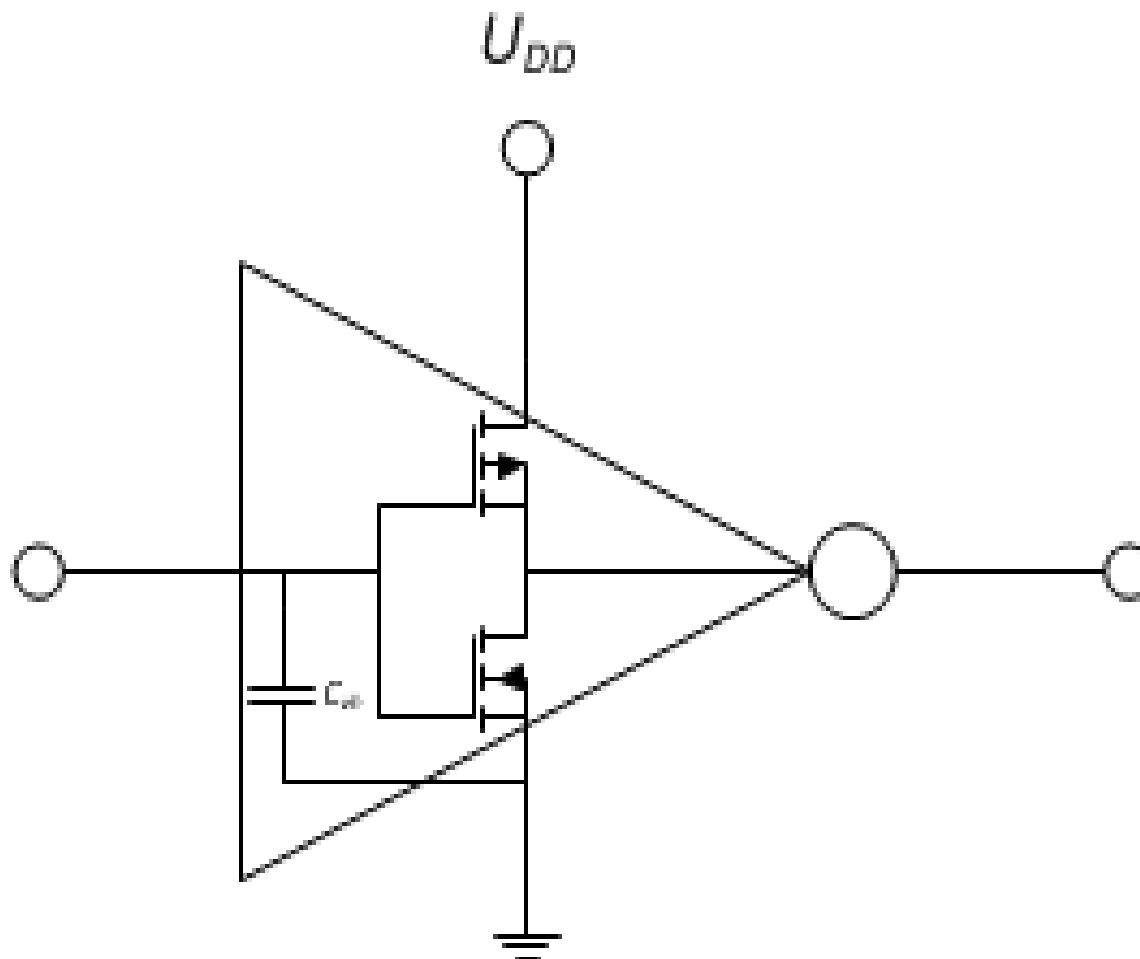


Realizacija elektronskih sklopov

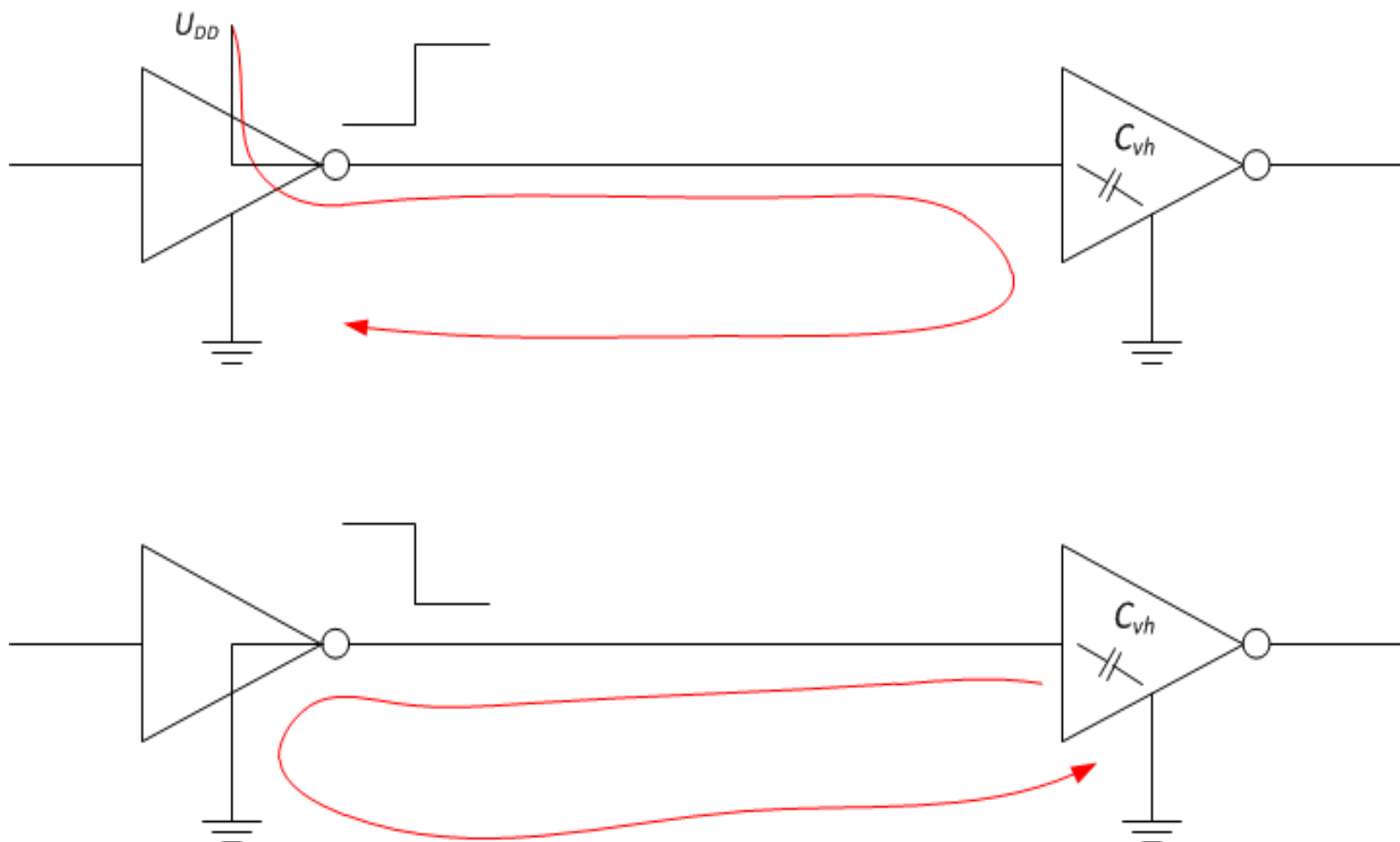
EMC načrtovanje tiskanih vezij

M. Jankovec

Tipično nadomestno vezje logičnih vrat

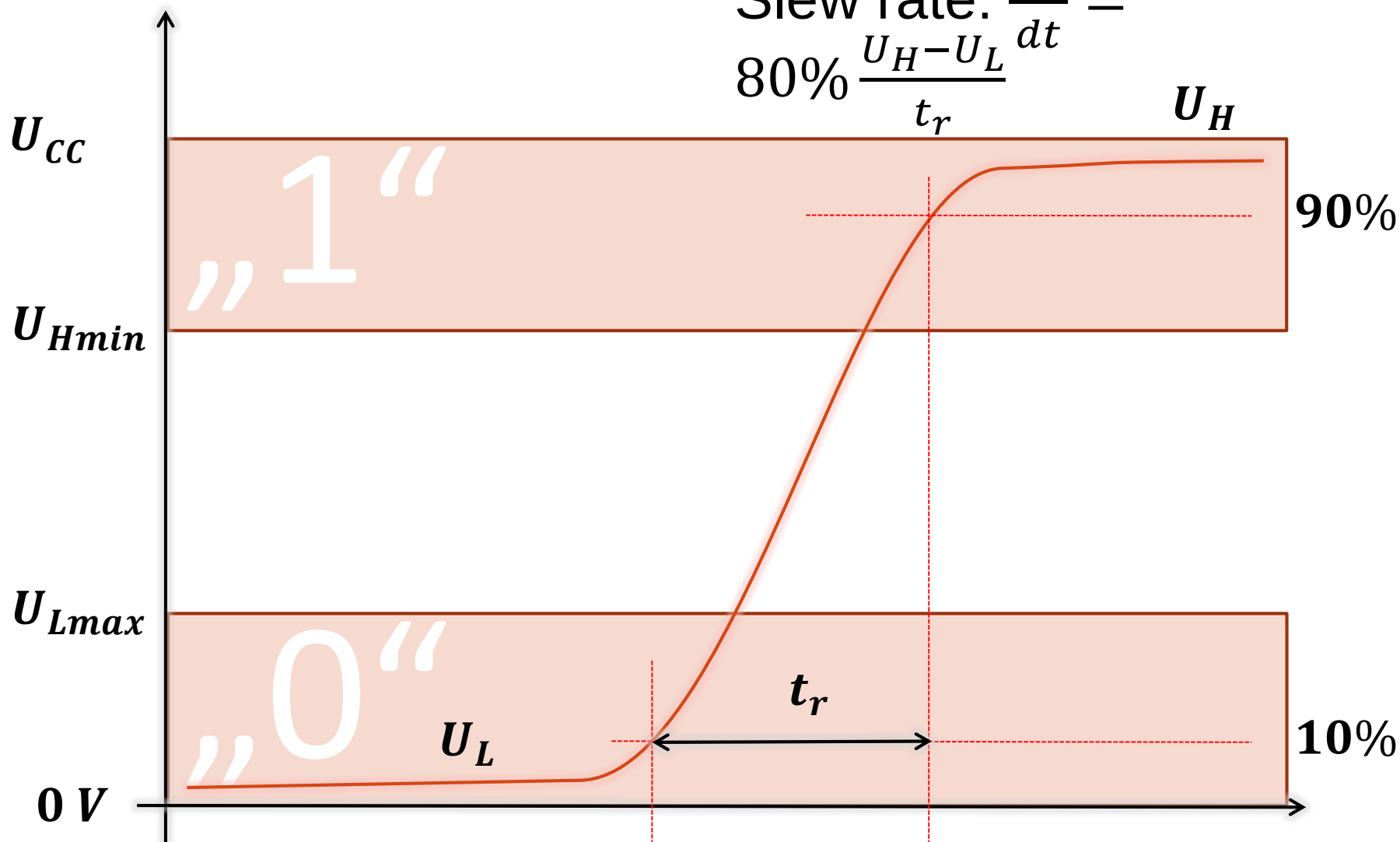


Kirchhofov tokovni zakon digitalnem vezju

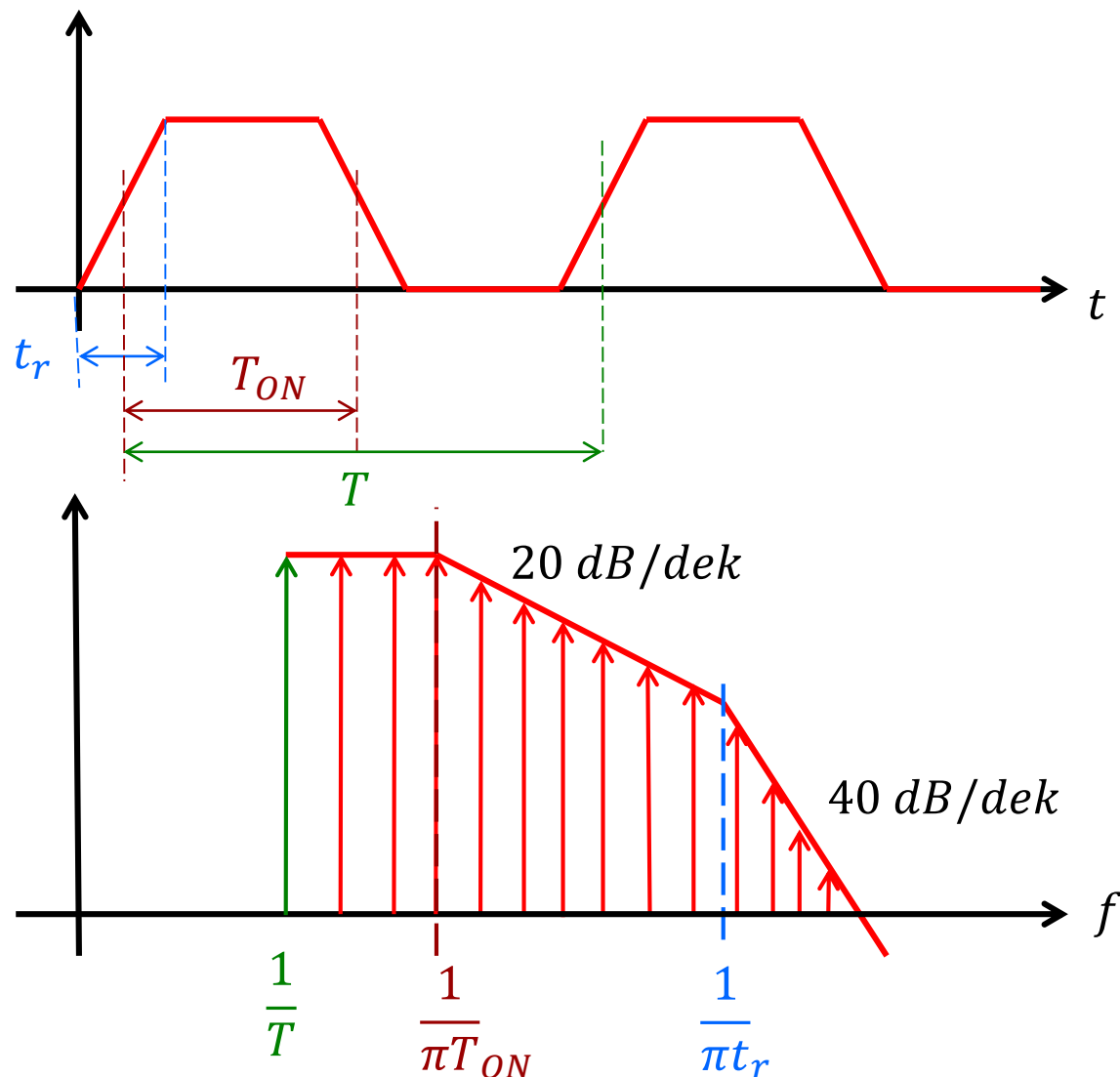


Digitalni signali

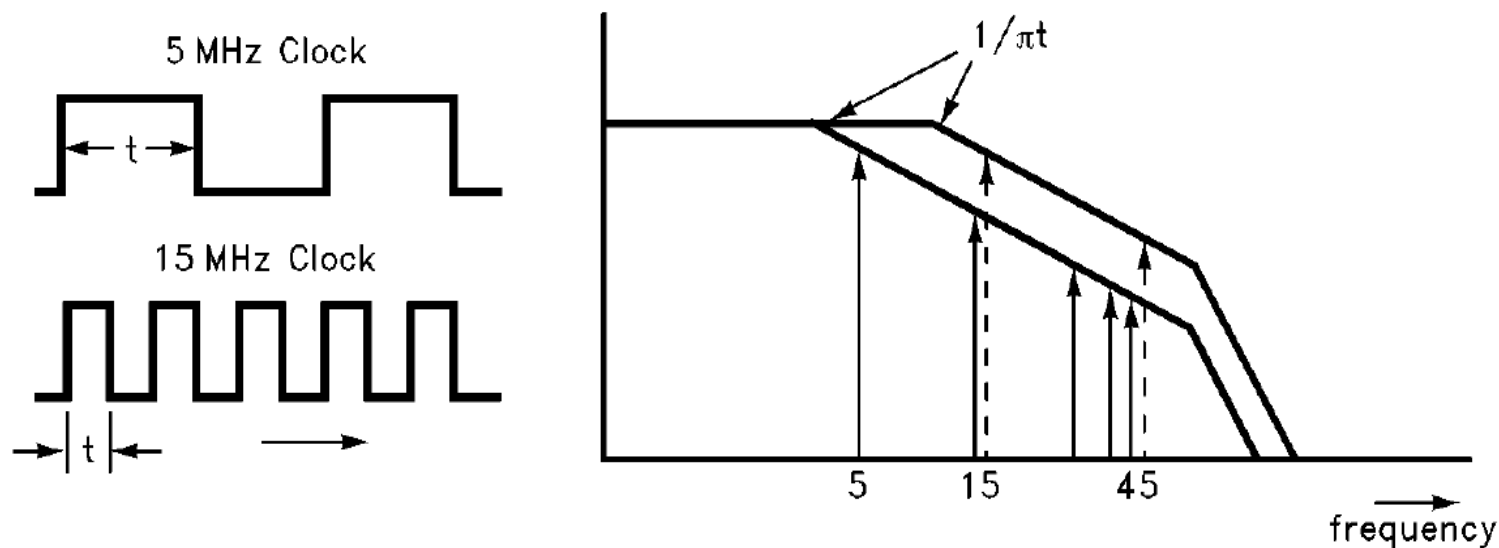
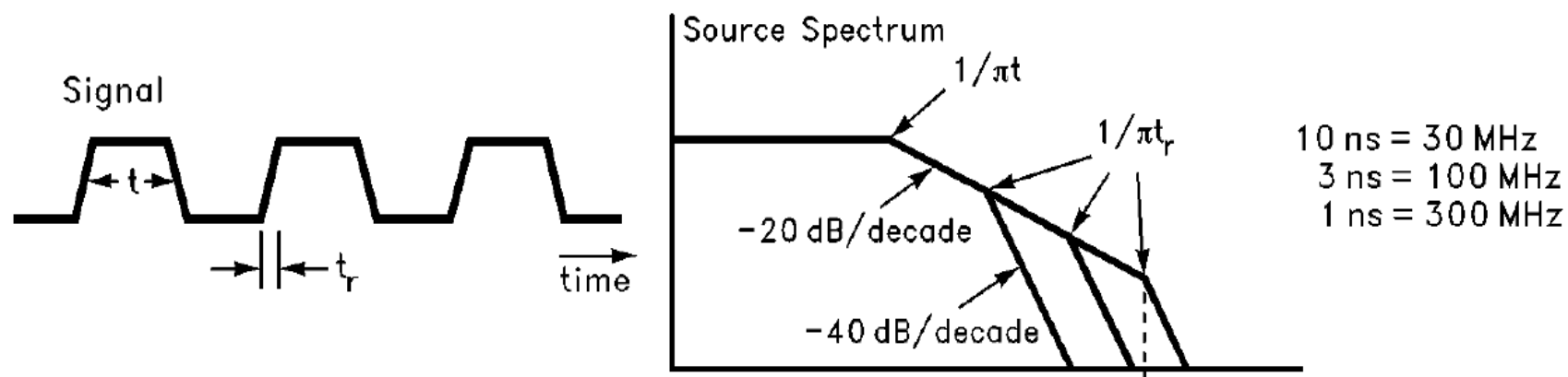
$$\text{Slew rate: } \frac{dU}{dt} = 80\% \frac{U_H - U_L}{t_r}$$



