

EE-464 STATIC POWER CONVERSION-II

DC/DC Converters Continued

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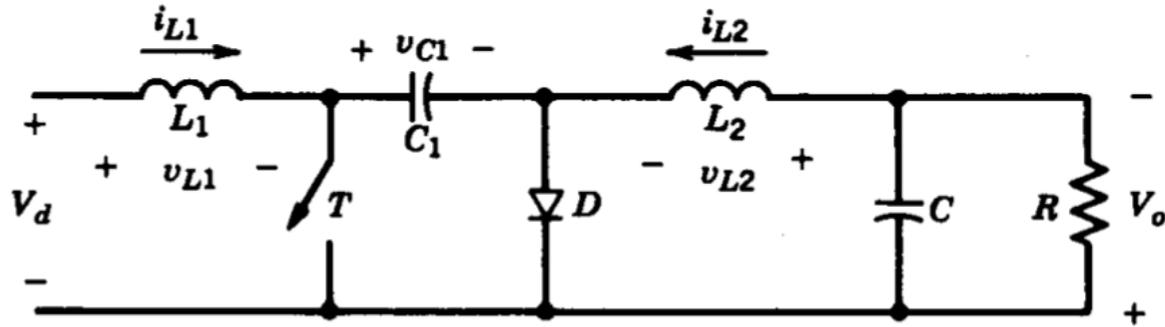




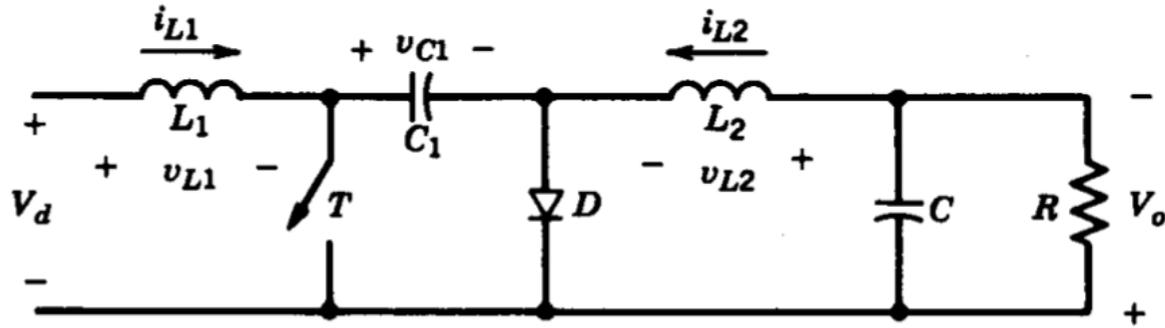
Slobodan Ćuk

[Linked-in profile](#)

