ÓBUDAI EGYETEM
ÓBUDA UNIVERSITY

ÓBUDA UNIVERSITY
KANDÓ KÁLMÁN FACULTY OF ELECTRICAL ENGINEERING

Investigation of the Maximum Power Point Position on a DSSC Solar Cell based on the Incoming Ligh Irradiation and Temperature

Made by: Dr. Ervin Rácz and Zoltán Varga

Outlook

- Introduction
- Preparing the Experiment
- Experimental Arrangement
- Analysing the Results
- Summary

Introduction

INTRODUCTION

What is the difference between Silicon based Solar Cell and Dye Sensitized Solar Cell?

The significant difference is that in case of Silicon (Si) based solar cell the semiconductor layer absorbs and divides the charge carrier, while in case of the DSSC the absorption and the division are done separately.

Goal of the Experience

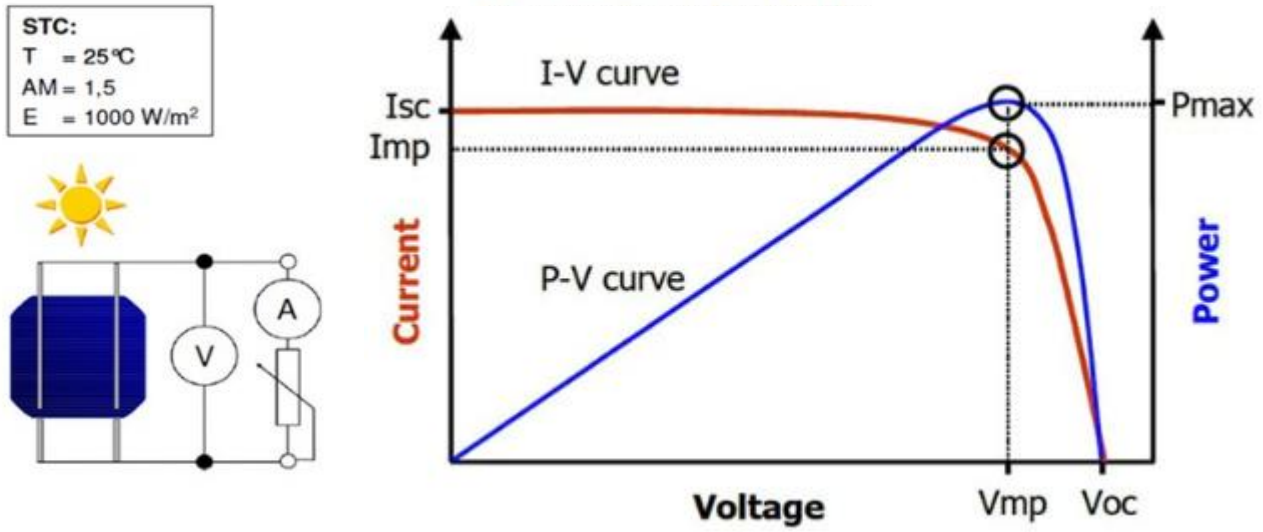
To run experiments to map the maximum power point of a Dye Sensitized Solar Cell (DSSC), not widely known in the Hungarian's energy design of buildings. The electrical response of the DSSC has been measured on the basis of incoming light irradiation and cell temperature.

Reference: top: http://www.joshuagallaway.com/?p=479
bottom: https://dyenamo.se/short_about_DSSC.php

