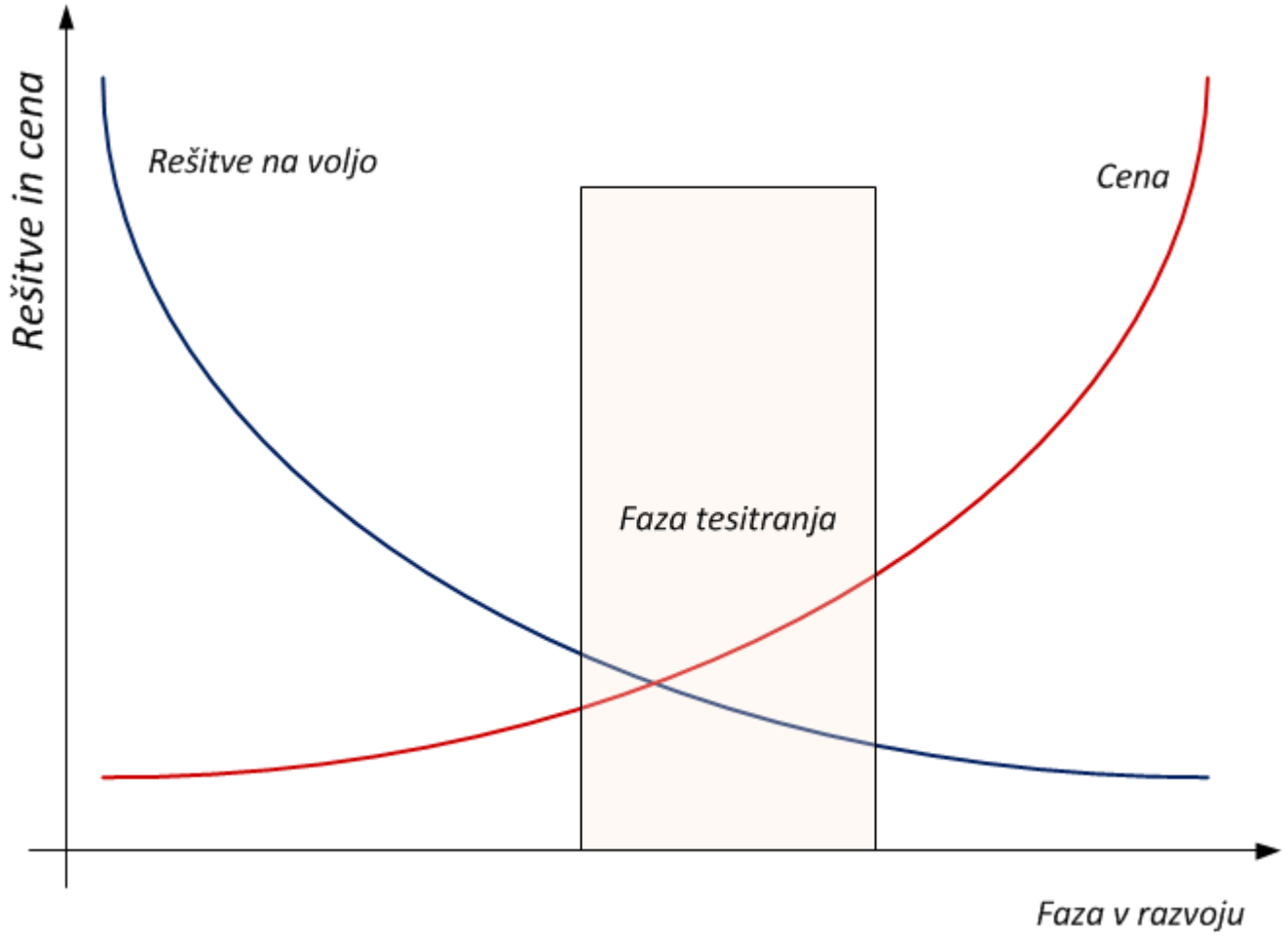
Seminar in delavnica
Načrtovanje elektronike za EMC

Elektromagnetna združljivost (EMC) 2

M. Jankovec

Doseganje EMC



Zakaj EMC?

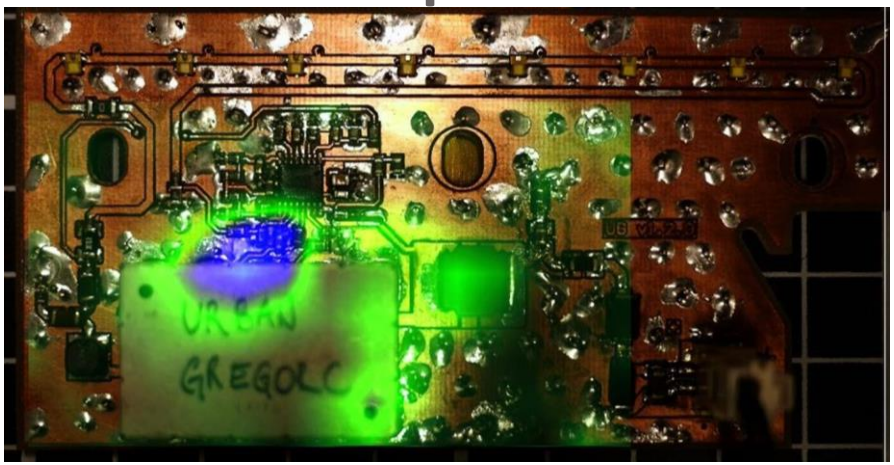
http://www.compliance-club.com/archive/old_archive/Bananaskins.htm

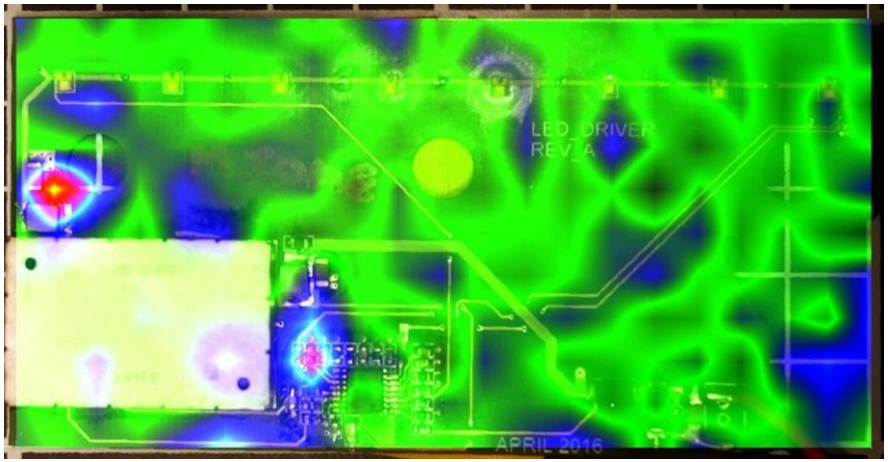
Resnica

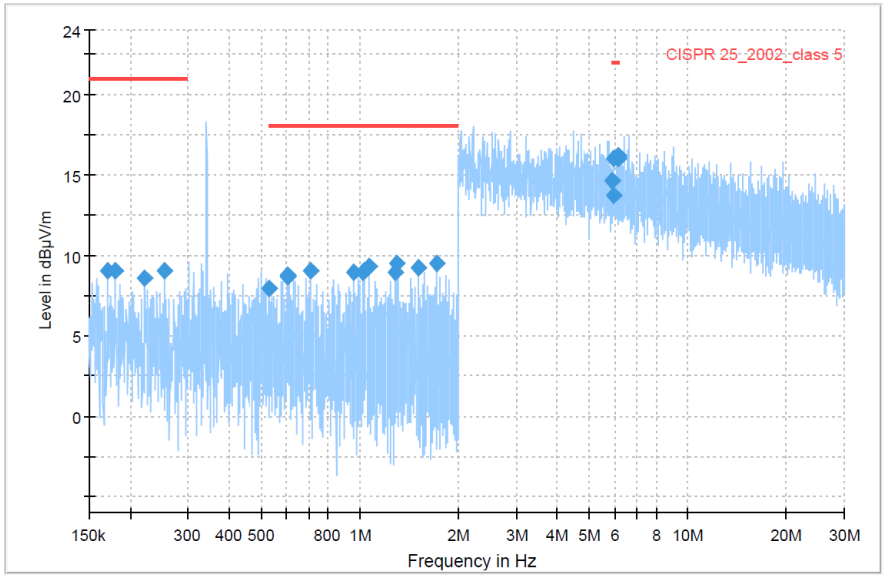
"Some of the worst printed circuit boards we've seen were designed by engineers who were trying to comply with a list of EMC design rules.„

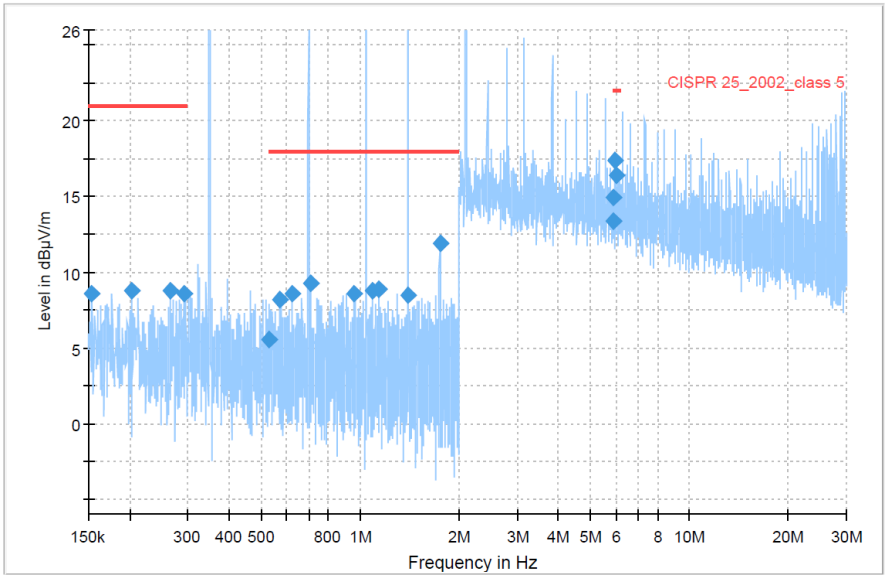
Todd Hubing

Resnica v praksi









http://lpvo.fe.uni-lj.si/izobrazevanje/seminarji/nacrtovanje-elektronike-za-emc/

Osnovna delitev EMC področja

Motnja/ emisija
- Prevodna (Conducted)
- Sevalna (Radiated)

Odpornost/ imunost
- Prevodna (Conducted)
- Sevalna (Radiated)

Model EMC

- Model, s katerim se prikaže elektromagnetne motnje, ima tri osnovne gradnike:
  - **izvor** sevanja (motenj),
  - **sprejemnik**,
  - **povezava** med izvorom in sprejemnikom.

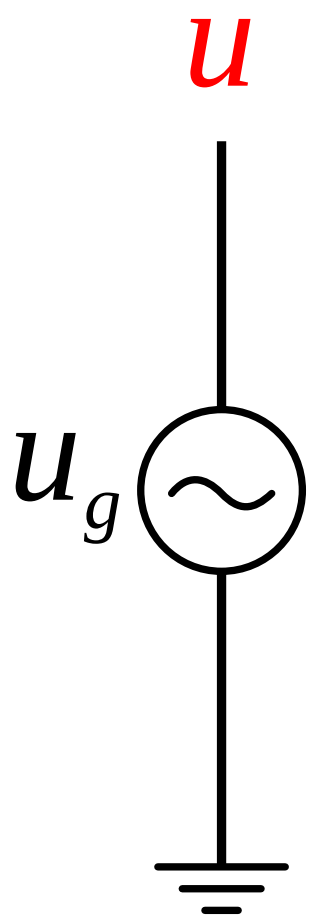
- Naravni
- Umetni
  - Namerni
  - Nenamerni

- Prevodne
- Električno polje
- Magnetno polje
- Elektromagnetno polje

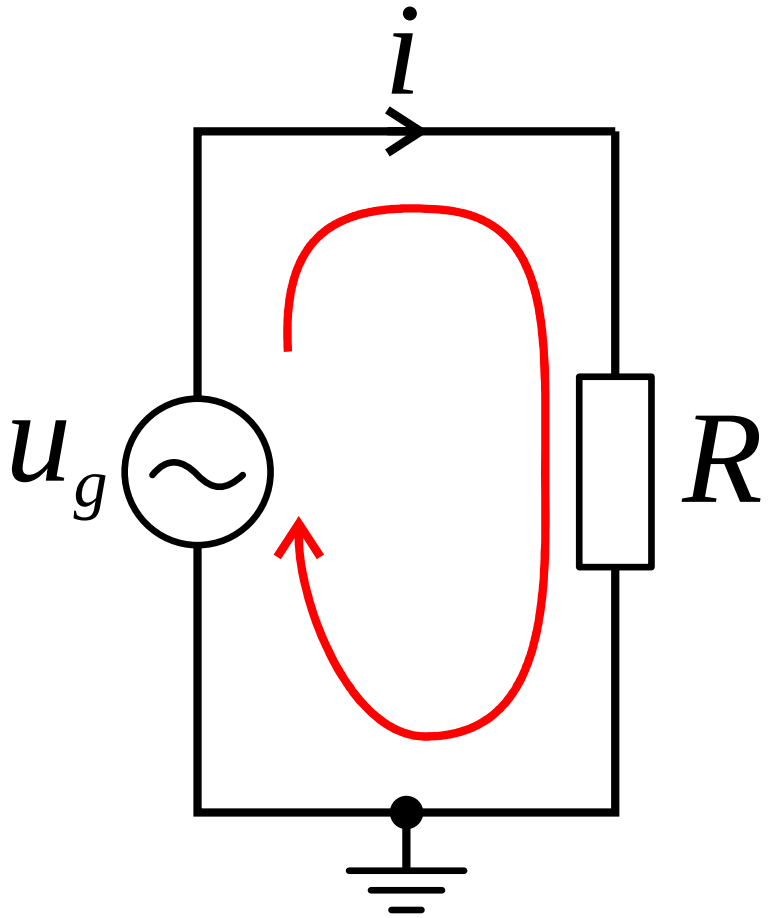
- Biološke
- Umetne

Izvori motenj

VF potenciali

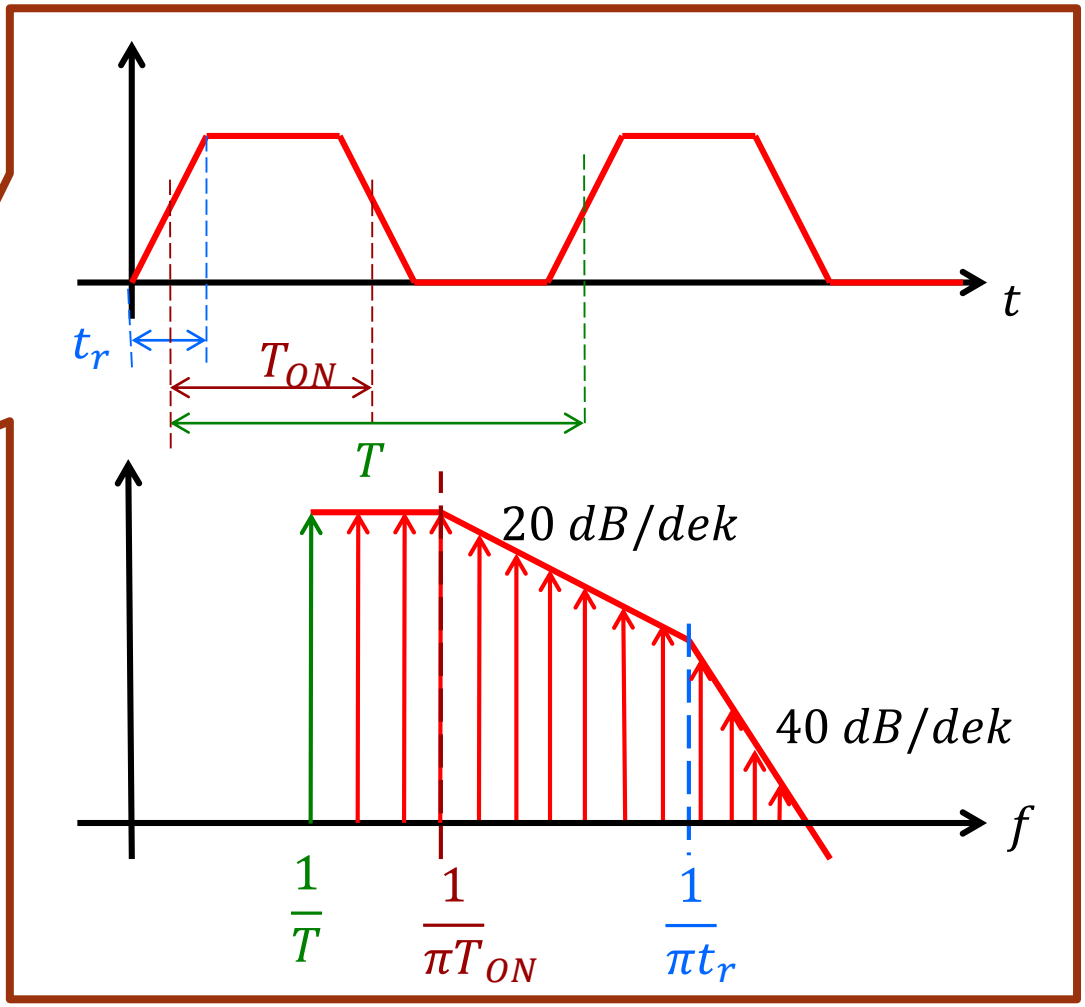


VF tokovne zanke

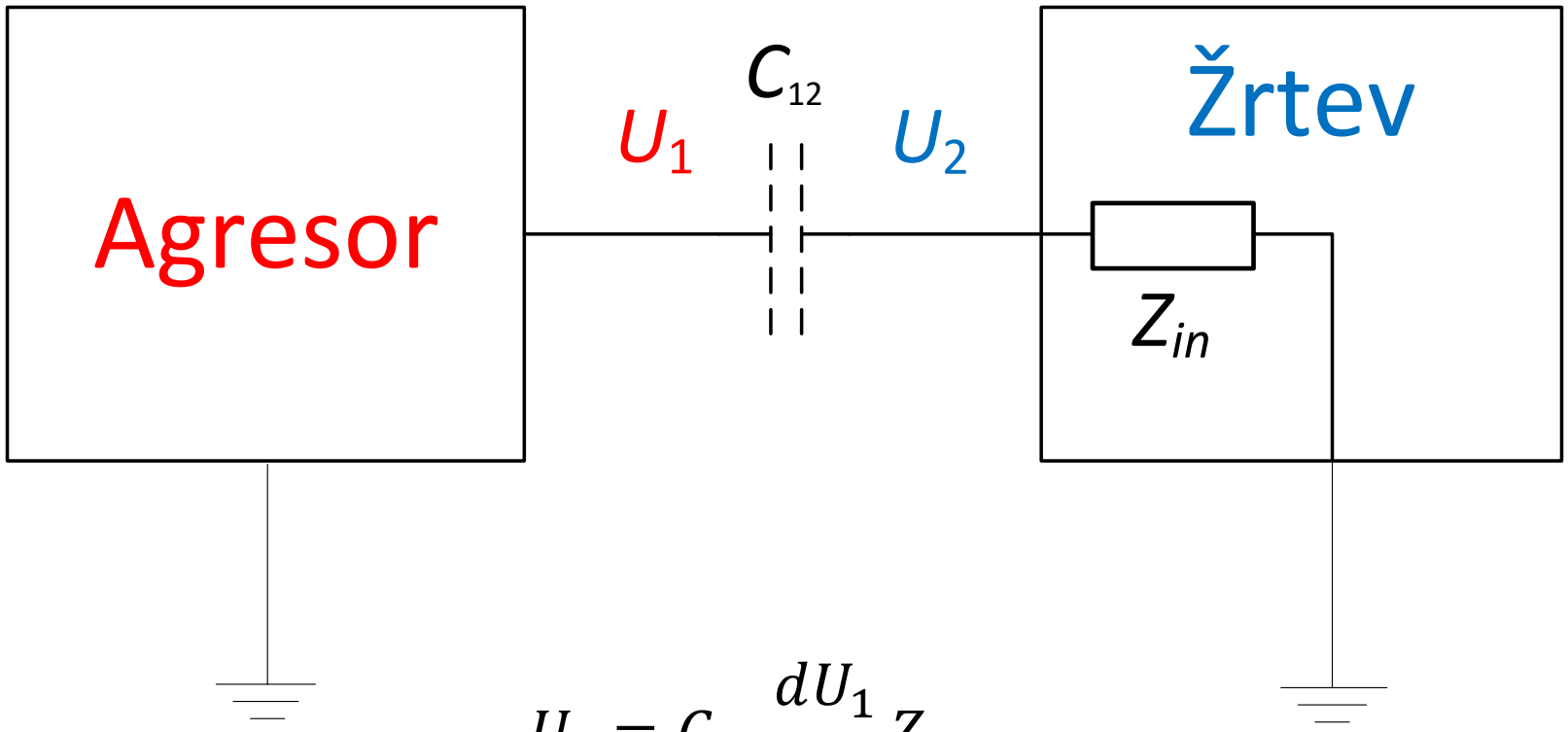


Izvori motenj

- Vprašanja:
  - Kje teče tok?
  - Kje so napetostna nihanja?
  - Kakšna je frekvenčna vsebina toka, napetosti?

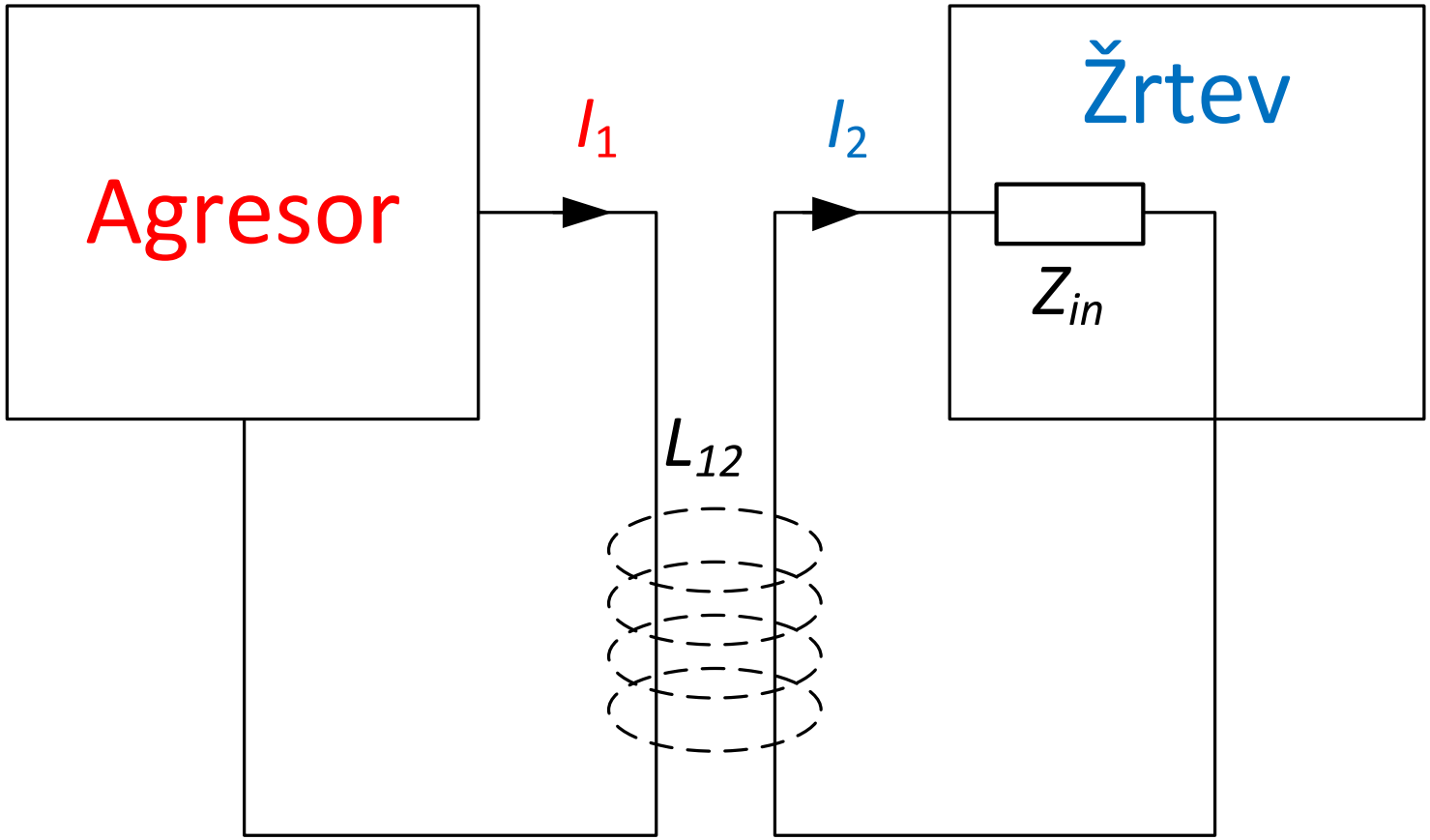


Kapacitivni prenos motenj (prek *E* polja)



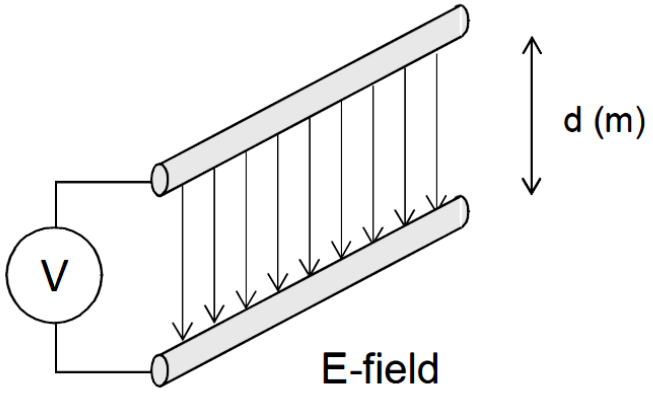
$$U_2 = C_{12}\frac{dU_1}{dt}Z_{in}$$

Induktivni prenos motenj (prek *H* polja)

