



ŠTUDENTSKA DELAVNICA IN TEKMOVANJE

Načrtovanje elektronike za

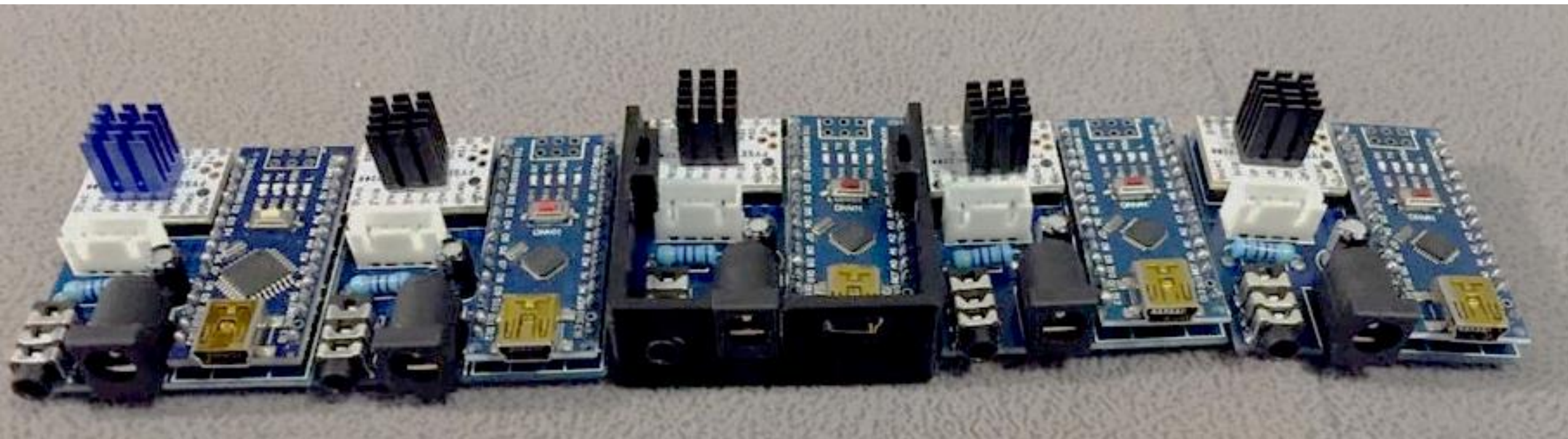
E=EMC²



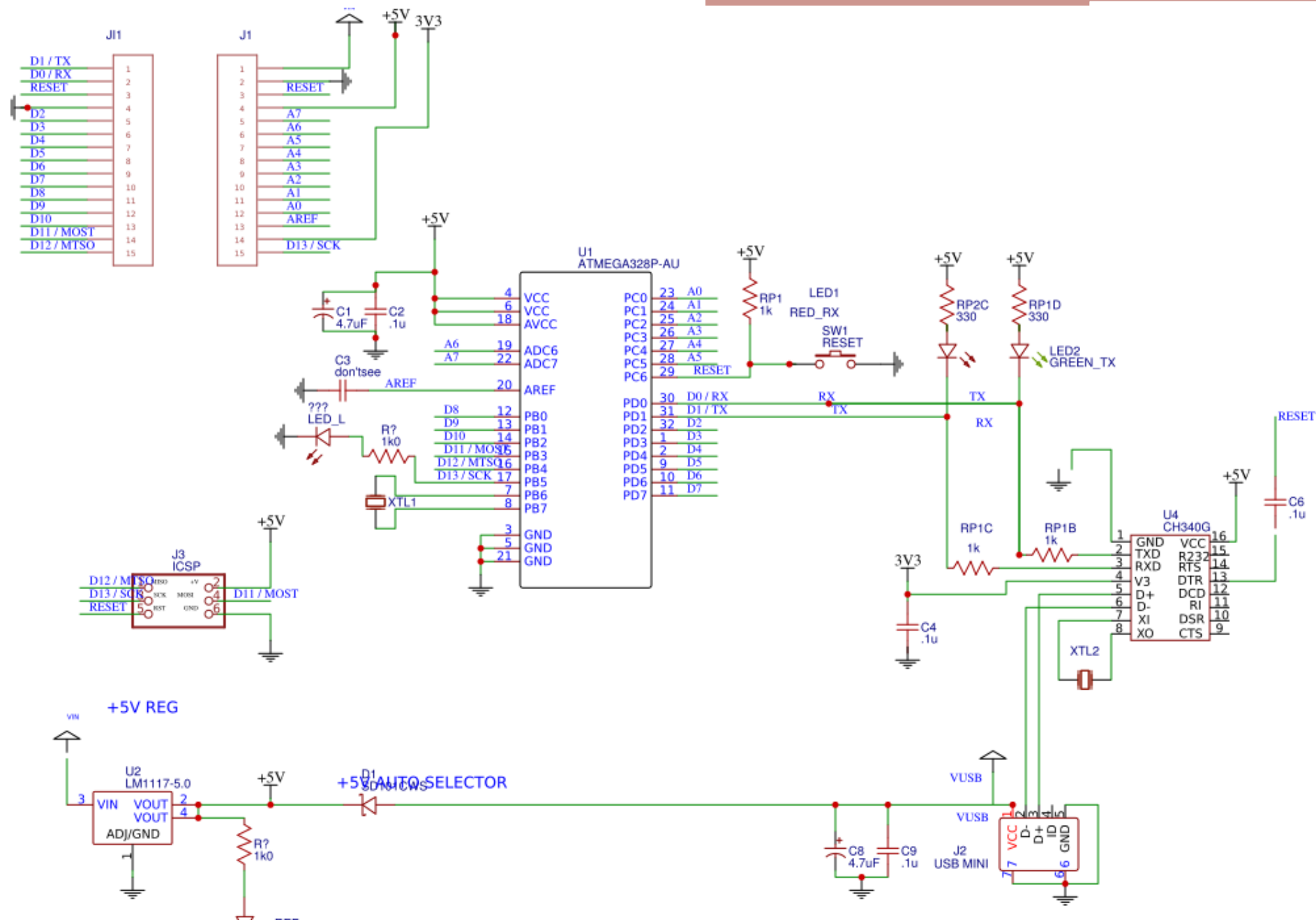
Univerza v Ljubljani
Fakulteta za elektrotehniko



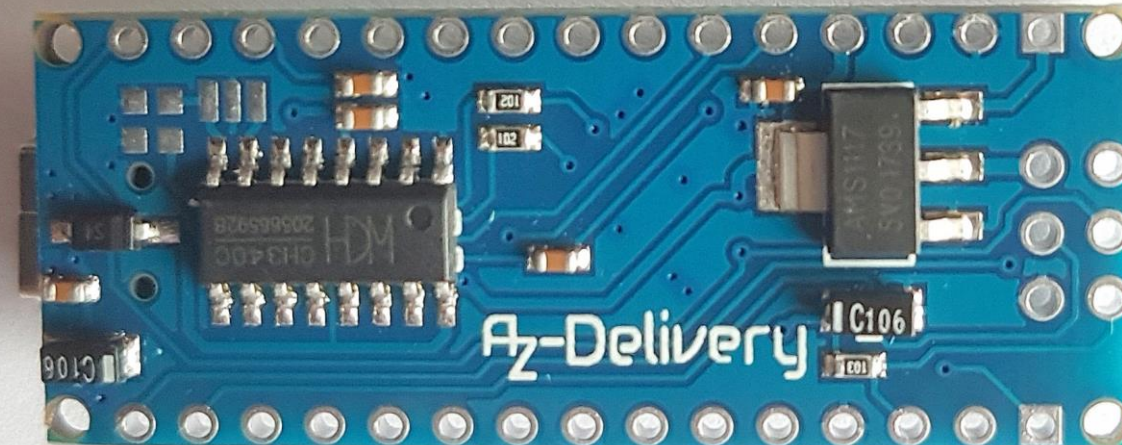
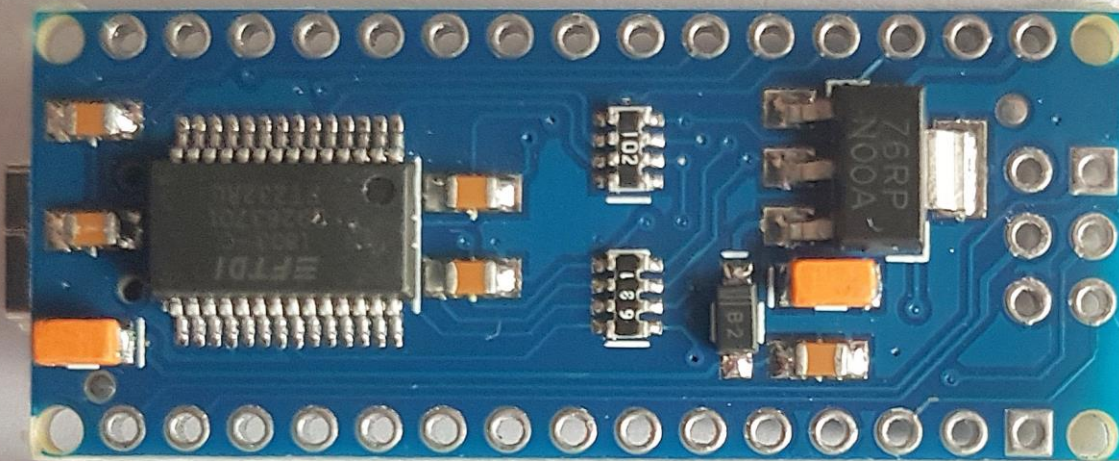
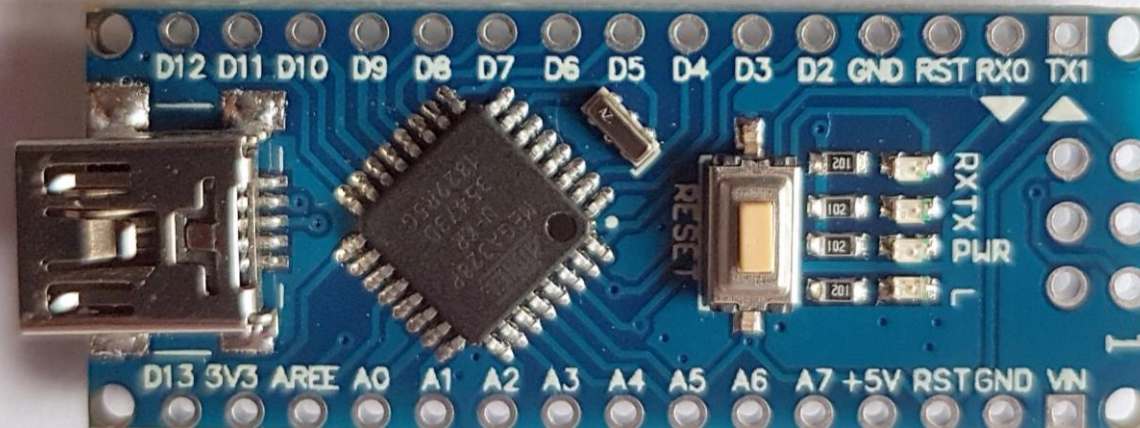
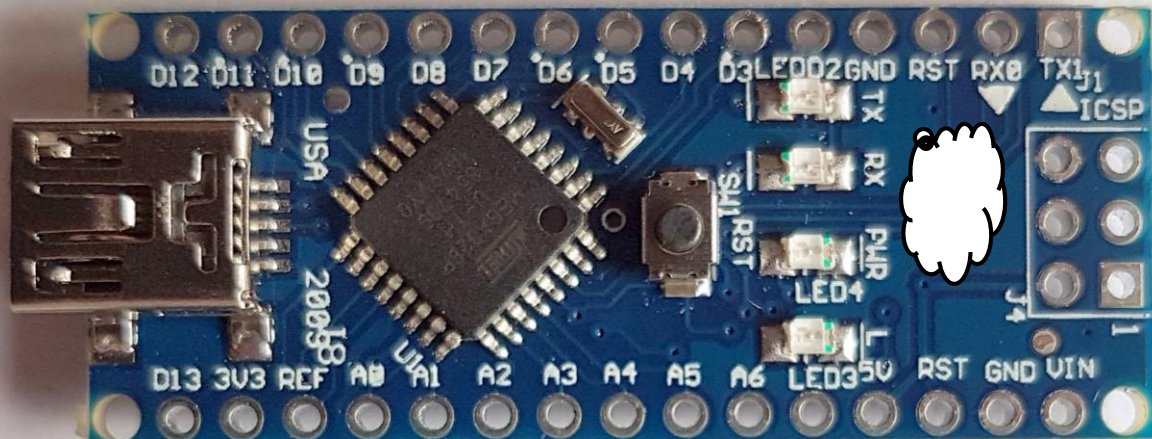
Zakaj?



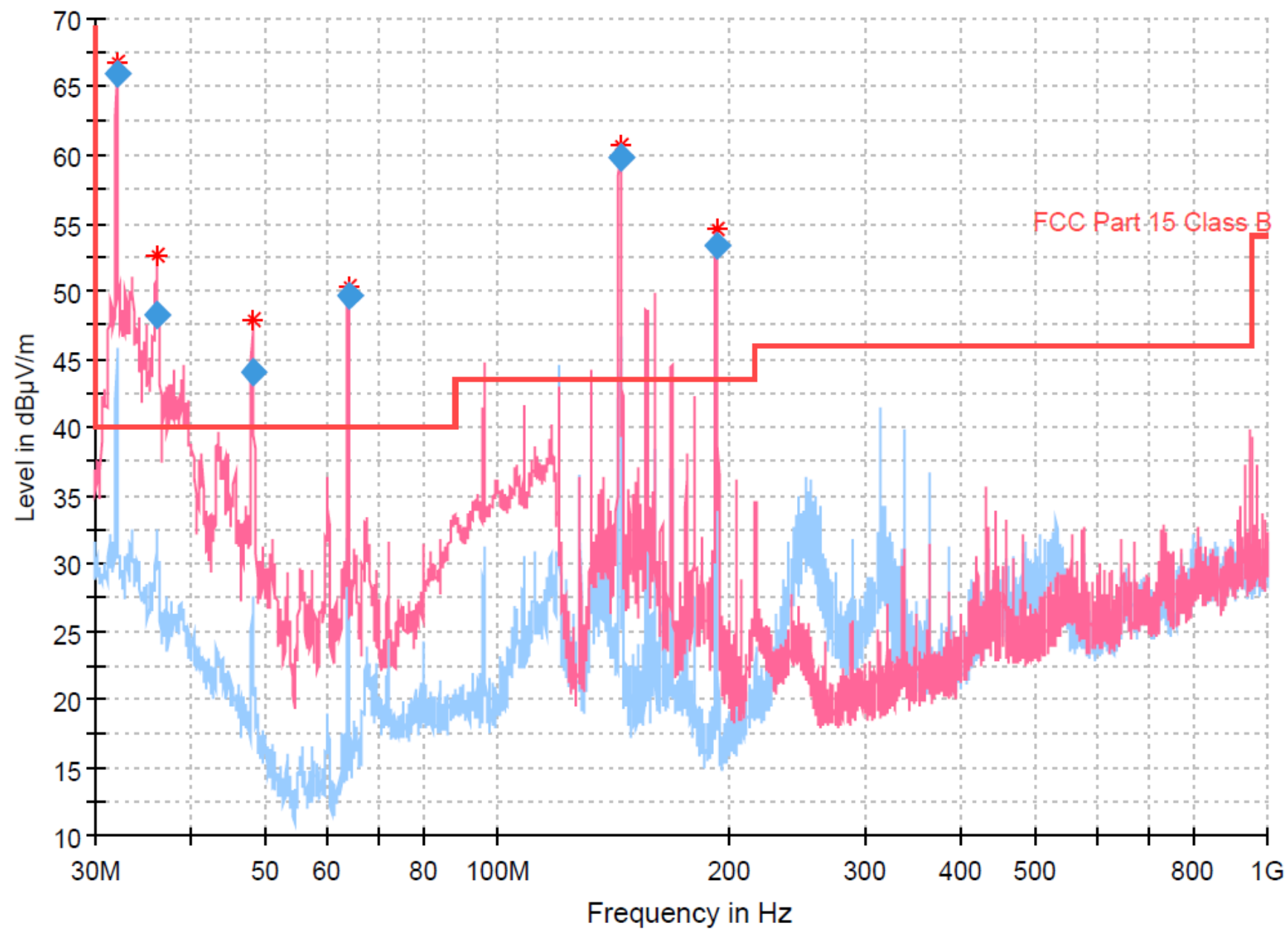
Zakaj?



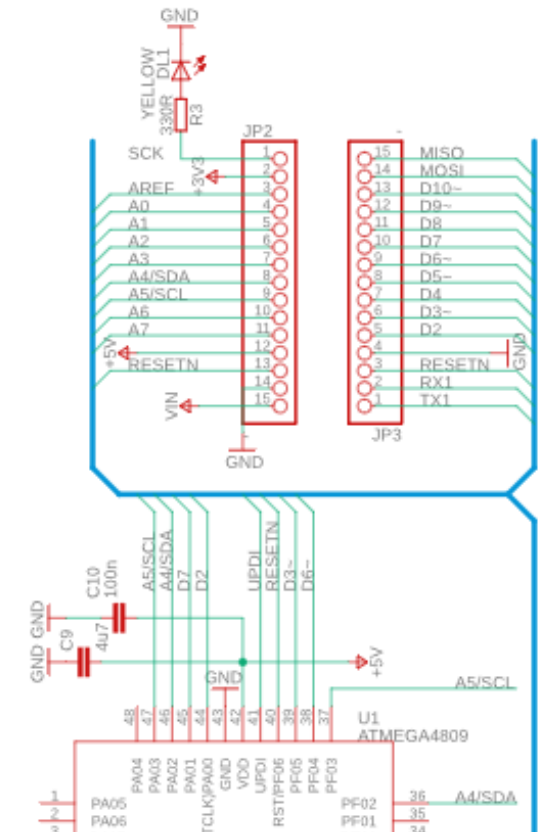
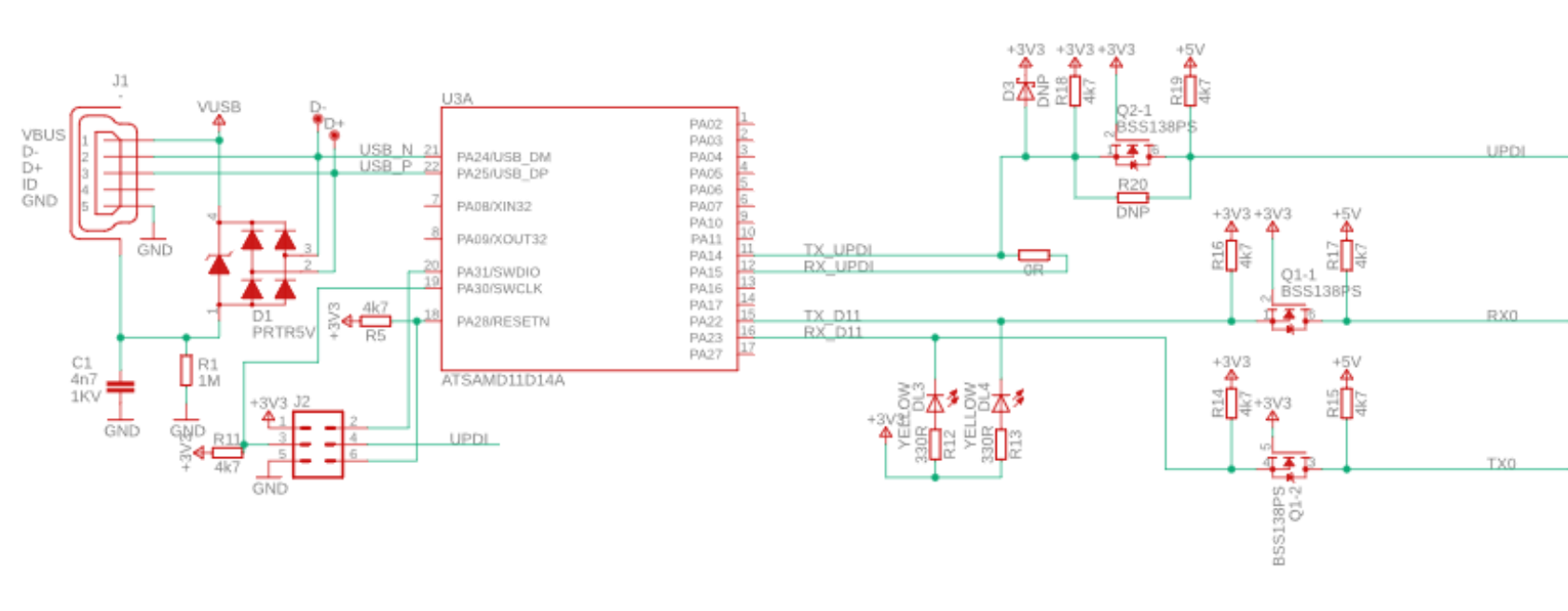
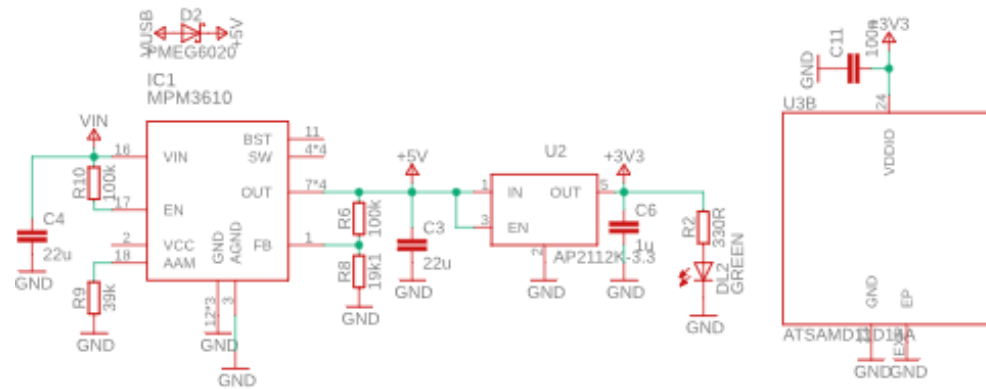
Zakaj?



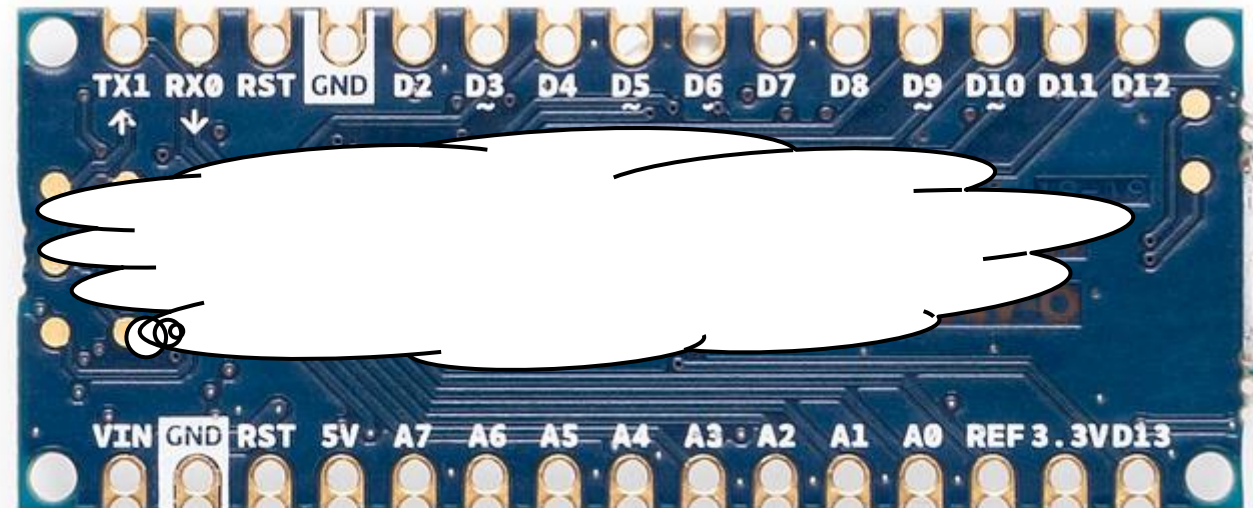
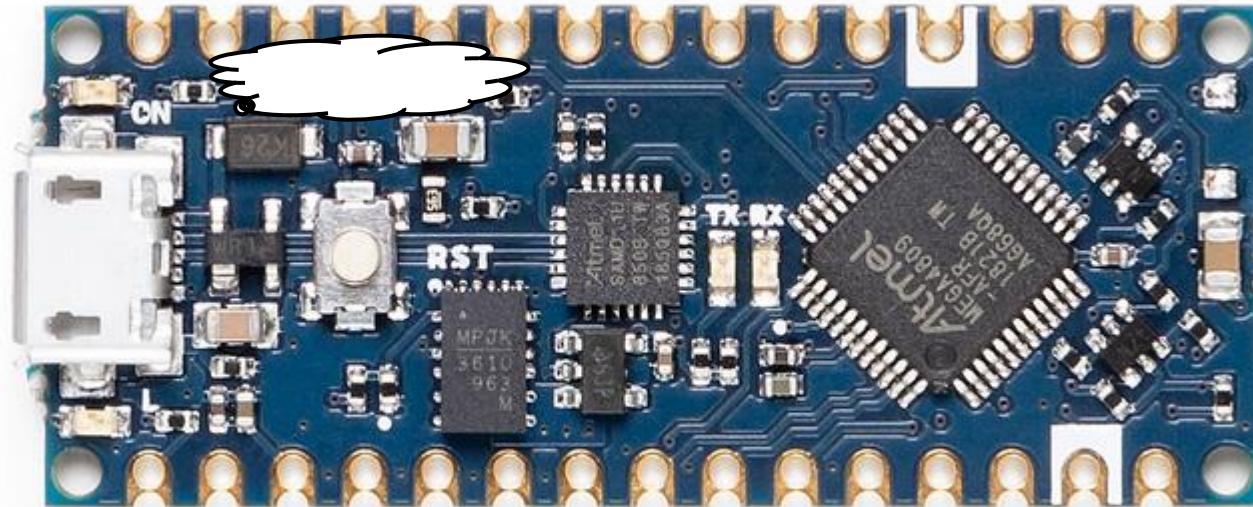
Zato!



Rešitev?

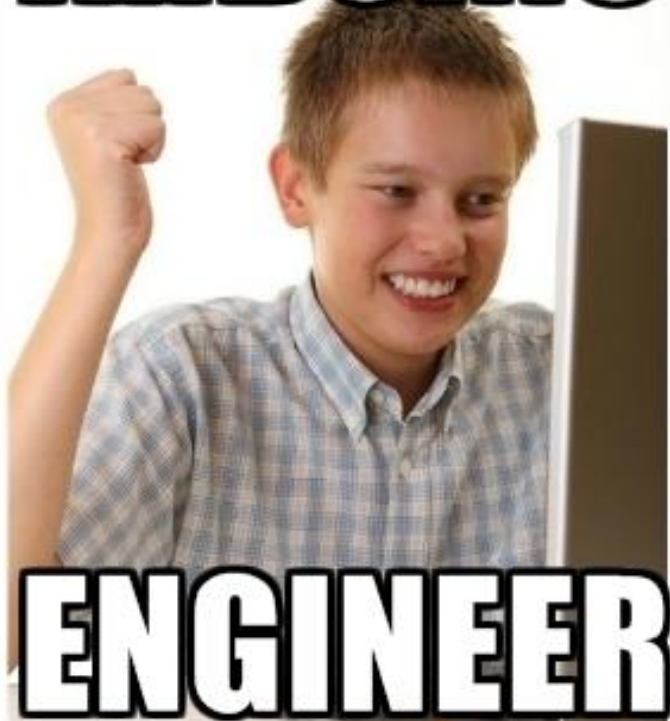


Rešitev?



Čemu?

