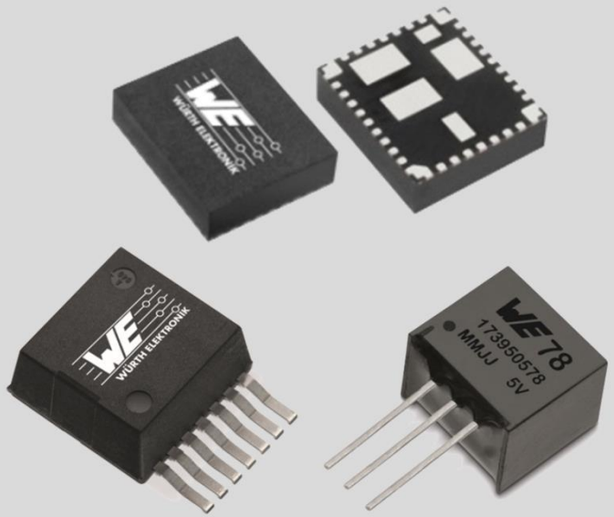
Negative Output Voltage with Inverting Buck-Boost



Roland Kratz

March, 6th 2018

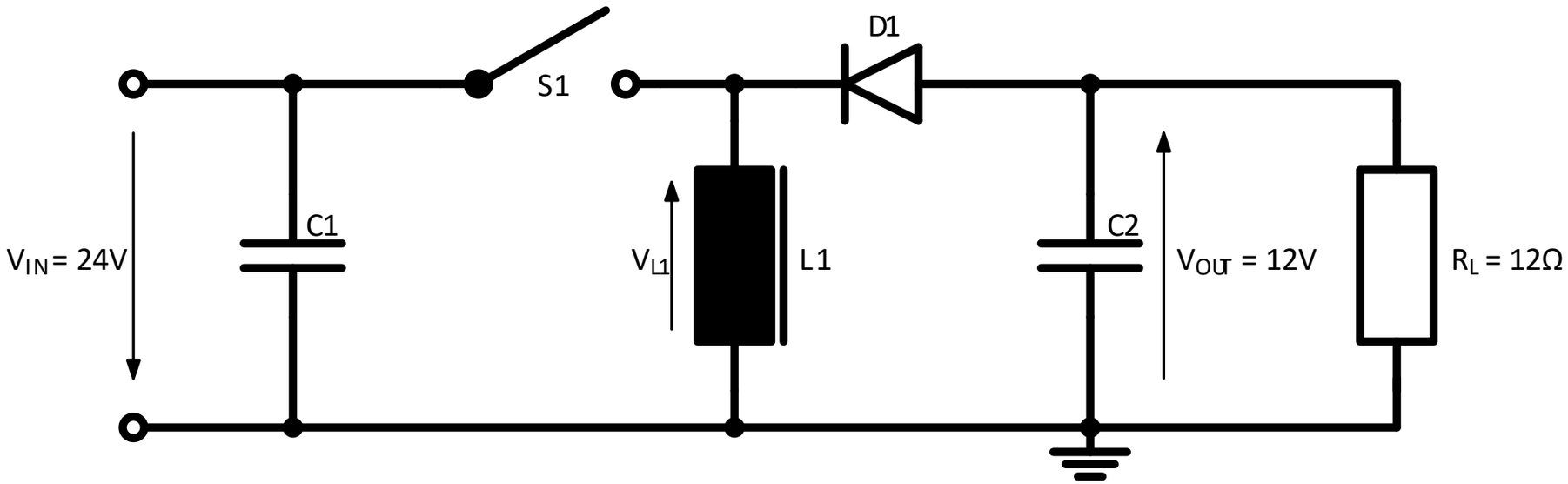
Negative Output Voltage with Inverting Buck-Boost

Agenda

- Typical Inverting Buck-Boost (Theory)
- Practical Inverting Buck-Boost
- Difference between Theory and Reality
- Buck Regulator as Inverting Buck-Boost