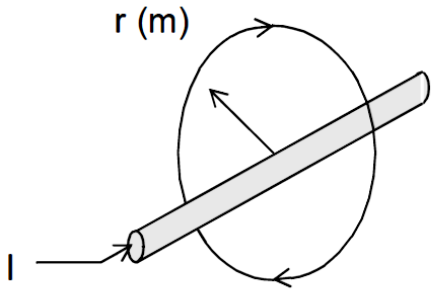


$$I_2 = -L_{12}\frac{dI_1}{dt}\frac{1}{Z_{in}}$$

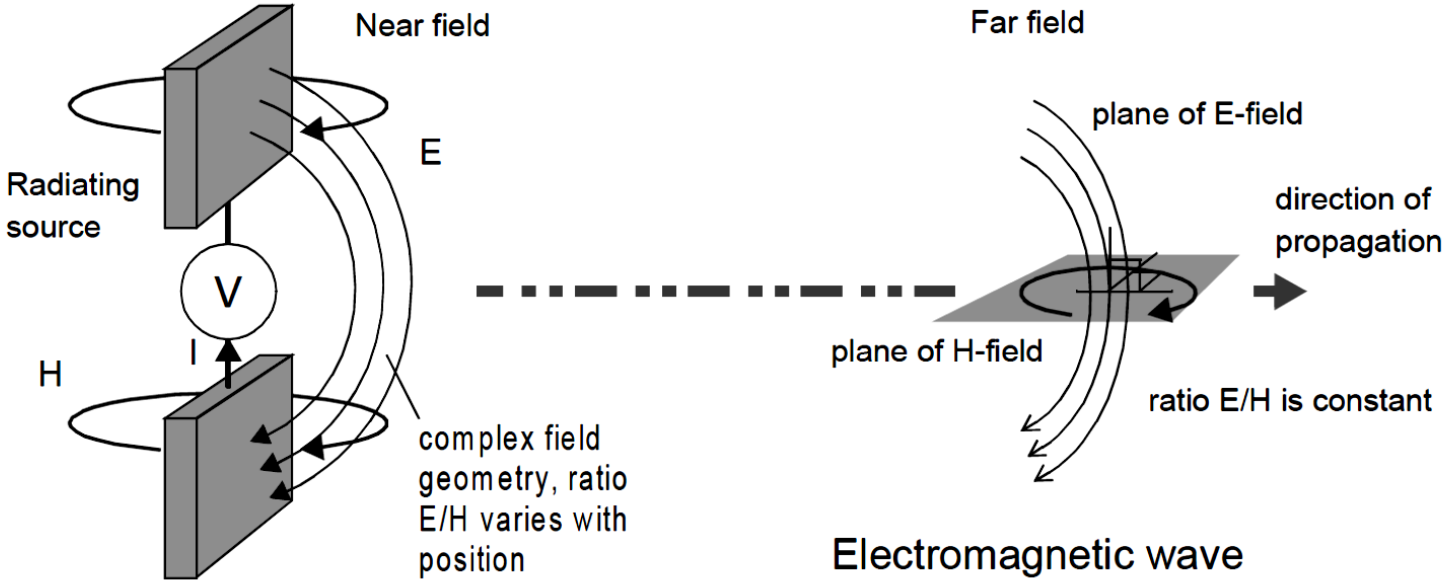
Prenos motnje preko EM polja



E-field



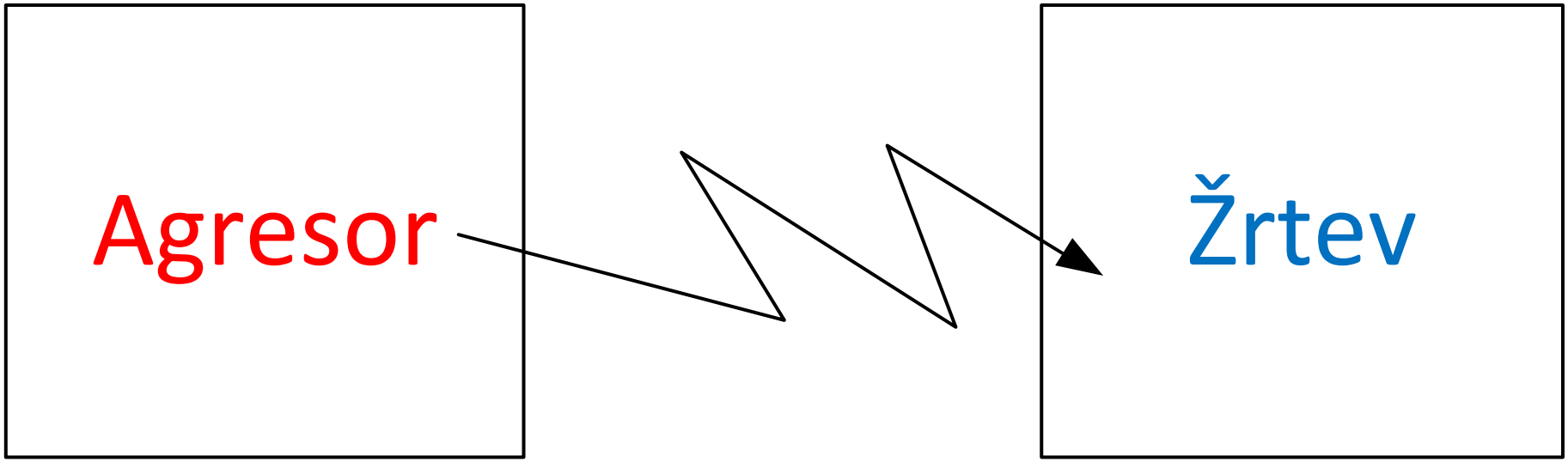
H-field



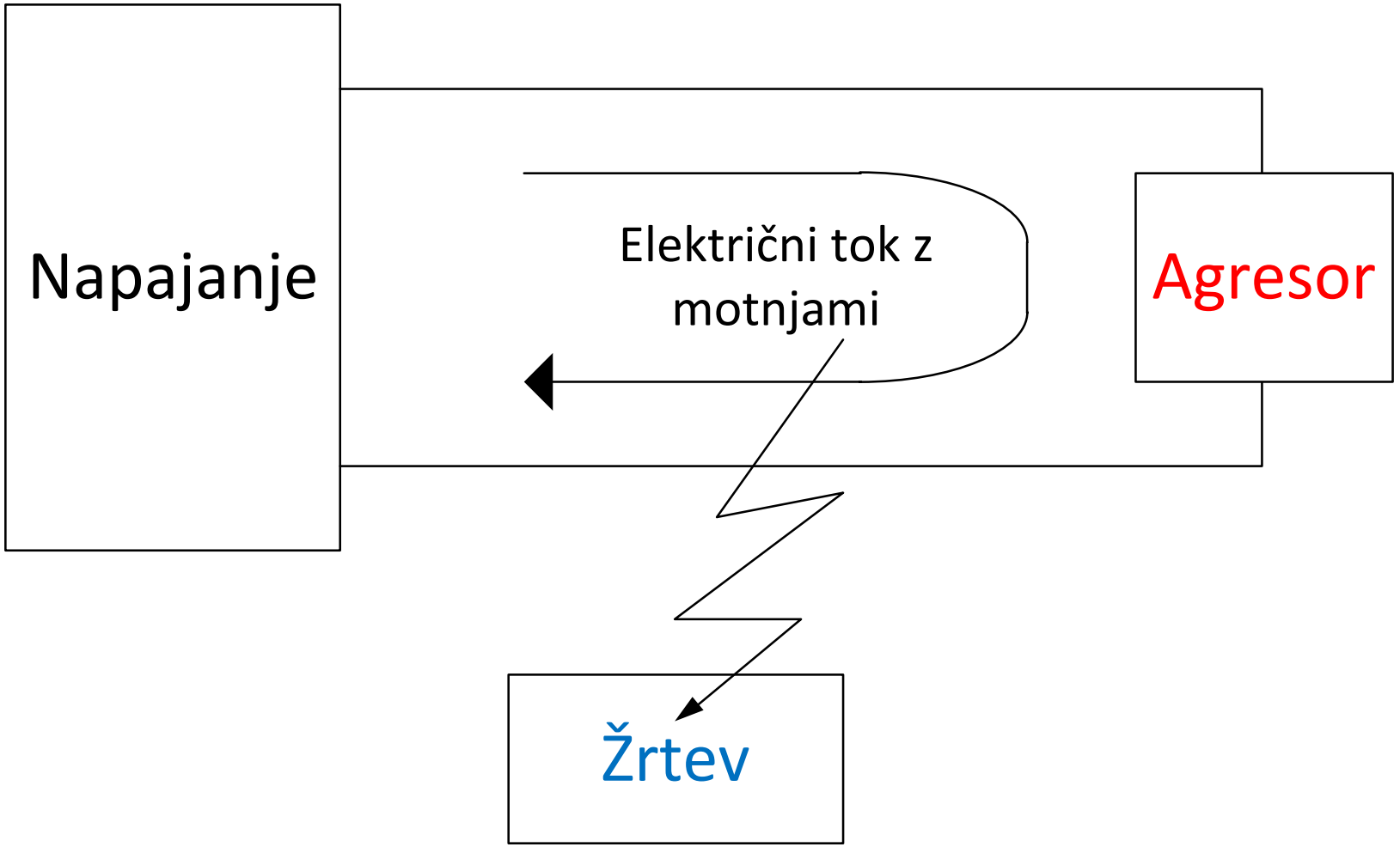
Electromagnetic wave

Tim Wiliams, EMC for product designers

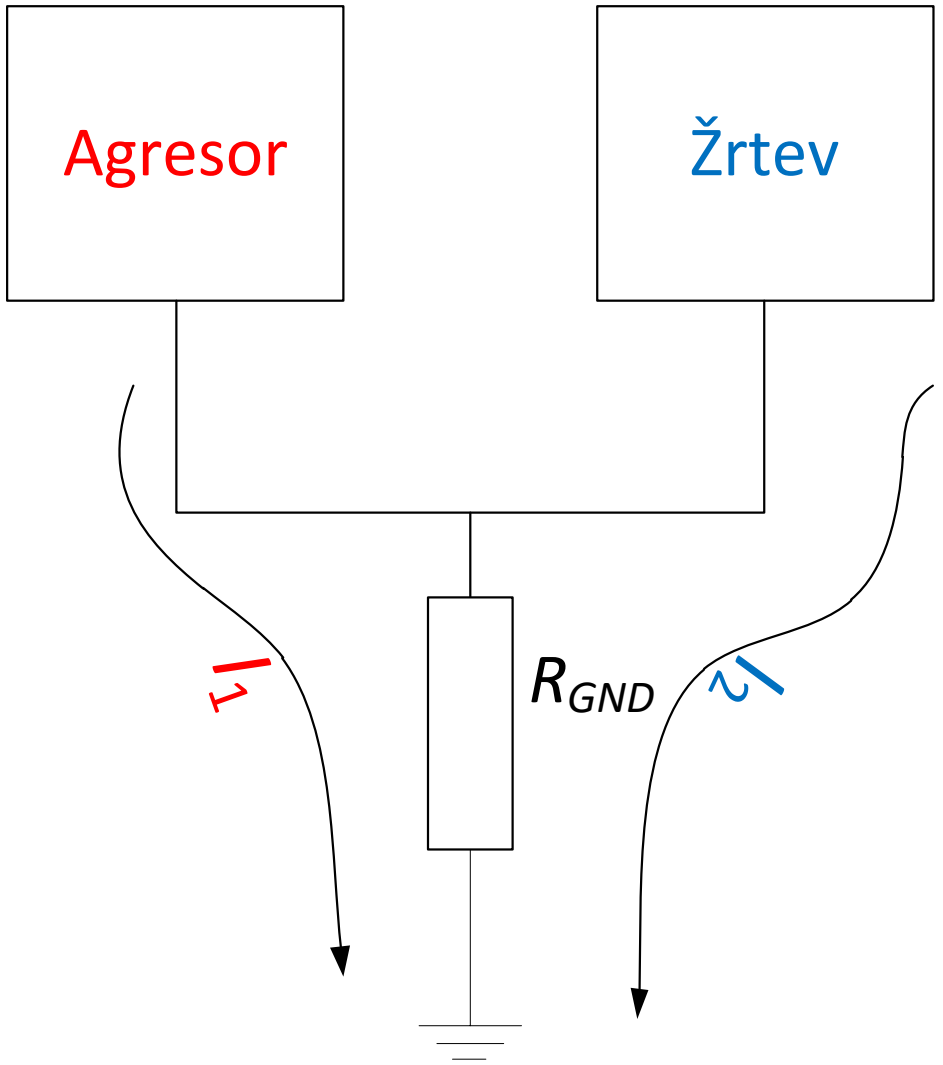
Prenos motnje preko EM polja



Prevodno-sevalni prenos motenj



Prevodni prenos motenj preko skupne mase

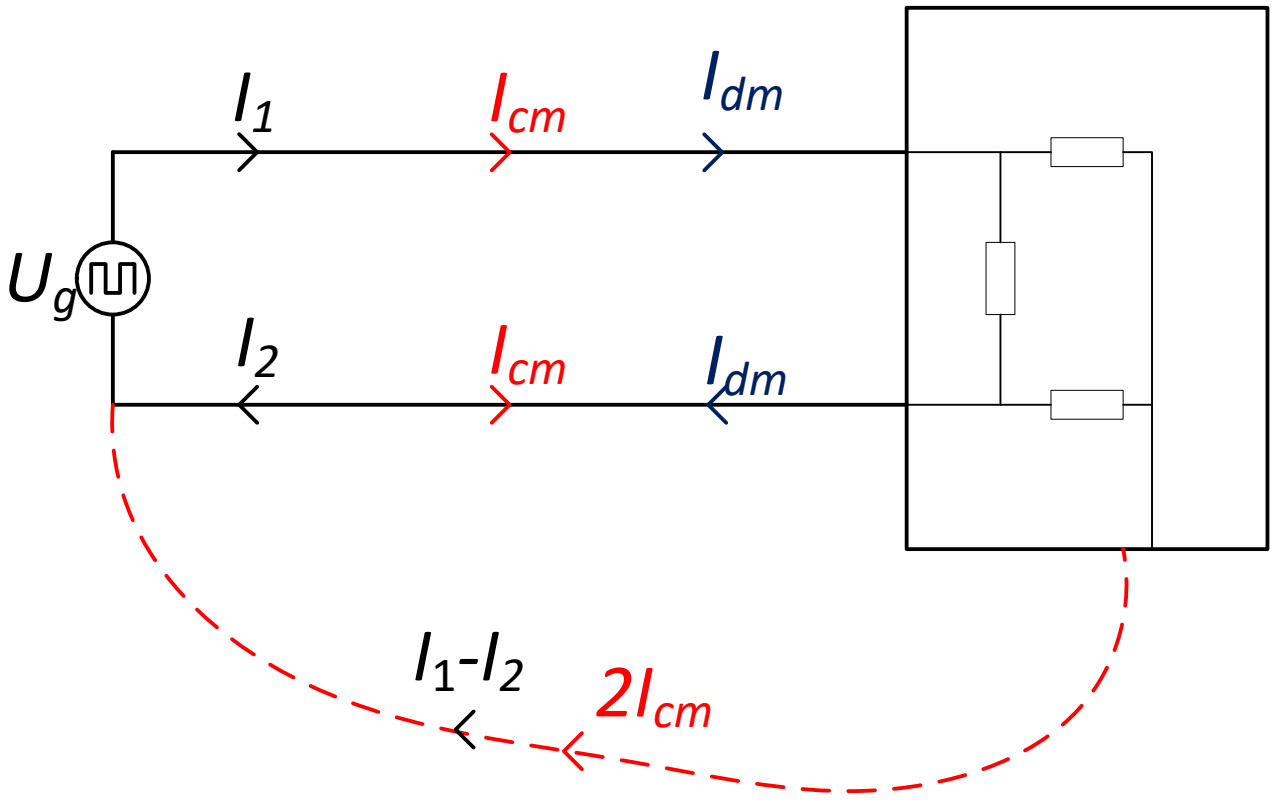


\+

$$U_{GND} = R_{GND} * (I_1 + I_2)$$

\-

Diferencialni in sofazni signali



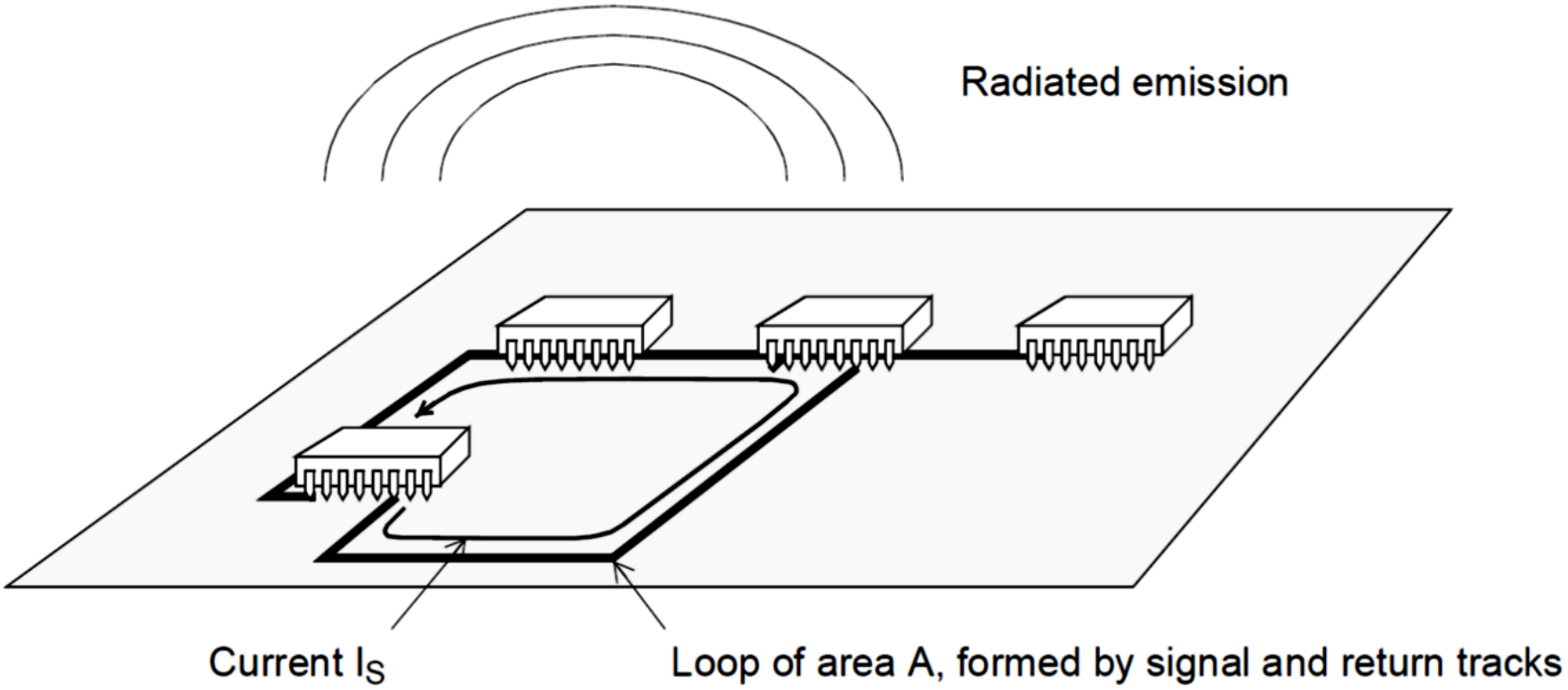
$$I_1 = I_{dm} + I_{cm}$$

$$I_2 = I_{dm} - I_{cm}$$

$$I_{dm} = \frac{I_1 + I_2}{2}$$

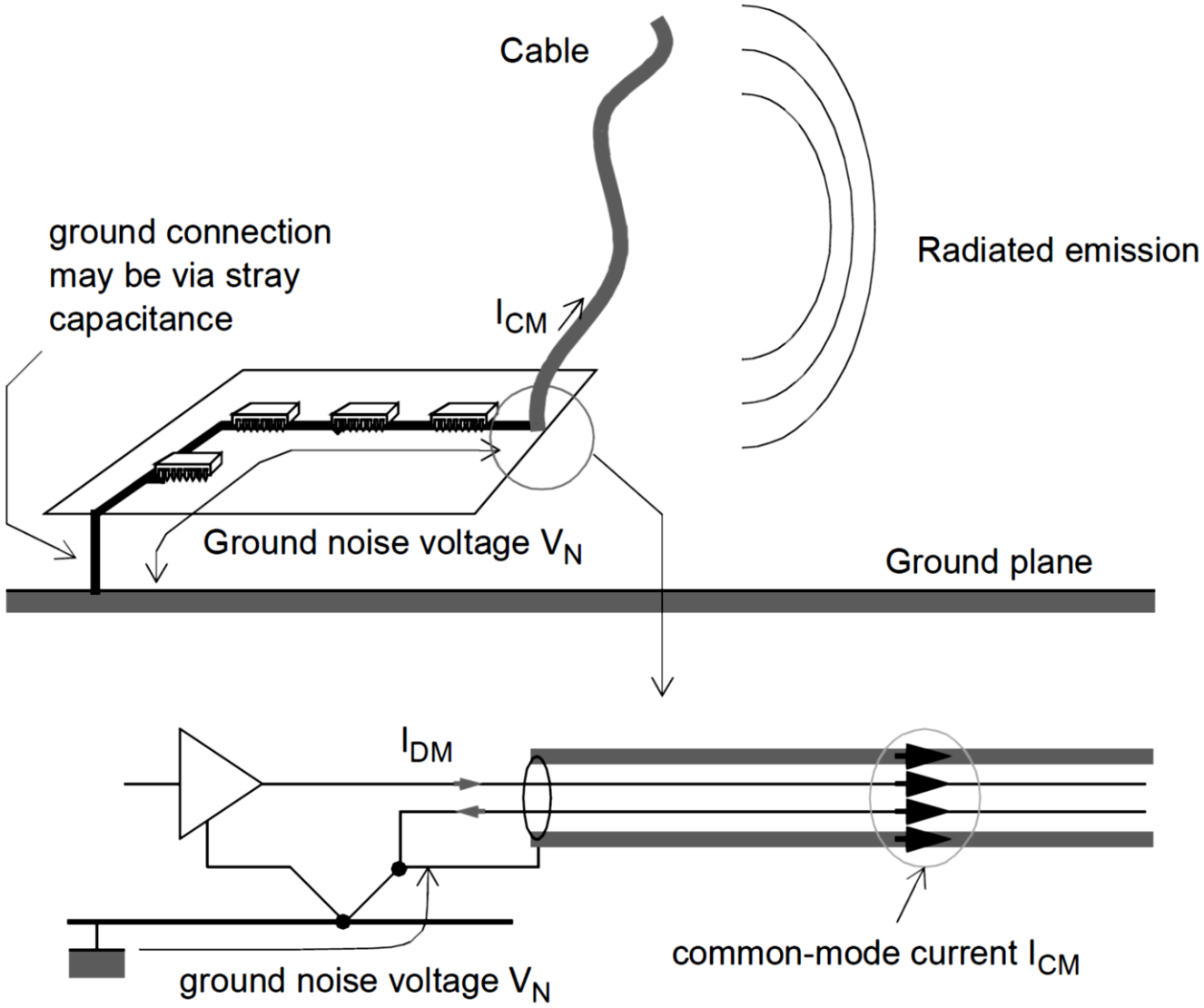
$$I_{cm} = \frac{I_1 - I_2}{2}$$

Primer vira diferencialne motnje na TIV



Tim Wiliams, EMC for product designers

Primer vira sofazne motnje na TIV



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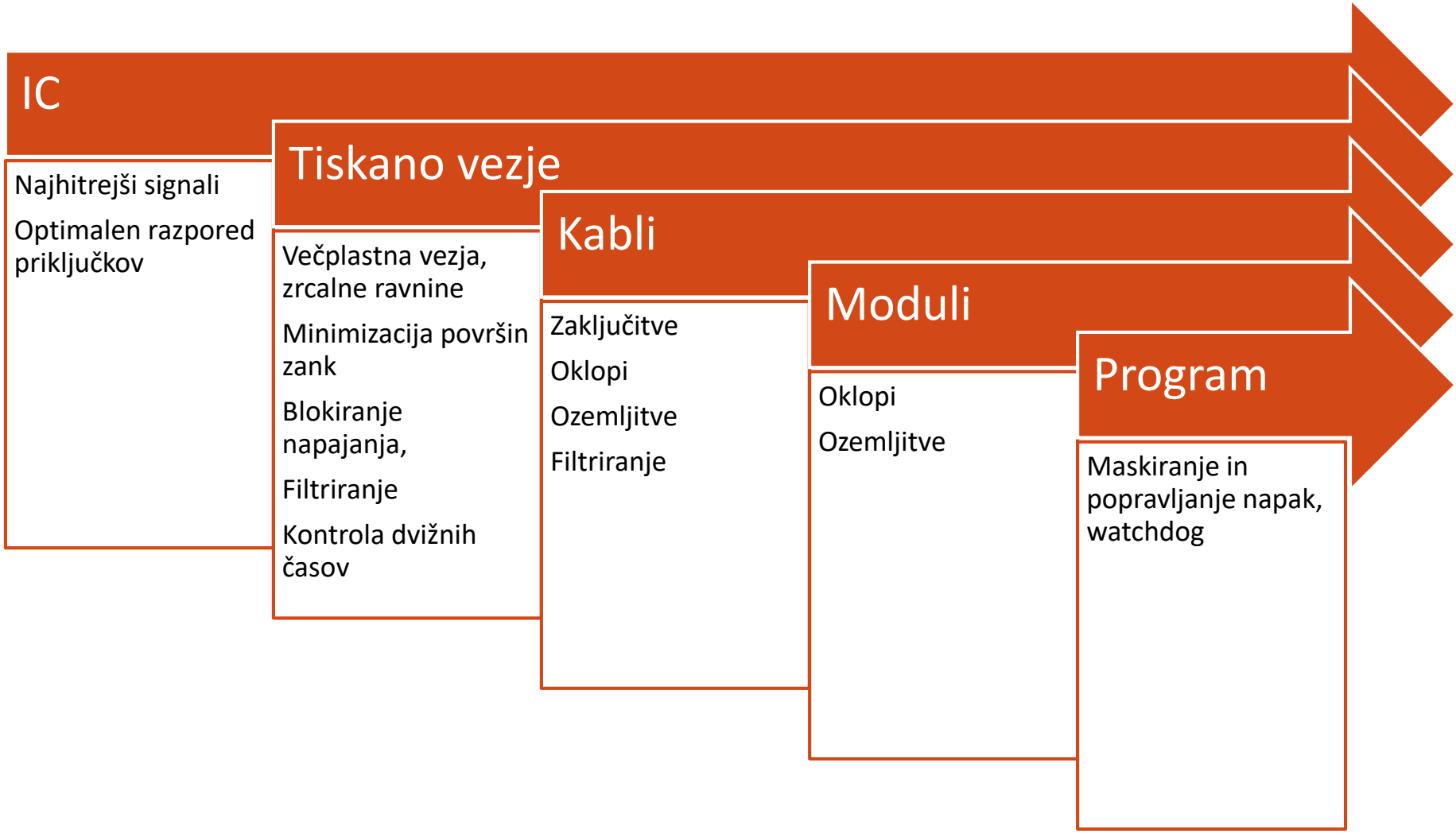
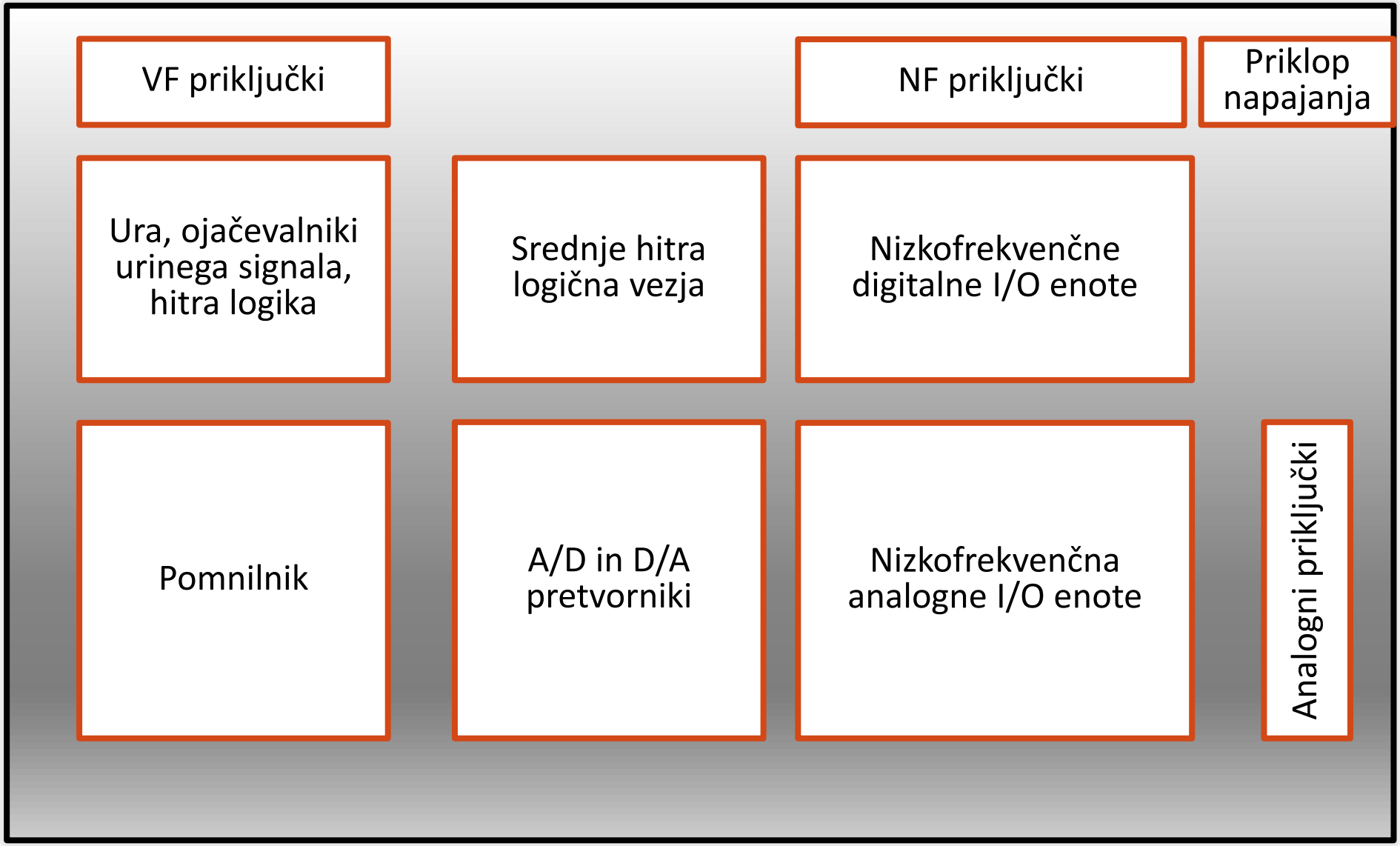
Nivoji zaščite EMI



Načrtovanje tiskanega vezja

Postavitev


VF priključki
NF priključki
Priklop napajanja
Ura, ojačevalniki urinega signala, hitra logika
Srednje hitra logična vezja
Nizkofrekvenčne digitalne I/O enote
Pomnilnik
A/D in D/A pretvorniki
Nizkofrekvenčna analogne I/O enote
Analogni priključki

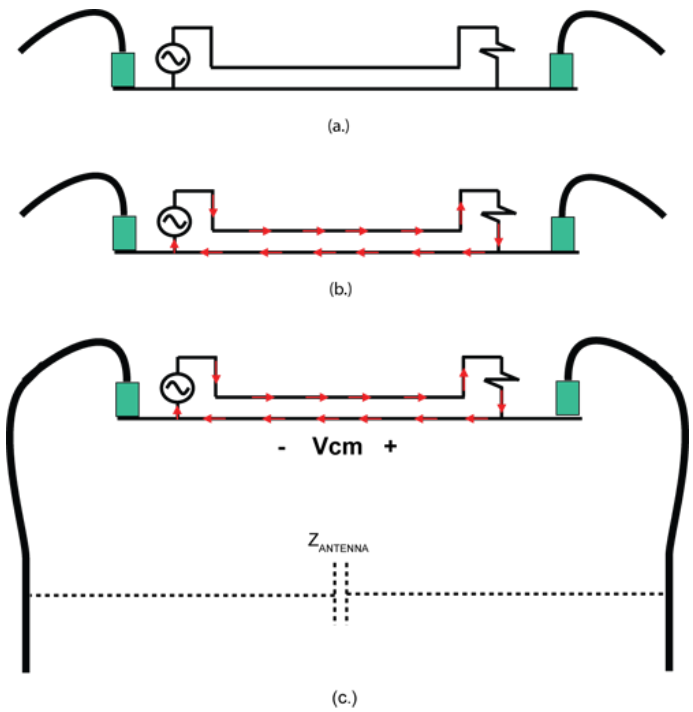
Priporočila za postavitev priključkov

- Vsa komunikacija iz istega čipa naj poteka preko enega skupnega priključka
  - Sofazni tokovi so mnogo lažje obvladljivi v vodnikih, ki so del istega priključka in kabla.
- Čip, katerega komunikacija je povezana na priključek, naj bo čim bližje tega priključka
  - S tem ohranimo povezave na TIV kratke. Če je linija daljša, potem je bolj verjetno, da se nanjo sklapljajo motnje iz TIV.