Cuk converter

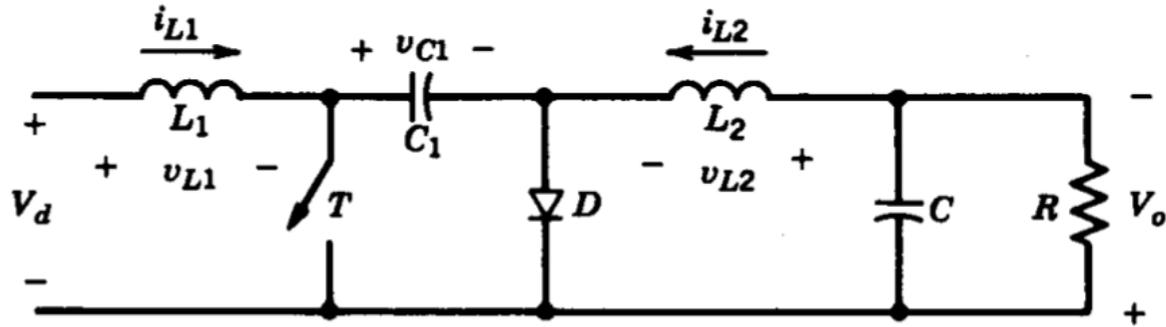


Cuk converter



Supplies a negative voltage

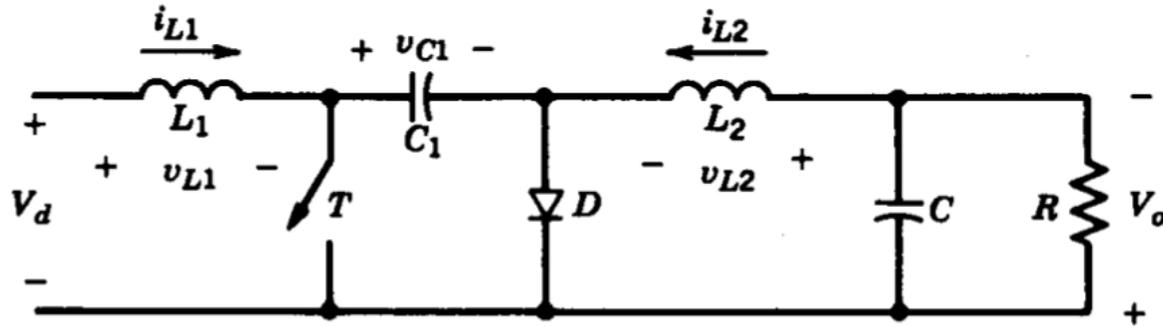
Cuk converter



Supplies a negative voltage

Reduced EMI and bi-directional power flow

Cuk converter

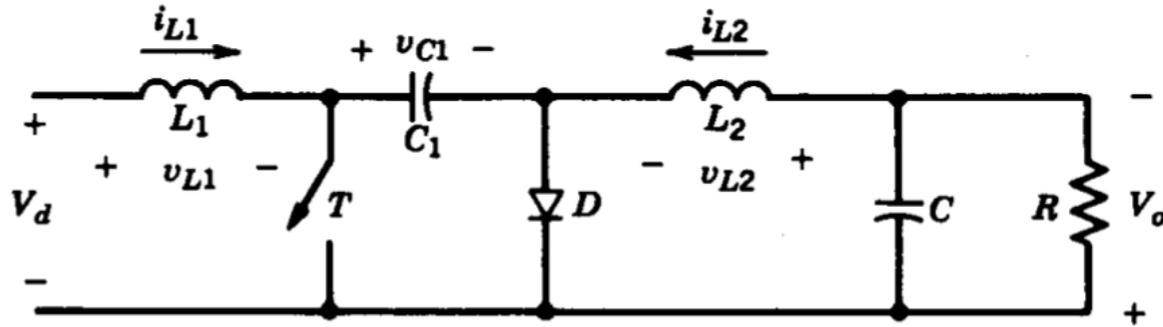


Supplies a negative voltage

Reduced EMI and bi-directional power flow

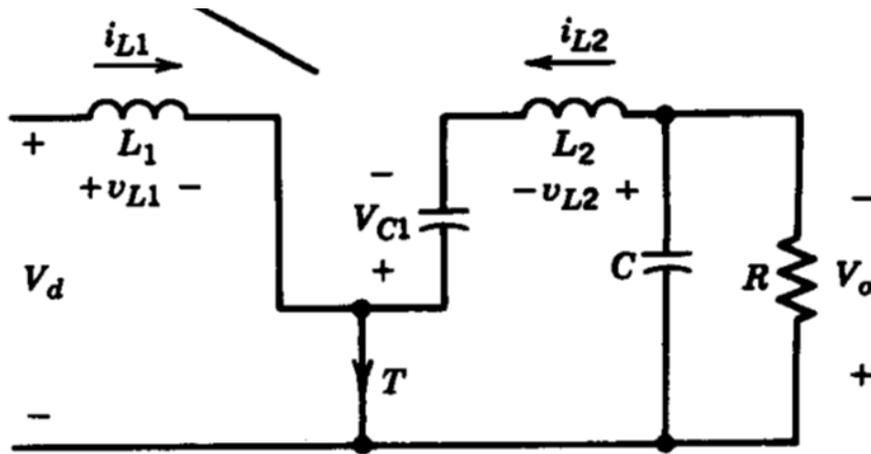
C_1 is the primary energy storage element (should be large)

Cuk converter

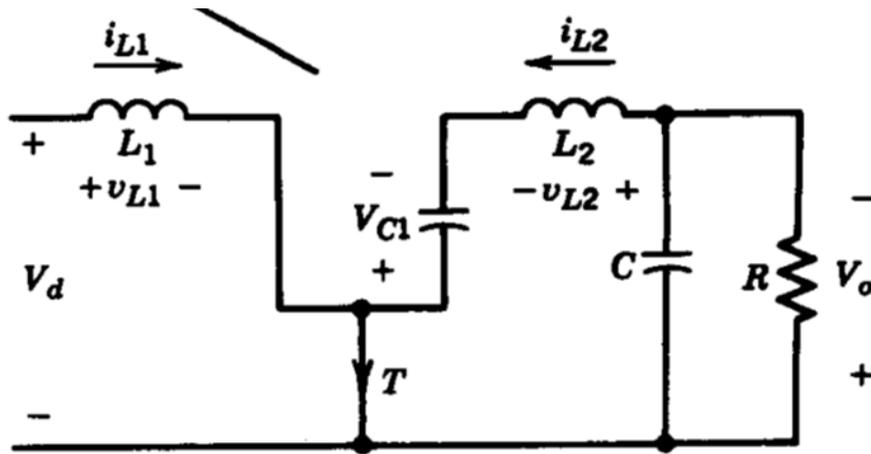


Can you plot the on & off states?

ON State

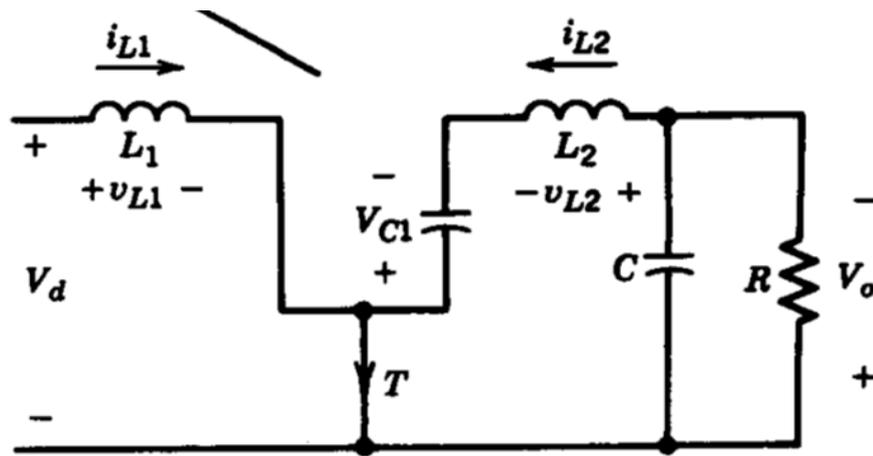


ON State



Diode off (reverse biased by C_1)

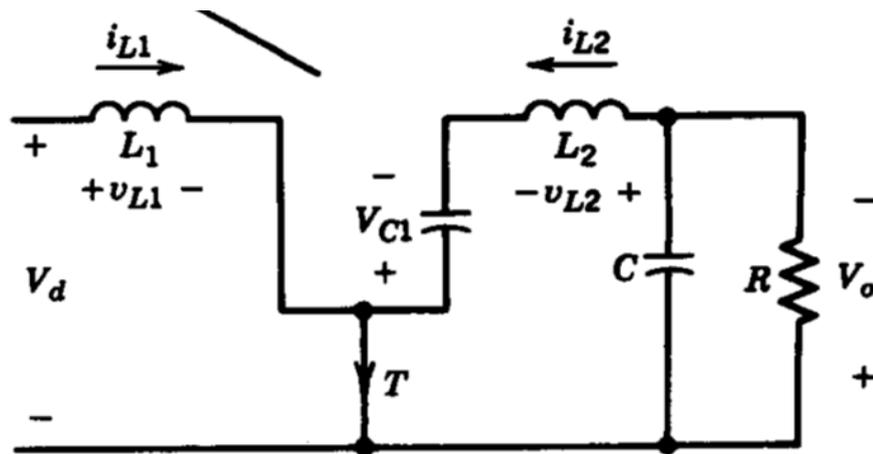
ON State



Diode off (reverse biased by C_1)

i_{L1} and i_{L2} passes through T_1

ON State

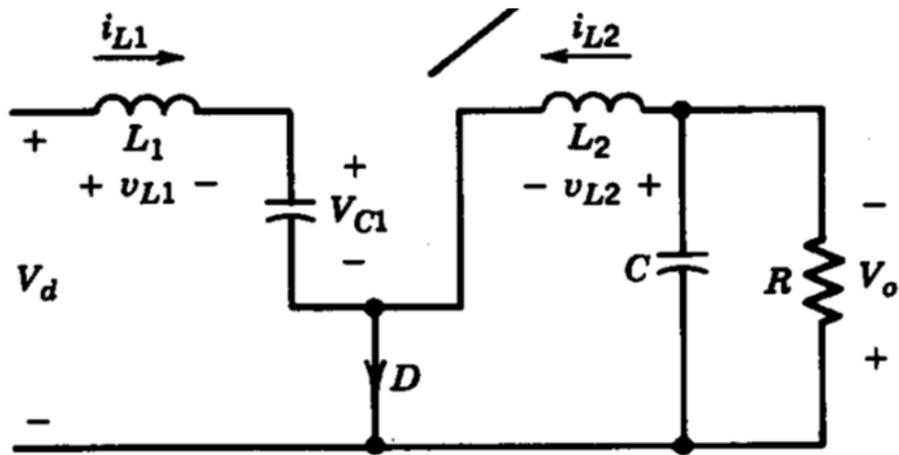


Diode off (reverse biased by C_1)