ÓBUDAI EGYETEM
ÓBUDA UNIVERSITY

INTRODUCTION

The current-voltage and power-voltage relationships for a photovoltaic cell



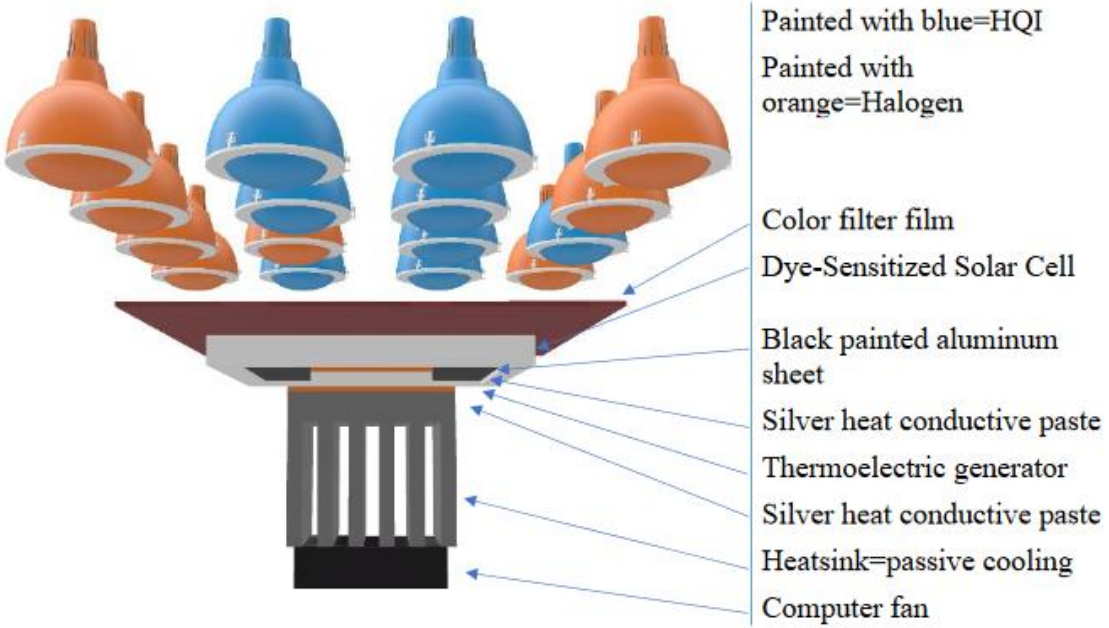
Reference: https://www.powerelectronics.com/technologies/solar/article/21863142/solar-system-efficiency-maximum-power-point-tracking-is-key

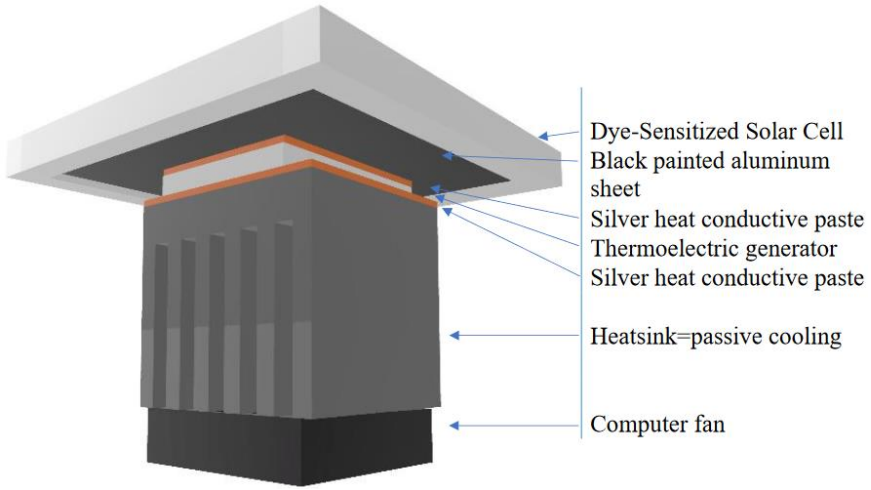
Basics and Overview

- From the user's aspect the installed system is expected to produce the maximum power possible.
- The efficiency of power transmission from the solar cell depends on the amount of irradiation, which is falling on the solar panel, the cell temperature, and the electrical current-voltage characteristics.
- If the values – the values of electrical current and values of electrical voltage – multiplied with each other, the electrical power value can be found.
- Examining the electrical power-voltage characteristics curve (left side of the slide), a maximum value of all measures electrical powers can be spotter, and it is symbolized with P_{MAX}