ARDUINO



ENGINEER

memegenerator.net



1. EMC delavnica 2016: HELLA SATURNUS



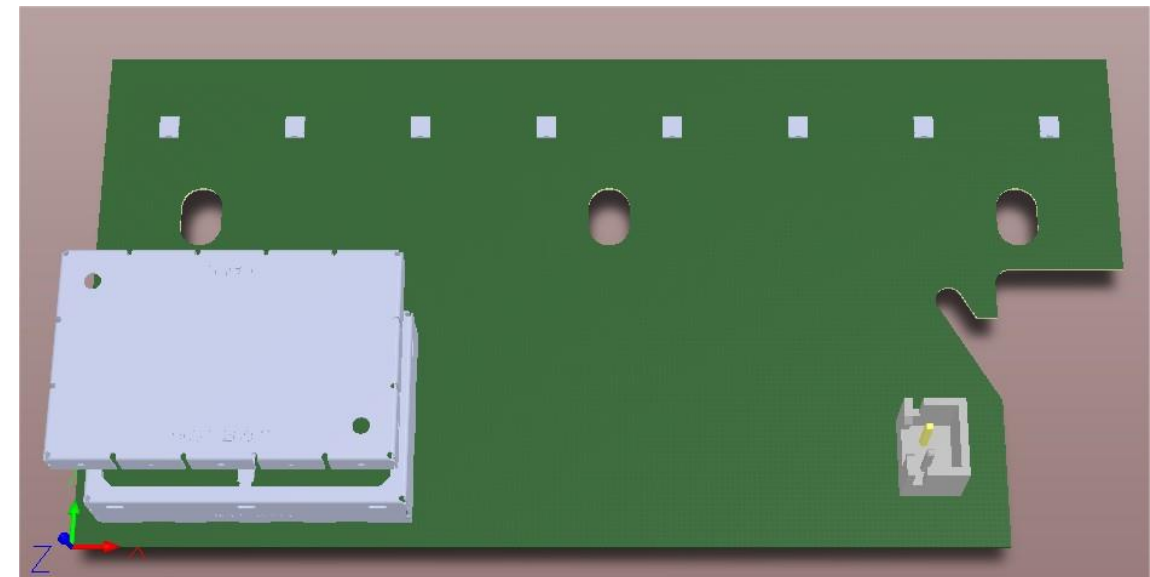
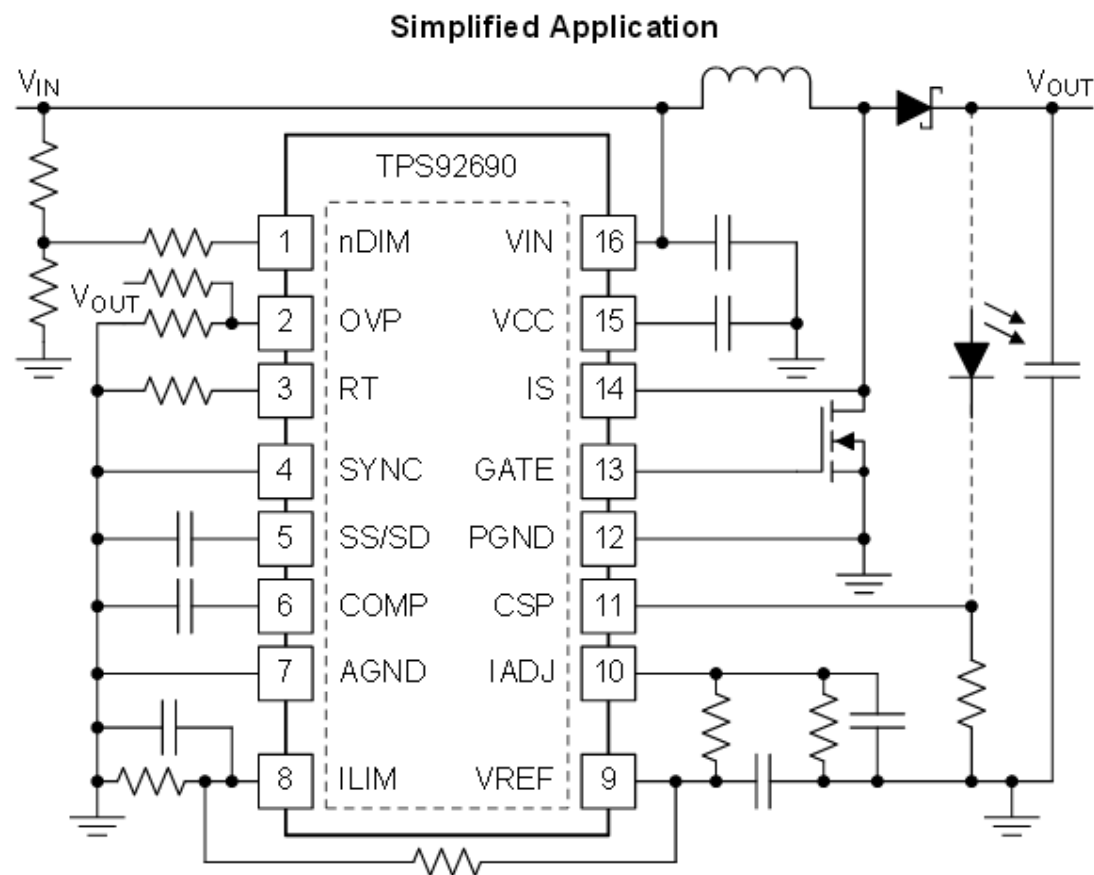
MAHLE



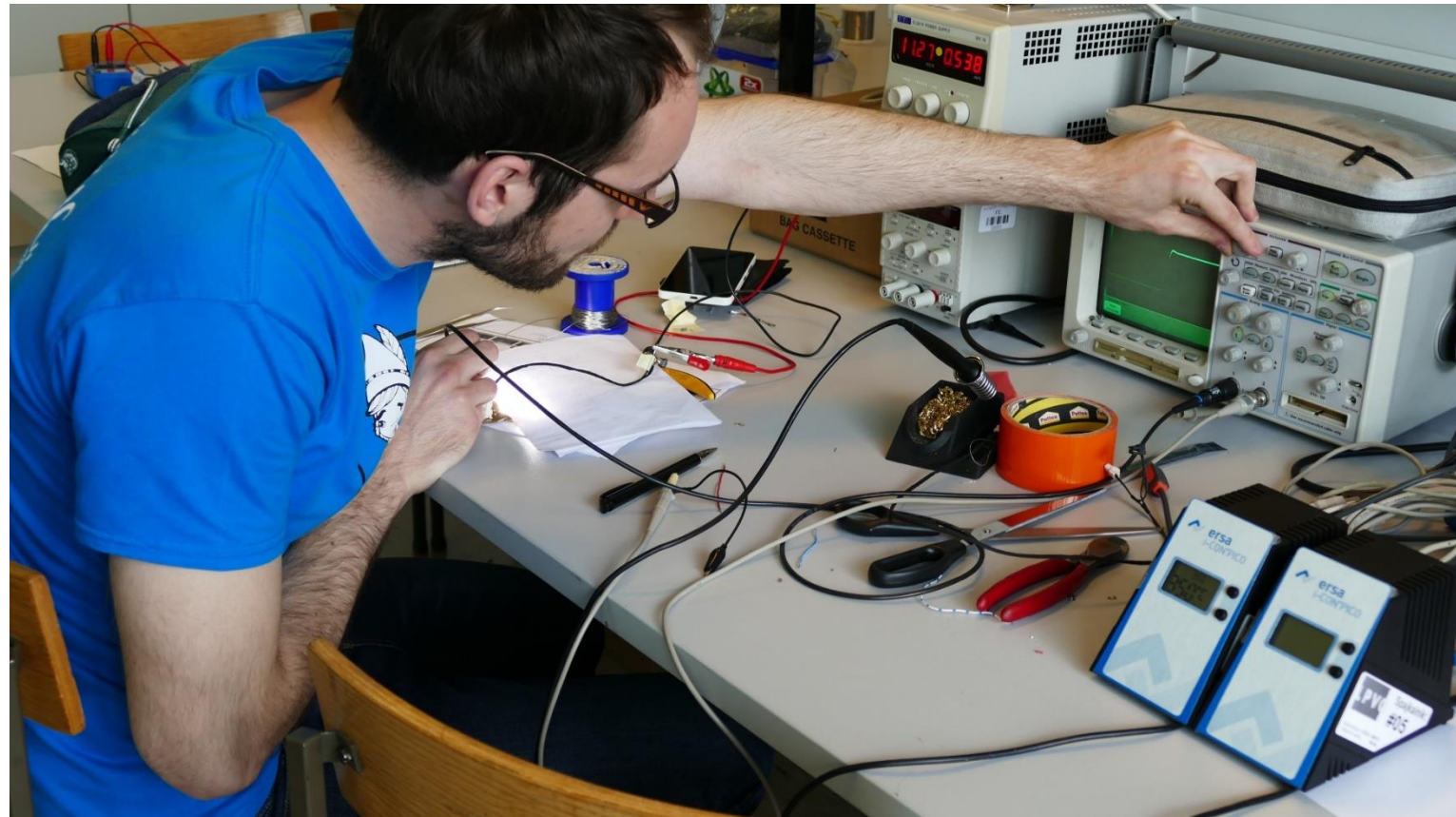
TEXAS INSTRUMENTS



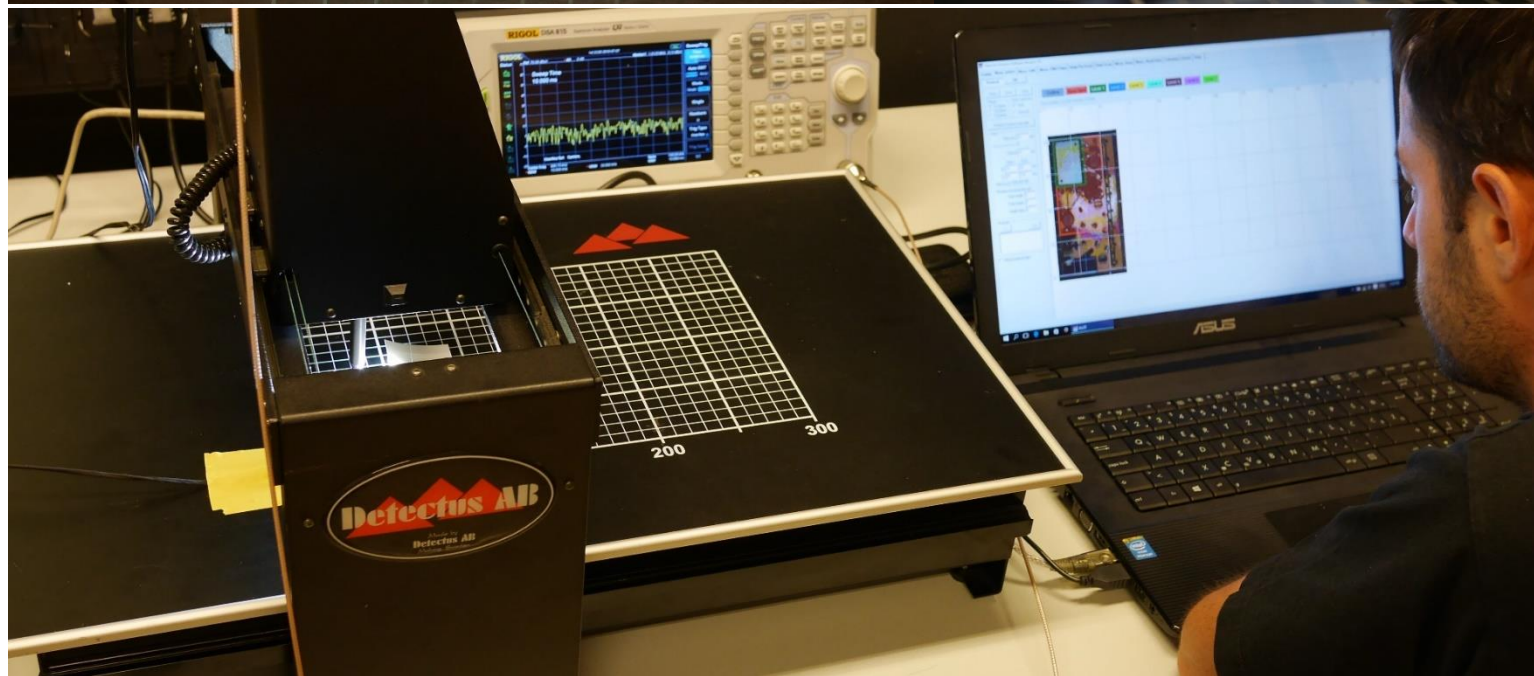
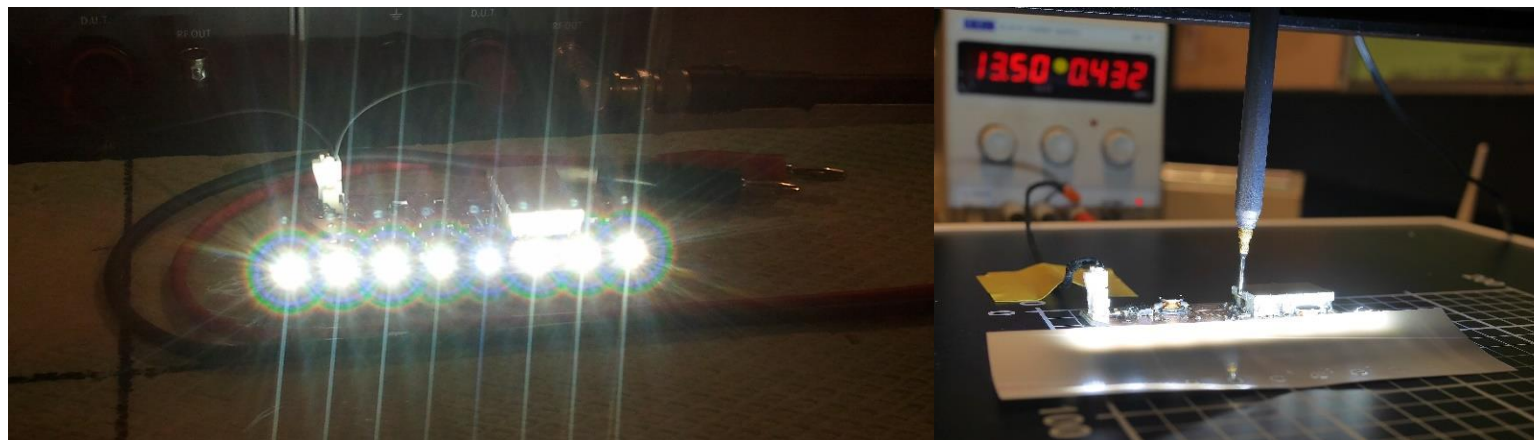
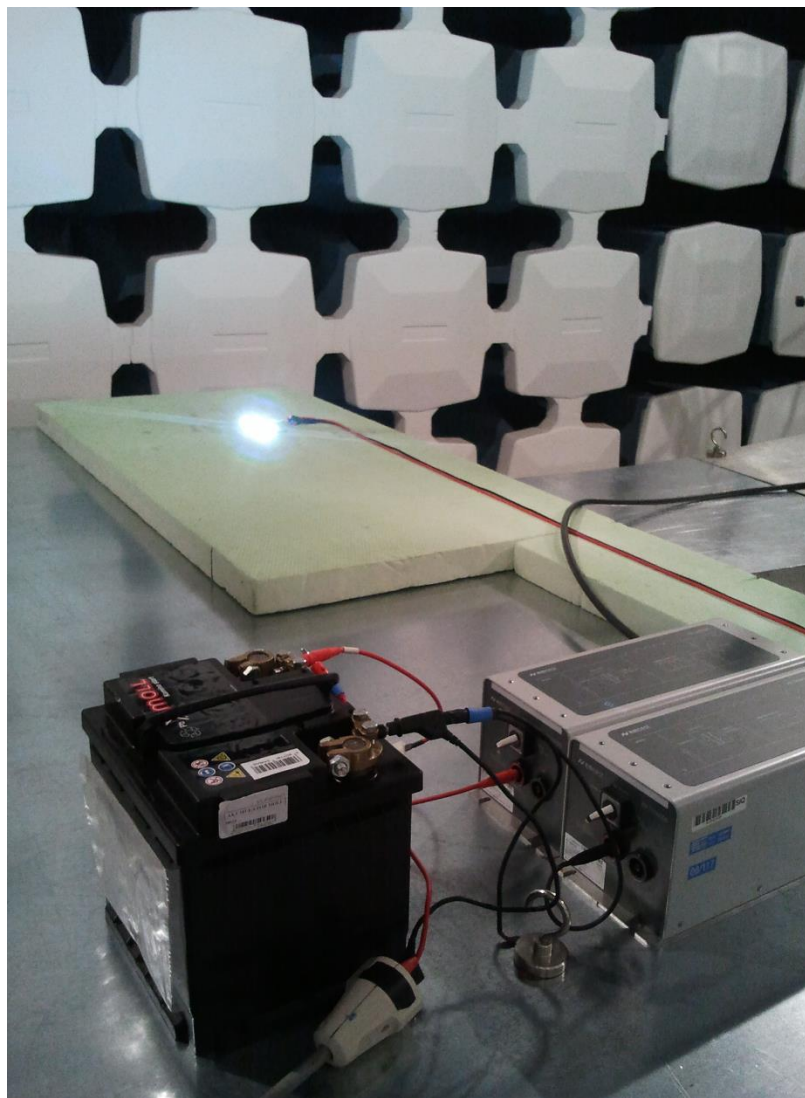
Izziv



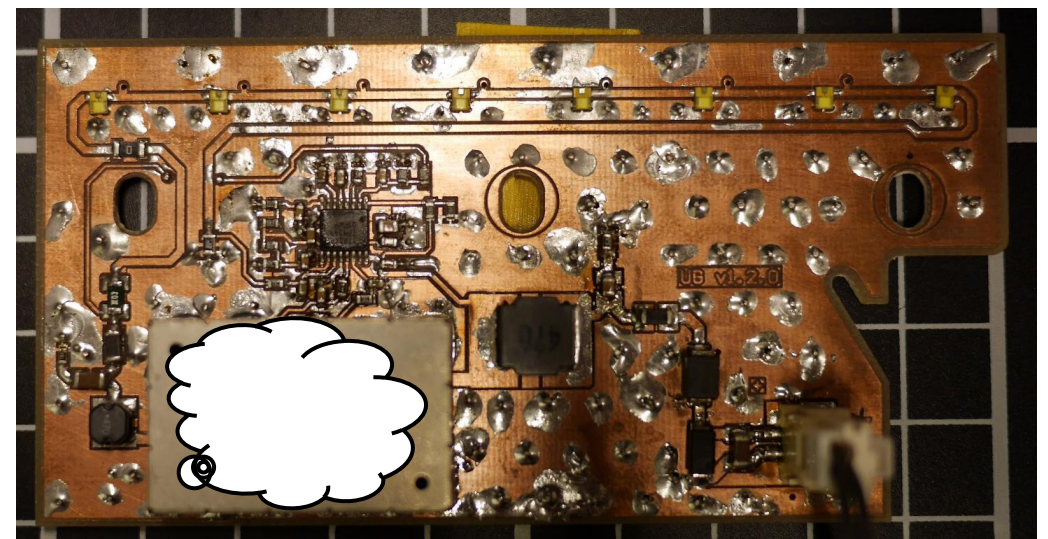
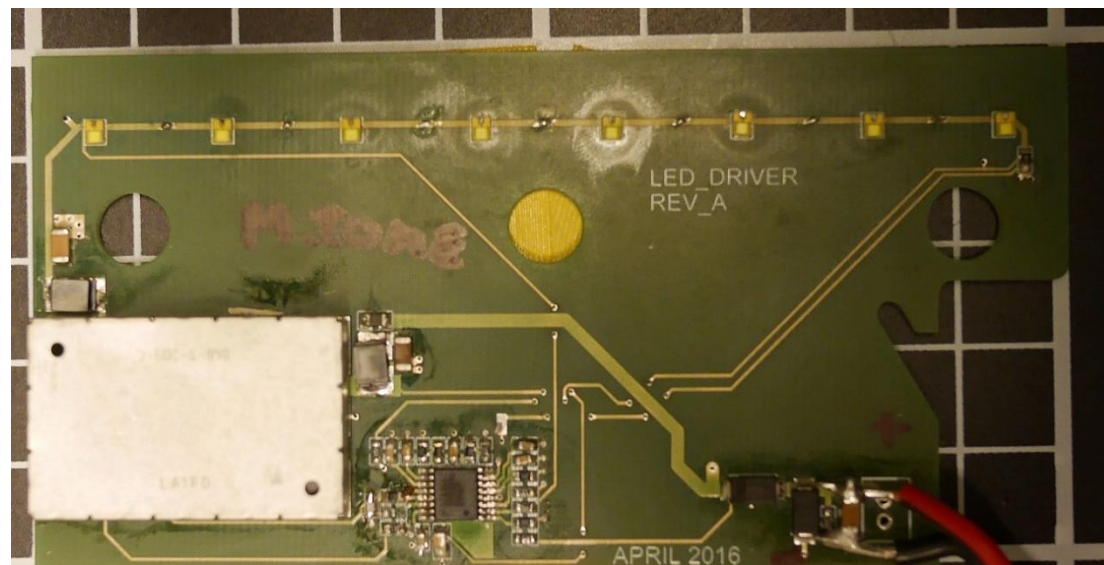
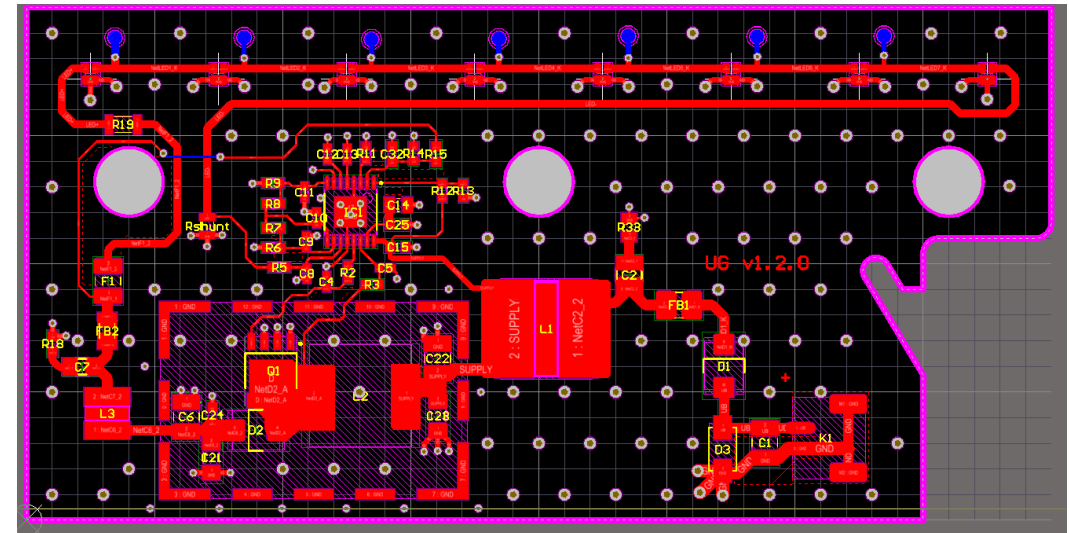
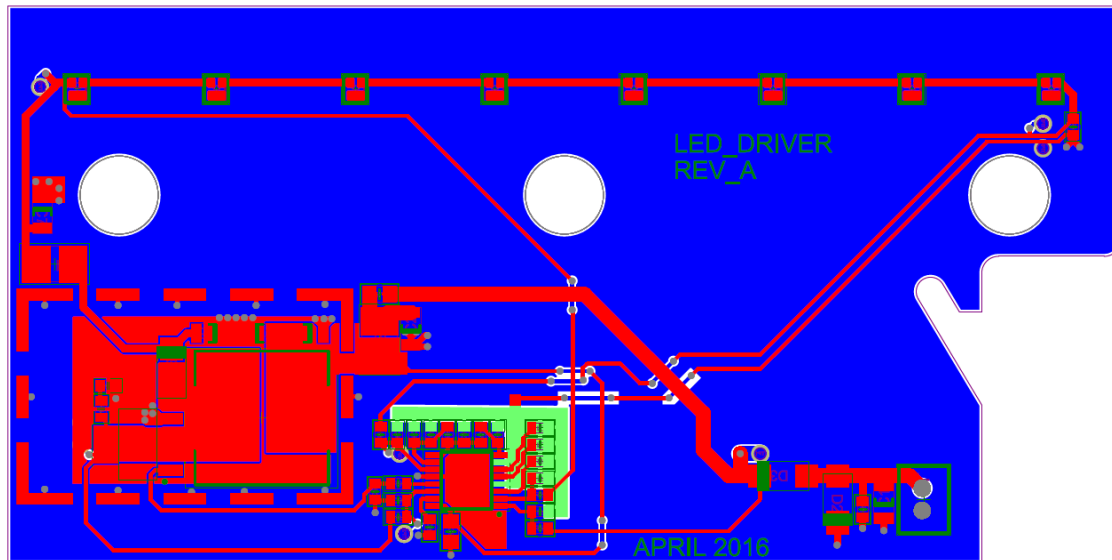
Izdelava projektov



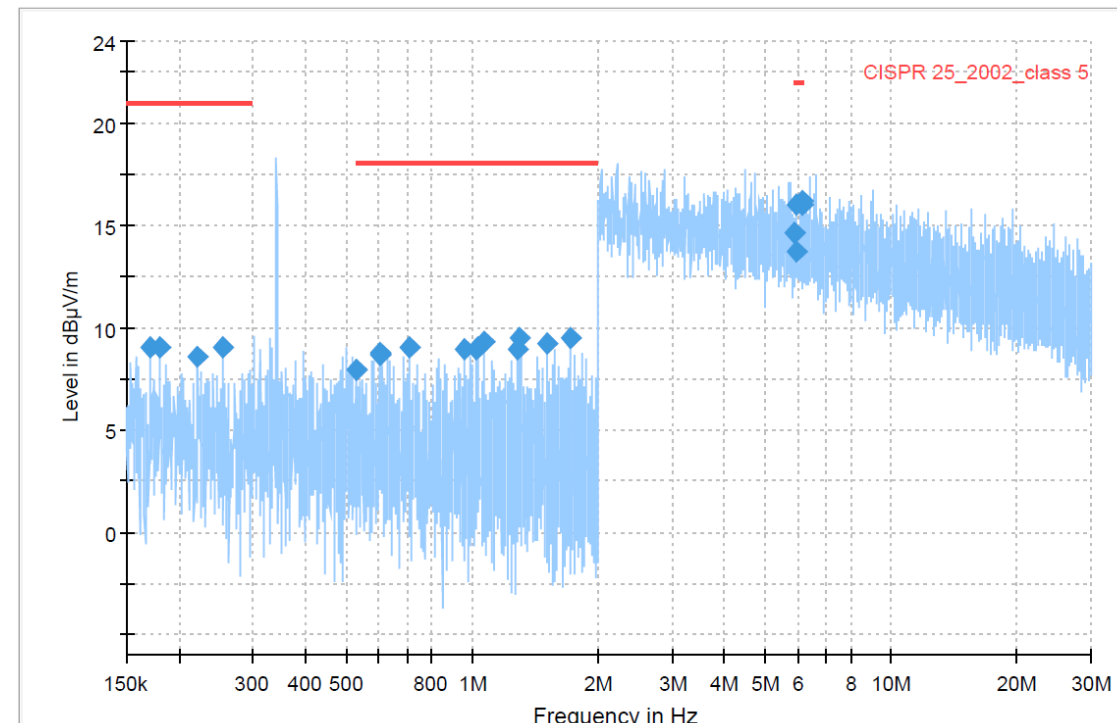
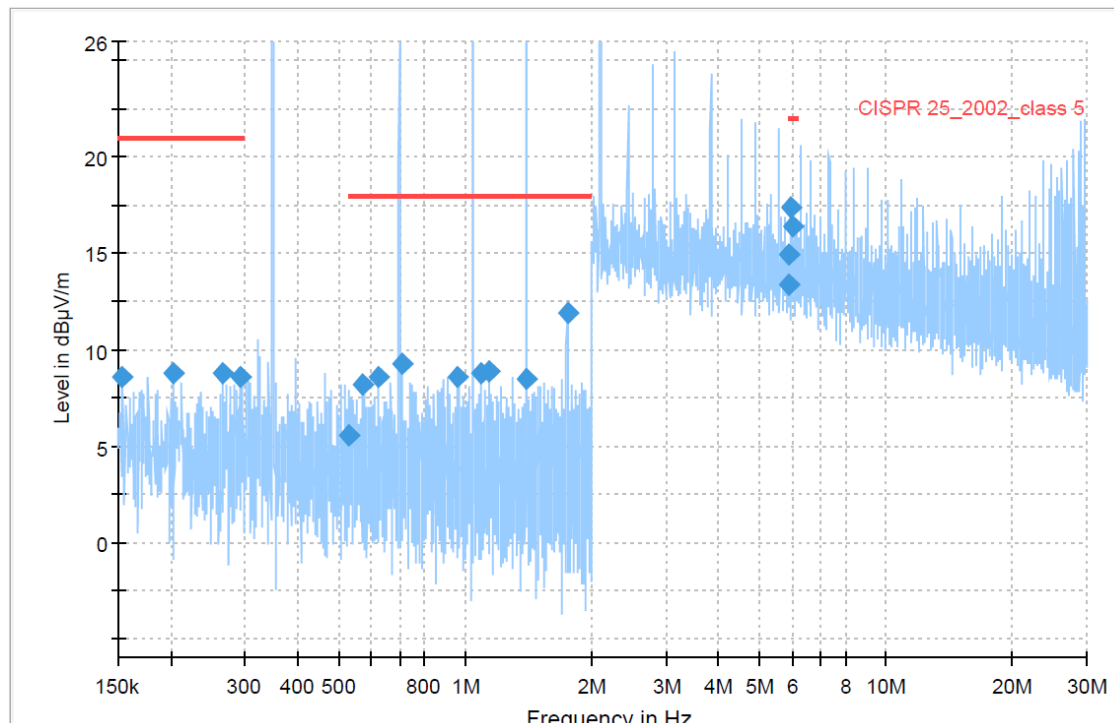
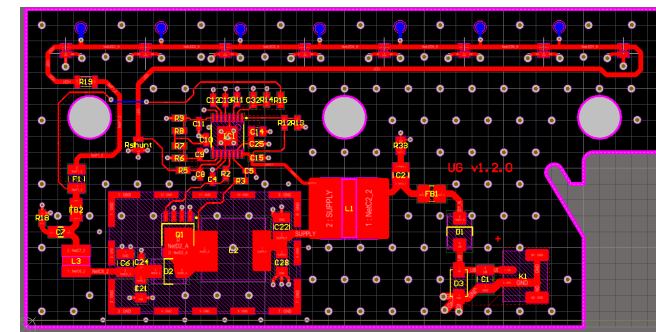
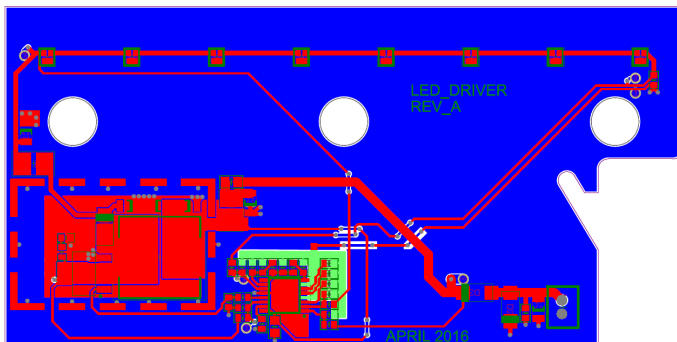
Meritve izdelkov



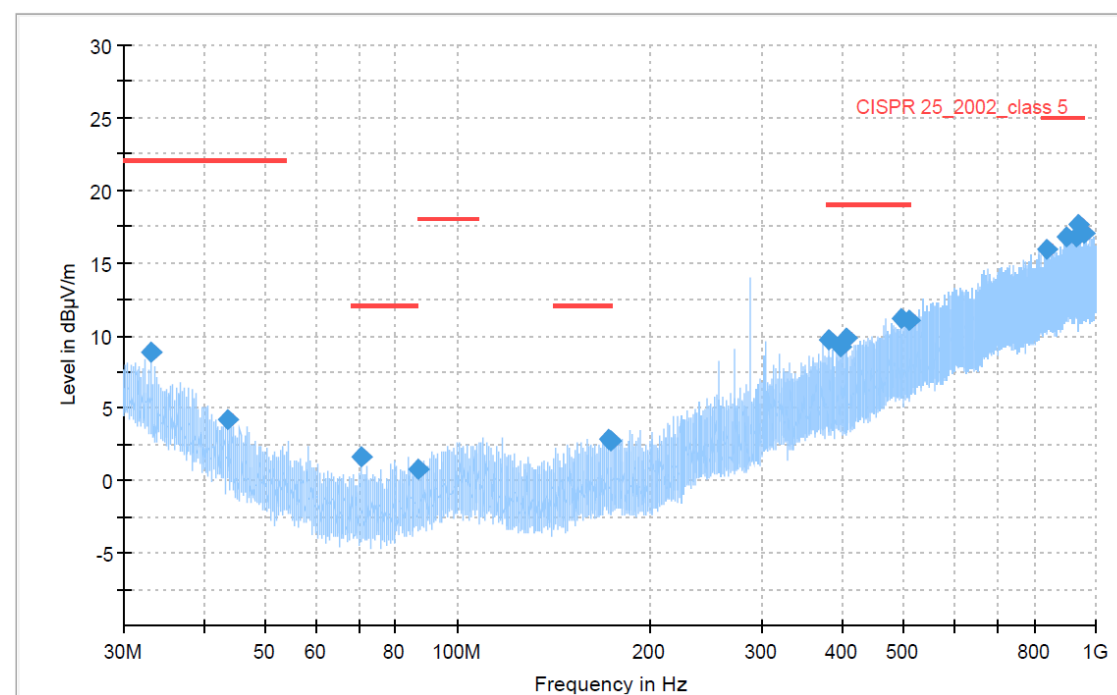
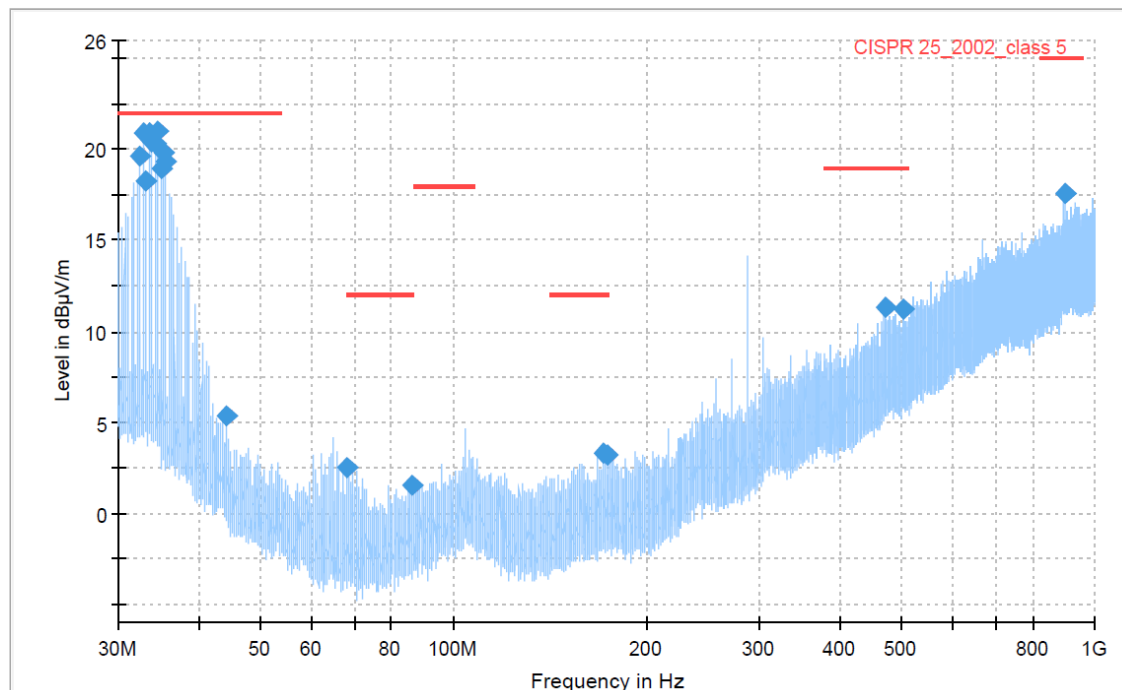
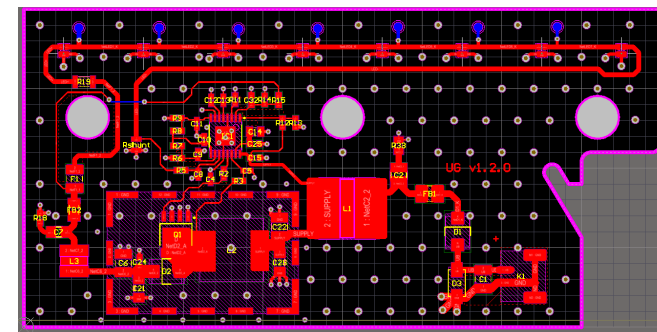
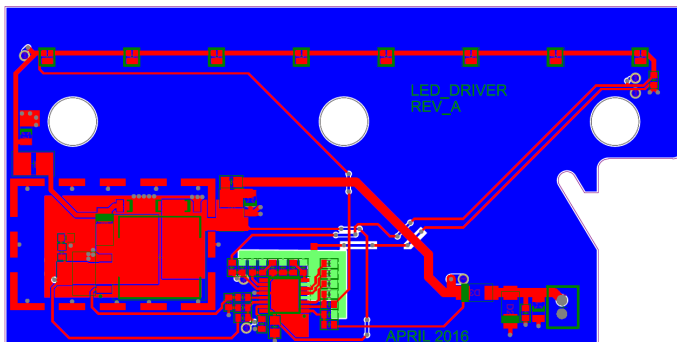
Rezultati