Negative Output Voltage with Inverting Buck-Boost

Typical Inverting Buck-Boost Schematic



Negative Output Voltage with Inverting Buck-Boost

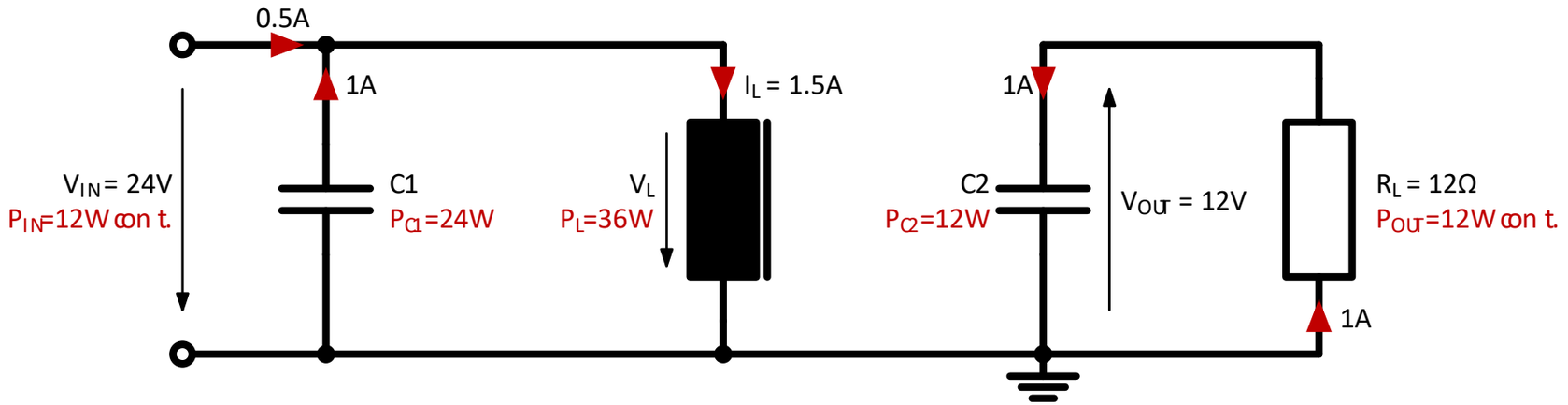
Duty Cycle of an Inverting Buck-Boost

$$Duty\ Cycle\ (D) = \frac{|V_{OUT}|}{(\ V_{IN} + |V_{OUT}|\ ) \cdot \eta} = \frac{12V}{(24V + 12V) \cdot 1} = 0{,}33$$

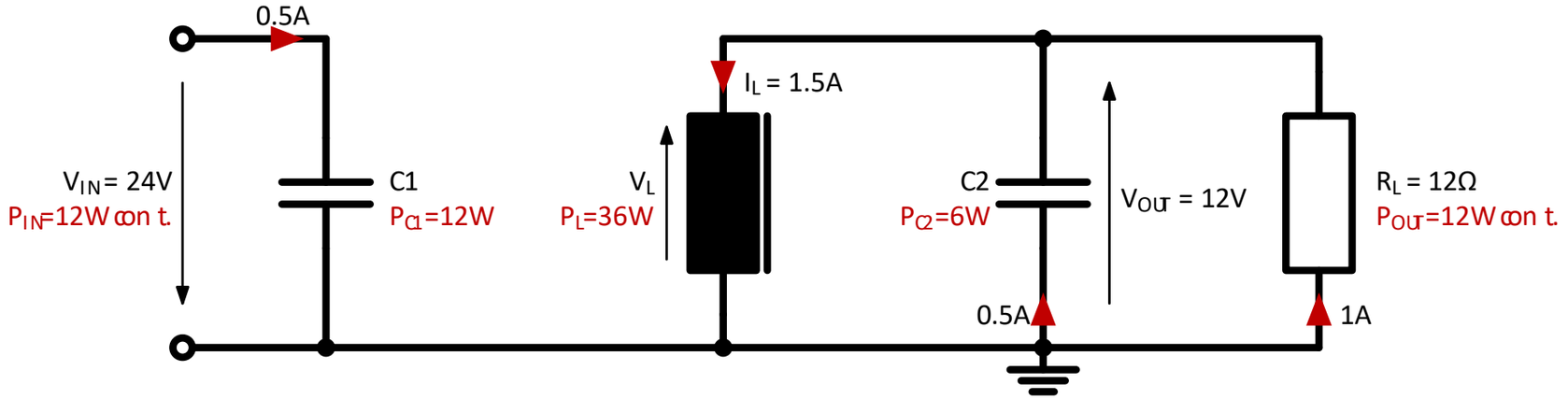
Negative Output Voltage with Inverting Buck-Boost