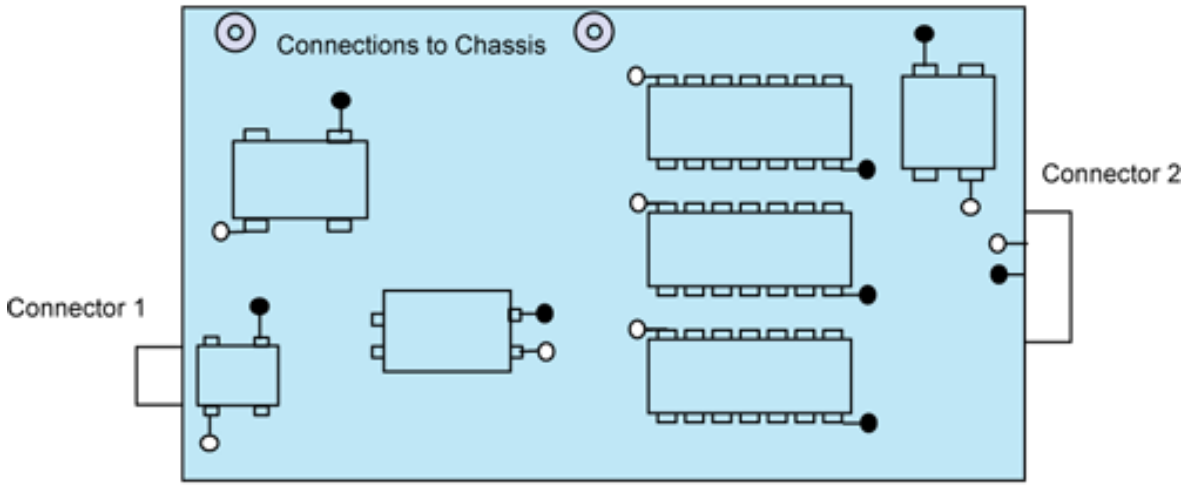
Priporočila za postavitev priključkov

- Komponenta, ki nima povezav na priključek, naj ne bo preblizu priključkov.
  - Tipično naj bo oddaljena vsaj 2 cm, odvisno od primera. Na ta način omejimo motnje drugih elementov, da se ne sklapljajo na priključek.
- Postavite priključke skupaj na eno stran ali v en vogal TIV
  - Na ta način jih je lažje ohranjati na istem potencialu
  - Ne postavite hitrih vezij med priključke

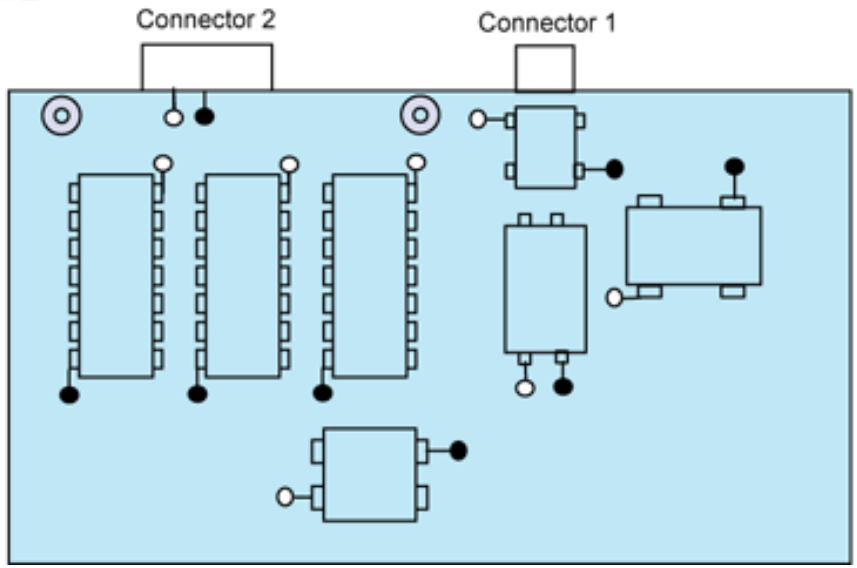
Primer



LAYOUT #1

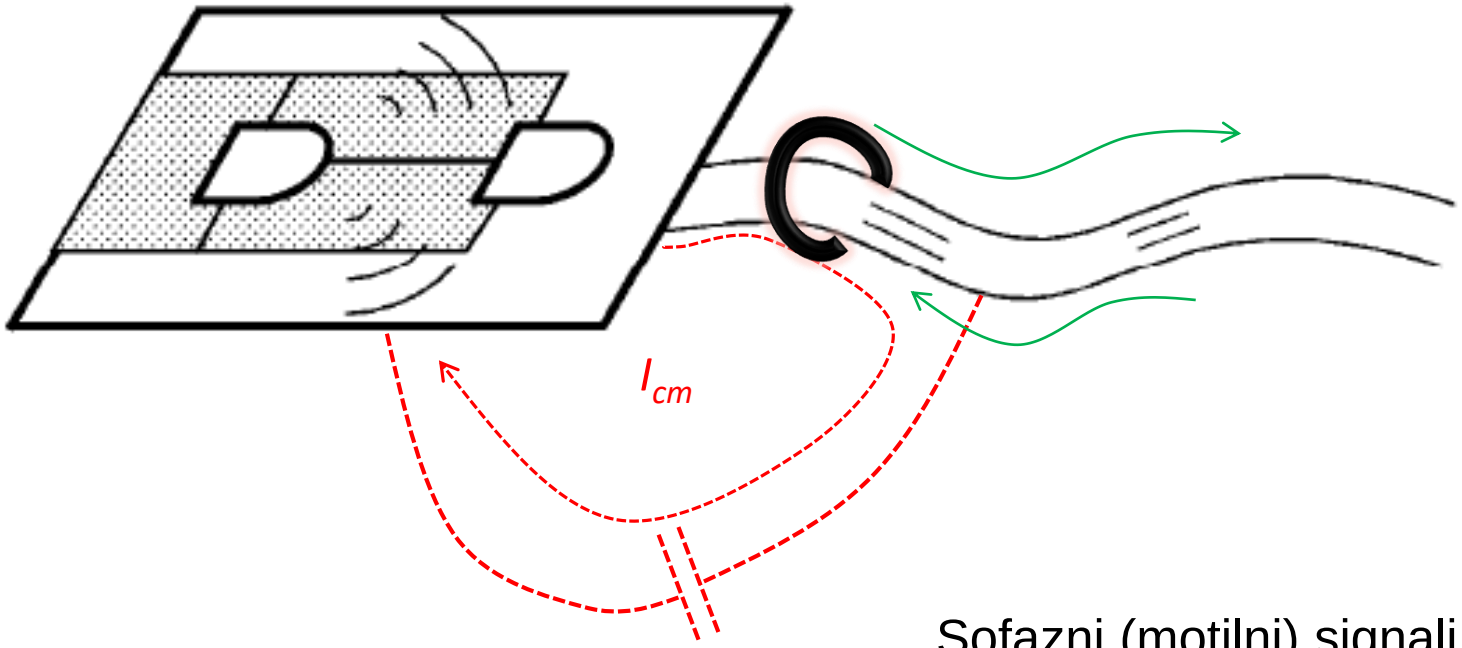


LAYOUT #2

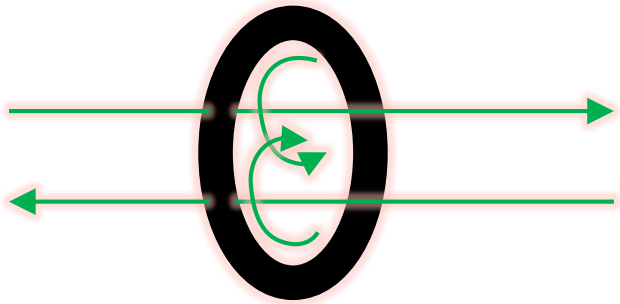


http://www.learnemc.com/tutorials/PCB_Layout/PCB_Layout.html

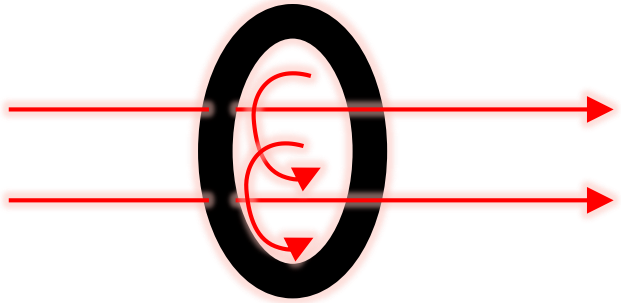
Feritni obroček



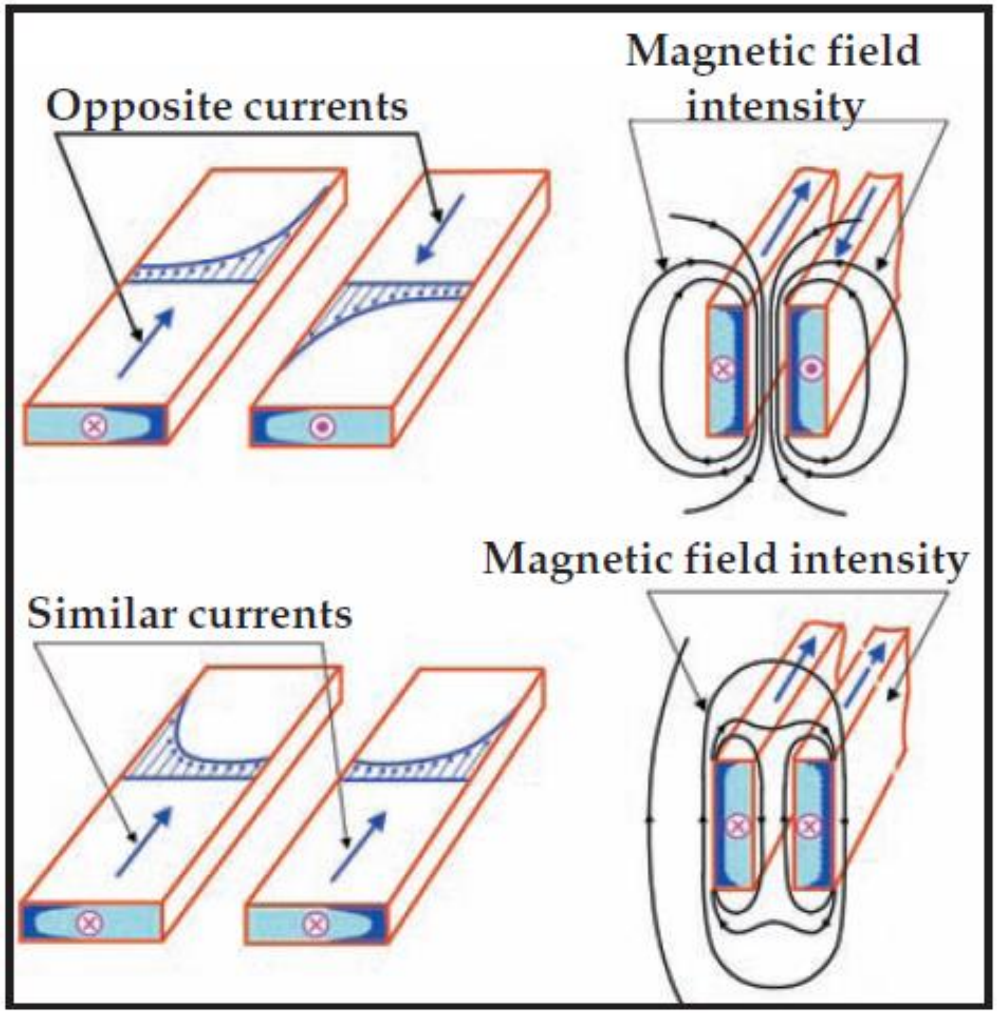
Diferencialni (koristni) signali



Sofazni (motilni) signali



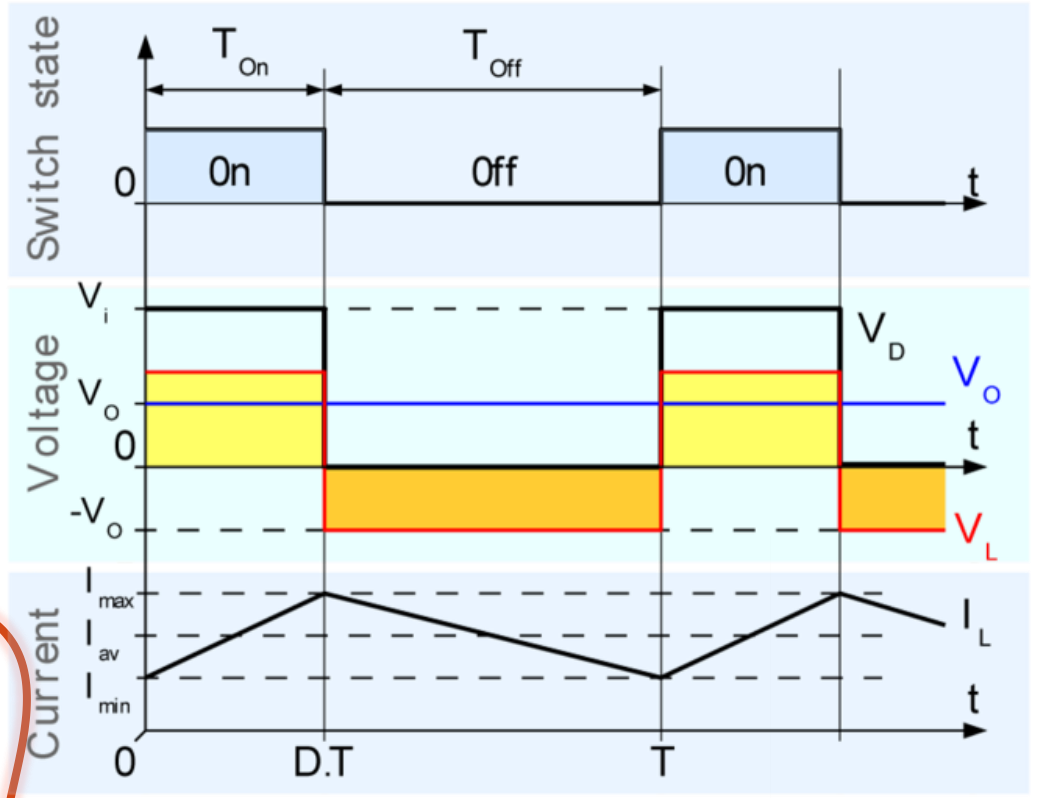
Tokovne zanke na tiskanem vezju

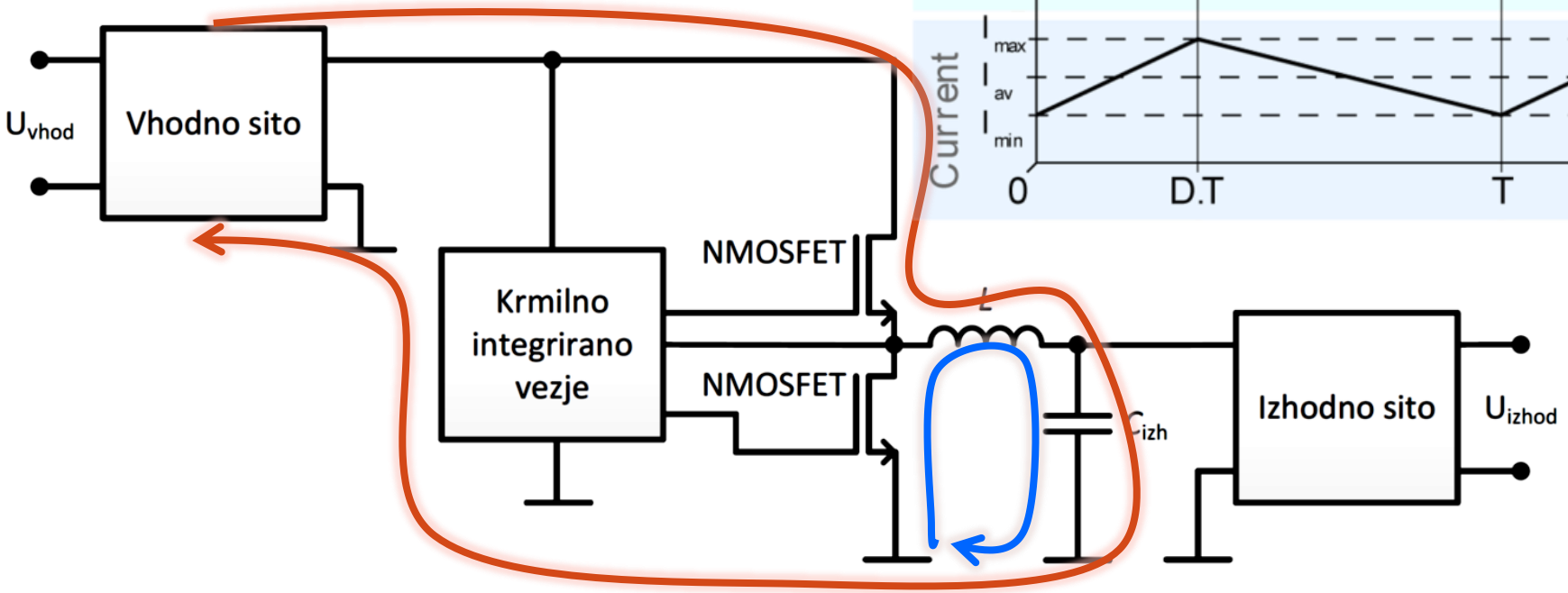


Izkustvena pravila

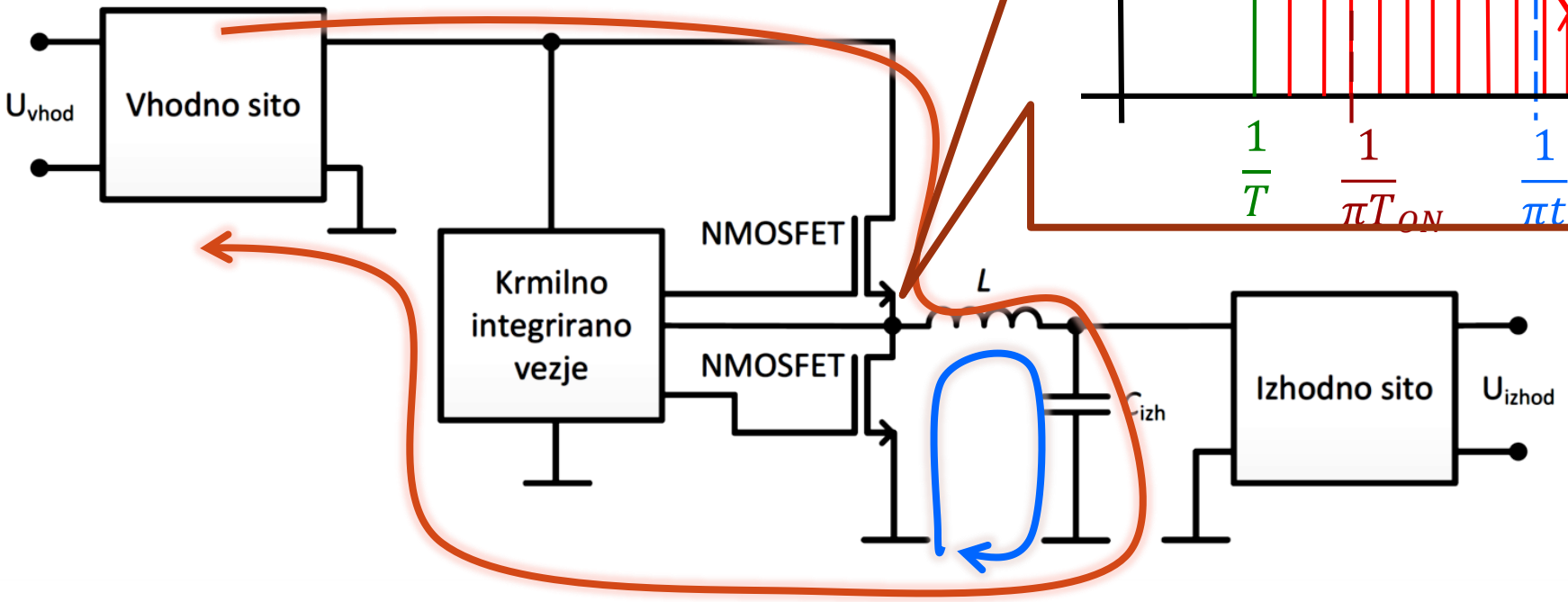
- Visokofrekvenčni tok bo vedno tekel blizu zunanjega roba vodnika
- Pri 35um debeli bakreni liniji se kožni pojav pojavi že pri 3.5 MHz
- Kožni pojav zmanjšuje efektivno induktivnost
- Žica z manjšim premerom ali vije imajo večjo induktivnost
- Širše linije imajo nižjo induktivnost
- Diferencialni visokofrekvenčni tokovi tečejo po notranjem robu diferencialnega vodnika in tako znižujejo induktivnost
- Izsevana energija je sorazmerna površini zanke, po kateri teče tok
- Visokofrekvenčno magnetno polje bo vedno našlo poz iz naprave in sevalo v daljnem polju, zato pri načrtovanju skušamo vedno zmanjšati zanke, kolikor je mogoče.

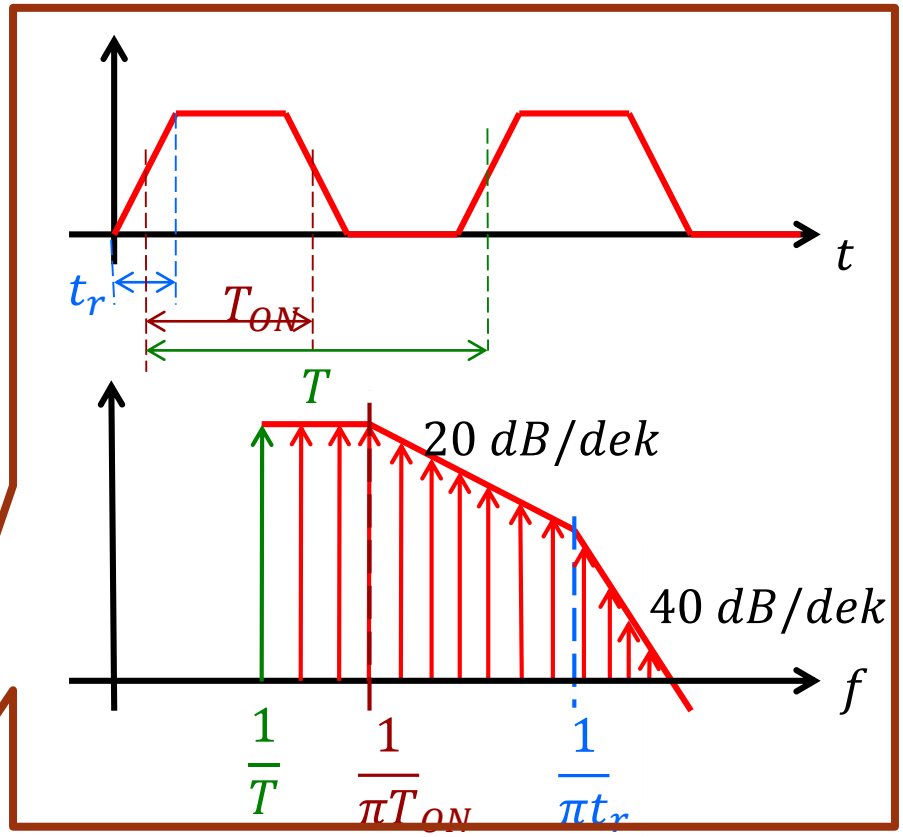
Pretvornik navzdol





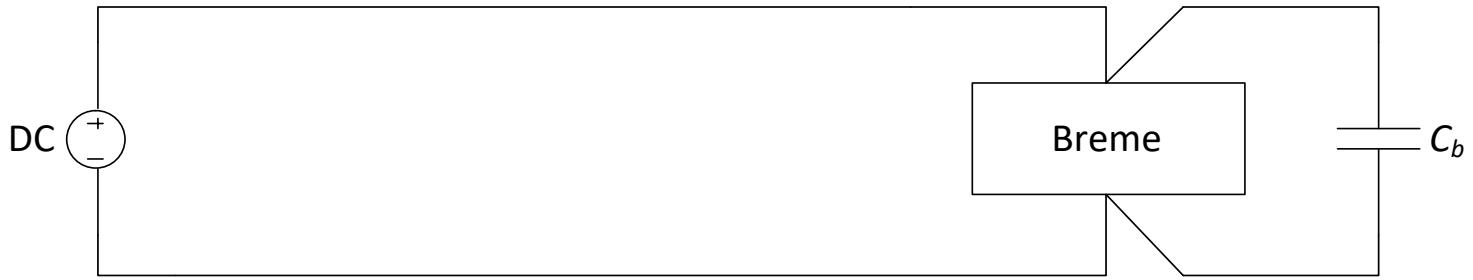
Pretvornik navzdol



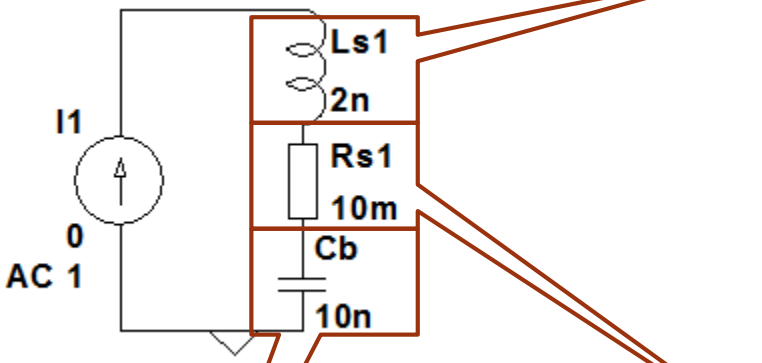


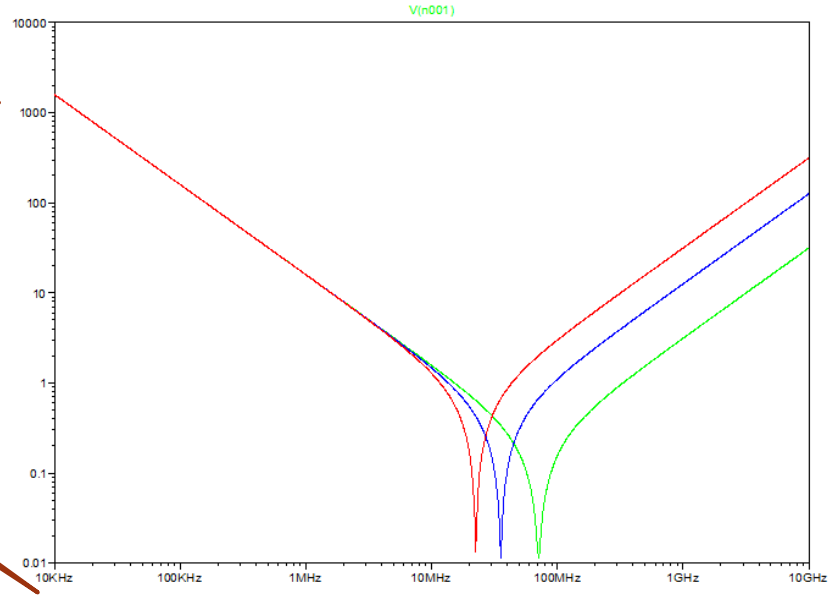
Blokiranje s kondenzatorji

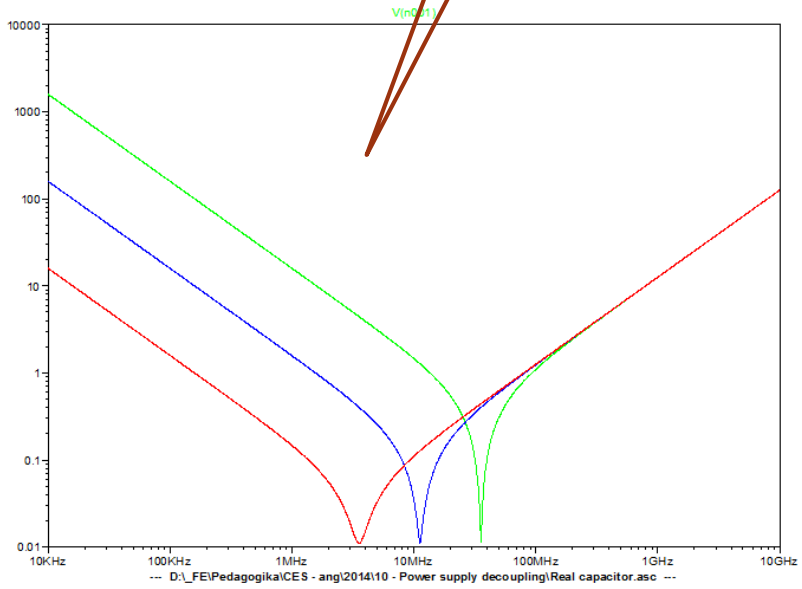
- Vzpostavitev dodatne visokofrekvenčne nizkoimpedančne poti za spreminjajoče tokove s pomočjo kondenzatorja
  - Pot naj se čim manj sklaplja z glavnimi napajalnimi linijami
  - Pot naj ima čim nižjo impedanco
    - Čim krajše linije
    - Uporaba več vzporedno vezanih kondenzatorjev