Ovojnica spektra signala trapezoidne oblike



Vpliv dviznega časa in frekvence signala



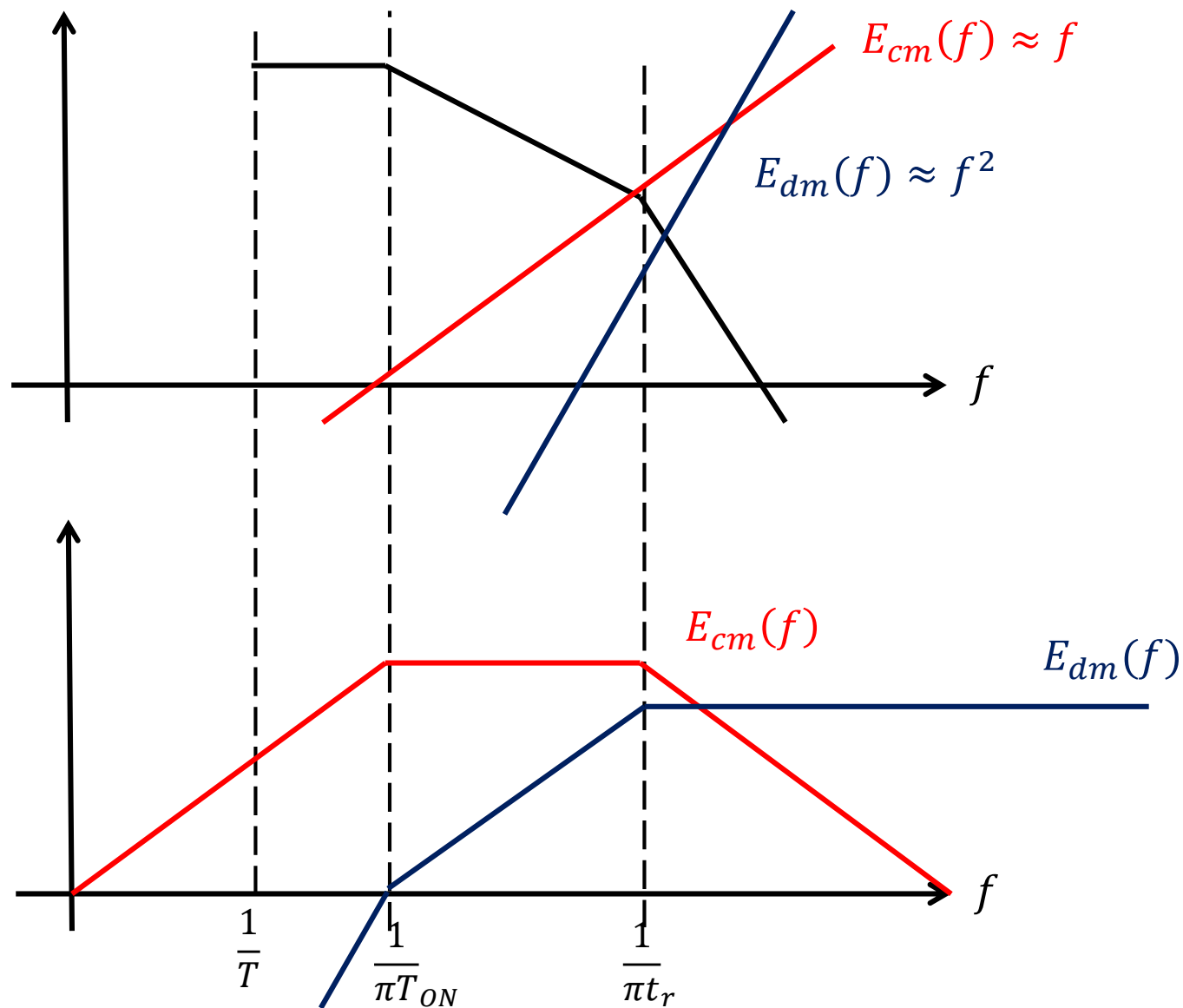
Dolžina linije, ki seva EMI

- Izkustveno pravilo:

- dolžina linije, ki deluje kot antena: $l > \frac{\lambda}{20}$

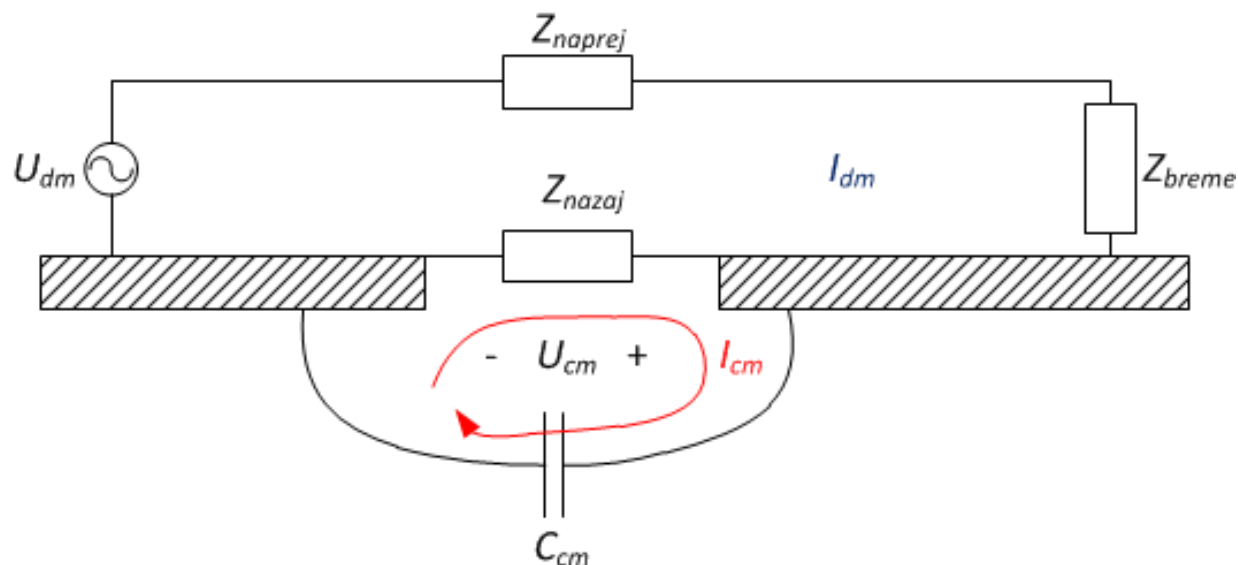
t_r	$f_{40dB} = \frac{1}{\pi t_r}$	λ	$\lambda/20$
1 μ s	300 kHz	1000 m	150 m
300 ns	1 MHz	300 m	15 m
100 ns	3 MHz	100 m	5 m
30 ns	10 MHz	30 m	1.5 m
10 ns	30 MHz	10 m	50 cm
3 ns	100 MHz	3 m	15 cm
1 ns	300 MHz	1 m	5 cm
300 ps	1 GHz	30 cm	1.5 cm