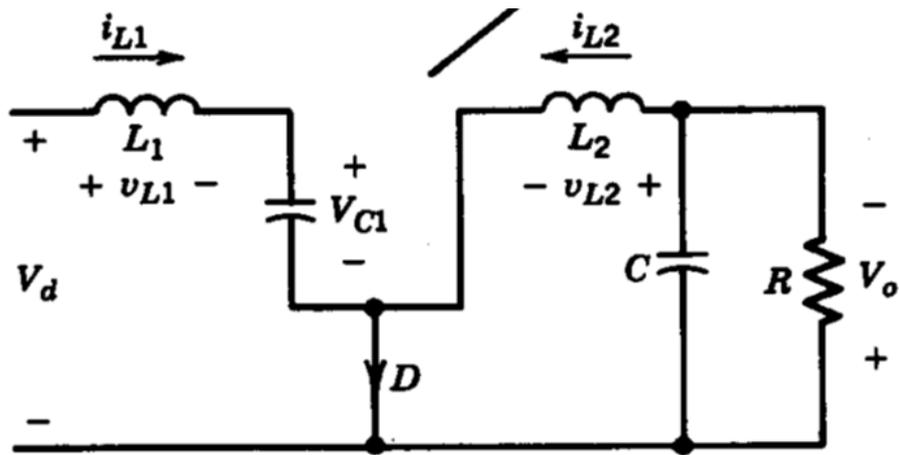
i_{L1} and i_{L2} passes through T_1

C_1 discharges through T_1 ($V_{C1} > V_o$)

OFF State

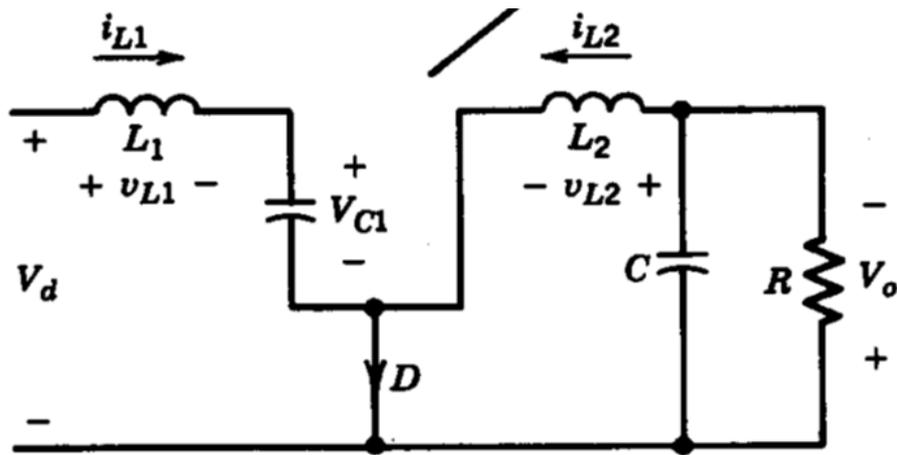


OFF State



Diode on

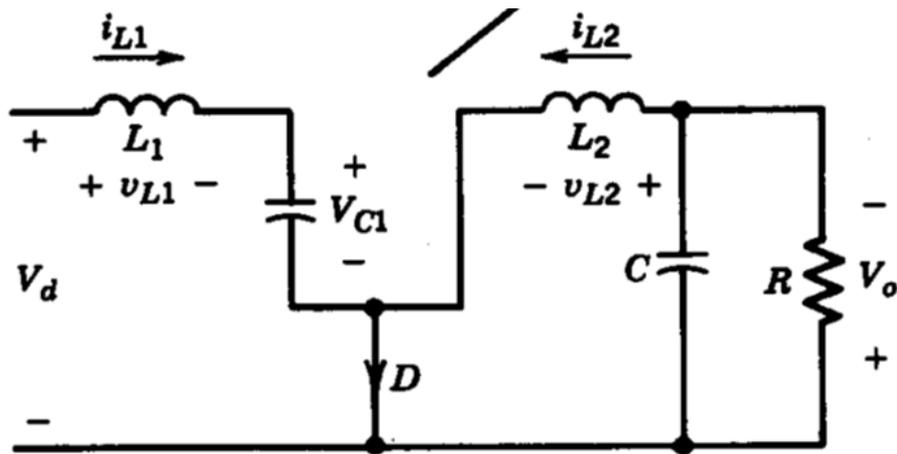
OFF State



Diode on

i_{L1} decreases ($V_{C1} > V_d$)

OFF State

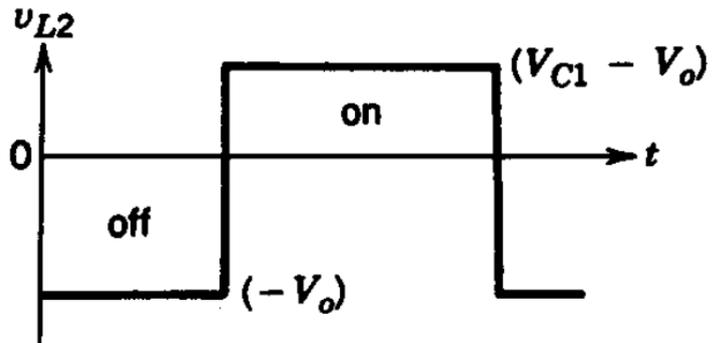
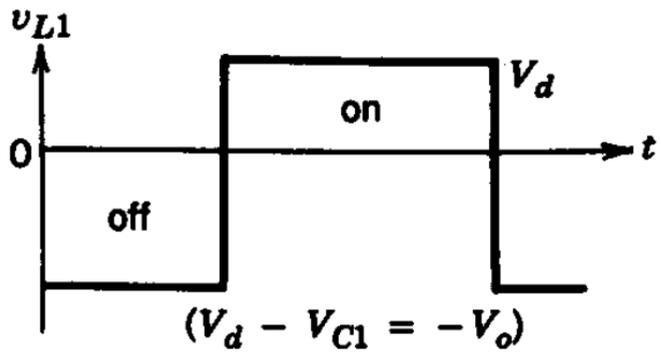


