Univerza v Ljubljani
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Biološko aktivna svetilka s štirimi svetlečimi diodami

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Motivation

Human Centric Lighting
HCL focuses on the visual and non-visual effects of the lighting. People need light to perform visual tasks and as "time-reference" for our internal clock.

Non-visual efects of light
The circadian path where photoreceptors in the retina, called ganglion cells, are affected by the amount of blue light. These cells set the biological clock that synchronizes our bodies with the external cycle of day and night. A major output of the biological clock system is the production of the hormone melatonin – a "sleep hormone". This production in the pineal gland varies with the time of day. Melatonin is secreted at night and has minimal levels during daytime.

And what kind of bodily discomfort can wrong lighting lead to?
Discomfort glare and a low lighting level may cause headaches, neck or back pains, general fatigue and fatigue in the eye muscles.

What are the positive non-visual effects when the lighting is correct?
Short-term bursts of cool white and intensive light may increase your concentration, without you knowing it. Or make you feel sleepier at night because you have shifted your daily rhythm a bit. Both are positive effects that you perhaps do not notice immediately, or at all.

Is HCL a new invention?
No, we have researched the effect of light on people for decades, if not centuries. What is new is that we have a new, cost-efficient and flexible light source – LEDs – that makes implementing Human Centric Lighting solutions easier and better. Still we need to do more research to learn about the optimal use of HCL.

So, who can benefit from HCL?
Everyone that spends the whole day, or parts of it, indoors. School children, office workers, elderly with dementia, shift workers etc.

Zakaj sploh?


https://store.yujiintl.com/collections/human-centric-lighting


https://northcliffe.org/en/p/39-human-centric-lighting

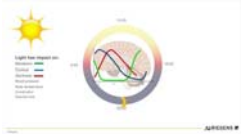
https://schmitz-wila.com/en/

Ideja:
Human centric lighting
Integrated lighting
Biodynamic lighting
Biološko aktivna razsvetljava
Dobro počutje
Vidno udobje

Zakaj sploh?

https://www.ledsmagazine.com/

https://www.architectureanddesign.com.au/sustainability-awards/lighting-the-way-human-centric-lighting-and-its-co



www.riegens.com

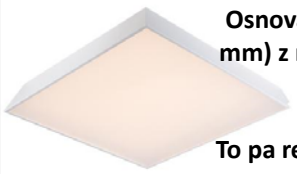
Ideja:
Human centric lighting
Integrated lighting
Biodynamic lighting
Biološko aktivna razsvetljava
Dobro počutje
Vidno udobje

Cilj naše študije

1.
Načrtovanje in izdelava svetilke *„nastavljivo belo svetlobo“ od 2700 do 8000 K pri CRI >90 (95)*
2.
Najti je potrebno tri svetleče diode z ustreznim spektrom
3.
Najti je potrebno ustrezno predstikalno napravo

Pa začnimo…

Tri svetleče diode
topla bela LED
hladna bela LED
modra (monokromatska) LED
Svetilka - ohišje
Osnova je Ledluks Arun (600x600 mm) z mikro-prizmatično optiko z nizkim UGR (<19)
Predstikalna naprava
To pa res ne bi smel biti problem;)



Analiza trga

Predstikalna naprava (PSN)
Ne bi smelo biti problem ;)
Tržišče pove:
Ni ustrezne PSN s tremi kanali
Izbrali smo 4 kanalno DALI/DMX PSN:
EldoLED POWERdrive 106M z:
4 x 1050 mA
Cena: 158 EUR

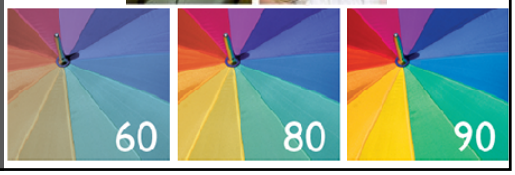
Pa začnimo… 2.0

L1
~~*Tri LED*~~ *Štiri LED*
Topla bela LED
Nevtralna bela LED
Hladna bela LED
Modra (monokromatska) LED

L2
~~*Tri LED*~~ *Štiri LED*
Topla bela LED
Nevtralna bela LED
Hladna bela LED
Kraljevsko modra (monokromatska) LED

Faktor barvne reprodukcije

CRI>90 (95)



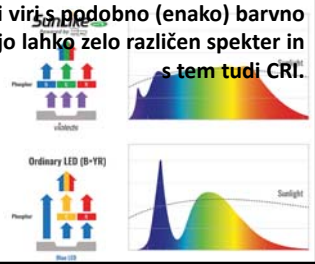
Izbor LED - CRI

- Baza spektrov približno 250 LED
- Računalniški program za izbor 3(4) LED, ki bi zagotavljali ustrezen skupen spekter

Svetlobni viri s podobno (enako) barvno temperaturo imajo lahko zelo različen spekter in s tem tudi CRI.