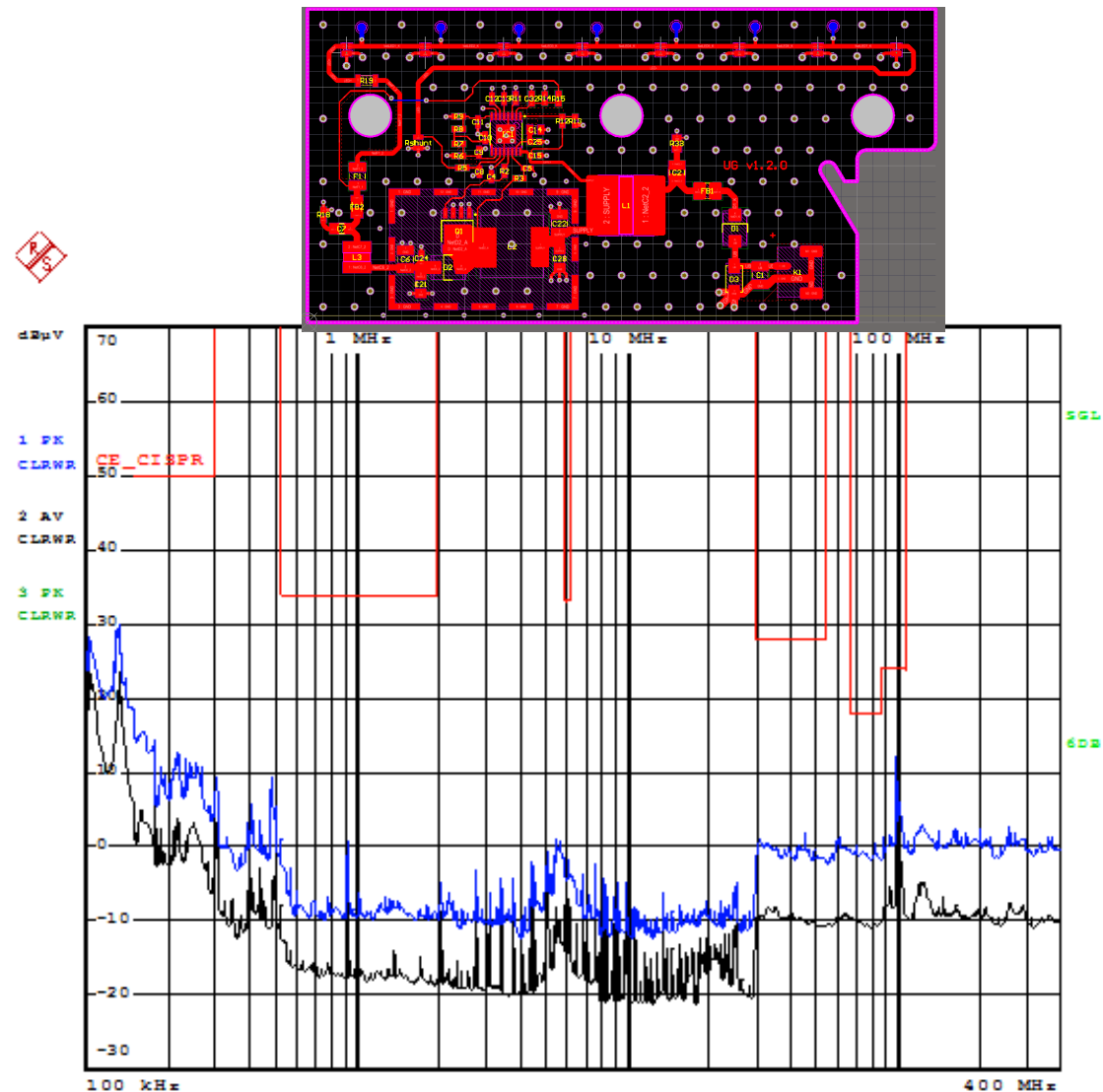
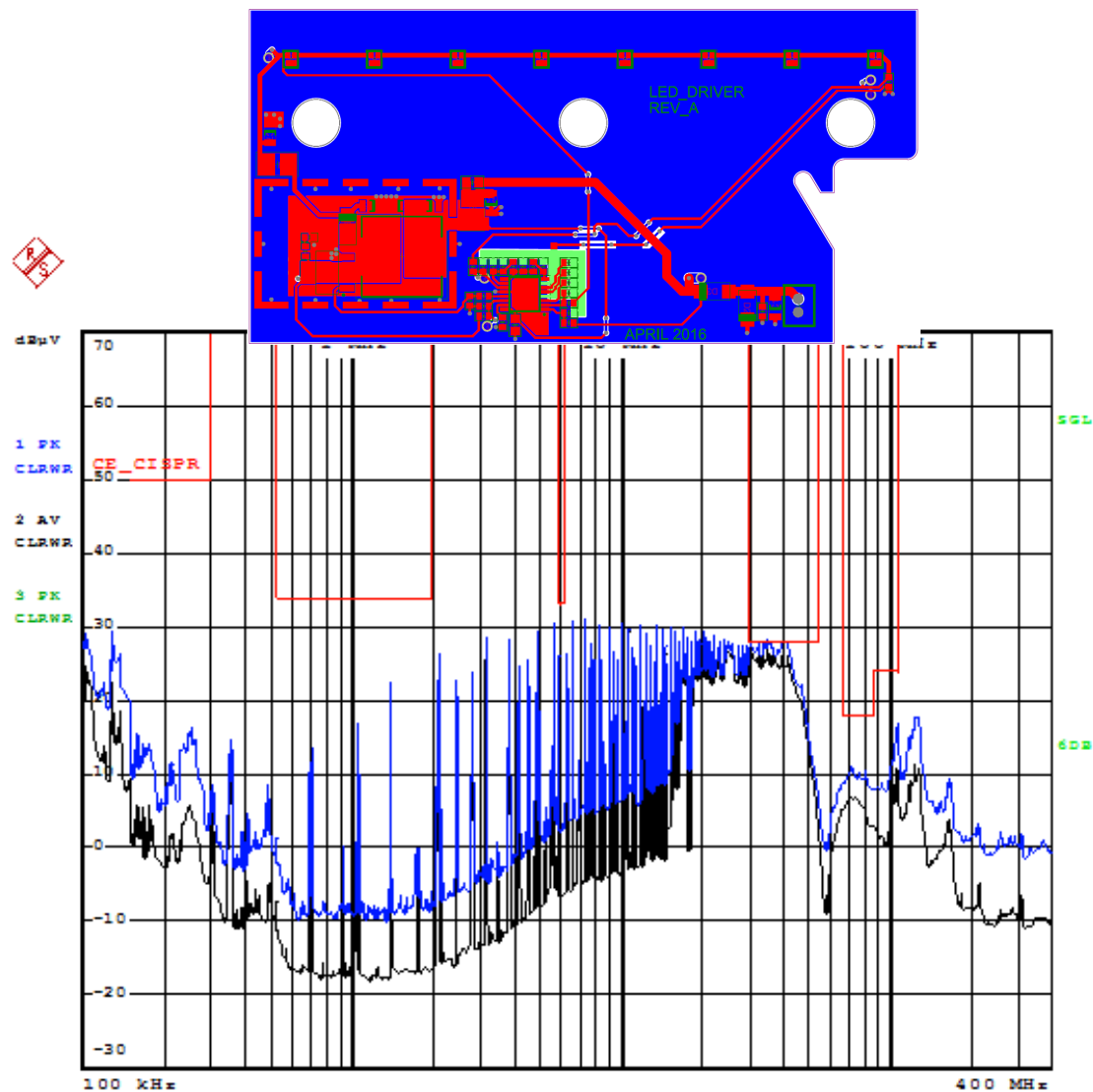
Rezultati



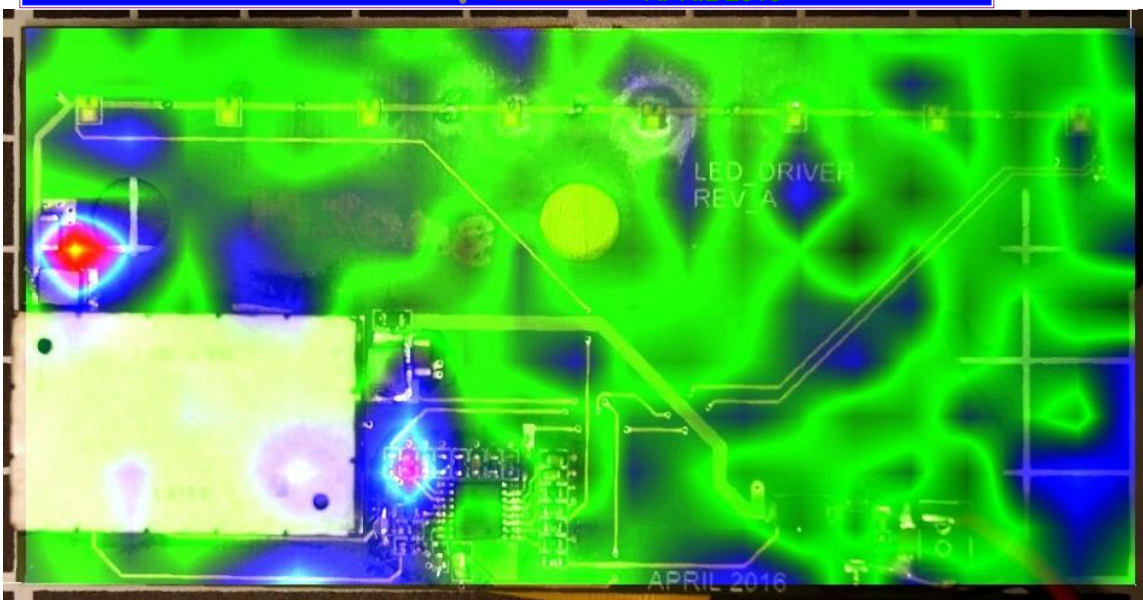
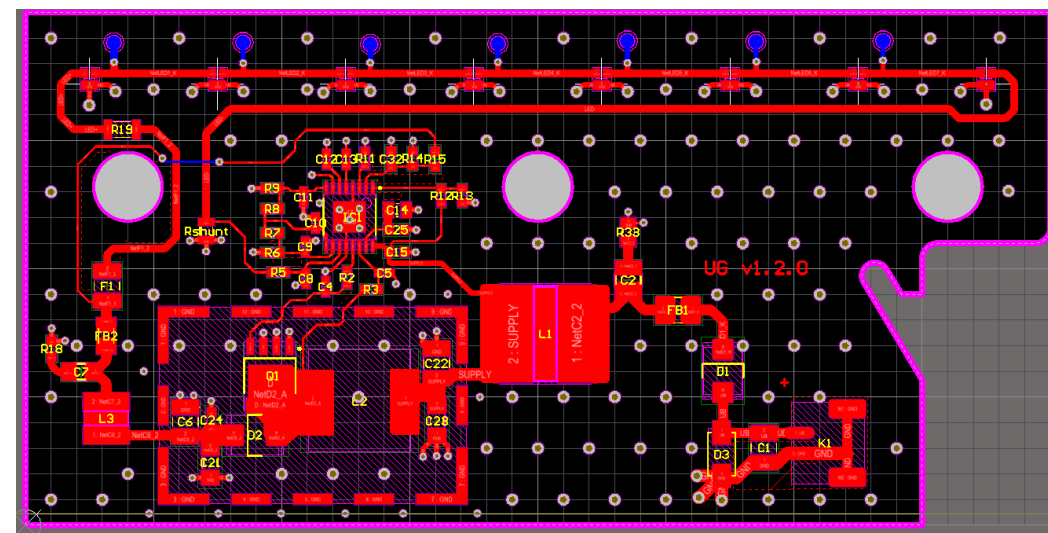
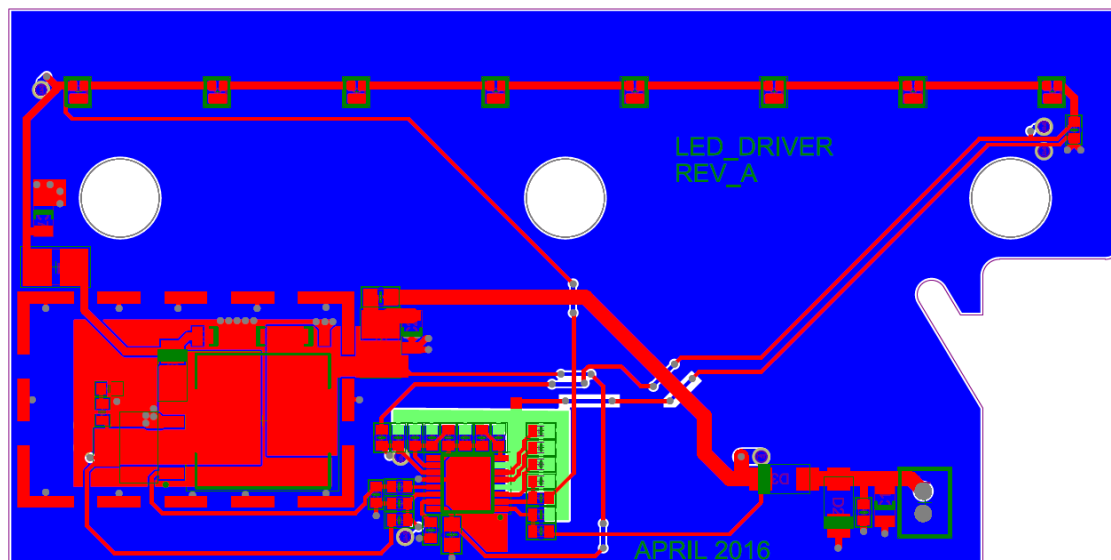
Rezultati



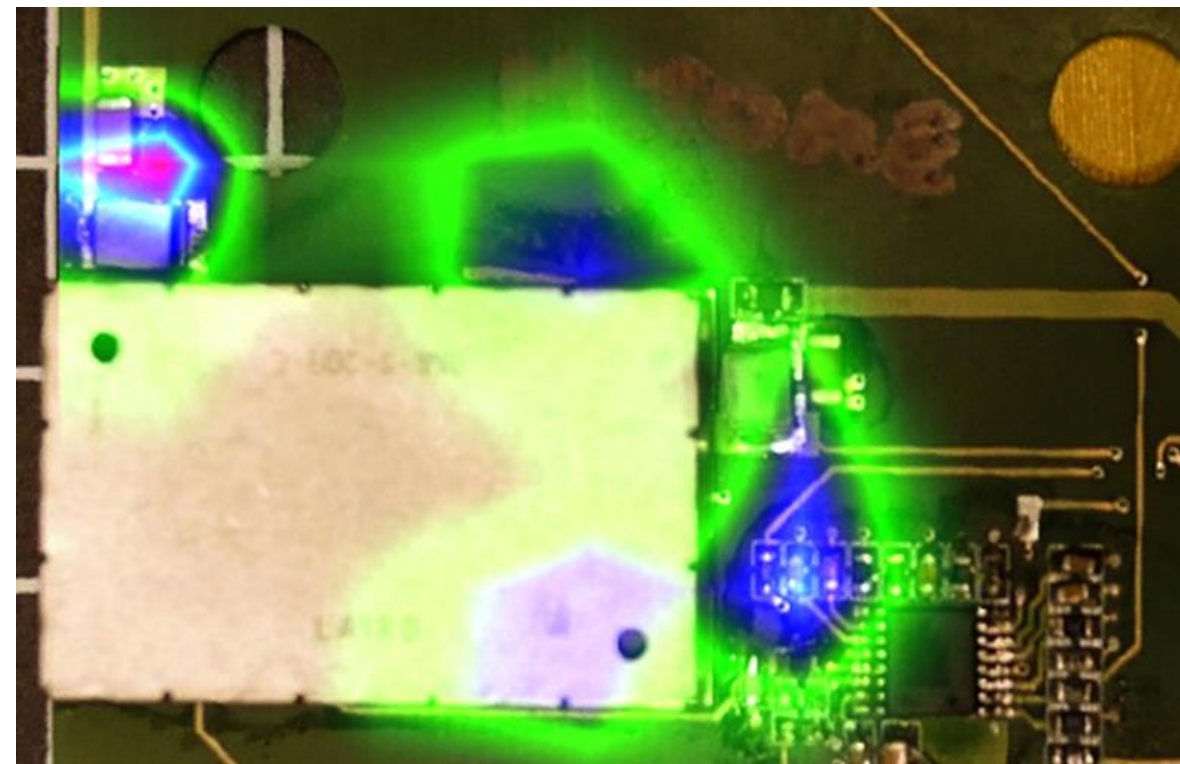
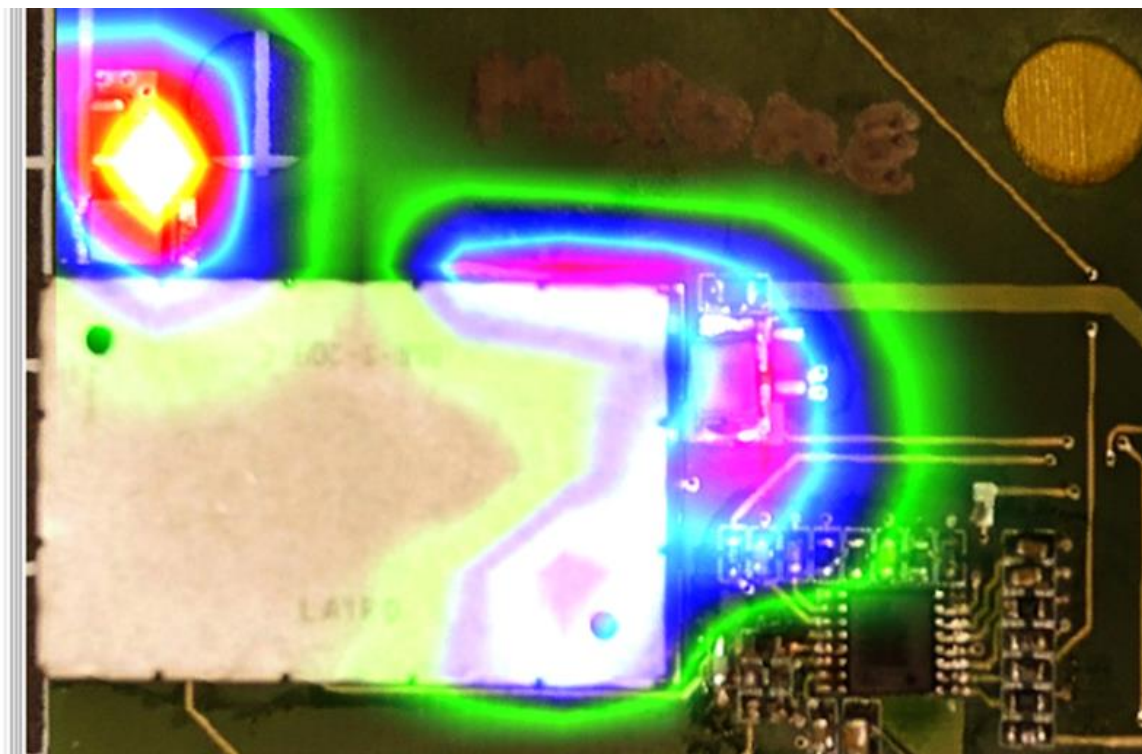
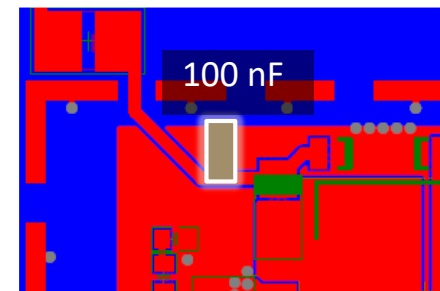
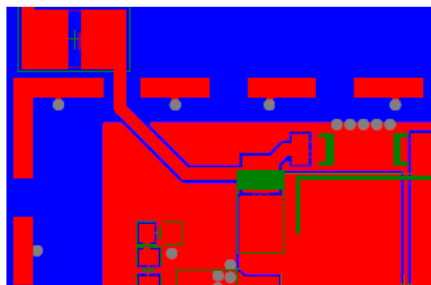
Rezultati



Rezultati



Analiza



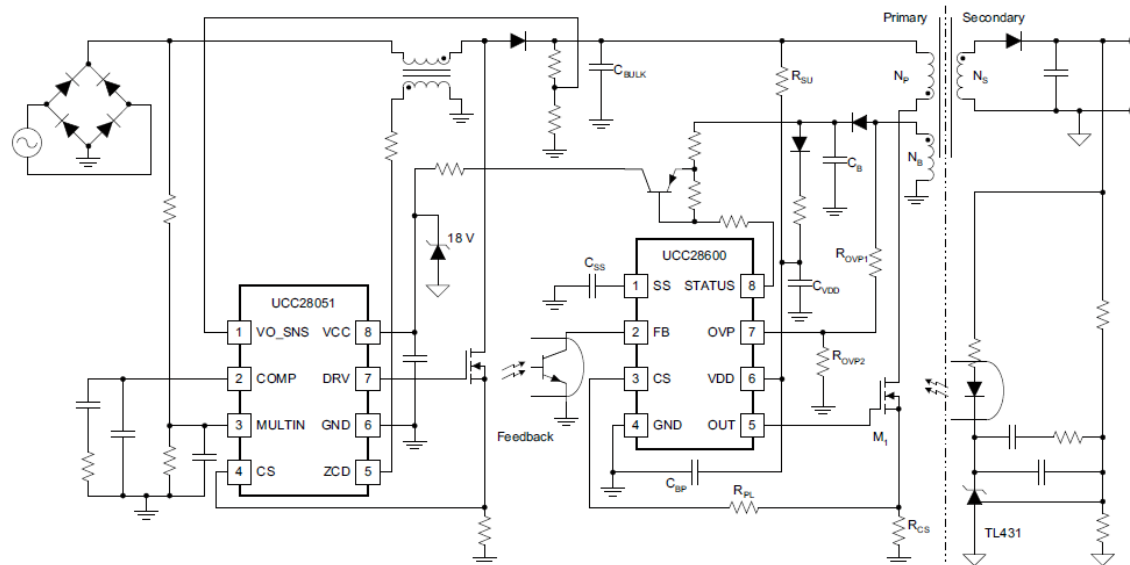
Rezultati

Funkcionalnost		Min dB pod limito			Točke					Rezultat	
Vklop	RP	CE	RE 30M	RE 1G	OP	T CE	T RE 30M	T RE 1G	BCI	Vsota	Mesto
OK	OK	12	5,83	7,35	10	10	5,83	7,35	10	43,18	1
OK	OK	10	4,04	7,74	10	10	4,04	7,74	10	41,78	2
OK	OK	11	3,94	7,42	10	10	3,94	7,42	10	41,36	3
OK	OK	5	0,51	7,04	10	5	0,51	7,04	10	32,55	4
Fail	OK	12			0	10	4	7	10	31	5
OK	OK	-0,5	-13,19	0,97	10	-0,5	-13,19	0,97	10	7,28	6
OK	OK	-9	4,19	-8,44	10	-9	4,19	-8,44	10	6,75	7

2. EMC delavnica 2017: ISKRA EMECO



Izziv



UCC28600
(MOS)

UCC28720
(BJT)

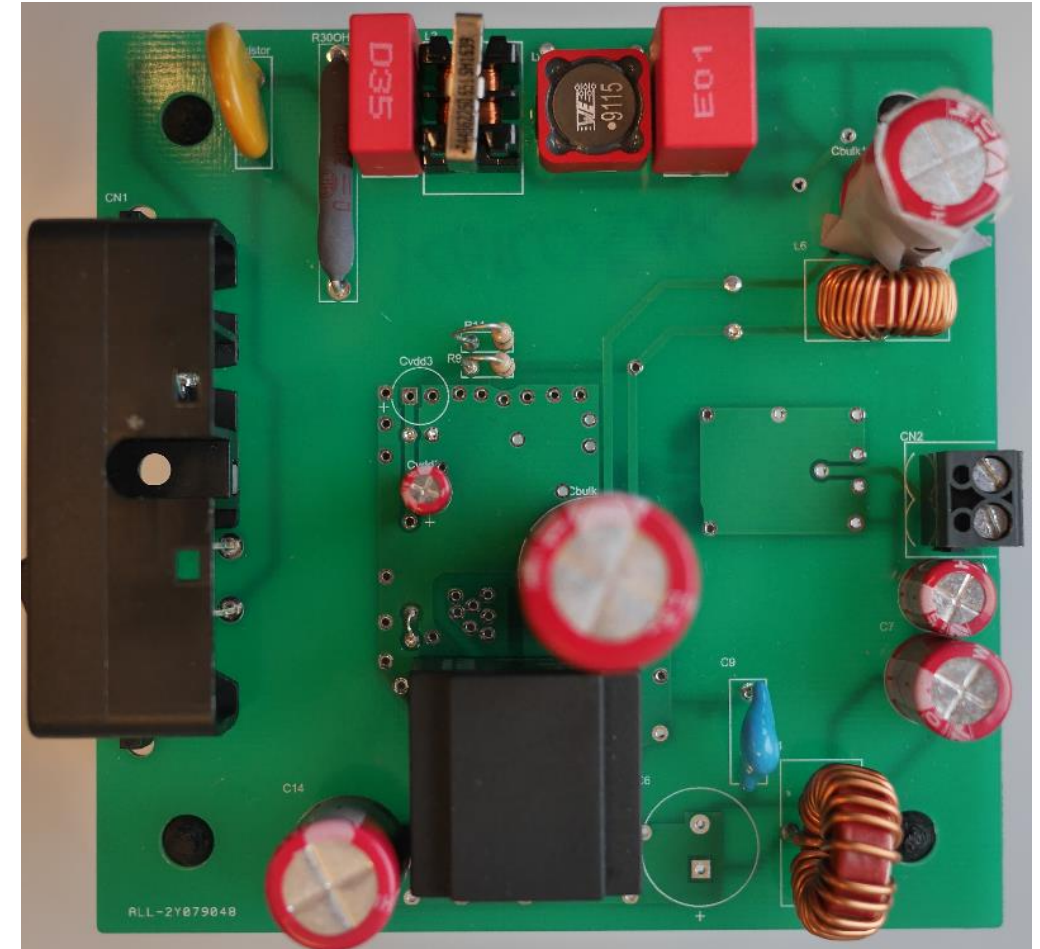
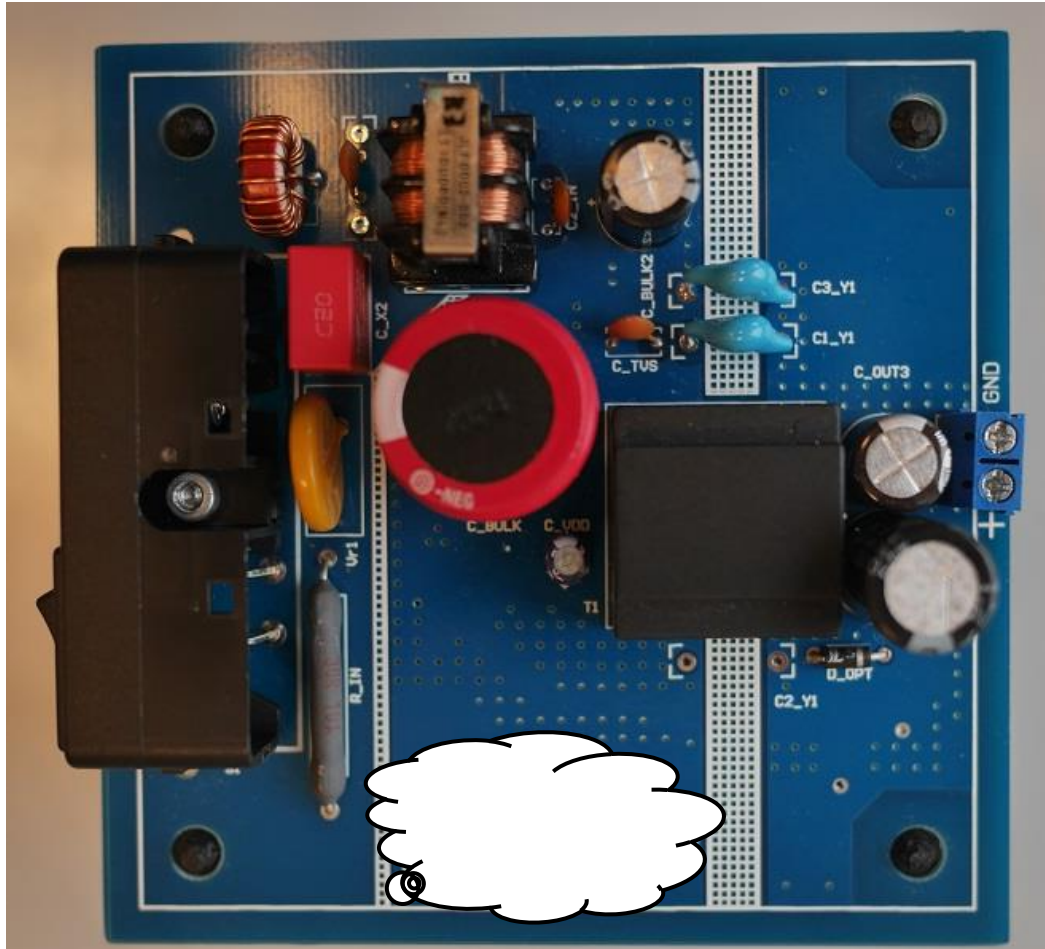
Predavanja in ekskurzije