Ovojnica sevalnih spektrov linije s trapezoidno obliko signala



Mehanizmi generiranja sofaznih motenj

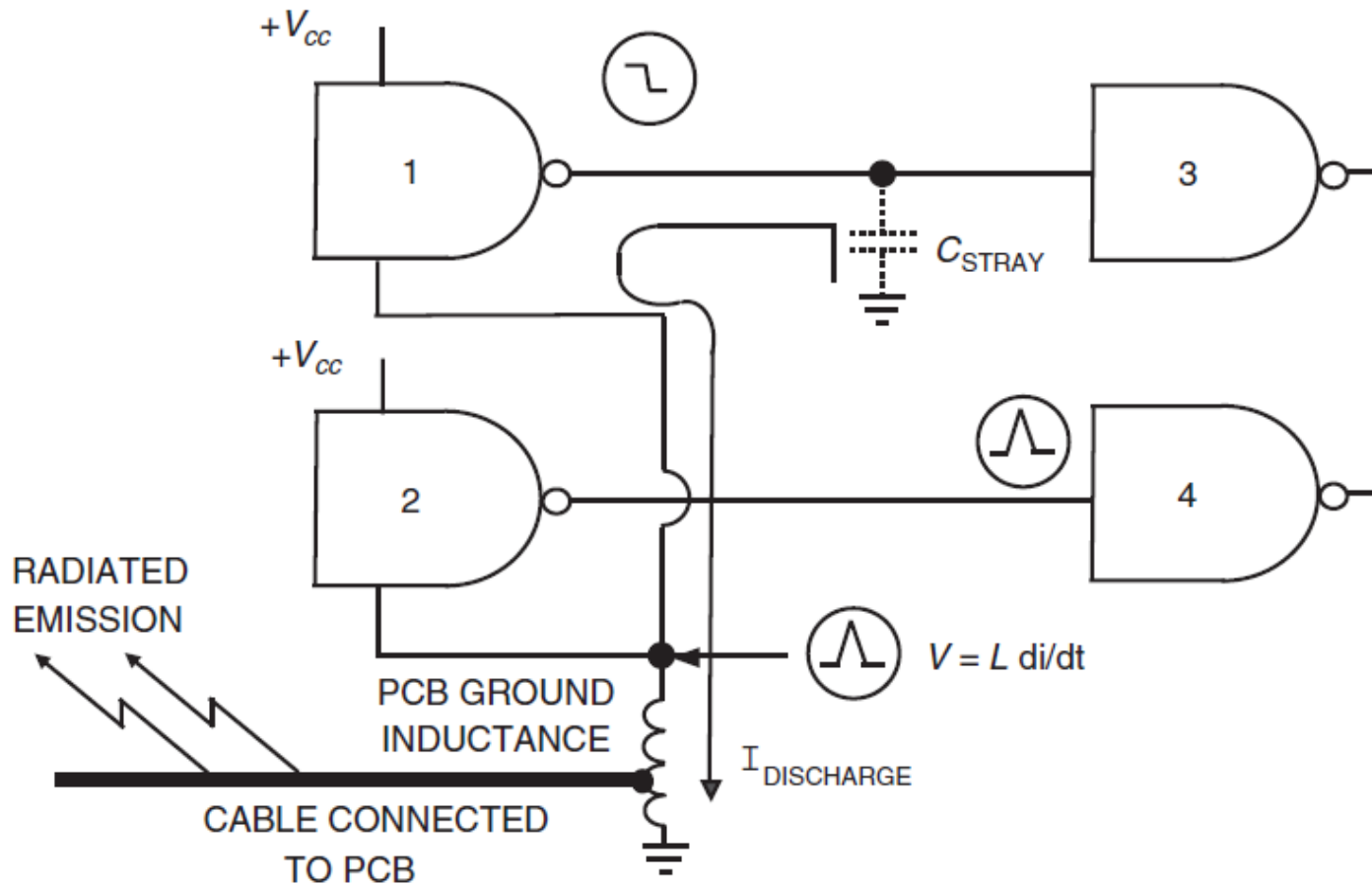
- Tokovni



$$I_{dm} = \frac{U_{dm}}{Z_{breme} + Z_{naprej} + Z_{nazaj}} \quad U_{cm} = I_{dm} \cdot Z_{nazaj} \quad I_{cm} = j\omega C_{cm} U_{cm}$$

$$Z_{nazaj} = j\omega L_{nazaj}, Z_{breme} = R_{breme}, Z_{naprej} = 0 \rightarrow I_{cm} = -\omega^2 L_{nazaj} C_{cm} \frac{U_{dm}}{R_{breme}}$$