Preparing the Experiment

Preparing the Experiment

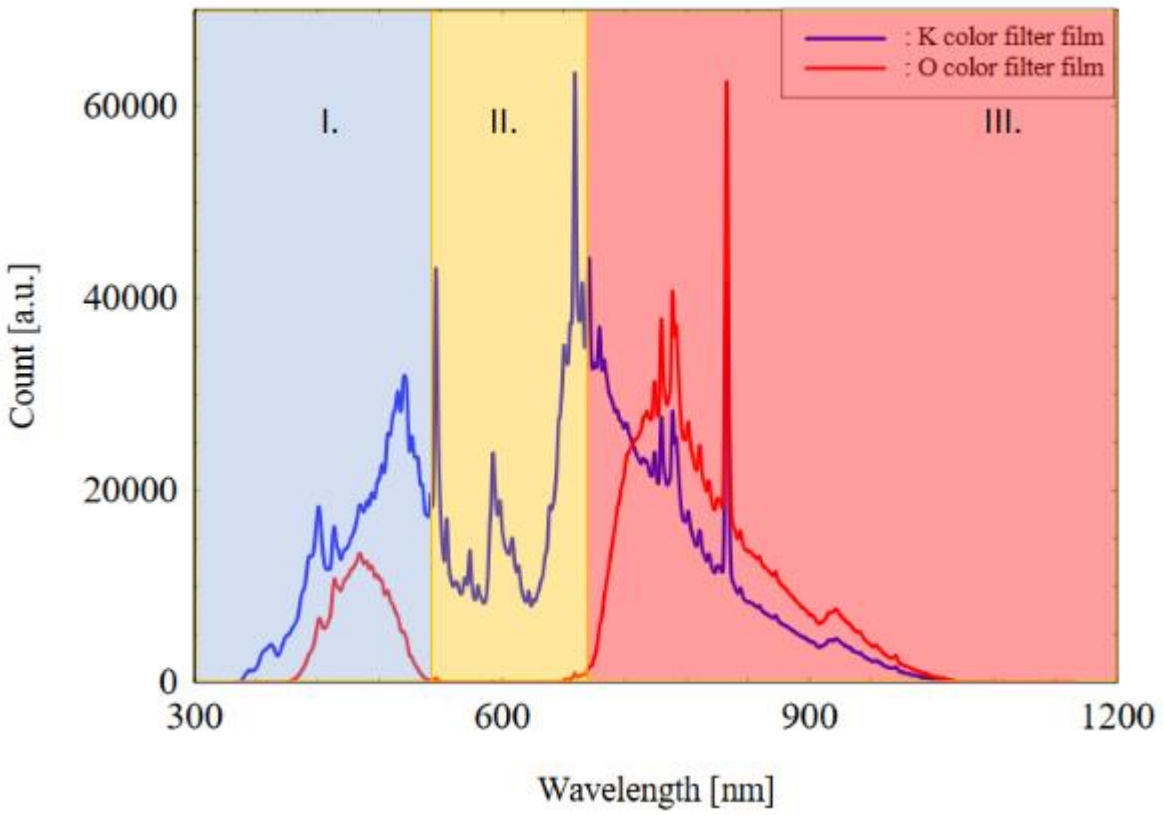




Experimental Setup

- To fulfill the goal of our experiment, the first thing was to find a suitable way to control the temperature of the DSSC. ⟹ Peltier generator was implemented.
- On the top of the surface the irradiation intensity was approximately 720 W/m^2.
- An artificial light source, sun simulator was used for during the measures which provided a stable, reproductive and controlled experiment and experimental environment.
- In the way of the incoming light, nine different shades of blue colour filter films (K-, L-, M-, N-, O-, P-, Q-, R-, S-marked colour filter films), were used.