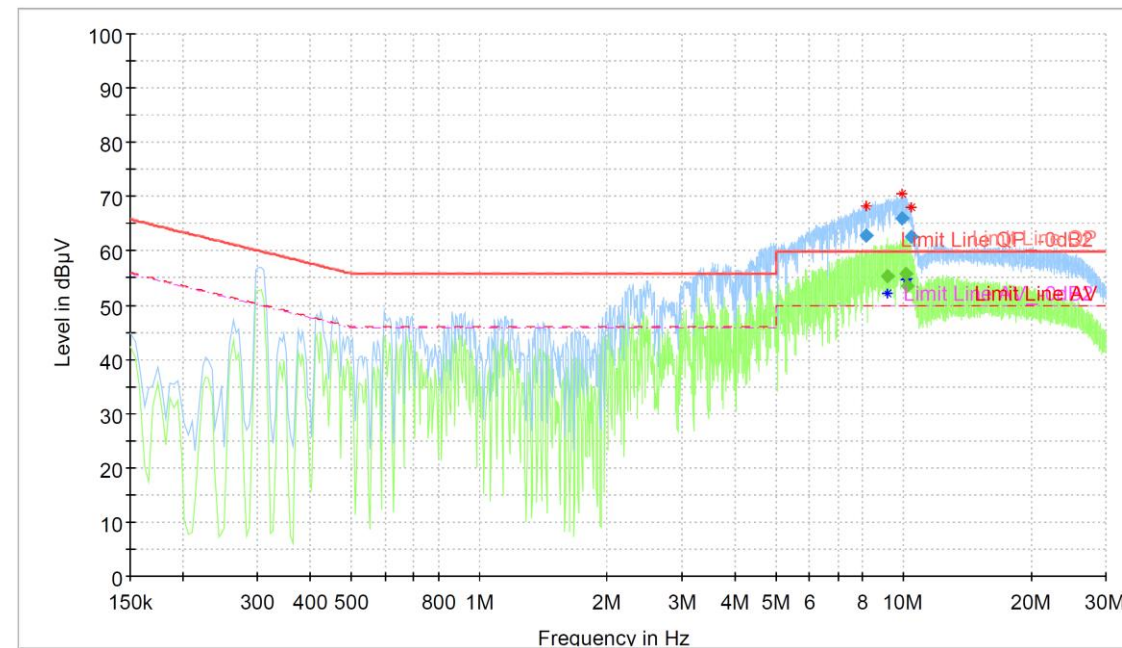
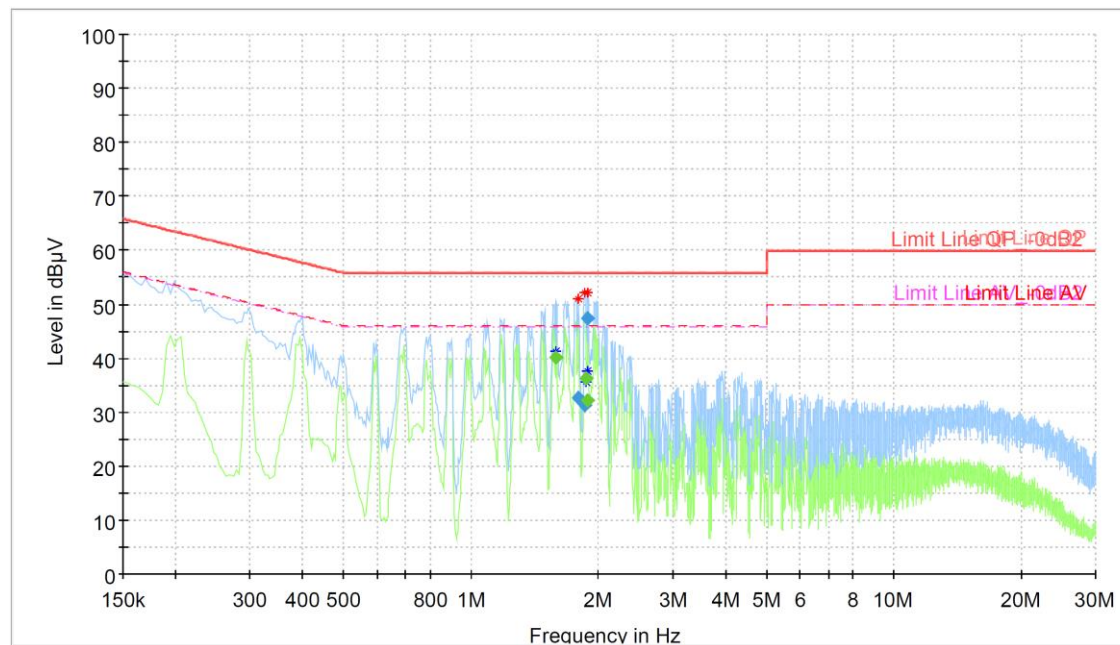
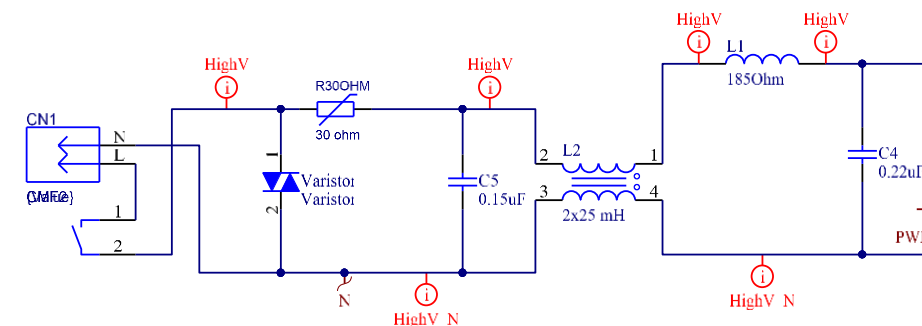
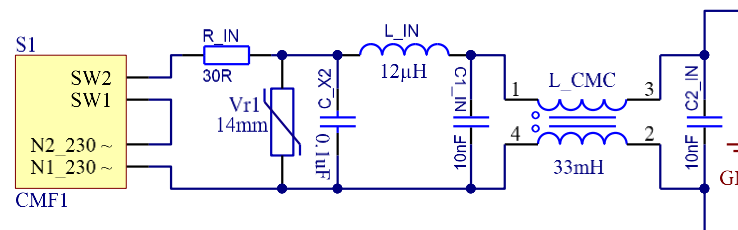
Izdelava projektov



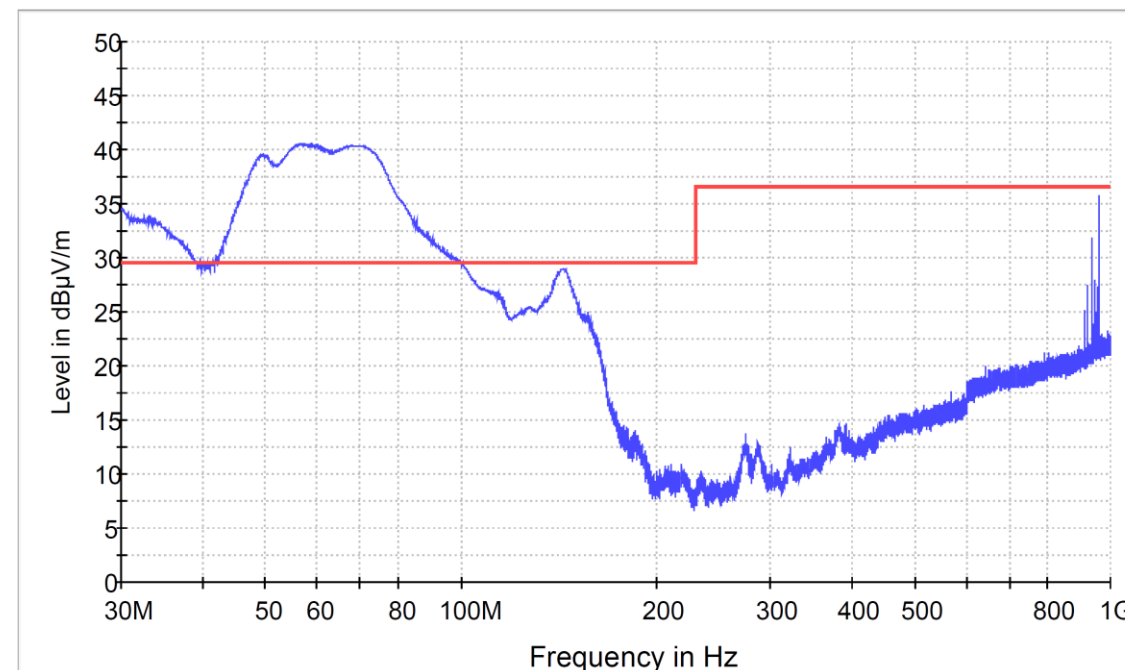
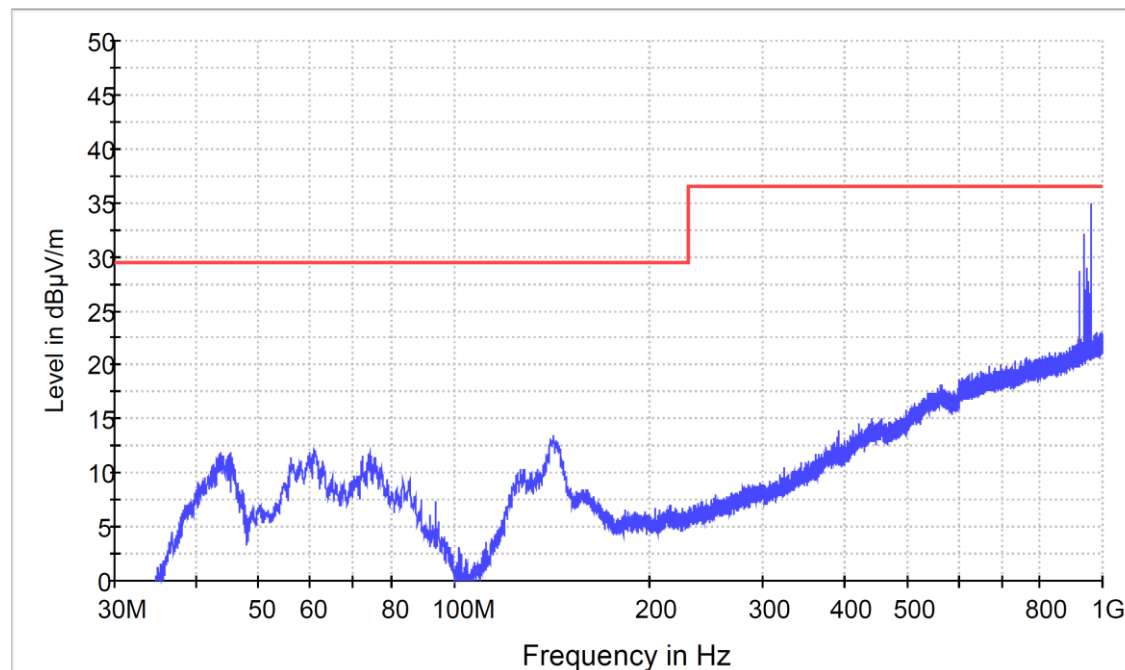
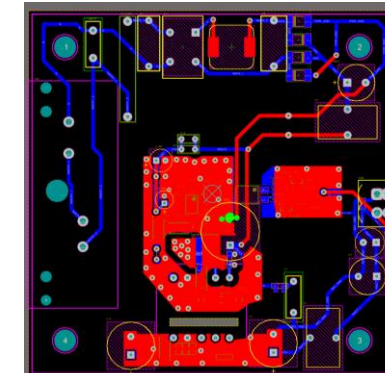
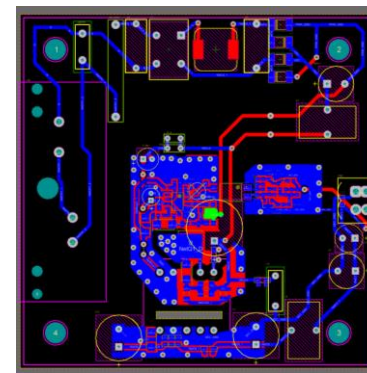
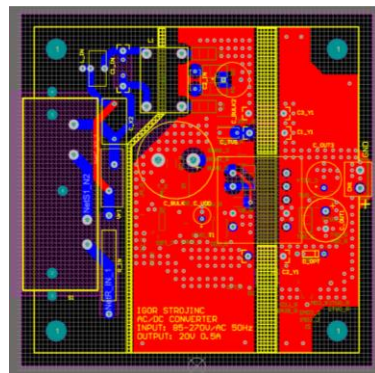
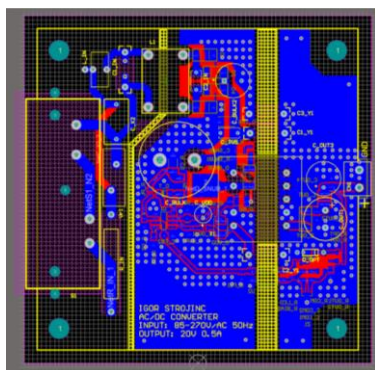
Rezultati



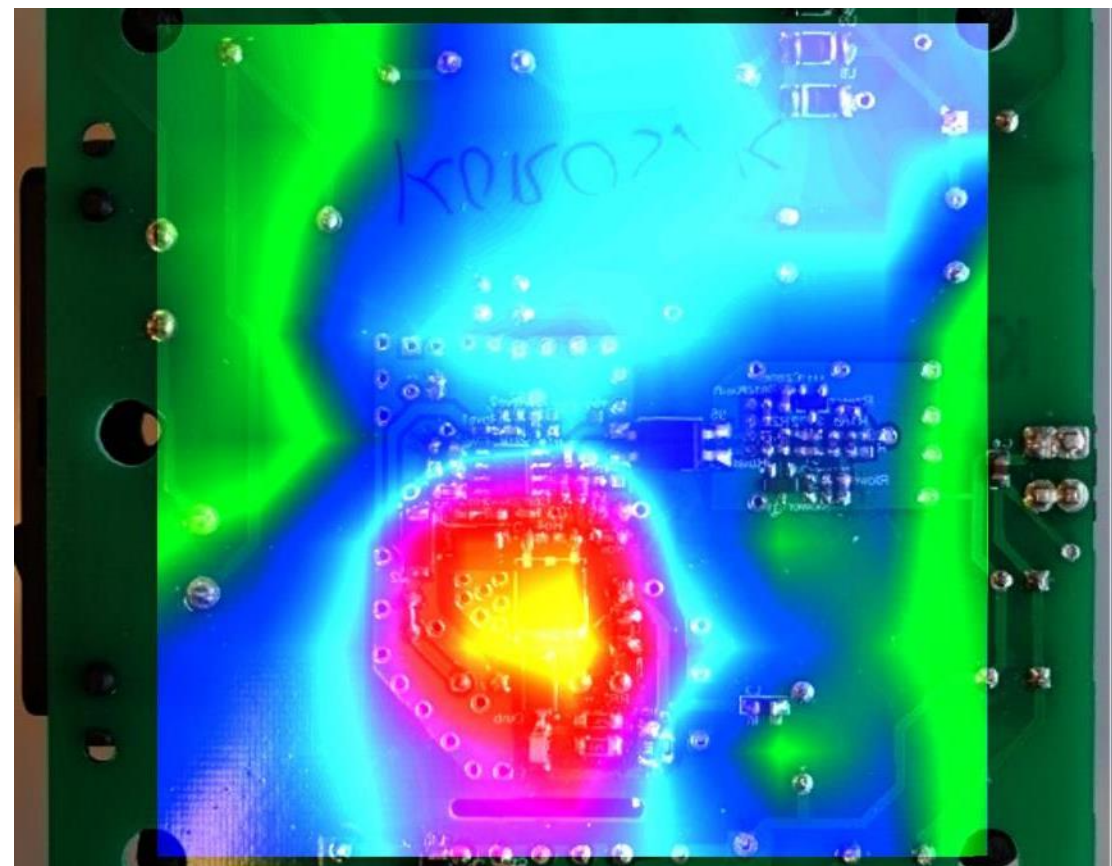
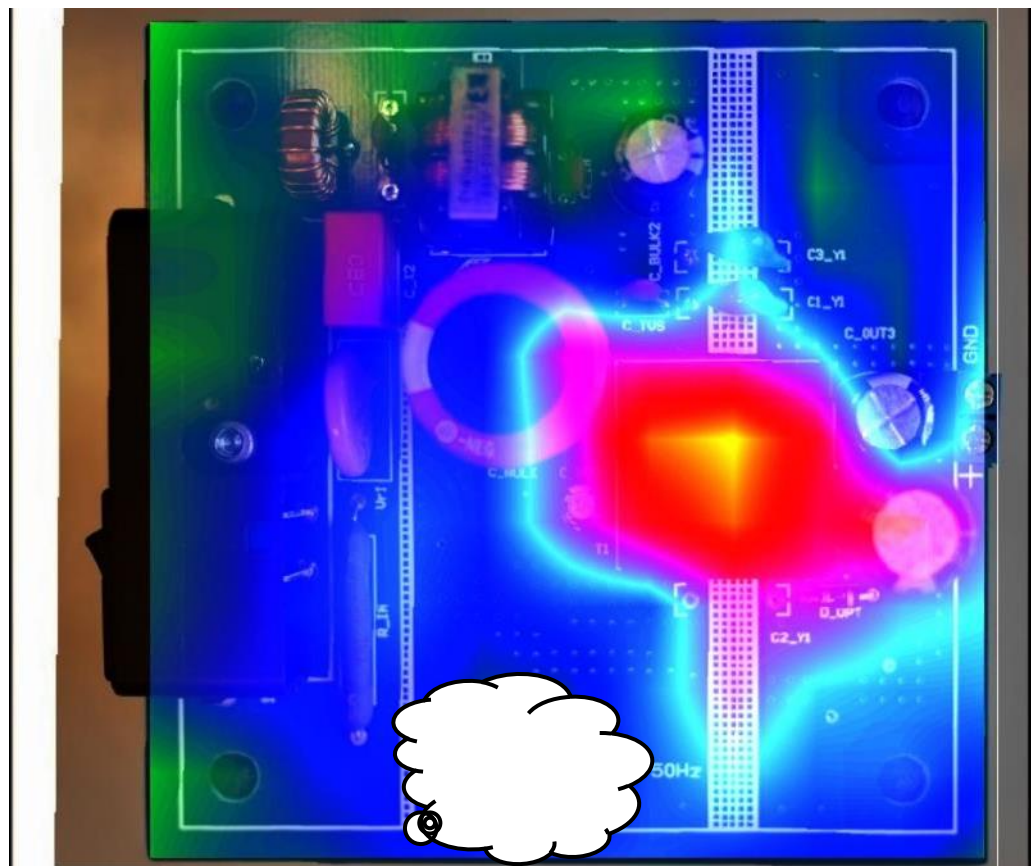
Rezultati



Rezultati



Rezultati



Rezultati

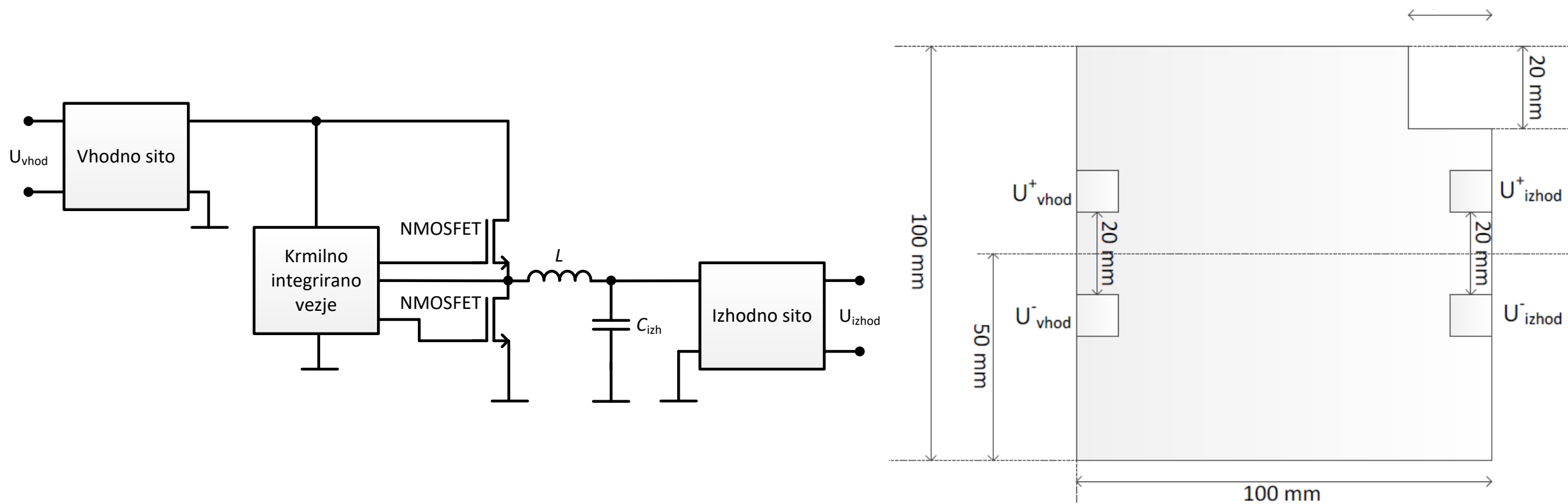
Funkcionalnost				Min dB pod limito				Točke				Rezultat	
Vklop	KS	Uout	VF šum	CE	RE	OP	T CE	T RE	Surge	Vsota	Mesto		
OK	OK	OK	OK	5.56	17	10	5.56	10	0	6.9	1		
OK	OK	OK	OK	-4.43	14	10	-4.43	10	0	4.4	2		
OK	OK	OK	OK	-5.03	4	10	-5.03	7	0	3.5	3		
OK	OK	OK	OK	-7.45	2	10	-7.45	2	0	1.6	4		
OK	OK	OK	OK	-4.88	-12	10	-4.88	-12	0	-1.2	5		
OK	OK	OK	OK	-6.16	-11	10	-6.16	-11	0	-1.3	6		
Fail	Fail	Fail	Fail			0	0	0	0	0.0	7		

3. EMC delavnica 2018: MAHLE EDS

MAHLE



Izziv

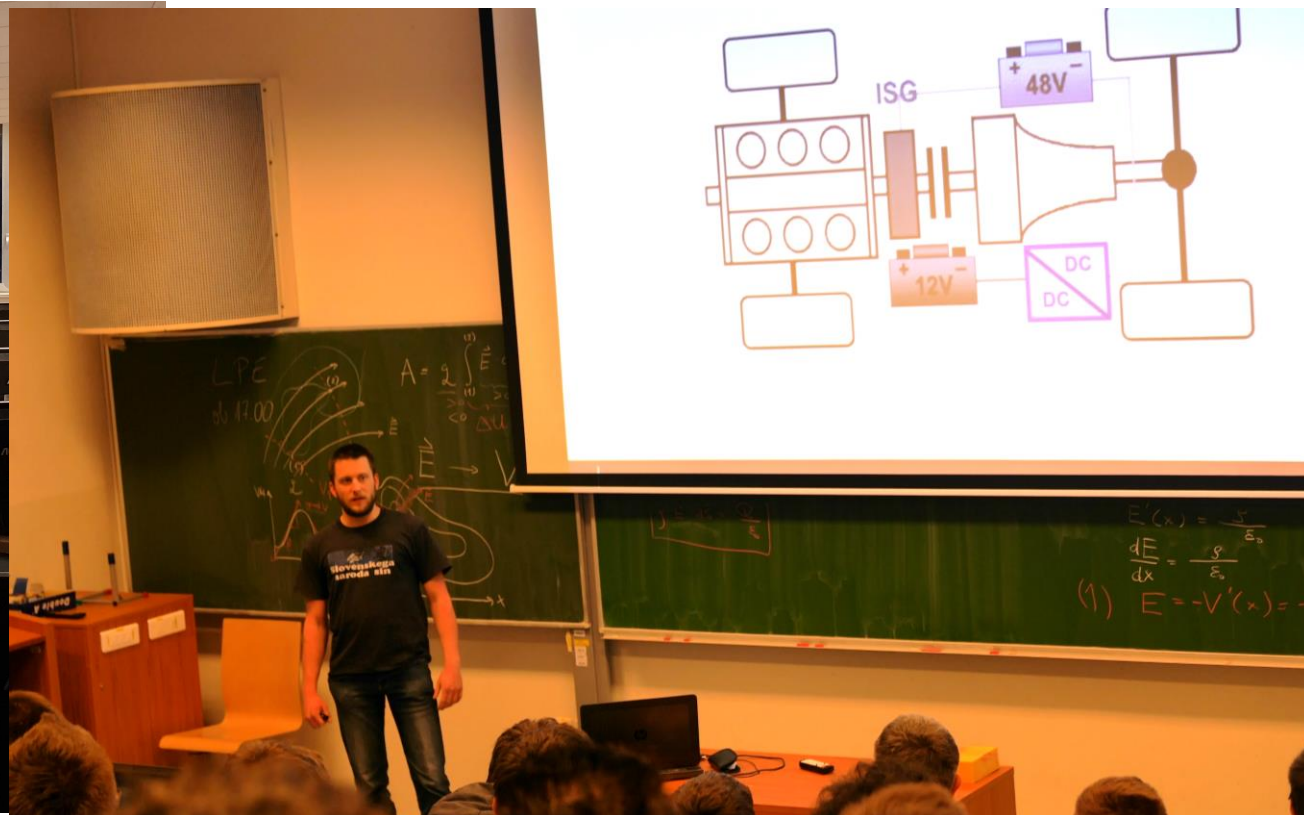


Kriteriji



Lastnost	Vrednost
Topologija	DC/DC pretvornik navzdol
Območje vhodne napetosti	36 V – 60 V
Območje nastavljene izhodne napetosti	14 V ± 0,7V
Vršna vrednost valovitosti izhodne napetosti	0,2 V
Vršna vrednost valovitosti izhodne napetosti	0,5 V
Območje izhodnega toka	[1,4 – 7] A
Izhodno breme	Upornost 2 Ohm – 7 A Upornost 10 Ohm – 1.4A
Izkoristek pretvornika	Večji od 75%

Predavanja in vaje

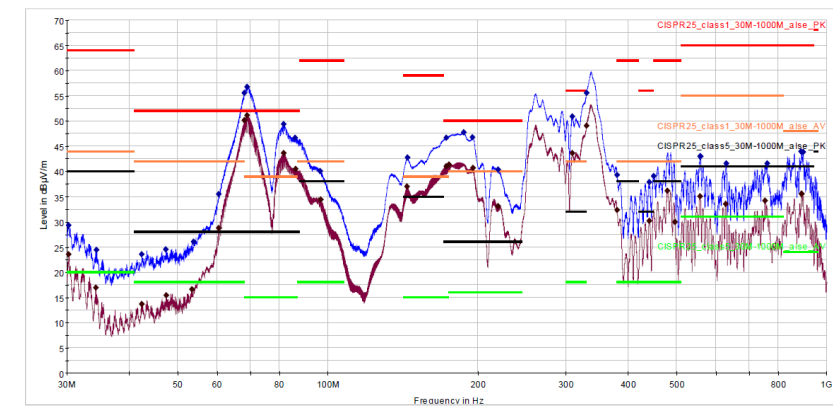
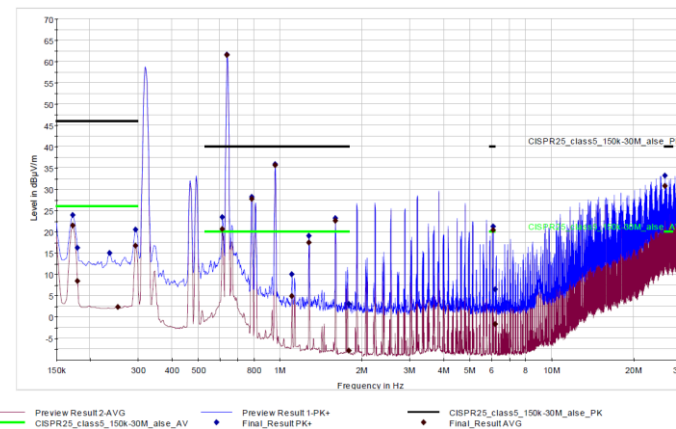
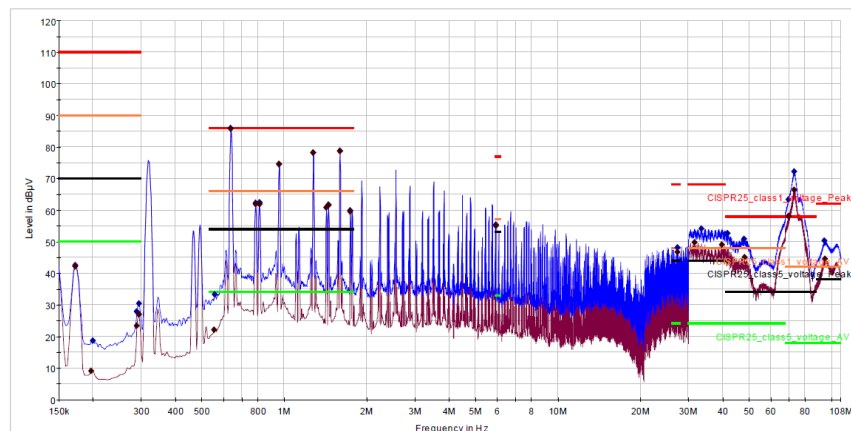


Ekскурzije



Rezultati

Mesto		Delovanje	Prevodne EMC	Konduktivne EMC	Cena	Skupaj
1		25	-24,47	-12,08	-23,64	-35,19
2		22	-30,44	-27,83	-33,6	-69,87
3		22	-36,37	-29,49	-28,1	-71,96
4		½	-	-	-	-
4		½	-	-	-	-
5		-	-	-	-	-
5		-	-	-	-	-
5		-	-	-	-	-