On and Off Phases of an Inverting Buck-Boost

ON-PHASE
0-33,3%



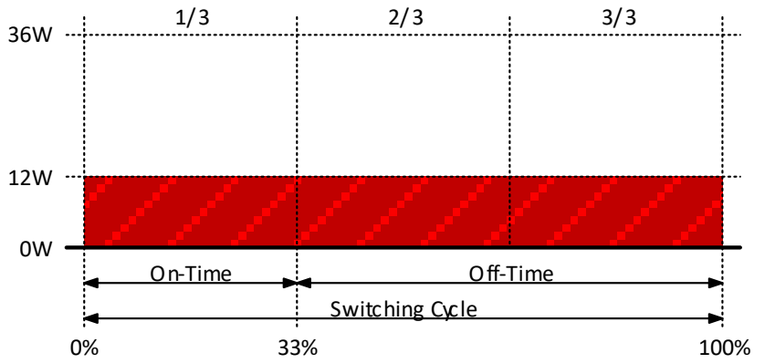
OFF-PHASE
33,3-100%



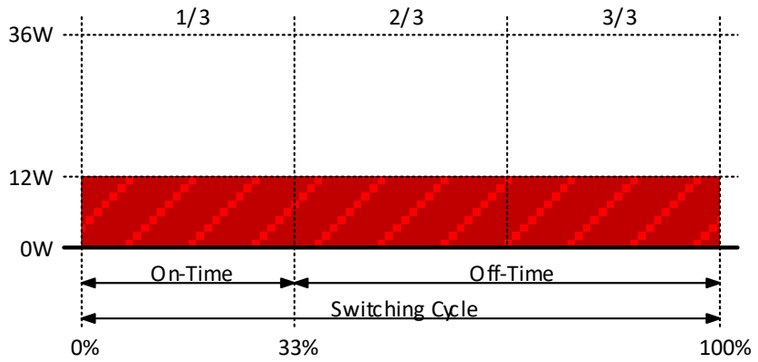
Negative Output Voltage with Inverting Buck-Boost

Energy Balance

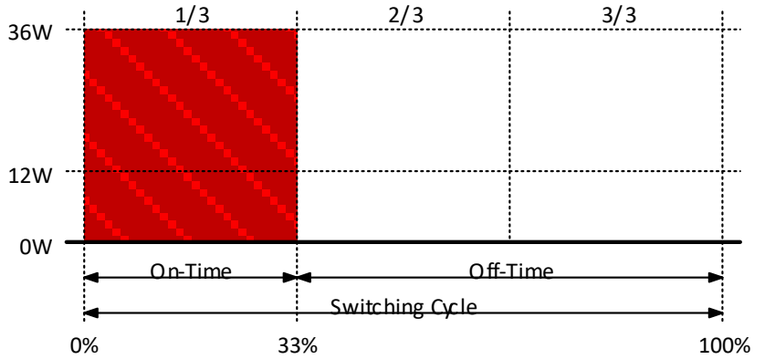
Input Power



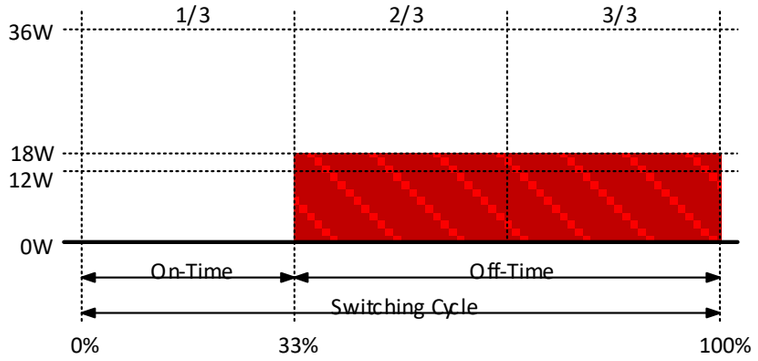
Output Power



Energy in L (On-Time)



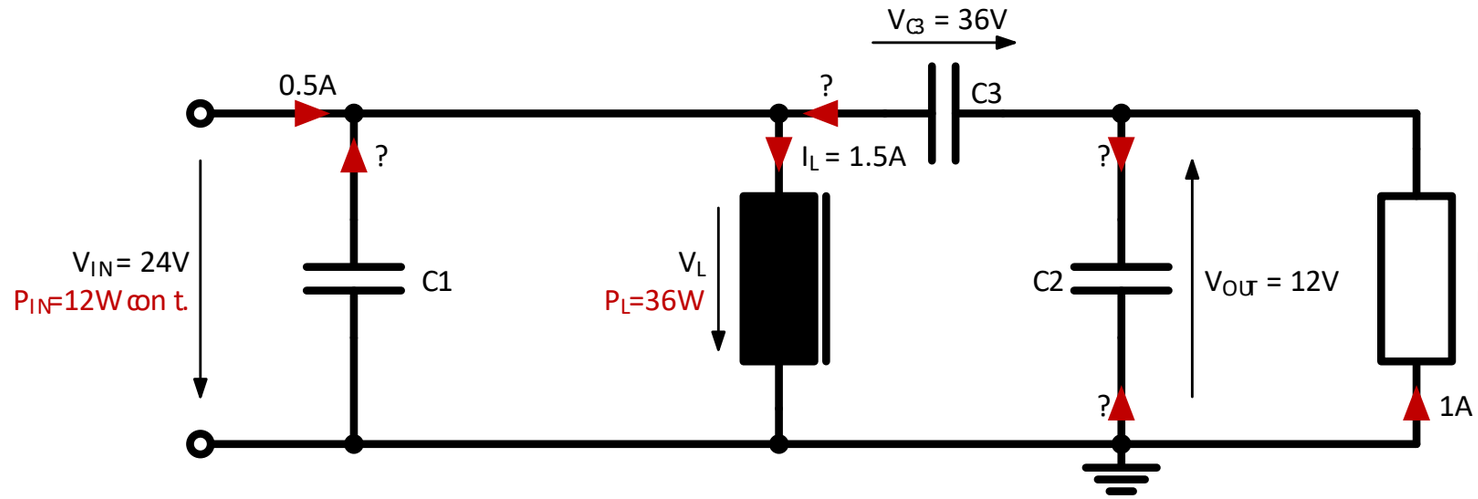
Energy in L (Off-Time)