Diode on

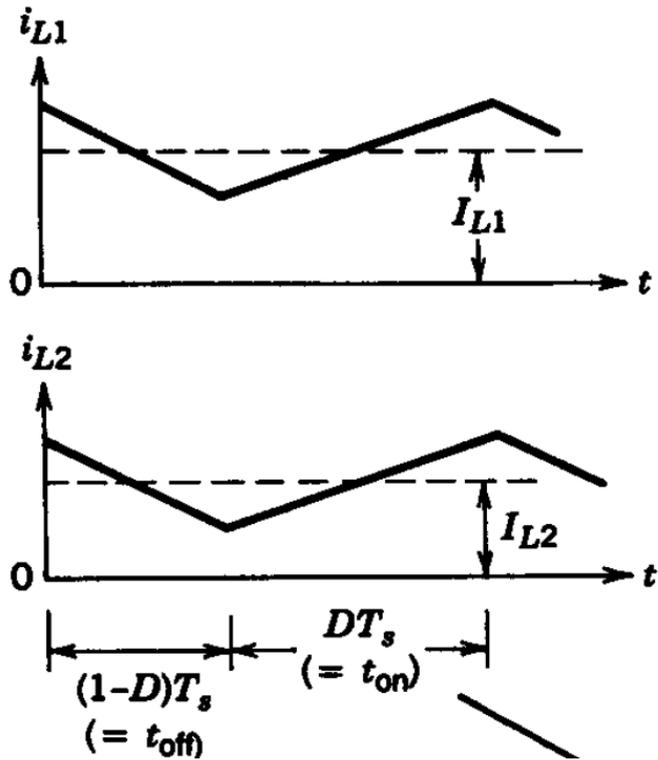
i_{L1} decreases ($V_{C1} > V_d$)

C charges through D (from input and L_1)

Operating States



Operating States

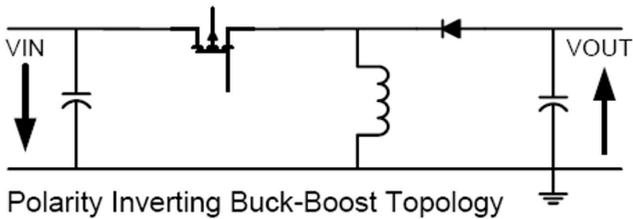
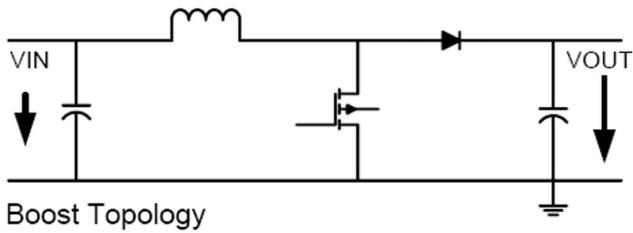
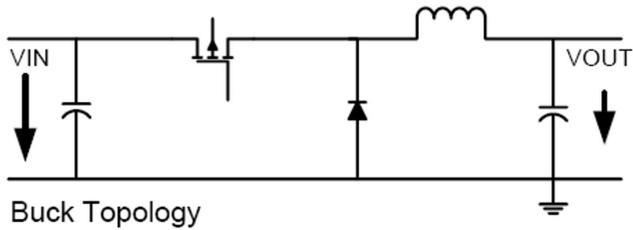


Cuk converter

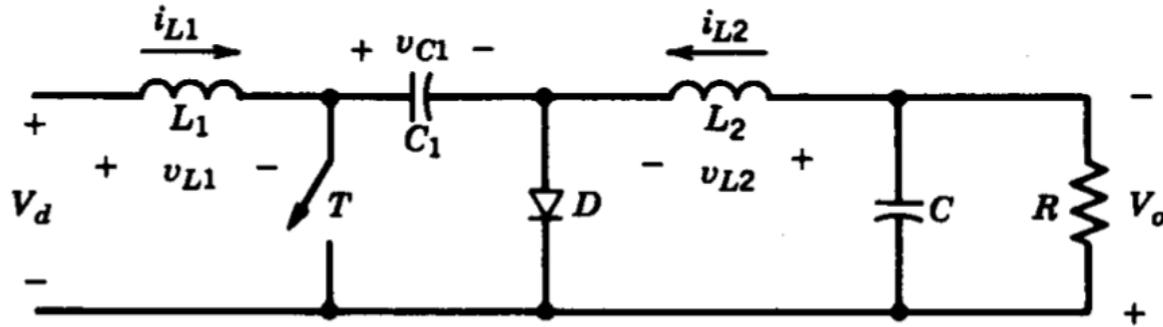
$$V_o = \frac{D}{(1 - D)} V_d$$

It is a buck-boost converter!

Input/Output Ripple?



Cuk converter



Double ended: Inductors placed at both the input and the output

Cuk converter

Advantages:

- Both input and output currents are ripple free (fed through inductors)

Cuk converter

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- Lower filtering requirements

Cuk converter

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- Both input and output currents are ripple free (fed through inductors)
- Lower filtering requirements
- Constant source current

Cuk converter

Disadvantages:

Cuk converter

Disadvantages:

- Capacitor(C_1) is quite bulky

Cuk converter

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- Capacitor (C_1) should have a large ripple current rating

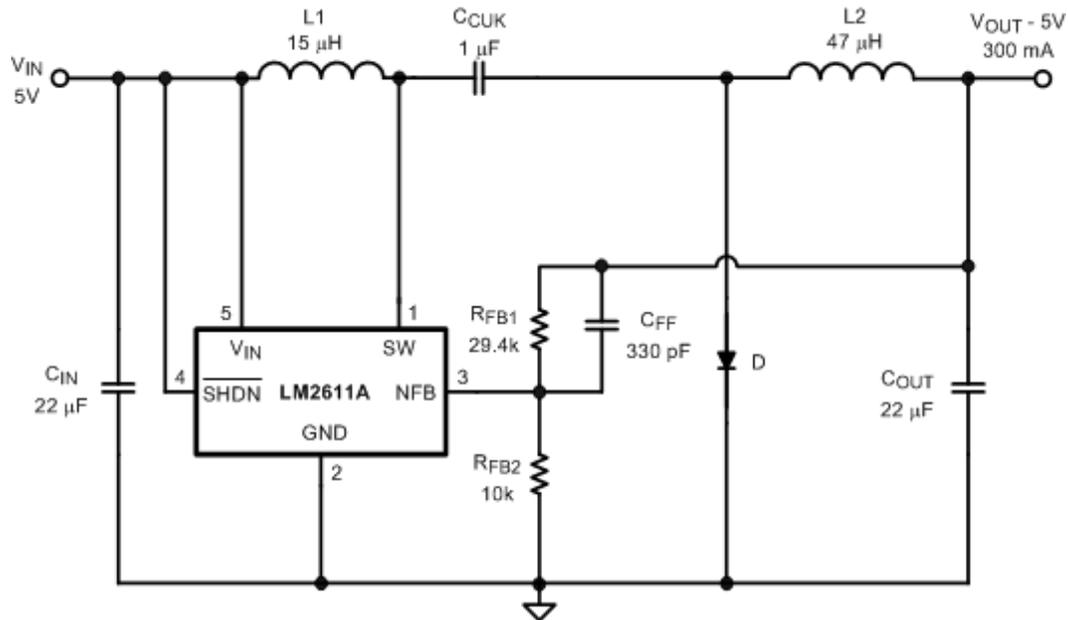
Ćuk converter

Disadvantages:

- Capacitor (C_1) is quite bulky
- Capacitor (C_1) should have a large ripple current rating
- Complex circuit

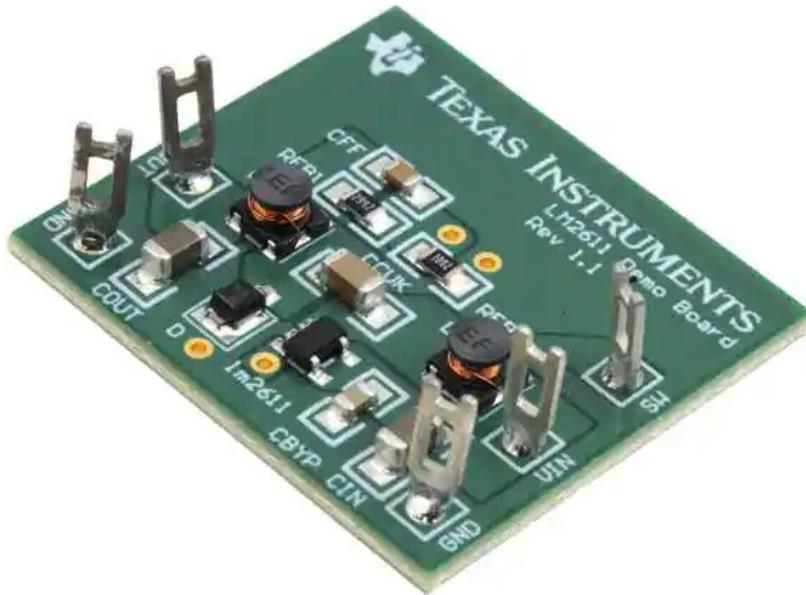
For curious students: [Power Electronics Manifesto](#) by Slobodan Ćuk

Practical Product: [LM2611](#)



C_{IN} : TAIYO YUDEN X5R JMK325BJ226MM
 C_{cuk} : TAIYO YUDEN X5R EMK316BJ105MF
 C_{OUT} : TAIYO YUDEN X5R JMK325BJ226MM
D: ON SEMICONDUCTOR MBR0520
L1: SUMIDA CR32-150
L2: SUMIDA CR32-470

Practical Product: [LM2611](#)



Example

Mohan Exercise 7-3

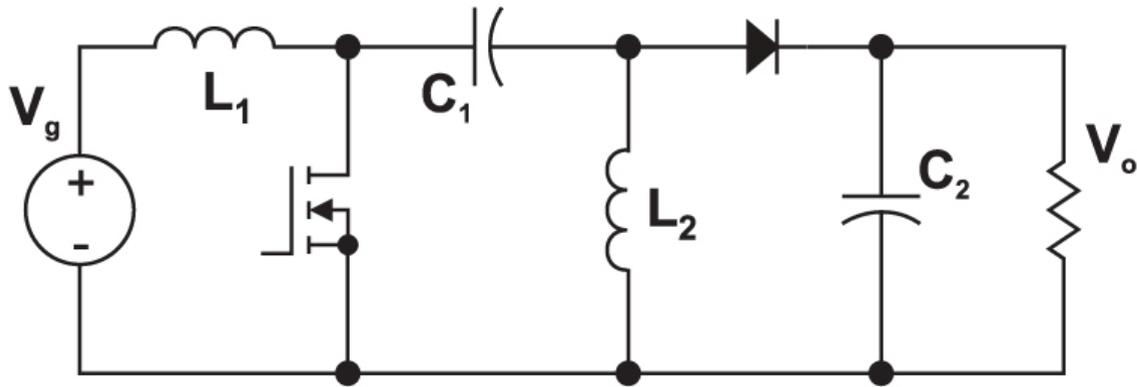
SEPIC Converter

SEPIC Converter

Single Ended Primary Inductor Converter

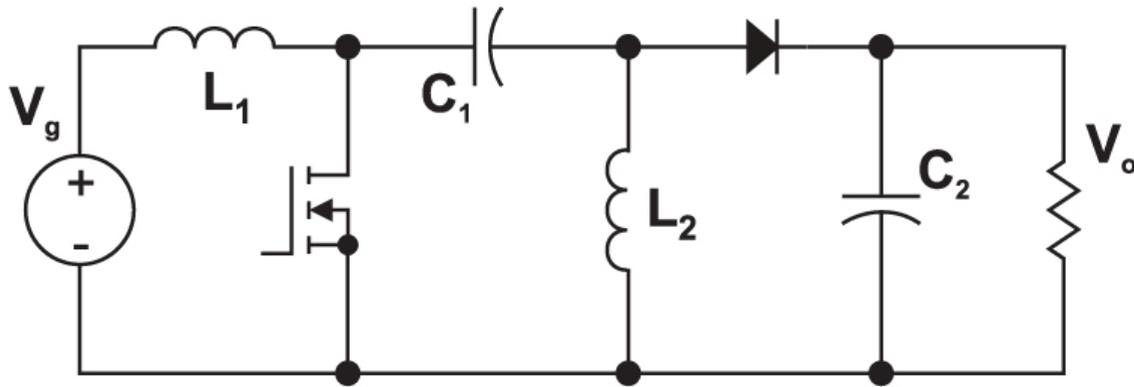
SEPIC Converter

Single Ended Primary Inductor Converter



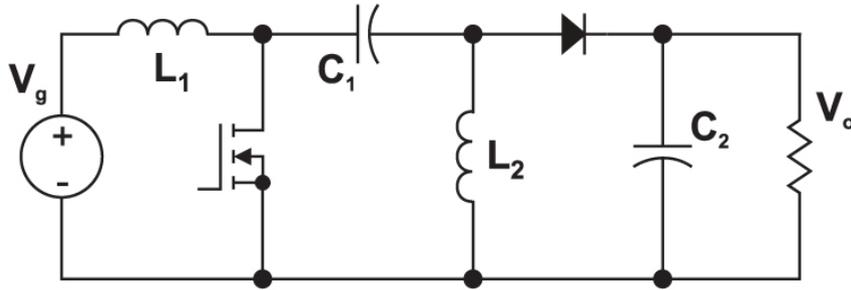
SEPIC Converter

Single Ended Primary Inductor Converter



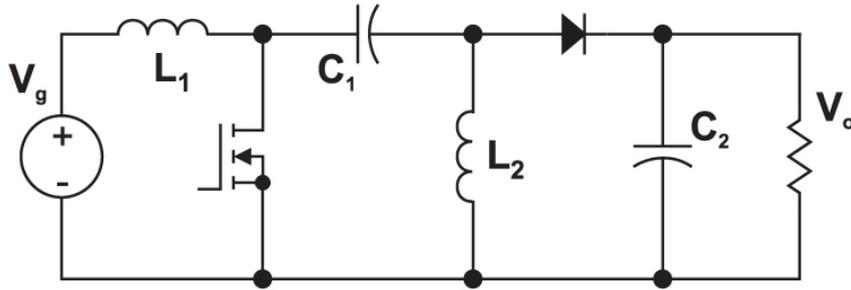
Essentially a boost converter cascaded with a buck-boost converter