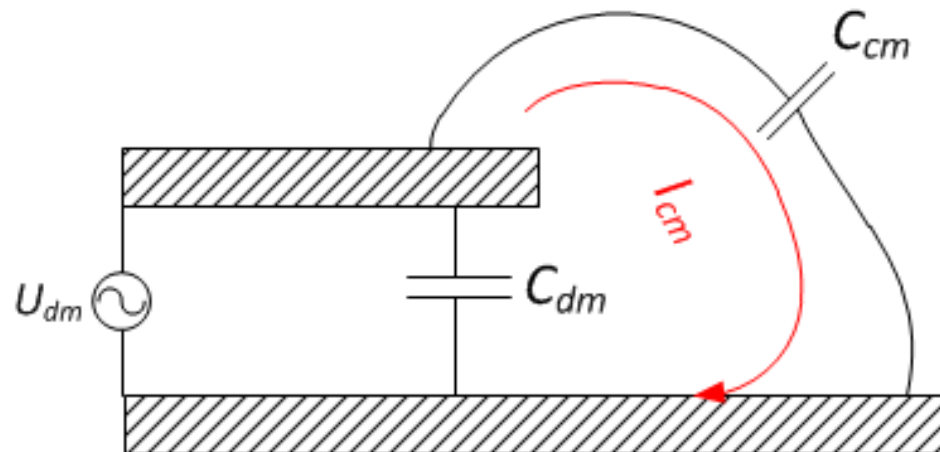
Tokovno generiranje sofaznih motenj



Vir: Henry W. Ott: Electromagnetic compatibility engineering

Mehanizmi generiranja sofaznih motenj

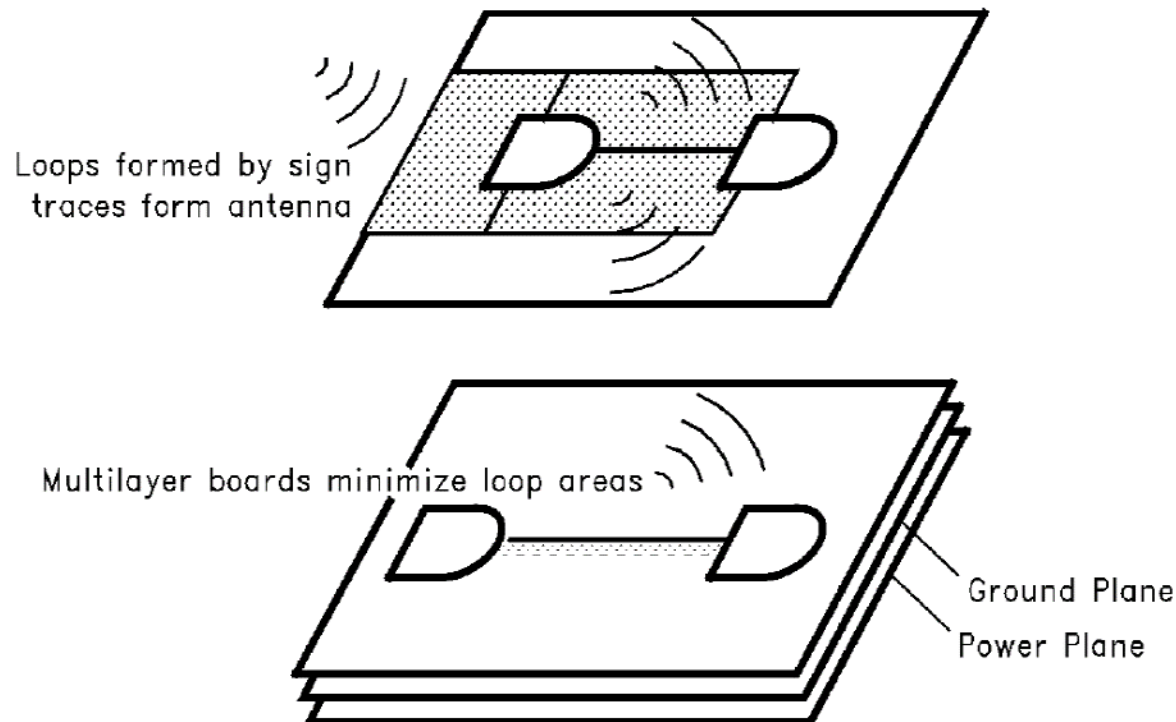
- Napetostni



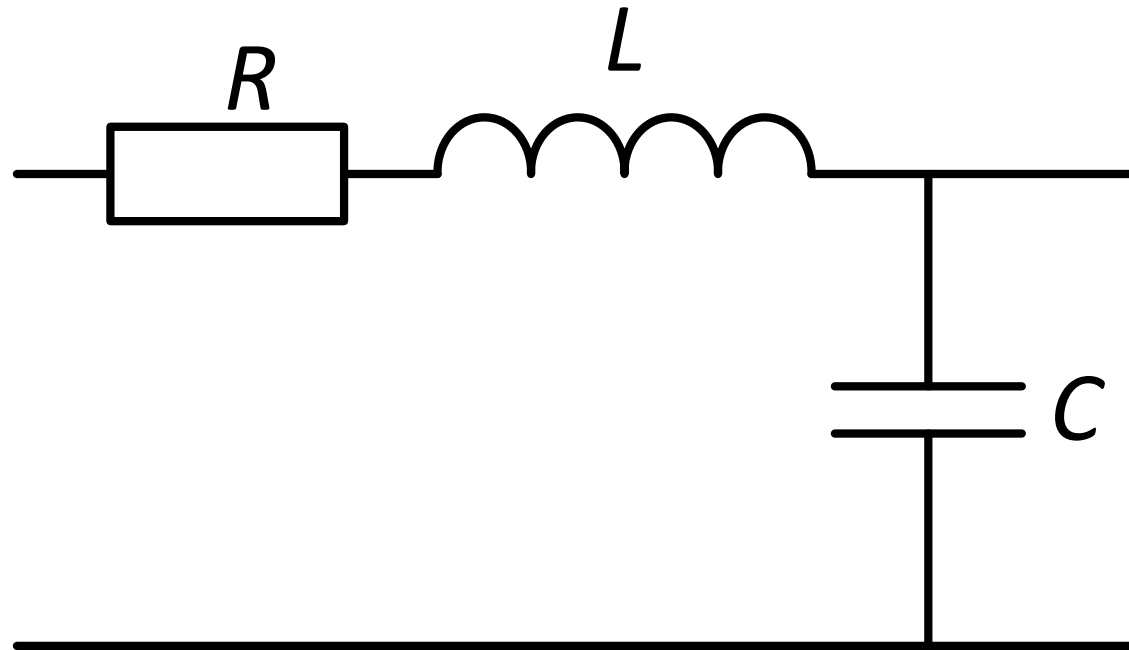
$$I_{cm} = j\omega C_{cm} U_{dm}$$

Izbira optimalne strukture plasti PCB

- Izbira števila plasti
- Izbira funkcije posamezne plasti



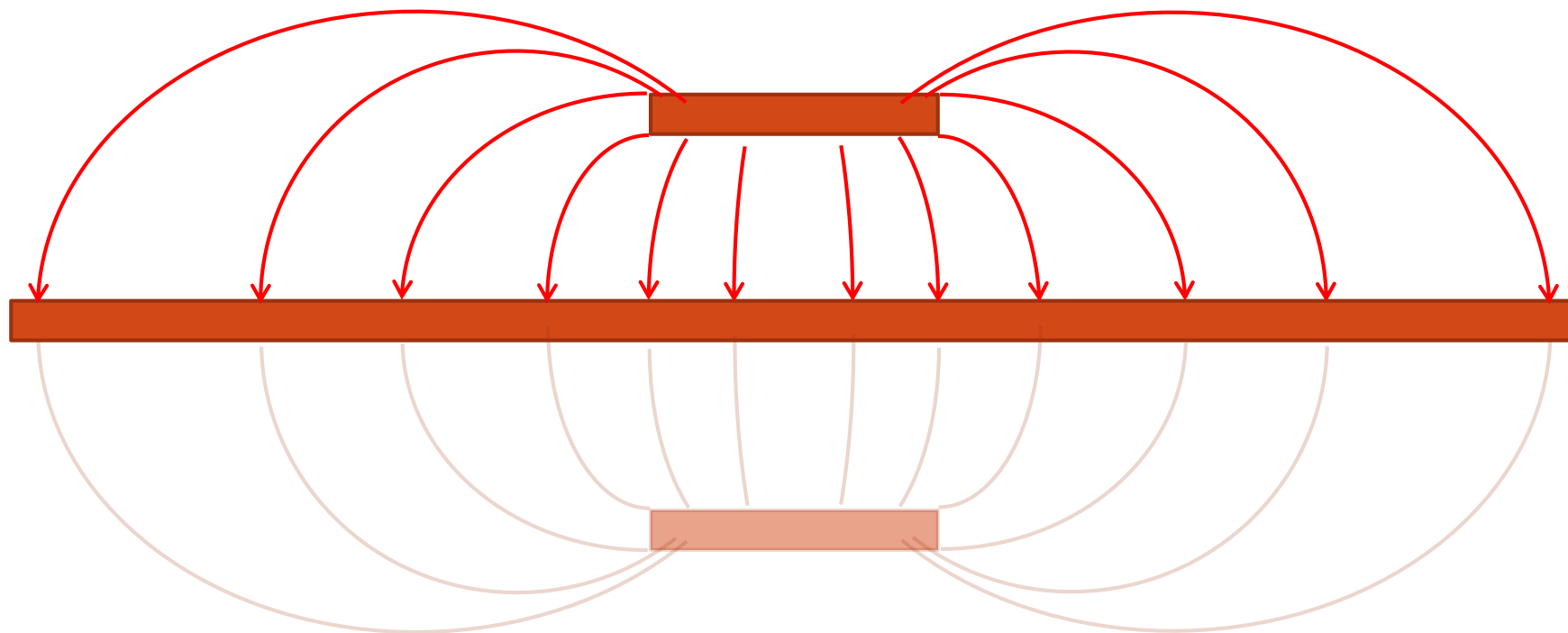
Linije na PCB



$$Z = R + j\omega L + \frac{1}{j\omega C}$$

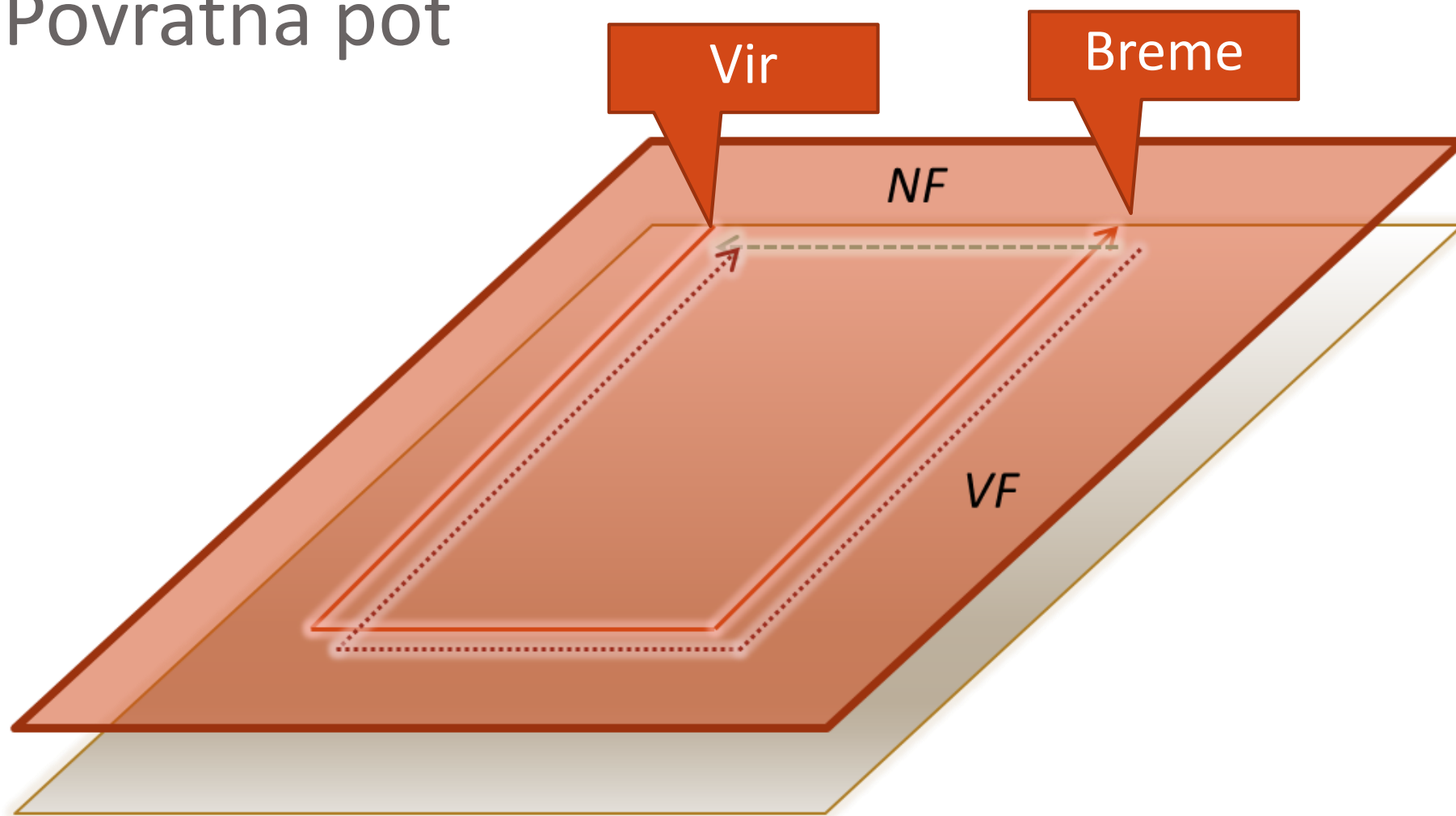
$$|Z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

Zrcalna ravnina



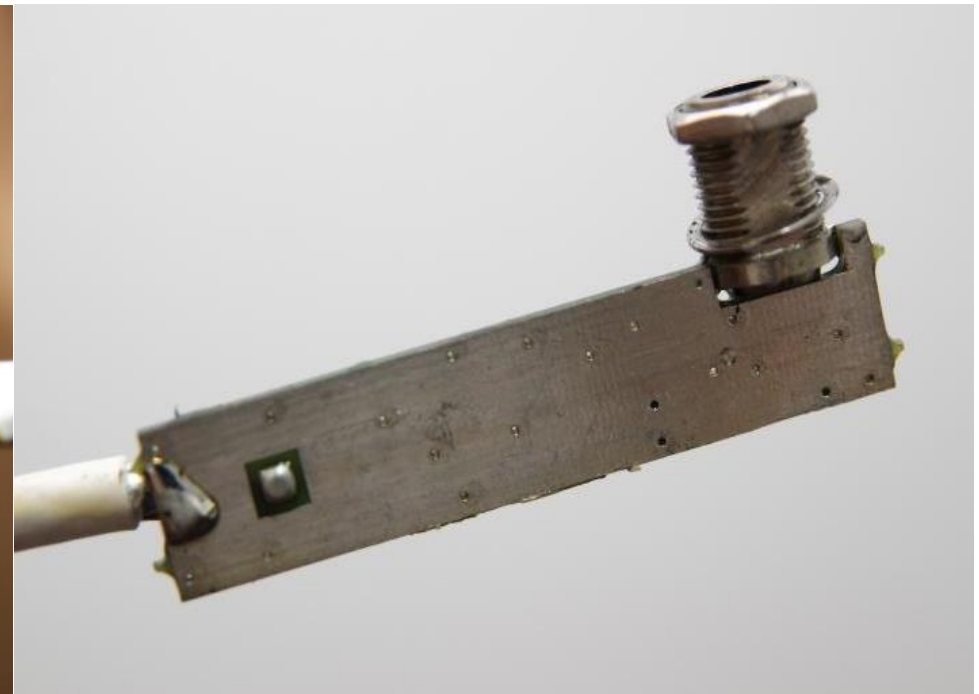
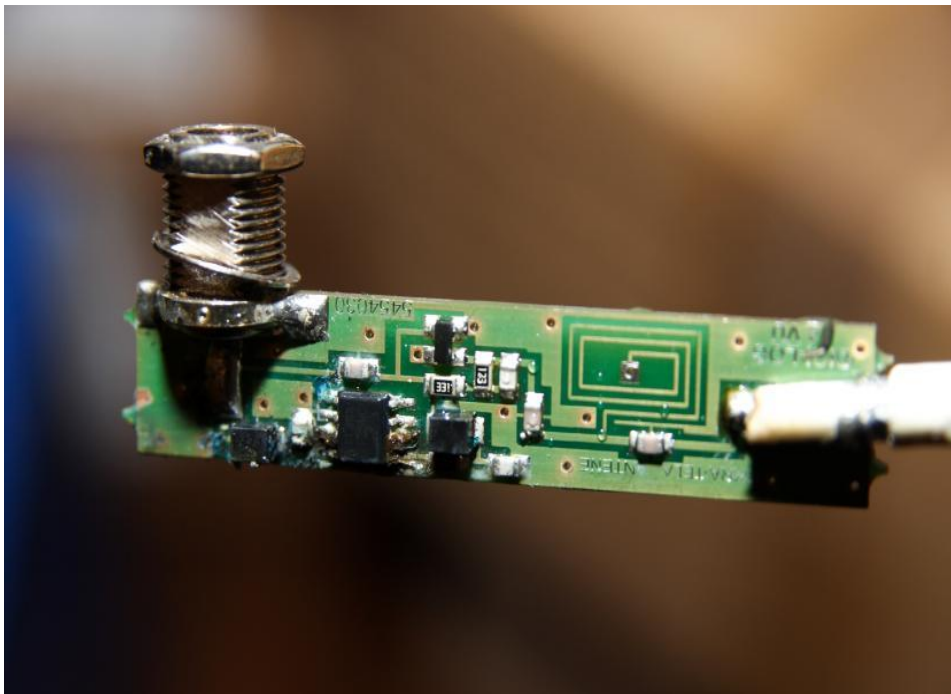
navidezna zrcalna slika