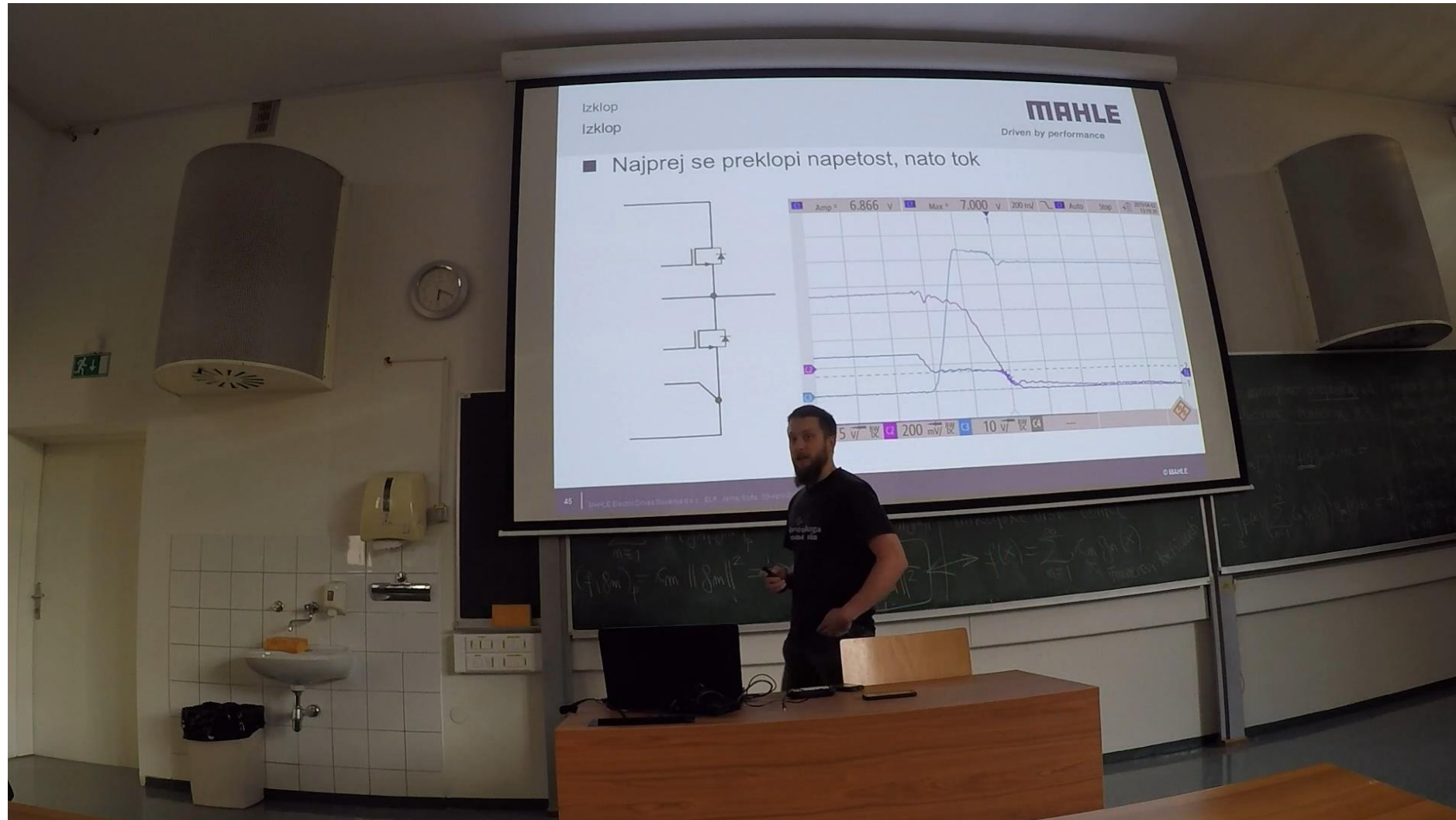


4. EMC delavnica 2019: MAHLE EDS - ponovitev

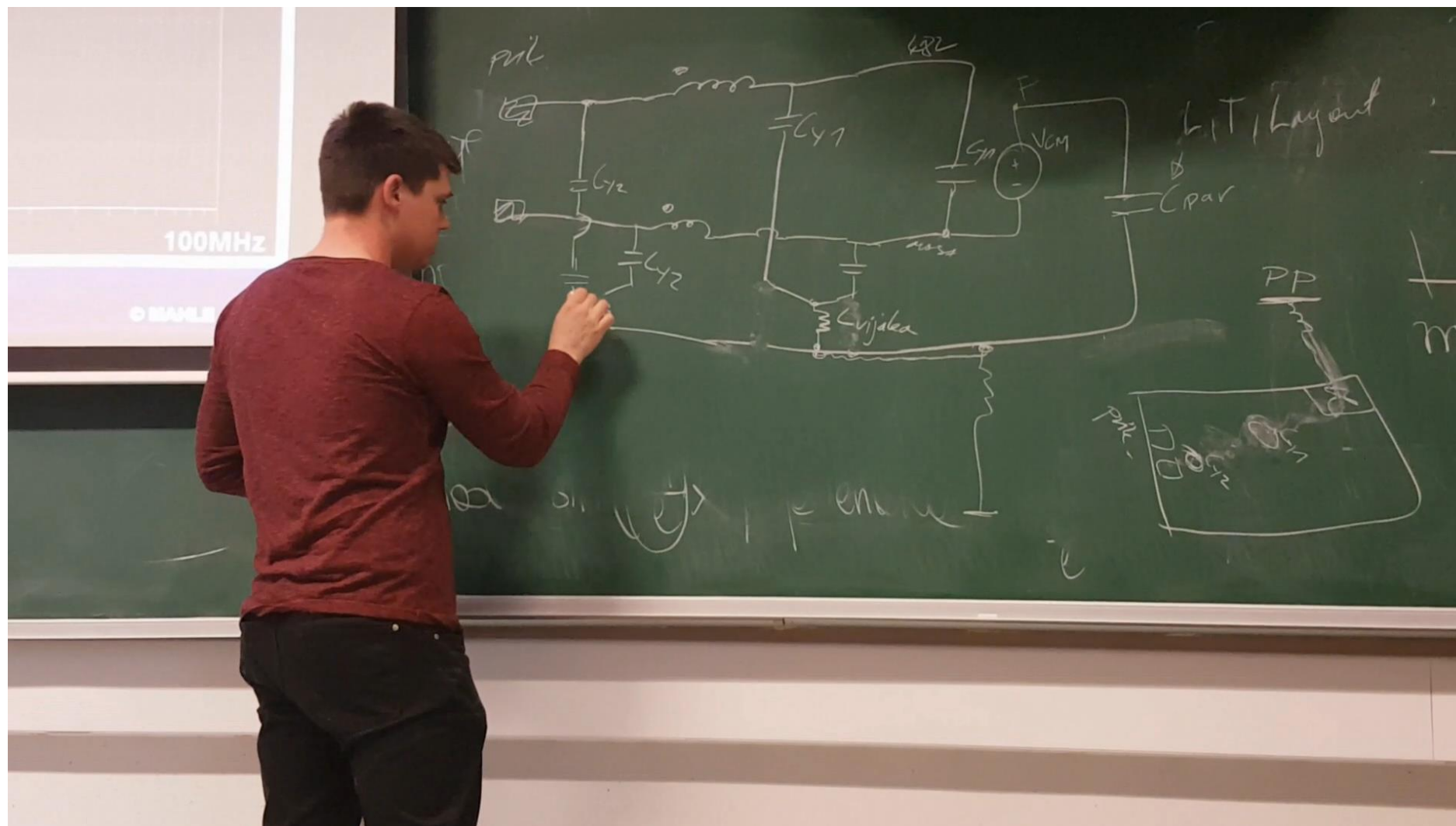
MAHLE



Predavanja: MAHLE (Sorta)



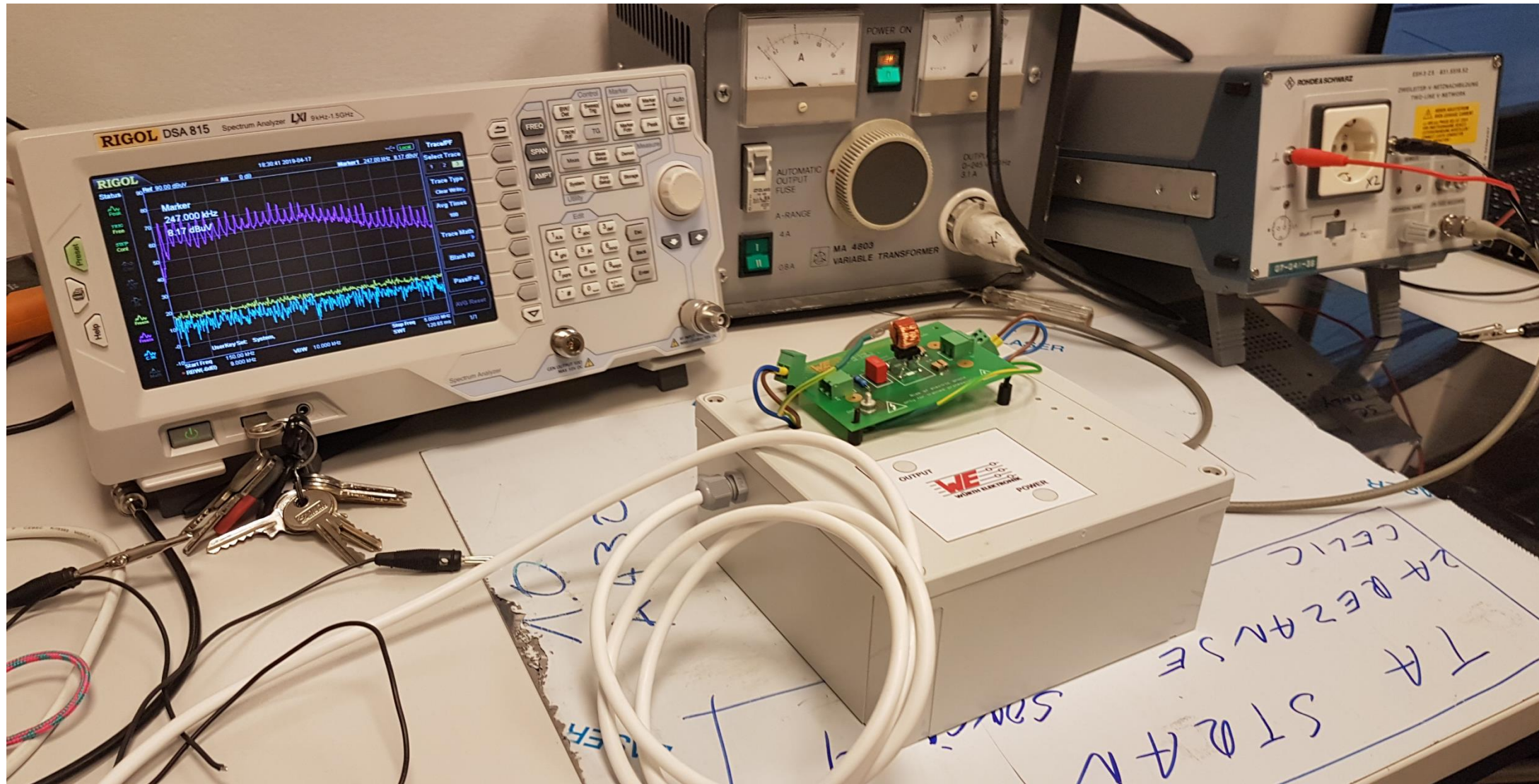
Predavanja: MAHLE (Ergaver)



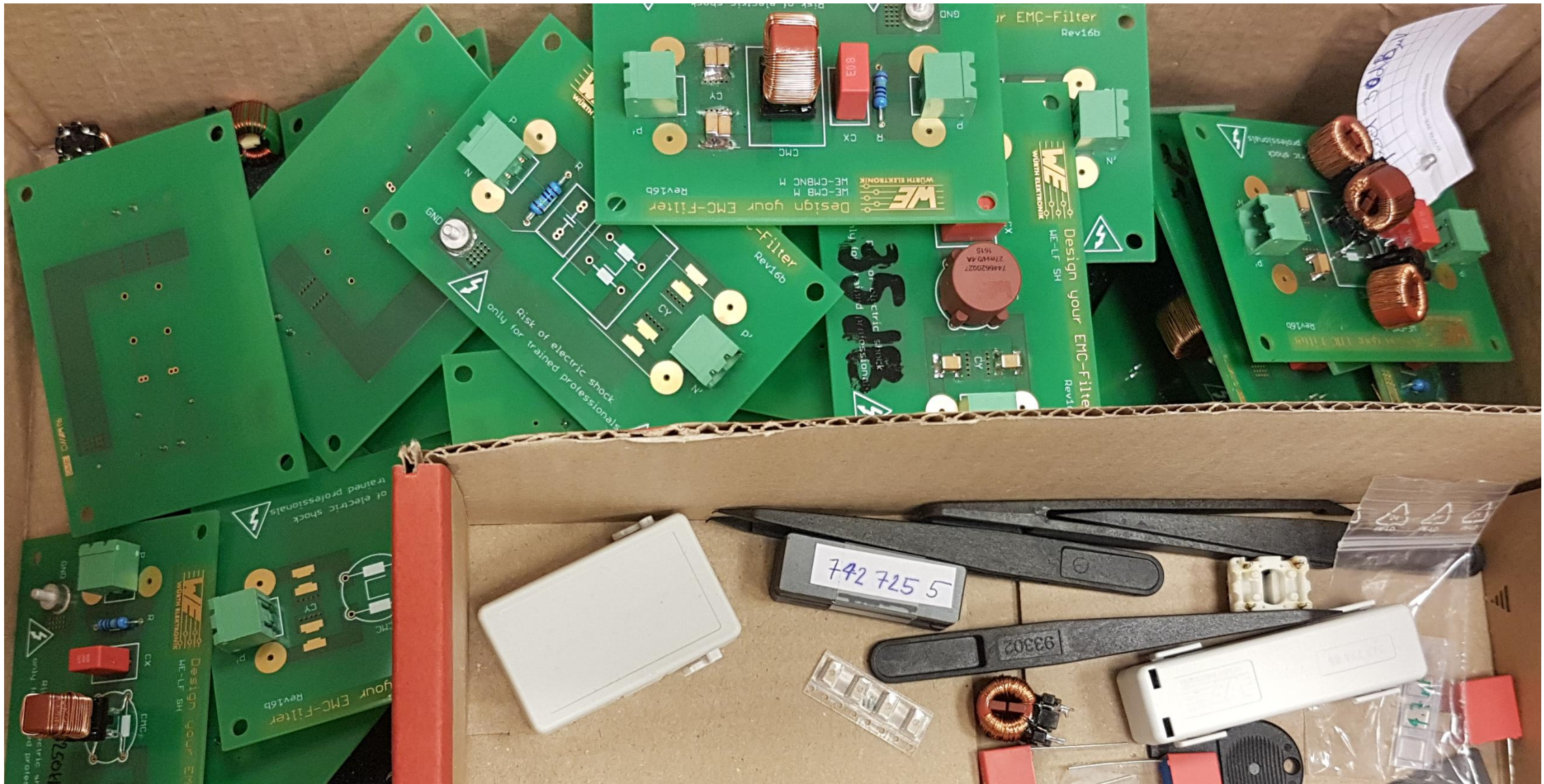
Delavnica načrtovanja filtrov – Würth elektronik



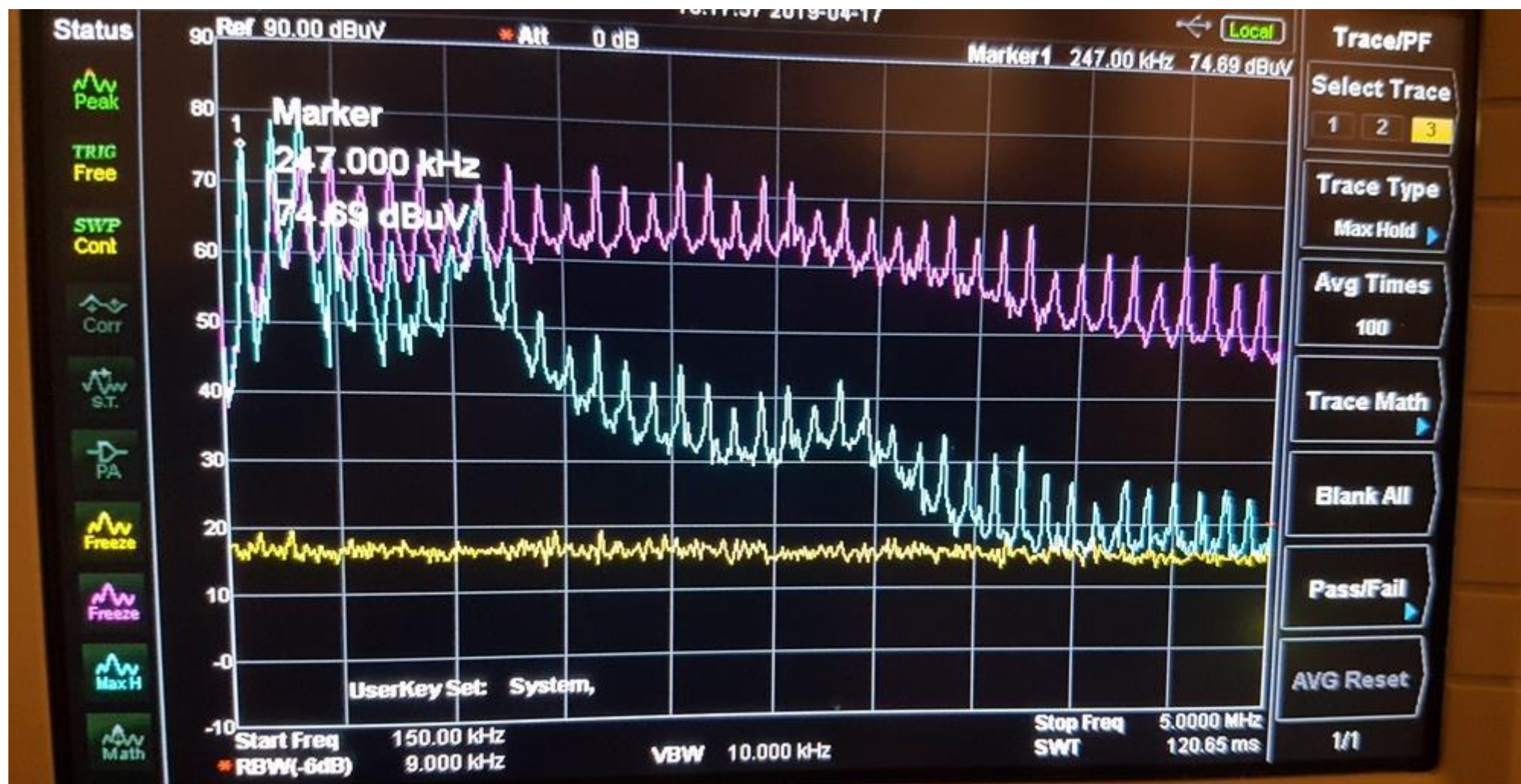
Delavnica načrtovanja filtrov – Würth elektronik



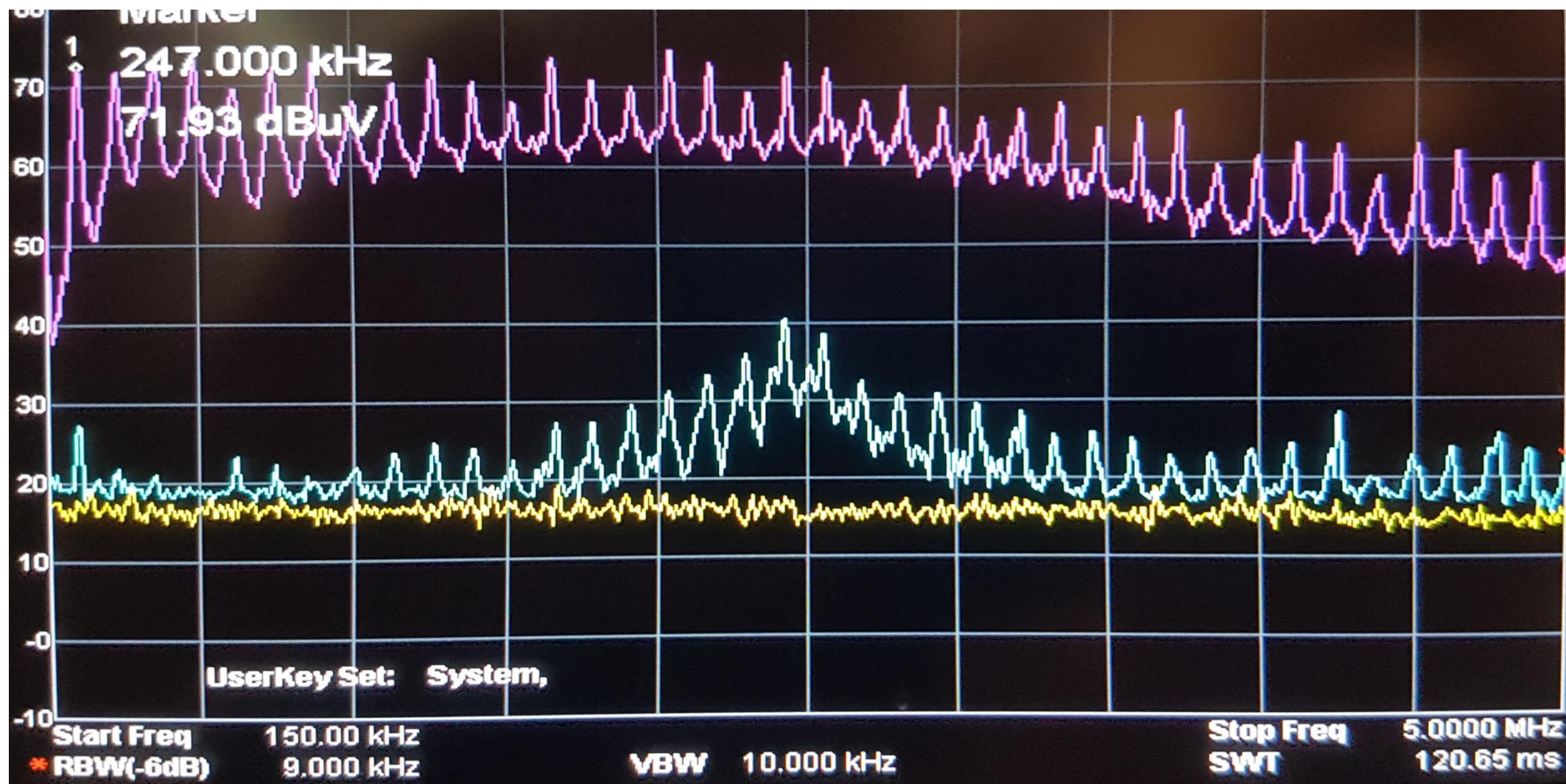
Delavnica načrtovanja filtrov – Würth elektronik



Delavnica načrtovanja filtrov – Würth elektronik



Delavnica načrtovanja filtrov – Würth elektronik



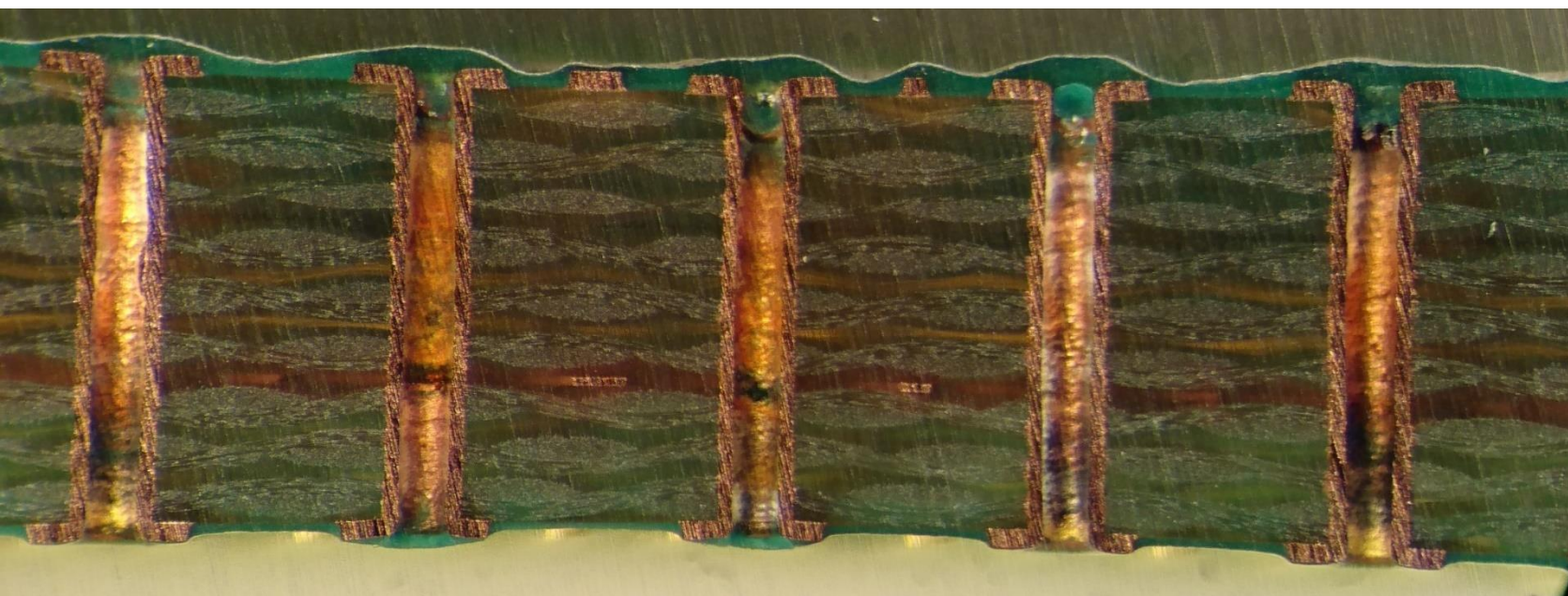
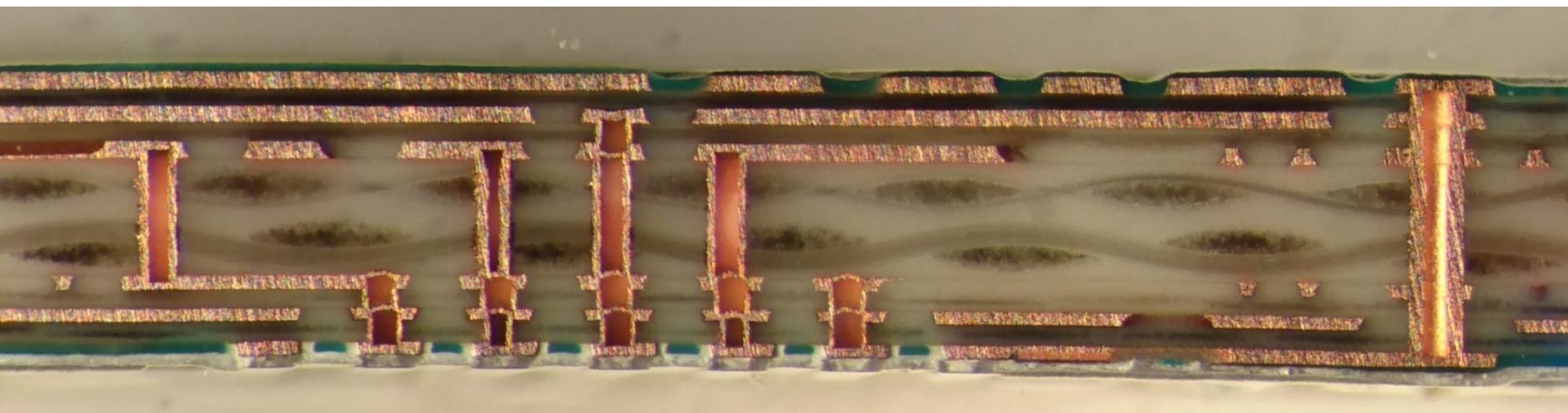
Delavnica načrtovanja filtrov – Würth elektronik