Negative Output Voltage with Inverting Buck-Boost

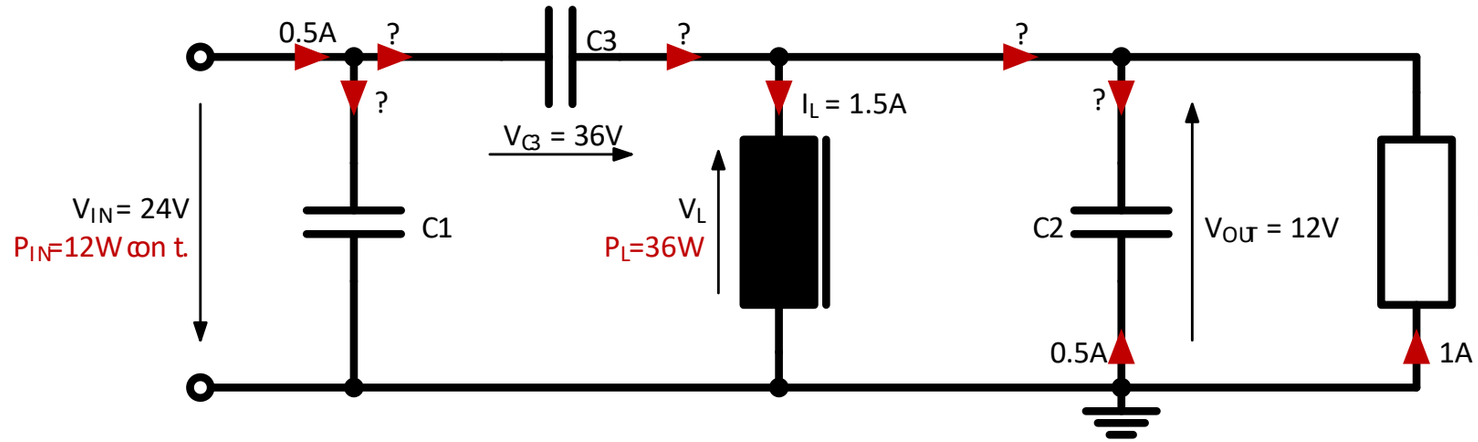
Real Inverting Buck-Boost

ON-PHASE
0-33,3%



I_{C3} charges L
I_{C3} charges C_2