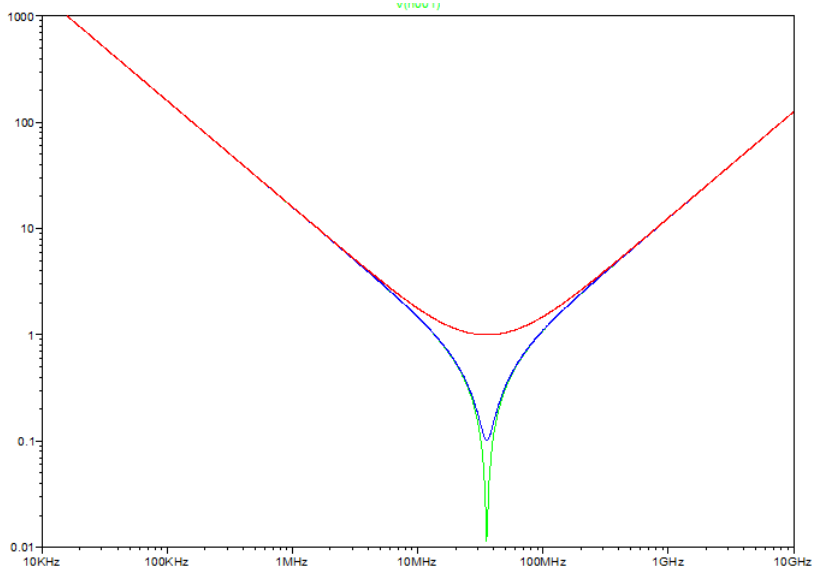


Realni kondenzator

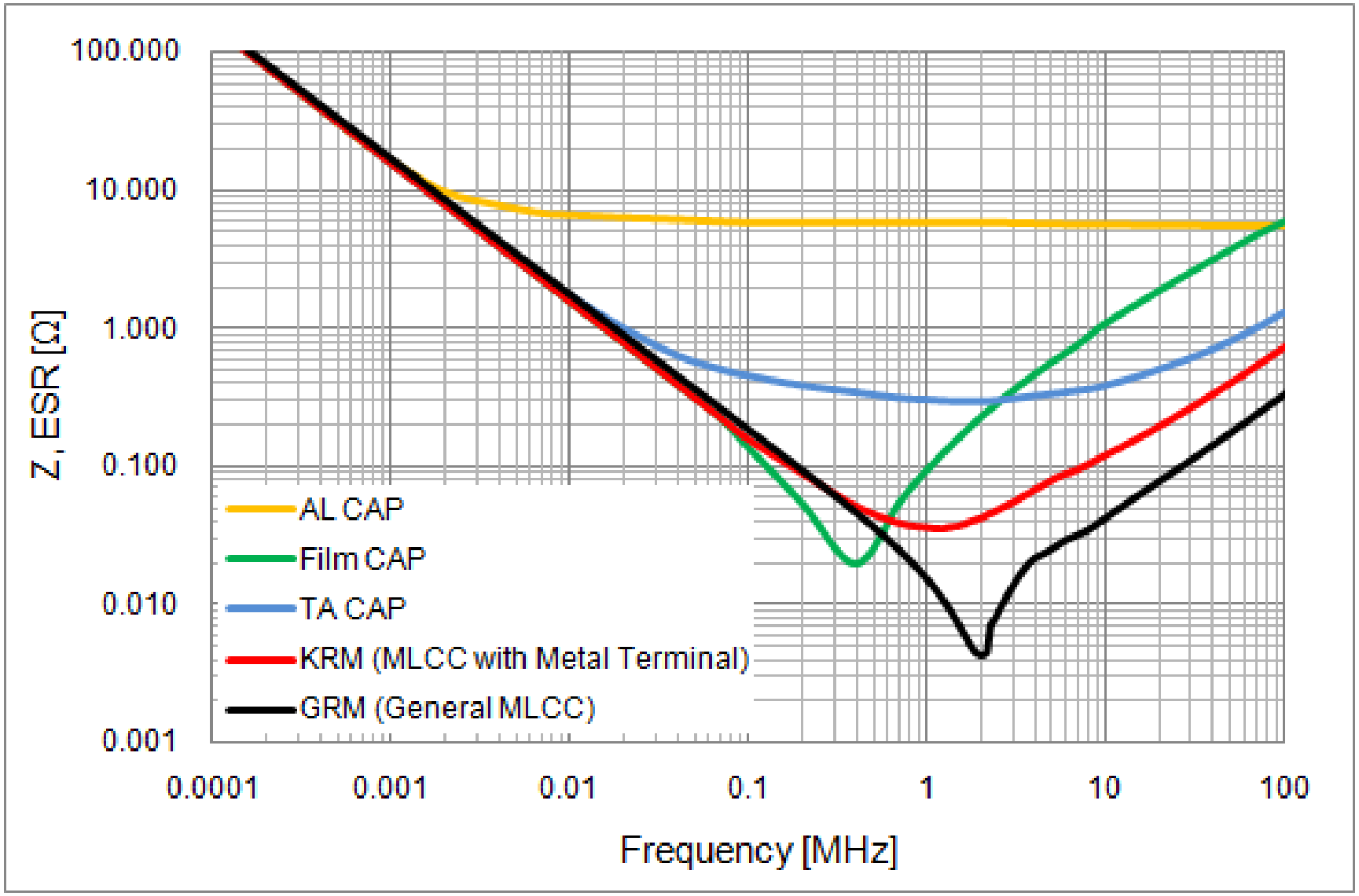




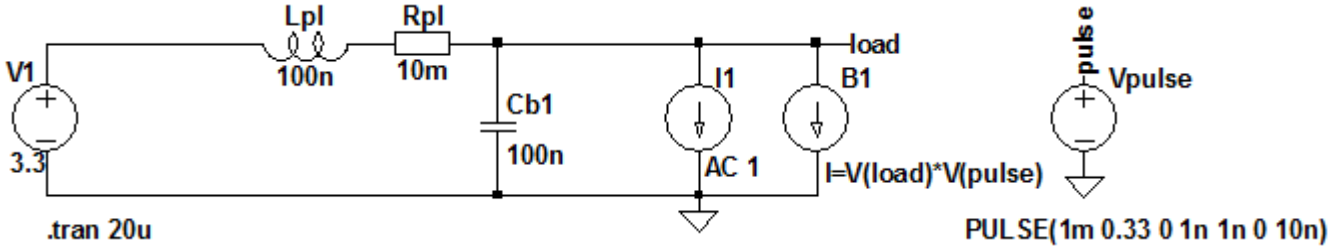


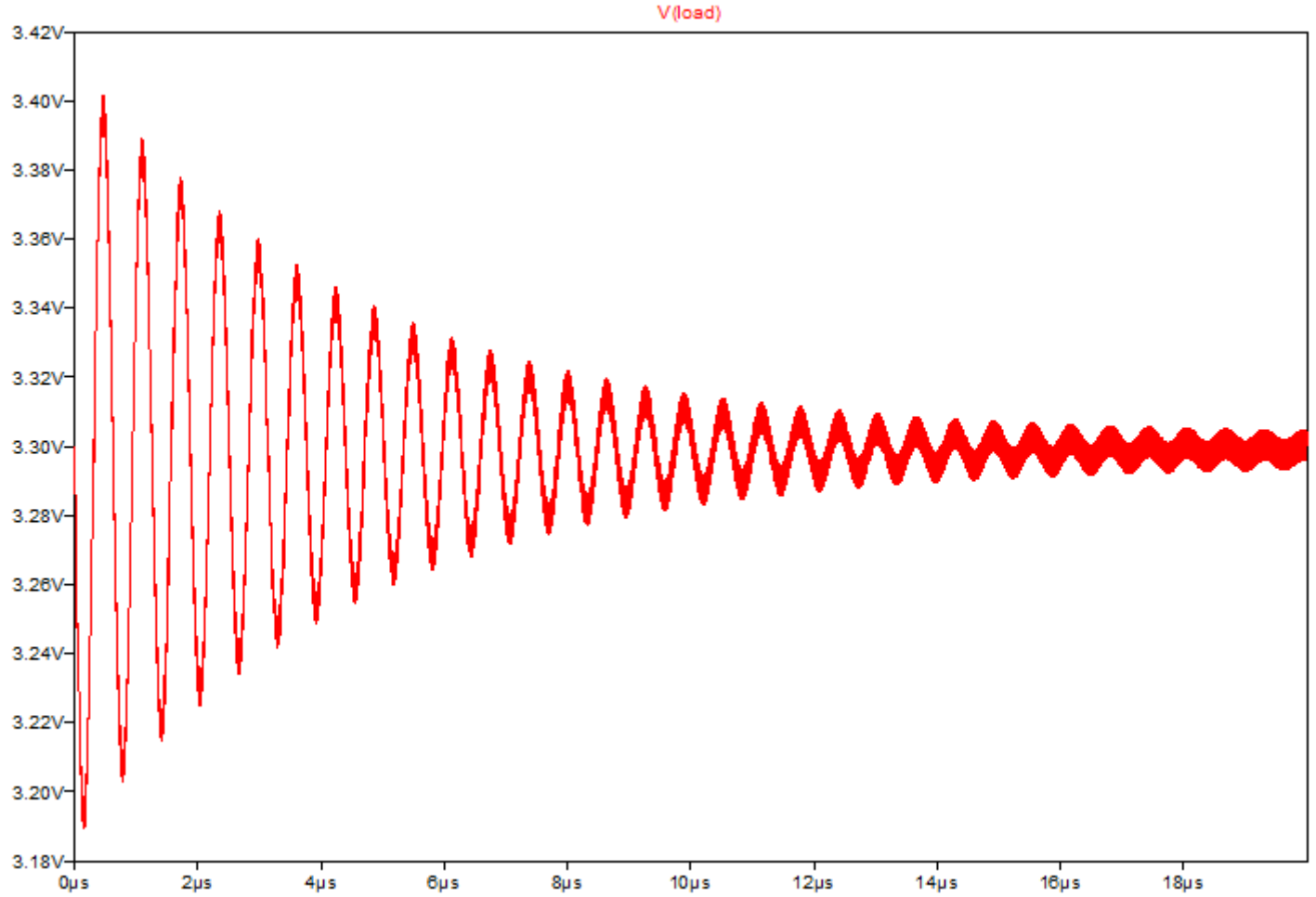


Razlika med kondenzatorji



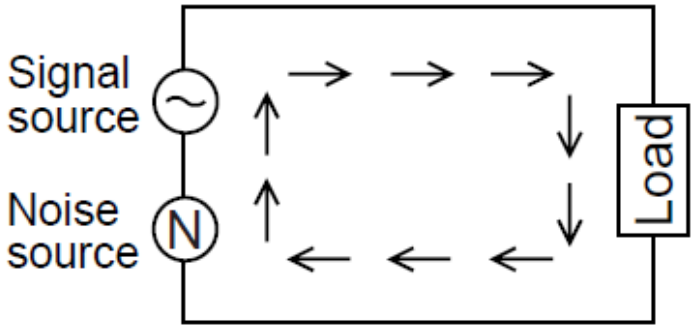
Učinek paralelne resonance



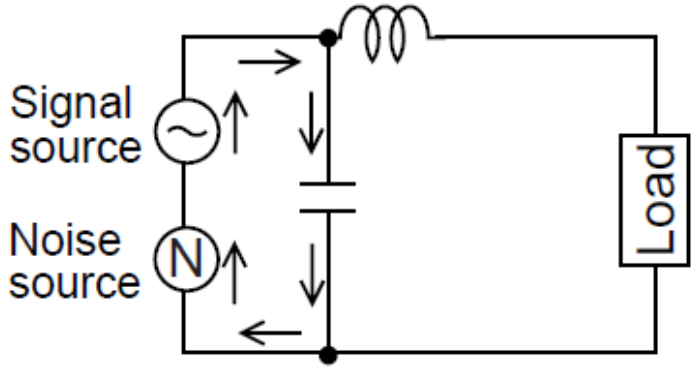


Filtriranje

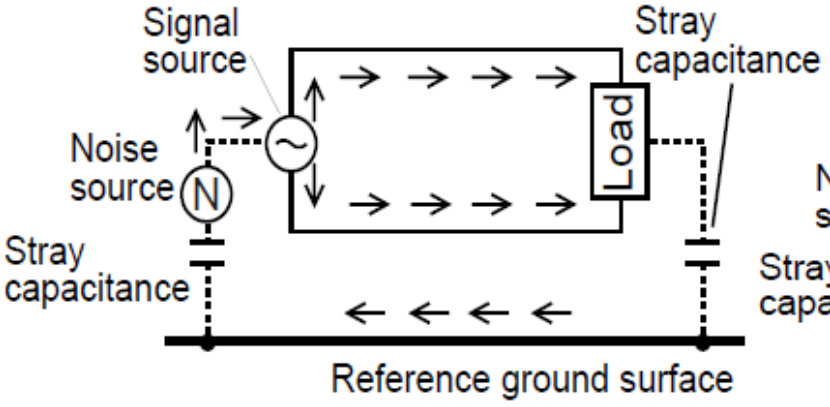
■ Differential mode noise



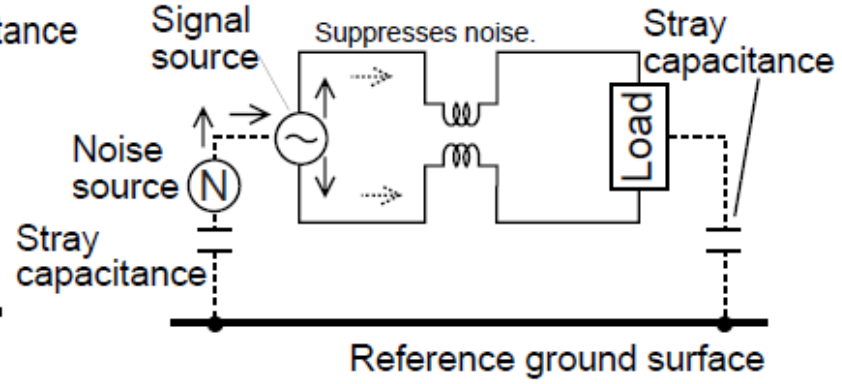
■ Suppression method of differential mode noise



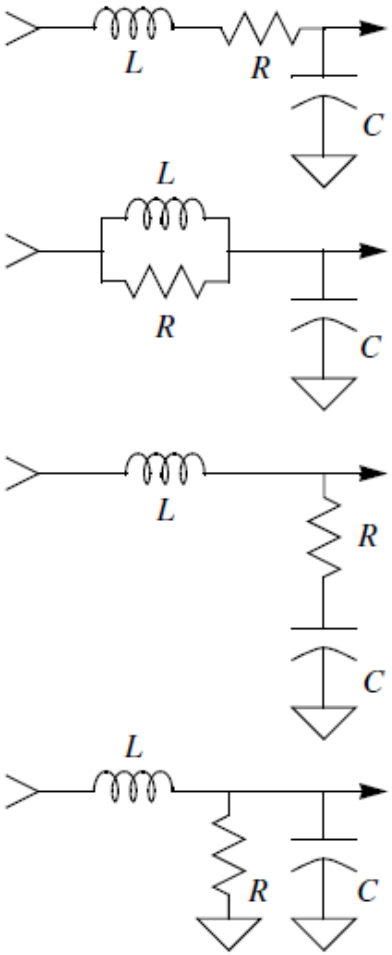
■ Common mode noise



■ Suppression method of common mode noise (1)



Dušenje resonanc filtrov



A. Reduced output voltage
Decreased supply regulation

$$R_{crit} = 2\sqrt{\frac{L}{C}}$$

B. Poor decoupling

$$R_{crit} = \frac{1}{2}\sqrt{\frac{L}{C}}$$

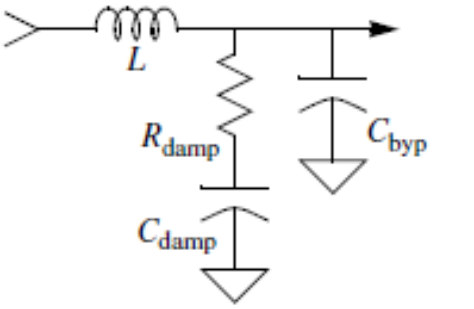
C. Decreased bypass effectiveness

$$R_{crit} = 2\sqrt{\frac{L}{C}}$$

D. High power dissipation

$$R_{crit} = \frac{1}{2}\sqrt{\frac{L}{C}}$$

- Best option



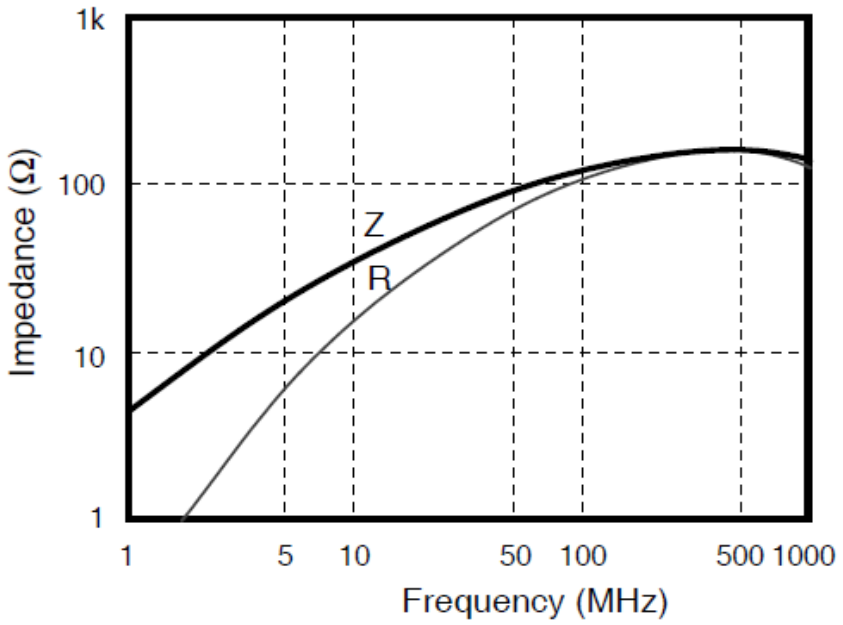
$$C_{damp} > 16 C_{byp}$$

$$R_{damp} > 2\sqrt{\frac{L}{C_{damp}}}$$

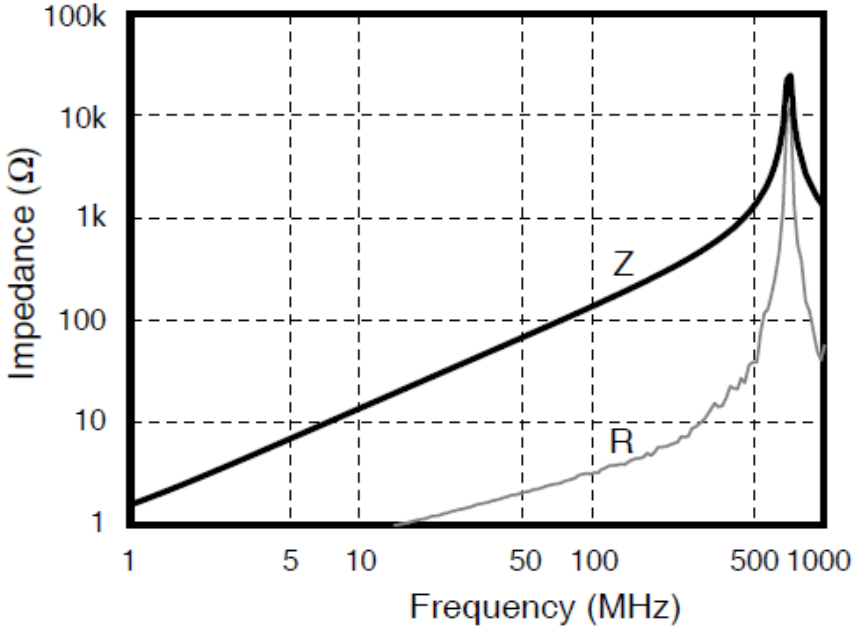
$$R_{damp} < \frac{1}{2}\sqrt{\frac{L}{C_{byp}}}$$

Feritna dušilka ali tuljava?

Feritna dušilka



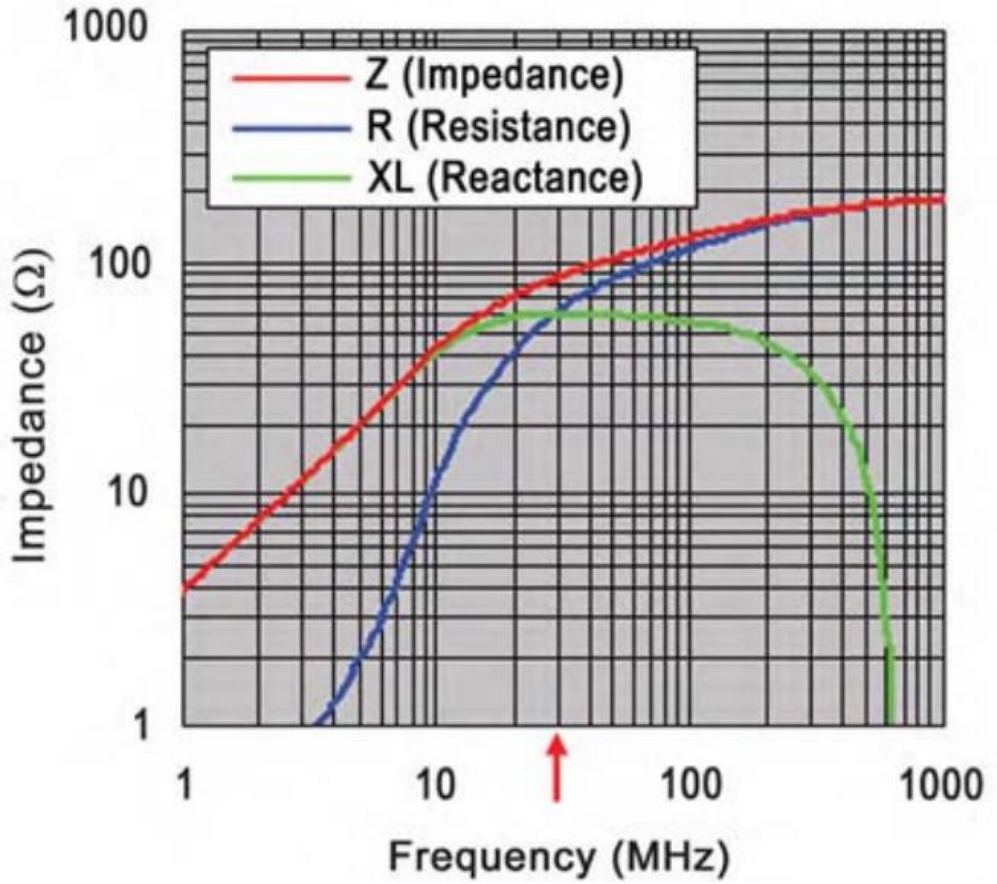
Tuljava

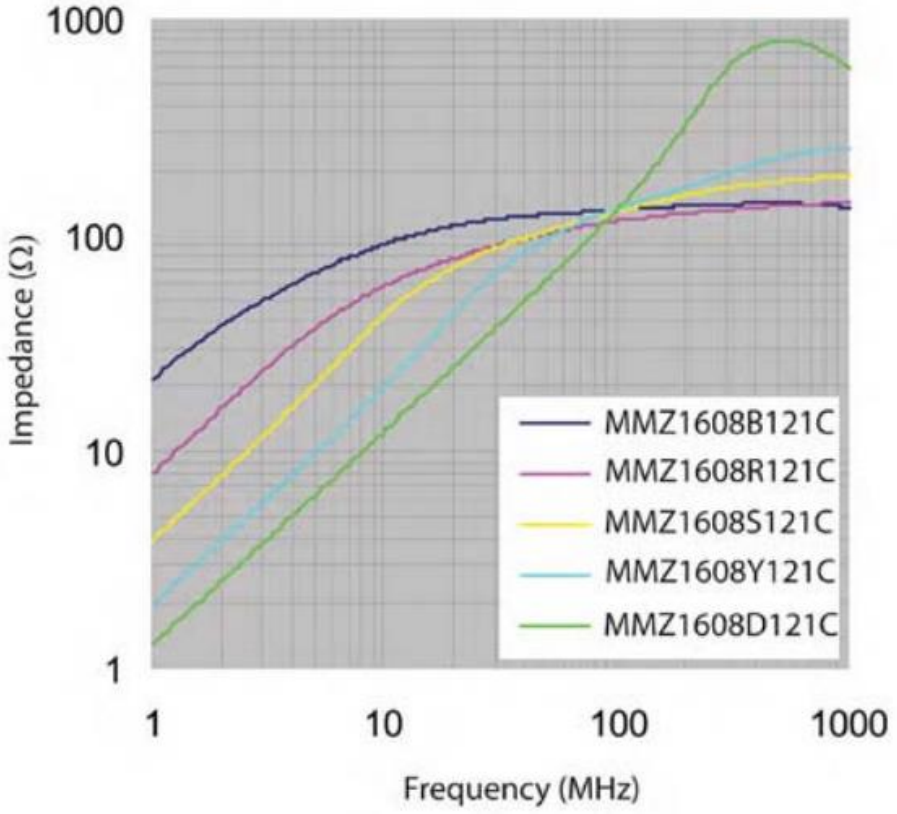


Podatki feritnih dušilk

Part No.	Impedance (Ω)[100MHz]*1	DC resistance (Ω)max.	Rated current*2 (A)max.	Thickness T(mm)
MPZ1608S300A	30±10Ω	0.01	5	0.6
MPZ1608S600A	60±25%	0.02	3.5	0.6
MPZ1608S101A	100±25%	0.03	3	0.6
MPZ1608S221A	220±25%	0.05	2.2	0.8
MPZ1608R391A	390±25%	0.12	1.2	0.8
MPZ1608S471A	470±25%	0.15	1	0.8
MPZ1608S601A	600±25%	0.15	1	0.8
MPZ1608Y600B	60±25%	0.03	2.3	0.8
MPZ1608Y101B	100±25%	0.04	2	0.8
MPZ1608Y151B	150±25%	0.05	1.8	0.8
MPZ1608D300B	30±10Ω	0.06	1.8	0.8
MPZ1608D600B	60±25%	0.1	1.2	0.8
MPZ1608D101B	100±25%	0.15	1	0.8

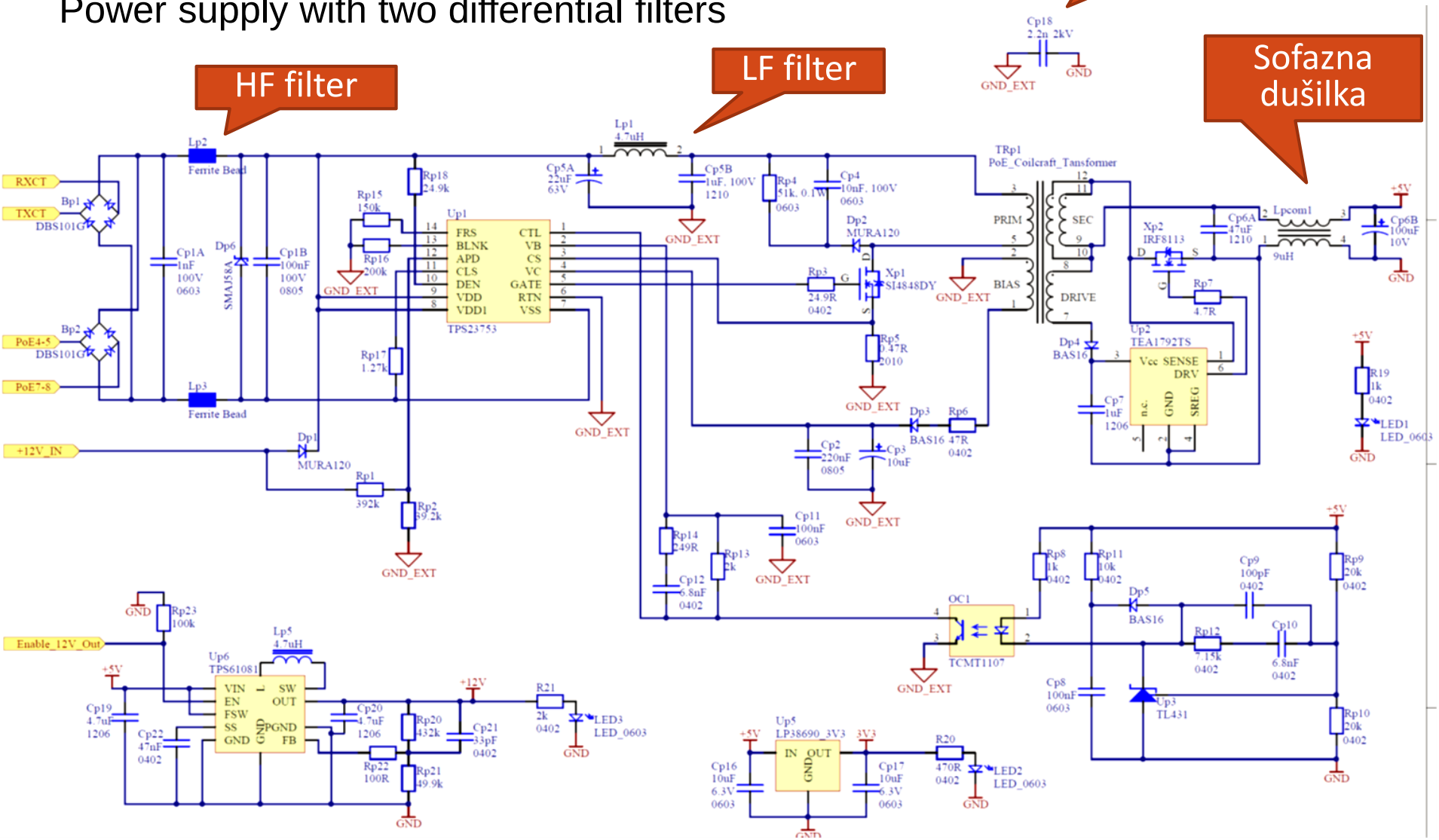
Razlike med feritnimi dušilkami z enakimi specifikacijami



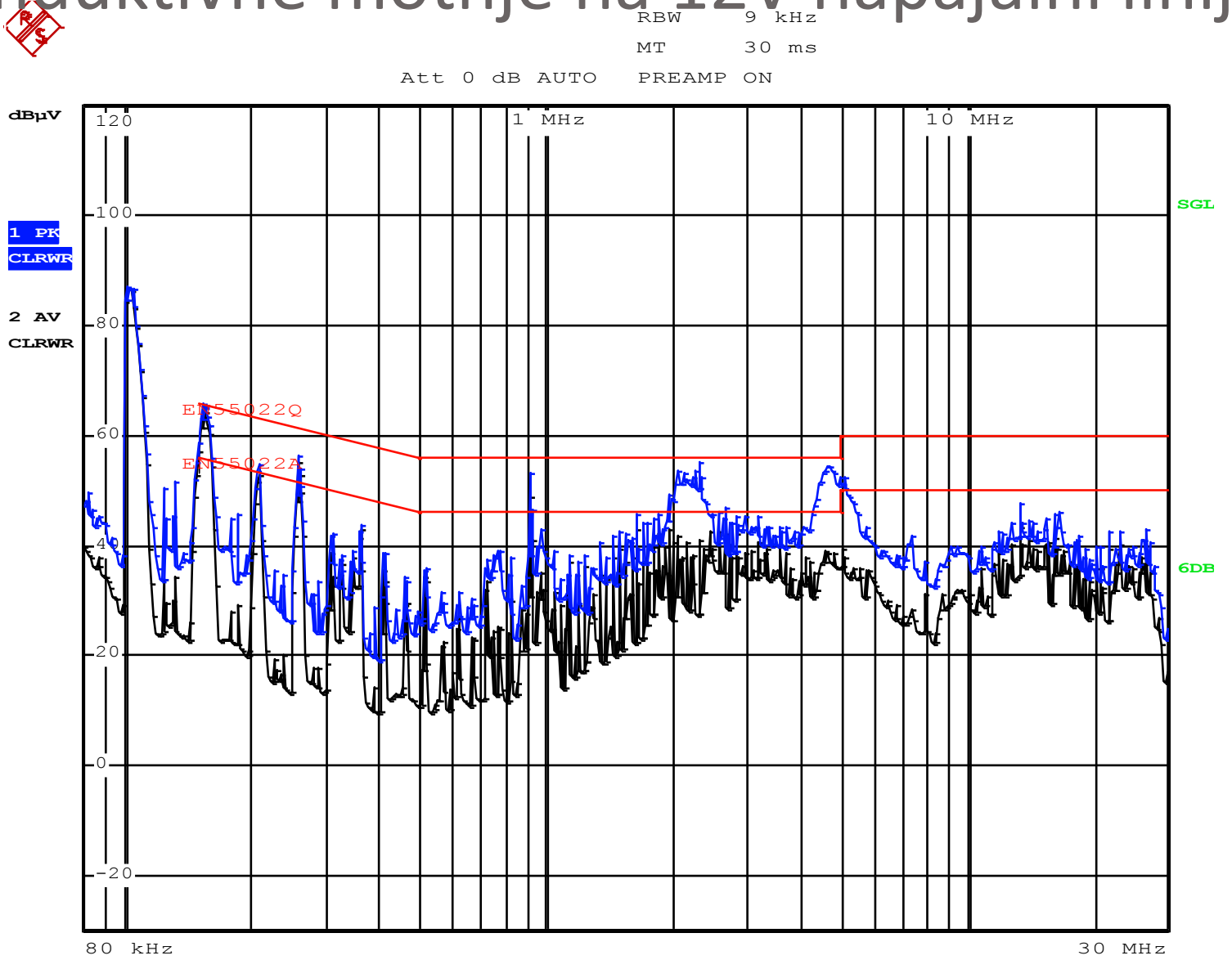


Primer dizajna filtra

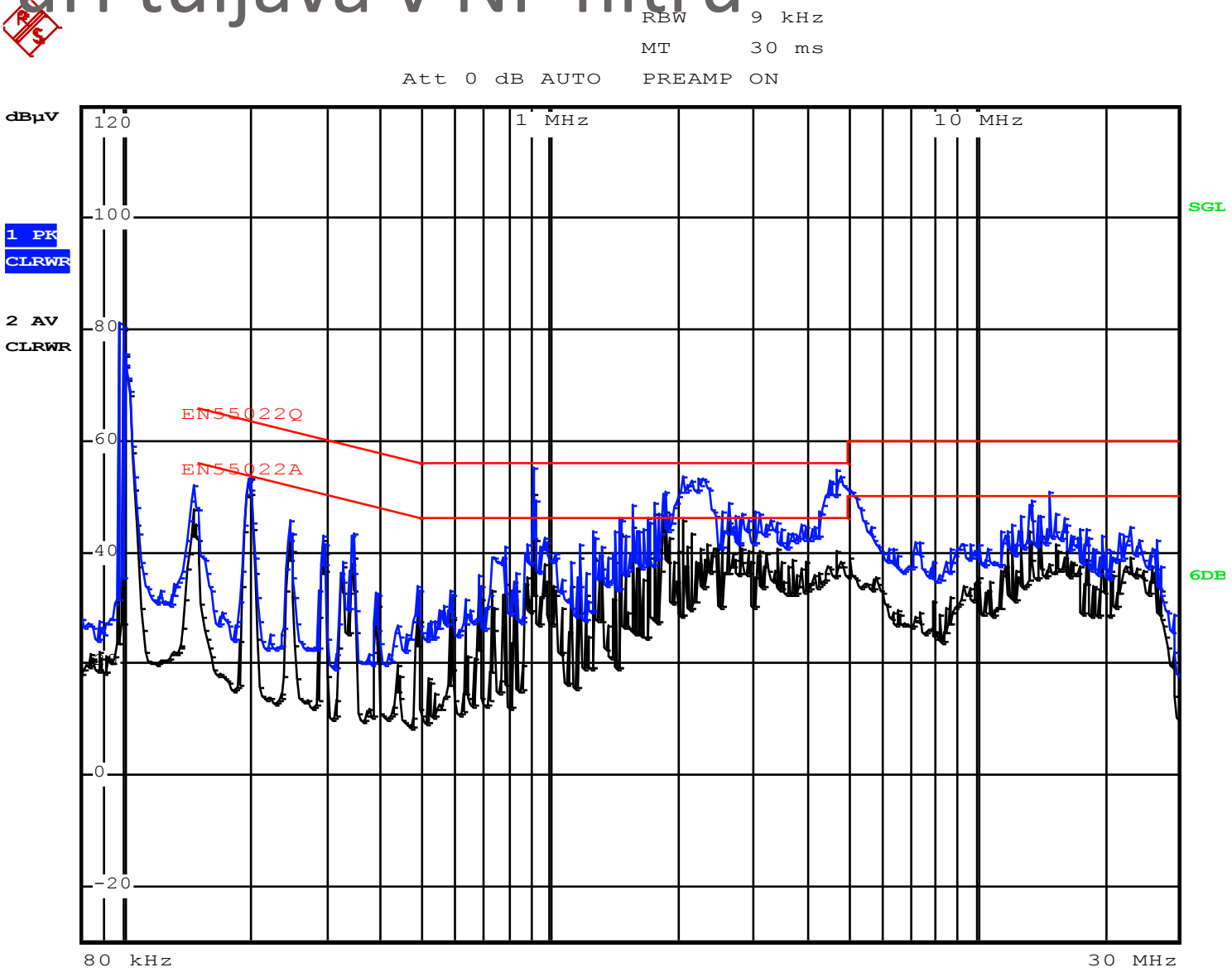
Power supply with two differential filters



