

Stikalni pretvorniki

Seminar: Načrtovanje elektronike za EMC – 27. 3. 2018

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Univerza v Ljubljani

Fakulteta za elektrotehniko

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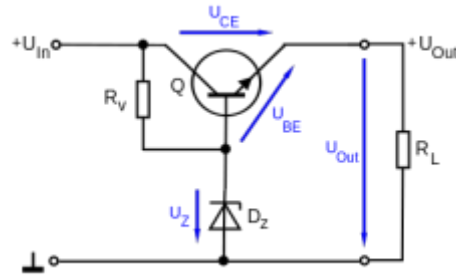


Vsebina

- Prednosti stikalnih pretvornikov
- Neizolirani pretvorniki
- Izvedba in načrtovanje
- Izolirani pretvorniki
- Krmiljenje
- Parazitne lastnosti transformatorja / sklopljene induktivnosti
- PFC

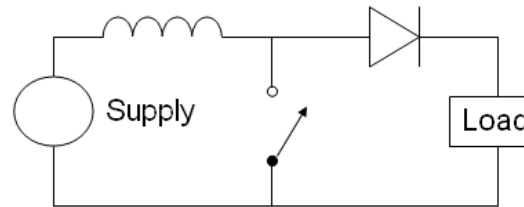
Zakaj stikalni pretvornik

- Izkoristek



$$\eta < \frac{U_{out}}{U_{in}}$$

- $U_{out} > U_{in}$



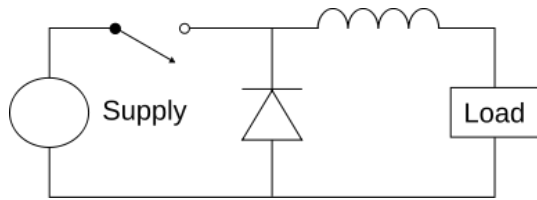
- Velikost



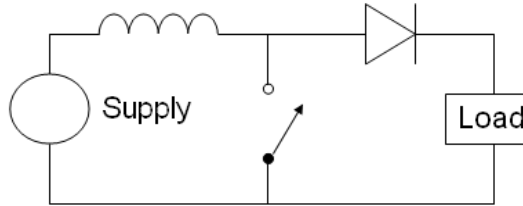
Vir slik: sheme: Wikipedia; foto: www.canford.co.uk, www.shivanitransformer.com

Neizolirani pretvorniki I

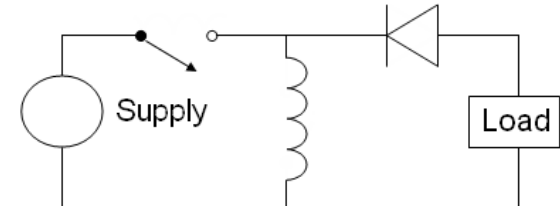
- Navzdol
(step-down, buck)



- Navzgor
(step-up, boost)



- Navzdol/Navzgor
(buck-boost)



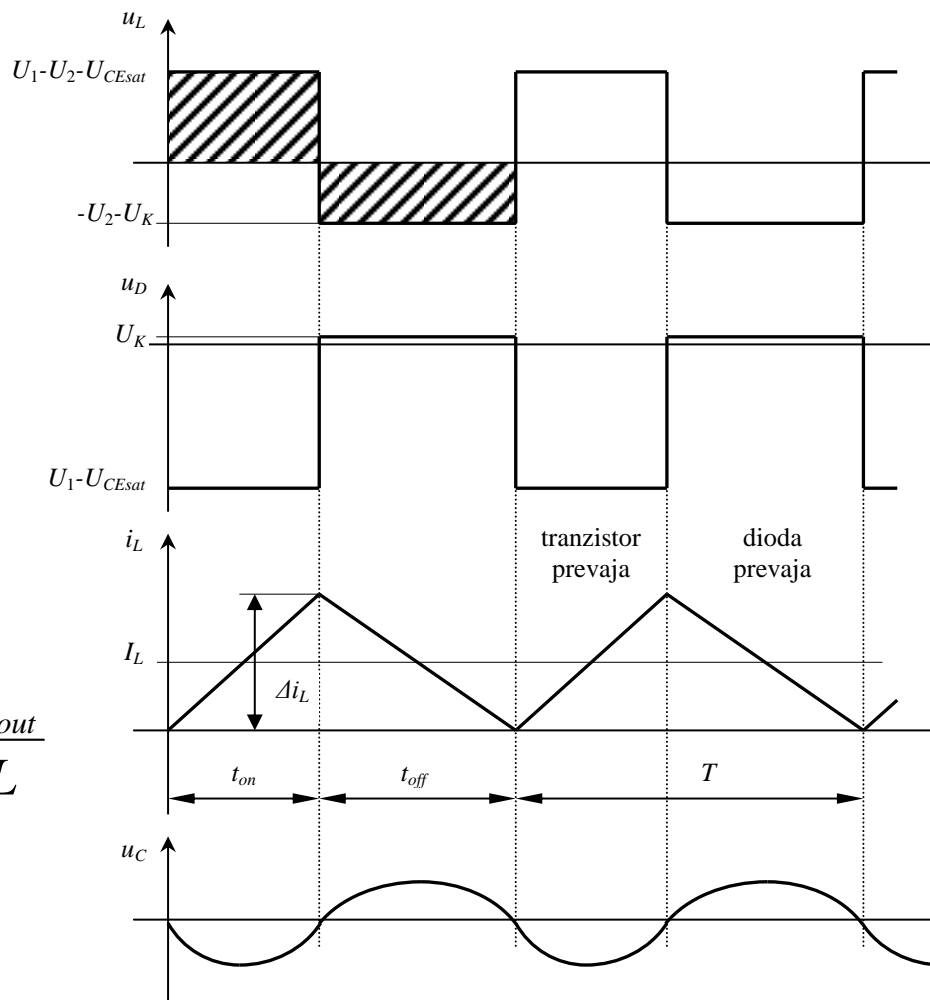
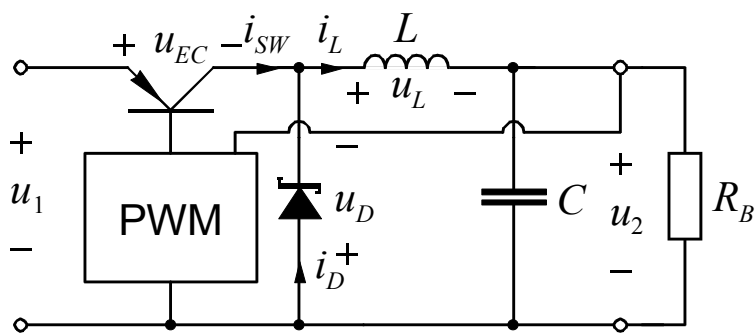
- Osnovne enačbe za neprekinjeno delovanje:

$$U_{out} = D \cdot U_{in}$$

$$U_{out} = \frac{1}{1-D} \cdot U_{in}$$

$$U_{out} = -\frac{D}{1-D} \cdot U_{in}$$

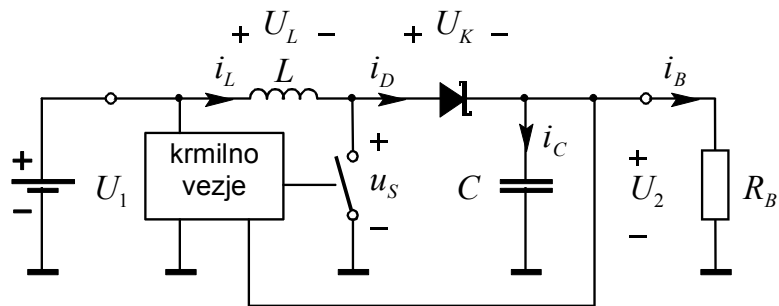
Pretvornik navzdol (step-down, buck)



$$U_{out} = D \cdot U_{in}$$

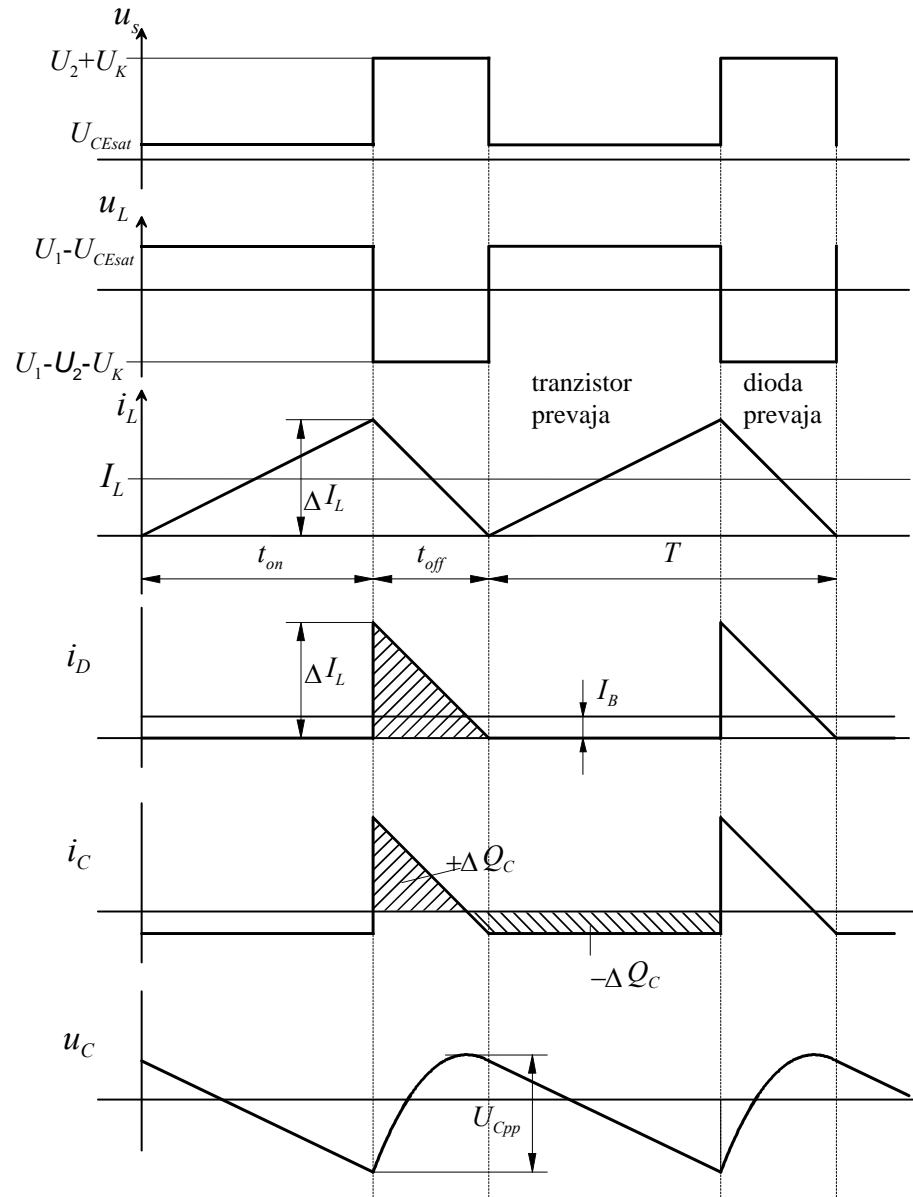
$$\Delta I_L = D \cdot T \cdot \frac{U_{in} - U_{out}}{L} = (1 - D) \cdot T \cdot \frac{U_{out}}{L}$$

Pretvornik navzgor (step-up, boost)

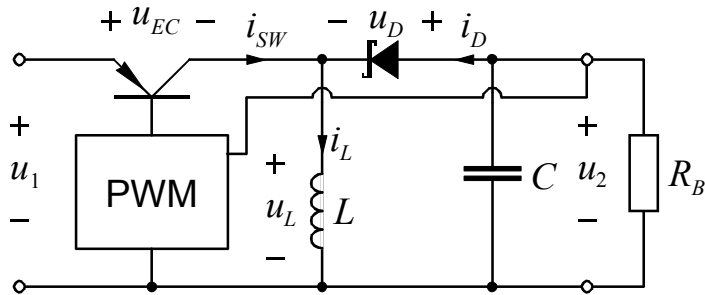


$$U_{out} = \frac{1}{1-D} \cdot U_{in}$$

$$\Delta I_L = D \cdot T \cdot \frac{U_{in}}{L} = (1-D) \cdot T \cdot \frac{U_{out} - U_{in}}{L}$$