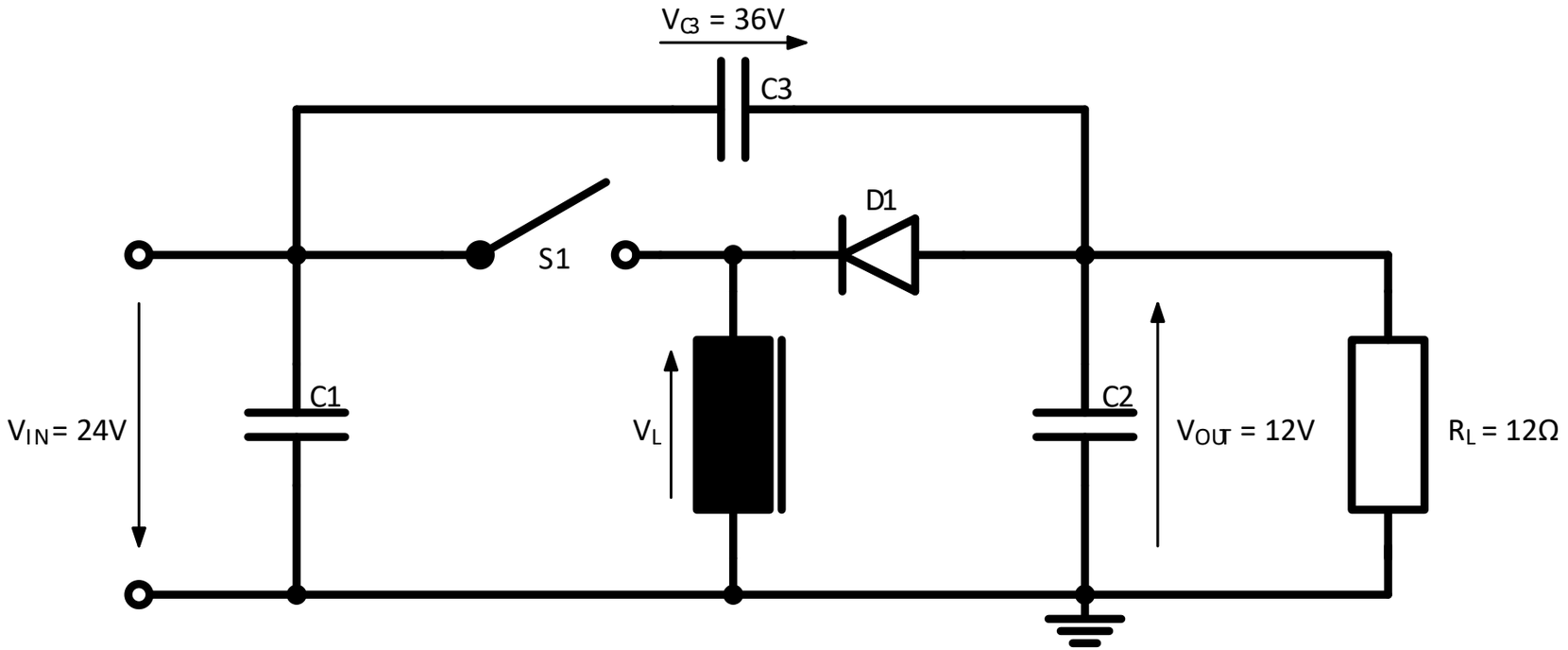
OFF-PHASE
33,3-100%



I_{C3} discharges L
I_{C3} discharges C_2

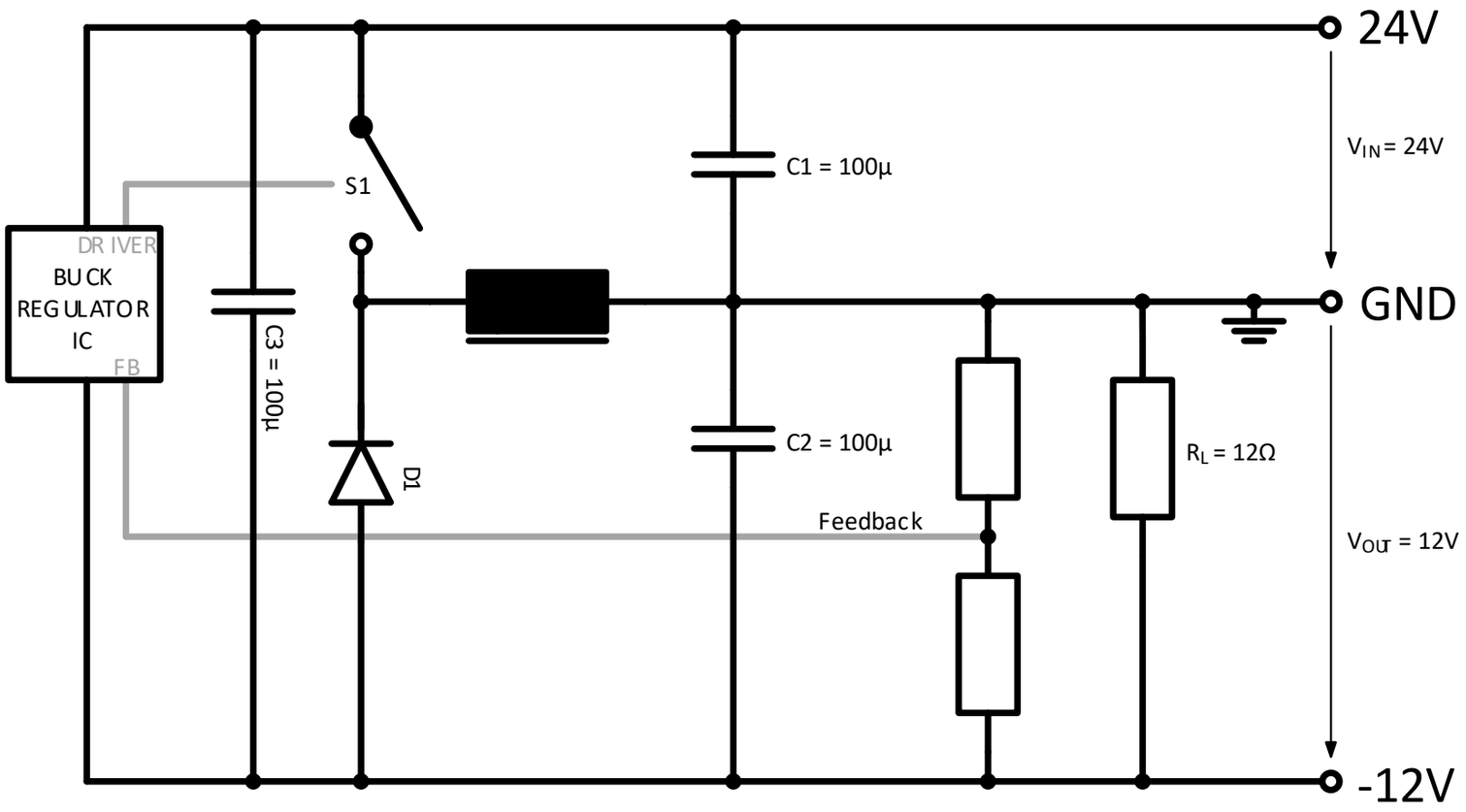
Negative Output Voltage with Inverting Buck-Boost

