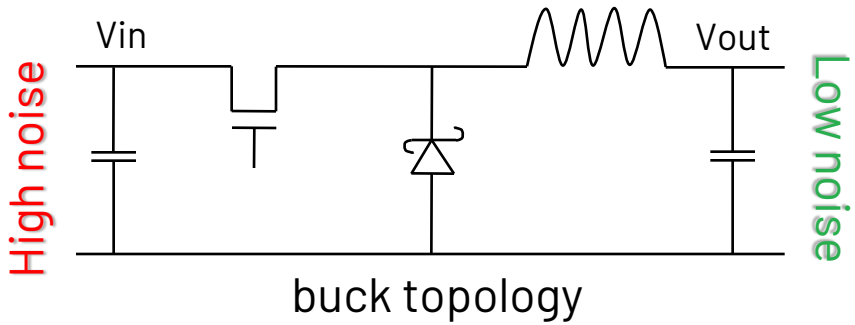
Often input and / or output traces radiate the most

Additional LC filter




Generally trace with inductance in series is less noisy



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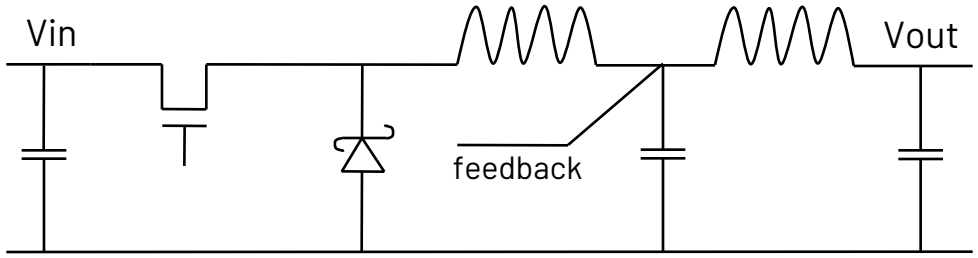


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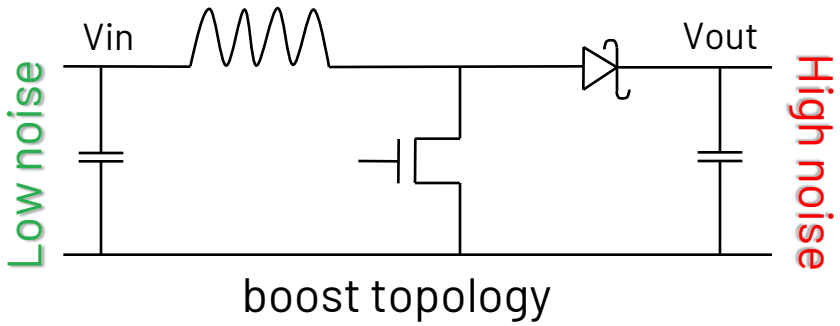


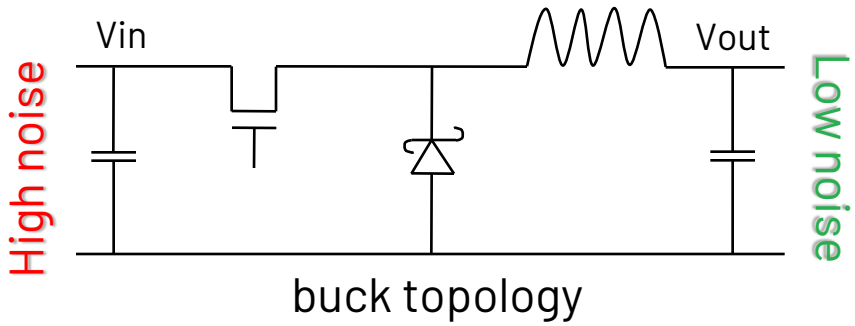

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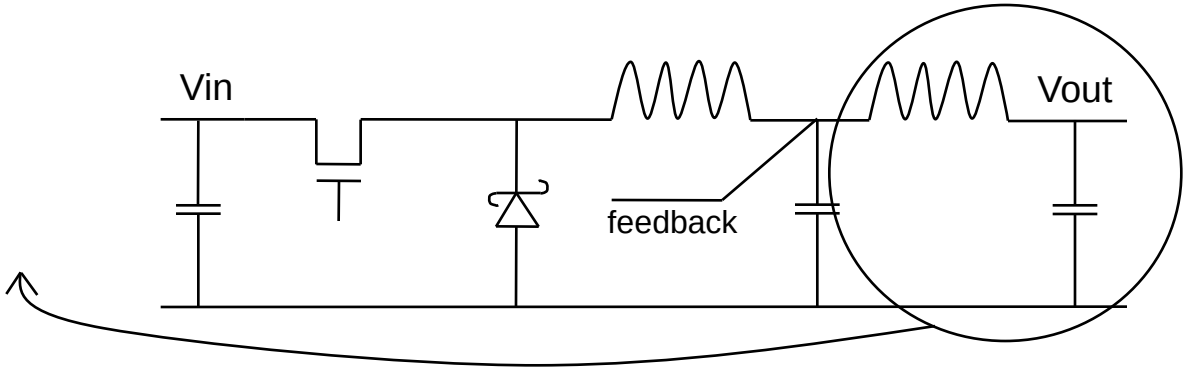


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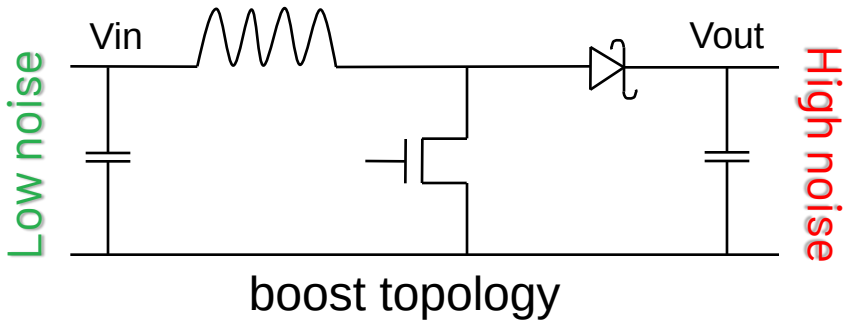
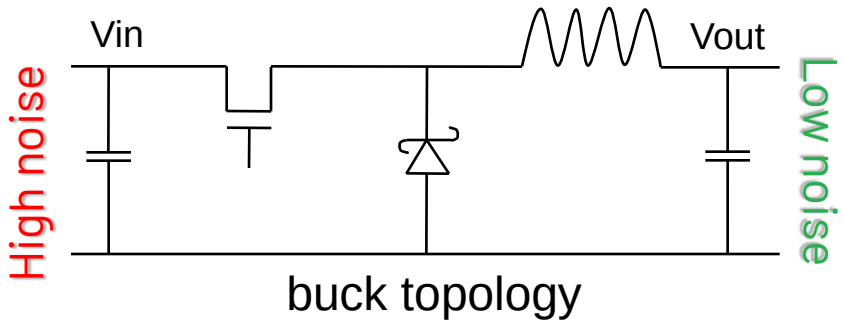
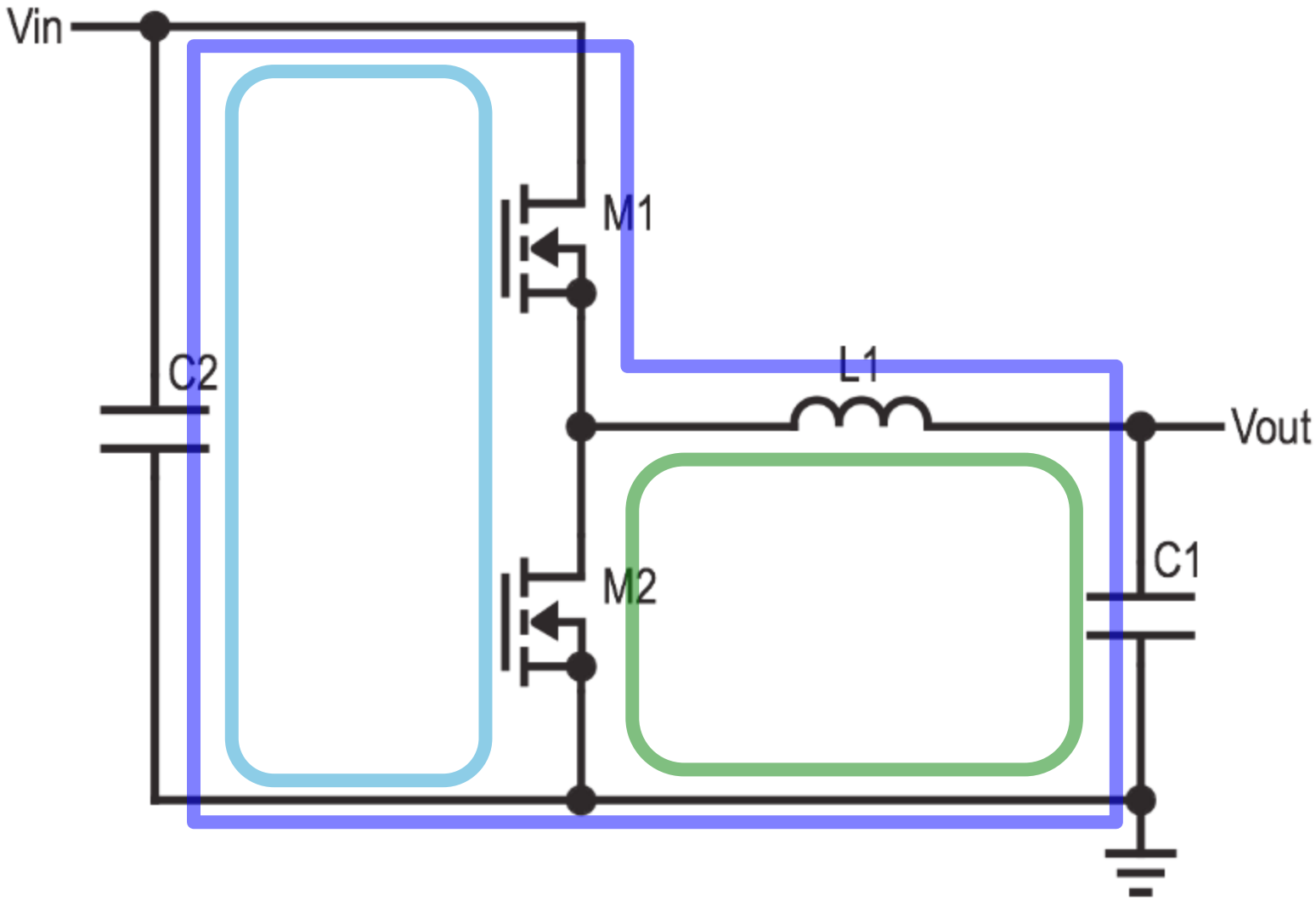
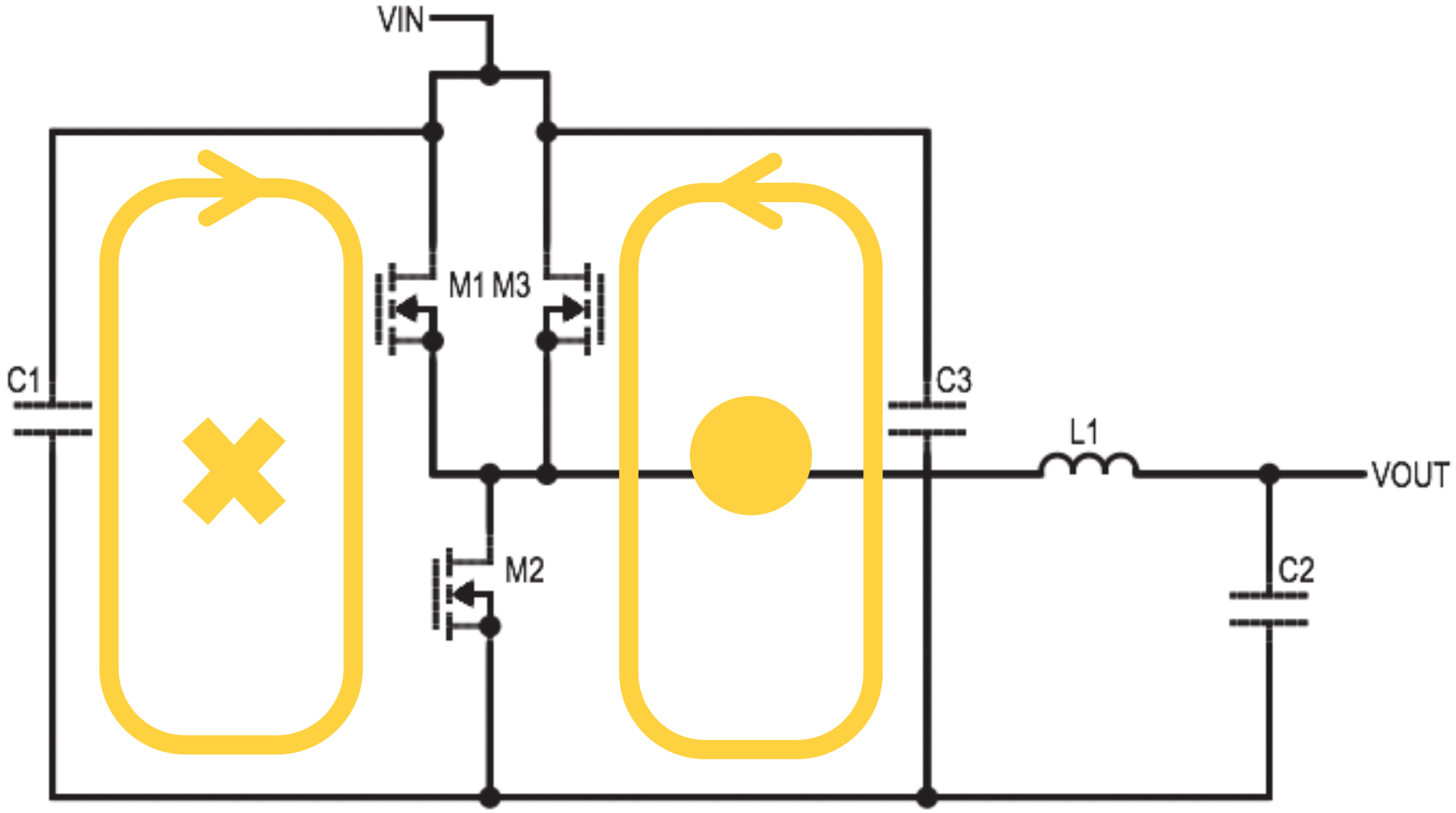