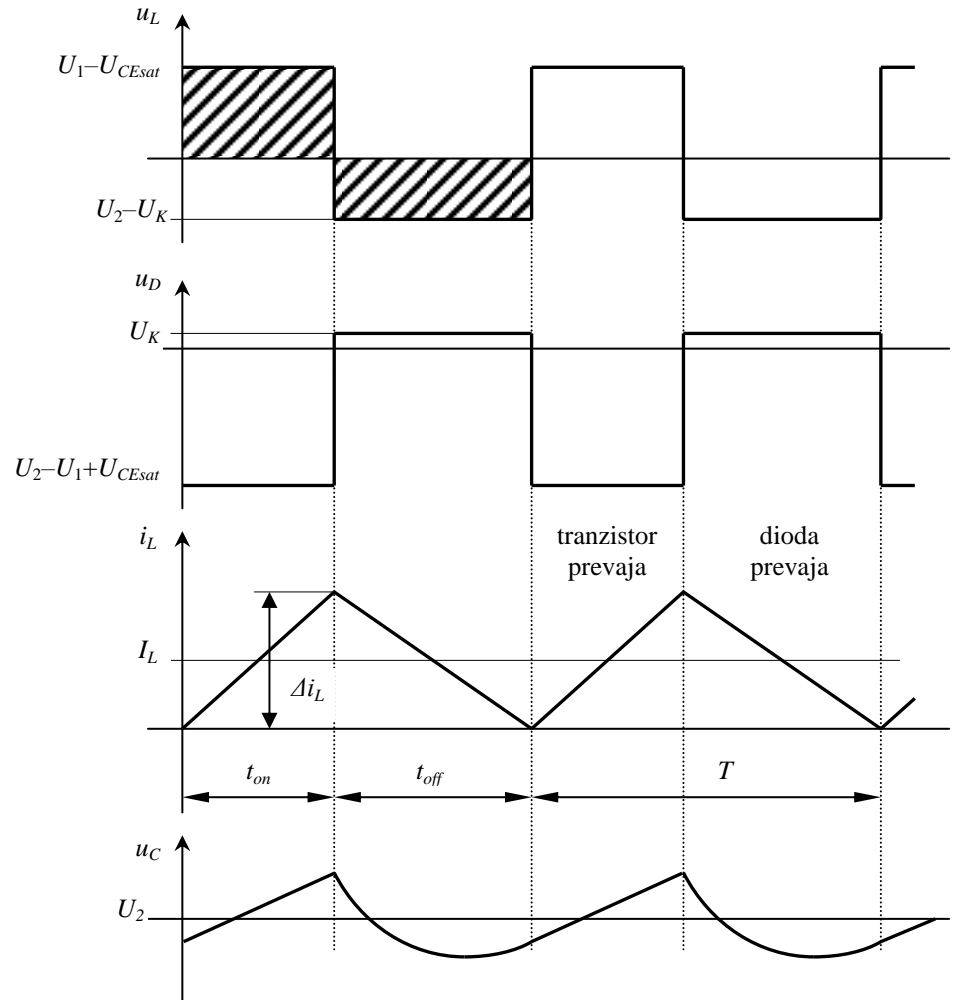


Pretvornik navzdol/navzgor invertirajoči (buck/boost, inverting, non-isolated flyback)



$$U_{out} = -\frac{D}{1-D} \cdot U_{in}$$

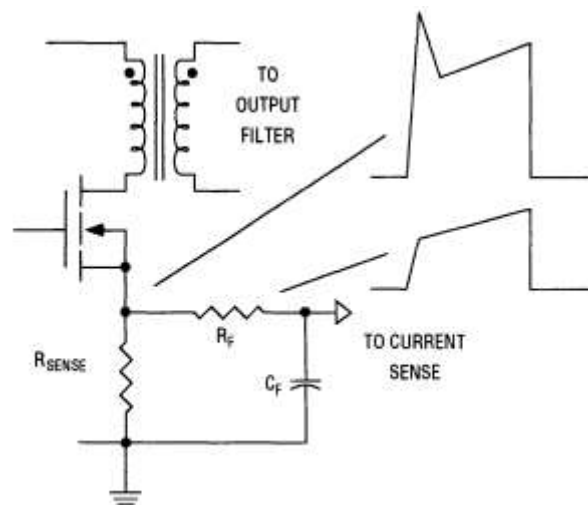
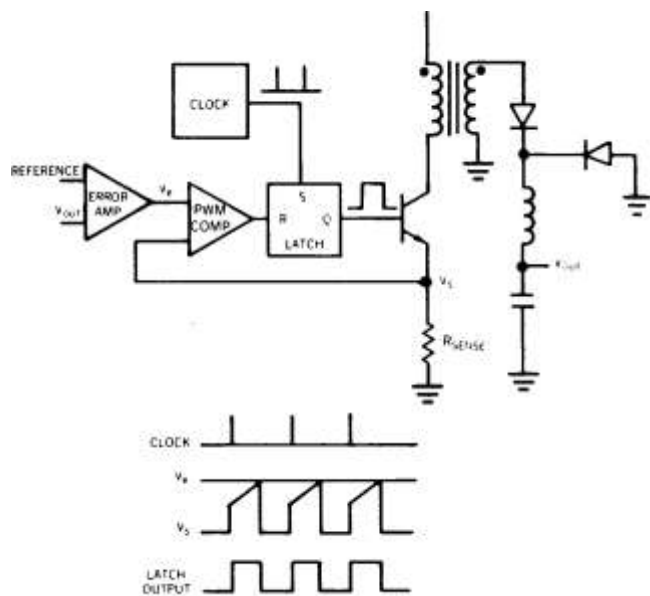
$$\Delta I_L = D \cdot T \cdot \frac{U_{in}}{L} = (1-D) \cdot T \cdot \frac{U_{out}}{L}$$



Krmiljenje I

- Napetostno (voltage-mode)
 - › Signal napake – žaga > PWM
- Tokovno (current-mode)