SEPIC Converter



Popular in battery powered systems (voltage level can be adjusted according to charge level)

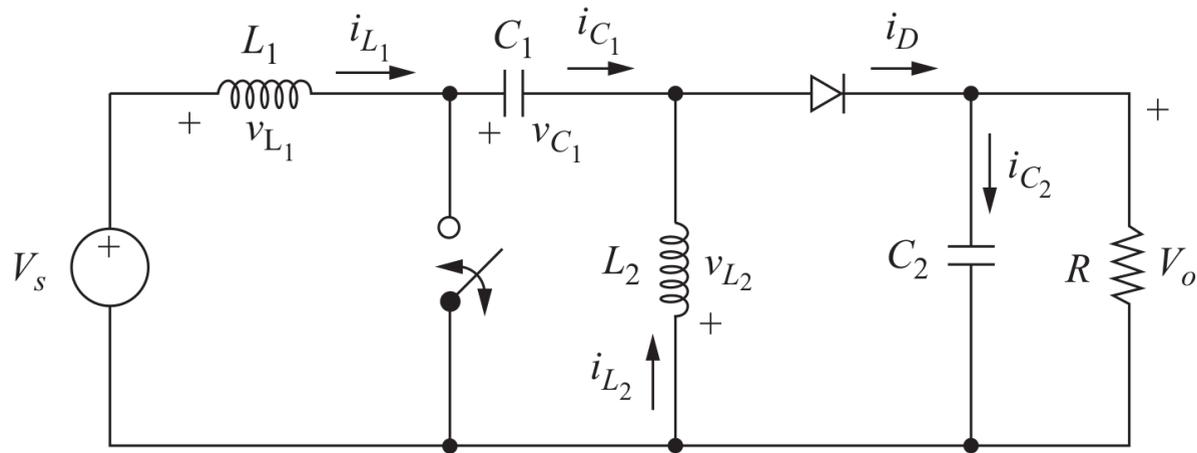
SEPIC Converter



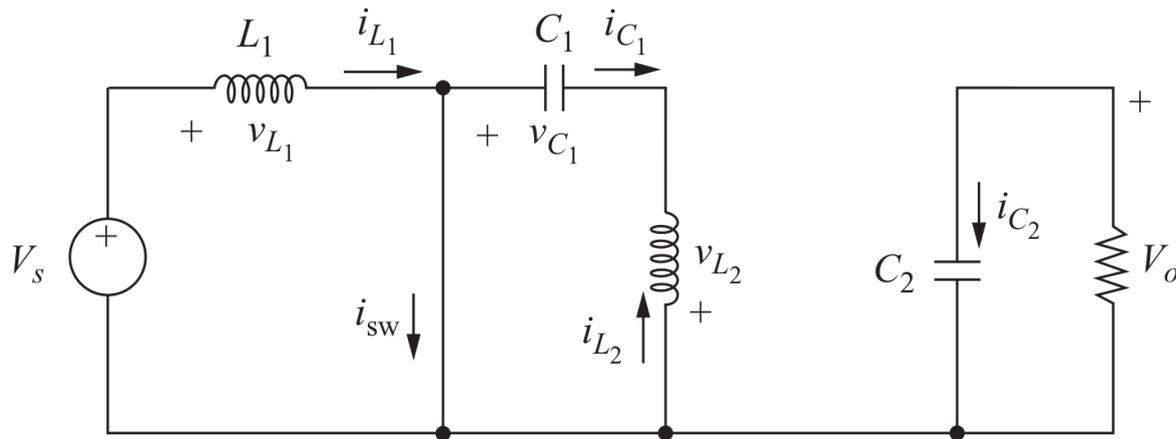
Popular in battery powered systems (voltage level can be adjusted according to charge level)

Possible to shutdown completely (when the switch is off)

Operating Modes:

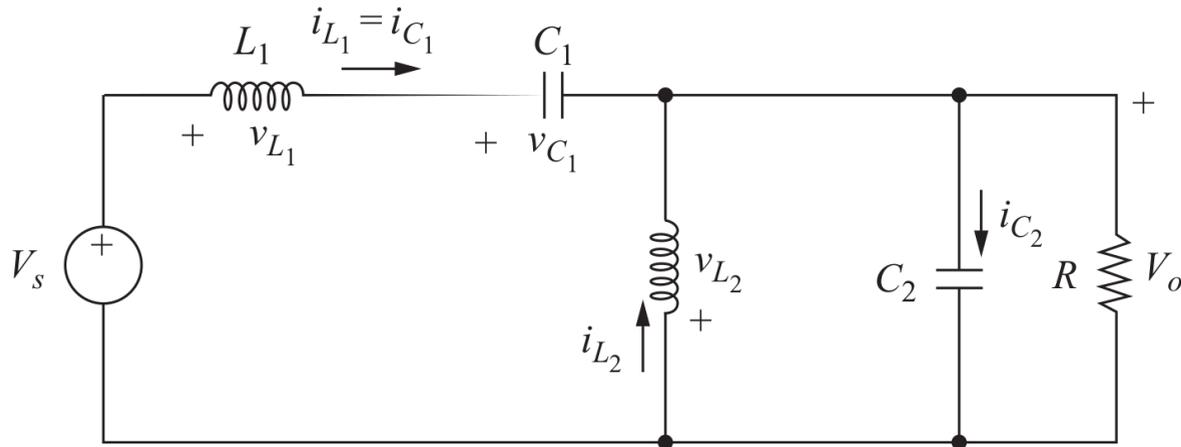


Operating Modes: ON State



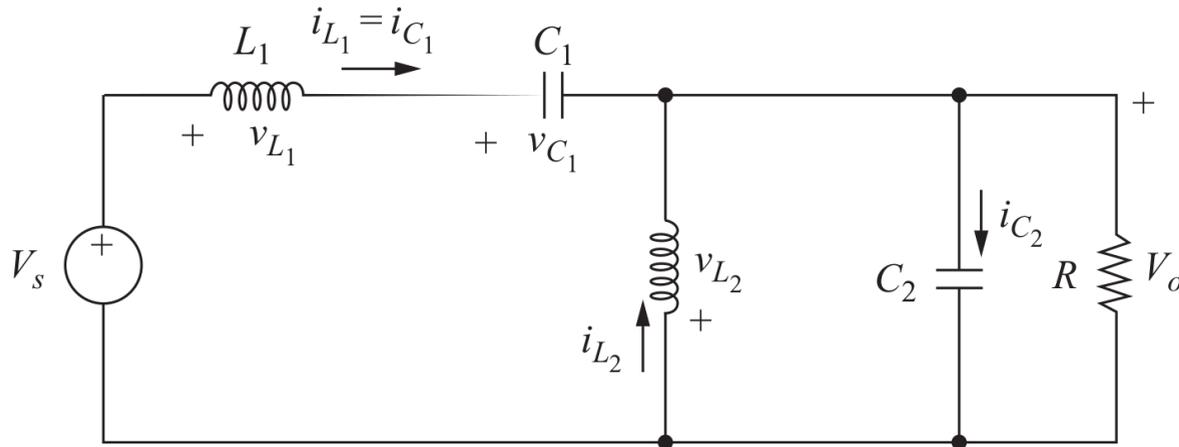
$$v_{L1} = V_s$$

Operating Modes: OFF State



$$-V_s + v_{L_1} + v_{C_1} + V_o = 0$$

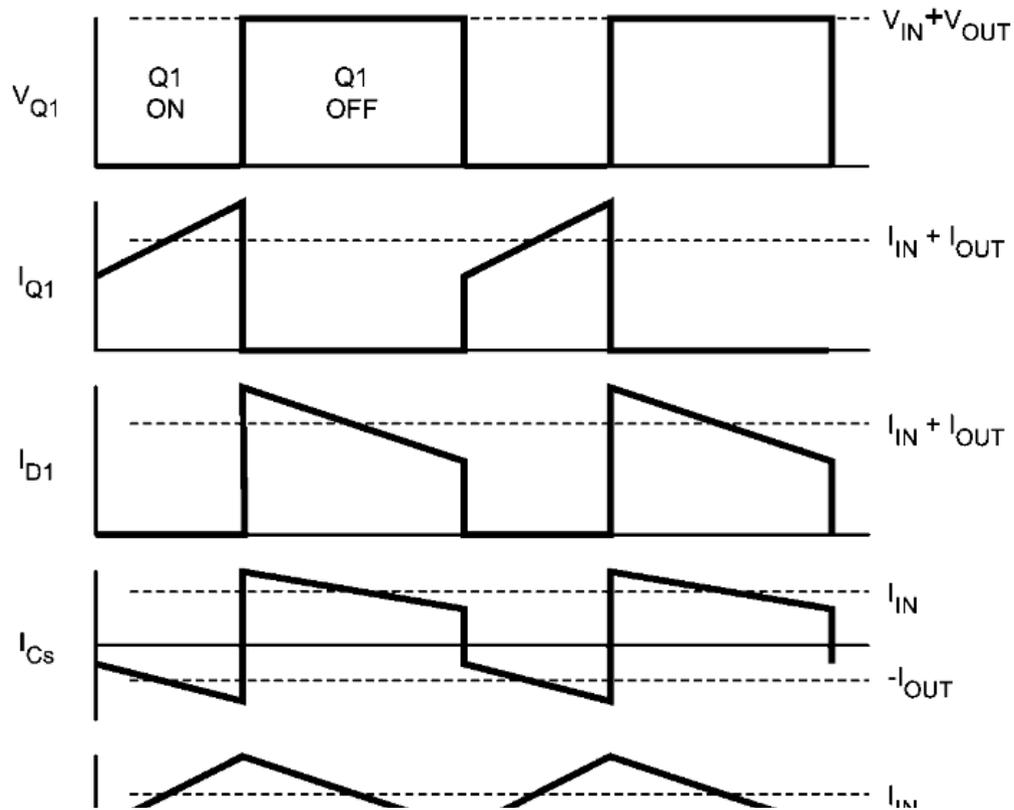
Operating Modes: OFF State



$$-V_s + v_{L1} + v_{C1} + V_o = 0$$

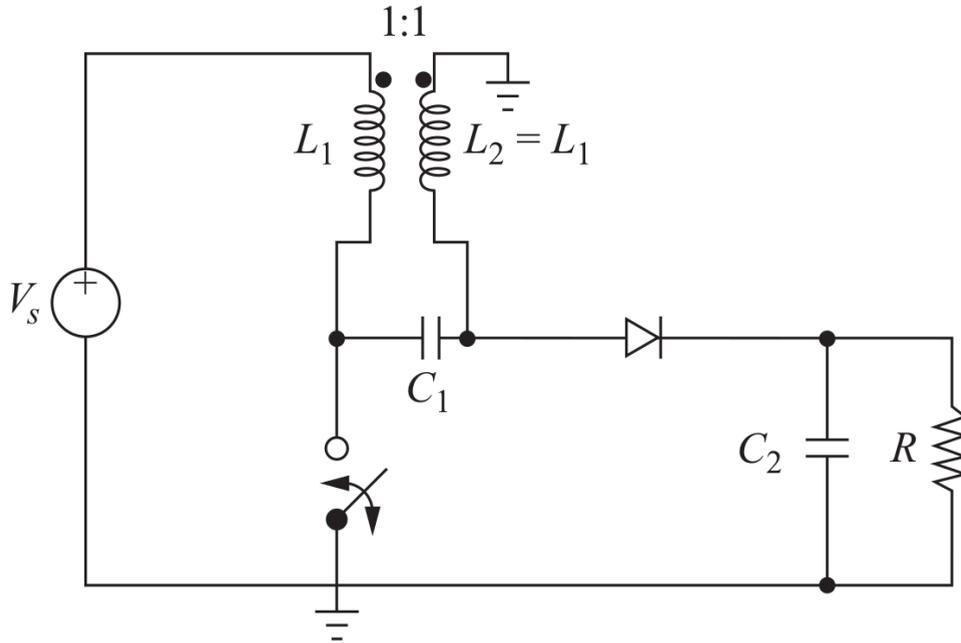
$$\text{If } v_{C1} = V_s \text{ then } v_{L1} = -V_o$$

Operating Modes: Currents



Example (Handout)

SEPIC With Mutually Coupled Inductors



SEPIC Converter

SEPIC Converter

Advantages:

- Non-inverting buck-boost converter

SEPIC Converter

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 - Energy Efficient (can be completely turned-off)
-

Disadvantages:

- Pulsating output current

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Disadvantages:

- Pulsating output current
- Large capacitance (and large ripple current rating)