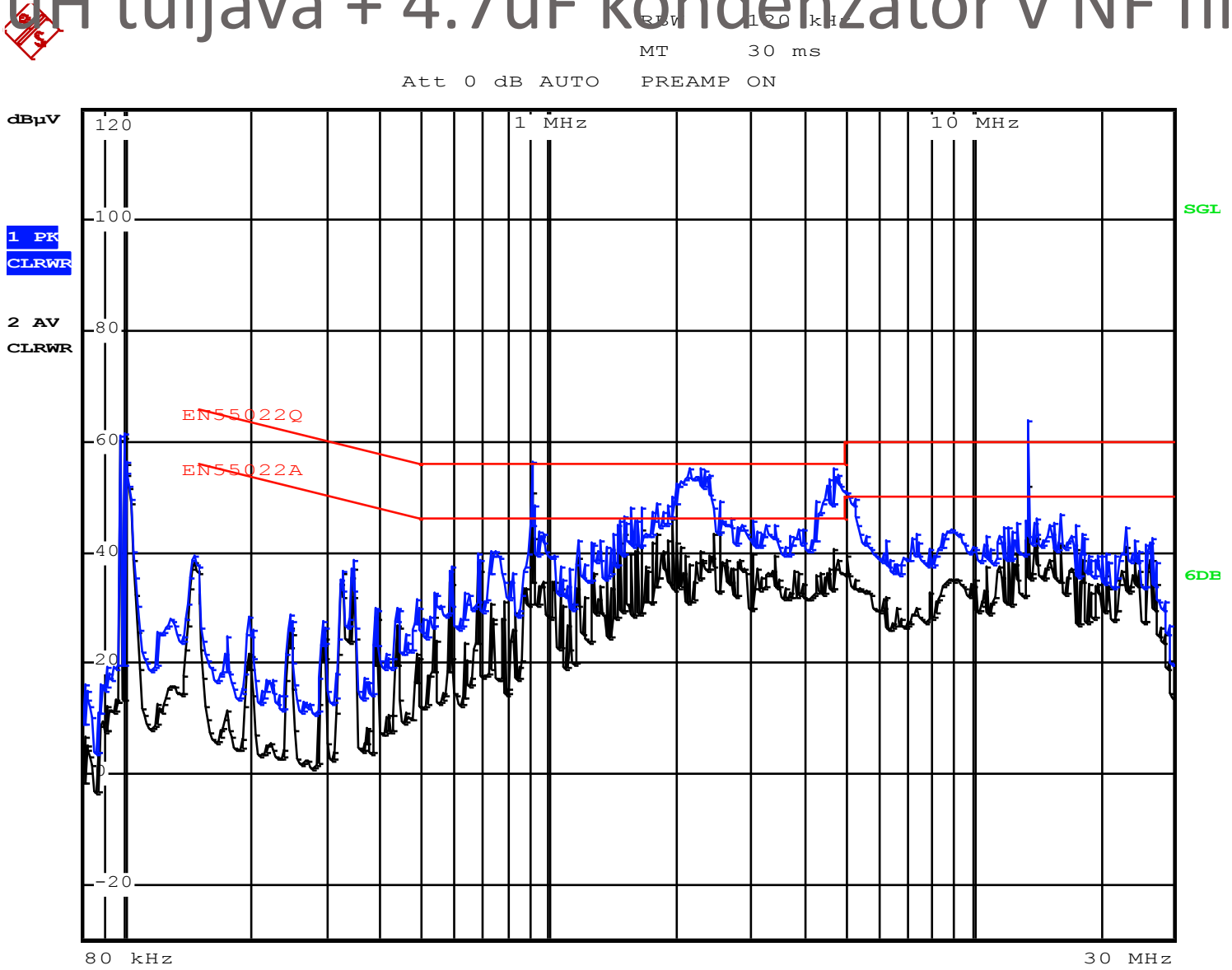
Konduktivne motnje na 12V napajalni liniji



10 uH tuljava v NF filtru

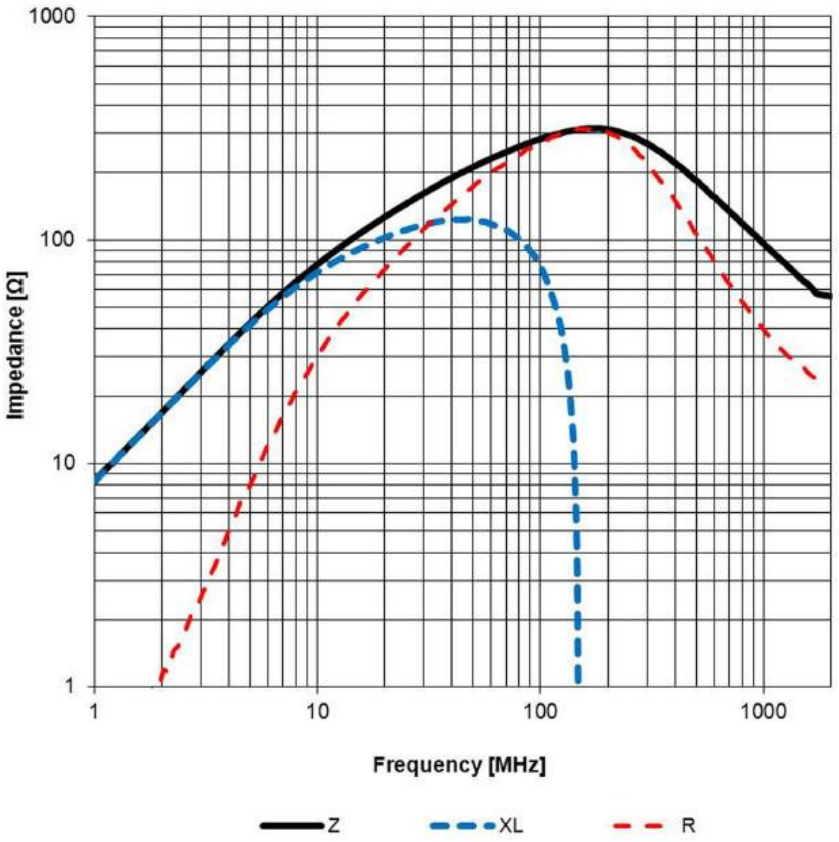


10 µH tuljava + 4.7uF kondenzator v NF filtru

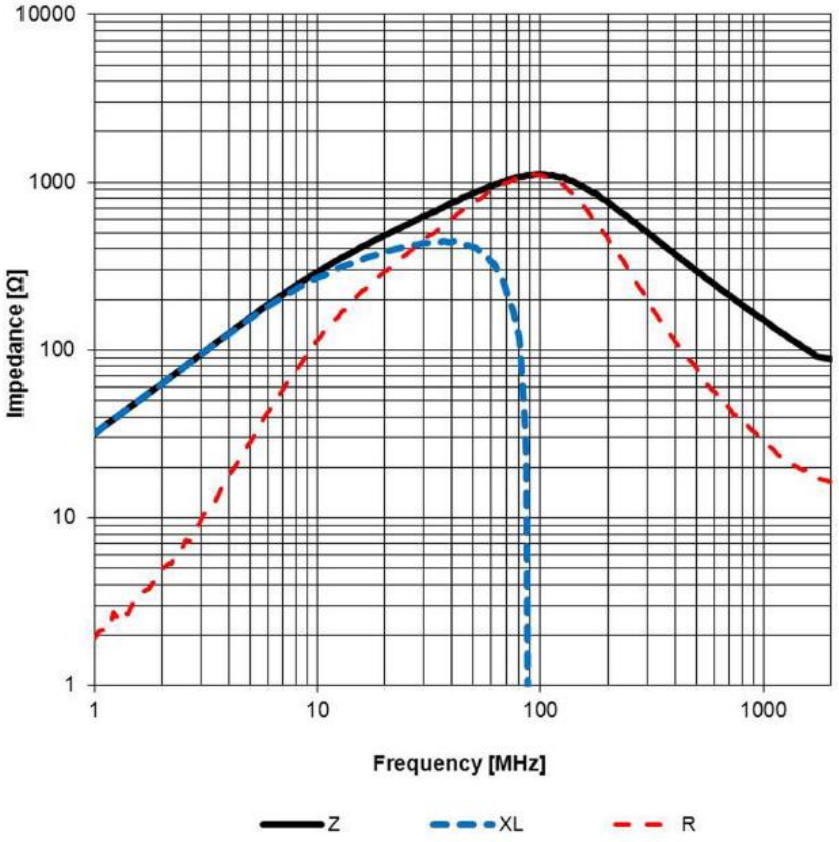


Različne feritne dušilke

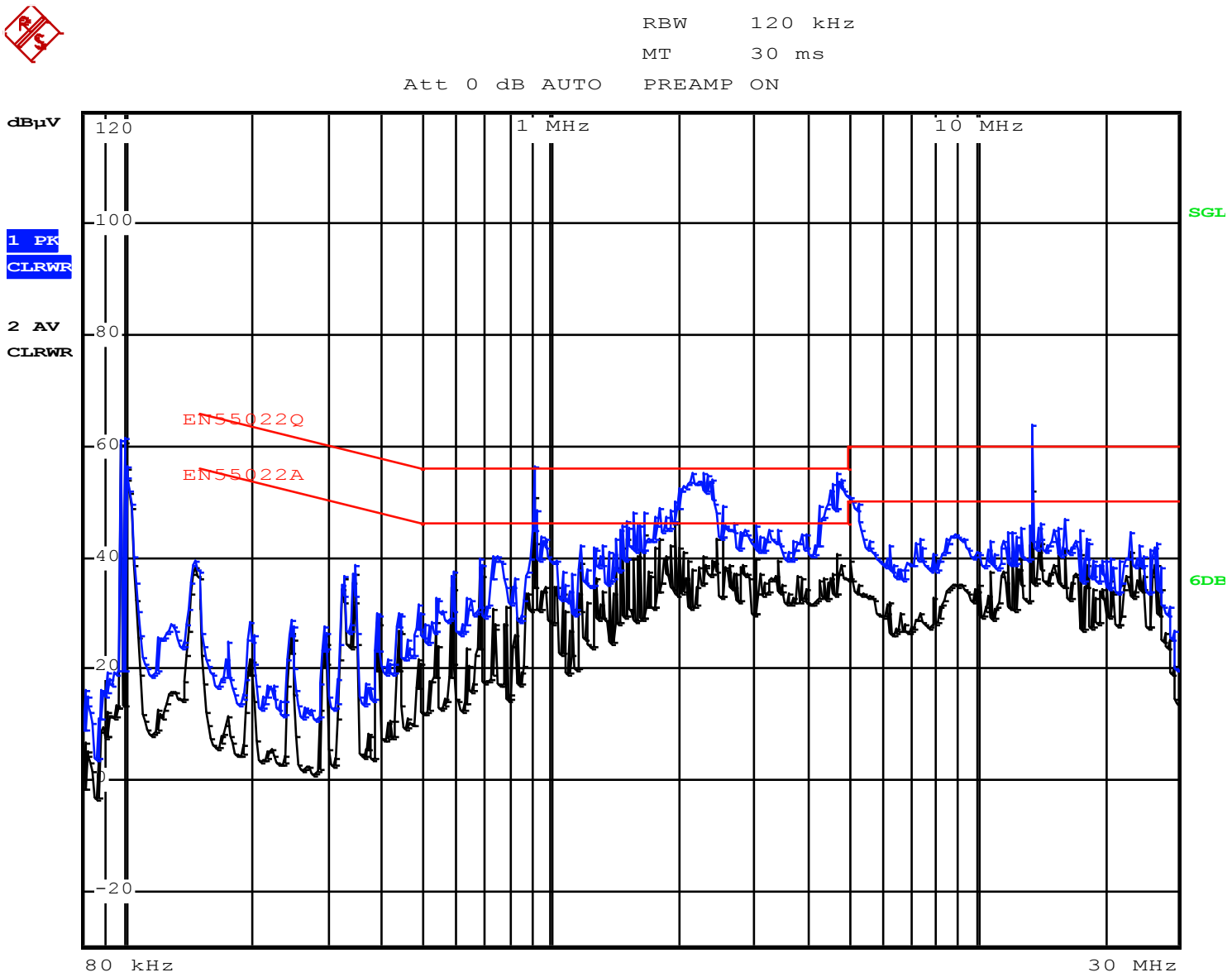
FB1



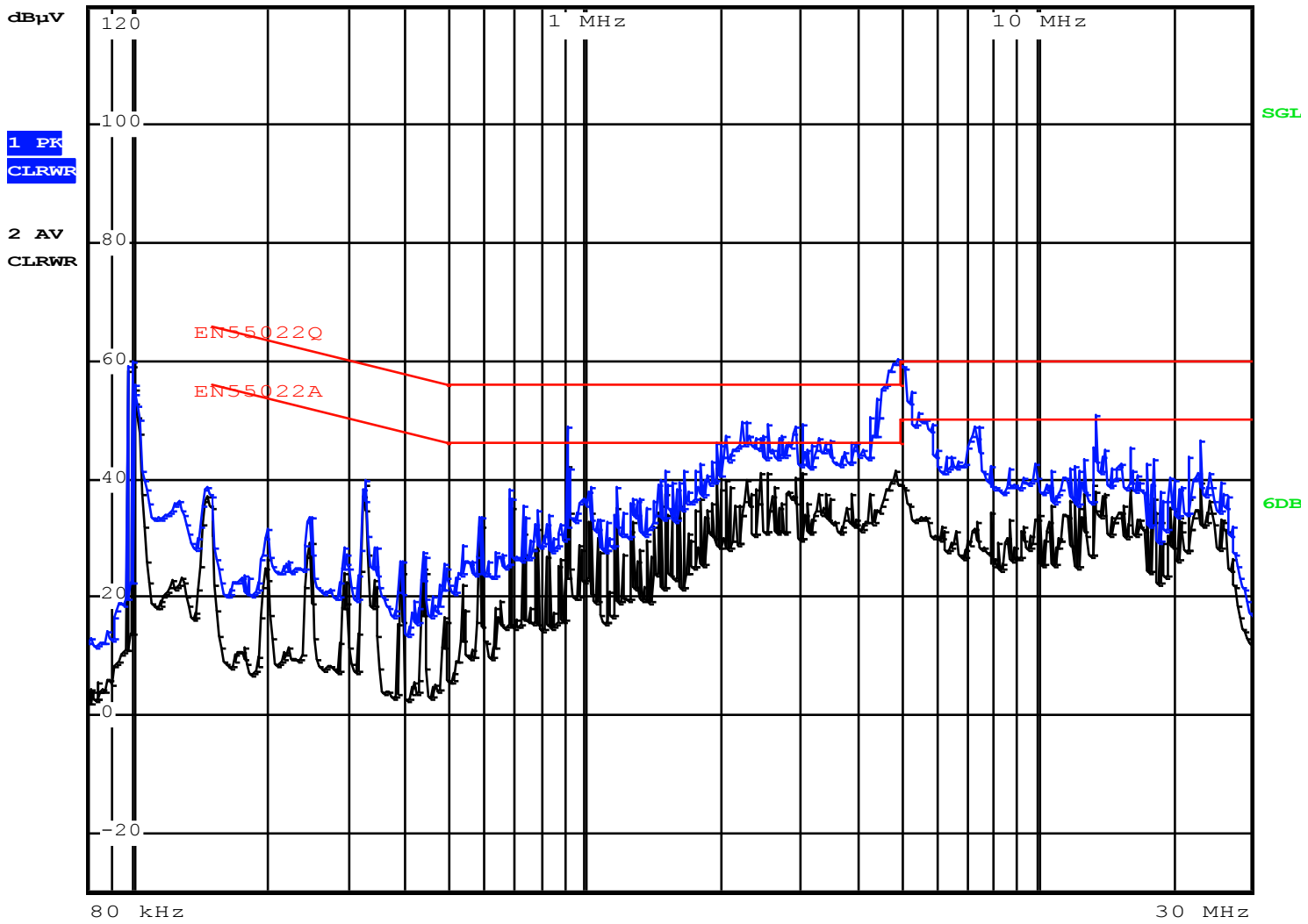
FB2



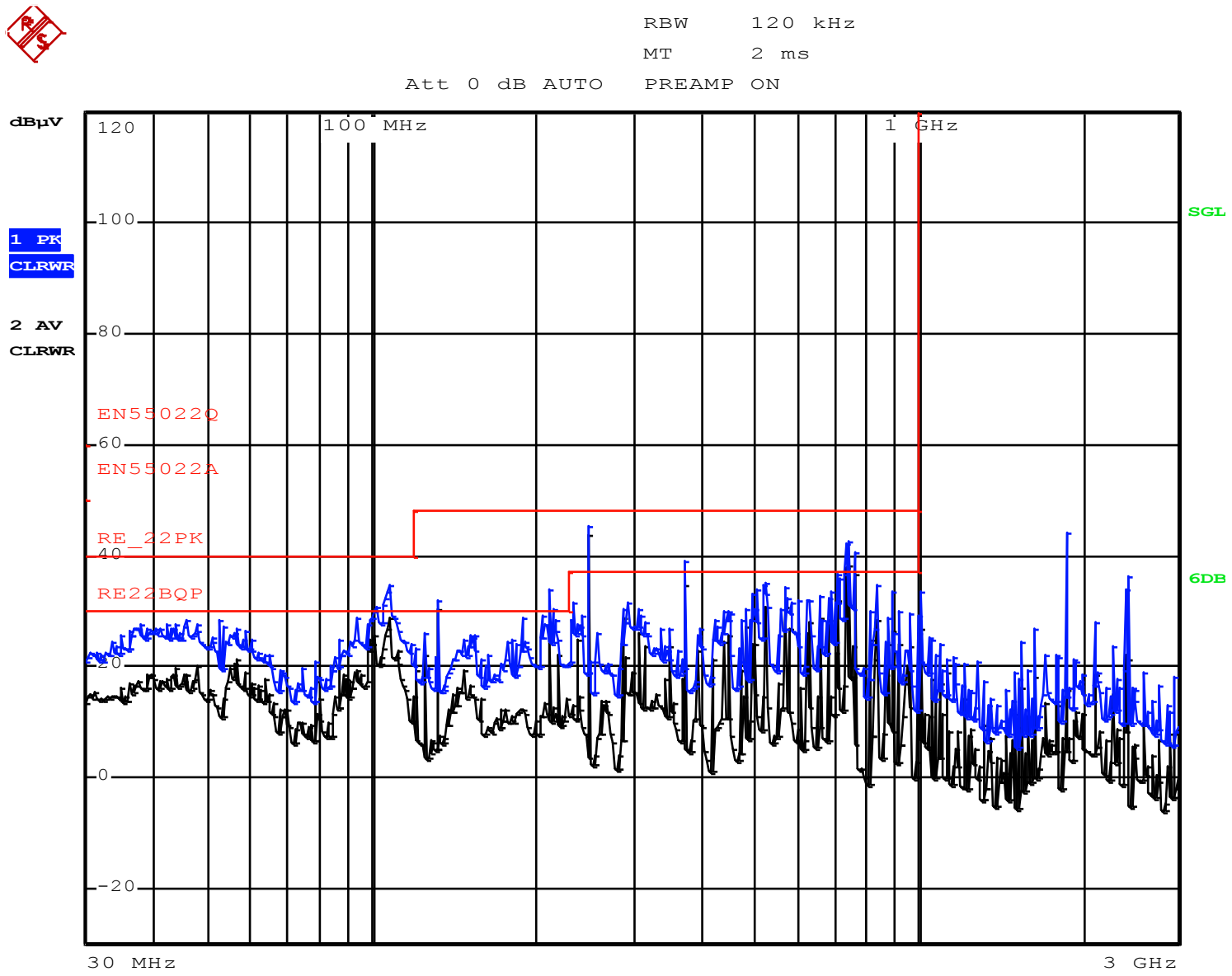
FB1


RBW 120 kHz
MT 30 ms
Att 0 dB AUTO PREAMP ON
dBµV
120
100
80
60
40
20
0
-20
1 MHz
10 MHz
1 PK
CLRWR
2 AV
CLRWR
SGL
6DB
EN55022Q
EN55022A
80 kHz
30 MHz

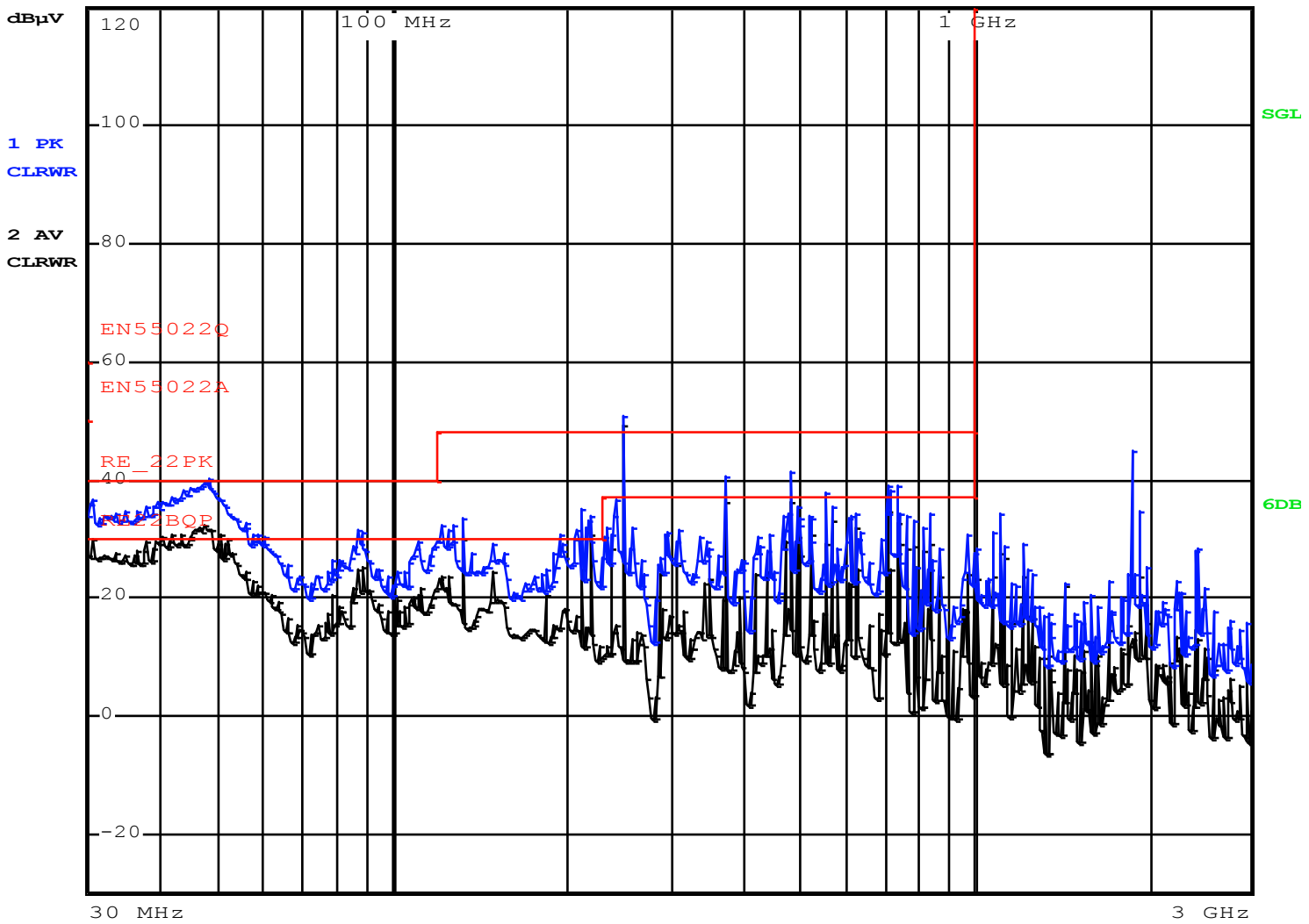
FB2


RBW 9 kHz
MT 30 ms
Att 0 dB AUTO PREAMP ON
dBµV
120
100
80
60
40
20
0
-20
1 MHz
10 MHz
1 PK
CLRWR
2 AV
CLRWR
EN55022Q
EN55022A
SGL
6DB
80 kHz
30 MHz

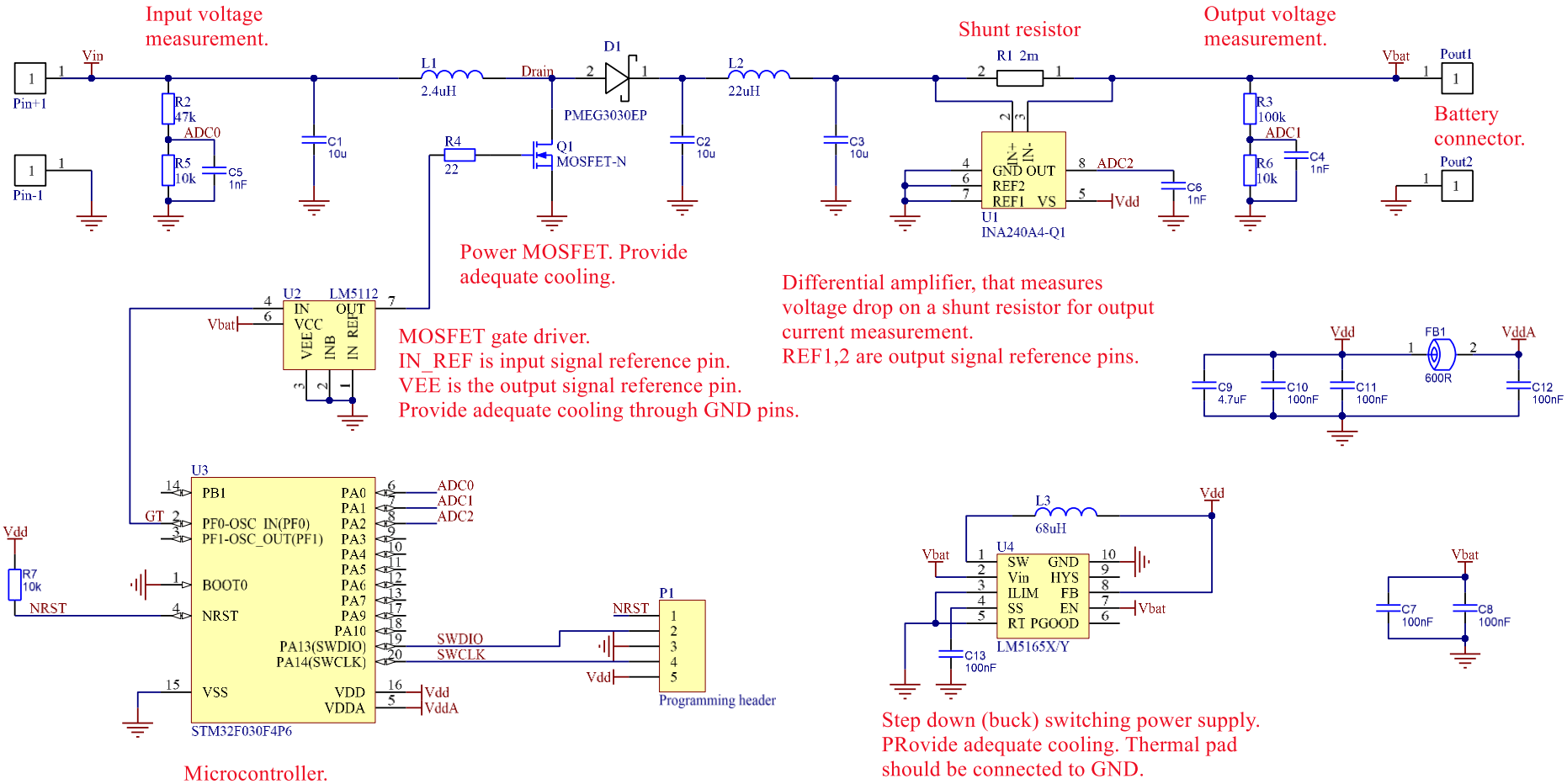
Z C_{IO}

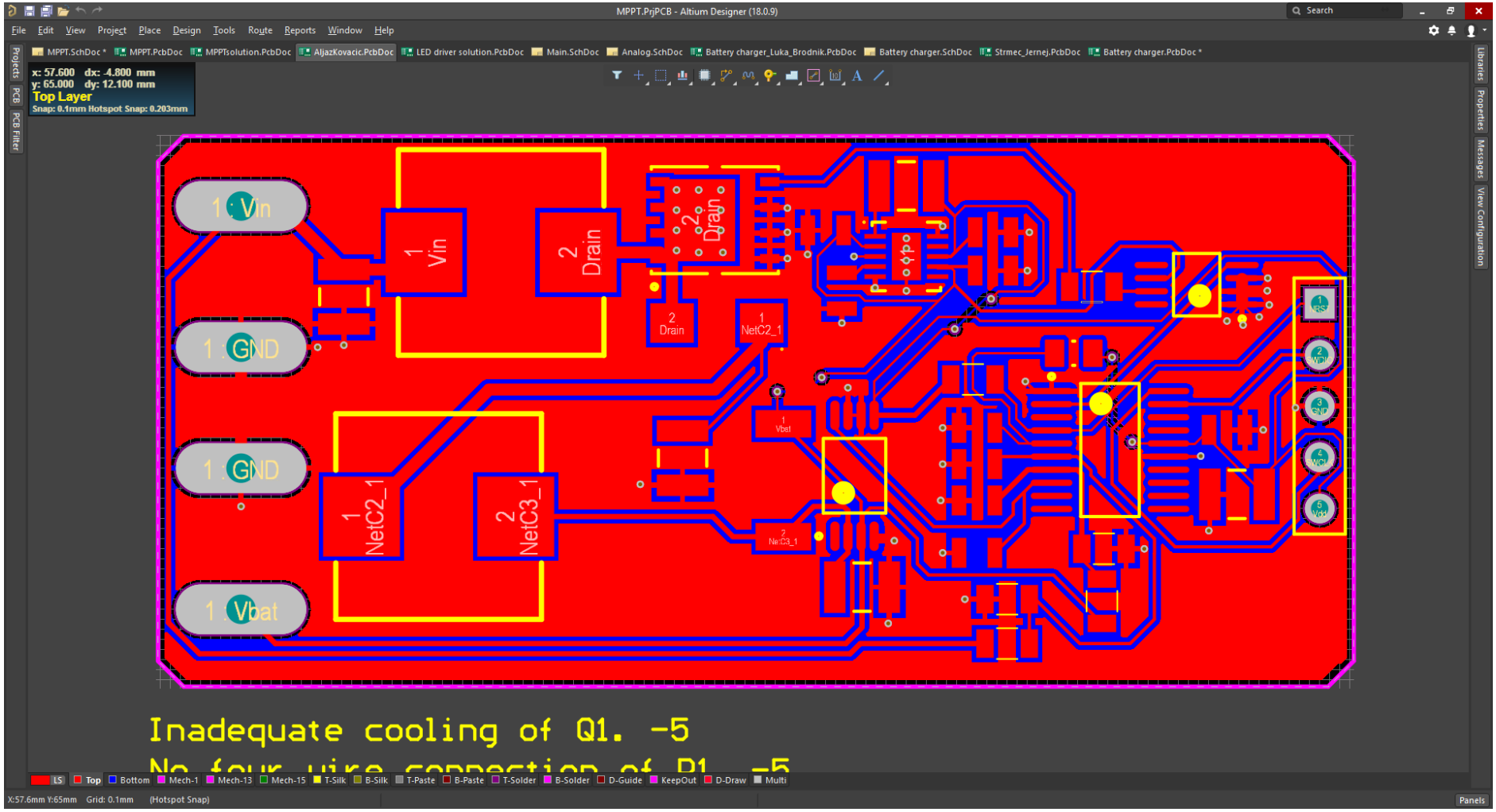

RBW 120 kHz
MT 2 ms
Att 0 dB AUTO PREAMP ON
dBµV
120
100 MHz
1 GHz
100
1 PK
CLRWR
2 AV
CLRWR
80
EN55022Q
60
EN55022A
RE_22PK
40
RE22BQP
20
0
-20
SGL
6DB
30 MHz
3 GHz