# Buck Hot Loops



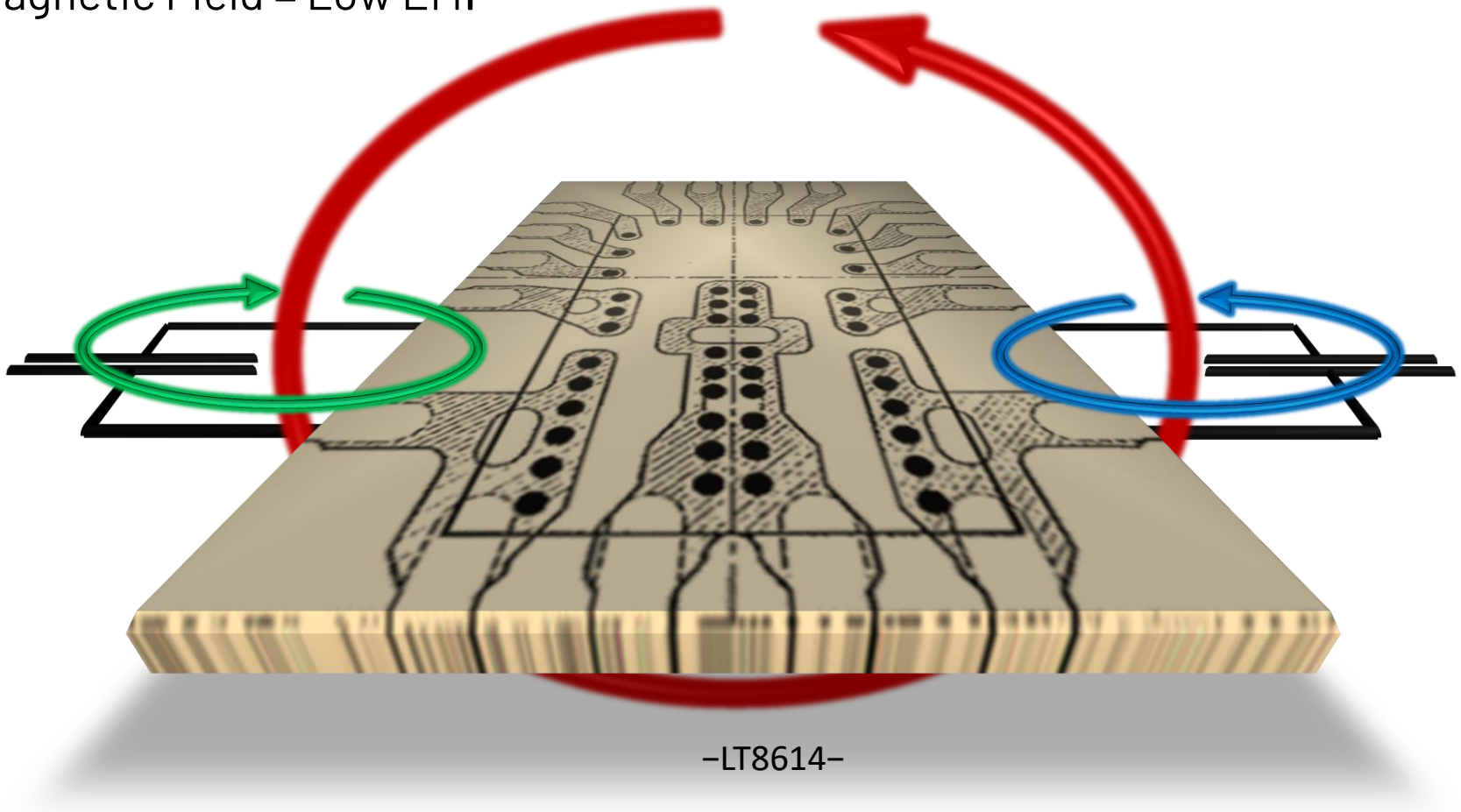
# Silent switcher – magnetic field cancellation