Povratna pot

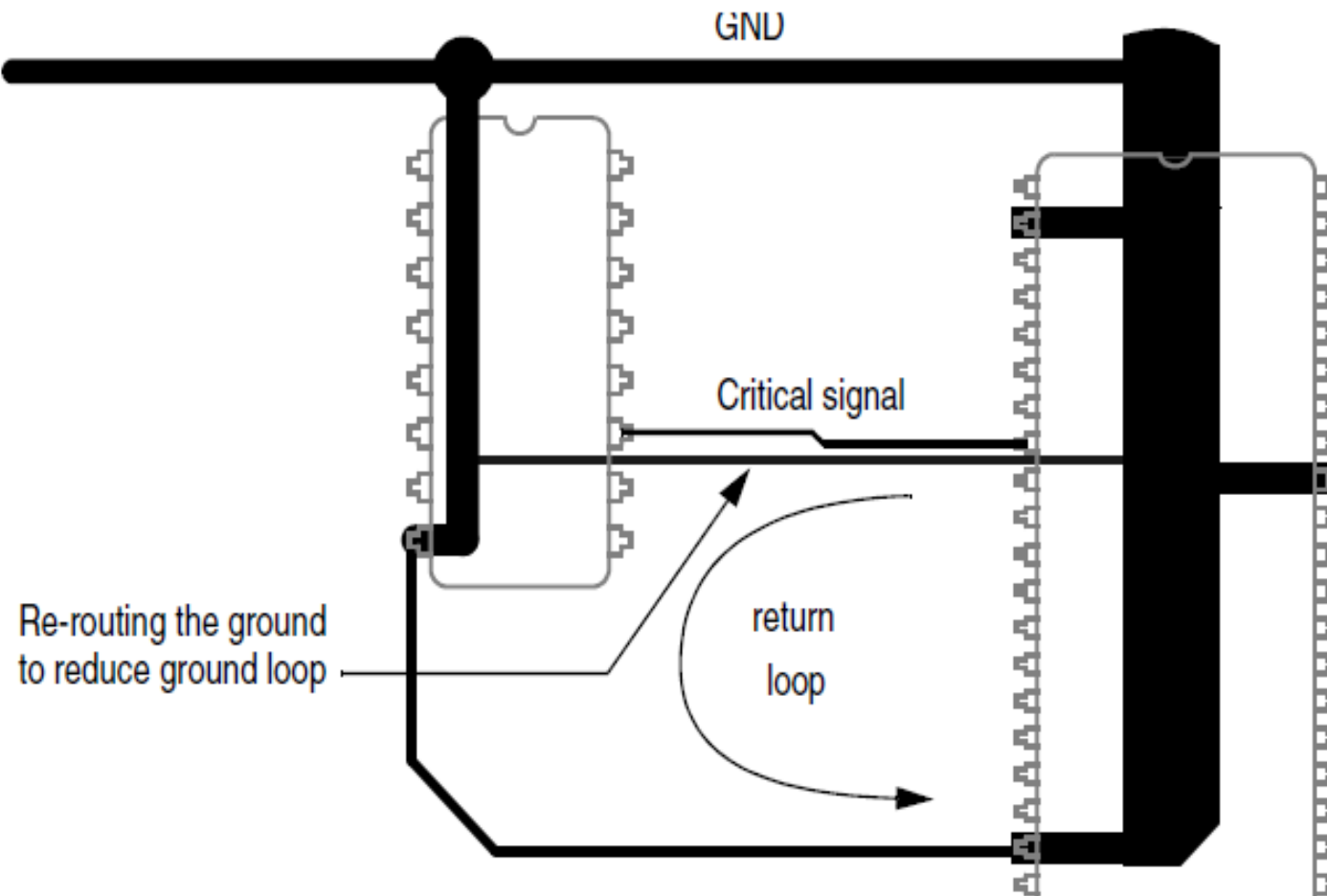


Dvoplastno vezje z zrcalno ravnino

- Primer: DVBT antenski ojačevalnik

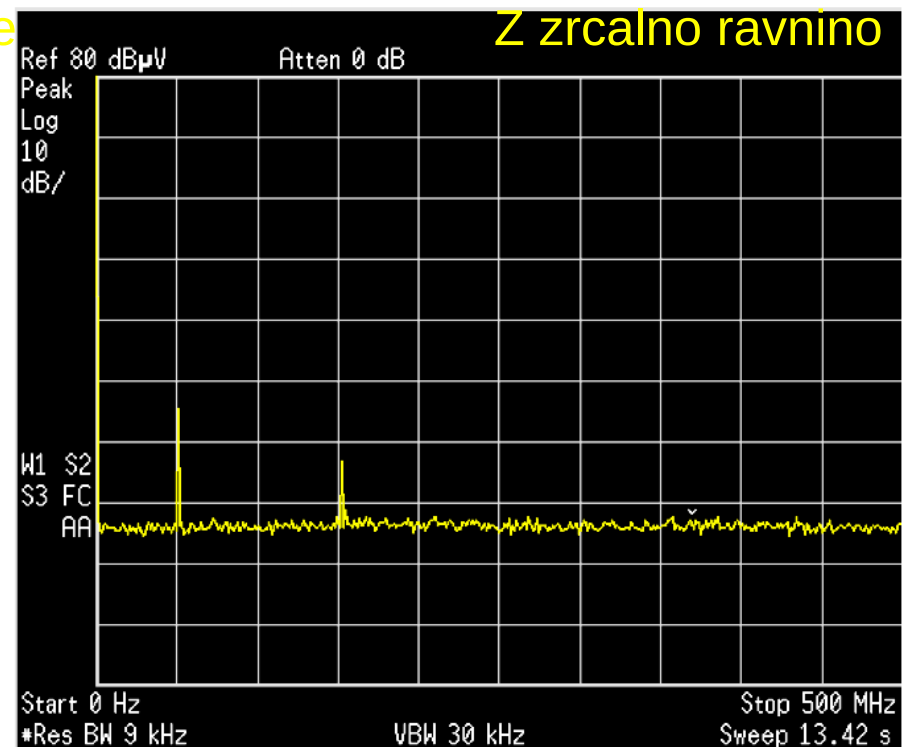
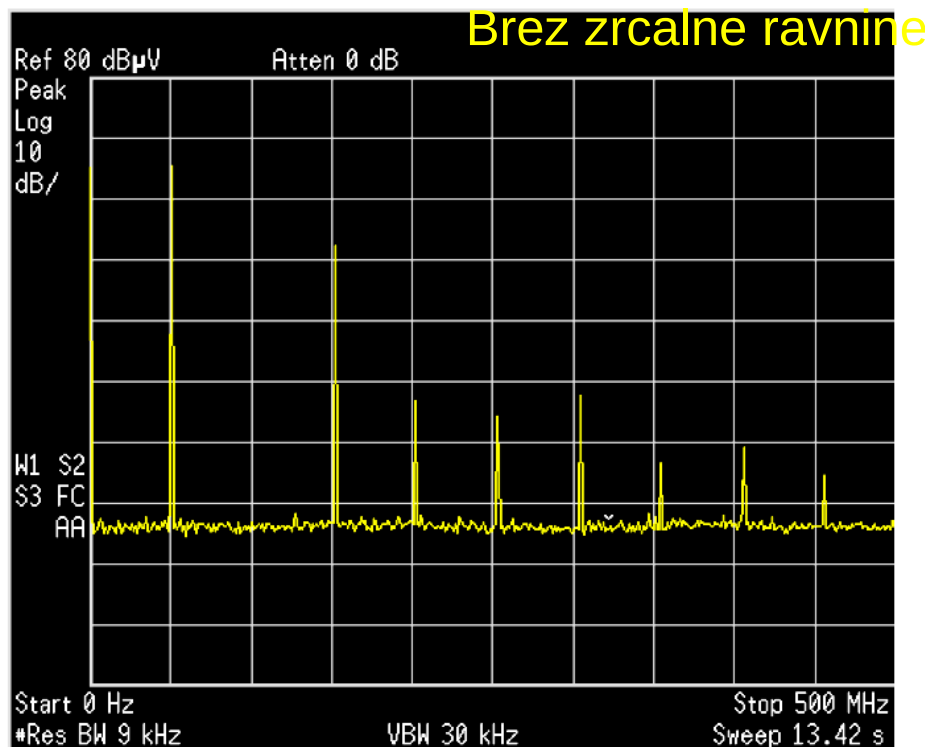