Dnevna svetloba (severno nebo)

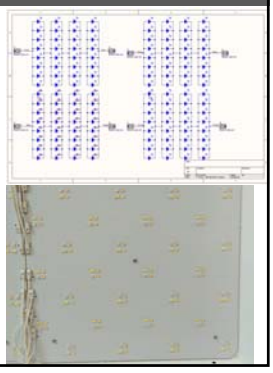
Žarnica



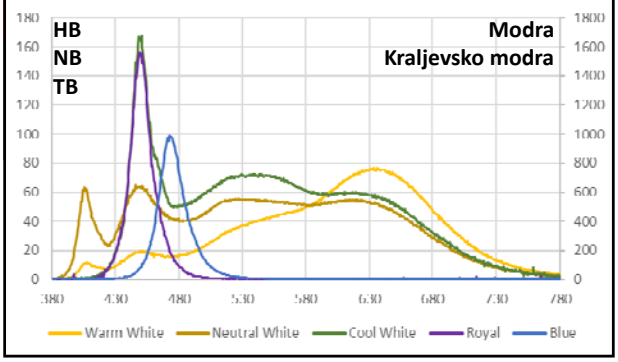
Izbrane LED

LED	Proizvajalec/ tip	CCT [K]	CRI	Sv. tok [lm]	Št. LED	Skupni sv. tok [lm]
Topla bela	SunLike Powered by		>95	85	32*4	10.880
Nevtralna bela			>95	100	32*4	12.800
Hladna bela	Seoul 5630 STW9Q14D	6500	>90	25	32*4	3.200
Modra	Cree 3535 LEDMLEBLU-A1-0000-000U01	vrh pri 472 nm		15	32*4	1.920
Kraljevsko modra	Cree 3535 LEDMLEROY-A1-0000-000501	vrh pri 450 nm		80 mW	32*4	10.240 mW

Tiskano vezje



Spekter izbranih LED



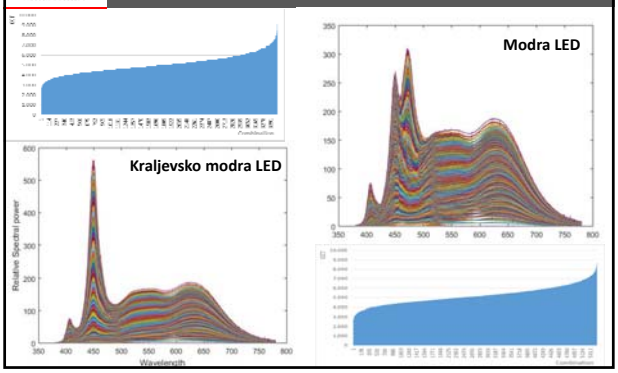
Matematika

$c_{A1} * SPD_A + c_{B1} * SPD_B + c_{C1} * SPD_C + c_{D1} * SPD_D \rightarrow CCT_1@E_1$
$c_{A2} * SPD_A + c_{B2} * SPD_B + c_{C2} * SPD_C + c_{D2} * SPD_D \rightarrow CCT_2@E_2$
$c_{A3} * SPD_A + c_{B3} * SPD_B + c_{C3} * SPD_C + c_{D3} * SPD_D \rightarrow CCT_3@E_3$
....
....
$c_{An} * SPD_A + c_{Bn} * SPD_B + c_{Cn} * SPD_C + c_{Dn} * SPD_D \rightarrow CCT_n@E_n$

kjer:

CCT	**podobna barvna temperatura**
E	**osvetljenost**
c	**tok skozi LED**
SPD	**spekter**

Matematika



Matematika

$c_{A1} * SPD_A + c_{B1} * SPD_B + c_{C1} * SPD_C + c_{D1} * SPD_D \rightarrow CCT_1@E_1$
$c_{A2} * SPD_A + c_{B2} * SPD_B + c_{C2} * SPD_C + c_{D2} * SPD_D \rightarrow CCT_2@E_2$
$c_{A3} * SPD_A + c_{B3} * SPD_B + c_{C3} * SPD_C + c_{D3} * SPD_D \rightarrow CCT_3@E_3$
....
....
$c_{An} * SPD_A + c_{Bn} * SPD_B + c_{Cn} * SPD_C + c_{Dn} * SPD_D \rightarrow CCT_n@E_n$