# Cancelling Hot Loops

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

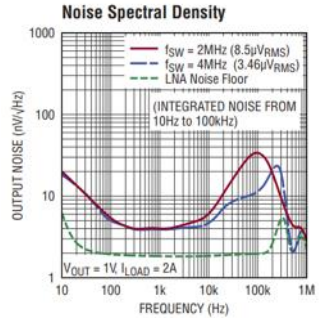
Confined Magnetic Field = Low EMI

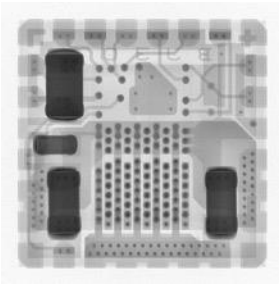


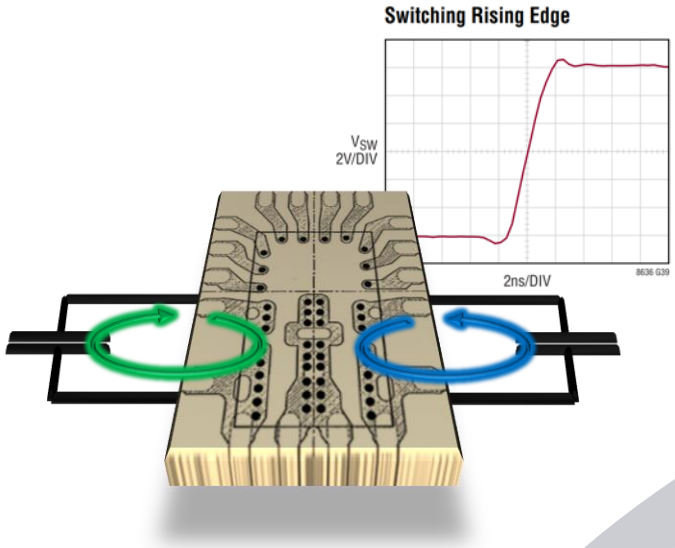
–LT8614–

# 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**

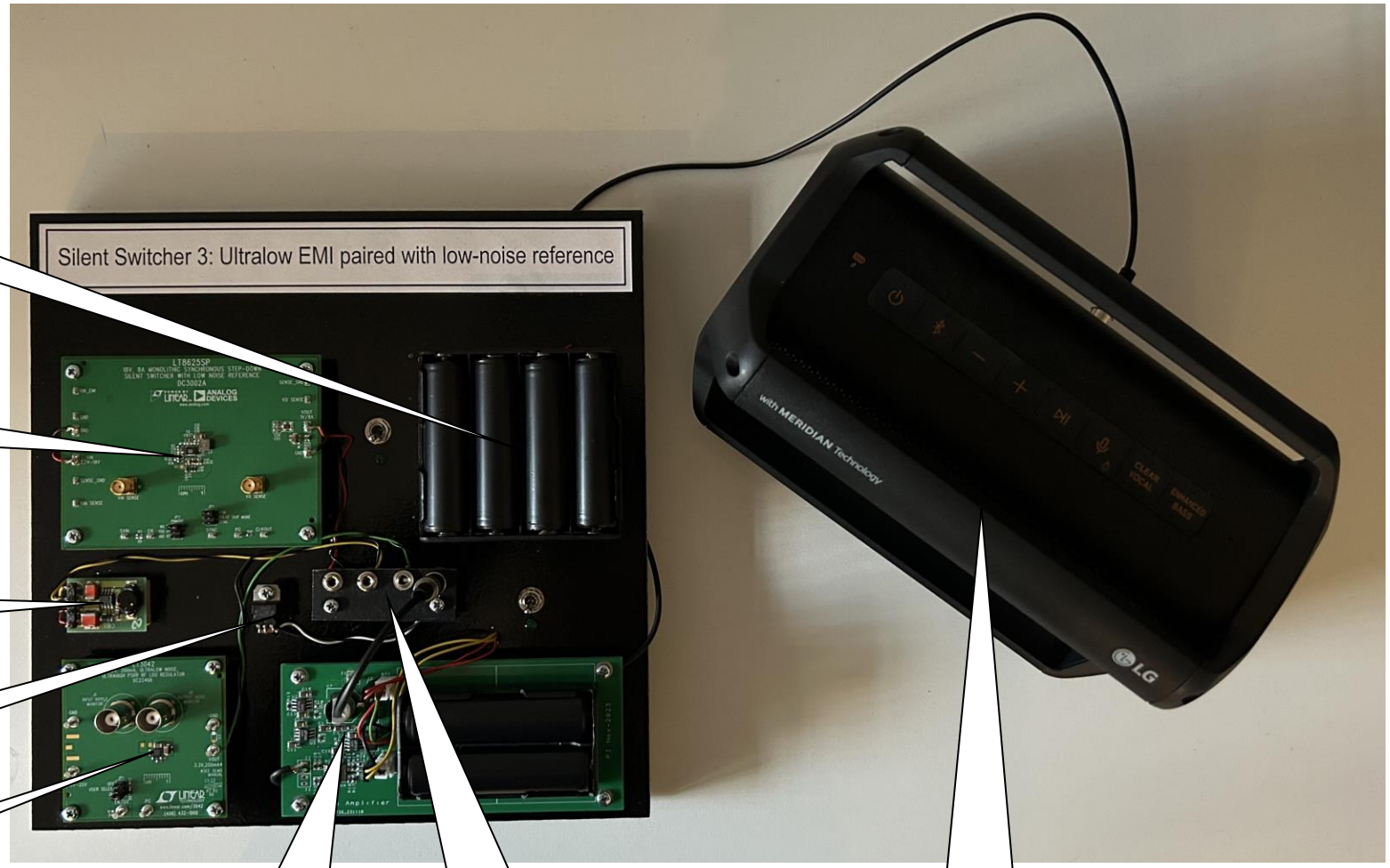



Silent Switcher®1

Silent Switcher®2

Silent Switcher®3

# Demo setup Silent Switcher 3




Batteries

Silent Switcher 3

Heritage Switcher

Simple Linear Regulator

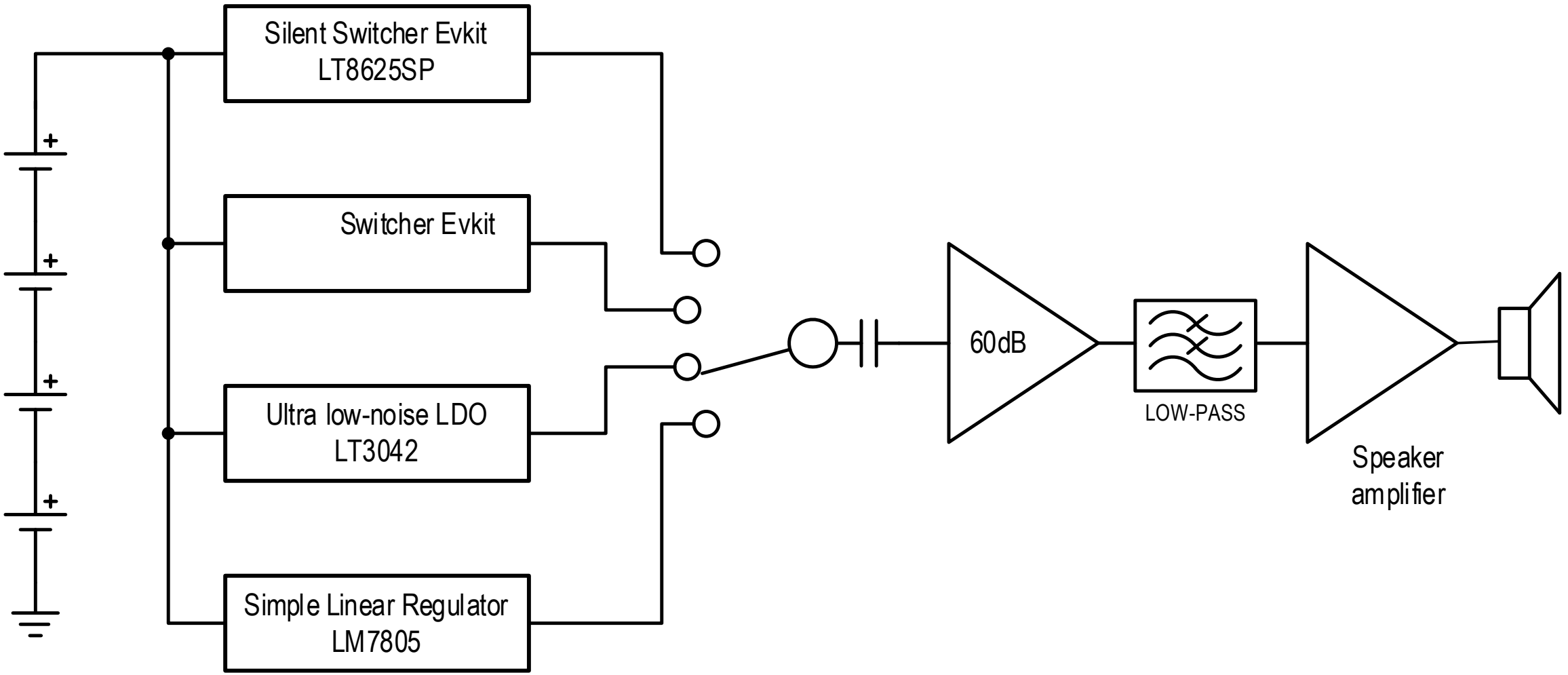
Ultra Low-noise LDO

60 dB noise amplifier

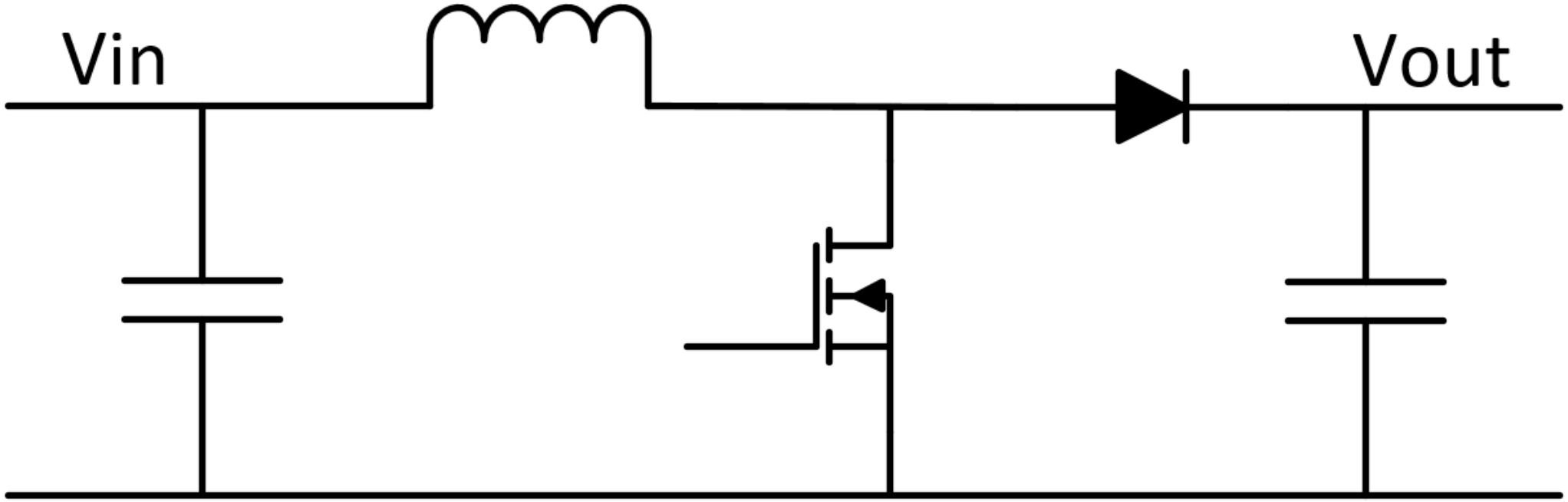
Selector

Speaker 20Hz to 20kHz

# Block diagram



# 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

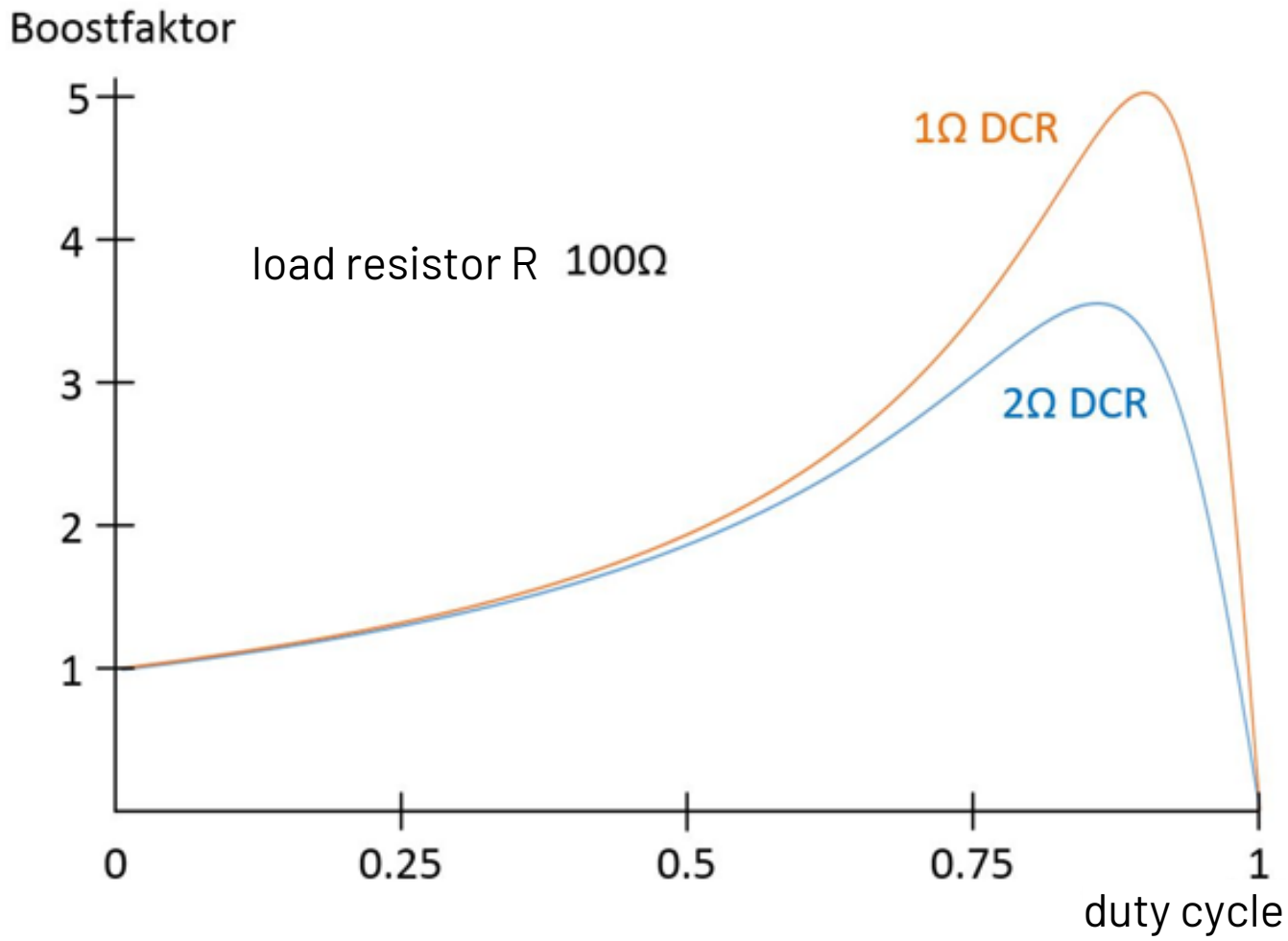
# Boost-Factor

Duty cycle for a boost:

$$V_{out} = \frac{V_{in}}{(1-D)}$$

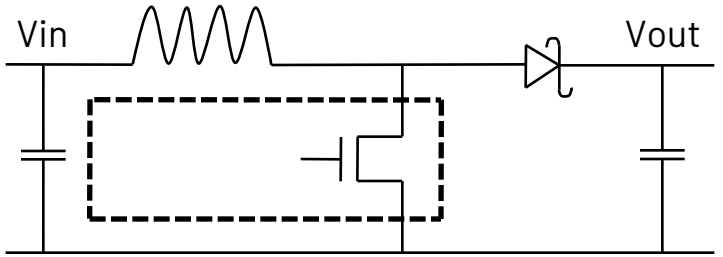
**But**, There is a limit to how much a boost can boost:

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

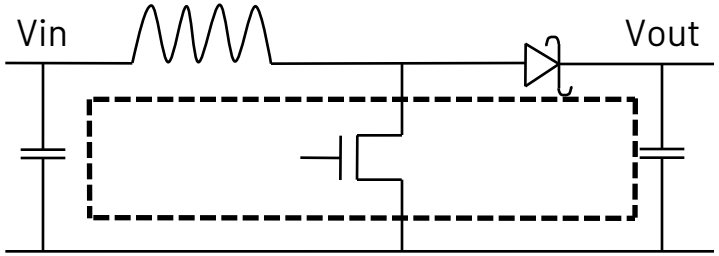


# Hot Loop Boost Regulator

Current flow during on-time:

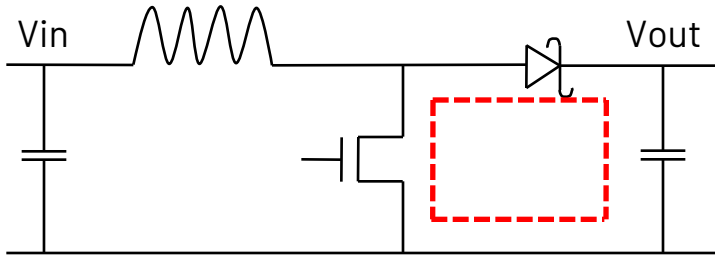



Current flow during off-time:

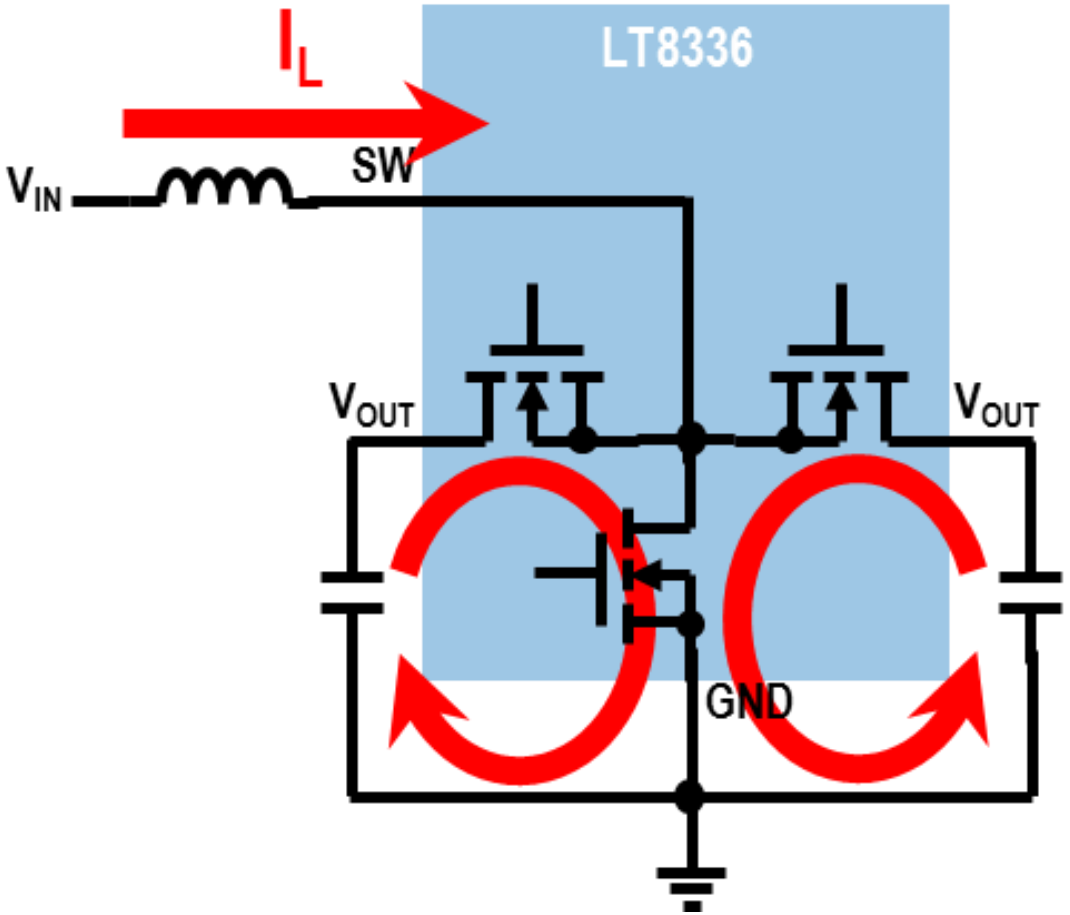


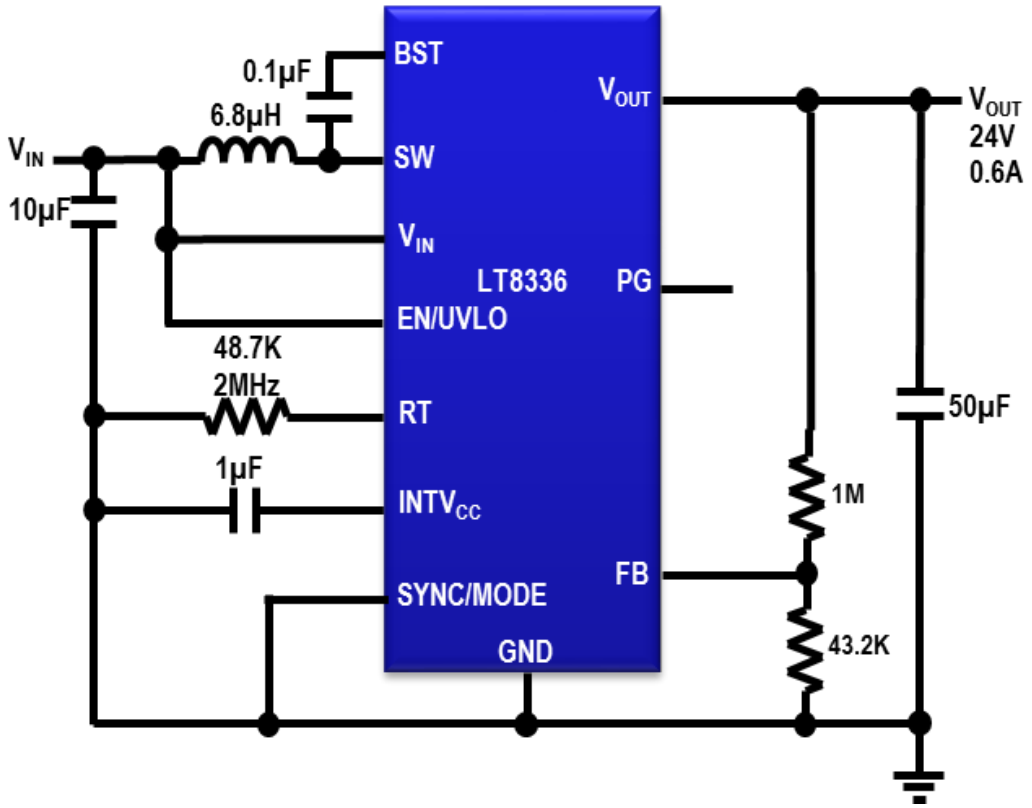

AC traces:

Keep AC traces as short as possible…(ASAP)