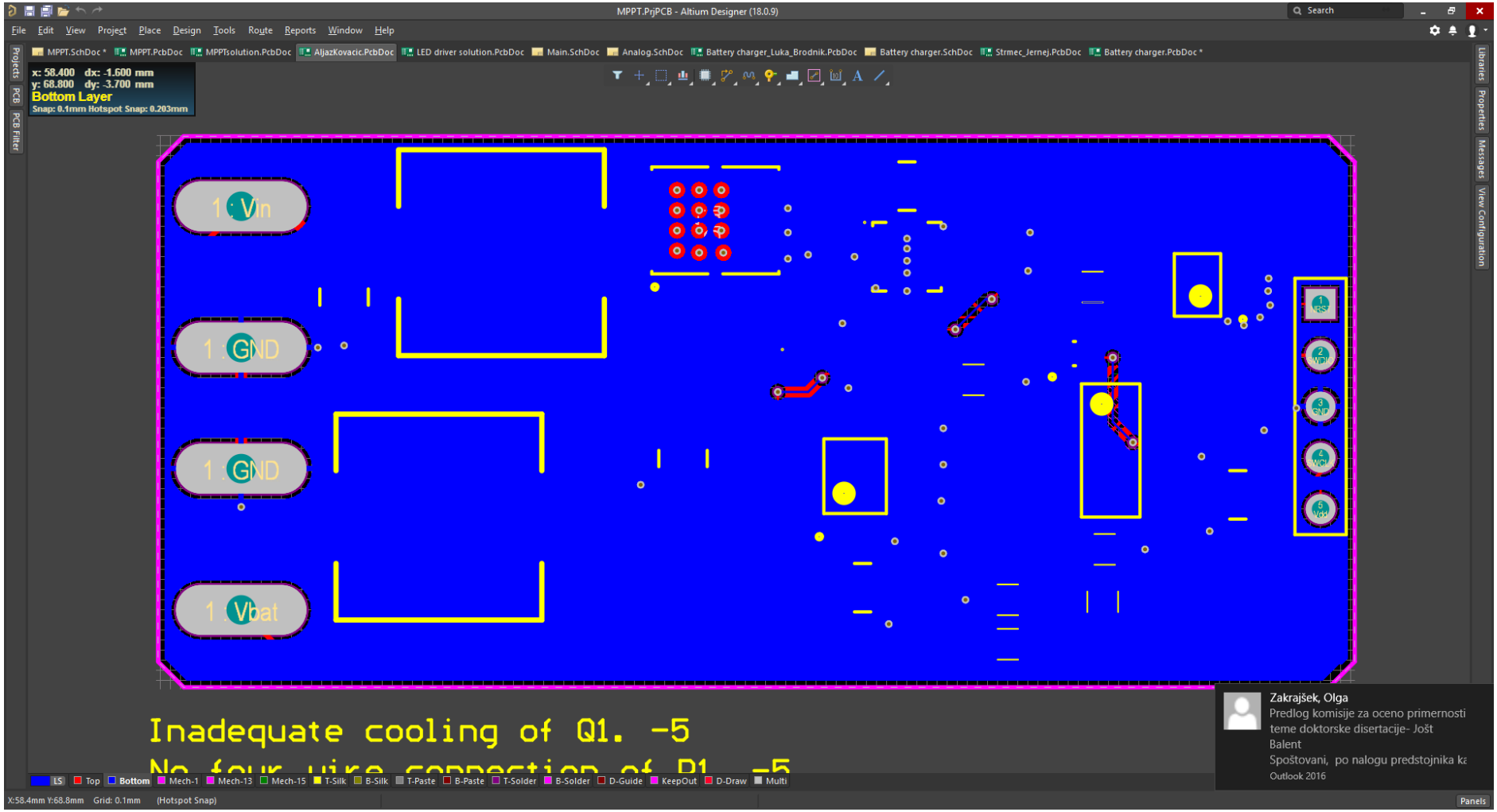
Brez C_{IO}

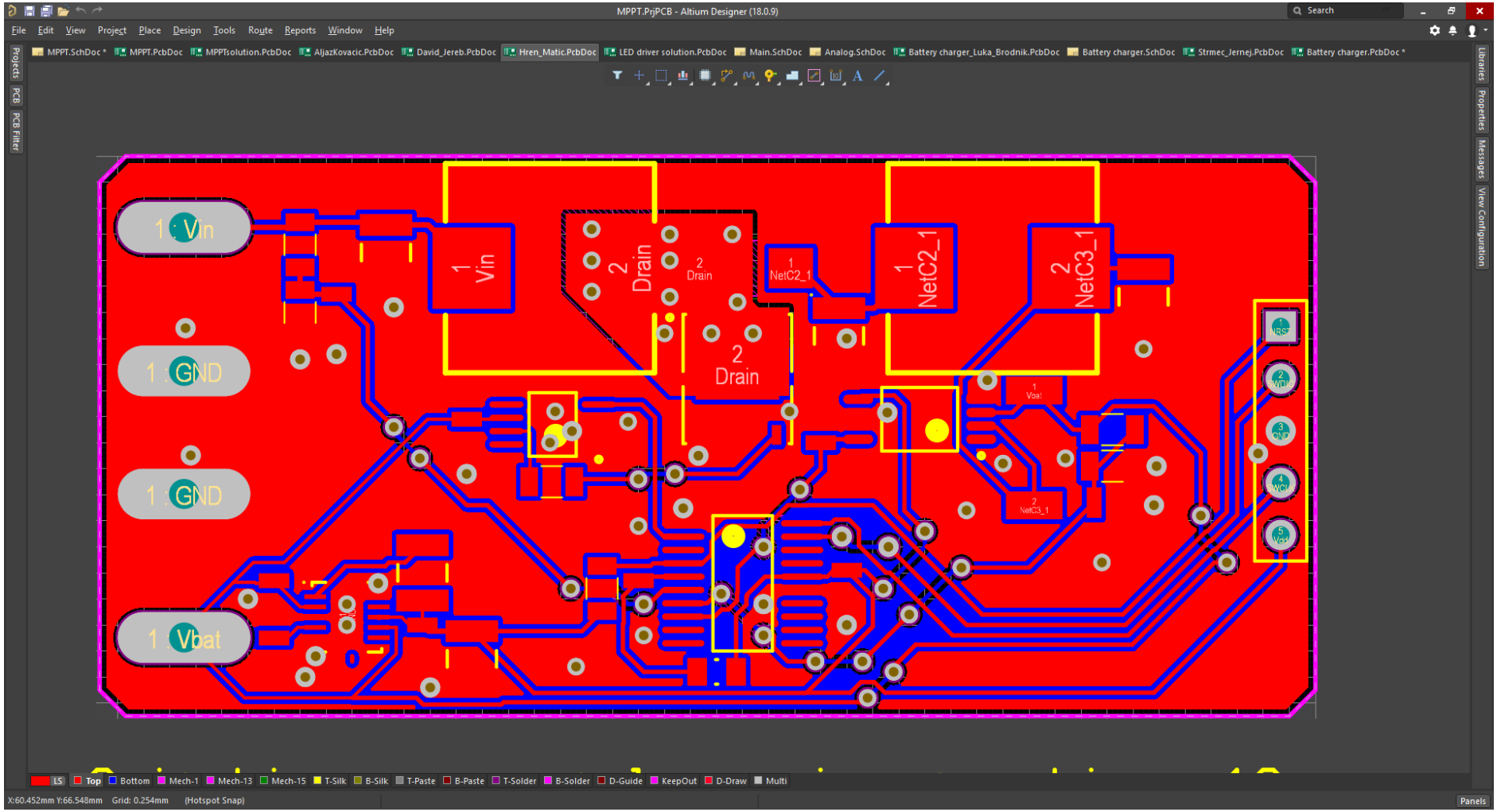

RBW 120 kHz
MT 2 ms
Att 0 dB AUTO PREAMP ON
dBµV
120
100
80
60
40
20
0
-20
100 MHz
1 GHz
1 PK
CLRWR
2 AV
CLRWR
SGL
6DB
EN55022Q
EN55022A
RE_22PK
RE_22BQP
30 MHz
3 GHz

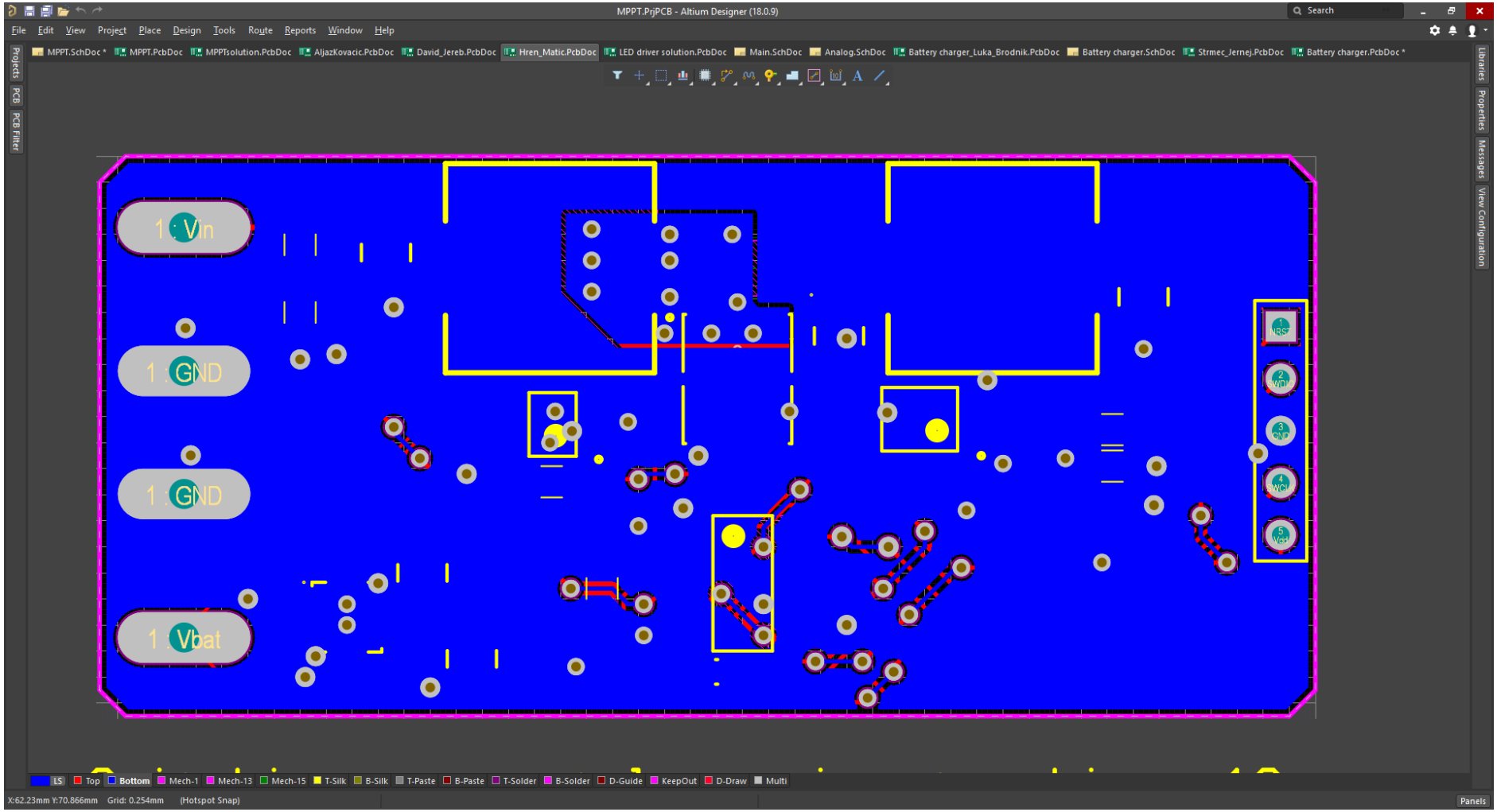
Primer pretvornika navzgor

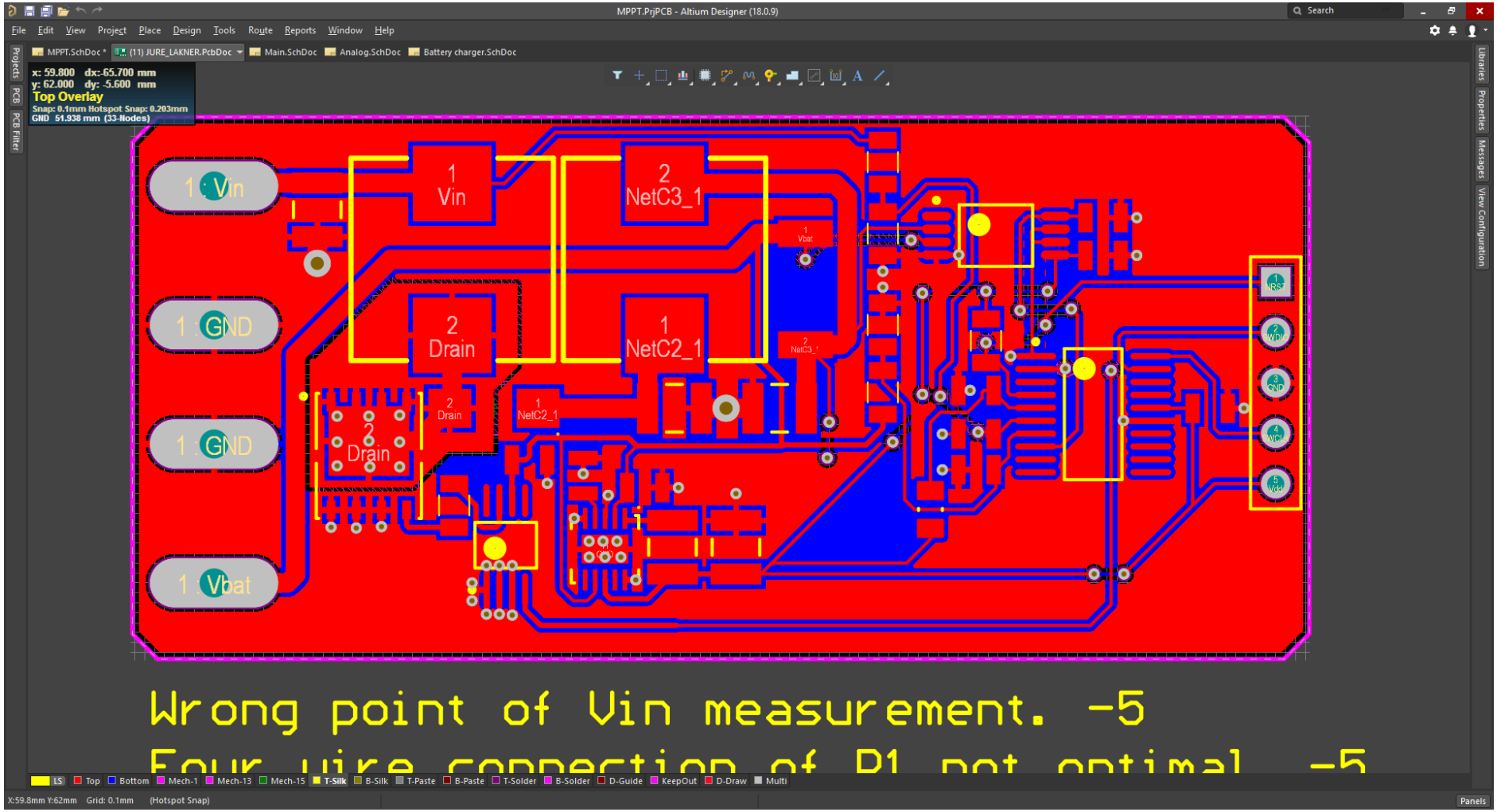


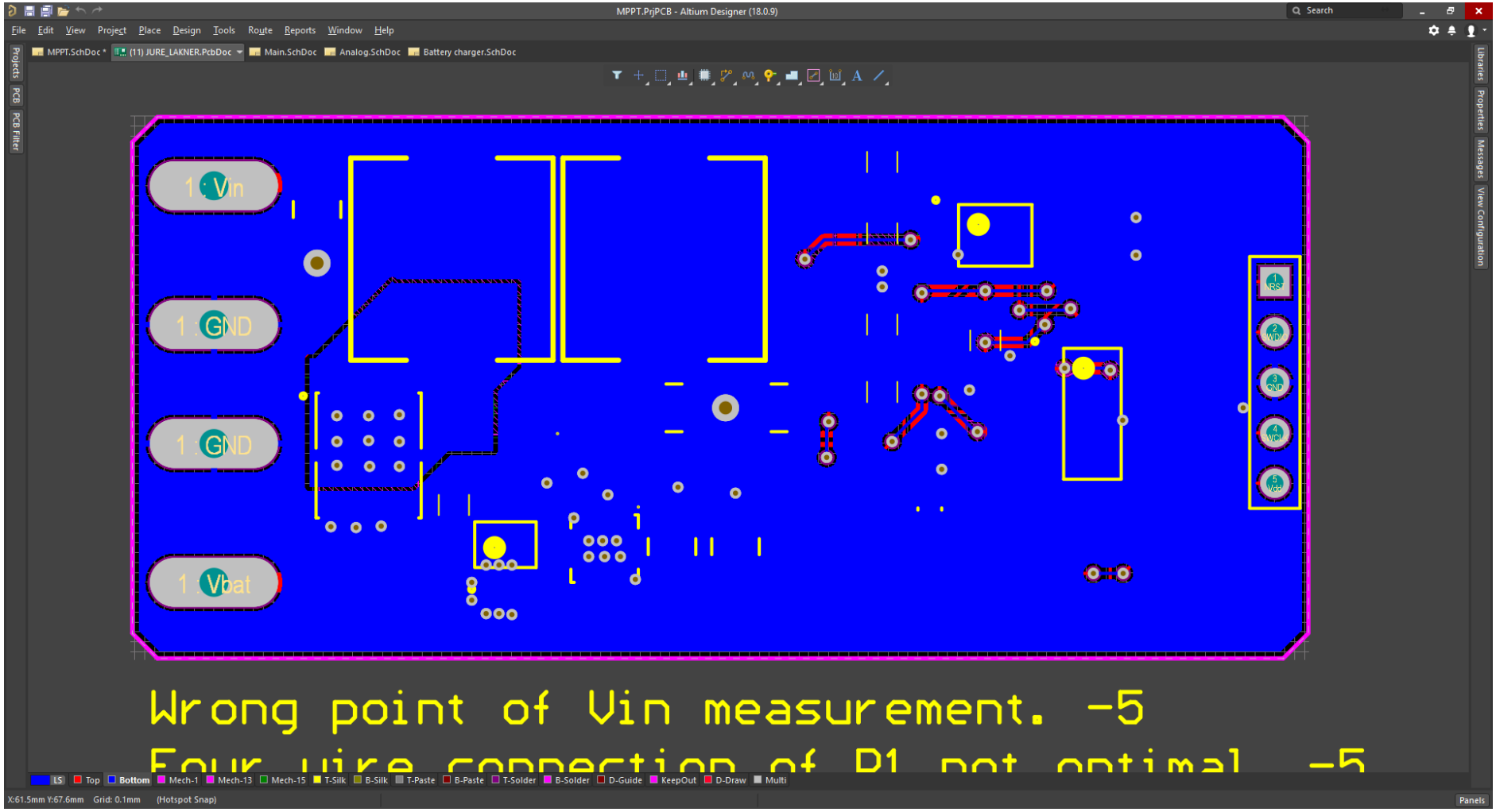

MPPT.PrjPCB - Altium Designer (18.0.9)
x: 57.600 dx: -4.800 mm
y: 65.000 dy: 12.100 mm
Top Layer
Snap: 0.1mm Hotspot Snap: 0.203mm
1 Vin
1 GND
1 GND
1 Vbat
1 Vin
2 Drain
2 Drain
2 Drain
1 NetC2_1
1 NetC2_1
2 NetC3_1
1 Vbat
Inadequate cooling of Q1. -5
No four wire correction of R1. -5

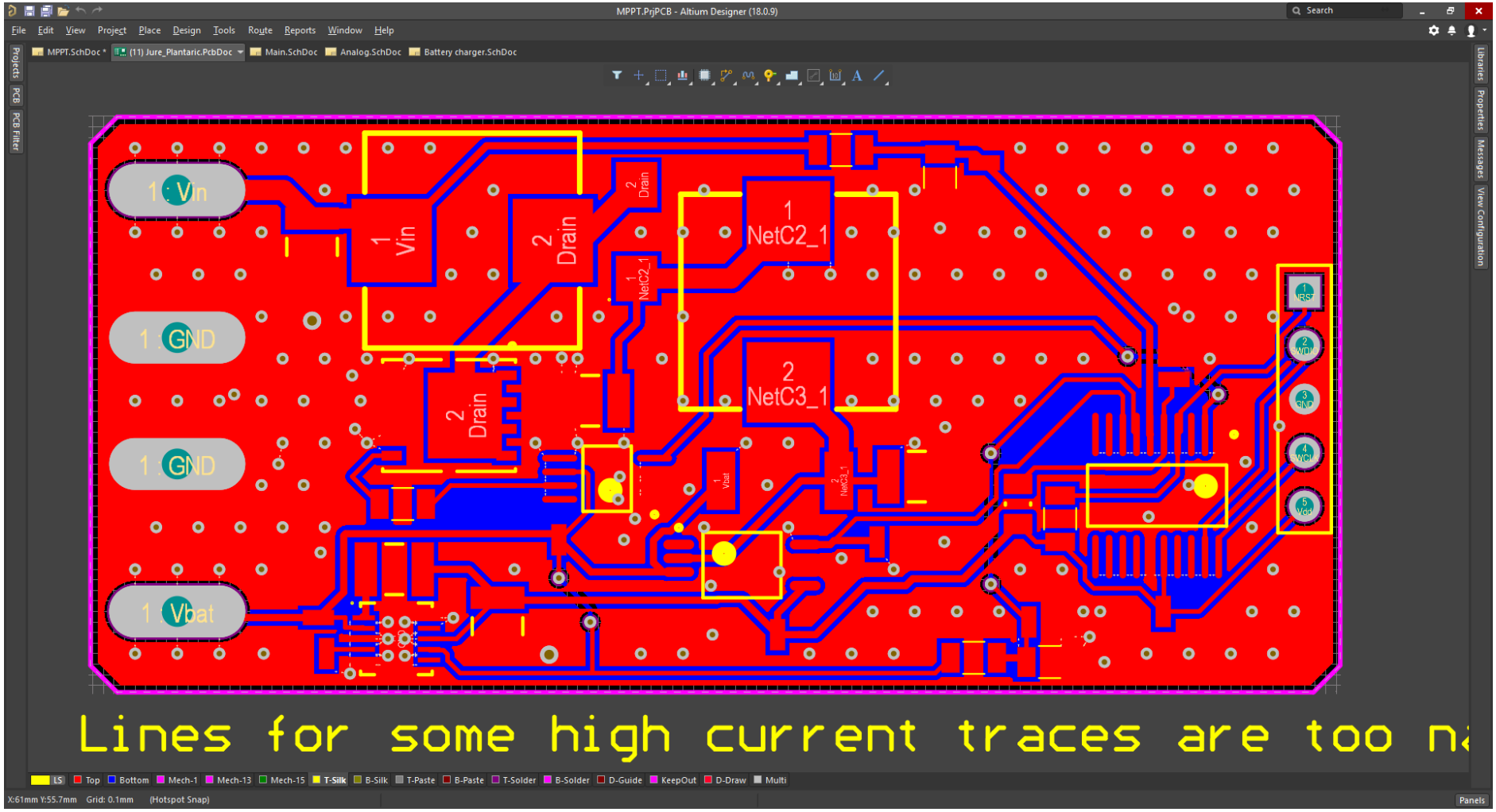

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * MPPT.PcbDoc MPPTsolution.PcbDoc AljazKovacic.PcbDoc LED driver solution.PcbDoc Main.SchDoc Analog.SchDoc Battery charger_Luka_Brodnik.PcbDoc Battery charger.SchDoc Strmec_Jernej.PcbDoc Battery charger.PcbDoc *
x: 58.400 dx: -1.600 mm
y: 68.800 dy: -3.700 mm
Bottom Layer
Snap: 0.1mm Hotspot Snap: 0.203mm
1 Vin
1 GND
1 GND
1 Vbat
Inadequate cooling of Q1. -5
No four wire connection of R1. -5
Zakrajšek, Olga
Predlog komisije za oceno primernosti teme doktorske disertacije- Jošt Balent
Spoštovani, po nalogu predstojnika ka
Outlook 2016

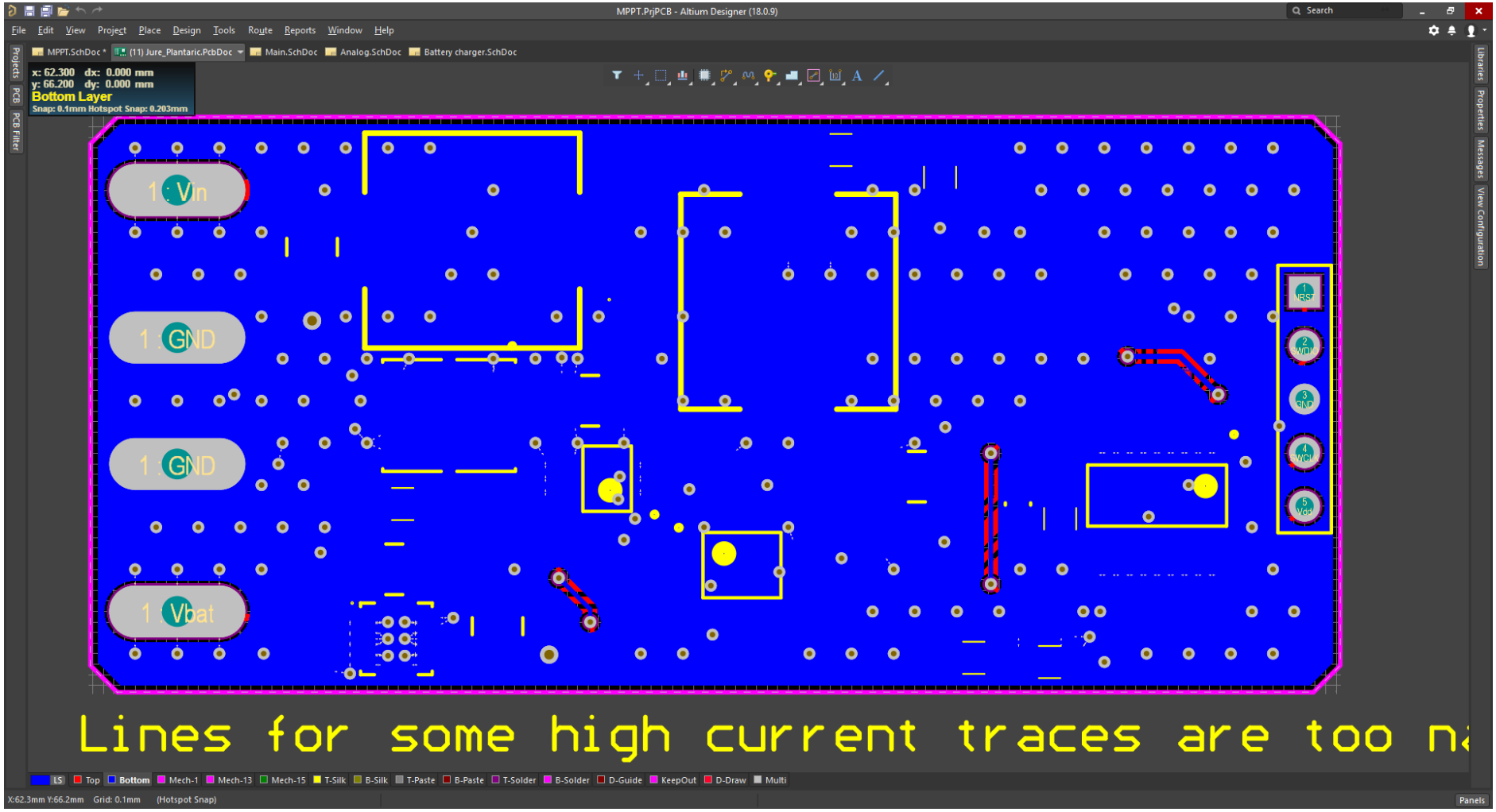

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * MPPT.PcbDoc MPPTsolution.PcbDoc AljazKovacic.PcbDoc David_Jereb.PcbDoc Hren_Matic.PcbDoc LED driver solution.PcbDoc Main.SchDoc Analog.SchDoc Battery charger_Luka_Brodnik.PcbDoc Battery charger.SchDoc Strmec_Jernej.PcbDoc Battery charger.PcbDoc *
1 Vin
1 GND
1 GND
1 Vbat
1 Vin
2 Drain
2 Drain
2 Drain
1 NetC2_1
1 NetC2_1
2 NetC3_1
Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:60.452mm Y:66.548mm Grid: 0.254mm (Hotspot Snap)

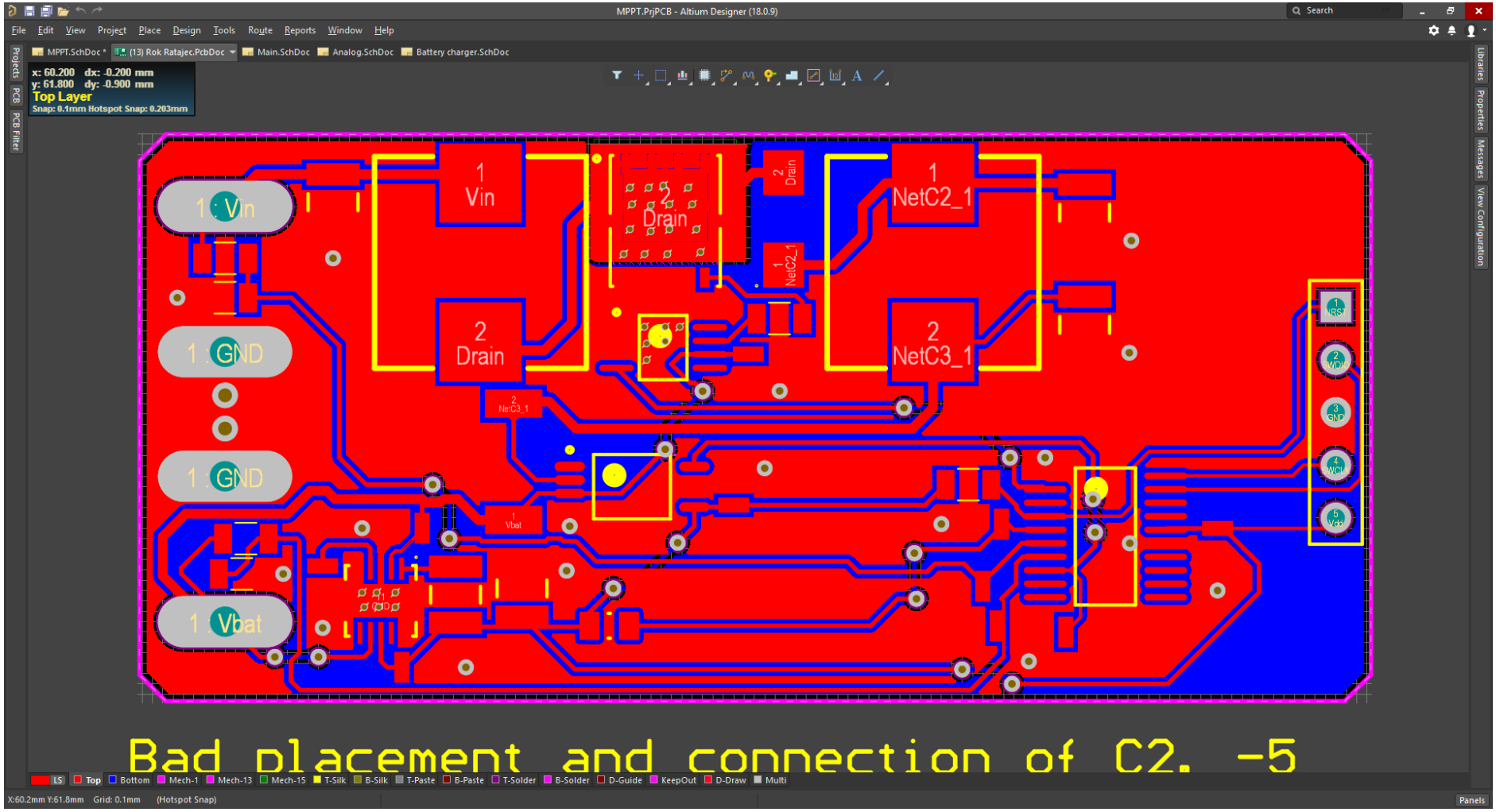

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * MPPT.PcbDoc MPPTsolution.PcbDoc AljazKovacic.PcbDoc David_Jereb.PcbDoc Hren_Matic.PcbDoc LED driver solution.PcbDoc Main.SchDoc Analog.SchDoc Battery charger_Luka_Brodnik.PcbDoc Battery charger.SchDoc Strmec_Jernej.PcbDoc Battery charger.PcbDoc *
Vin
GND
GND
Vbat
LS Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:62.23mm Y:70.866mm Grid: 0.254mm (Hotspot Snap)
Panels