Povratna signalna pot

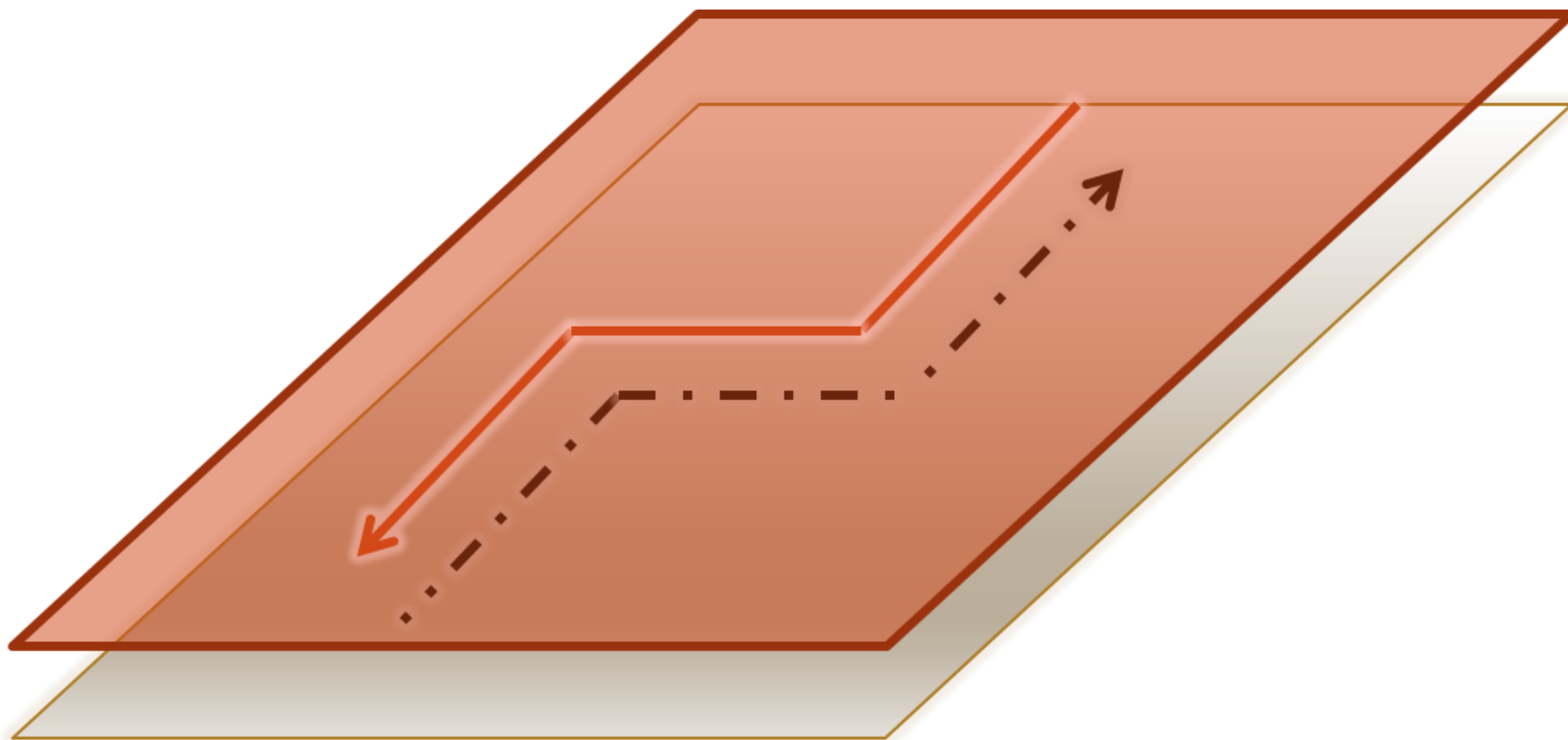


Primer sevanja linije s 50 MHz signalom

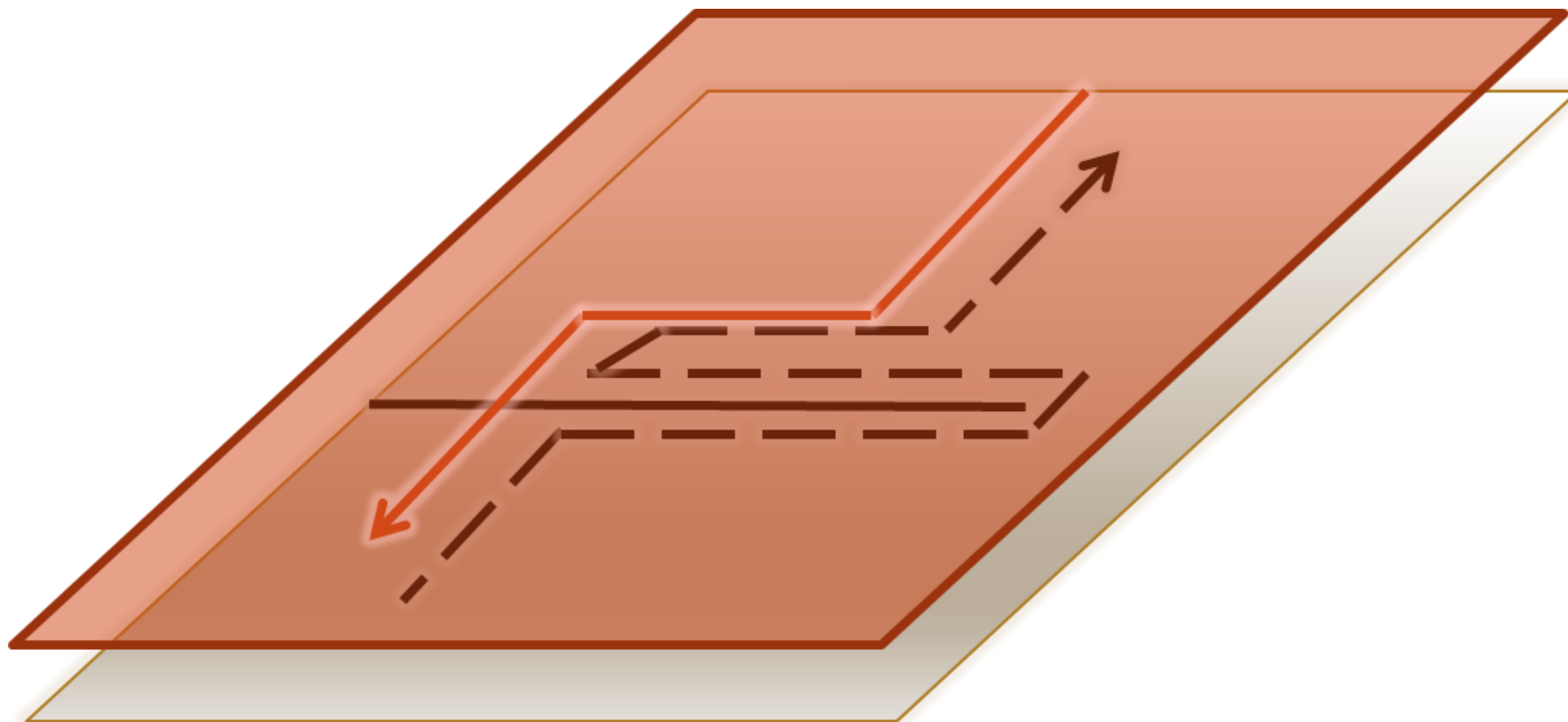
- PCB FR4, debeline 1.5 mm
- Linija dolga 10 cm, širine 1.2 mm
- Signal 50 MHz, dvižni čas 4ns, amplituda 3 V
- Meritev jakosti E polja 5 cm nad linijo