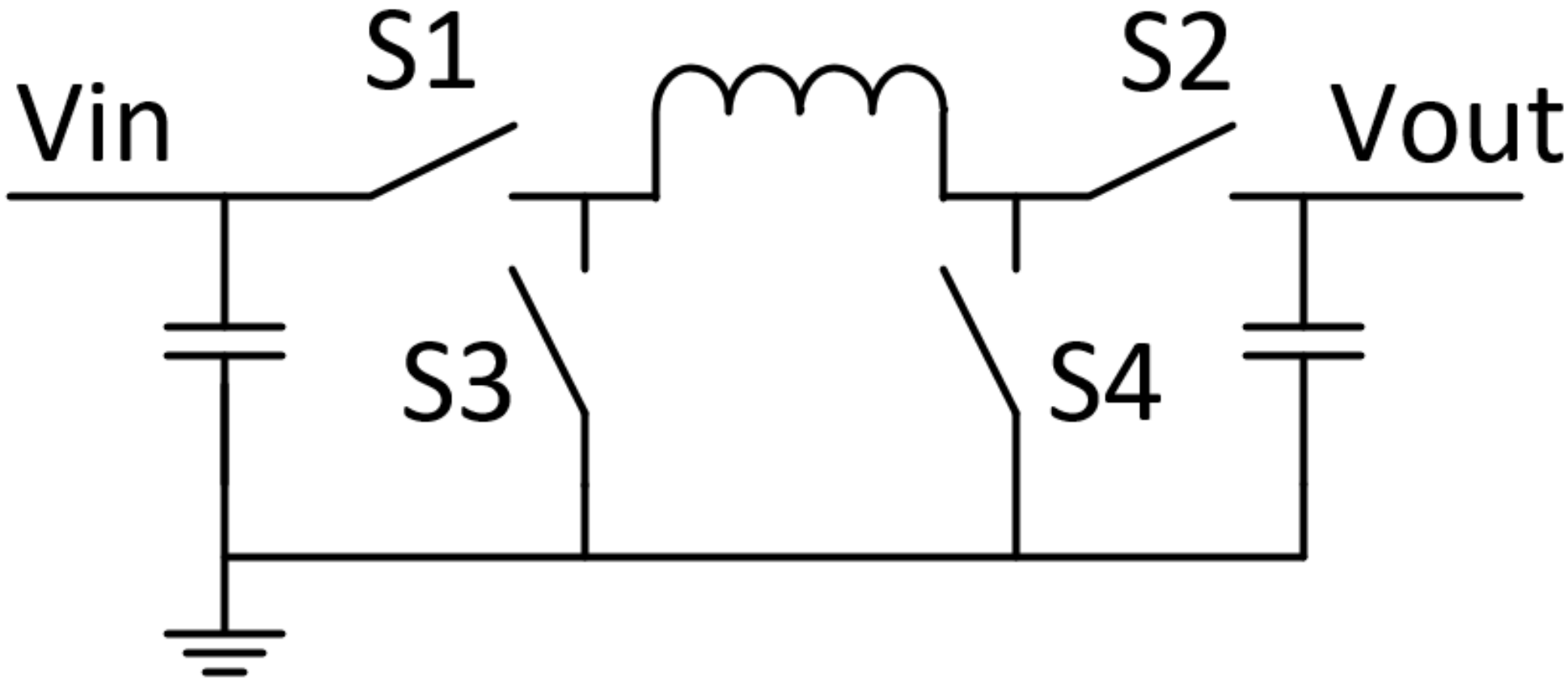


# Silent Switcher Boost Converters



# Buck-Boost (Step Up and Step Down)



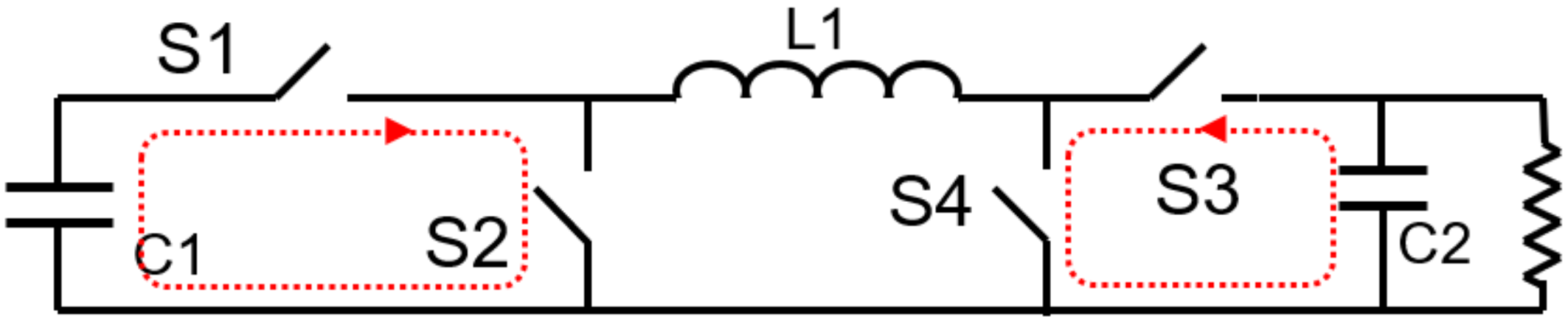

Very efficient

More silicon / fewer passives

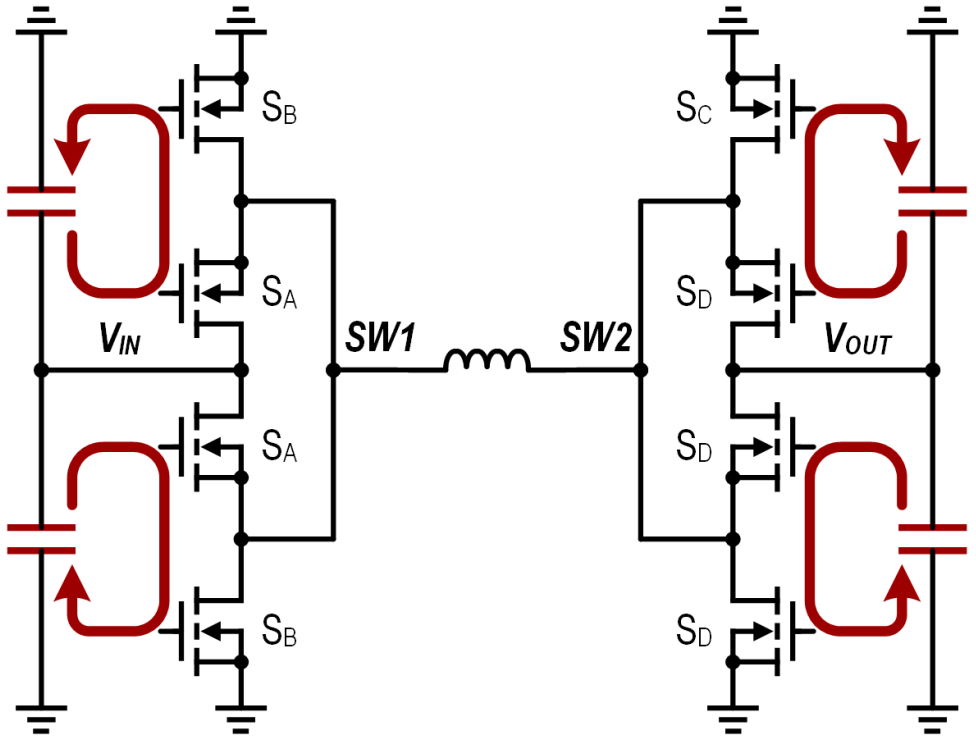
Challenge is switch over

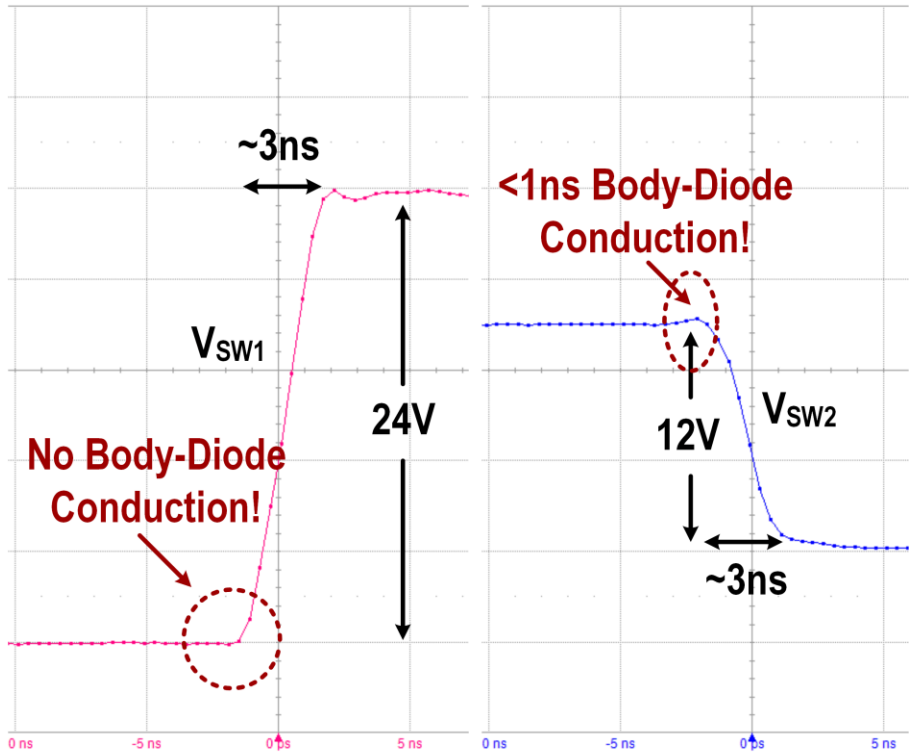
# Synchronous Buck-Boost Topology Hot Loops

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



# LT8350S – New Generation Silent Switcher 2

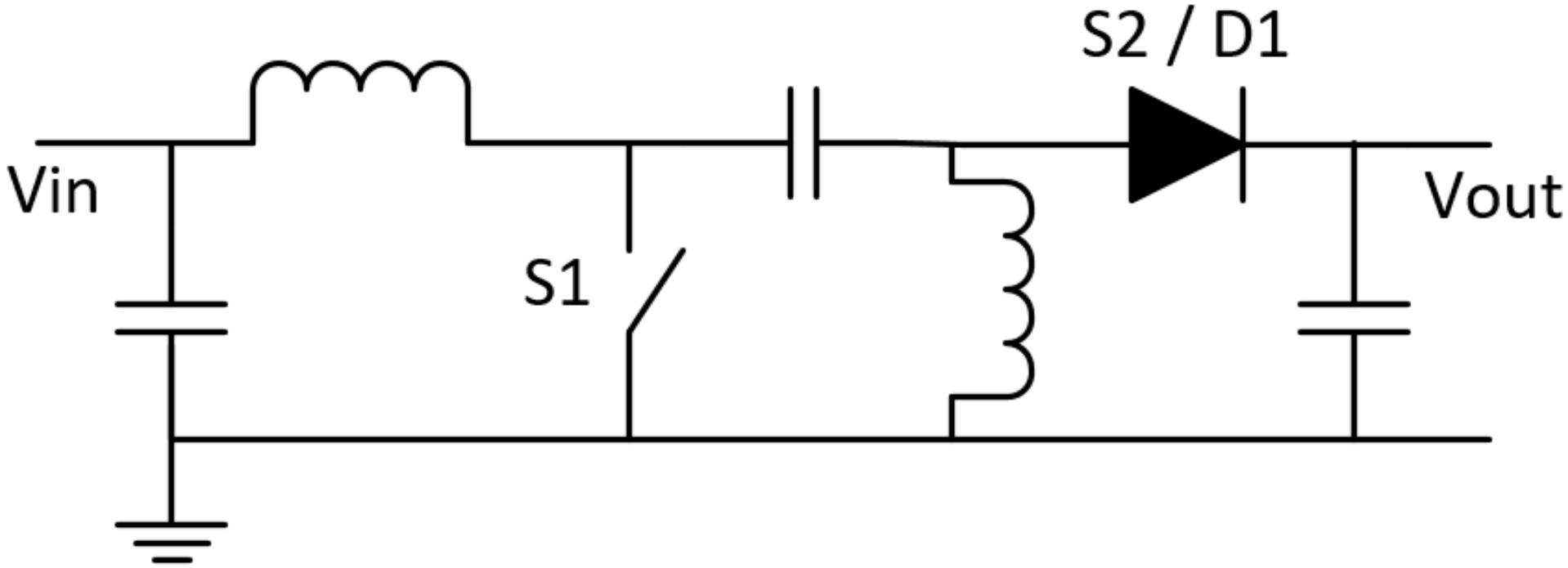



- Silent Switcher 2 Architecture
  - Symmetrical hot loops
  - Internal hot loop caps
  - Cu pillars instead of bond wire
- Safe zero-deadtime