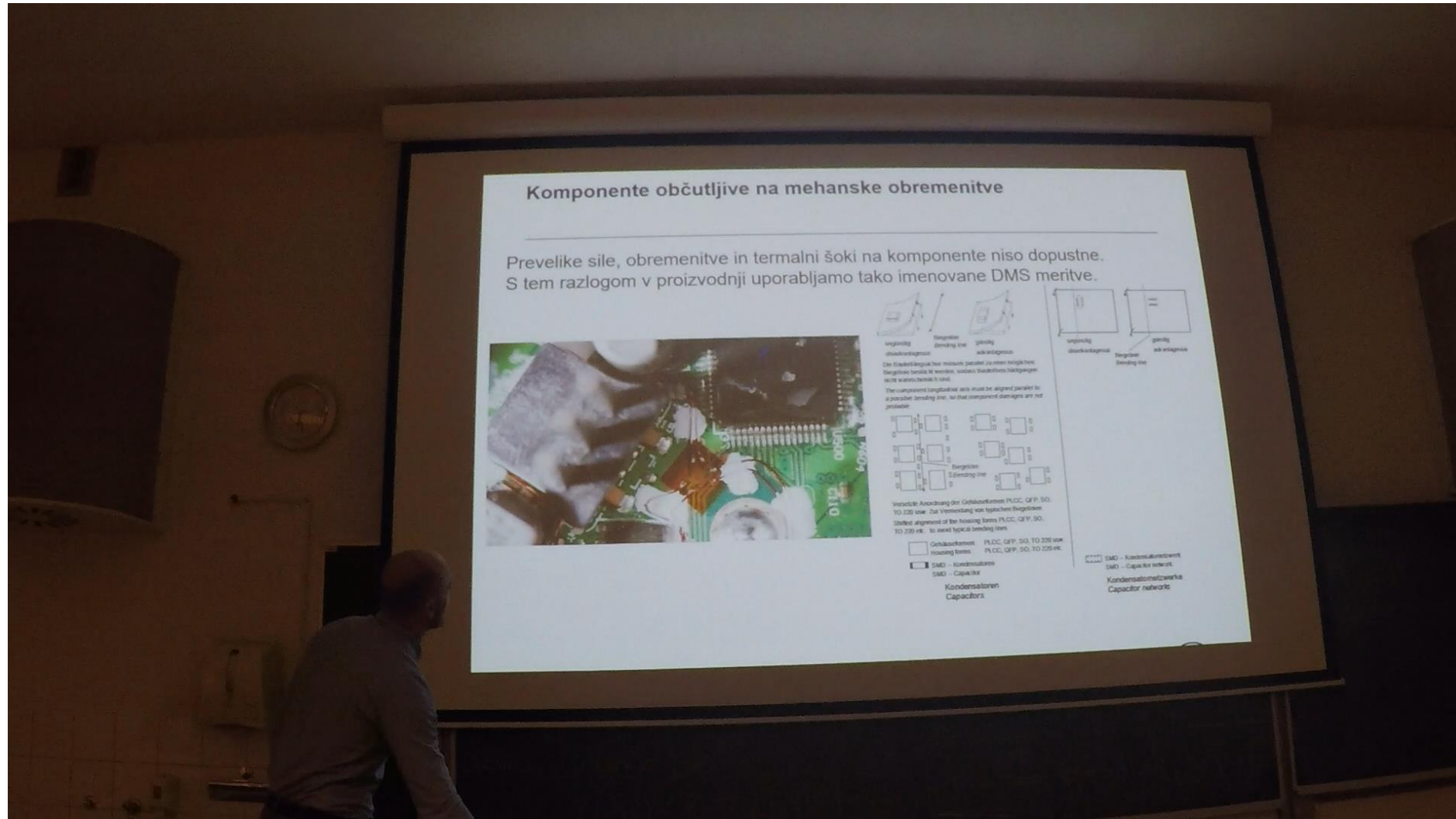
Tečaj Osnove Altiuma



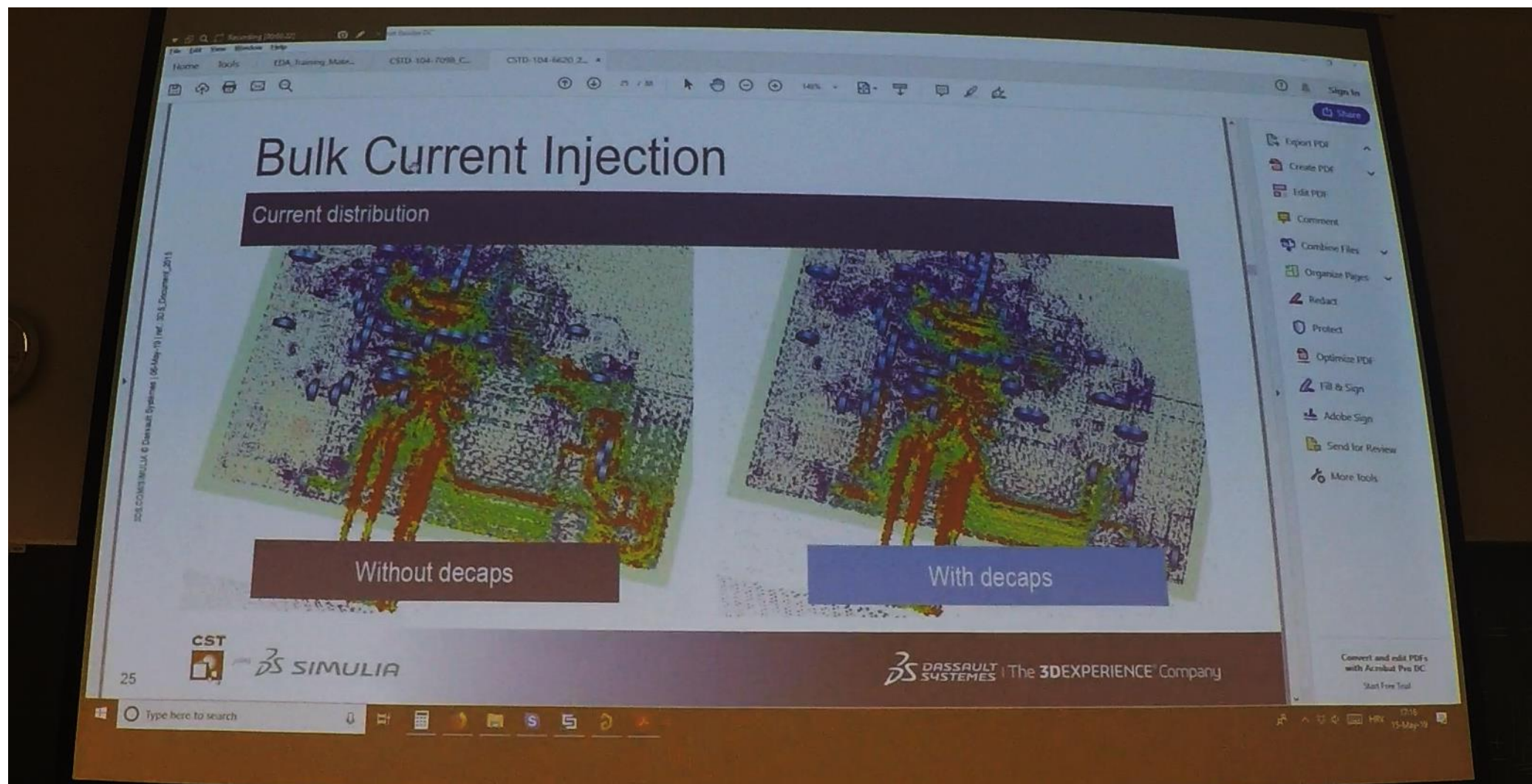
Predavanja: INTEC TIV



Predavanja: HELLA SATURNUS



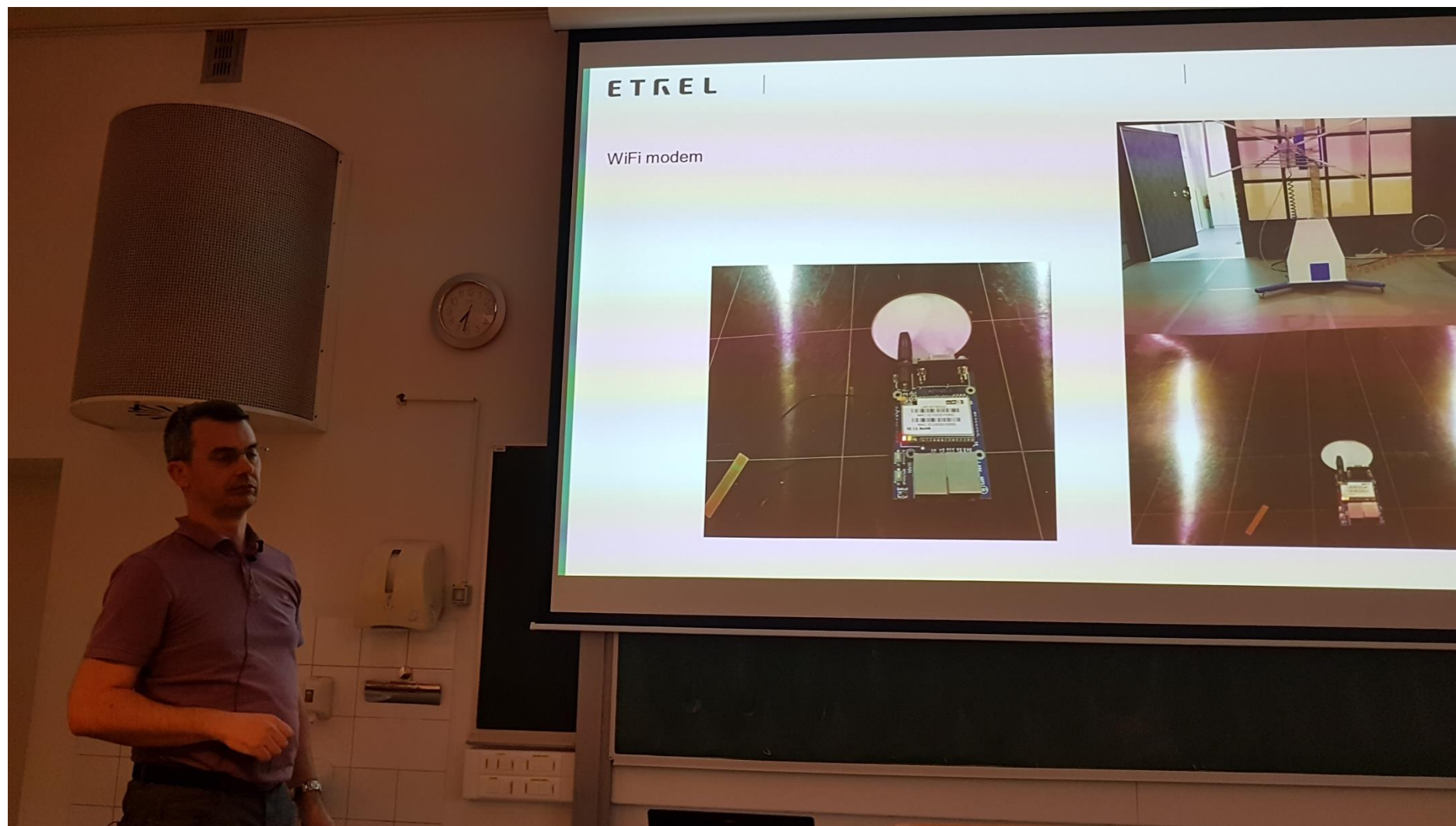
Predavanje: HT EUREP



Predavanja: METREL



Predavanja: ETREL



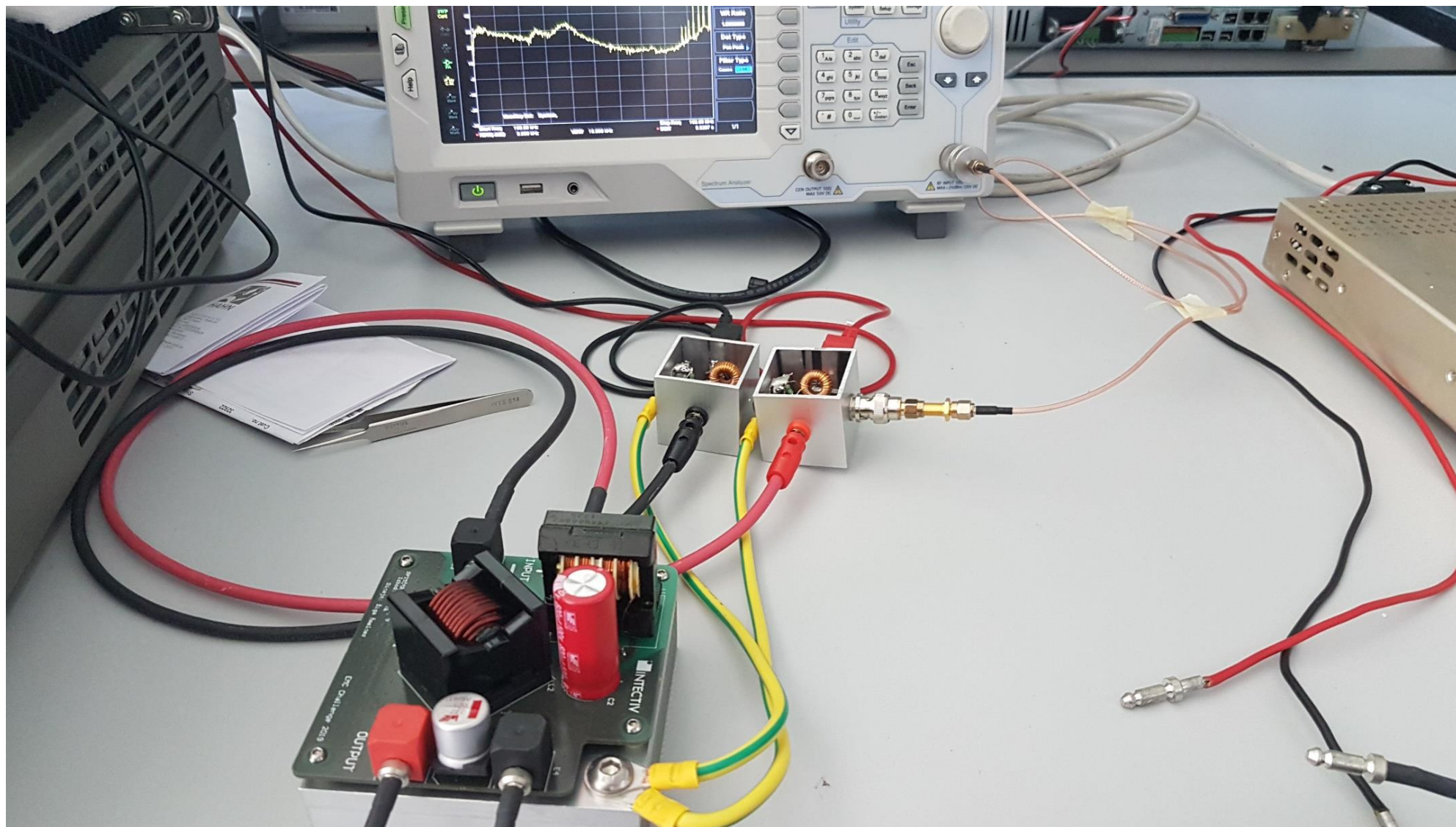
Ekskurzija v Intec TIV



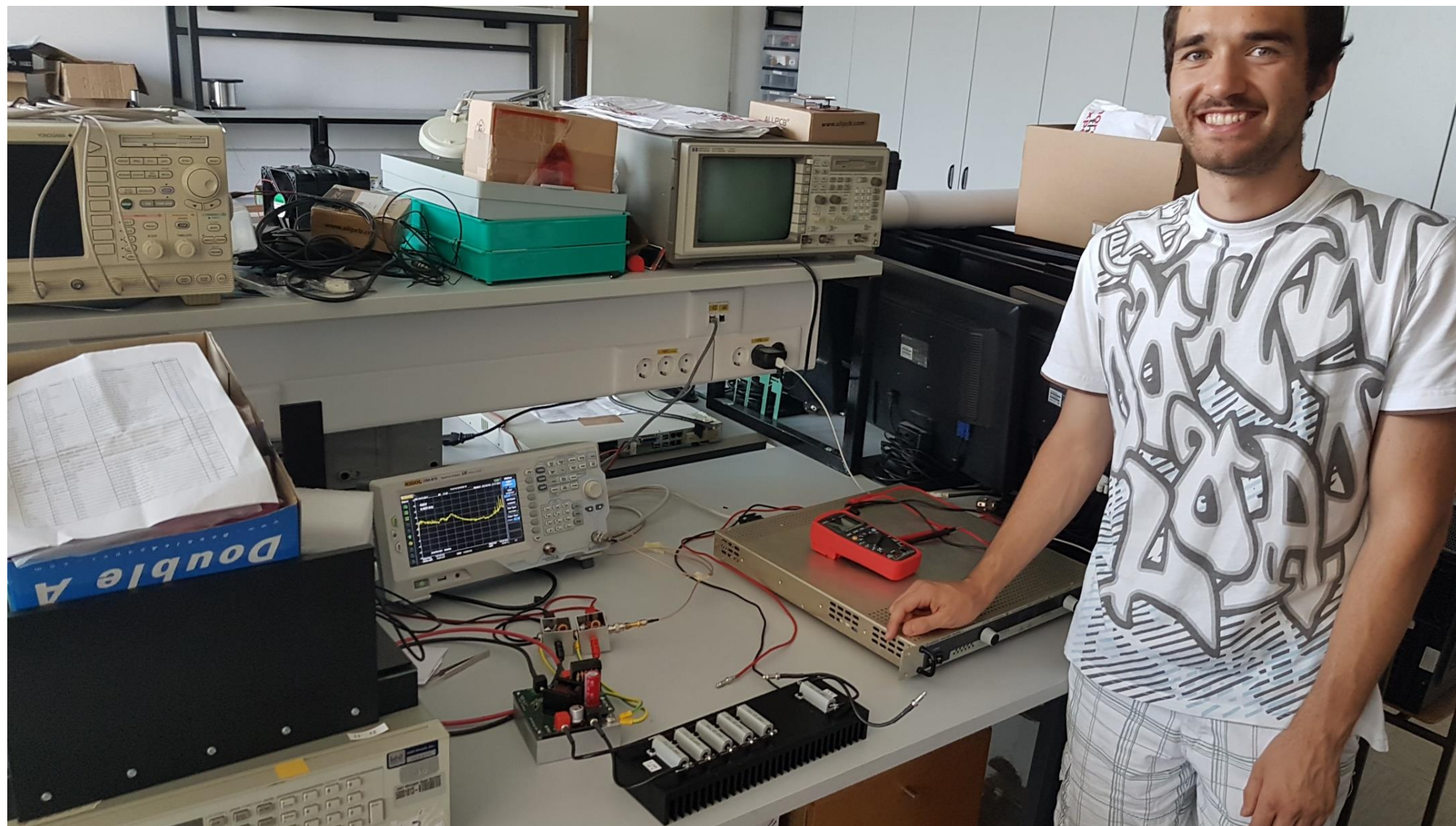
Naročilo materiala



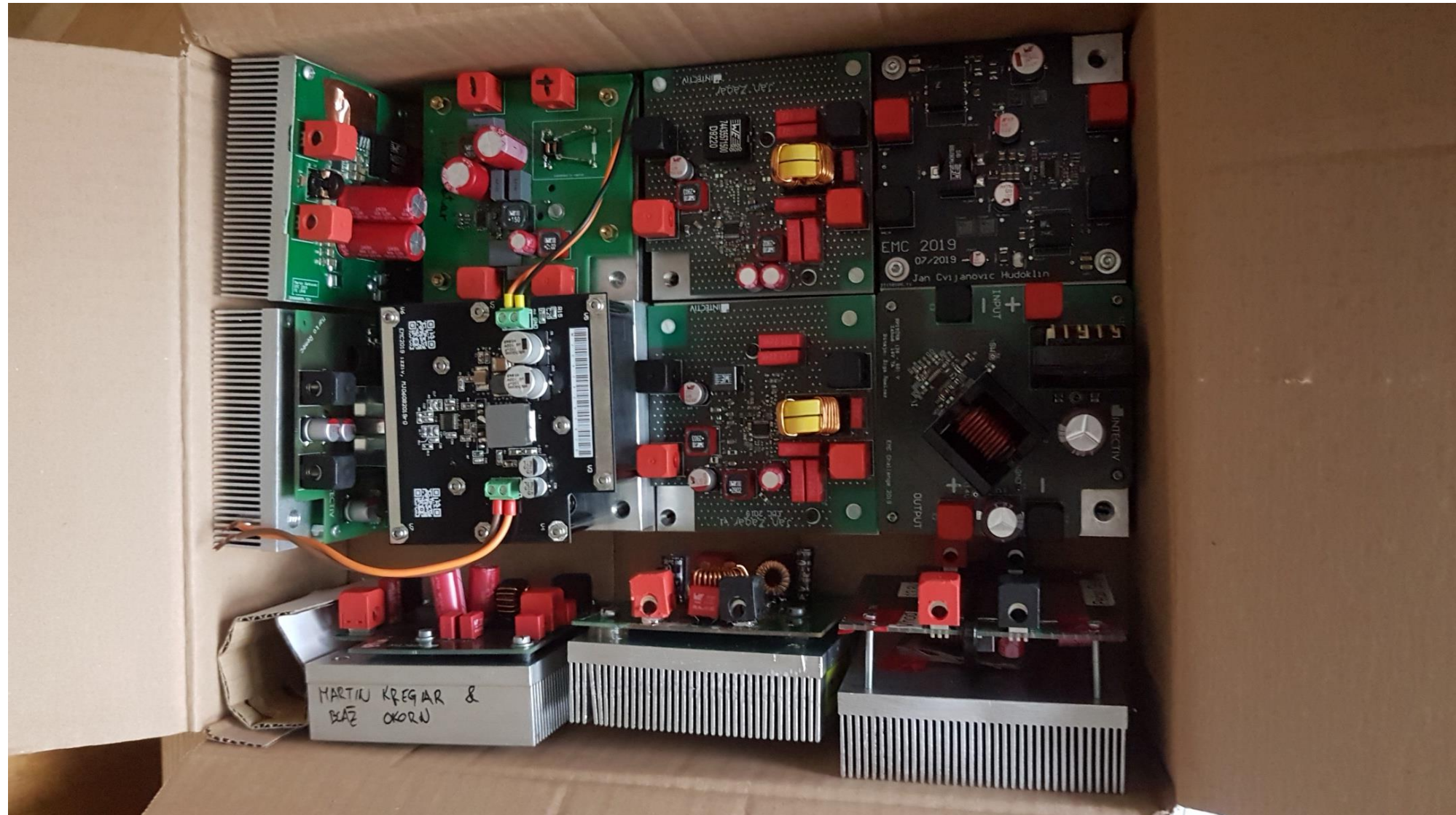
Preizkušanje



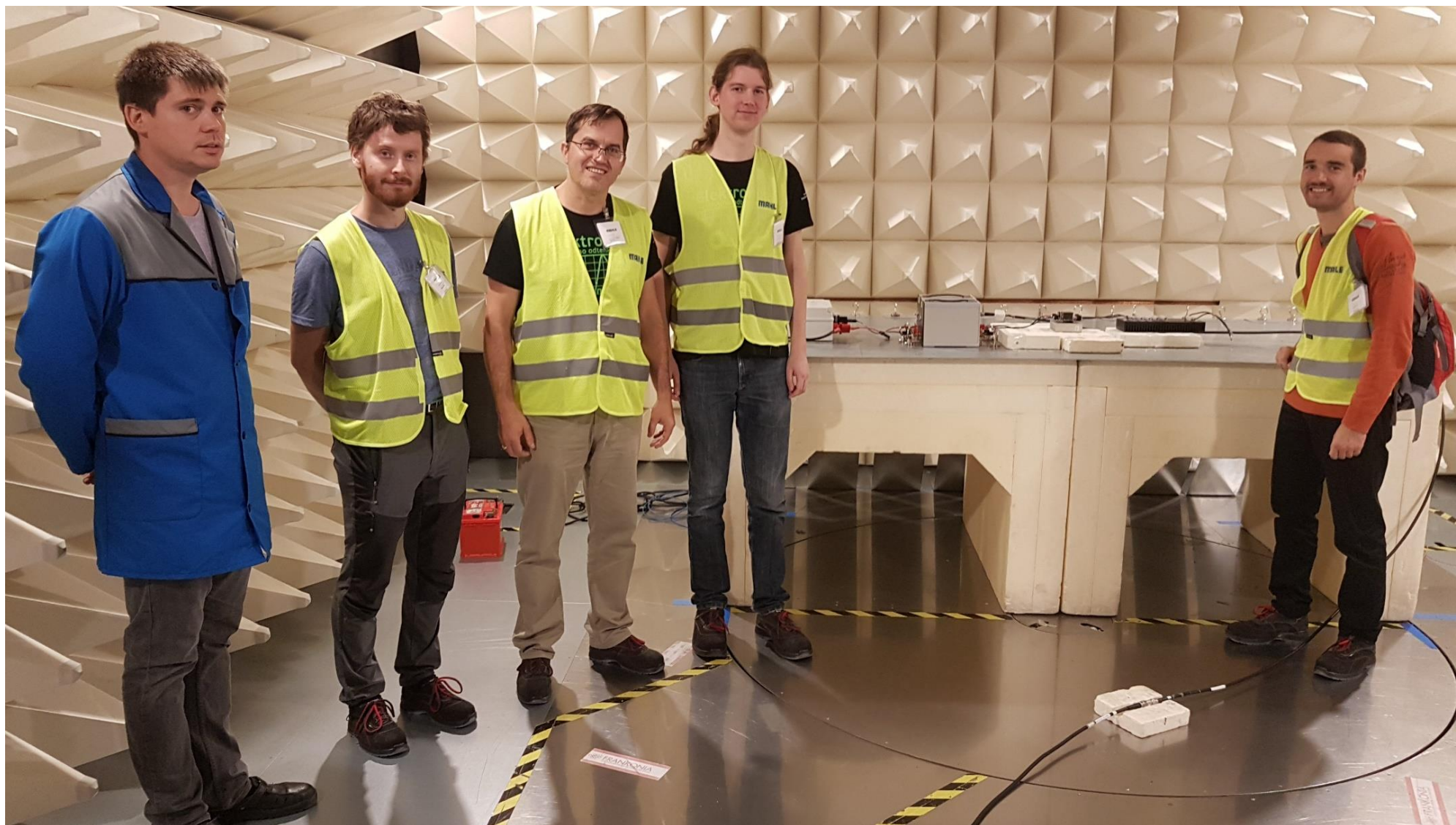
Preizkušanje



Oddaja projektov



Meritve v MAHLE



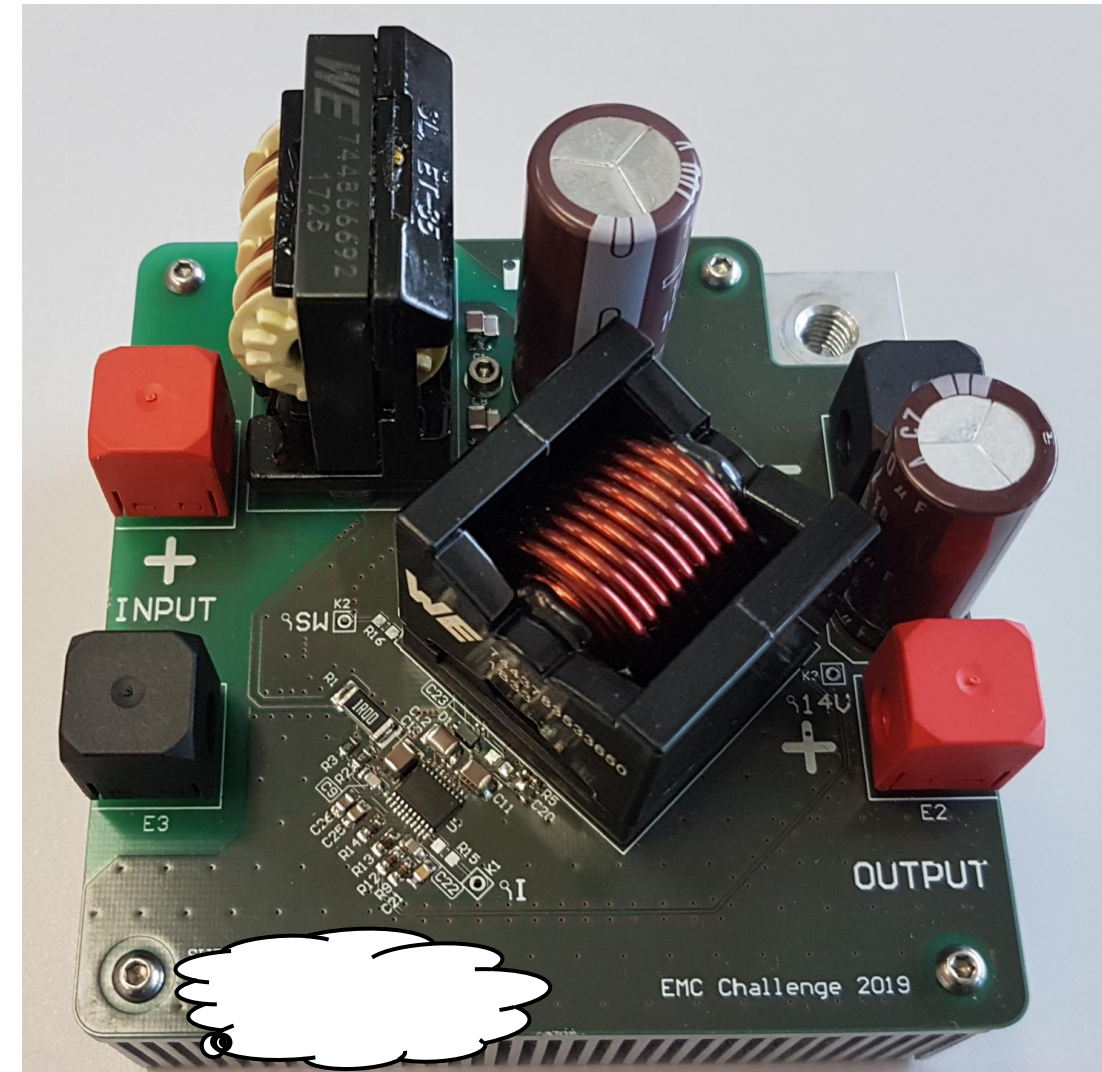
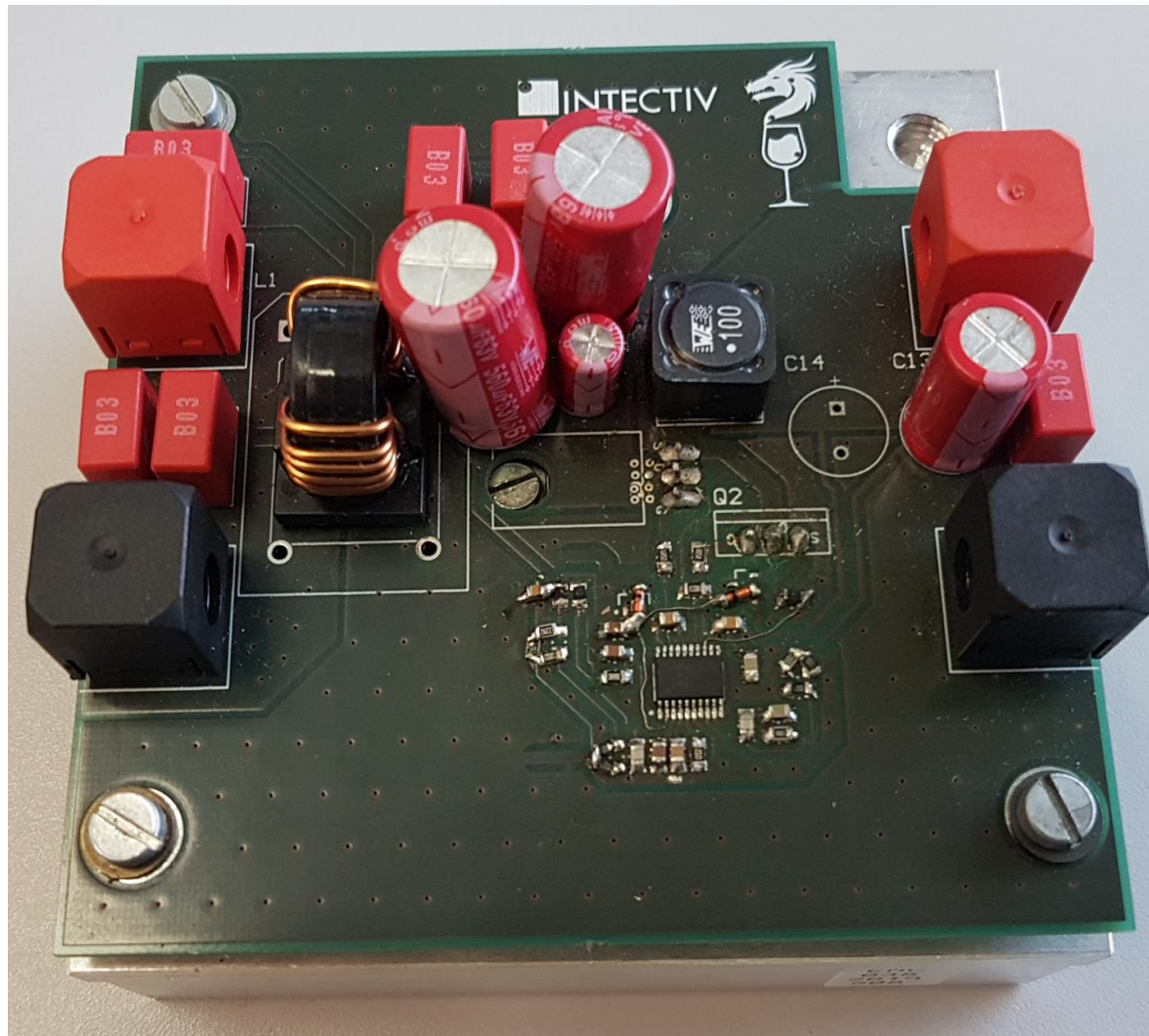
Meritve v MAHLE



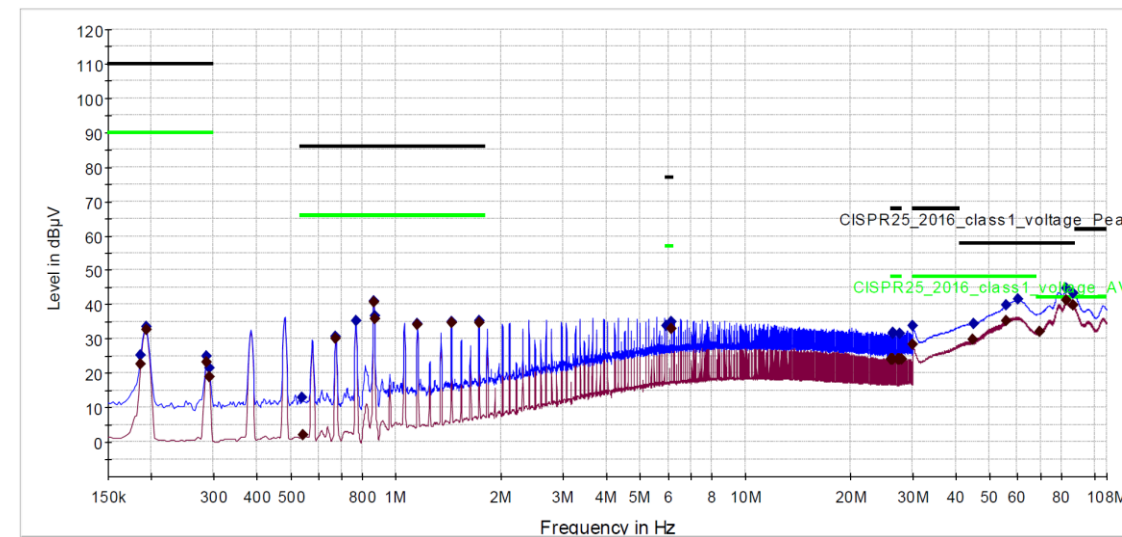
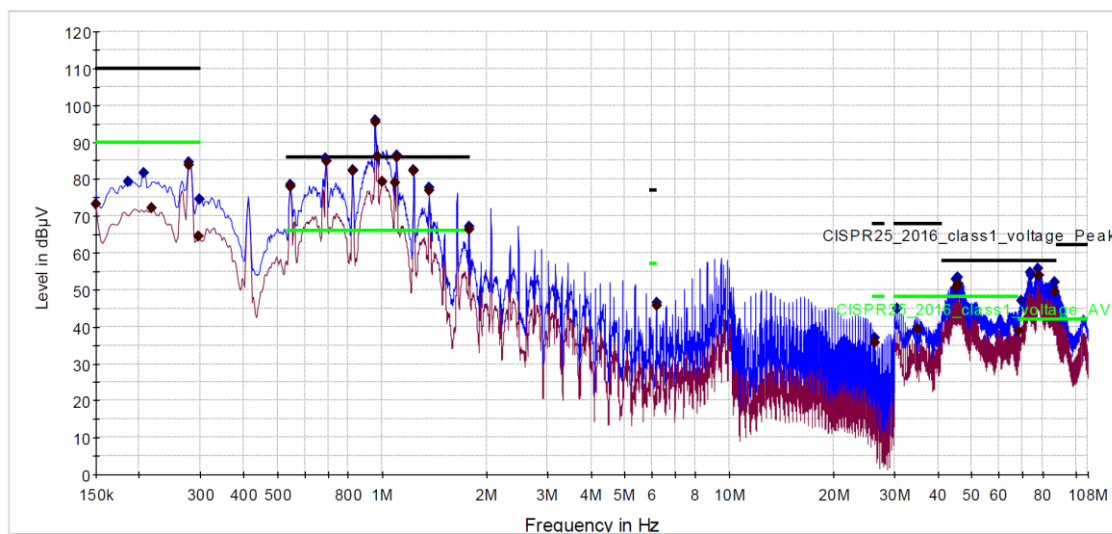
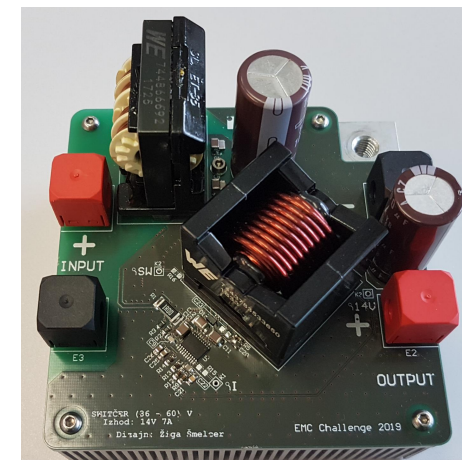
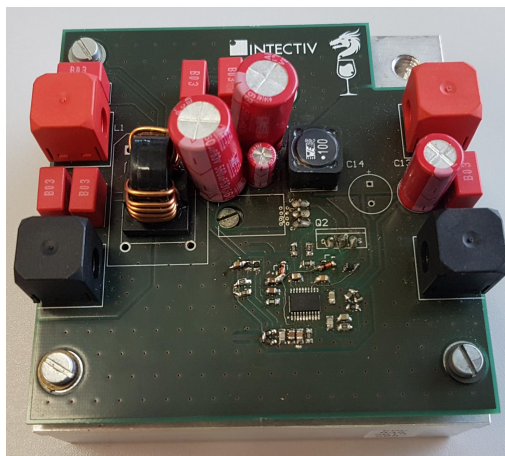
Zaključek