- Filtriranje špic
 - › RC filter
 - › Mrtvi čas

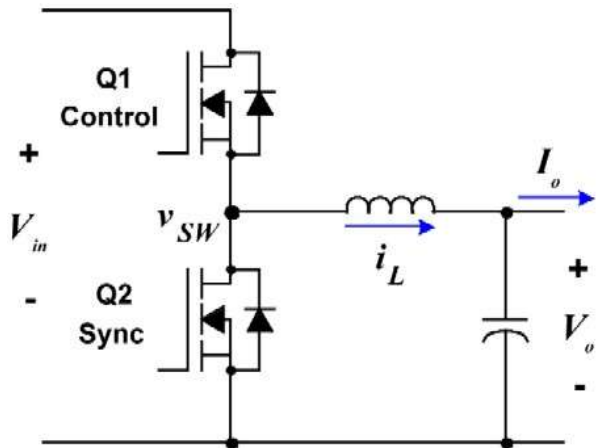


Vir slik: Unitrode U-93, U-128 app.note

Izboljšave

- Sinhroni pretvornik

- › Tranzistor namesto diode

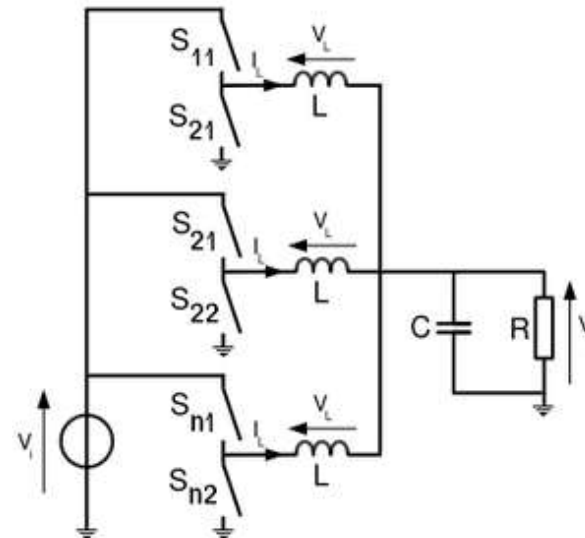


- Večfazni pretvornik

- › Velik izhodni tok

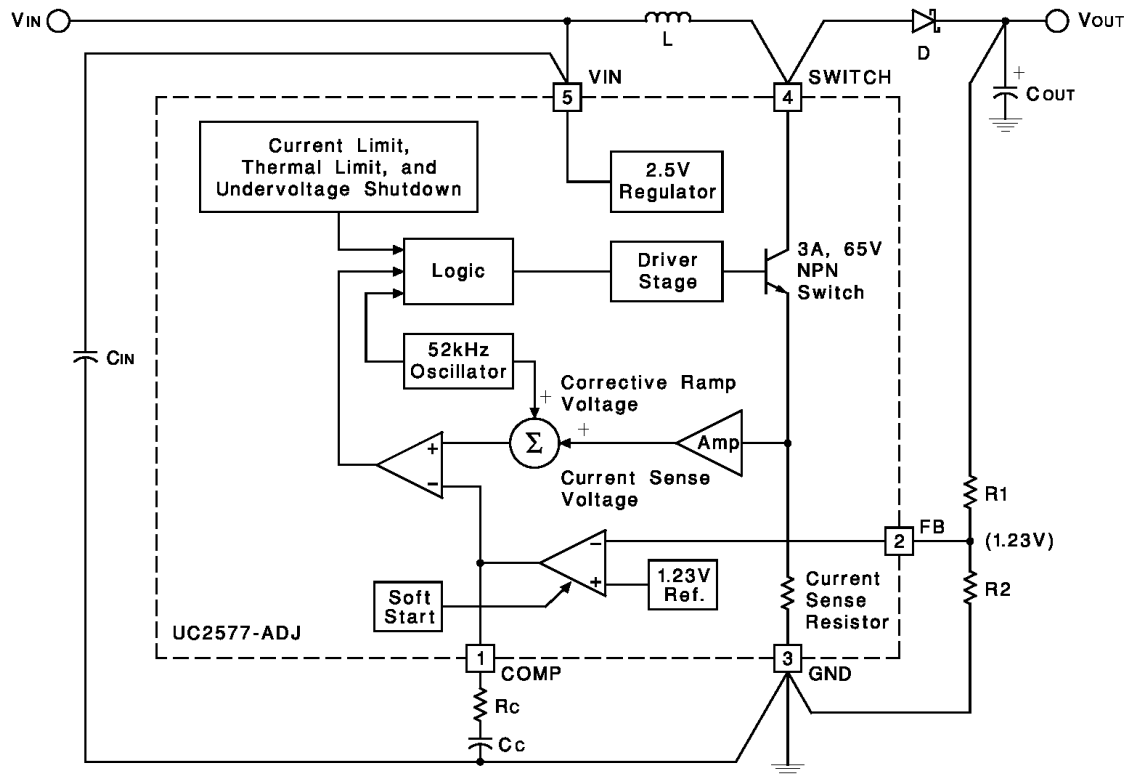
- › Hitrejši odziv

- › Manjša valovitost toka



Vir slik: Eric Persson, How FET selection can optimize synchronous buck converter efficiency, EEtimes;

Primer izvedbe – pretvornik navzgor

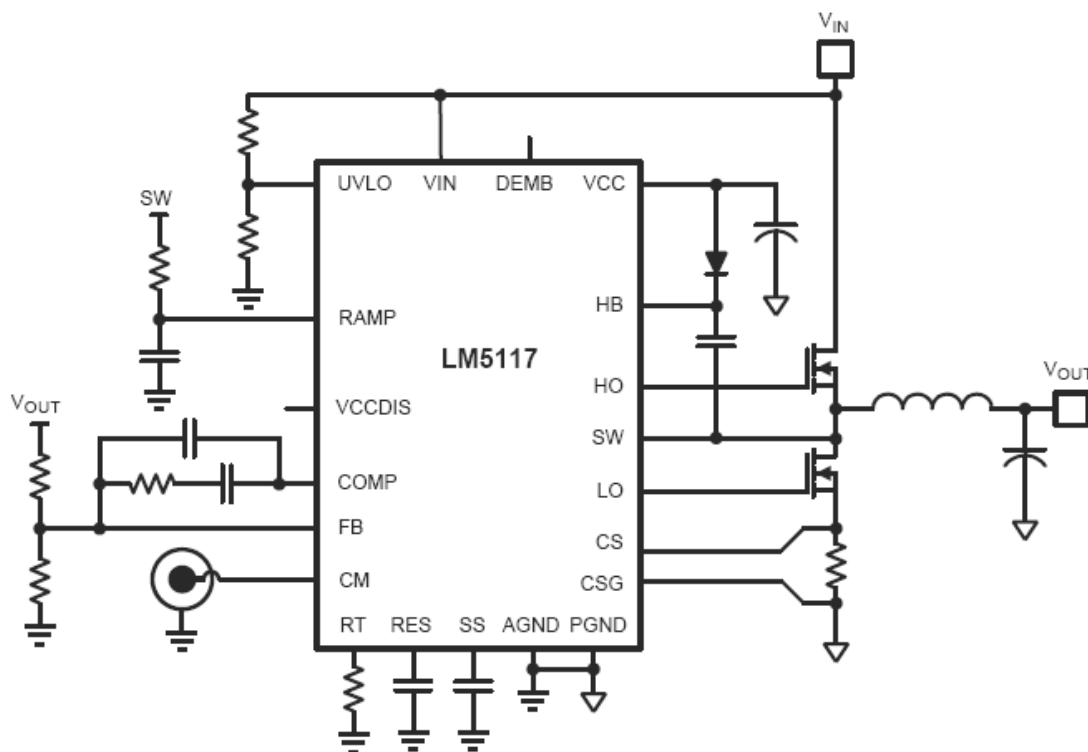


- Texas Instruments (Unitrode) UC2577

- › Topologije: navzgor, flyback, forward
- › Vhod: do 40 V
- › Stikalo: 3 A, 65 V
- › TO-220-5
- › Izkoristek: 80 % @ 5 / 12 V, 800 mA