**For Good EMI, Good Efficiency, Simple PCB**

# SEPIC (Step Up and Step Down)

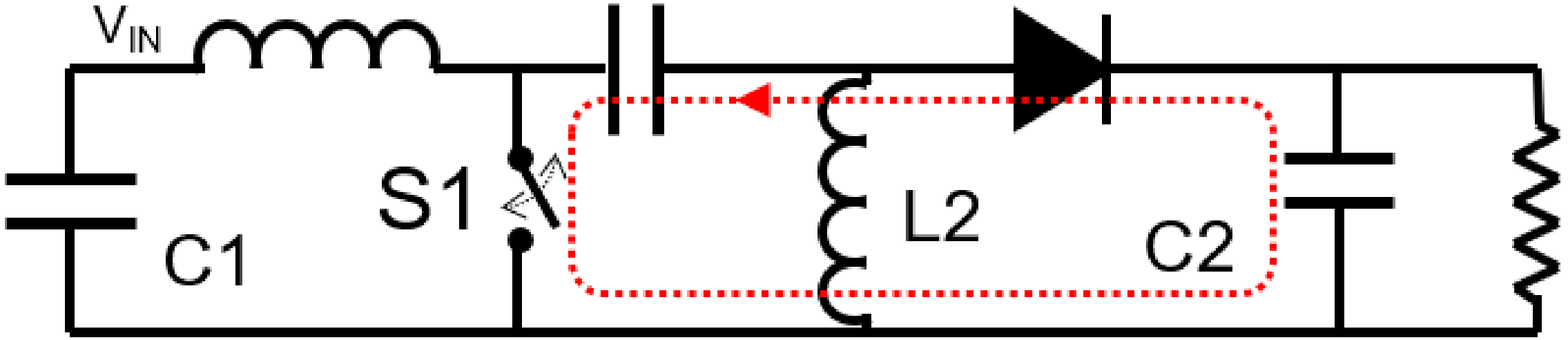



Coupled inductors / coupling capacitor

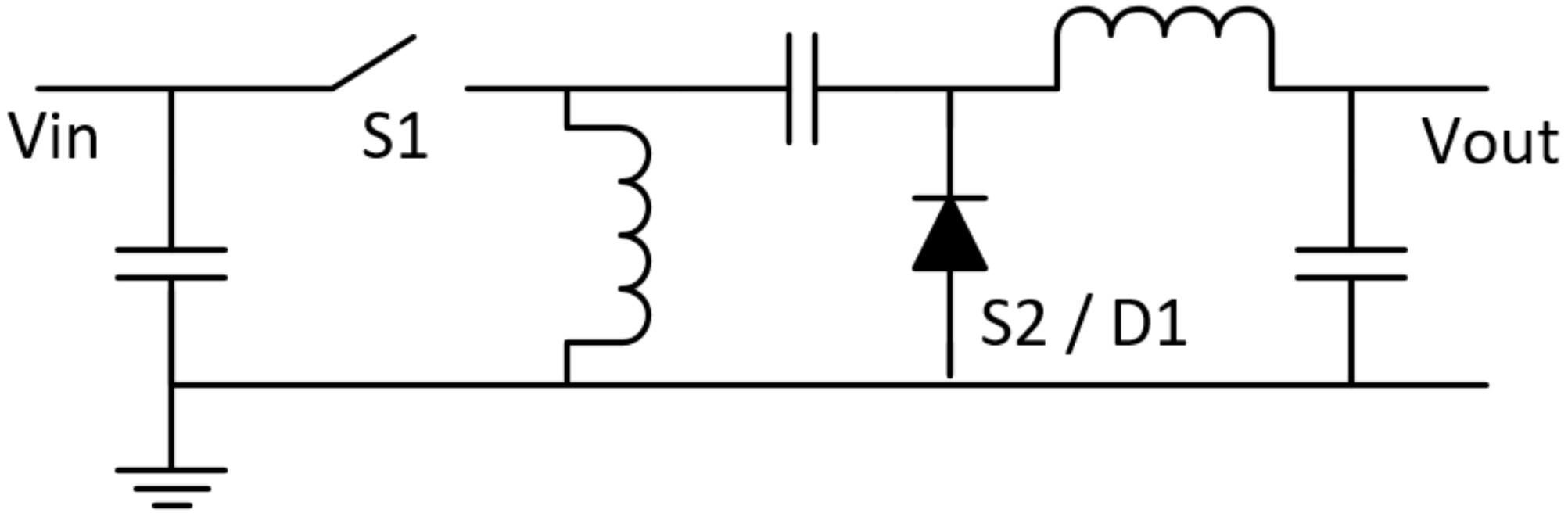
RHP Zero

Lower efficiency compared to buck-boost

# SEPIC Topology Hot Loop



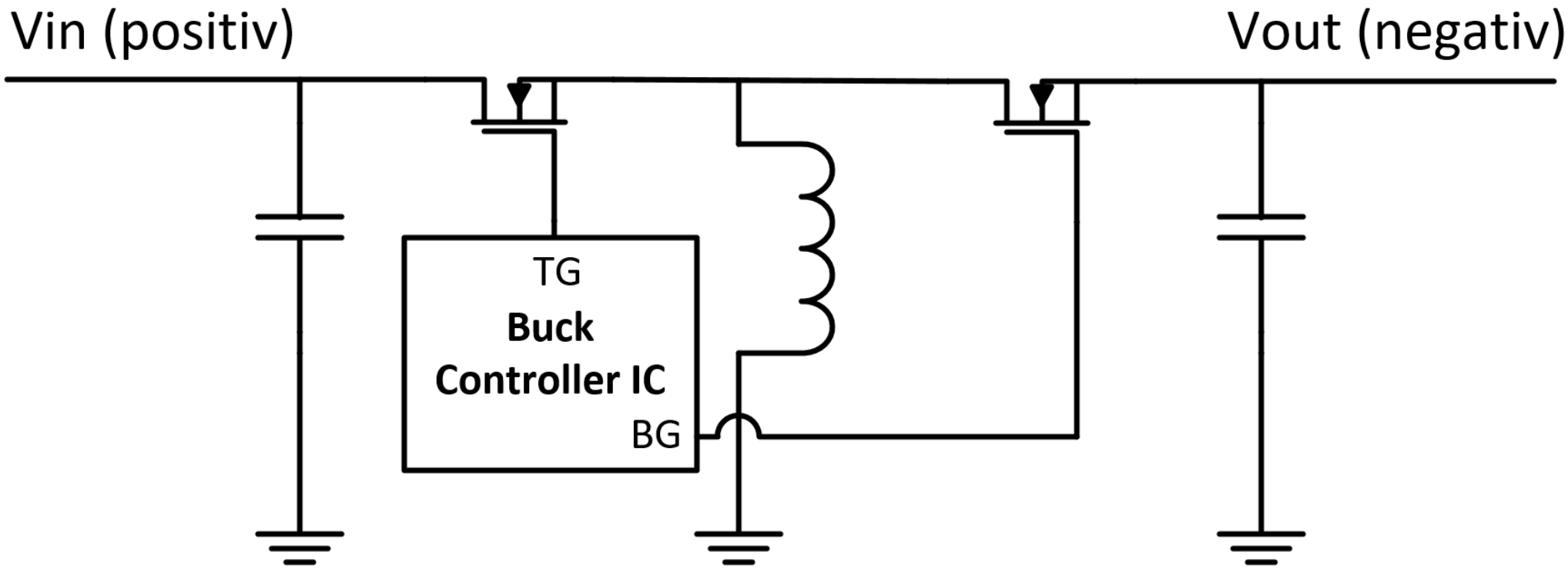
# Zeta (Inverse SEPIC)



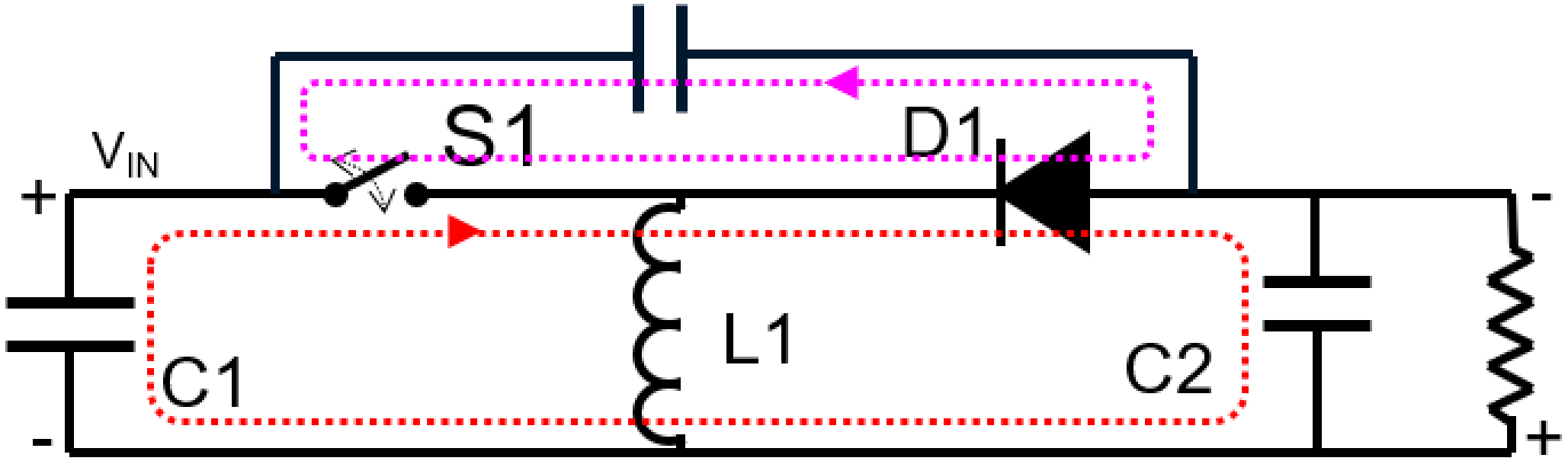

No right half plane zero

Active high side switch needed (buck converter type)

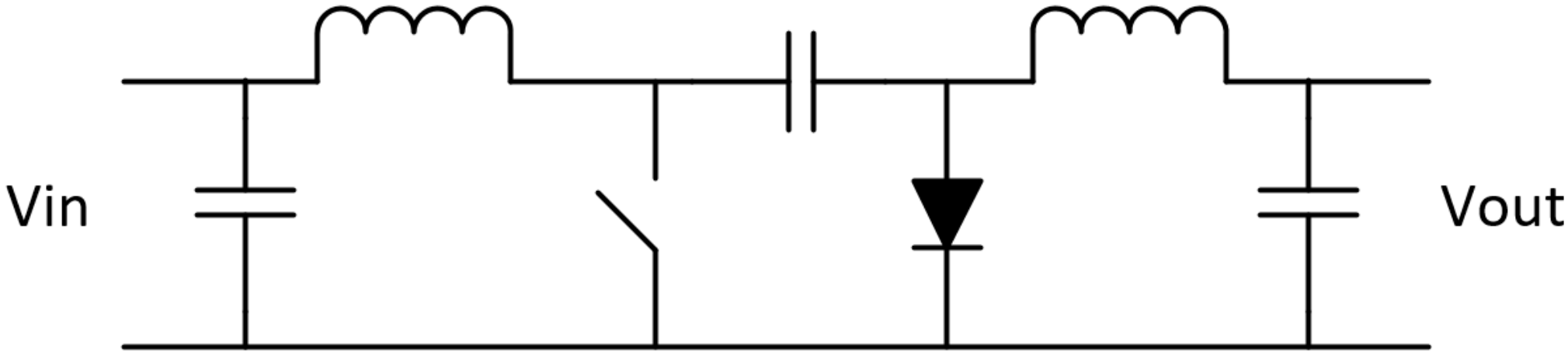
# Inverting (Buck-Boost)