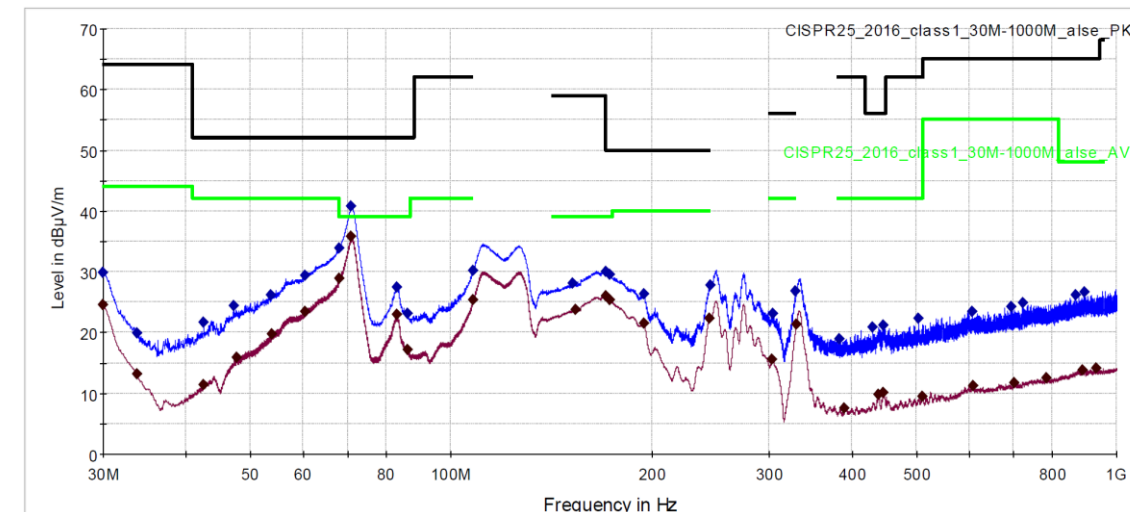
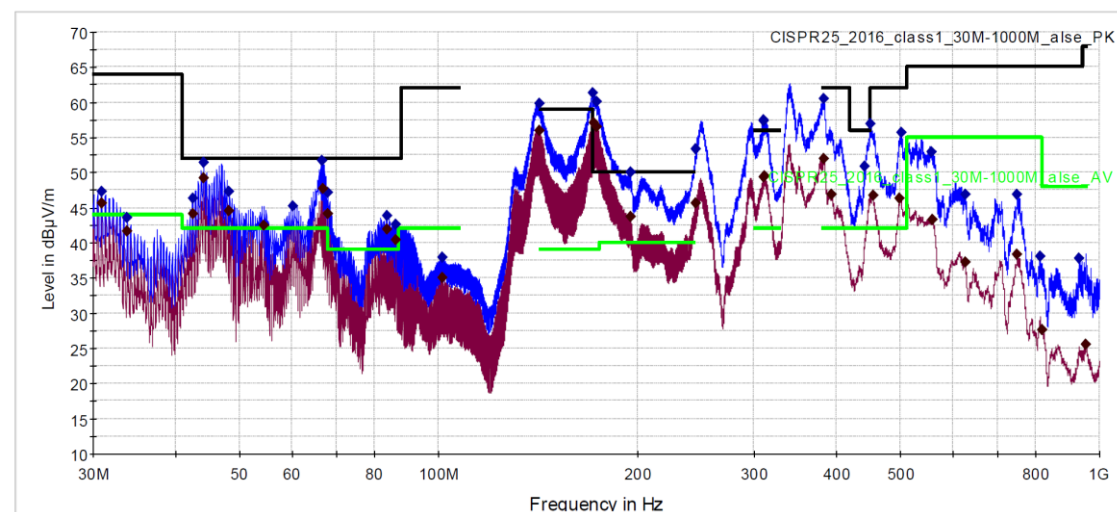
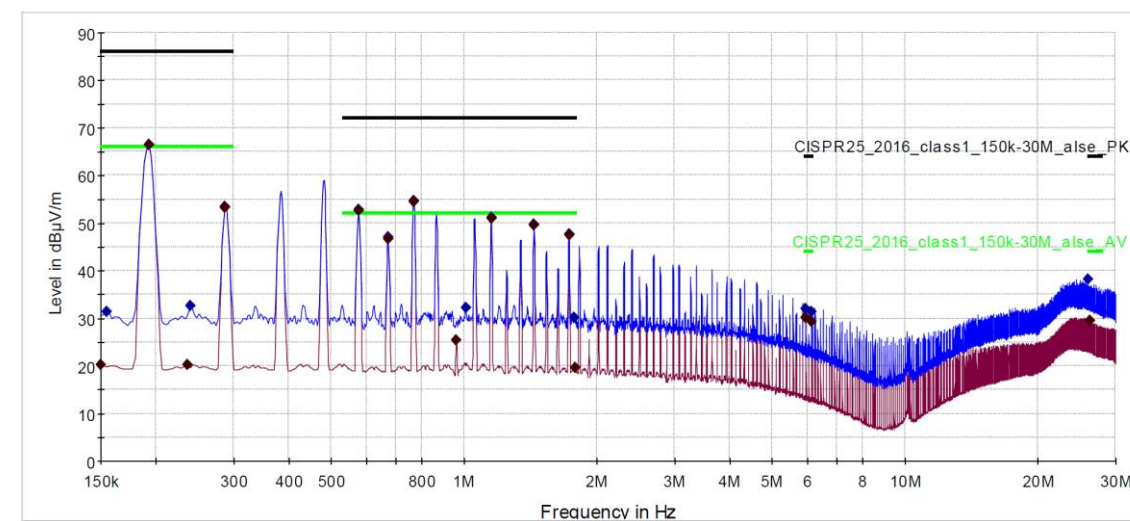
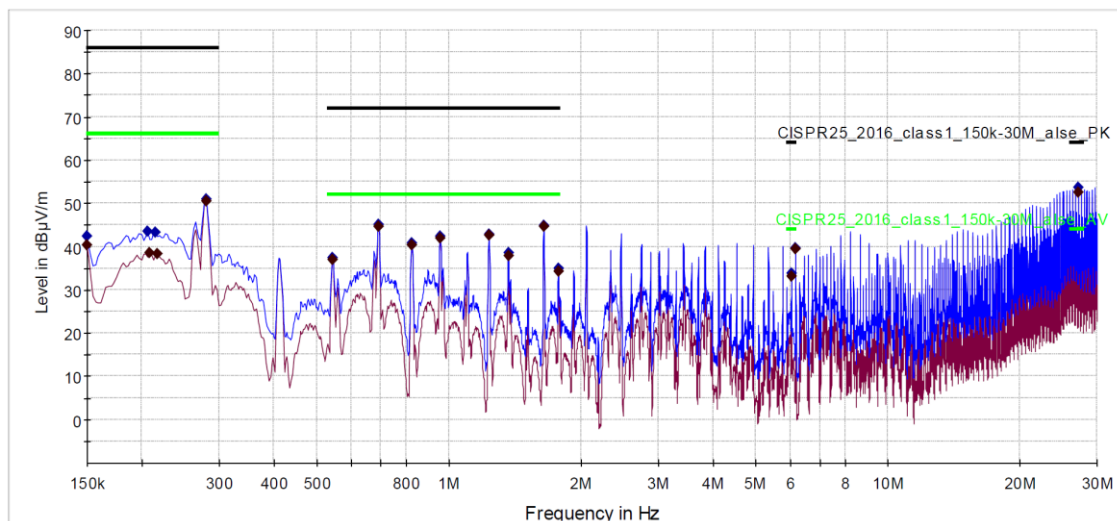
Rezultati



Rezultati



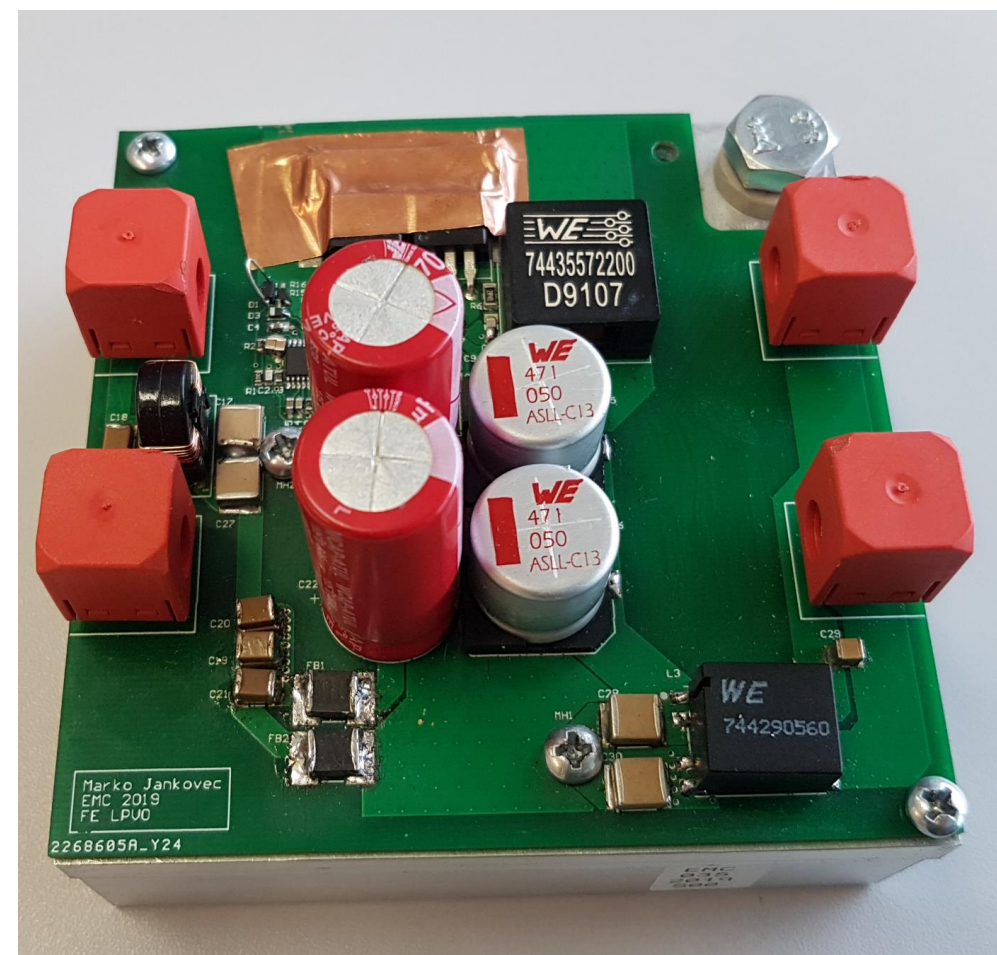
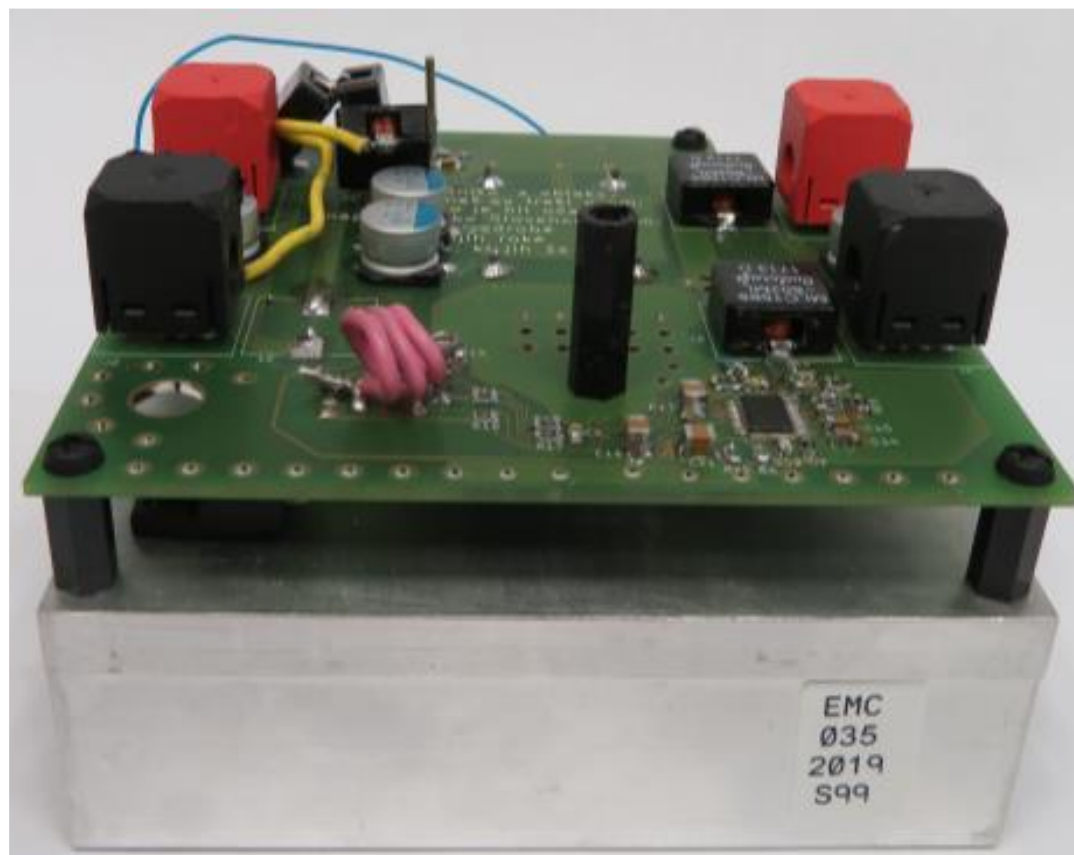
Rezultati



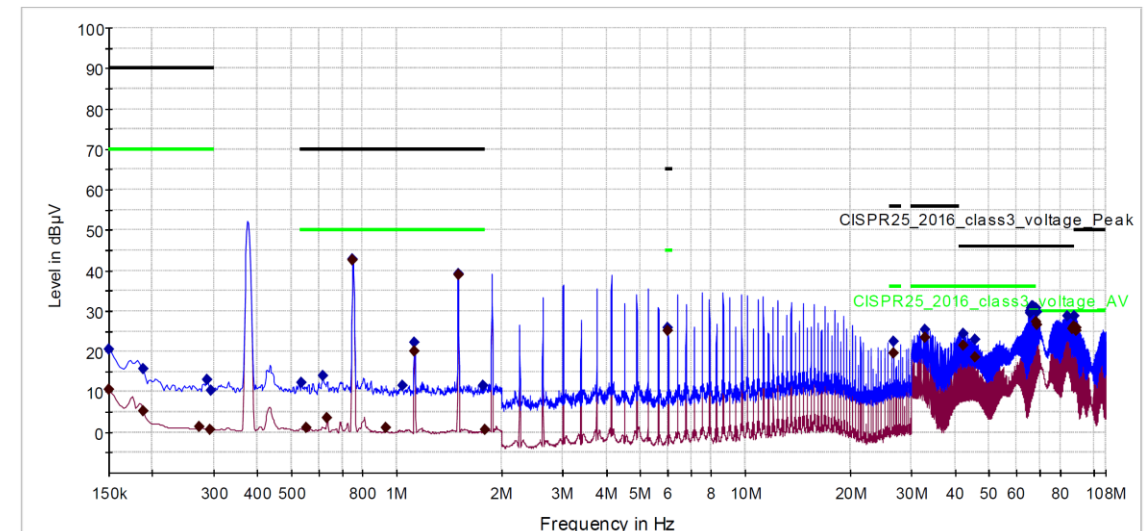
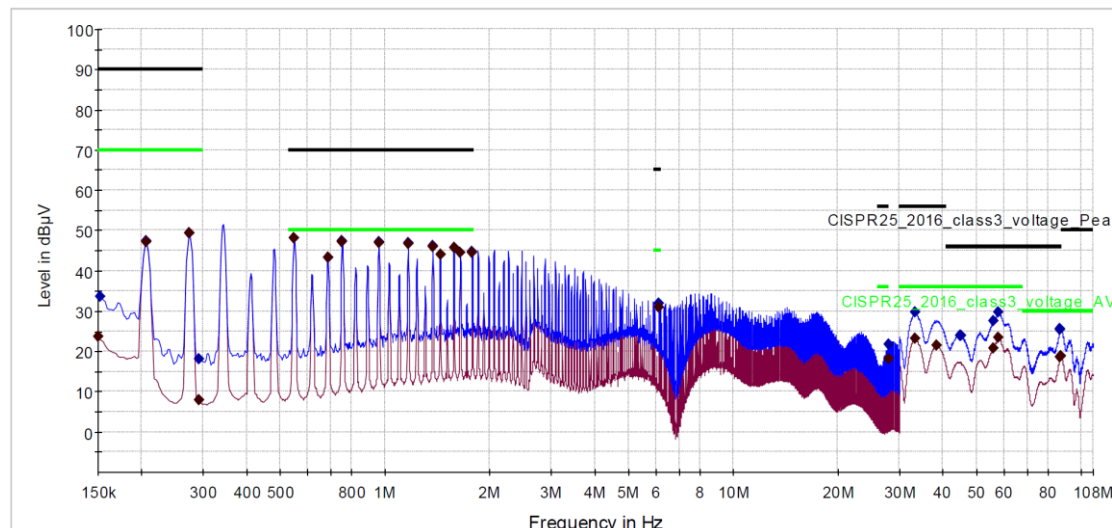
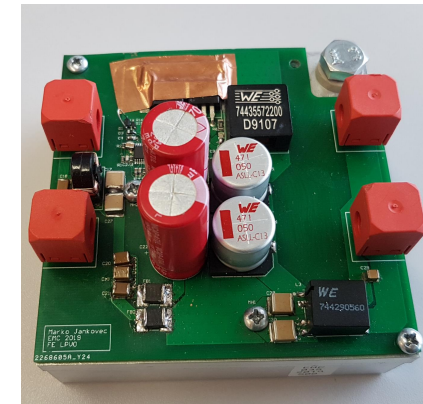
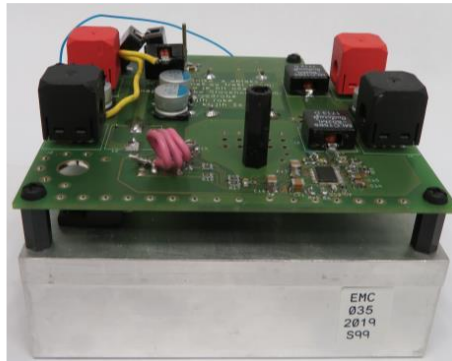
Rezultati

Funkcionalnost				Valovitost / mV		Emisije				Točke						Rezultat	
Meh.	Del.	Cena	Izk.	Osn.	Cel.	CE	class	RE	class	Zam.	Fun.	Cena	Izk.	CE	RE	Vsota	Mesto
NE	DA	20.85 €	93%	24.7	102	0.79	1	-2.54	0		8	19.53	19.6	0.66	-2.54	45.25	1
DA	DA	30.61 €	92%	15.3	443	2.62	1	-5.81	0	-10	10	0	21.4	2.18	-5.81	17.77	2
DA	DA	28.25 €	90%	24.2	232	-10.3	0	-12.1	0		10	4.72	13.4	-10.3	-12.1	5.66	3
NE	DA	11.71 €	88%	53.5	1290	-33.6	0	-30.7	0		6	37.81	18.2	-33.6	-30.7	-2.274	4
DA	DA	13.59 €	95%	25.3	1050	-35.3	0	-32.3	0		8	34.04	14.2	-35.3	-32.3	-11.41	5
DA	DA	23.17 €	96%	110	1118	-29.5	0	-18.1	0		6	14.89	14.5	-29.5	-18.1	-12.26	6
DA	NE	21.74 €															DNF
DA	NE	24.13 €															DNF
DA	DA	25.31 €	91%							-10							DNF

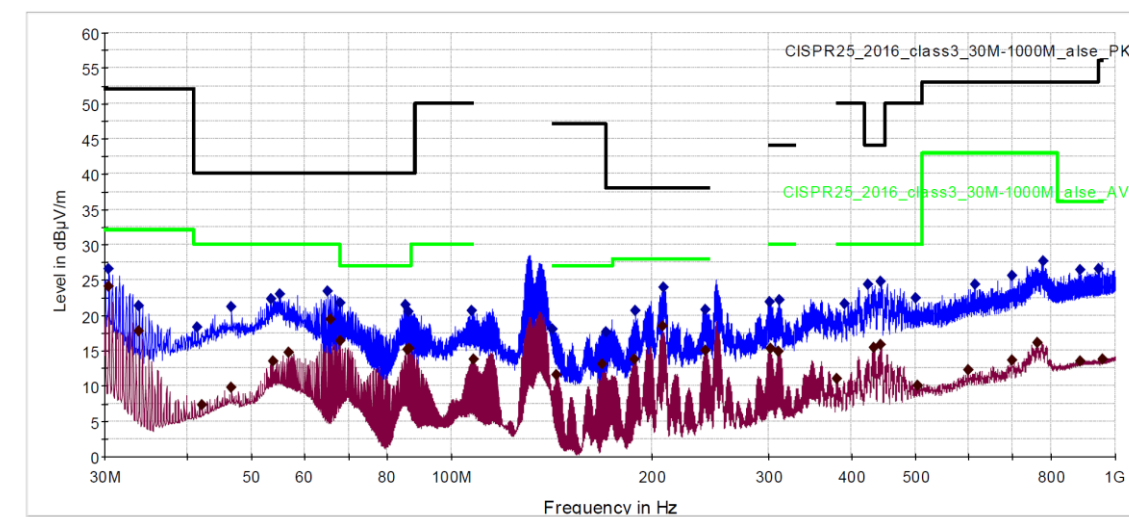
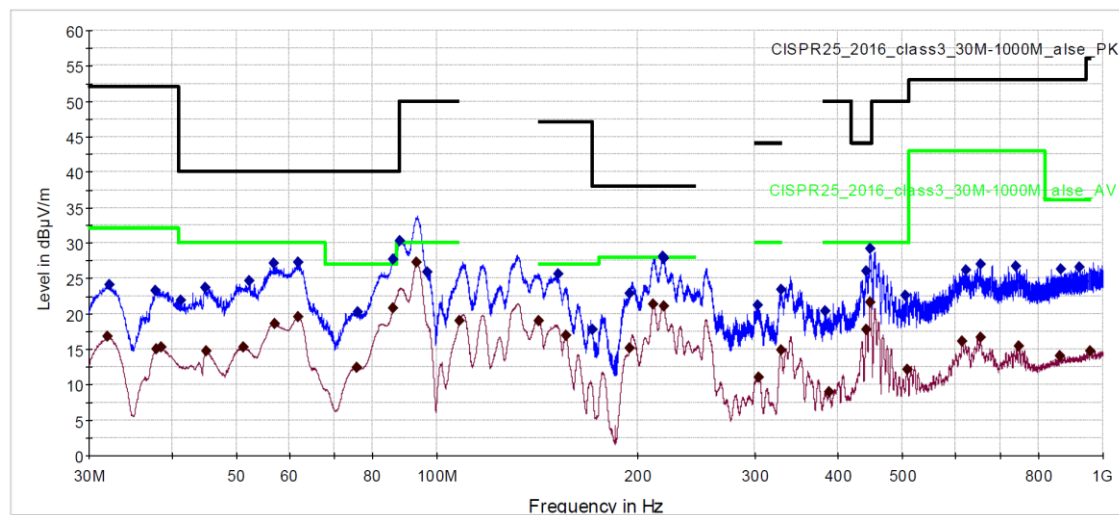
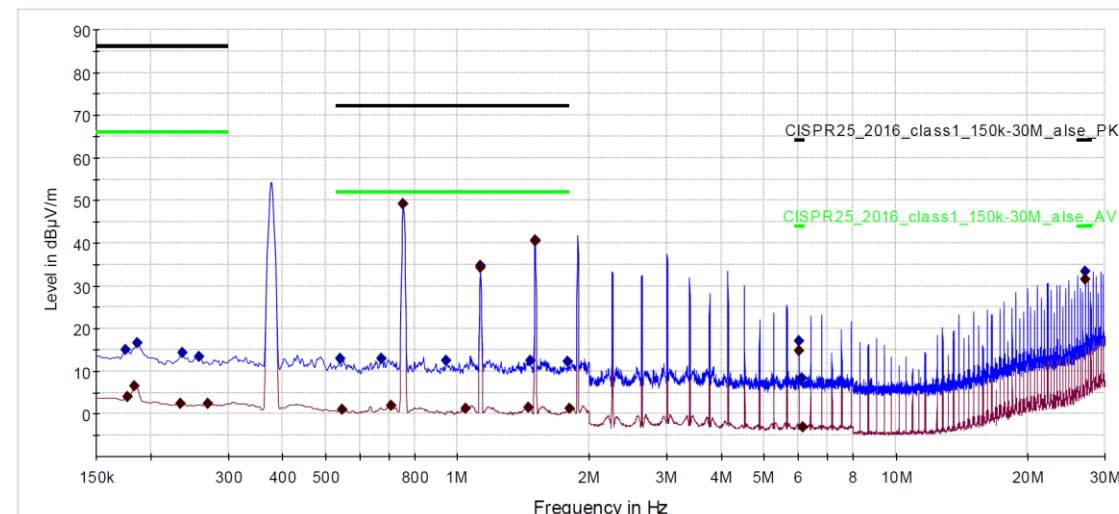
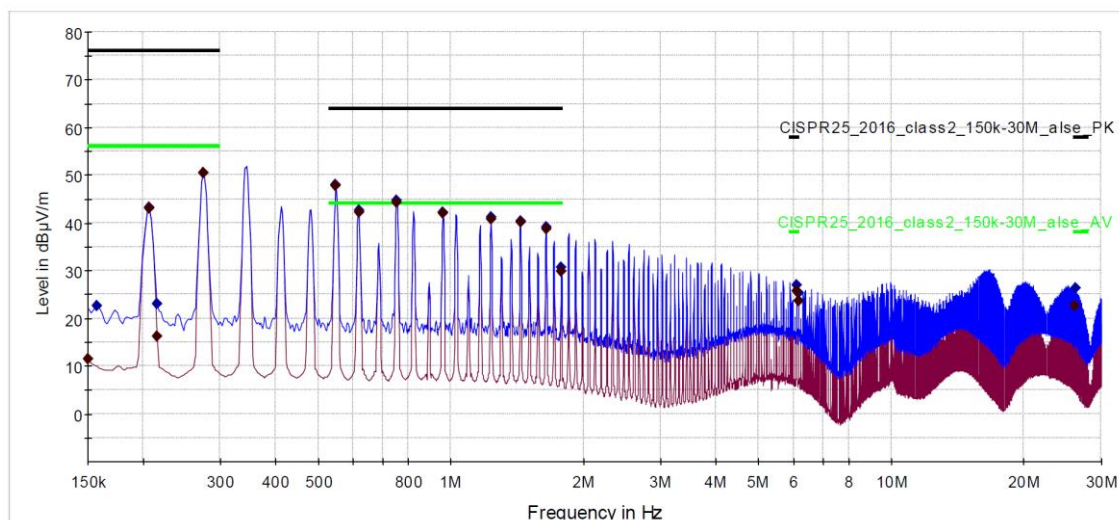
Kaj pa MAHLE in FE?



Kaj pa MAHLE in FE?



Kaj pa MAHLE in FE?

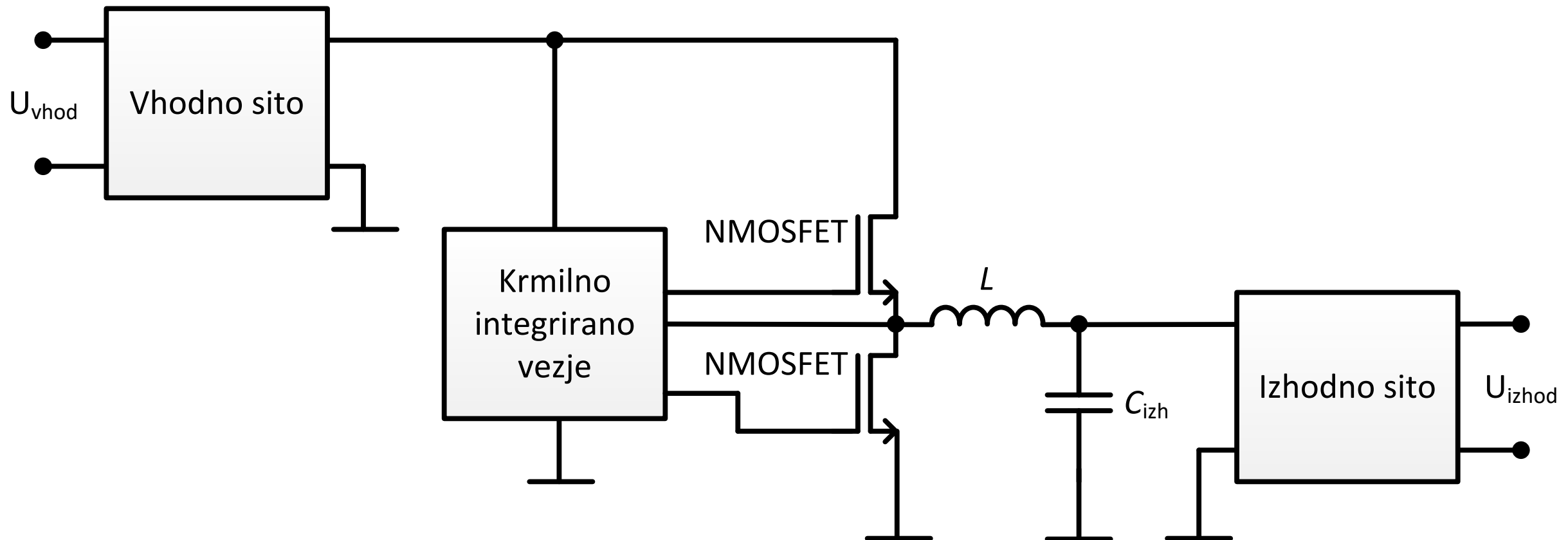


Namesto zaključka



<http://lpvo.fe.uni-lj.si/izobrazevanje/seminarji/>

Izziv: DC/DC stikalni napajalnik za LED žaromet



S čim?

- TI: Donira integrirana vezja
- HELLA: Pripravi ohišja in testna bremena
- Würth elektronik: Donira vso magnetiko in kondenzatorje
- Ostale elemente kupite s Farnella (IC elektronika?)
- FE, LPVO:
 - pomoč pri fizični izdelavi prototipa TIV
 - pomoč pri meritvah (napajalniki, multimetri, osciloskopi, spektralni analizator, EMC sonde)
- Amiteh: Preliminarna EMC meritev z Detectusom
- SIQ: končne meritve

Vzpodbuda

- HELLA Saturnus Slovenija
 - 1000 €
- MAHLE Electric Drives Slovenia
 - 700 EUR
- KOLEKTOR
 - 600 EUR
- Metrel
 - Multimetri?
- Intectiv
 - Izdelava TIV za delavnico
- Wurth elektronik
 - Elektromaterial za delavnico
 - Doživljenjski free-refill design kiti?
- Amiteh
 - Meritve z EMC skenerjem
 - Multimeter?
- SIQ
 - Meritve
 - Multimeter?
- TI
 - Integrirana vezja
 - Sponzorske gadžete?