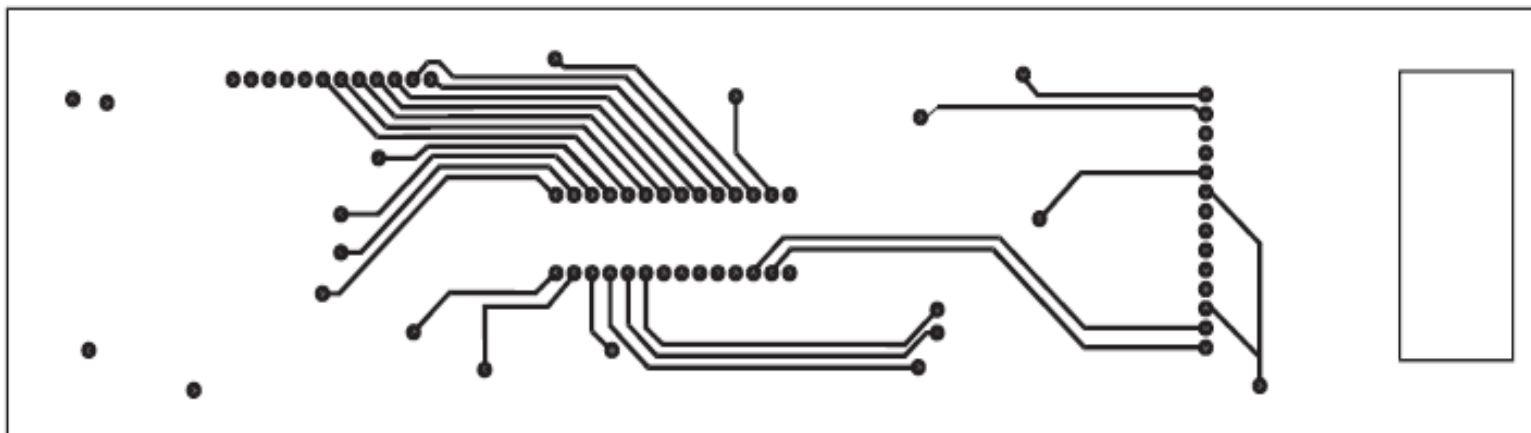
Neprekinjena zrcalna ravnina



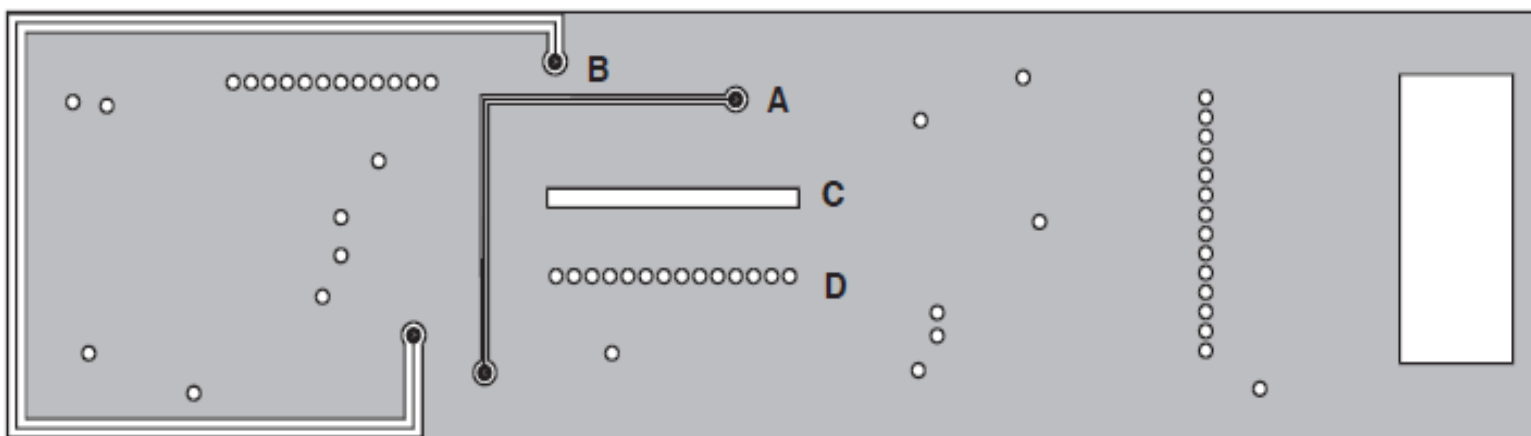
Prekinitev zrcalne ravnine



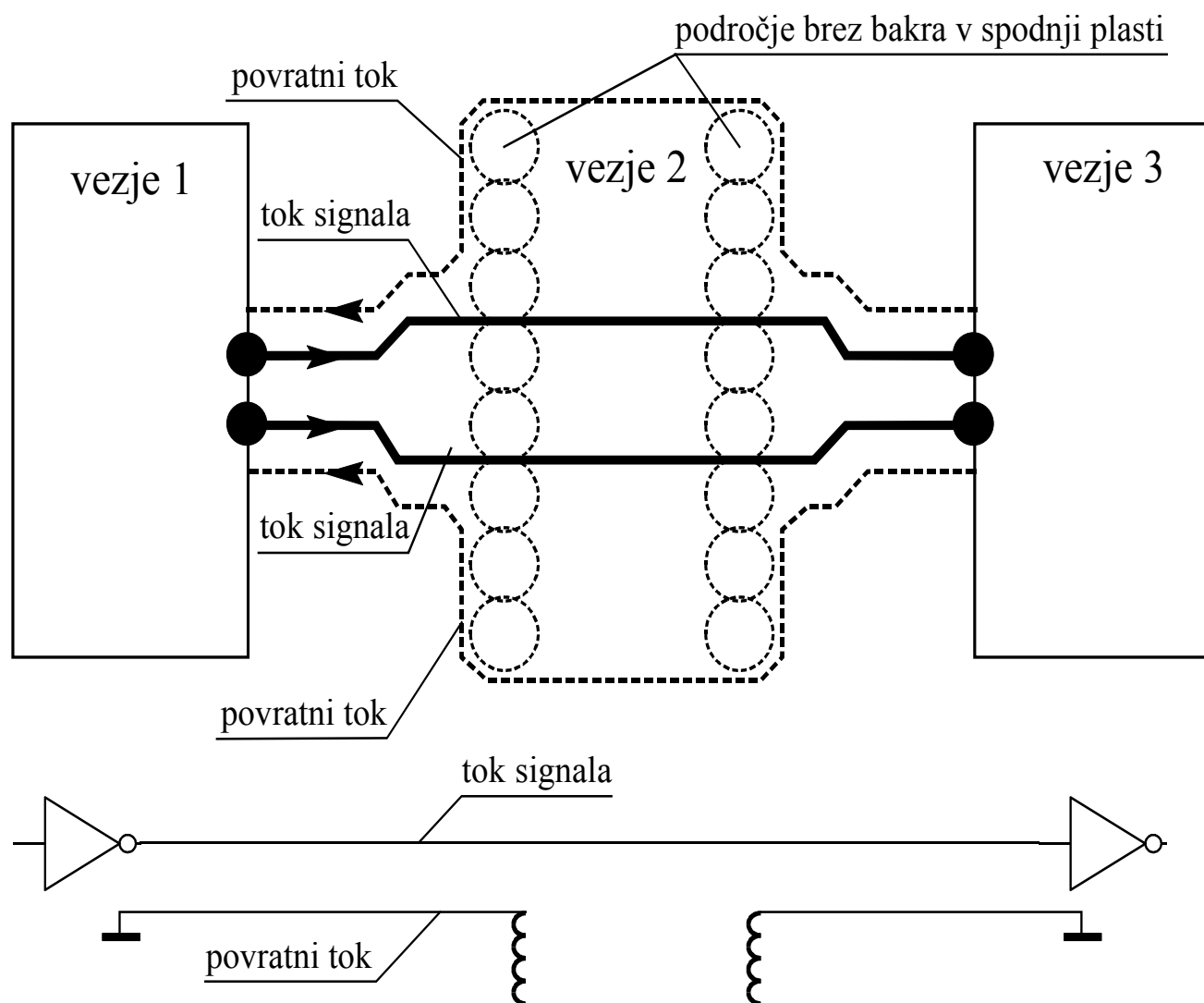
Prekinitev zrcalne ravnine



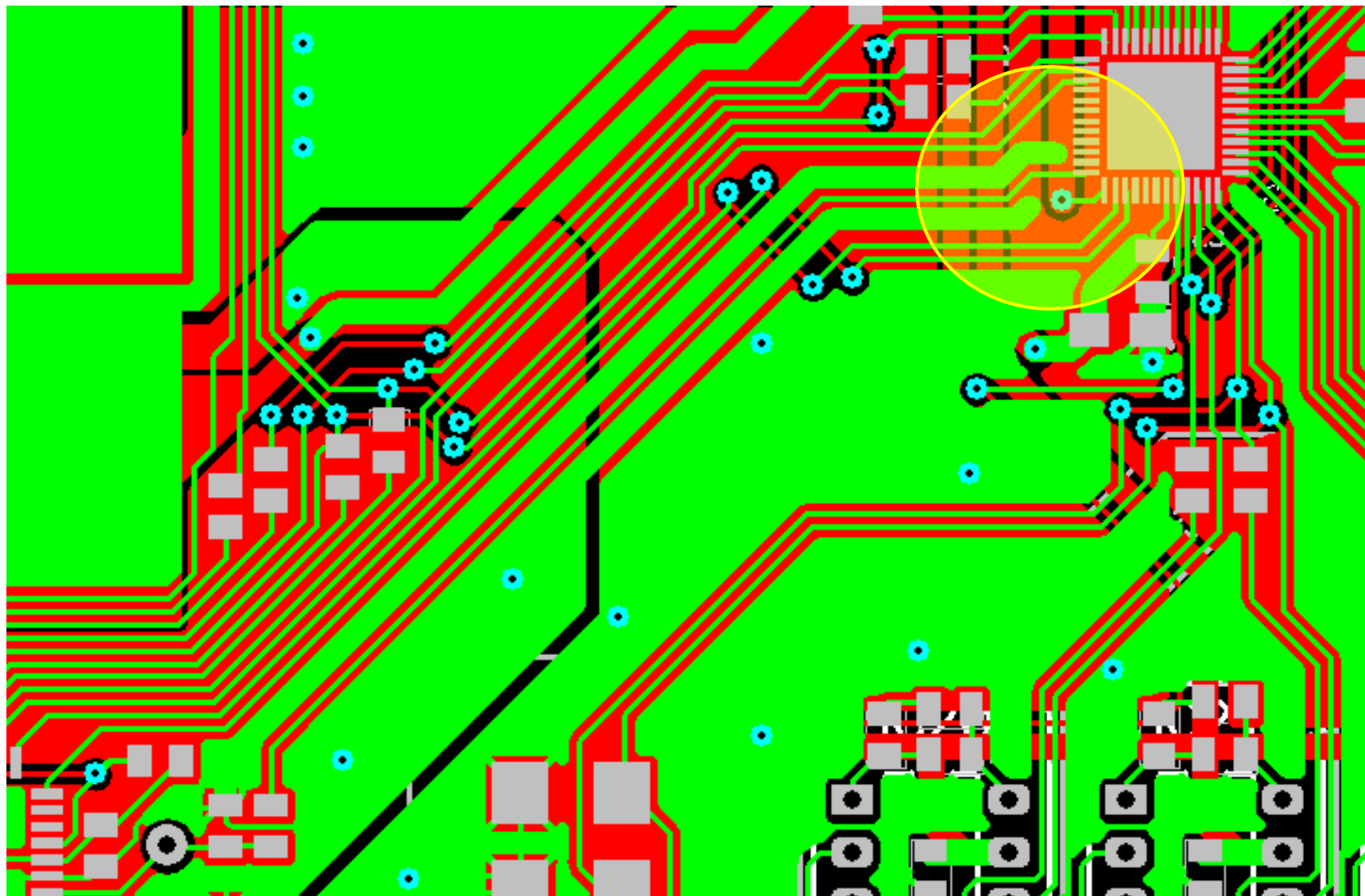
Ground Plane



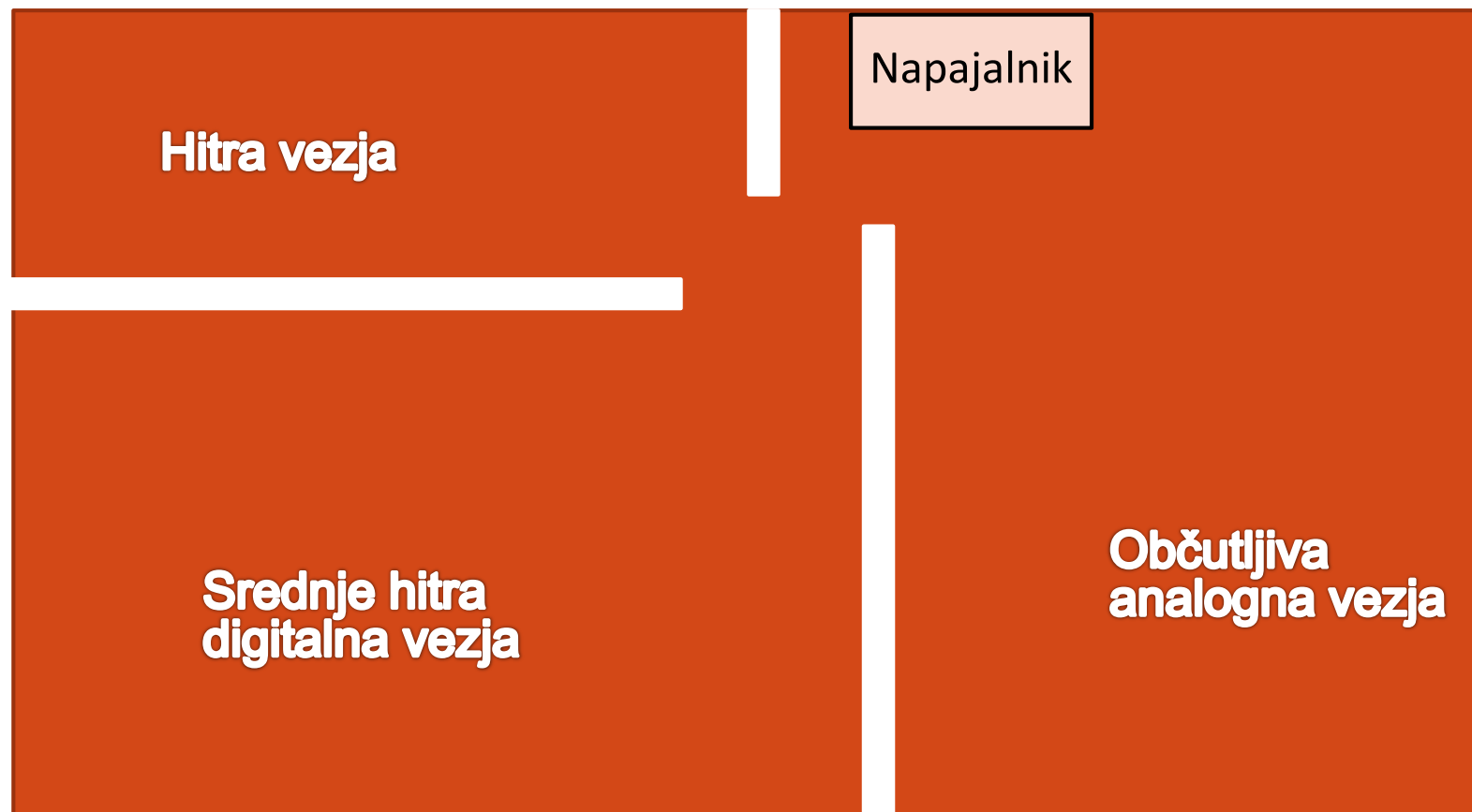
Prekinitev zrcalne ravnine zaradi izvrtin