# Inverting (Buck-Boost) Topology Hot Loop



# CUK (Inverting) (Ćuk)



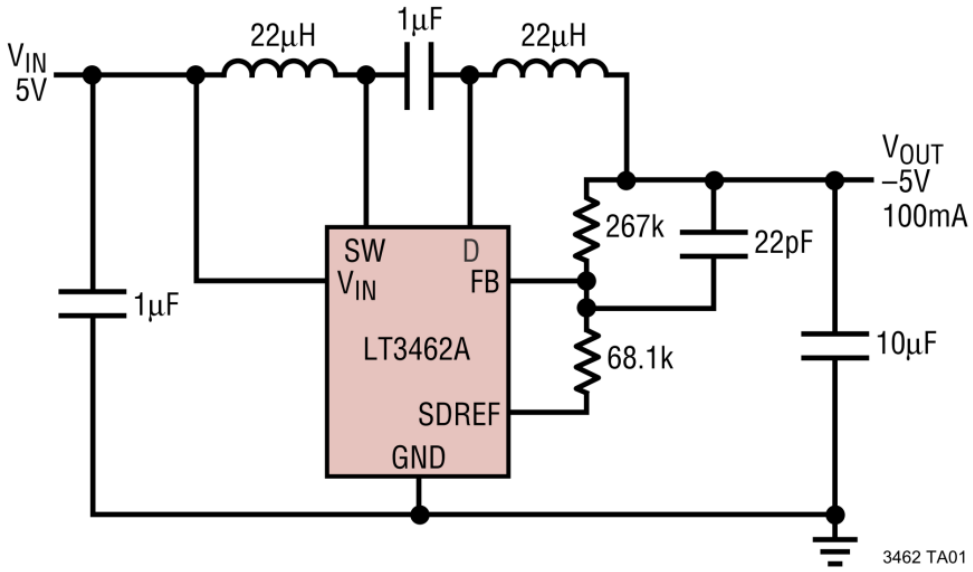

Continuous power flow on Vin and Vout

Low noise

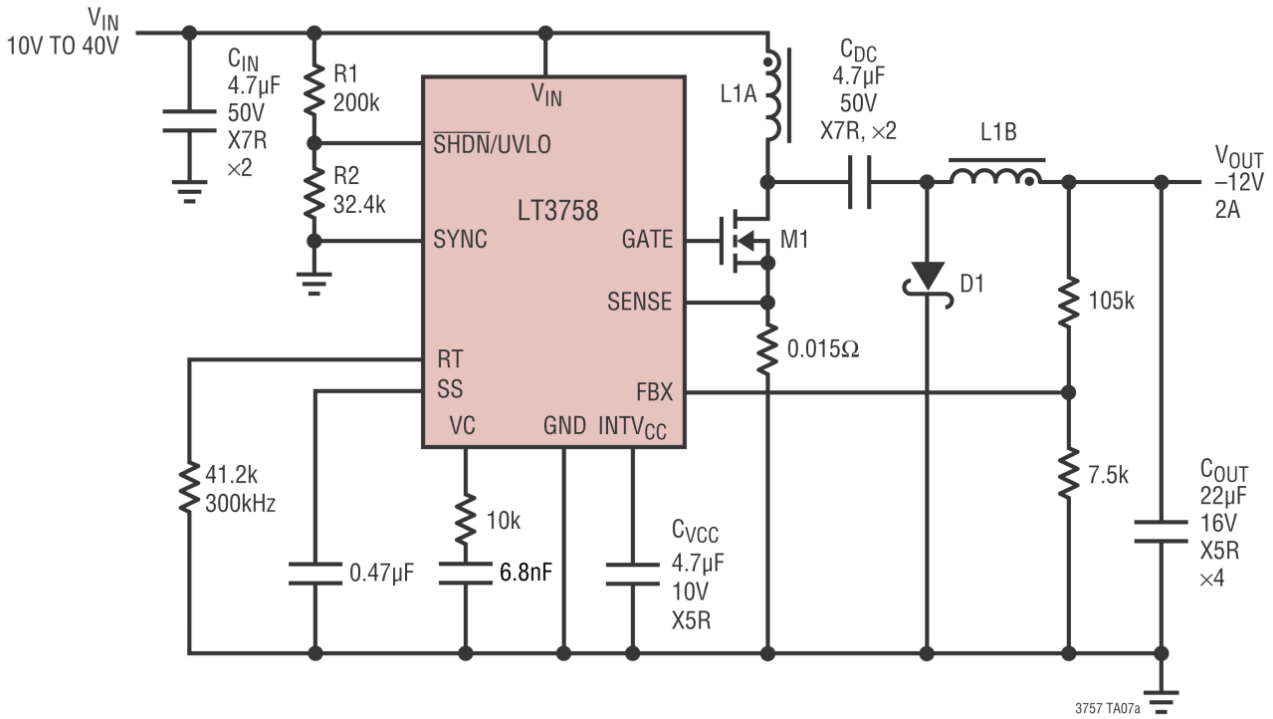
Special converter needed

# Ćuk Converter Examples

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

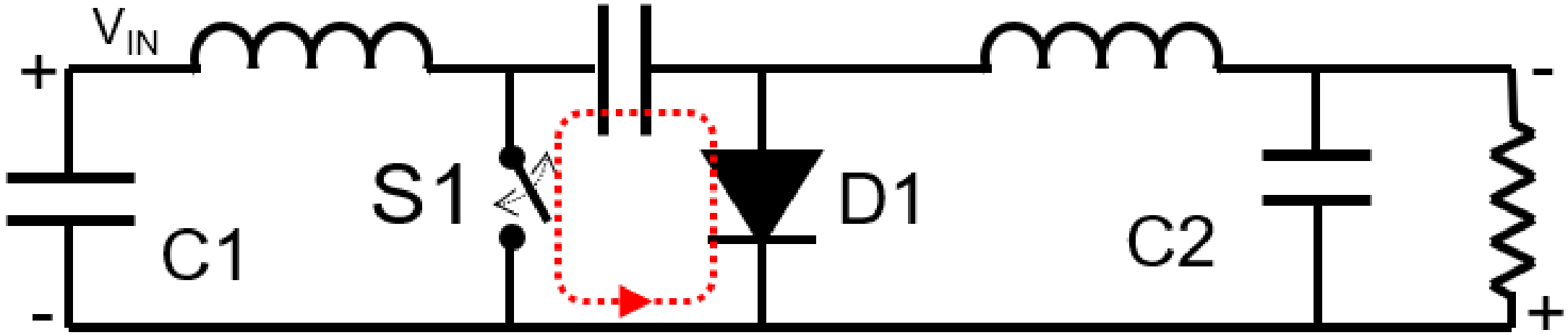



10V to 40V Input, –12V Output Inverting Converter

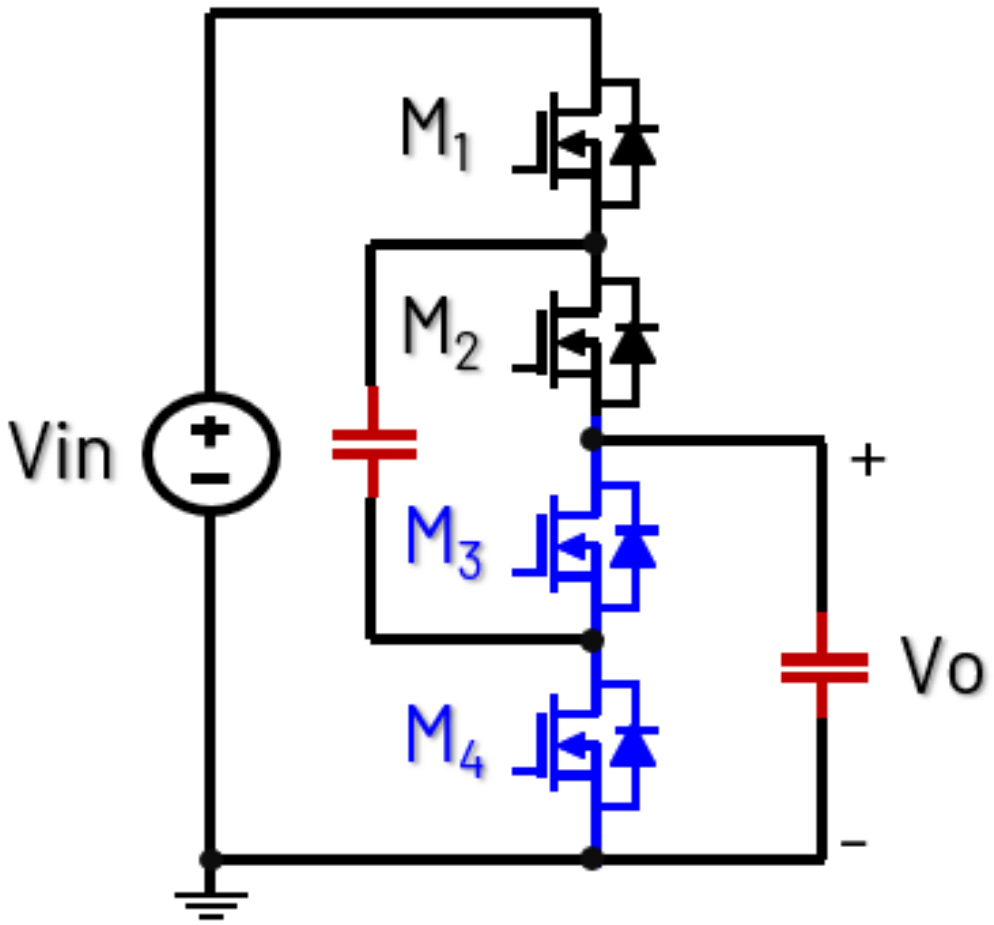


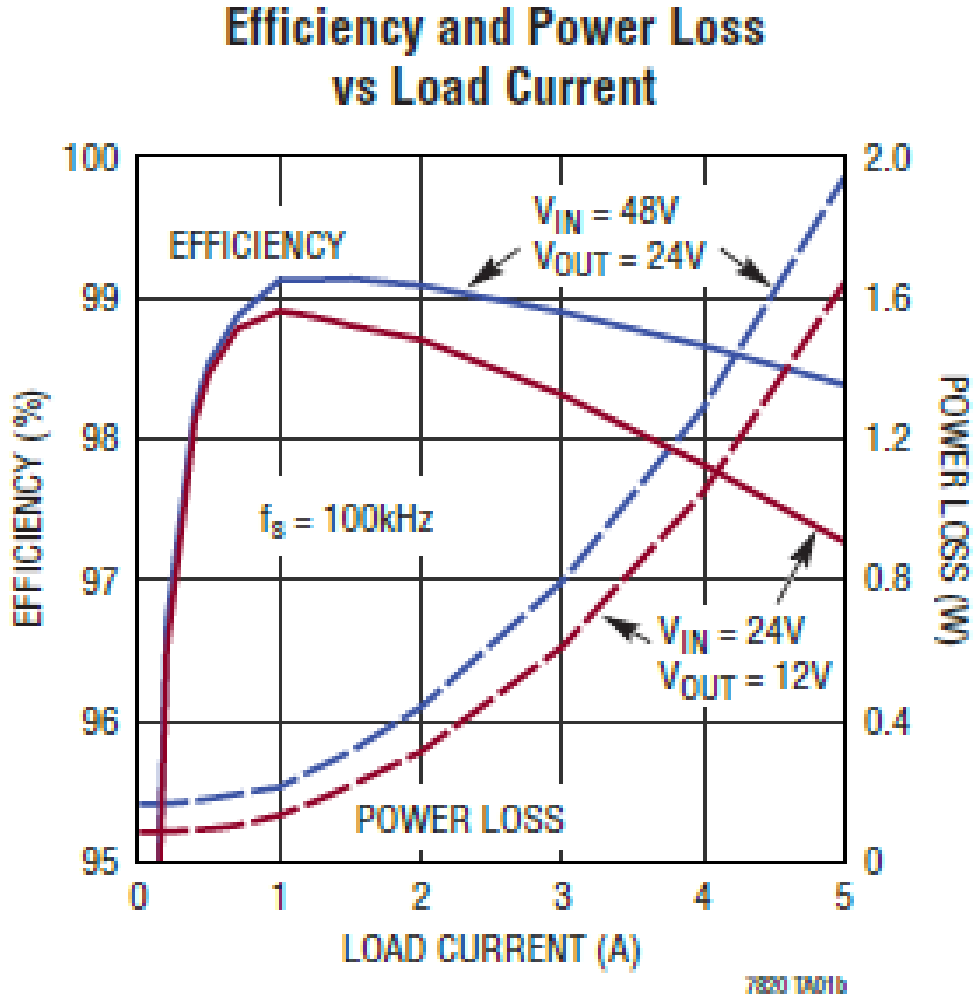
# Ćuk Topology Hot Loop

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



# Charge Pump (High Power)



# Hybrid Converter

Low FET voltage stress (Vin/2)

Low switching loss

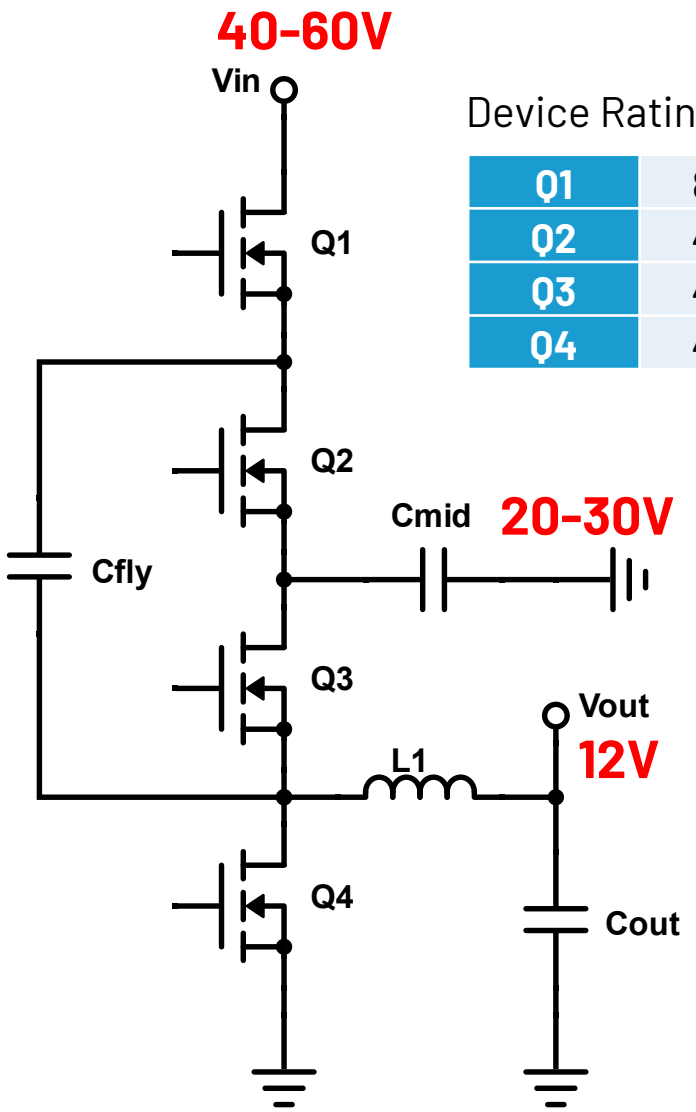
High switching frequency

Small inductor

Vo = ½Vin*D, tightly regulated

Current Mode control

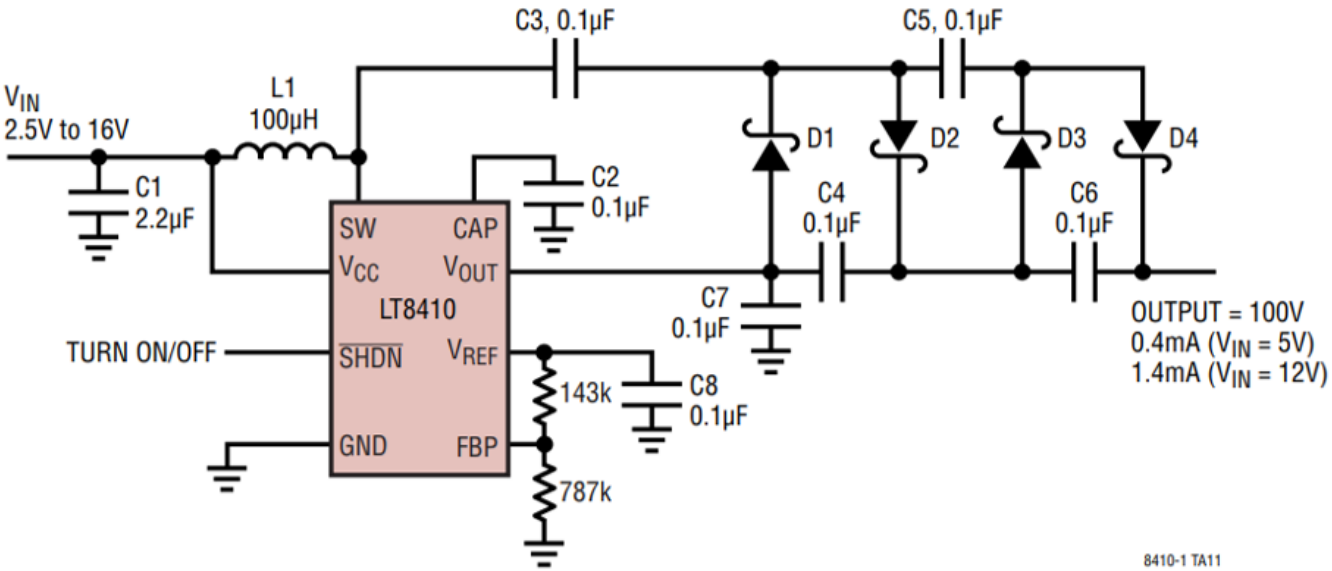
Current Sharing (Scalable)