Real Inverting Buck-Boost



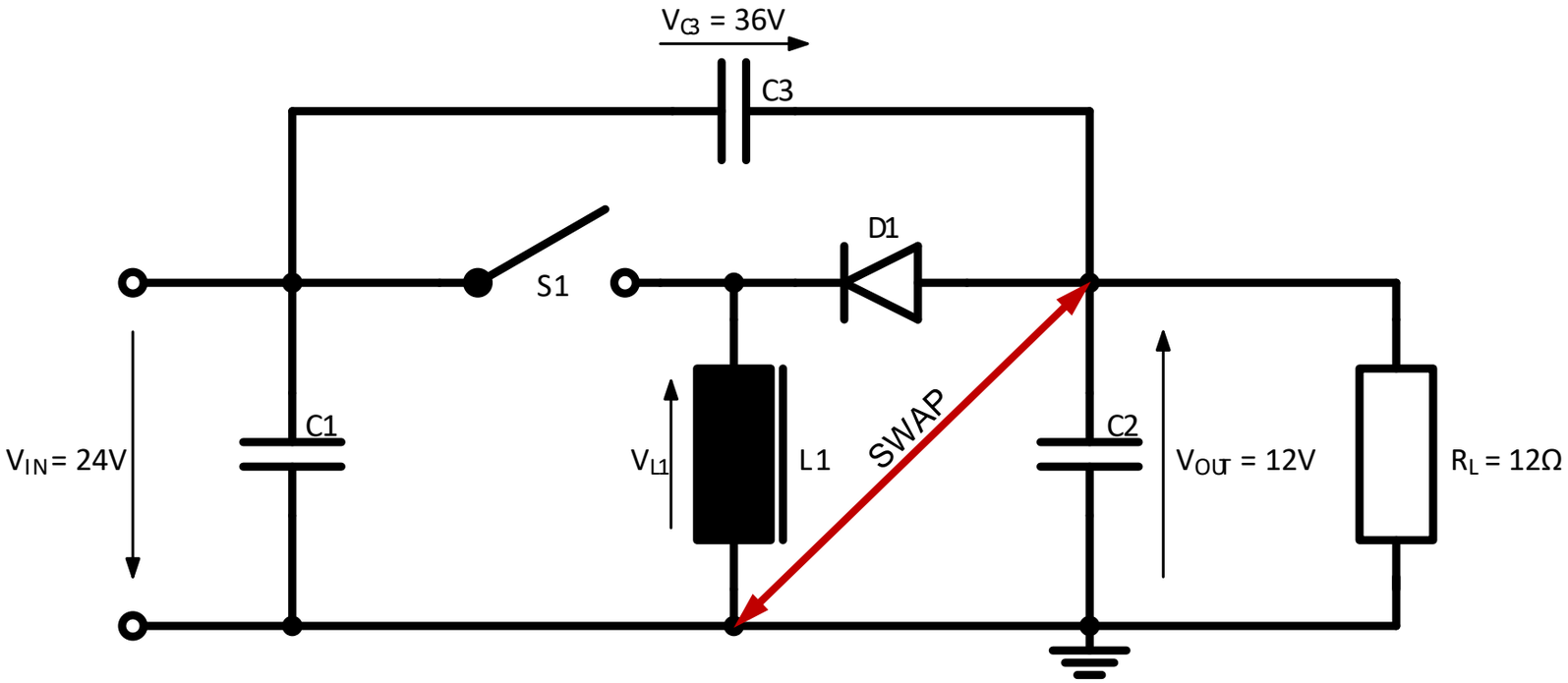
Negative Output Voltage with Inverting Buck-Boost