SEPIC Converter

Advantages:

- Non-inverting buck-boost converter
 - Energy Efficient (can be completely turned-off)
-

Disadvantages:

- Pulsating output current
- Large capacitance (and large ripple current rating)
- Fourth order transfer function, difficult to control

SEPIC Converter

SEPIC Converter

Inductors can be combined is a single core (coupled inductors)

Lower required inductance, and size

Minimize oscillation in the circuit (more on that later)

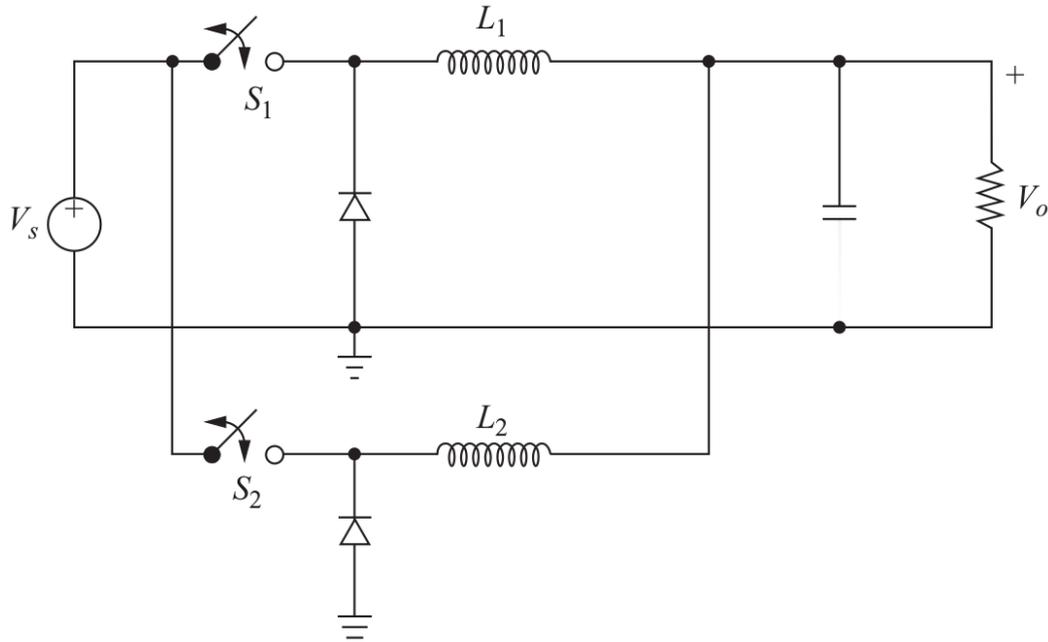
Interleaved Converters

Interleaved Converters

Interleaved Buck Converter

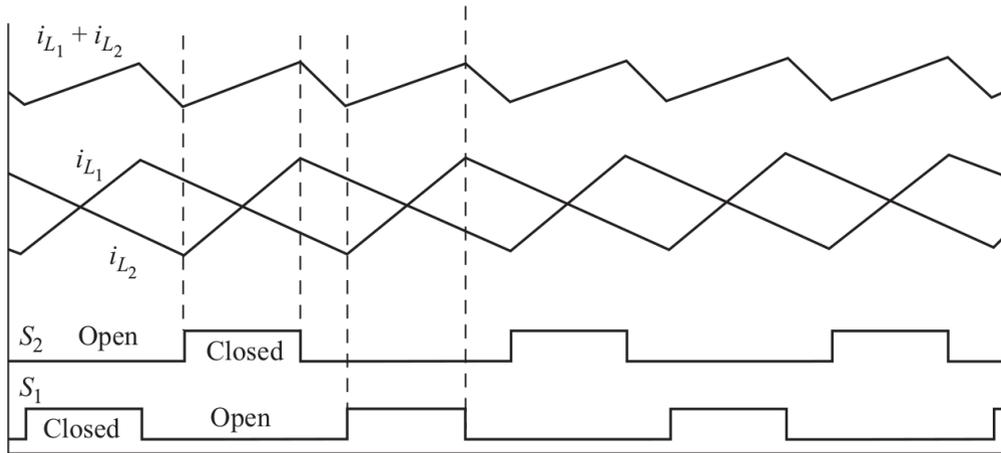
Interleaved Converters

Interleaved Buck Converter



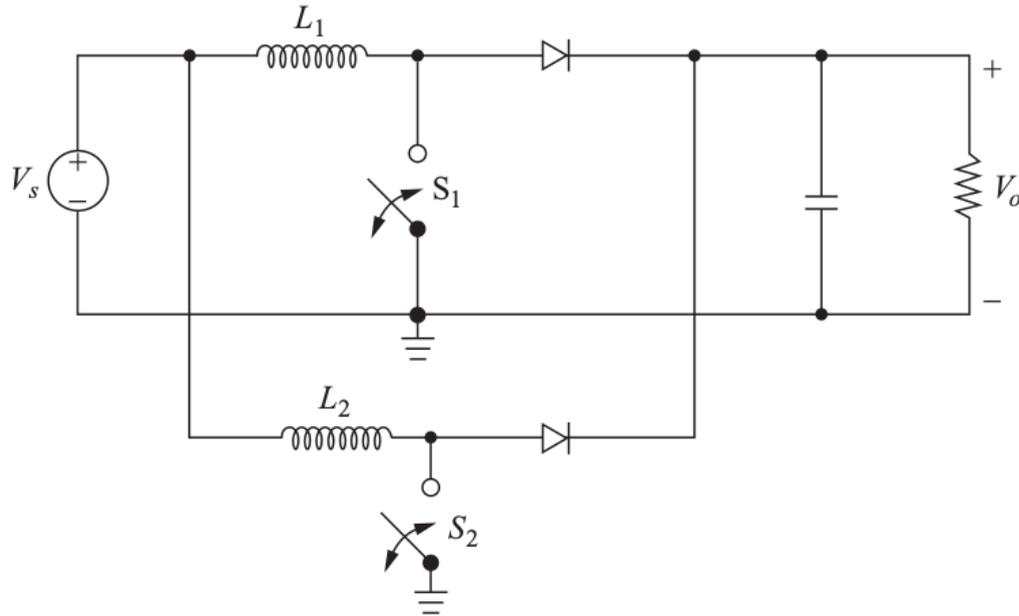
Interleaved Converters

Interleaved Buck Converter



Interleaved Converters

Interleaved Boost Converter



Reading Assignments

- [TI Training Videos](#)
- [MATLAB Topology Comparison](#)
- [Application Note: Designing A SEPIC Converter](#)
- [Sepic and Ćuk Converters](#)
- [Sepic Converter Basics](#)
- [Power supply topology: SEPIC vs Flyback](#)

You can download this presentation from:
keysan.me/ee464