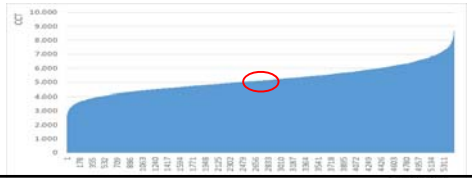
Normiranje tokov pri 1 lx (lm)

$$\boldsymbol{c_{An}/E_1 * SPD_A + c_{Bn}/E_1 * SPD_B + c_{Cn}/E_1 * SPD_C + c_{Dn}/E_1 * SPD_D \rightarrow CCT_n@1\ lx\ (lm)}$$

Matematika

$CCT_1 = c'_{A1} * SPD_A + c'_{B1} * SPD_B + c'_{C1} * SPD_C + c'_{D1} * SPD_D$
$CCT_2 = c'_{A2} * SPD_A + c'_{B2} * SPD_B + c'_{C2} * SPD_C + c'_{D2} * SPD_D$
$CCT_3 = c'_{A3} * SPD_A + c'_{B3} * SPD_B + c'_{C3} * SPD_C + c'_{D3} * SPD_D$
....
....
$CCT_n = c'_{An} * SPD_A + c'_{Bn} * SPD_B + c'_{Cn} * SPD_C + c'_{Dn} * SPD_D$

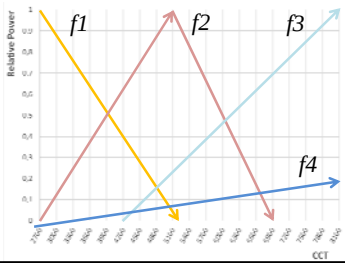
Predeterminiran sistem!



Matematika

Naša skromna želja

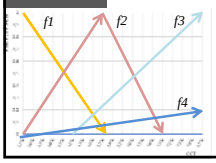
$c_A = f1(CCT)$
$c_B = f2(CCT)$
$c_C = f3(CCT)$
$c_D = f4(CCT)$

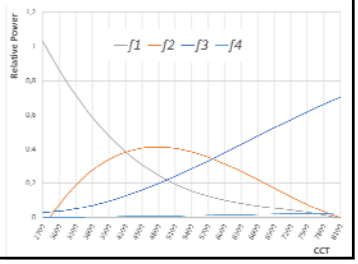


Matematika

Rezultat je polinom 3. stopnje

CA=3.87524 - 0.00157204*CCT + 2.18527*10^-7*CCT^2 - 1.02361*10^-11*CCT^3
CB=-2.82221 + 0.00165682*CCT - 2.69001*10^-7*CCT^2 + 1.33892*10^-11*CCT^3
CC=0.228825 - 0.000214869*CCT + 6.04162*10^-8*CCT^2 - 3.45306*10^-12*CCT^3
CD=0.0436958 - 0.0000299087*CCT + 6.1163*10^-9*CCT^2 - 3.25428*10^-13*CCT^3

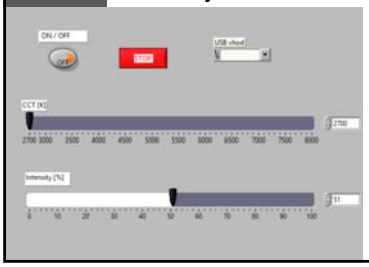


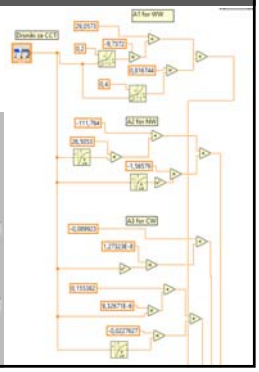


Labview

Dva drsnika:

- CCT
- osvetljenost



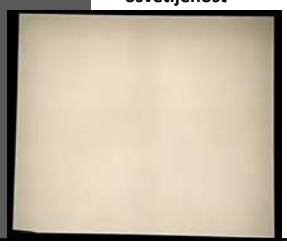


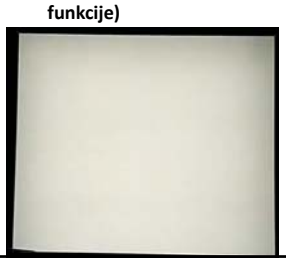
Zaključki & prihodnji koraki

CCT: 2700 – 9000 K
CRI >95
Dva drsnika:

- **CCT**
- **osvetljenost**

- **Računalnik + USB/RS485**
- **Arduino**
- **DMX krmilnik (matem. funkcije)**





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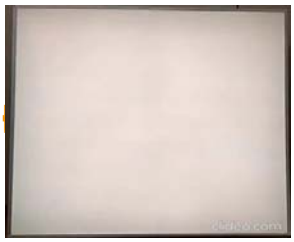
- **Računalnik + USB/RS485**
- **Arduino**

- **DMX/DALI krmilnik**



Cena: 990 EUR

In sedaj…

… kakšno

VPRAŠANJE?