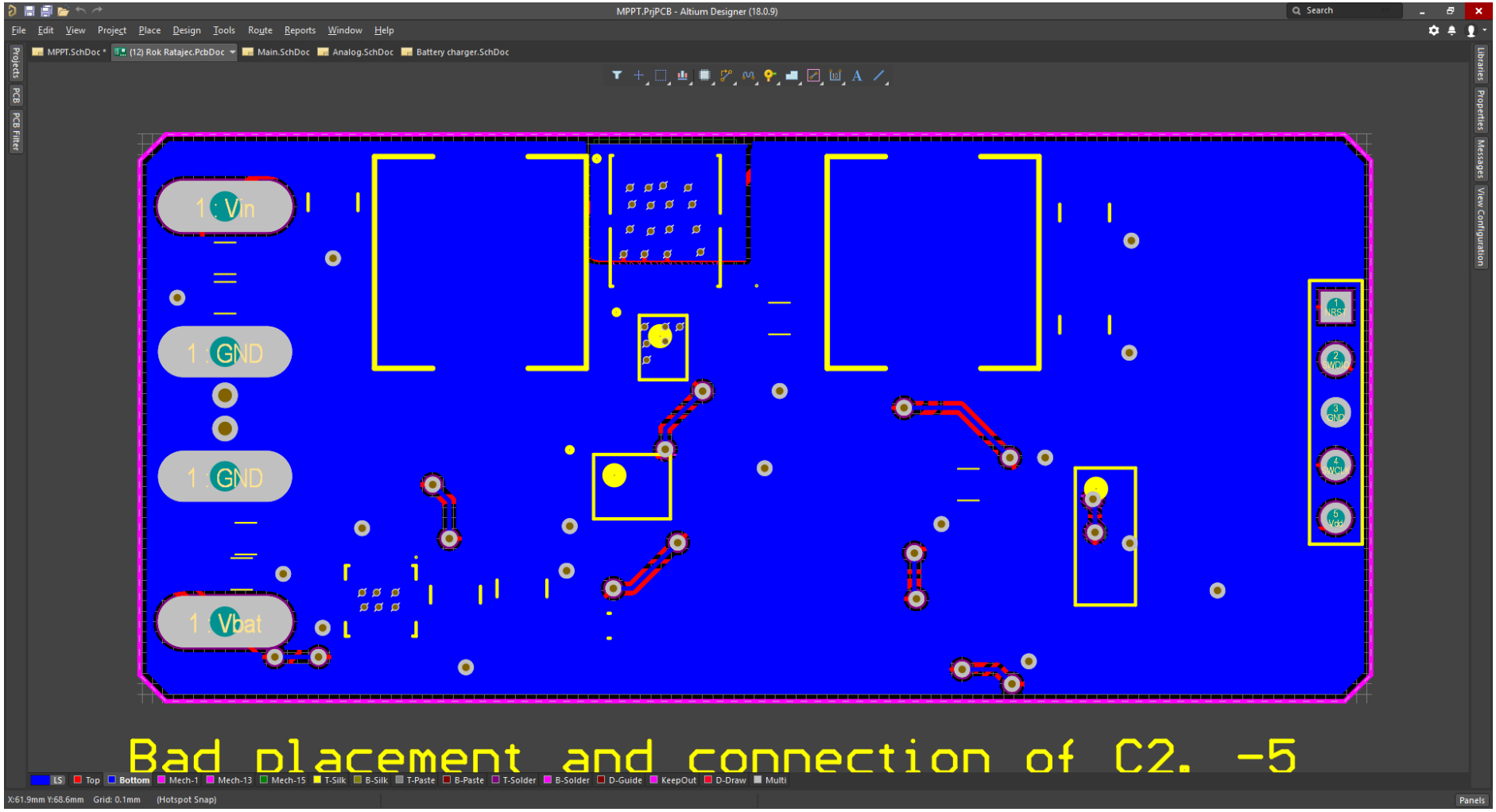

MPPT.PrjPCB - Altium Designer (18.0.9)
Vin
GND
GND
Vbat
Drain
Drain
NetC3_1
NetC2_1
Wrong point of Vin measurement. -5
Four wire connection of P1 not optimal -5

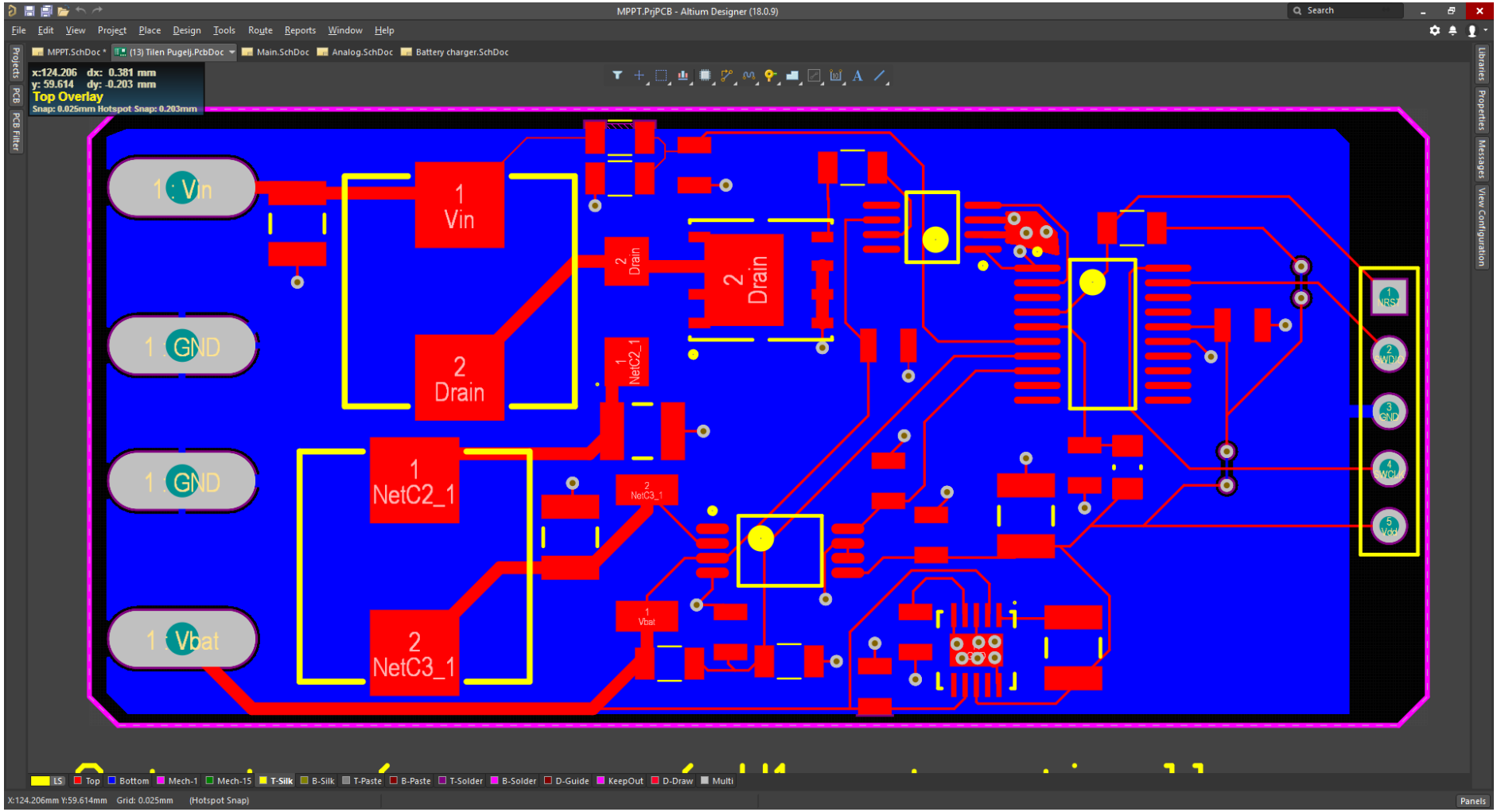

MPPT.PrjPCB - Altium Designer (18.0.9)
Vin
GND
GND
Vbat
Wrong point of Vin measurement. -5
Four wire connection of P1 not optimal -5

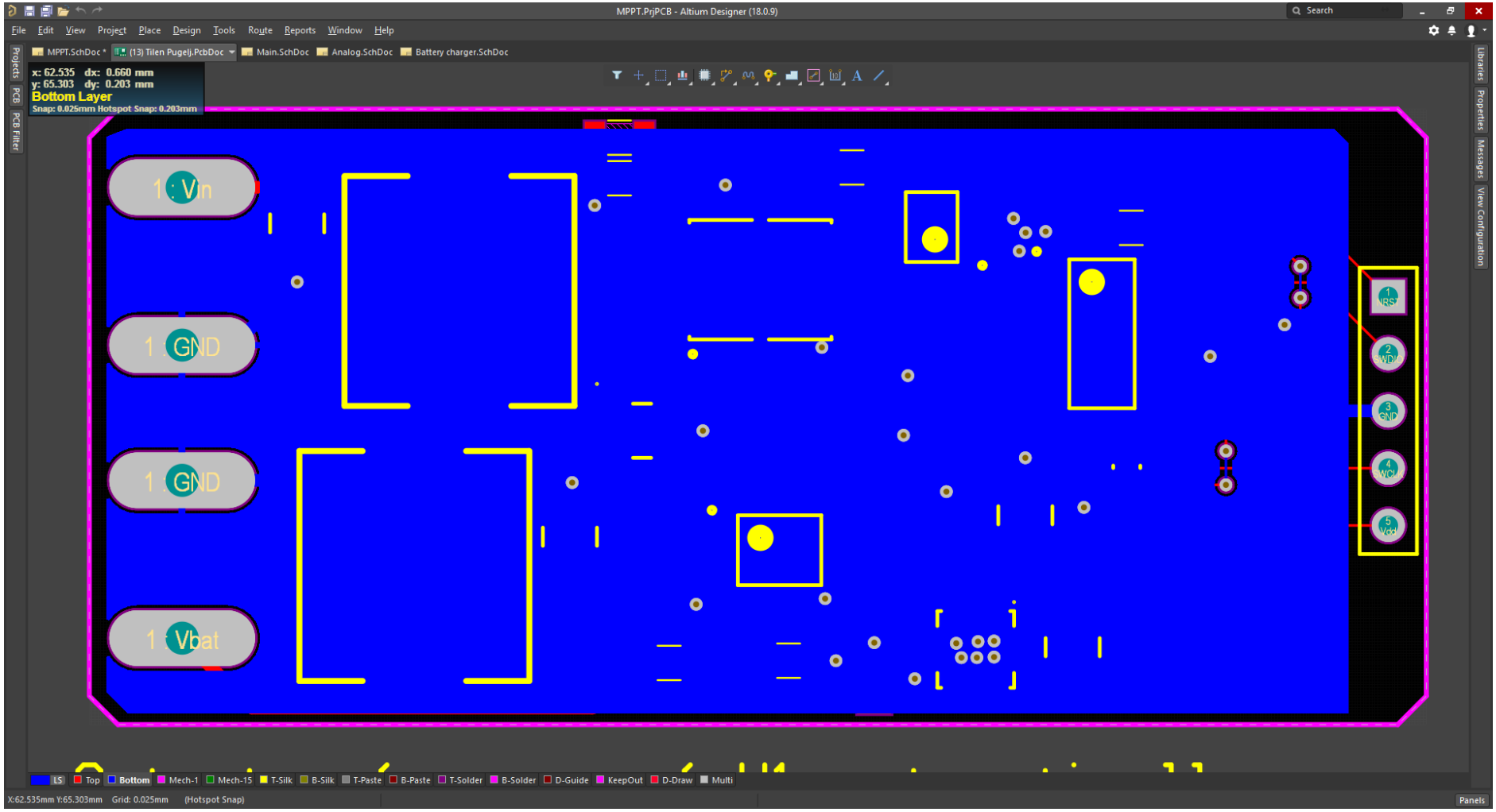

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (11) Jure_Plantaric.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
1 Vin
1 GND
1 GND
1 Vbat
1 Vin
2 Drain
2 Drain
1 NetC2_1
2 NetC3_1
Lines for some high current traces are too n
Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:61mm Y:55.7mm Grid: 0.1mm (Hotspot Snap)
Panels

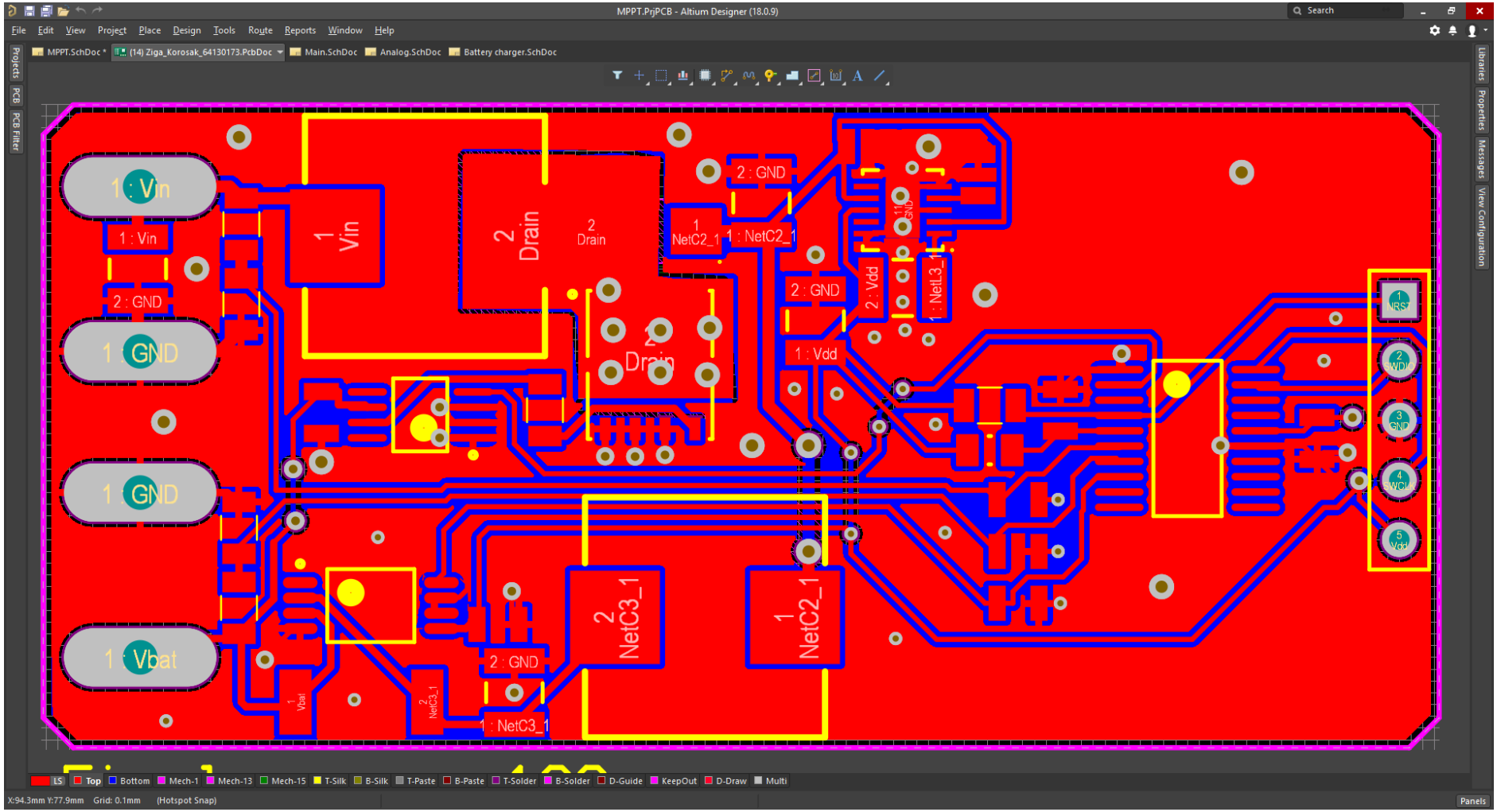

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (11) Jure_Plantaric.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
x: 62.300 dx: 0.000 mm
y: 66.200 dy: 0.000 mm
Bottom Layer
Snap: 0.1mm Hotspot Snap: 0.203mm
1 Vin
1 GND
1 GND
1 Vbat
Lines for some high current traces are too n
LS Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:62.3mm Y:66.2mm Grid: 0.1mm (Hotspot Snap)
Panels

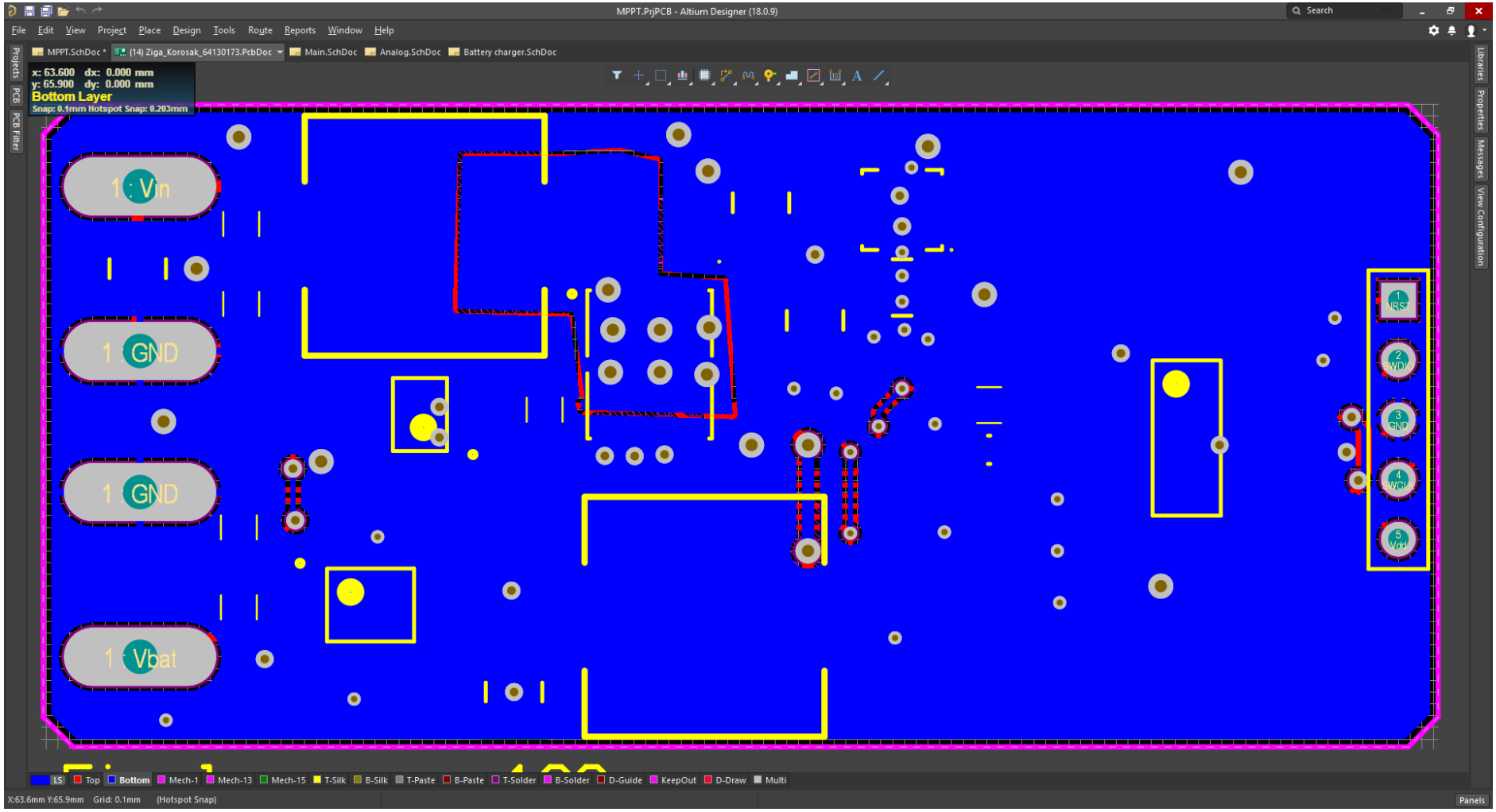

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (13) Rok Ratajec.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
x: 60.200 dx: -0.200 mm
y: 61.800 dy: -0.900 mm
Top Layer
Snap: 0.1mm Hotspot Snap: 0.203mm
1 Vin
GND
GND
Vbat
1 Vin
2 Drain
2 Drain
1 NetC2_1
2 NetC3_1
1 NetC2_1
2 NetC3_1
1 Vbat
1 NRST
2 WDI
3 GND
4 WCI
5 VCC
Bad placement and connection of C2. -5
LS Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:60.2mm Y:61.8mm Grid: 0.1mm (Hotspot Snap)
Panels

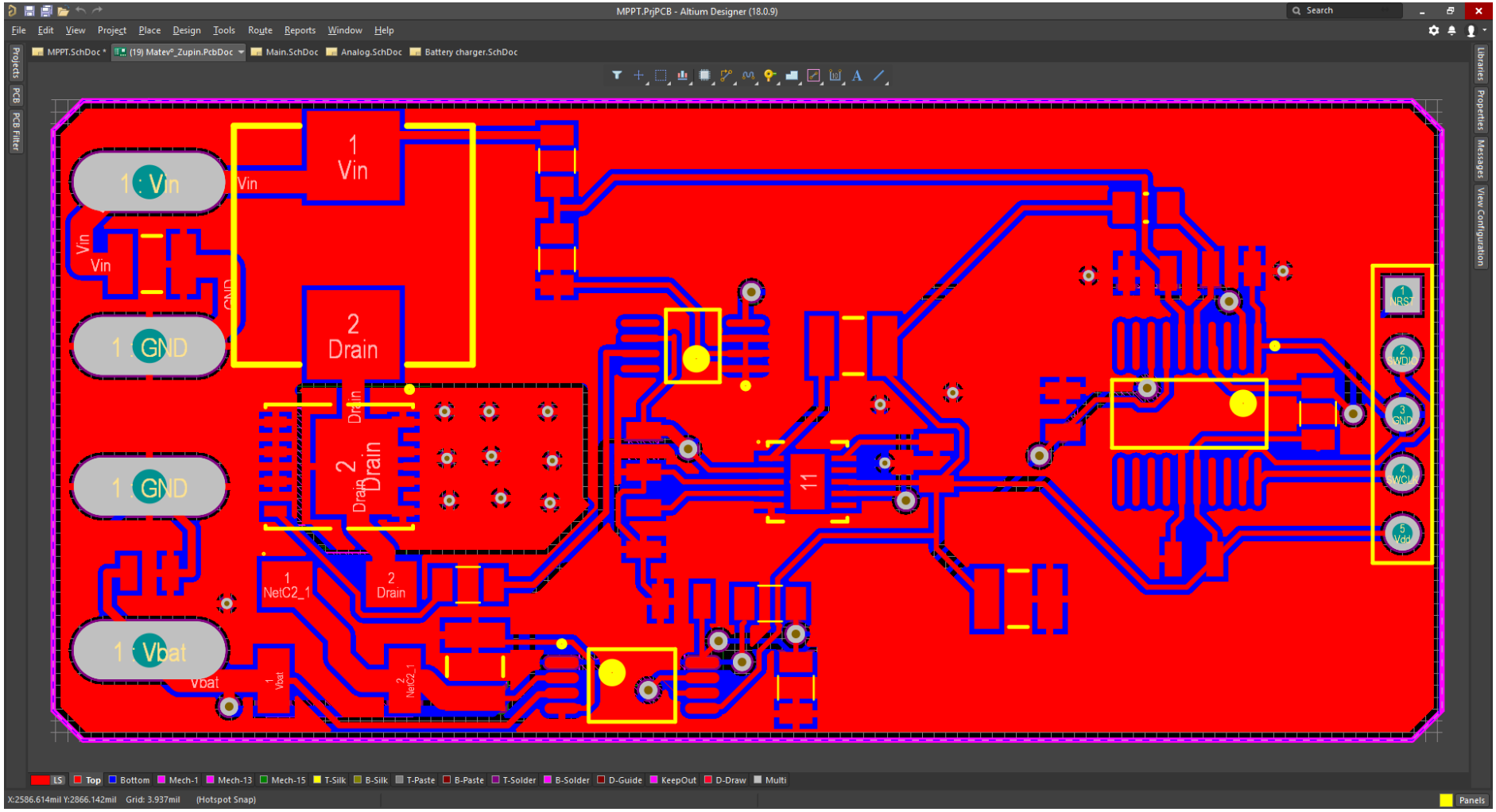

MPPT.PrjPCB - Altium Designer (18.0.9)
Vin
GND
GND
Vbat
Bad placement and connection of C2. -5

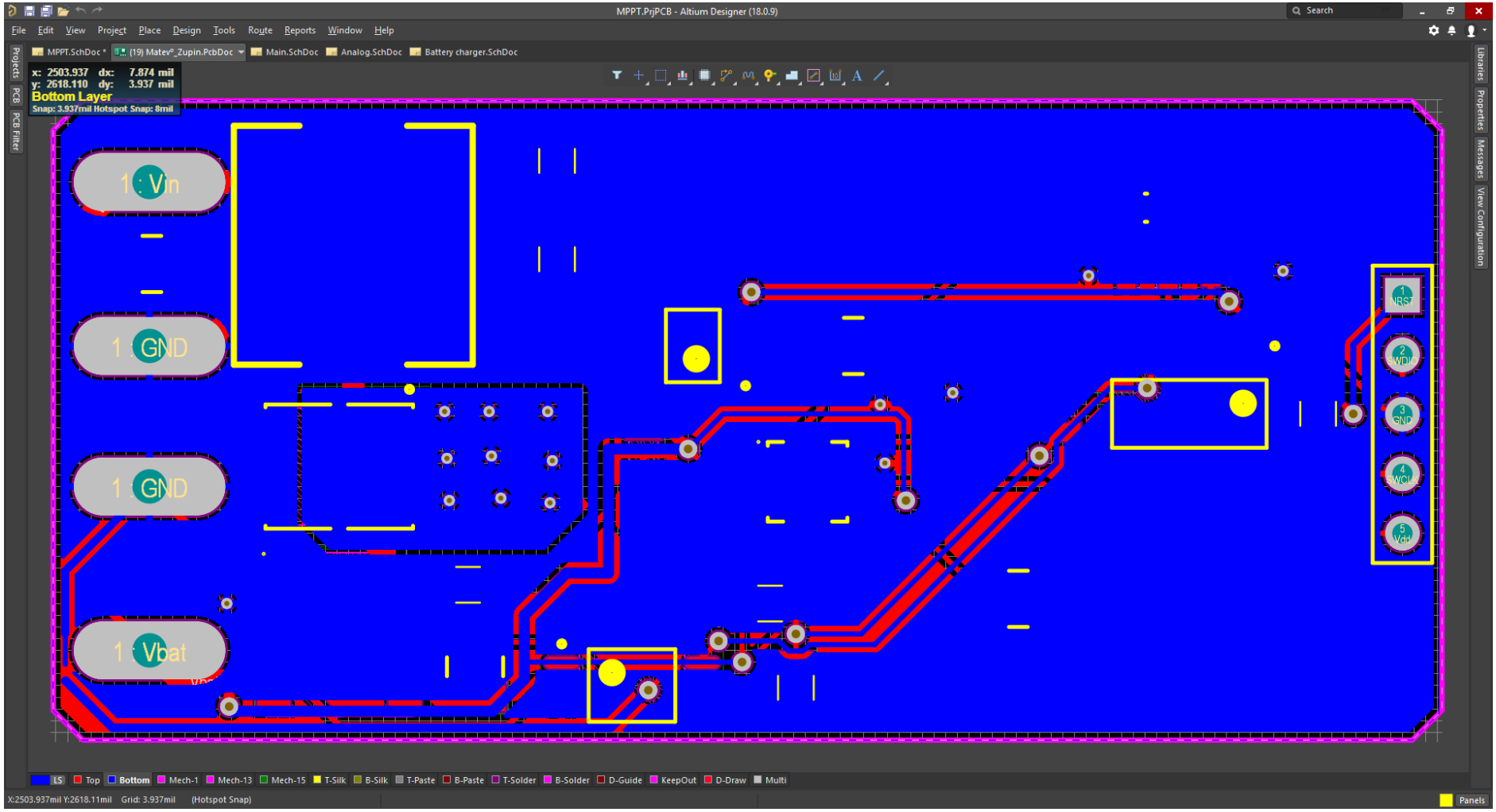

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (13) Tilen Pugelj.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
x:124.206 dx: 0.381 mm
y: 59.614 dy: -0.203 mm
Top Overlay
Snap: 0.025mm Hotspot Snap: 0.203mm
1 Vin
1 GND
1 GND
1 Vbat
1 Vin
2 Drain
1 NetC2_1
2 NetC3_1
2 Drain
2 Drain
1 NetC2_1
2 NetC3_1
1 Vbat
1 VRST
2 WDI
3 GND
4 WCI
5 VCC
Top Bottom Mech-1 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:124.206mm Y:59.614mm Grid: 0.025mm (Hotspot Snap)
Panels

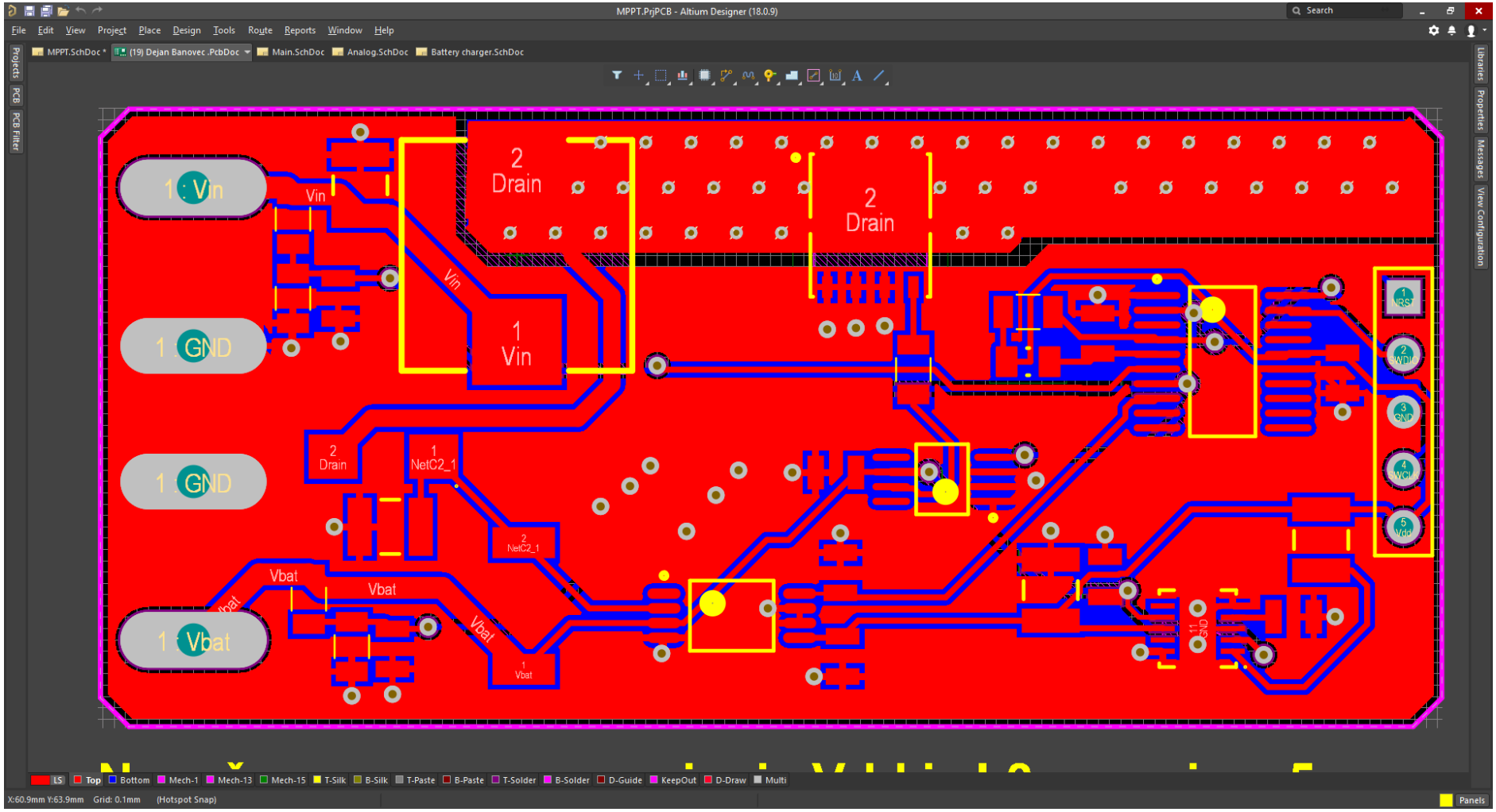

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (13) Tilen Pugelj.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
x: 62.535 dx: 0.660 mm
y: 65.303 dy: 0.203 mm
Bottom Layer
Snap: 0.025mm Hotspot Snap: 0.203mm
1 Vin
1 GND
1 GND
1 Vbat
1 VRST
2 WDI
3 GND
4 WCI
5 VCC
LS Top Bottom Mech-1 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:62.535mm Y:65.303mm Grid: 0.025mm (Hotspot Snap)
Panels