Real Inverting Buck-Boost



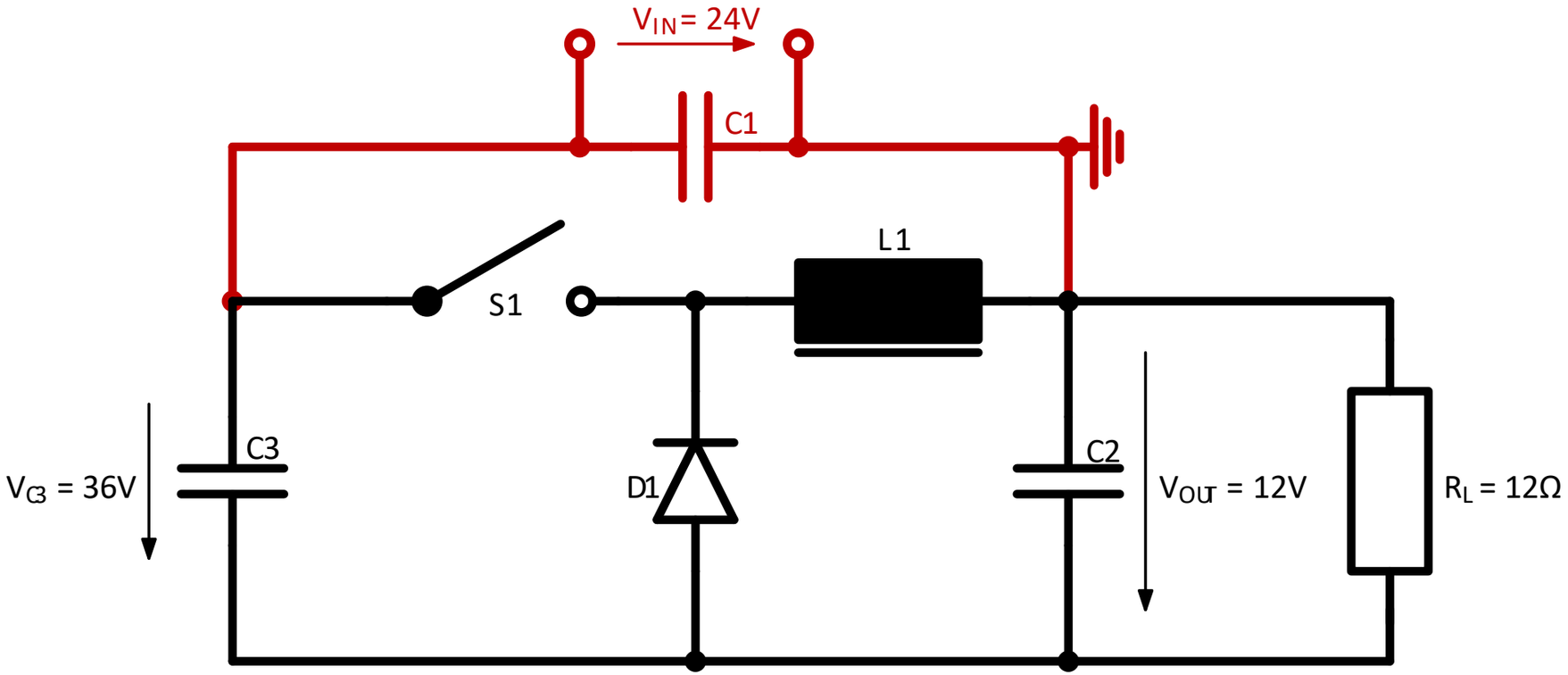
Negative Output Voltage with Inverting Buck-Boost

Comparing Inverting Buck-Boost with Buck



Negative Output Voltage with Inverting Buck-Boost

Comparing Inverting Buck-Boost with Buck



Negative Output Voltage with Inverting Buck-Boost

Important Considerations

Designer has 24V and needs -12V / 1A

Can we use a buck regulator with nominal input voltage of 24V (abs. max of 28V) and max output current of 1A ?

Negative Output Voltage with Inverting Buck-Boost

Important Considerations

The average inductor current is higher than the output current

$$I_L = \frac{I_{OUT}}{(1-D)} = \frac{1A}{(1-0{,}33)} = 1{,}5A$$

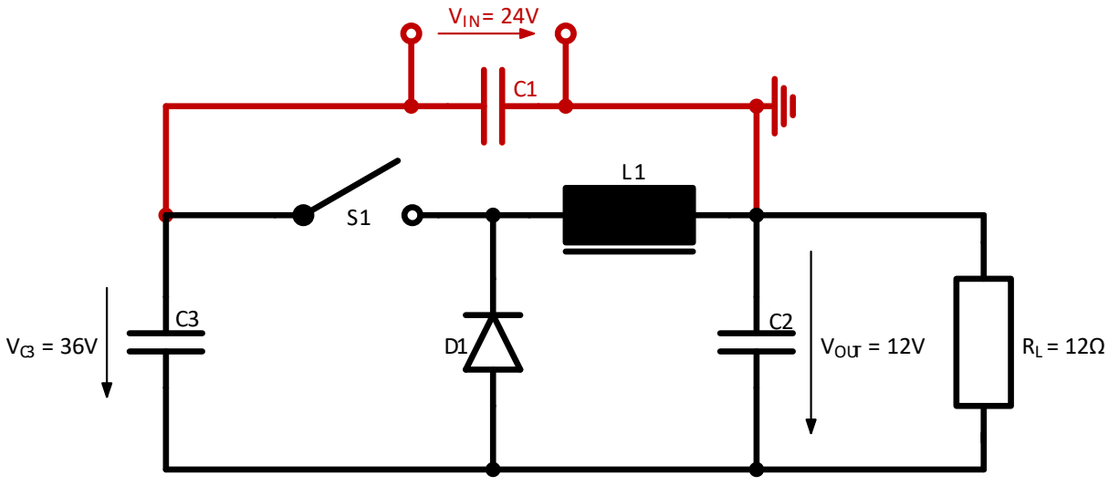
With 85% Efficiency

$$Duty\ Cycle\ (D) = \frac{|V_{OUT}|}{(\,V_{IN} + |V_{OUT}|\,)\cdot 0{,}85} = \frac{12V}{(24V + 12V)\cdot 0{,}85} = 0{,}39$$