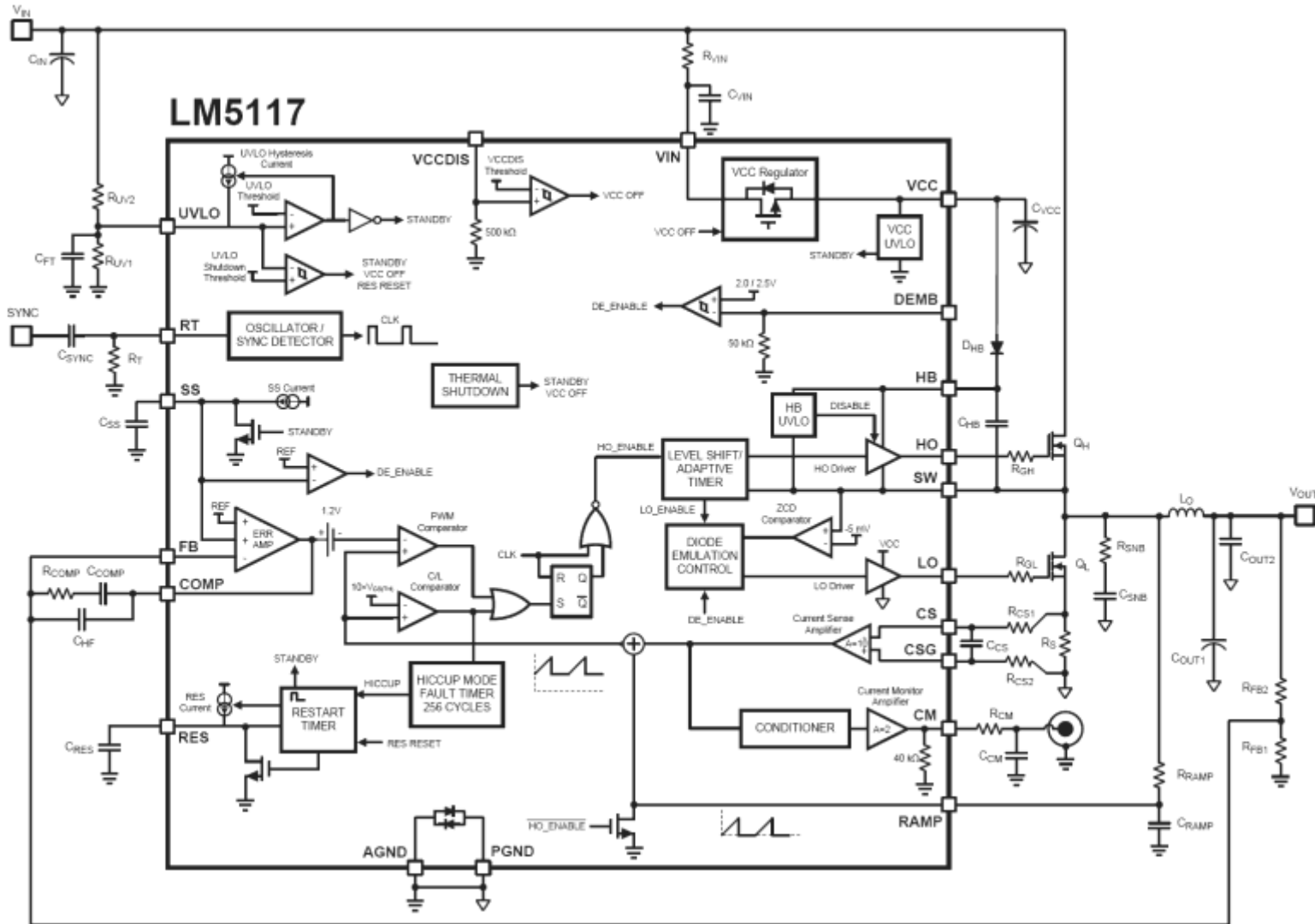
Primer izvedbe – pretvornik navzdol

sinhroni, z zunanji tranzistorji



- Texas Instruments TLM5117
 - › Vhod: 5,5 – 65 V
 - › Oscilator: do 750 kHz
 - › Emulirani tokovni način krmiljenja
 - › Sinhrono delovanje
 - › Zaščite

Primer izvedbe – pretvornik navzdol



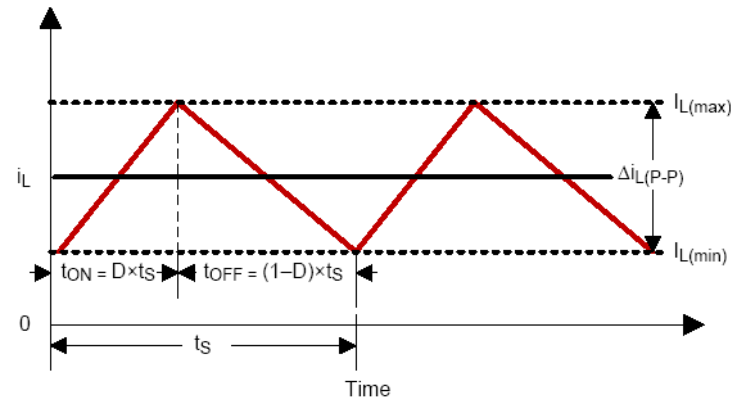
Pretvornik navzdol – potek načrtovanja

- Specifikacije: U_{in} , U_{out} , I_{out} , f

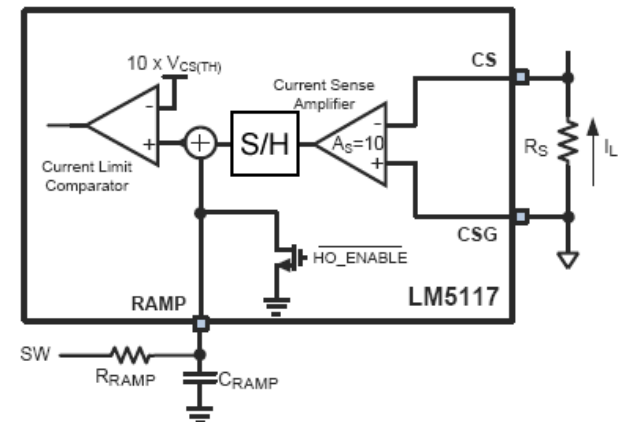
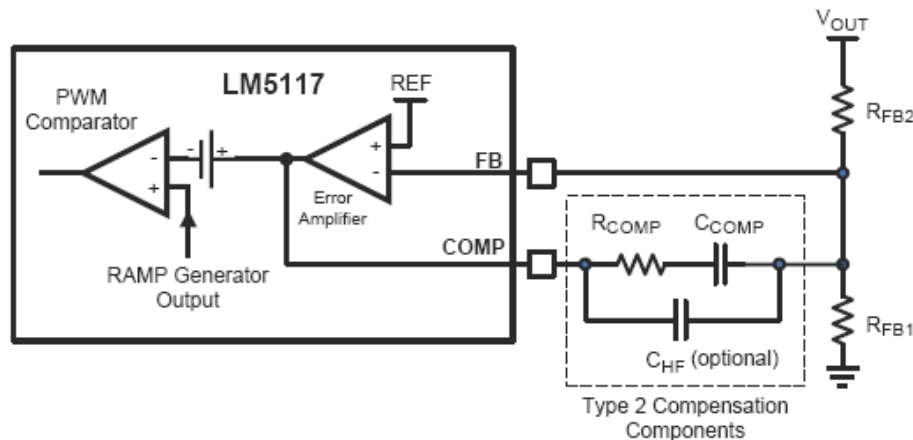
> $\Delta I_L \rightarrow L, Q1, Q2$