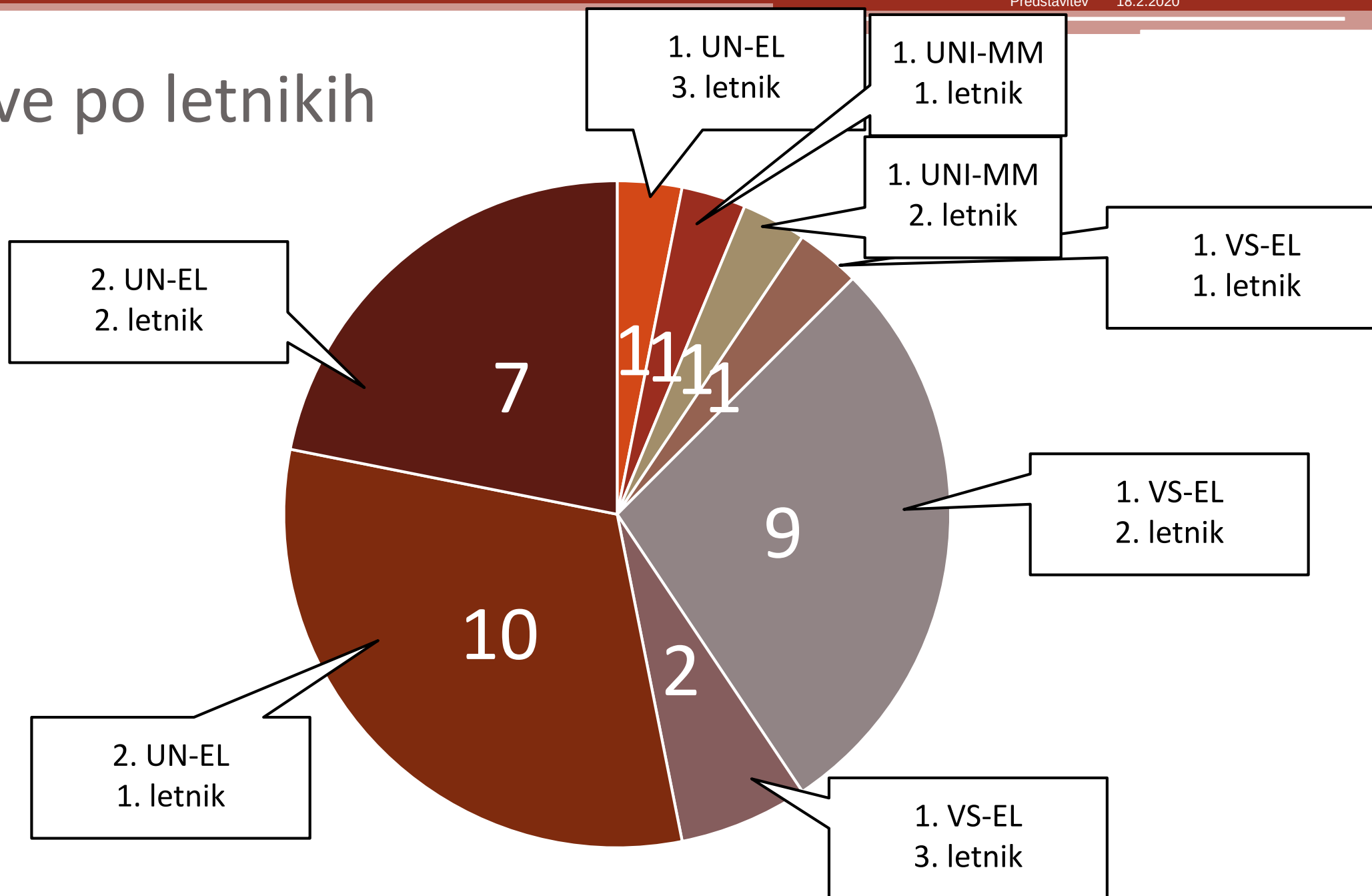
Za koga?

- Za vse, ki si želijo poglobiti znanje iz področja
 - standardov za elektronske izdelke
 - izbire in izračun vrednosti komponent
 - simulacij elektronskih vezij
 - branja in interpretacije podatkovnih listov
 - pravilnega načrtovanja tiskanega vezja
 - EMC preliminarne in končne meritve
- Utrditev in praktična nadgraditev vsebine KEN
- Povezave s perspektivnimi podjetji, ki zaposlujejo

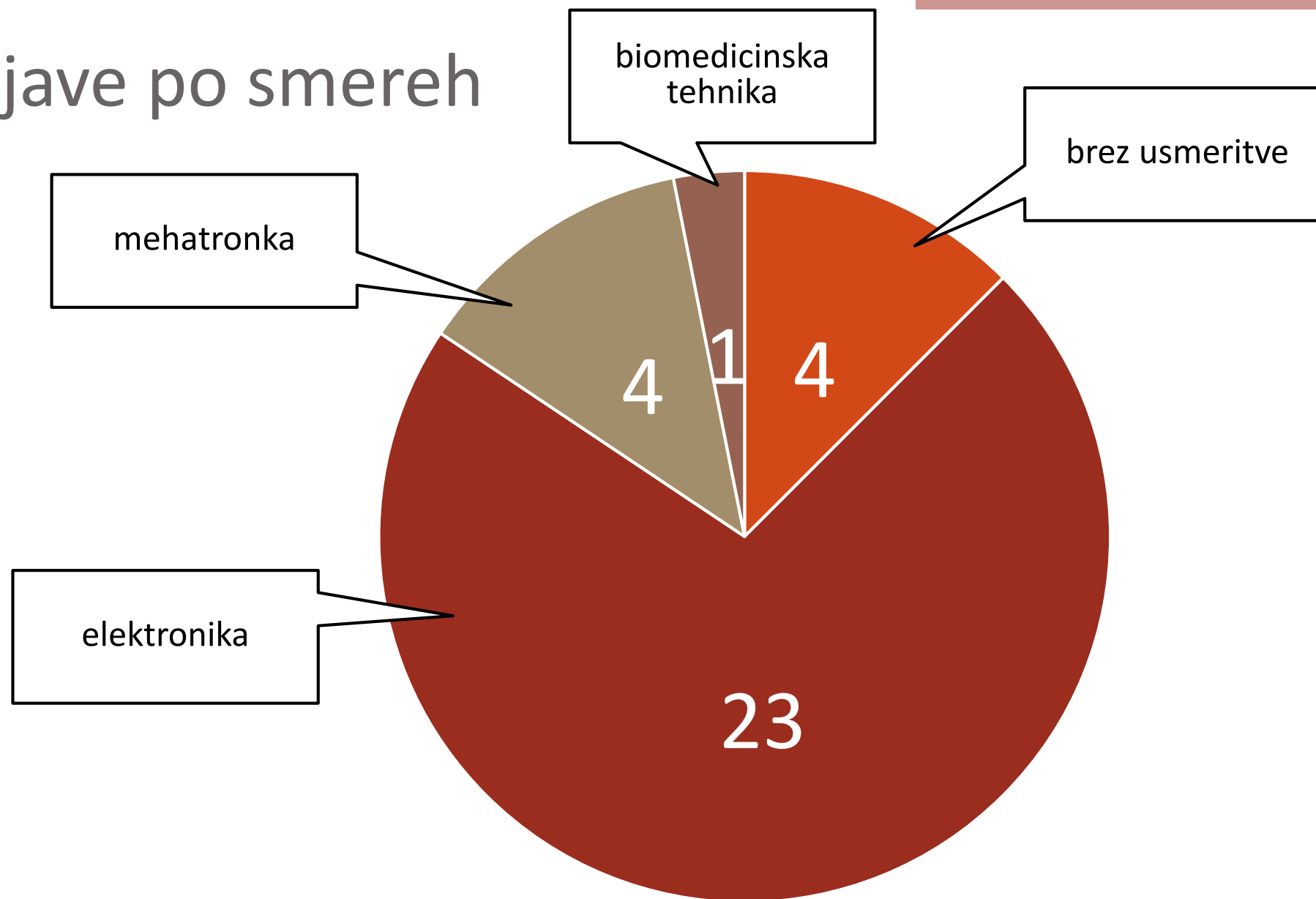
Kako?

Termin	Vsebina	Predavatelj
torek 18.2.	Predstavitev EMC delavnice	Marko Jankovec (LPVO, FE)
ponedeljek 24.2.	Sinhroni stikalni napajalniki	Peter Kržič (HELLA)
torek 3.3.	Praktična delavnica načrtovanja EMI filtrov	Marko Jankovec in Gregor Ergaver (MAHLE)
torek 10.3 (LAE)	Praktična delavnica načrtovanja EMI filtrov	Tomo Kozeljnik in Sašo Božjak (Wurth elektronik)
torek 17.3. (LAE)	Altium delavnica (SCH)	Jankovec/Tome
torek 31.3. (LAE)	Altium delavnica (PCB)	Jankovec/Tome
ponedeljek, 6.4.	<i>Naročilo materiala Würth elektronik in tiskanih vezij</i>	
torek 7.4.	Merilna oprema za EMC	Mirko Ivančič (Amiteh)
ponedeljek, 18.5.	<i>Oddaja izdelanih končanih projektov.</i>	
sreda 20.5.	Ekskurzija v SIQ	
??	Ekskurzija v HELLA	
ponedeljek, 2.6.	<i>Razglasitev rezultatov</i>	

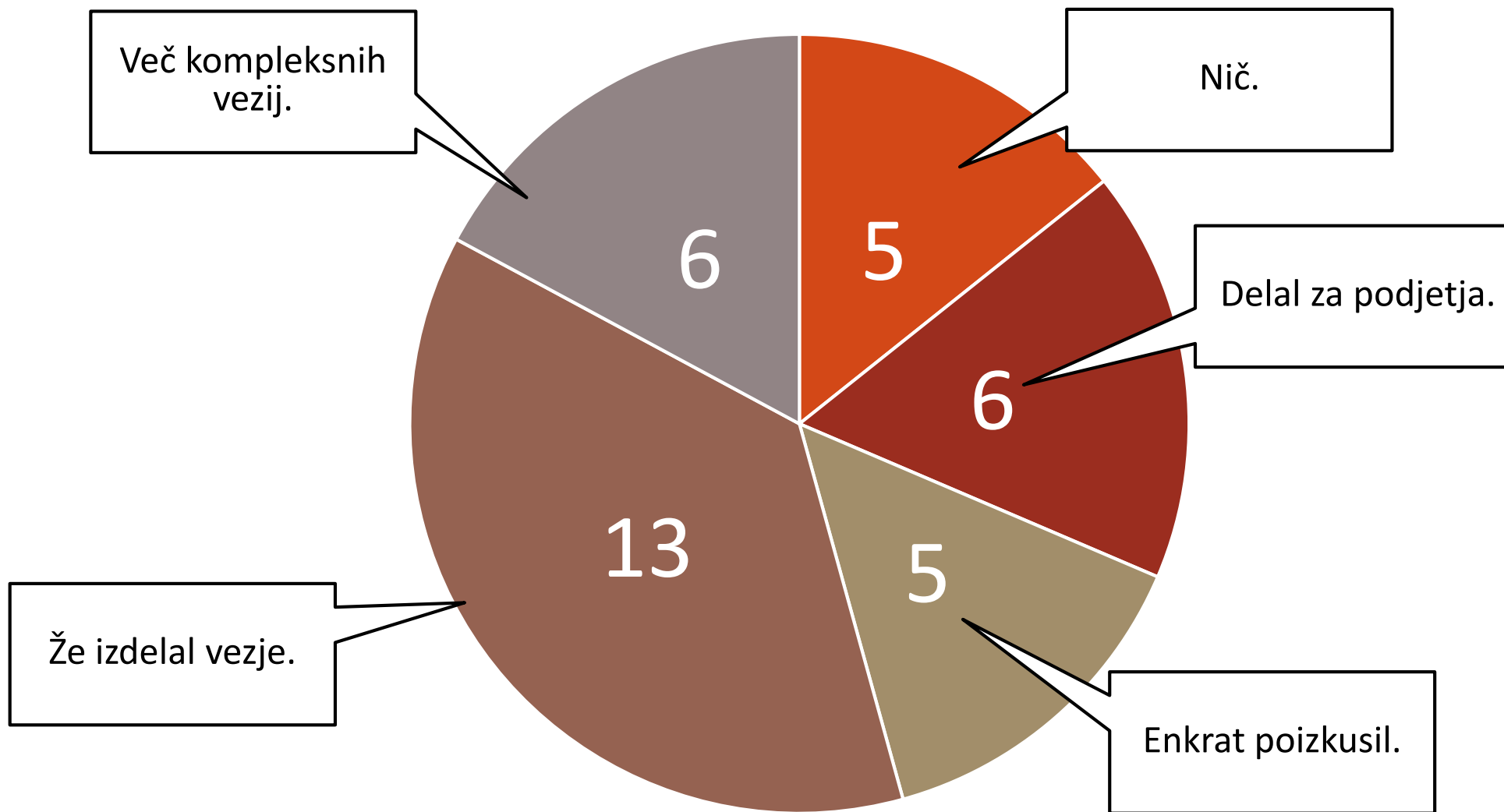
Prijave po letnikih



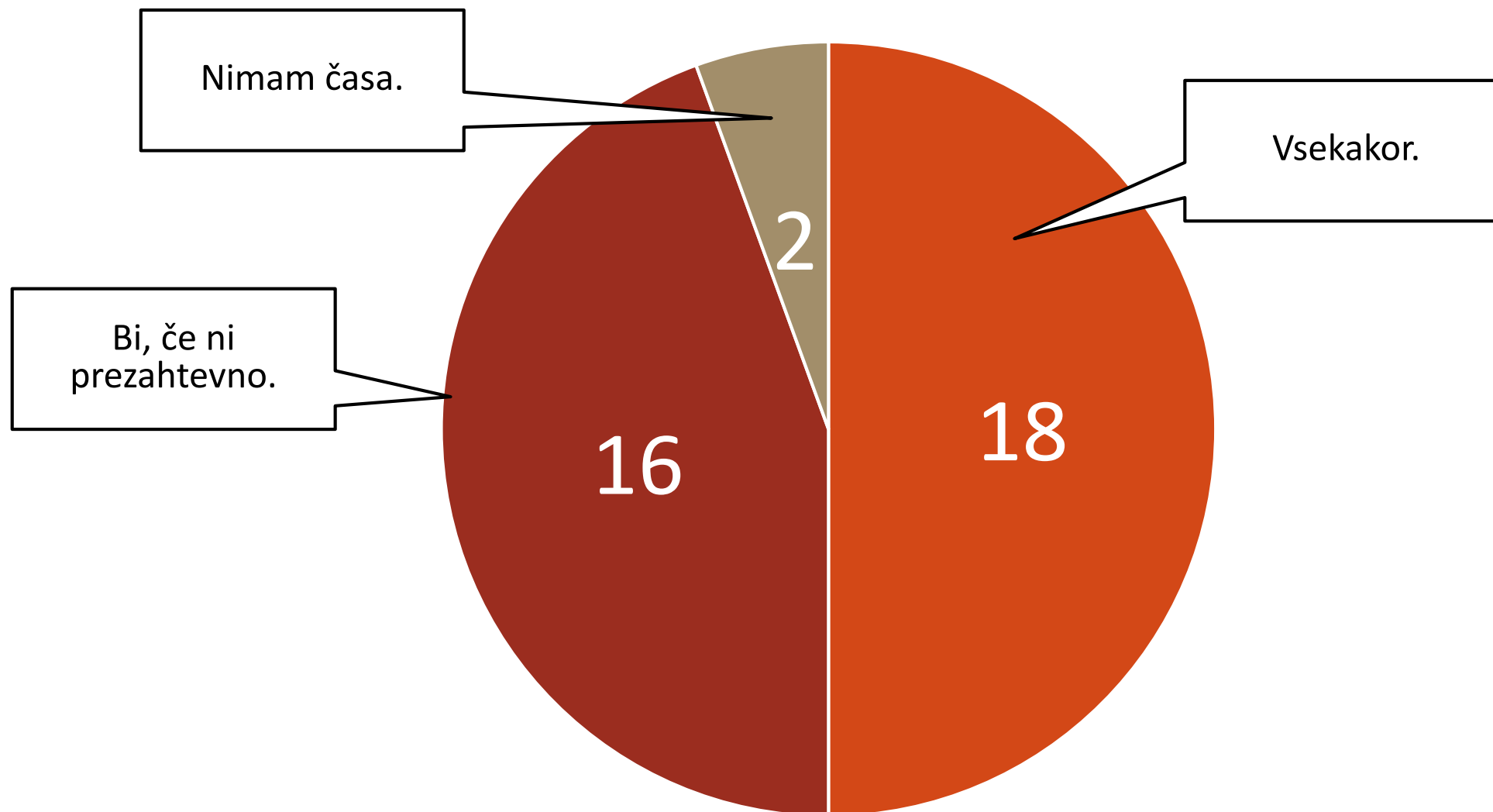
Prijave po smereh



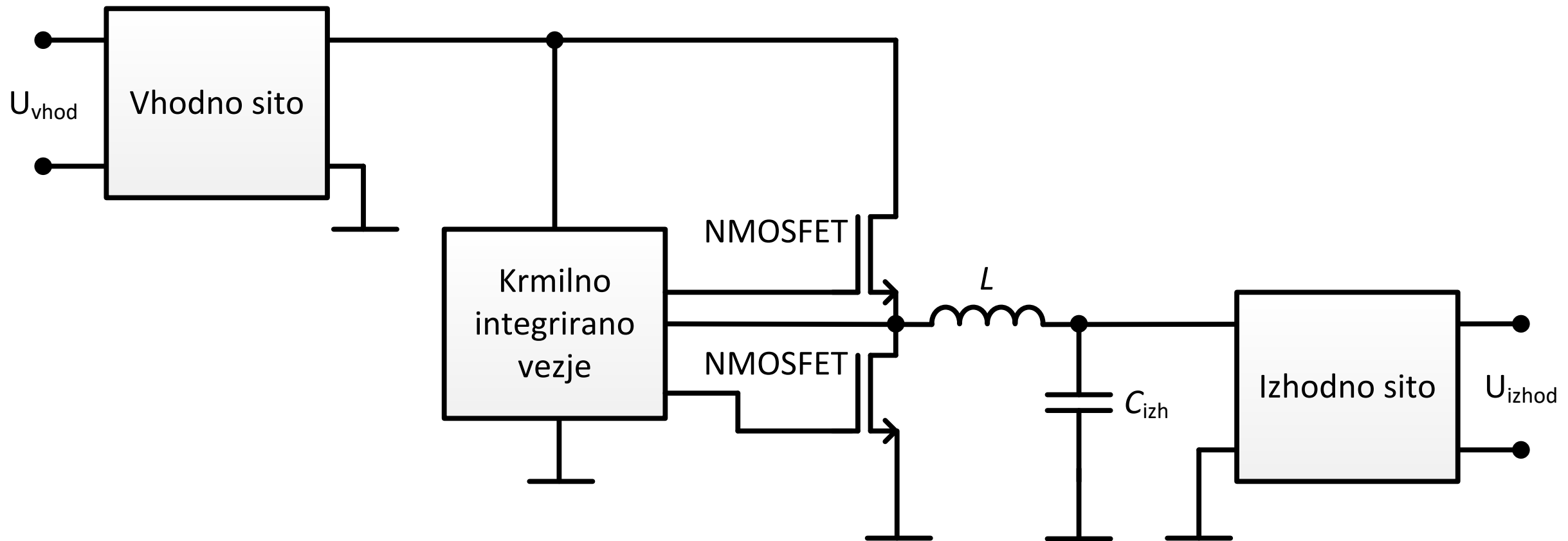
Pretekle izkušnje z načrtovanjem TIV



Sodelovanje pri tekmovanju



Izziv: DC/DC stikalni napajalnik za LED žaromet



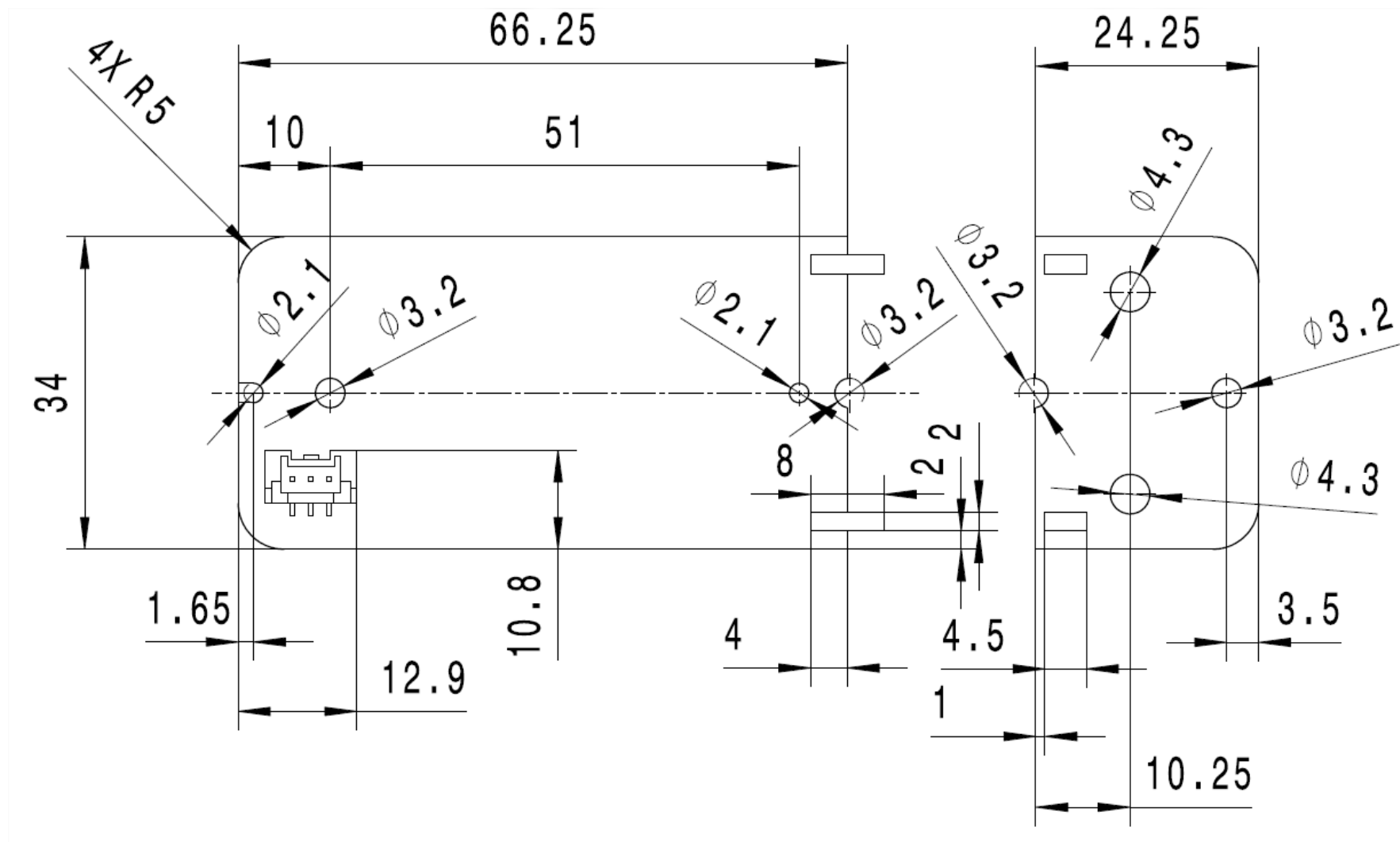
Izziv: DC/DC stikalni napajalnik navzdol

Lastnost	Vrednost	Opomba
Topologija	DC/DC pretvornik navzdol	Integrirano vezje TPS92641
Območje vhodne napetosti delovanja	[6 – 18] V	V tem napetostnem področju je izhodni tok lahko < 6A, vendar ne nižji od 50% nominalnega.
Območje vhodne napetosti za polno delovanje	[8 – 18] V	V tem področju mora pretvornik zagotavljati nazivni izhodni tok
Nazivni izhodni tok	6 A $\pm$ 10%	Pretvornik mora v predpisanem območju delovati v neprekinjenem režimu.
Območje izhodne napetosti	[3 – 4] V	1x LED Osram oslon boost
Vršna vrednost valovitosti izhodne napetosti	0,2 V	Pri osnovni frekvenci
Vršna vrednost valovitosti izhodnega toka	0,2 A	Vse skupaj
Izhodno breme	1 x LED OSOLON [®] Boost HL	Bremena bo zagotovilo podjetje Hella Saturnus.

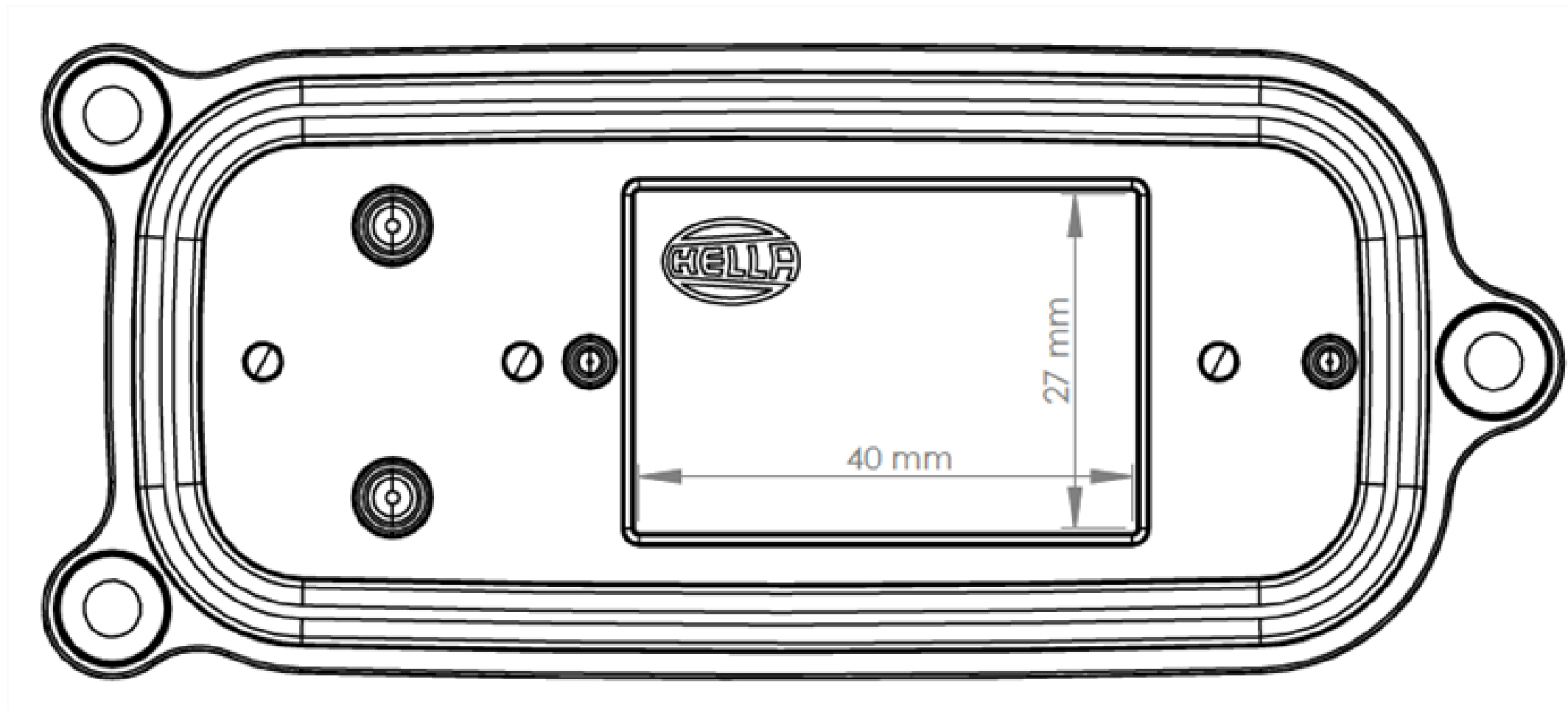
Izziv: DC/DC stikalni napajalnik navzdol

Lastnost	Vrednost	Opomba
Izkoristek pretvornika	>85%	Merjen pri temperaturi okolice 25 °C, vhodni napetosti 13,5 V in izhodnem toku 6 A.
Dolgotrajno delovanje	Pri sobni temperaturi ($T_{amb} = 25\text{ °C}$), temperatura nikjer na vezju ne sme preseči 125 °C	Nobena komponenta ne sme biti preobremenjena pri temperaturi okolice 25 °C. Lega vezja je vodoravna, položena na mizo s hladilnim telesom navzdol. Temperatura se izmeri po 30 minutah delovanja vezja.
Zaščita obrnjene polaritete	-20 V	Vhodna zaščita proti napačni priključitvi napajalnih sponk
Podnapetostna zaščita	$U_{supp} < 6\text{ V}$	Izklop pretvornika, ko je vhodna napetost manjša od 6V
Kratko-stična zaščita	$U_{iz} < 2\text{ V}$	Zaščita proti kratkemu stiku na izhodnih sponkah bremena . Zahtevan izklop stikalnega dela.
Odprte sponke na bremenu	$U_{iz} > 6\text{ V}$	Zaščita v primeru odprtih sponk na bremenu. Zahtevan izklop stikalnega dela.

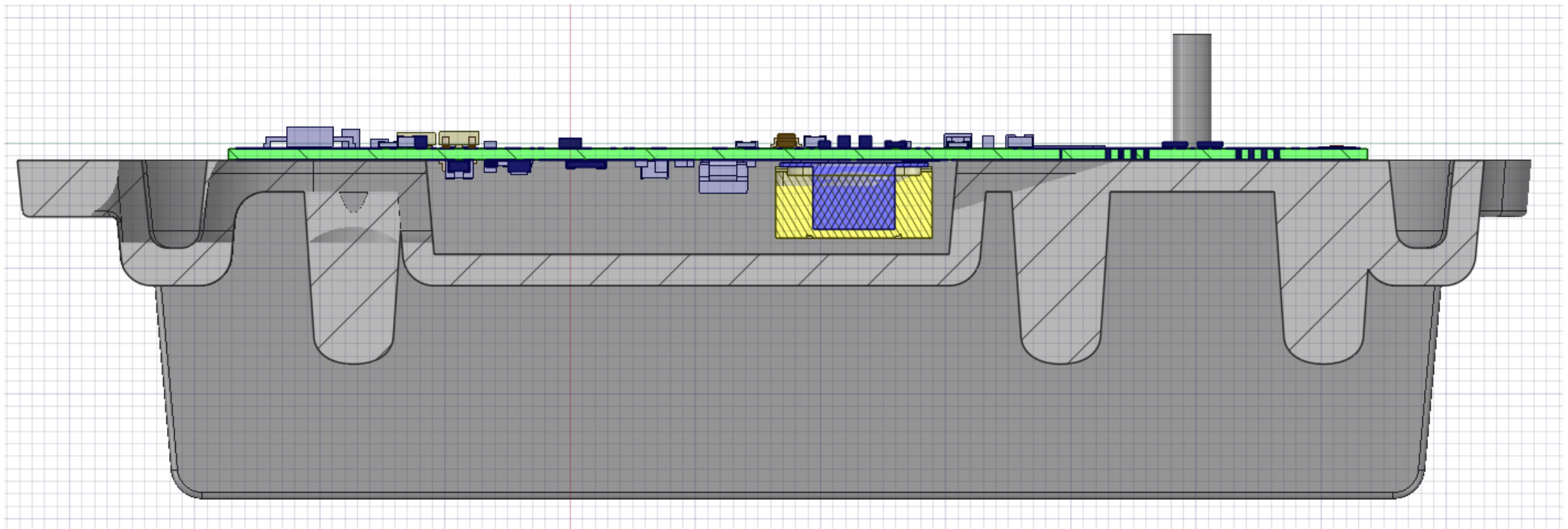
Mehanske zahteve



Mehanske zahteve



Mehanske zahteve



Točkovanje

- Načrtovalske zahteve
 - Za vsako doseženo alinejo 5 točk (do 50 točk)
 - Izkoristek: za vsak % nad 85% se dobi 5 točk
- EMC
 - Prevodne emisije do 2x35 točk
 - Sevalne emisije do 2x35 točk
 - Imunost na vsiljene tokove do 30 točk
- Cena (L, Q, C)
 - Iskalnik octopart iz redne ponudbe za 1000 izdelkov
 - Za vsak € se odbije 5 točk.

Do naslednjič si pogledjte

Elektromagnetna združljivost 1 (pdf , video)	Jankovec (LPVO, FE)
Elektromagnetna združljivost 2 (pdf , video)	Jankovec (LPVO, FE)
Teorija stikalnih napajalnikov (pdf , video)	Glažar (LPVO, FE)
EMC Focused Power Supply Design Practices (prezi , video)	Szoke (TI)
Preklopi pri močnostnih pretvornikih (pdf , video1 , video2)	Sorta (MAHLE)