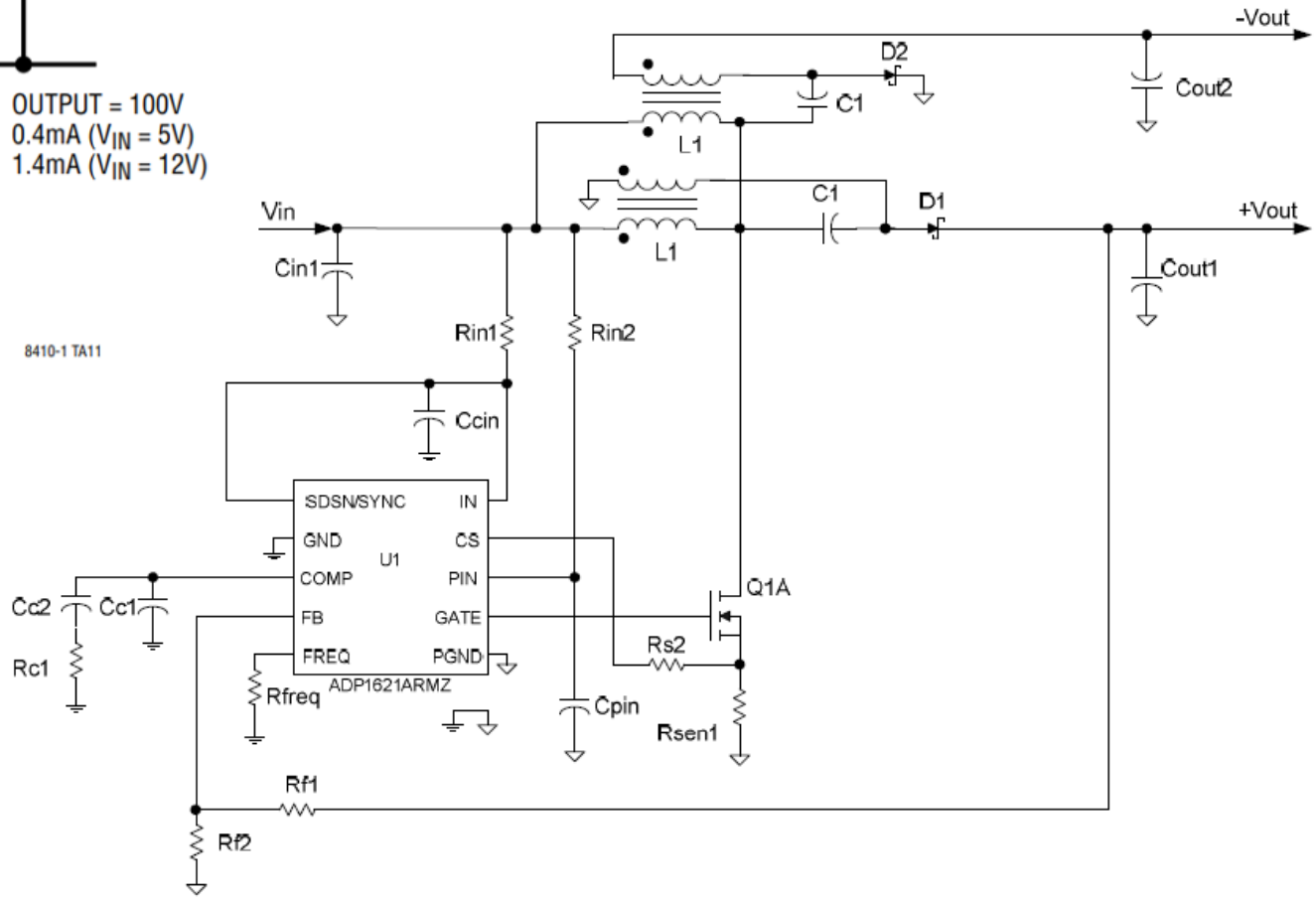

Device Rating:

| | |
|---|---|
| Q1 | 80V |
| Q2 | 40V |
| Q3 | 40V |
| Q4 | 40V |

# Other combined Topologies (Cascaded)

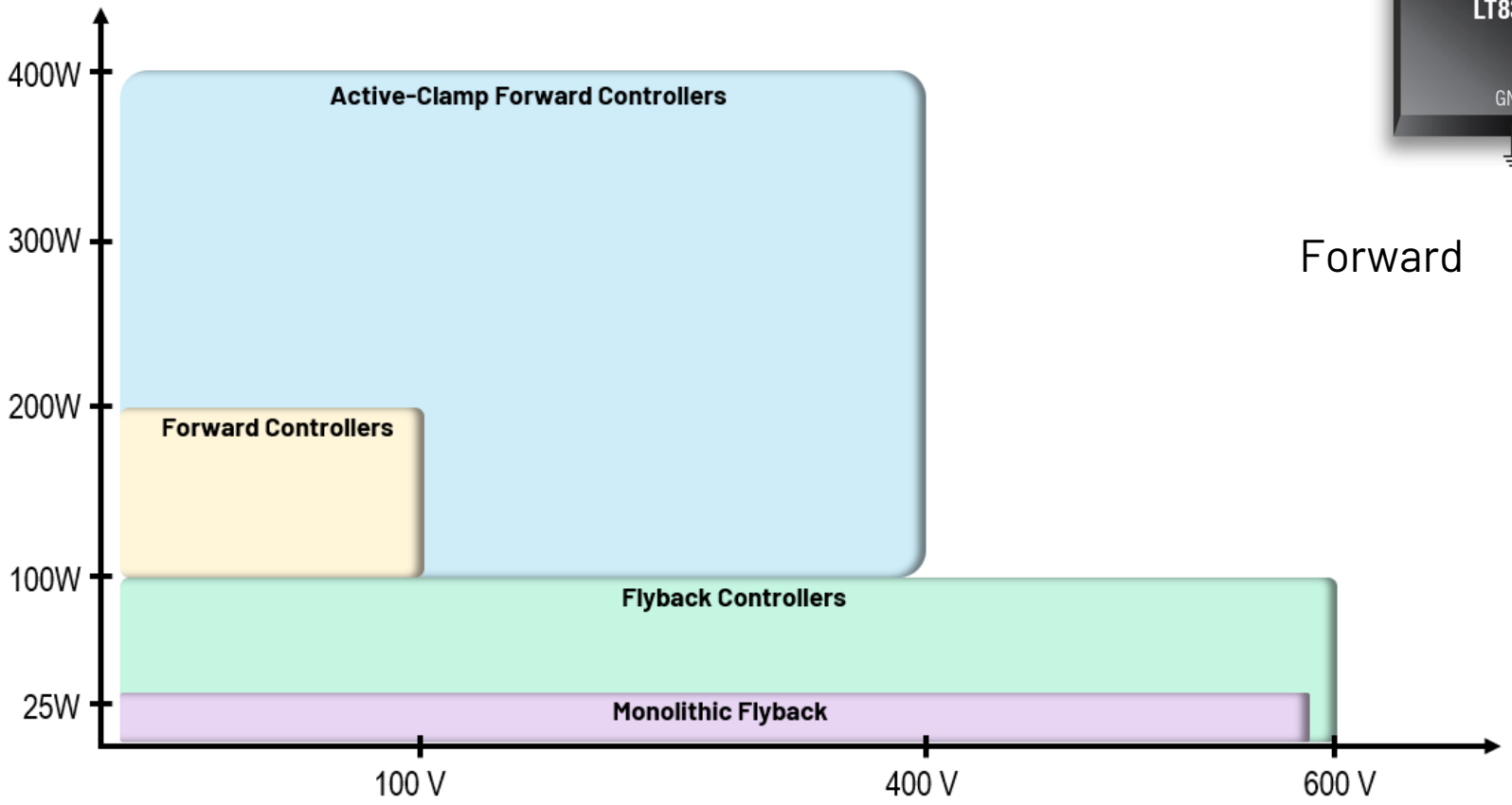



Boost and Charge Pump (voltage doublers)

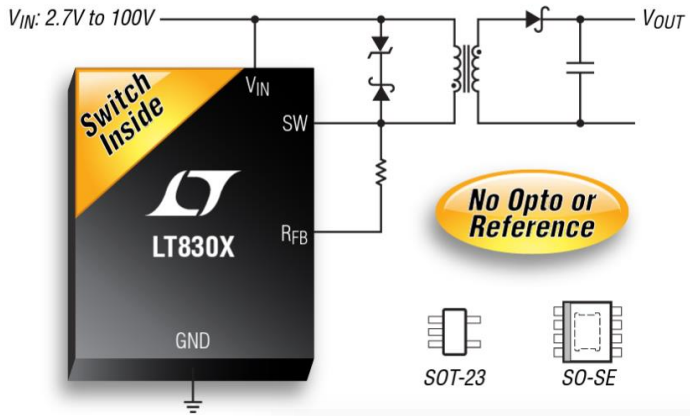



Coupled SEPIC - CUK

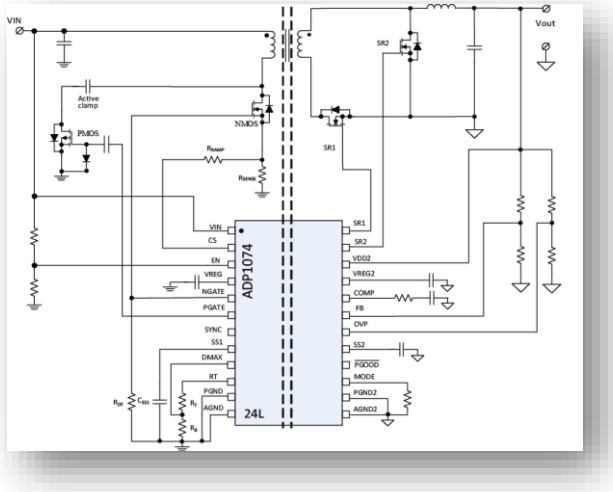
# Isolated Topologies



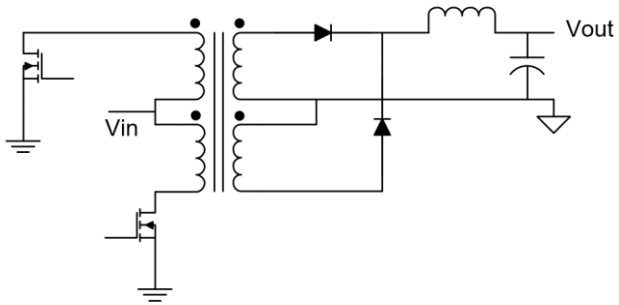

Flyback




Forward




Push-Pull



# AHEAD OF WHAT'S POSSIBLE

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