> $U_{out(p-p)} \rightarrow C_{out}$, $U_{in(p-p)} \rightarrow C_{in}$

$$R_T = \frac{5.2 \times 10^9}{f_{SW}} - 948 \text{ } [\Omega]$$

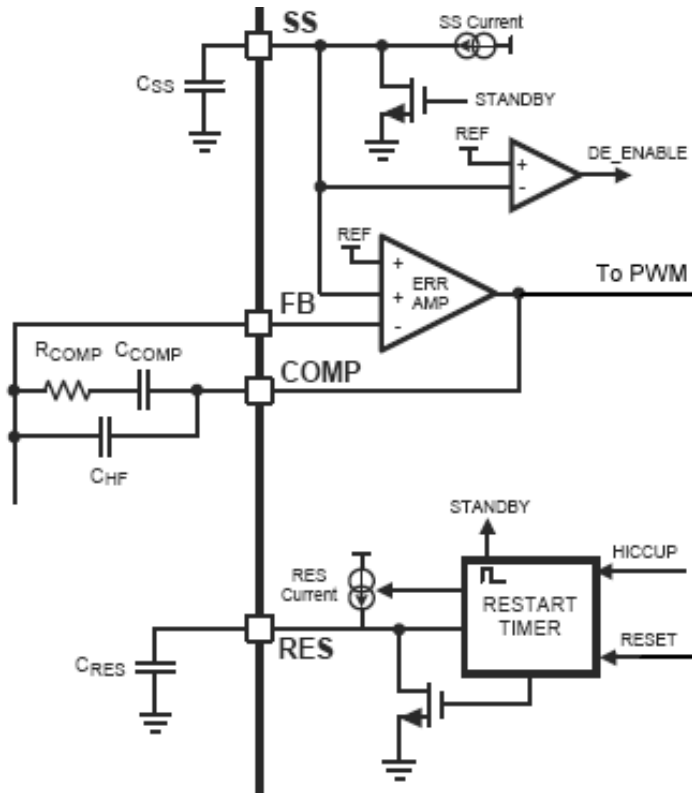


- Povratna vezava: I_{out} , U_{outMAX}

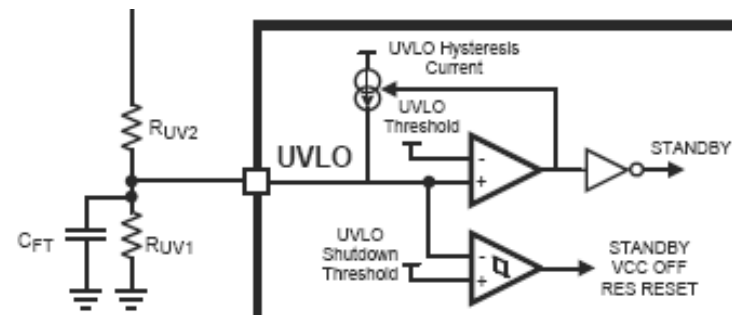


Pretvornik navzdol – potek načrtovanja

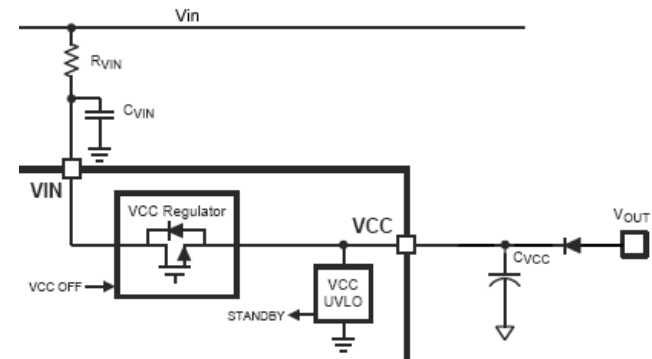
- Mehki zagon



- Onemogočenje pri nizki vhodni napetosti (UVLO)



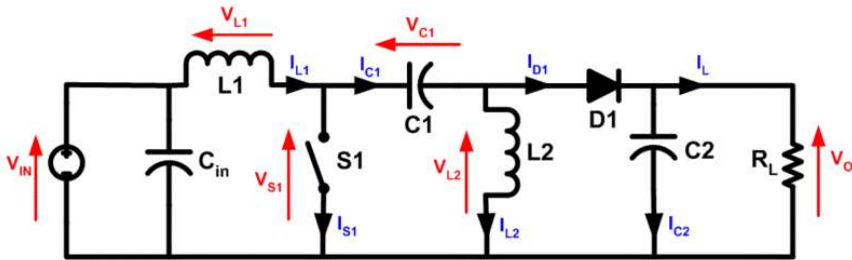
- Učinkovito napajanje



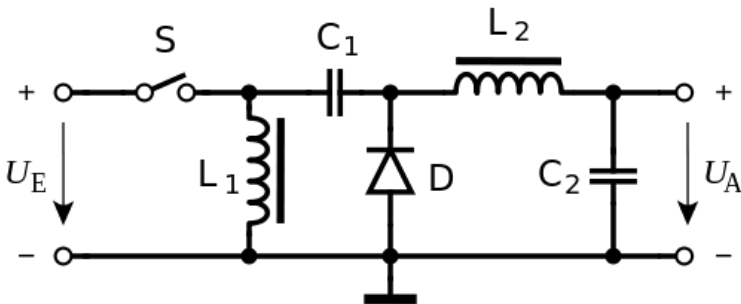
Neizolirani pretvorniki II

▪ SEPIC

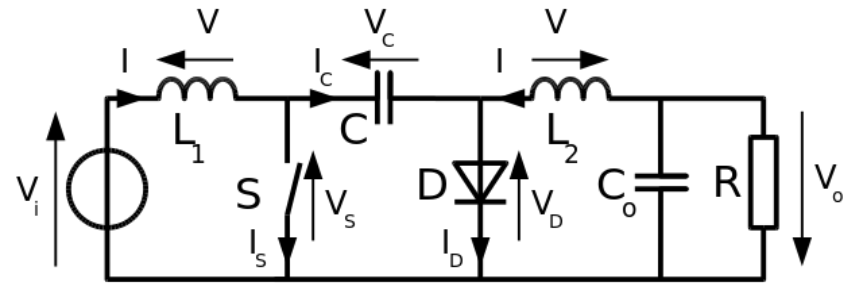
(Single-ended primary-inductor converter)