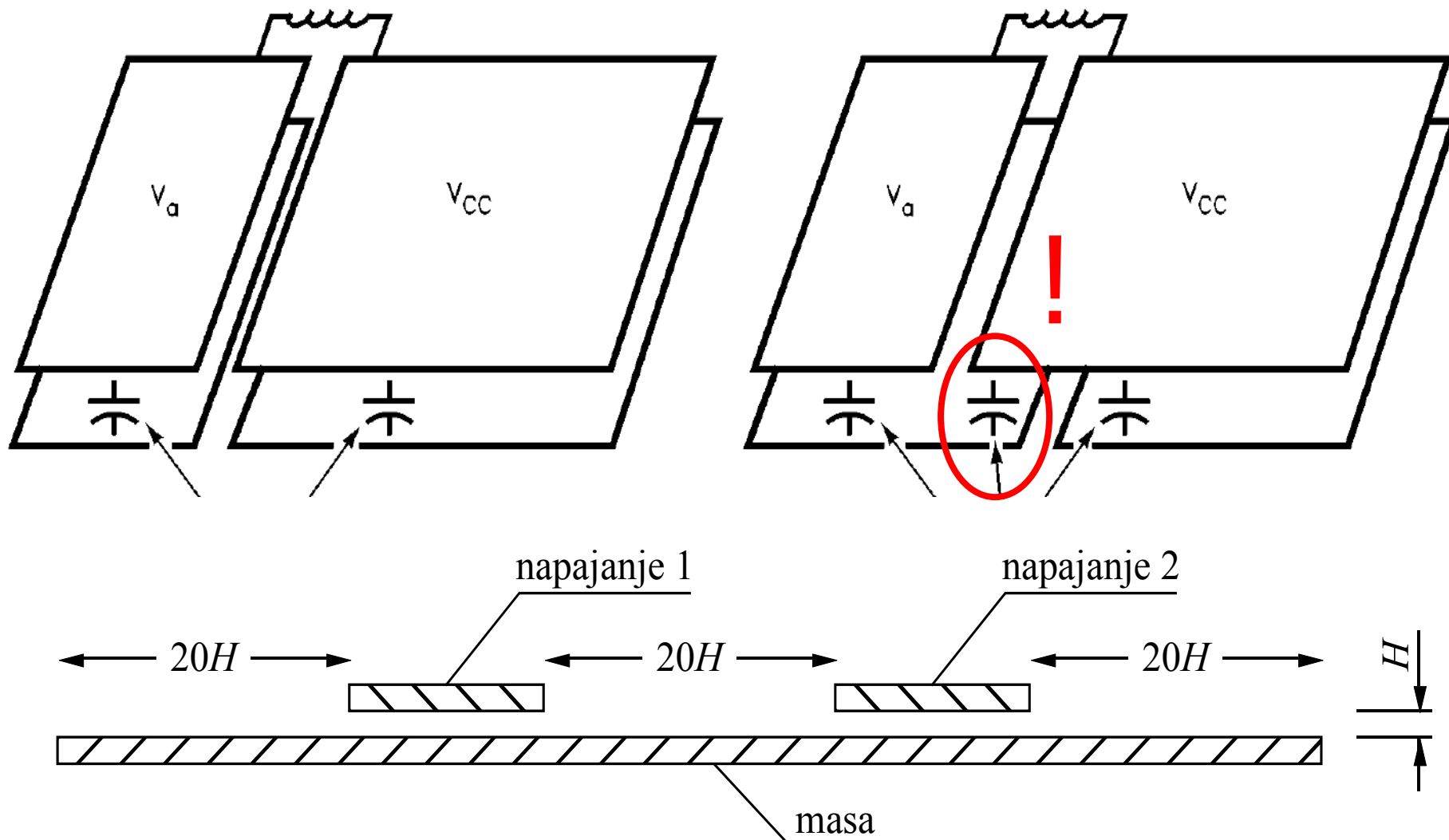
Primer prekinjene zrcalne ravnine



Segmentacija zrcalne ravnine

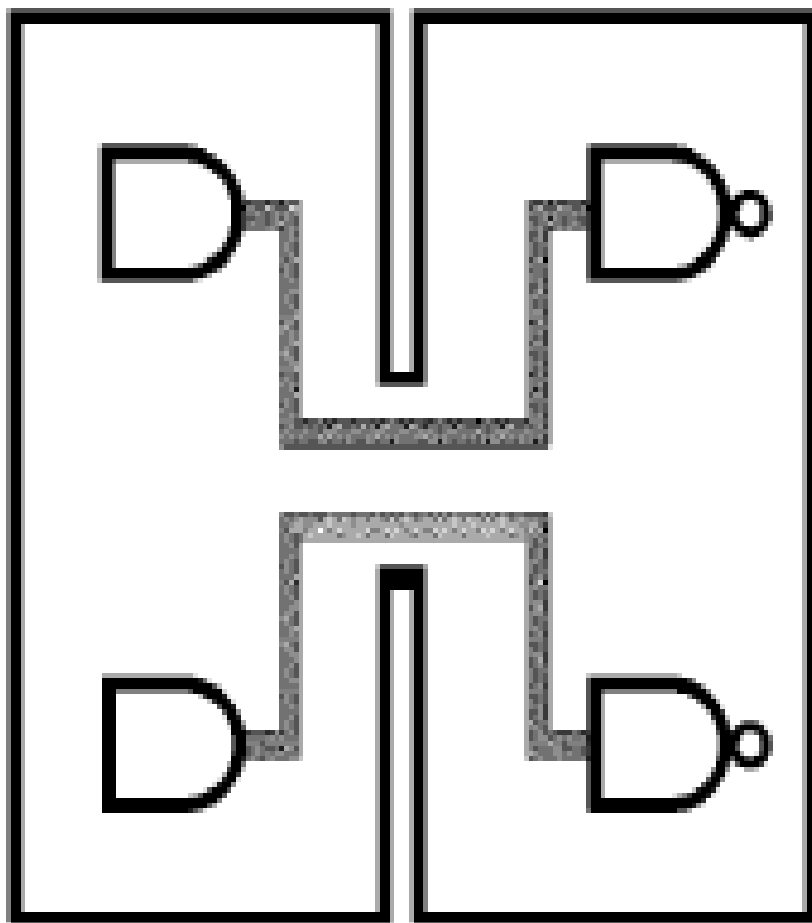


Ločitev zrcalnih ravnin

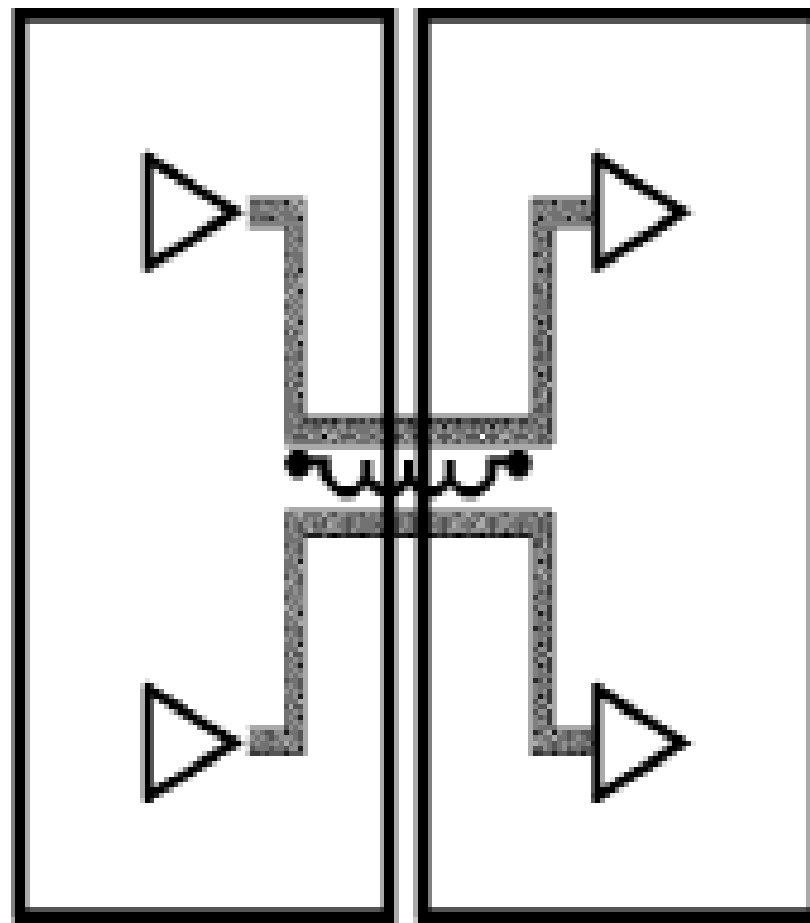


Signalne povezave med otoki

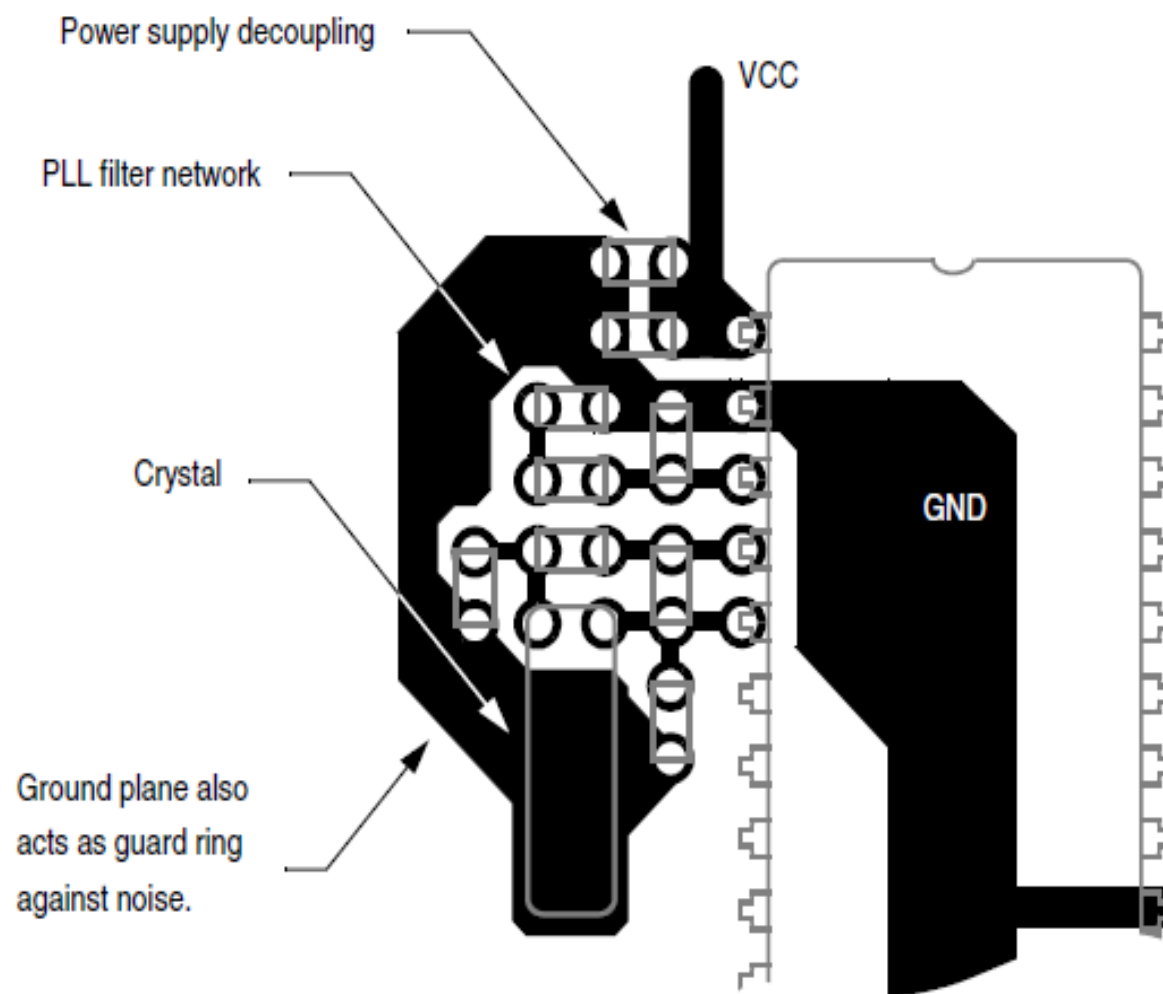
Visokofrekvenčne povezave



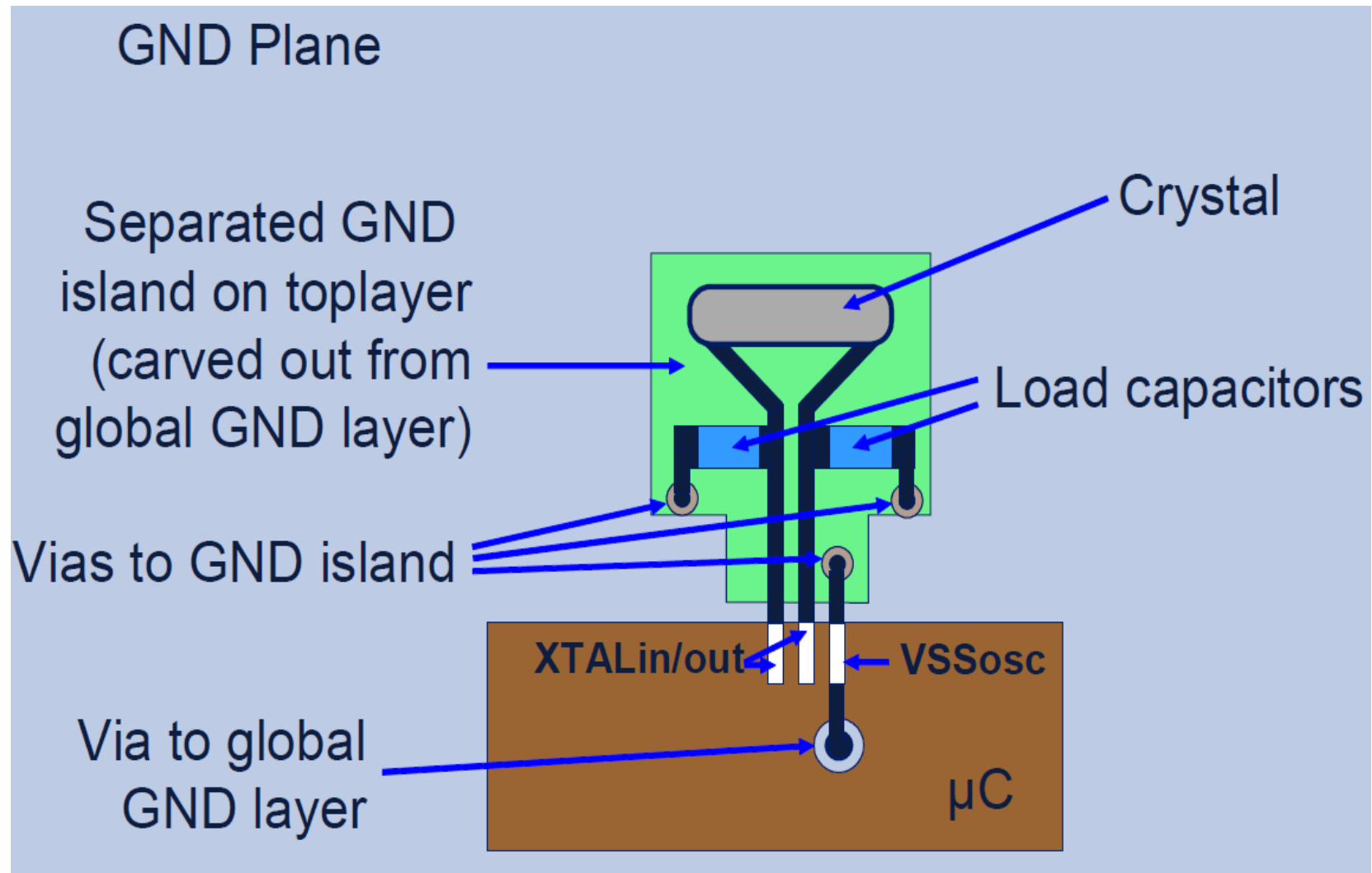
Nizkofrekvenčne povezave



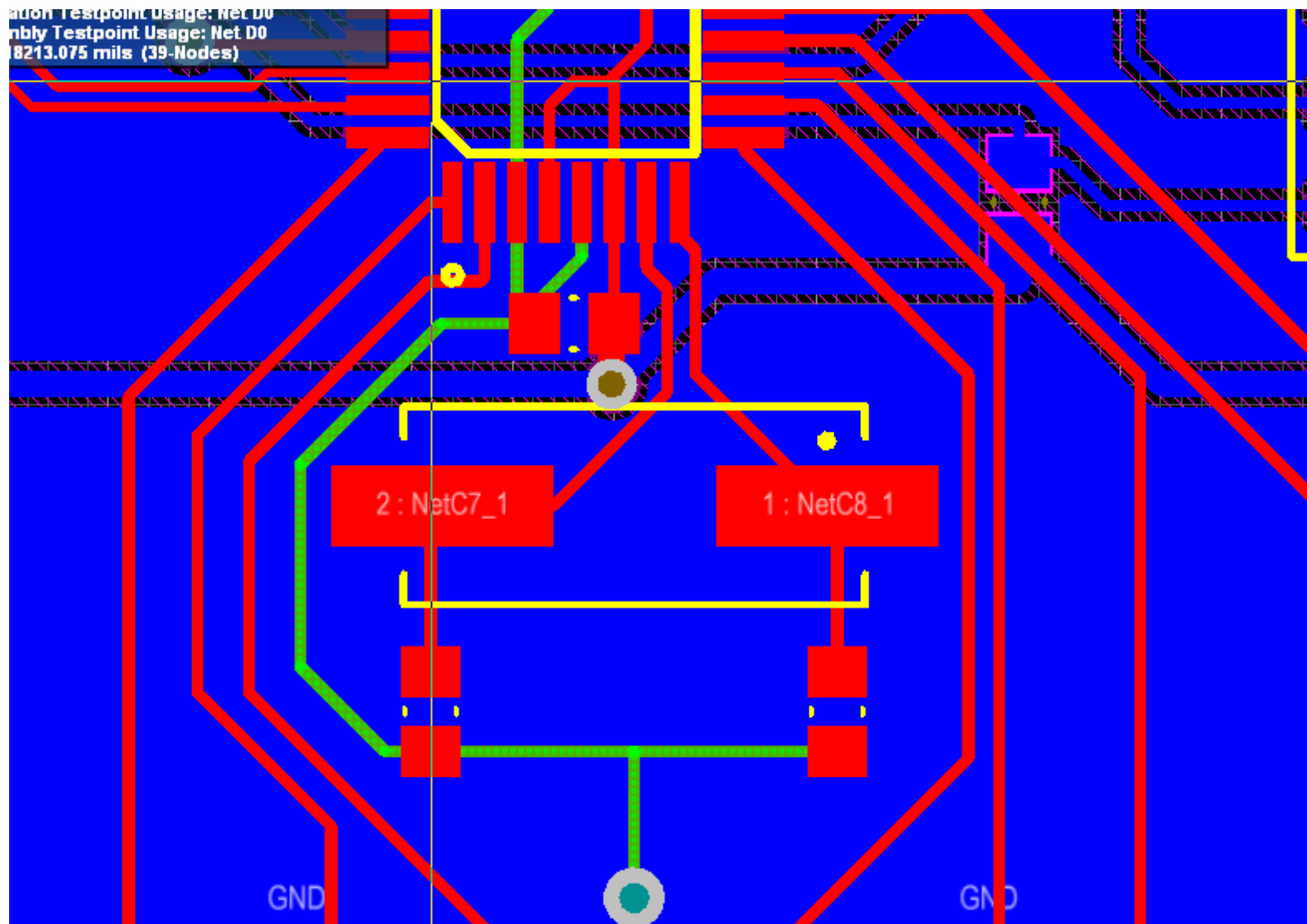
Zaščitni obroč (guard ring)



Primer priklopa oscilatorja



Primer napačnega priklopa oscilatorja



Popravek