$$I_L = \frac{I_{OUT}}{(1-D)} = \frac{1A}{(1-0{,}39)} = 1{,}64A$$

Negative Output Voltage with Inverting Buck-Boost

Important Considerations



The regulator ICs supply voltage is the input voltage plus the absolut value of the output voltage. V_{IC} = 36V

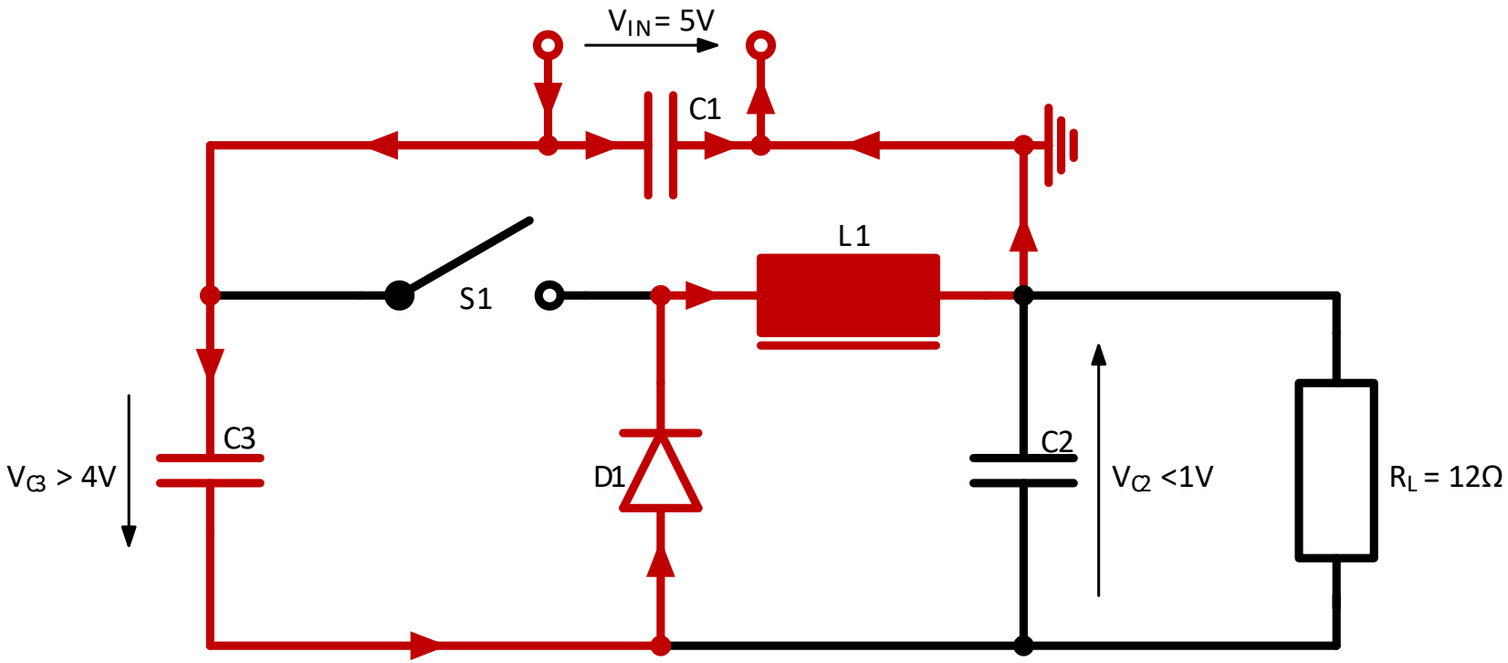
Negative Output Voltage with Inverting Buck-Boost

Important Considerations

For $24V_{IN}$ and $-12V_{OUT}$ / 1A we need a $36V_{IN}$ 2A buck regulator.
(abs. max. input voltage higher than 36V – e.g. 42V)

Negative Output Voltage with Inverting Buck-Boost

Start Up Phase



The voltage across C3 is dominant compared to the voltage across C2.

Negative Output Voltage with Inverting Buck-Boost

Thank You for Your Attention

Negative Output Voltage with Inverting Buck-Boost

If You Need More Informations…

Negative Output Voltage with Inverting Buck-Boost

- „Designing an Inverting Buck-Boost with MagI³C Power Modules“ application note on our website: we-online.com/ANS007
- powermodules@we-online.com
- Ask your sales representative