▪ Zeta



▪ Čuk

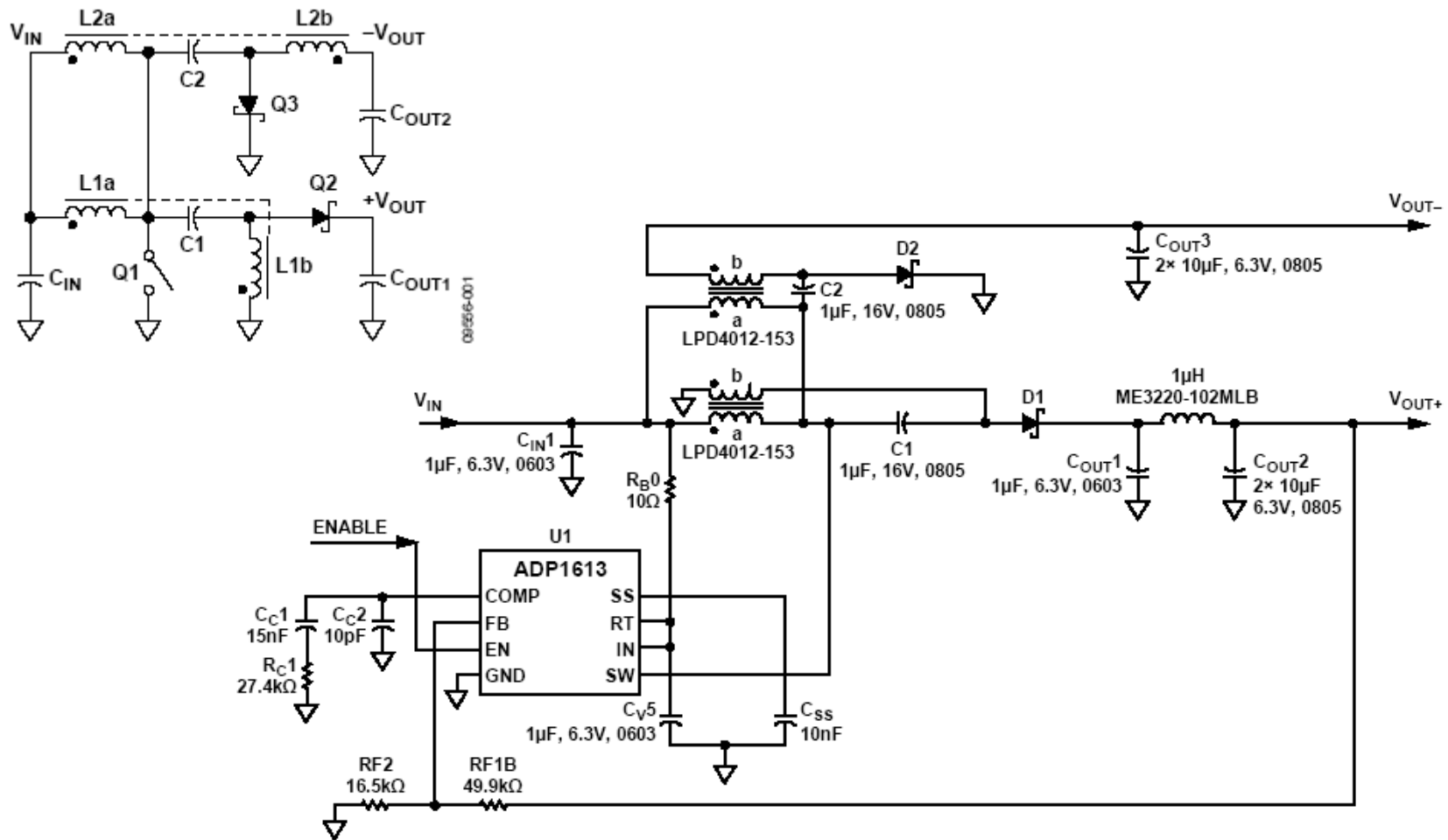


▪ Neprekinjeno delovanje:

$$U_{out} = -\frac{D}{1-D} \cdot U_{in}$$

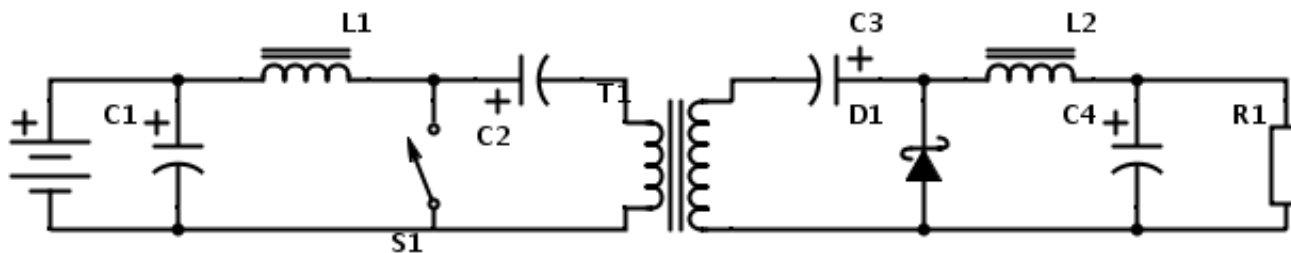
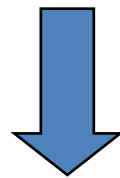
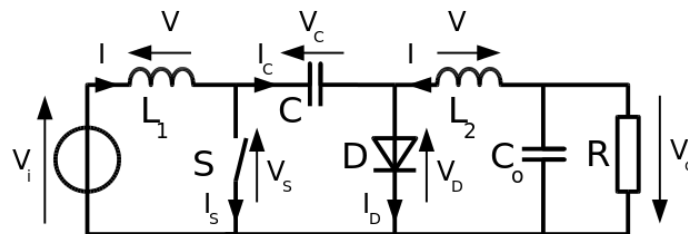
$$U_{out} = \frac{D}{1-D} \cdot U_{in}$$