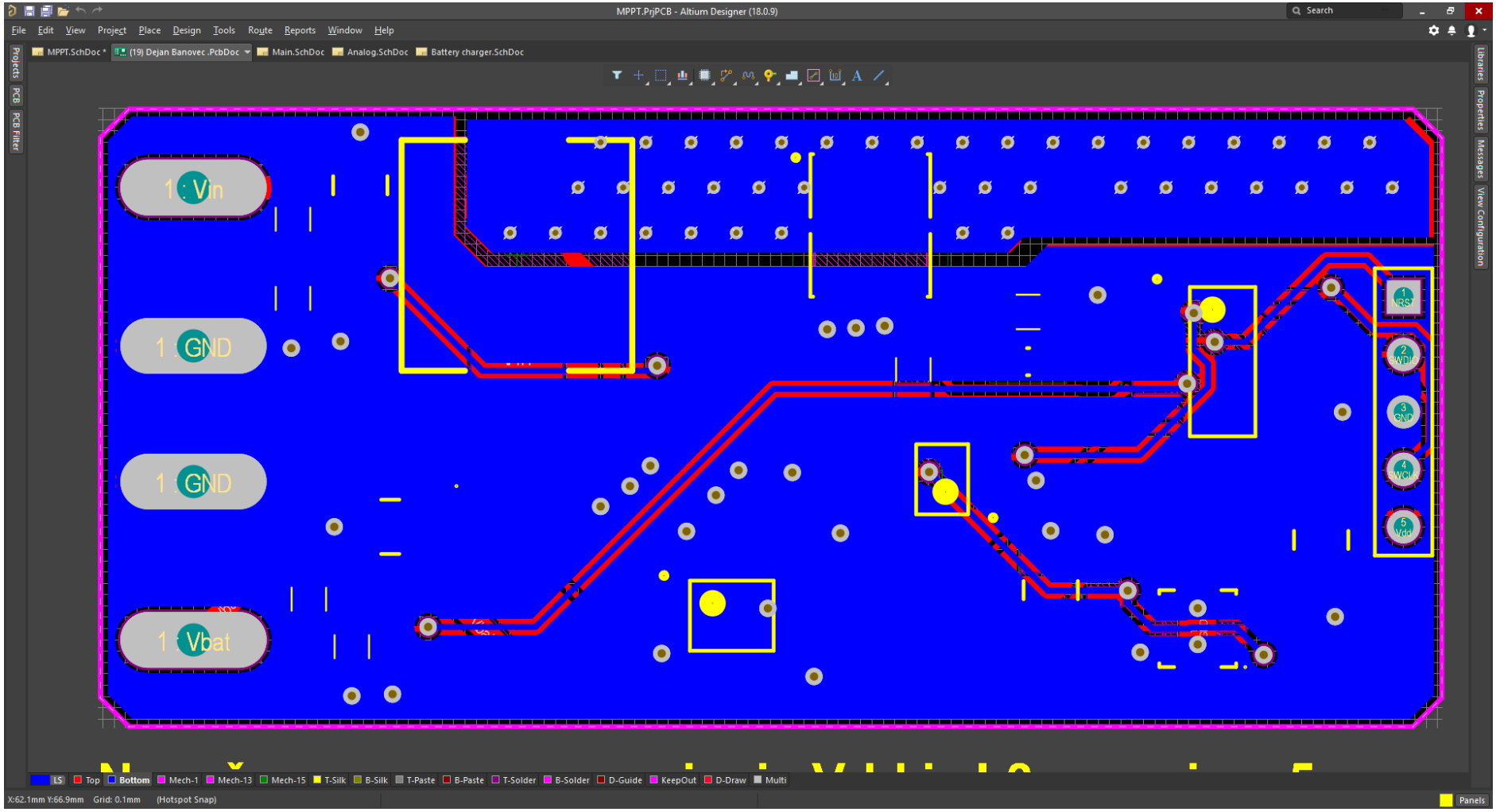

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (14) Ziga_Korosak_64130173.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
1 : Vin
1 : Vin
2 : GND
1 GND
1 GND
1 Vbat
1 Vin
2 Drain
2 Drain
Drain
2 : GND
1 NetC2_1
1 : NetC2_1
2 : GND
2 : Vdd
1 : NetL3_1
1 : Vdd
1 IRS
2 WDI
3 GND
4 WCU
5 Vcc
2 NetC3_1
1 NetC2_1
2 : GND
1 : NetC3_1
Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:94.3mm Y:77.9mm Grid: 0.1mm (Hotspot Snap)

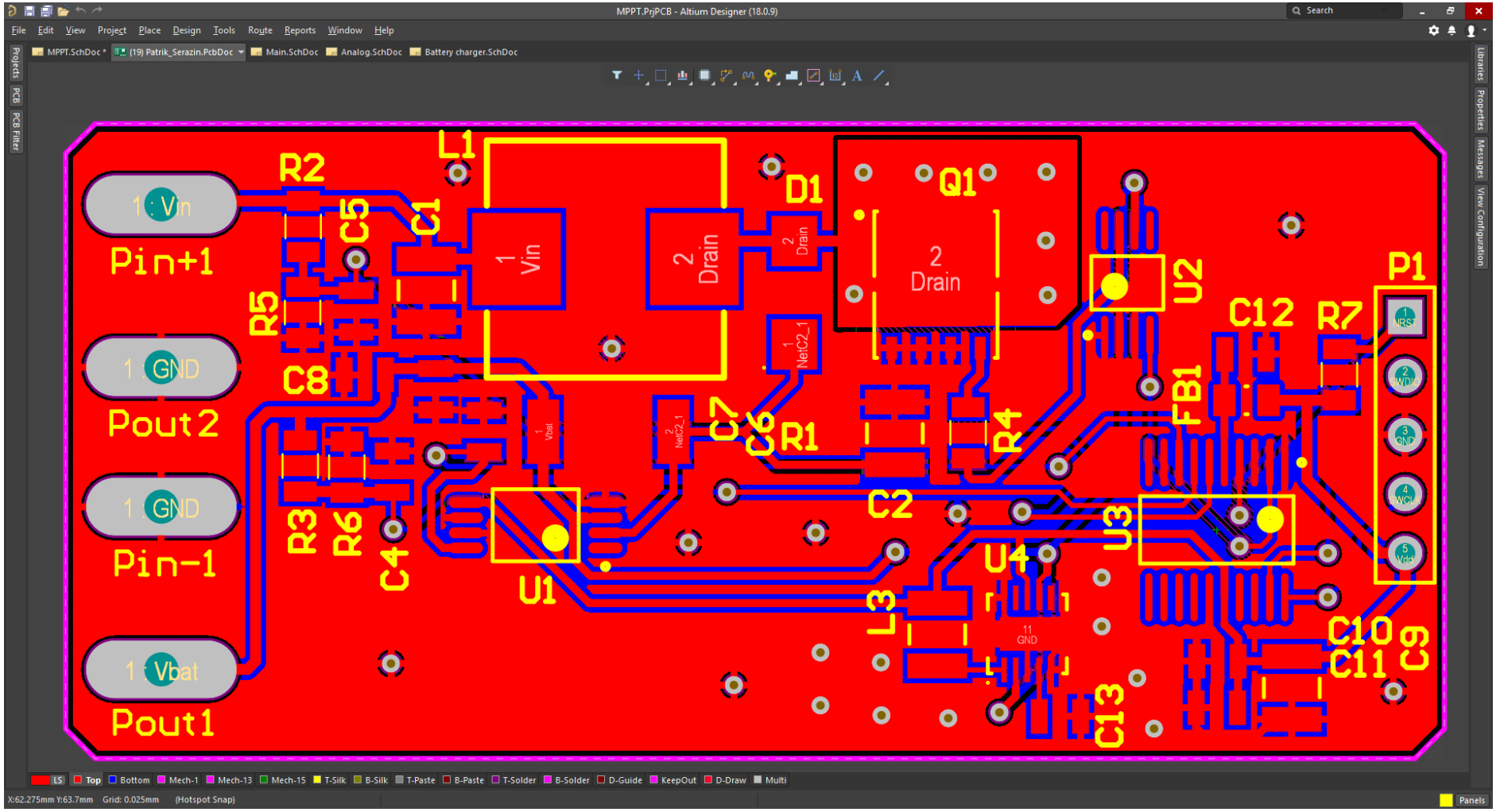

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (14) Ziga_Korosak_64130173.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
x: 63.600 dx: 0.000 mm
y: 65.900 dy: 0.000 mm
Bottom Layer
Snap: 0.1mm Hotspot Snap: 0.203mm
1 Vin
1 GND
1 GND
1 Vbat
1 IRST
2 WDI
3 GND
4 WCI
5 Vcc
LS Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:63.6mm Y:65.9mm Grid: 0.1mm (Hotspot Snap)
Panels

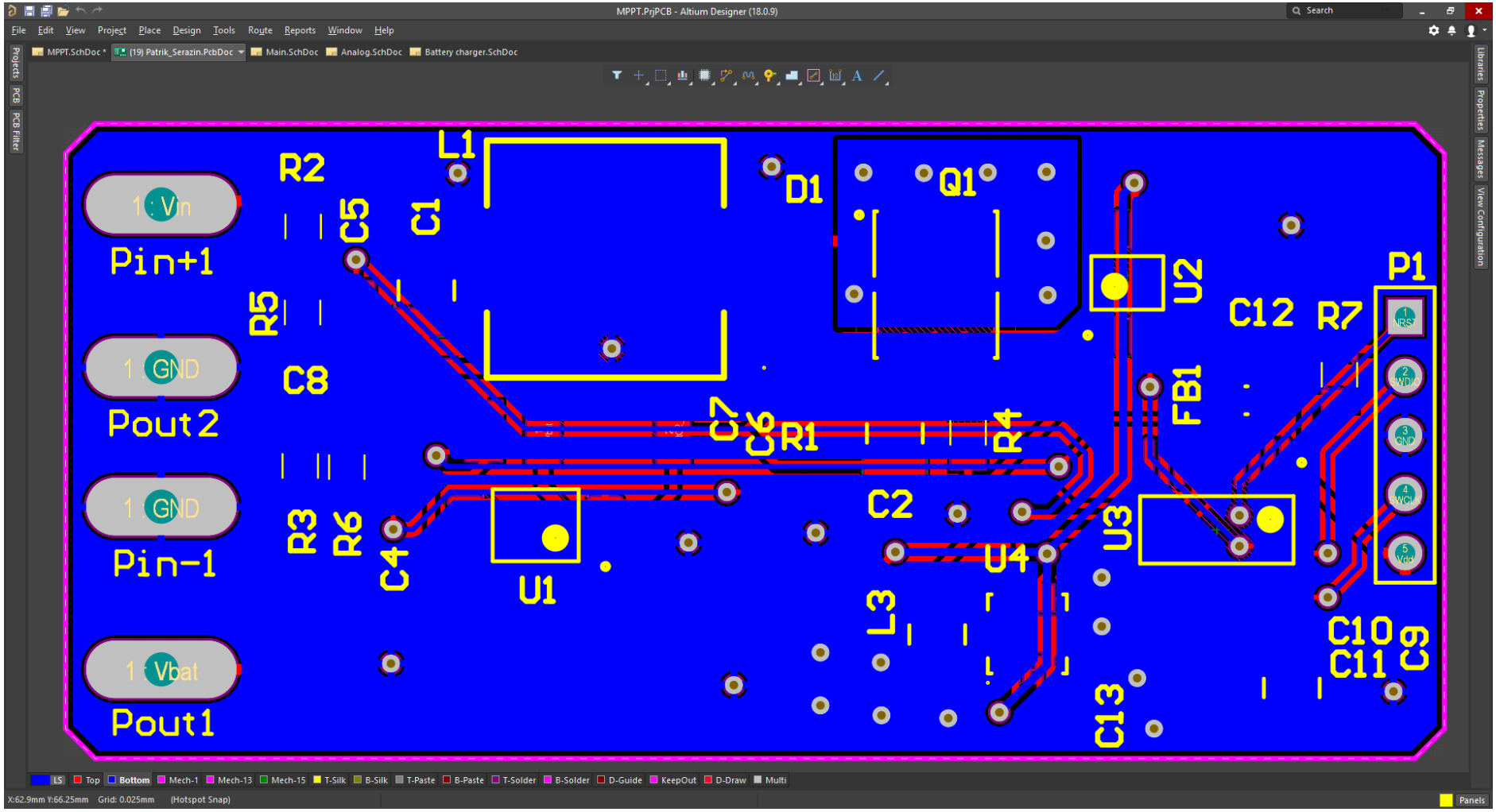

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (19) Matev?_Zupin.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
1 Vin
Vin
2 Drain
GND
Vbat
NetC2_1
11
1 NRST
2 WDU
3 SND
4 WCU
5 VddU
Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:2586.614mil Y:2866.142mil Grid: 3.937mil (Hotspot Snap)
Panels

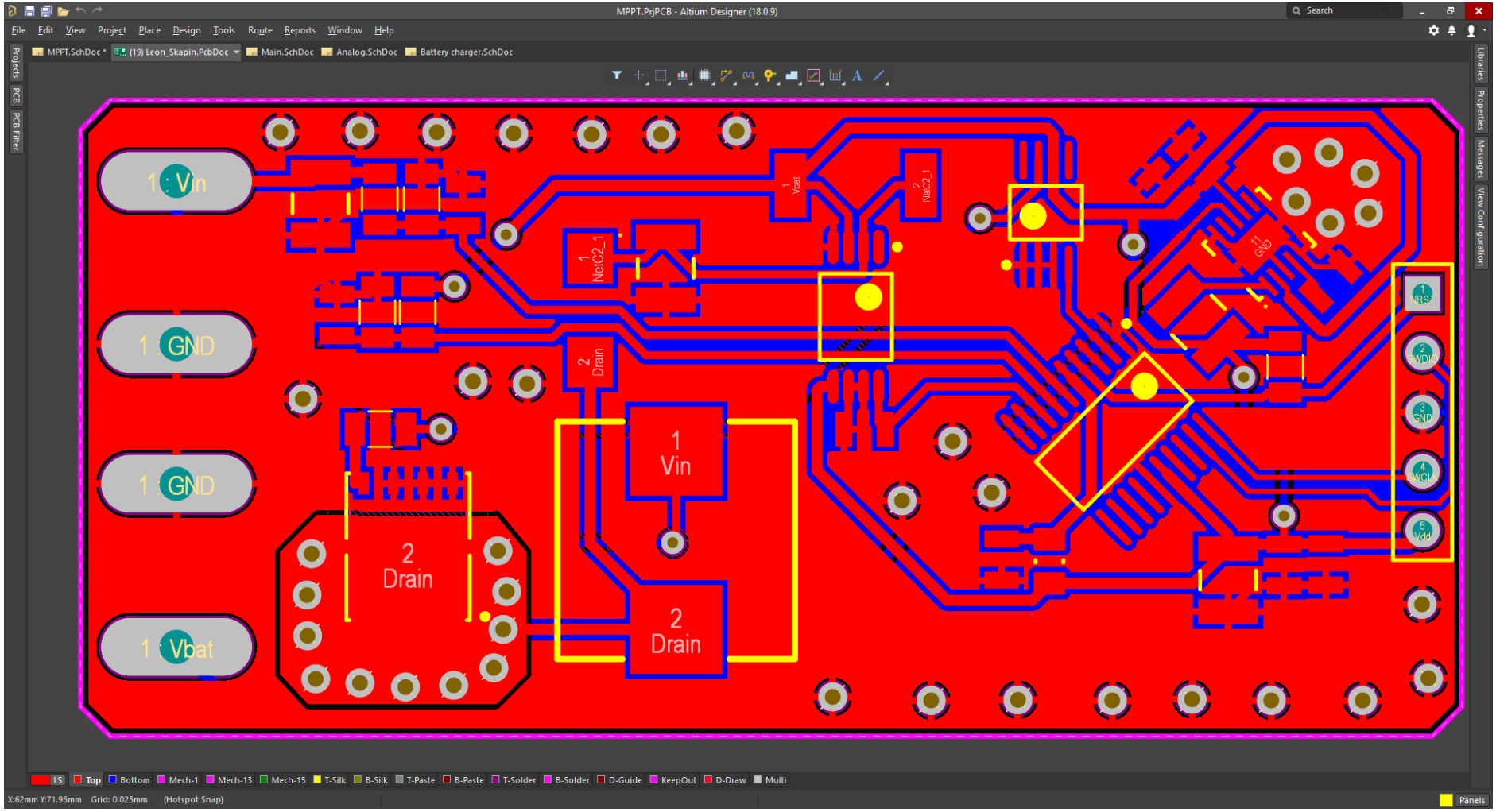

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (19) Matev_Zupin.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
x: 2503.937 dx: 7.874 mil
y: 2618.110 dy: 3.937 mil
Bottom Layer
Snap: 3.937mil Hotspot Snap: 8mil
1 Vin
1 GND
1 GND
1 Vbat
1 NRST
2 WDI
3 GND
4 WCI
5 Vdd
LS Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:2503.937mil Y:2618.11mil Grid: 3.937mil (Hotspot Snap)
Panels

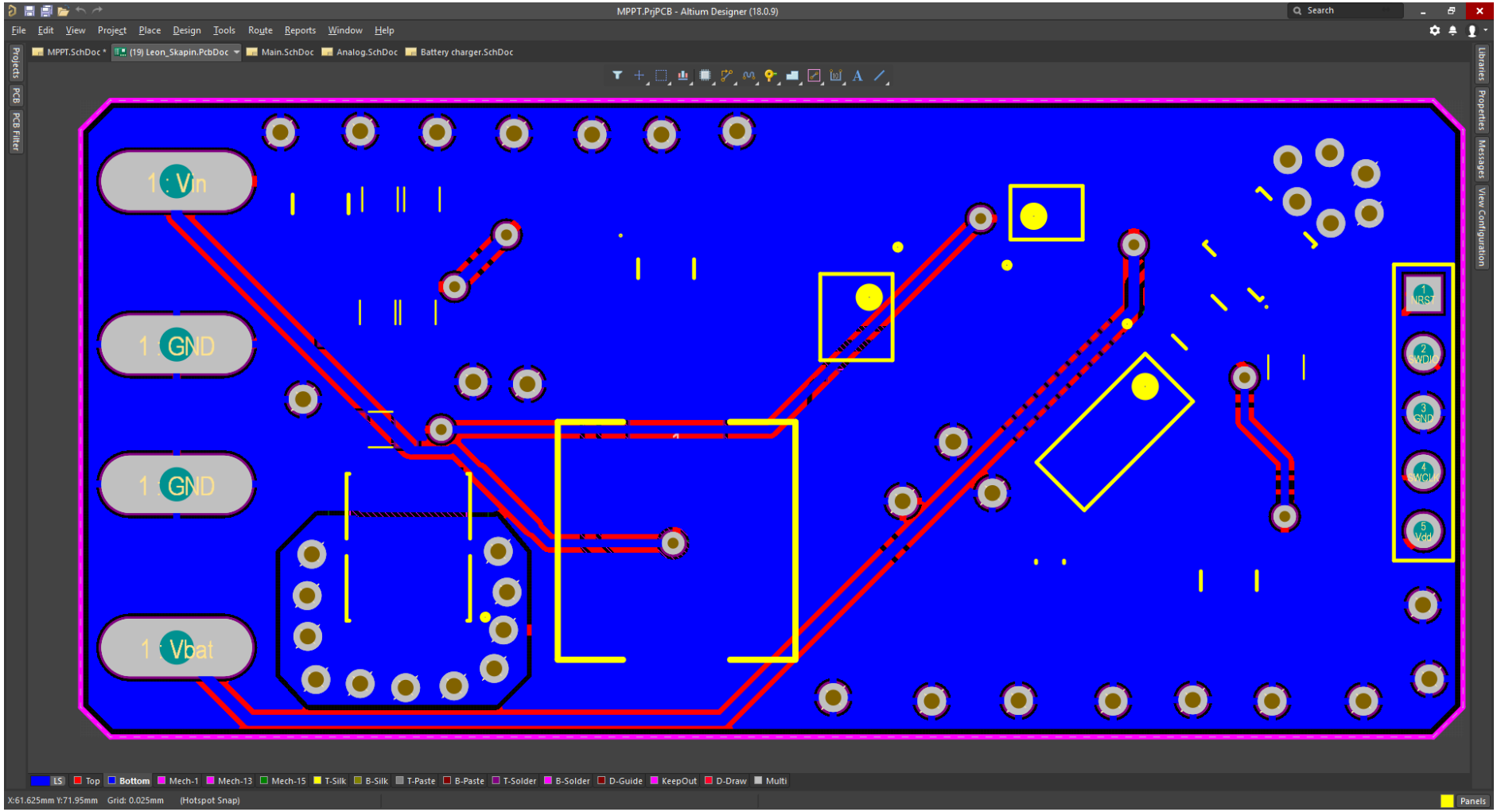

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (19) Dejan Banovec .PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
1 Vin
1 GND
1 GND
1 Vbat
Vin
2 Drain
2 Drain
1 Vin
Vin
2 Drain
1 NetC2_1
2 NetC2_1
Vbat
Vbat
Vbat
Vbat
1 Vbat
1 NRST
2 WDV
3 GND
4 WCV
5 Vdd
GND
Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:60.9mm Y:63.9mm Grid: 0.1mm (Hotspot Snap)
Panels

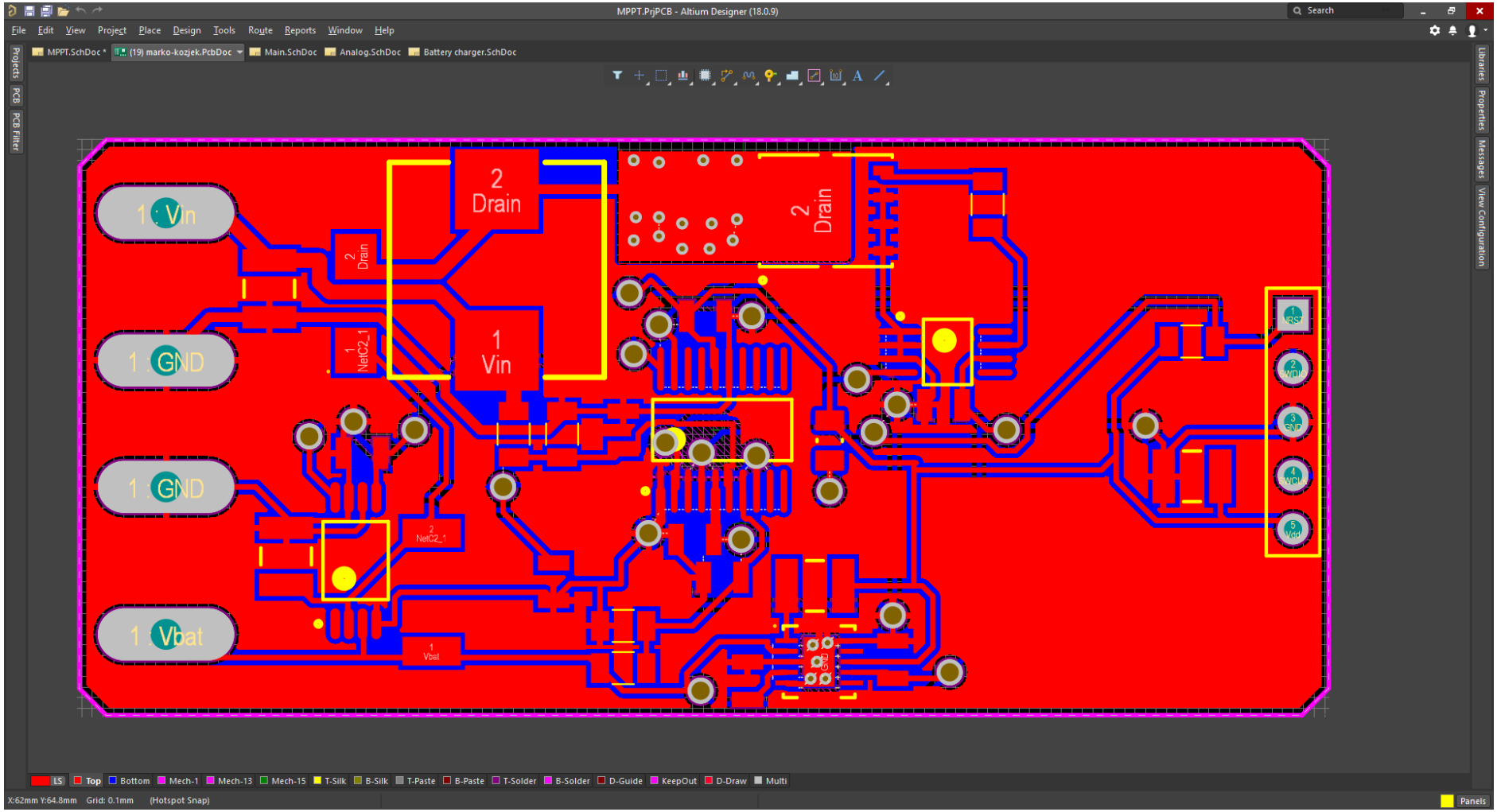

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (19) Dejan Banovec .PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
1 Vin
1 GND
1 GND
1 Vbat
1 NRST
2 WDI
3 GND
4 WCI
6 Vdd
Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:62.1mm Y:66.9mm Grid: 0.1mm (Hotspot Snap)
Panels

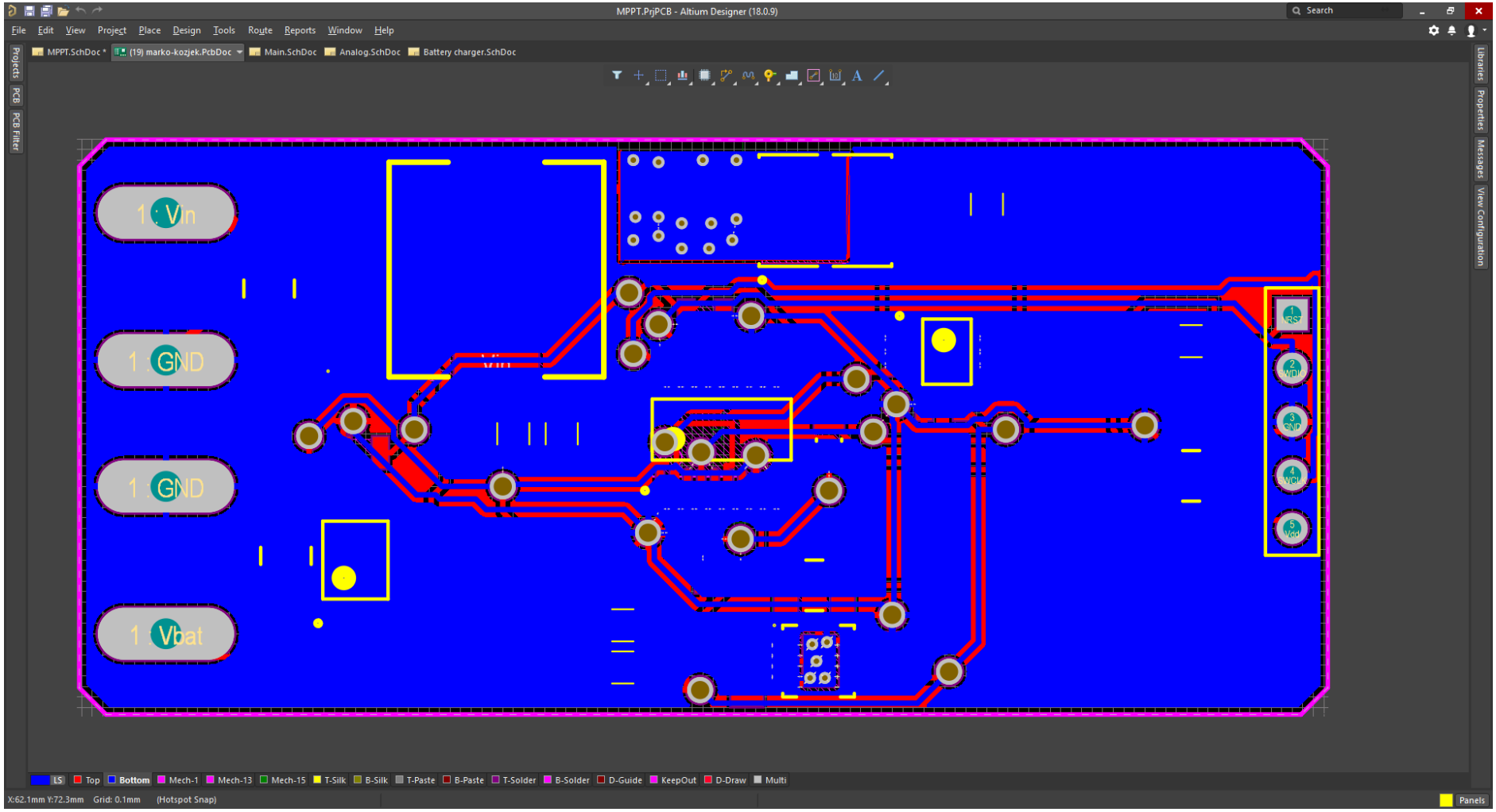

MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (19) Patrik_Serazin.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
Pin+1
Pout2
Pin-1
Pout1
Vin
GND
GND
Vbat
R2
C5
C1
L1
D1
Q1
Drain
Drain
Drain
R5
C8
C7
C9
R1
R4
FB1
U2
C12
R7
P1
R3
R6
C4
U1
C2
U3
U4
L3
C10
C11
C6
C13
Top
Bottom
Mech-1
Mech-13
Mech-15
T-Silk
B-Silk
T-Paste
B-Paste
T-Solder
B-Solder
D-Guide
KeepOut
D-Draw
Multi
X:62.275mm Y:63.7mm Grid: 0.025mm (Hotspot Snap)
Panels


MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (19) Patrik_Serazin.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
Vin
Pin+1
GND
Pout2
GND
Pin-1
Vbat
Pout1
L1
D1
Q1
U2
P1
C12
R7
R2
C5
C1
R5
C8
C7
C6
R1
R4
FB1
C2
U3
U4
R3
R6
C4
U1
L3
C10
C11
C9
C13
Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:62.9mm Y:66.25mm Grid: 0.025mm (Hotspot Snap)
Panels


MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (19) Leon_Skapin.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
1 Vin
1 GND
1 GND
1 Vbat
2 Drain
1 Vin
2 Drain
1 NetC2_1
2 NetC2_1
2 Drain
1 Vbat
1 GND
1 RST
2 WDI
3 GND
4 WDI
5 Vdd
Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:62mm Y:71.95mm Grid: 0.025mm (Hotspot Snap)


MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (19) Leon_Skapin.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
1 Vin
1 GND
1 GND
1 Vbat
RST
2 WDI
3 GND
4 WDI
5 Vdd
LS Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:61.625mm Y:71.95mm Grid: 0.025mm (Hotspot Snap)
Panels


MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (19) marko-kozjek.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
1 Vin
1 GND
1 GND
1 Vbat
2 Drain
2 Drain
1 Vin
2 Drain
1 NetC2_1
2 NetC2_1
1 Vbat
GND
Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:62mm Y:64.8mm Grid: 0.1mm (Hotspot Snap)
Panels


MPPT.PrjPCB - Altium Designer (18.0.9)
File Edit View Project Place Design Tools Route Reports Window Help
MPPT.SchDoc * (19) marko-kozjek.PcbDoc Main.SchDoc Analog.SchDoc Battery charger.SchDoc
1 Vin
1 GND
1 GND
1 Vbat
Top Bottom Mech-1 Mech-13 Mech-15 T-Silk B-Silk T-Paste B-Paste T-Solder B-Solder D-Guide KeepOut D-Draw Multi
X:62.1mm Y:72.3mm Grid: 0.1mm (Hotspot Snap)