Primer izvedbe – Dvojni pretvornik



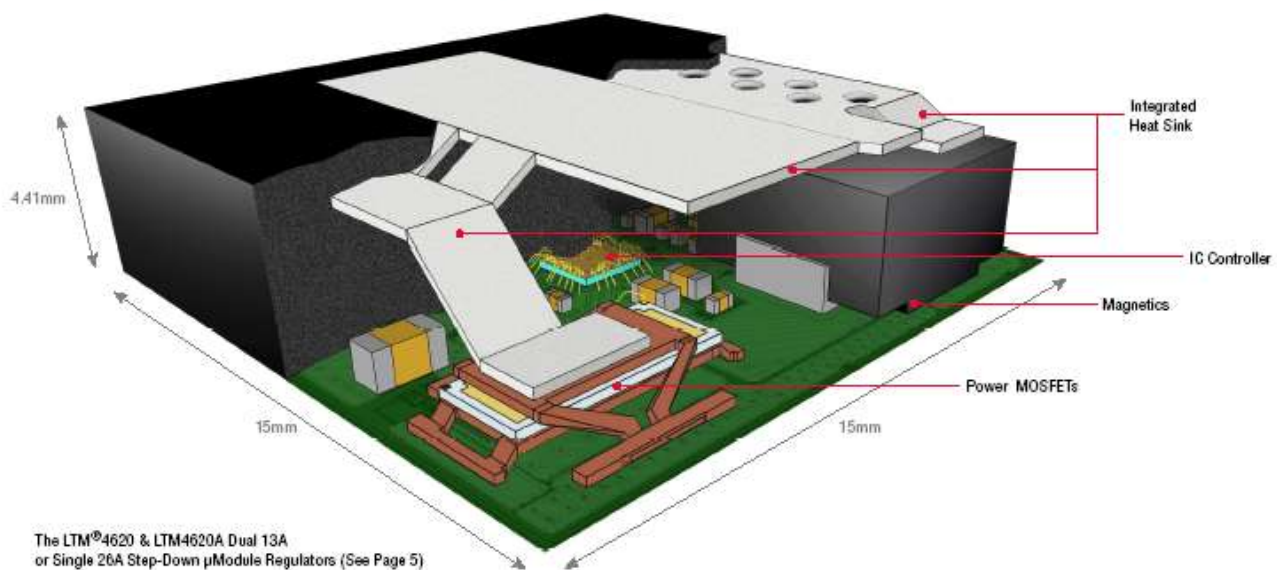
Vir: Application note Analog Devices AN-1106

Izolirani p. III – Čuk pretvornik



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- 6.25 x 11.25
- 9 x 11.25
- 9.25 x 15
- 11.25 x 15

Low Noise	Inverting	LED Driver	Step Down	Step Up & Down	EN55022 Class B Certified	Isolated	Battery Charger
Page 3		Page 4-5		Page 6	Page 7		

- 15 x 15
- 15 x 15
- 16 x 16

In BGA & LGA Packages

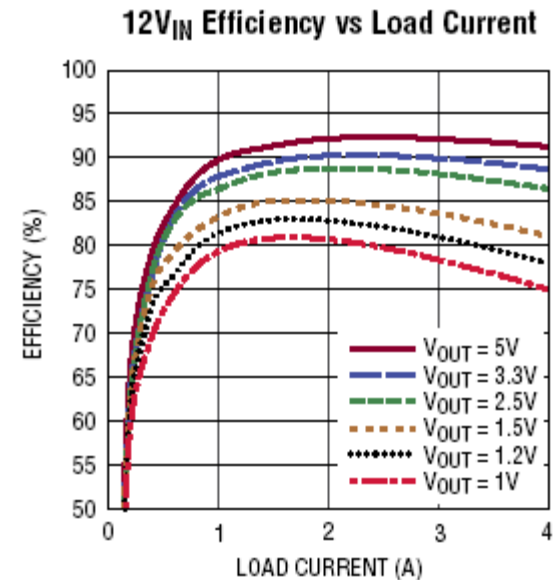
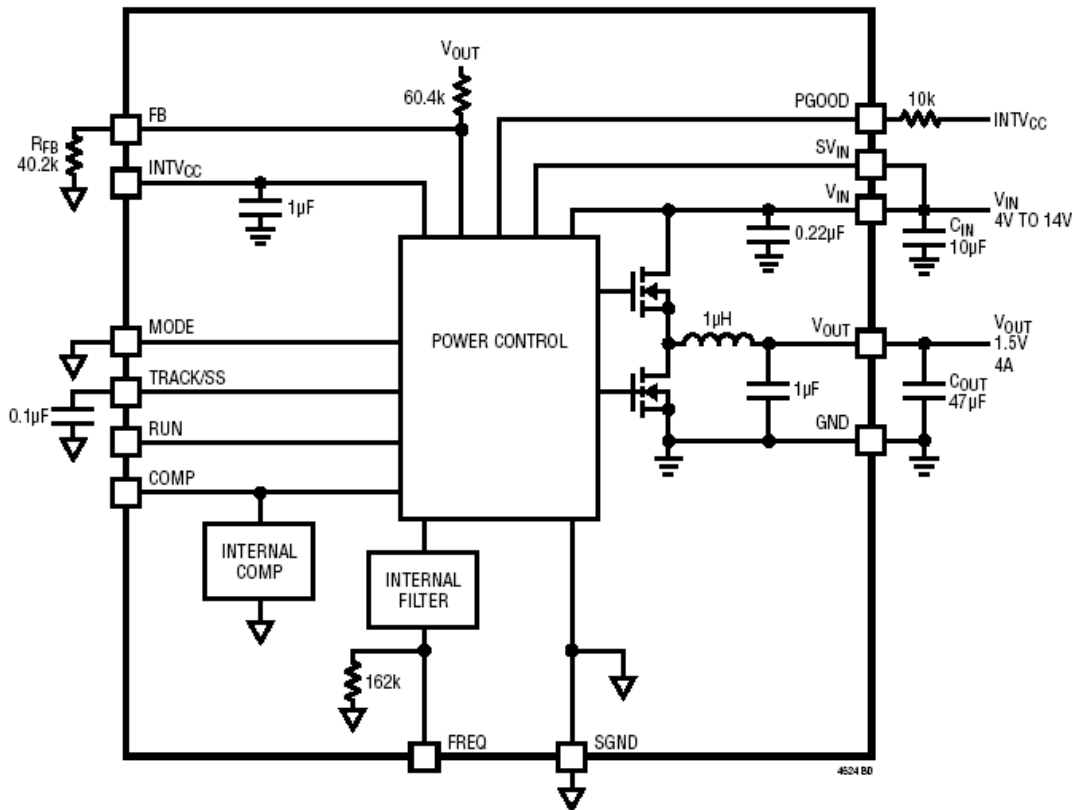
Dimensions in mm



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Primer LTM4624 – pretvornik navzdol

6,25 x 6,25 x 5,01 mm³ BGA



Literatura

- Power Semiconductor Applications – Chapter 2: Switched Mode Power Supplies, Philips Semiconductors, http://www.moodle2.tfe.umu.se/pluginfile.php/60819/mod_label/intro/nxp/APPCHP2.pdf
- Under the Hood of Flyback SMPS Designs – SLUP261, Texas Instruments, <http://www.ti.com/lit/ml/slup261/slup261.pdf>
- Compensation Design With TL431 for UCC28600 – SLUA671, Texas Instruments (Max Han, Zhong Ye)

Konec

Hvala za vašo pozornost

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