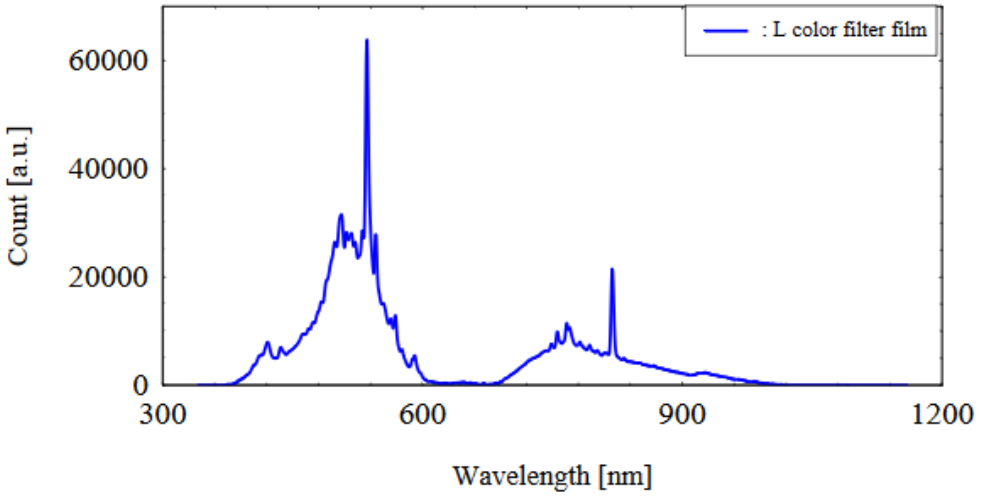
Preparing the Experiment

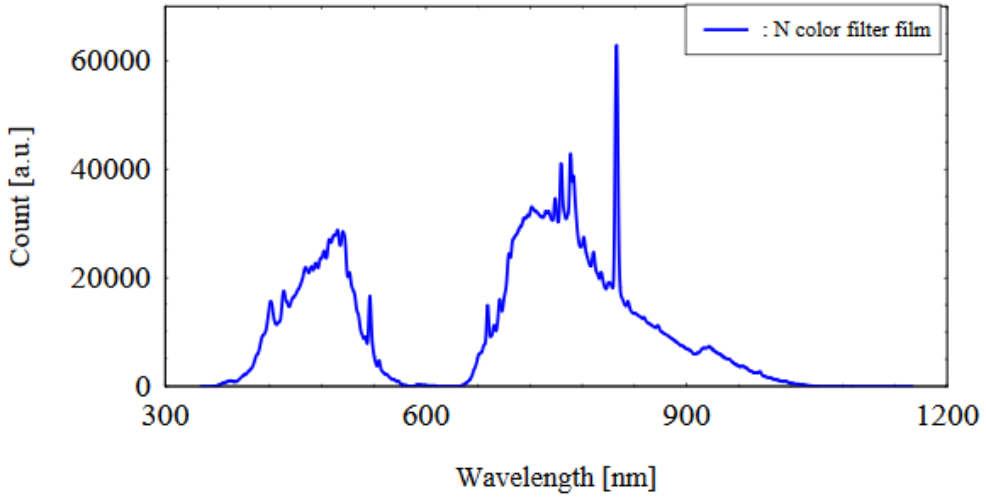


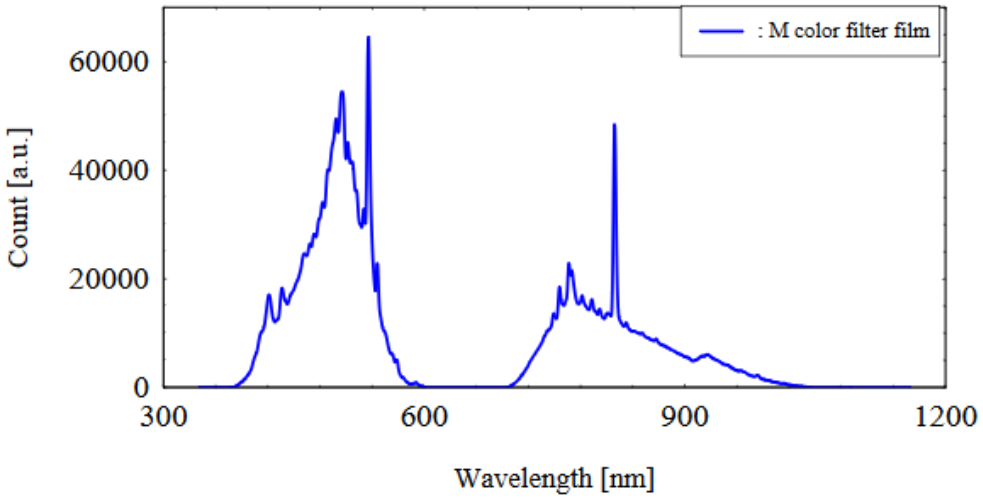
Spectrum of the Colour Filter Films

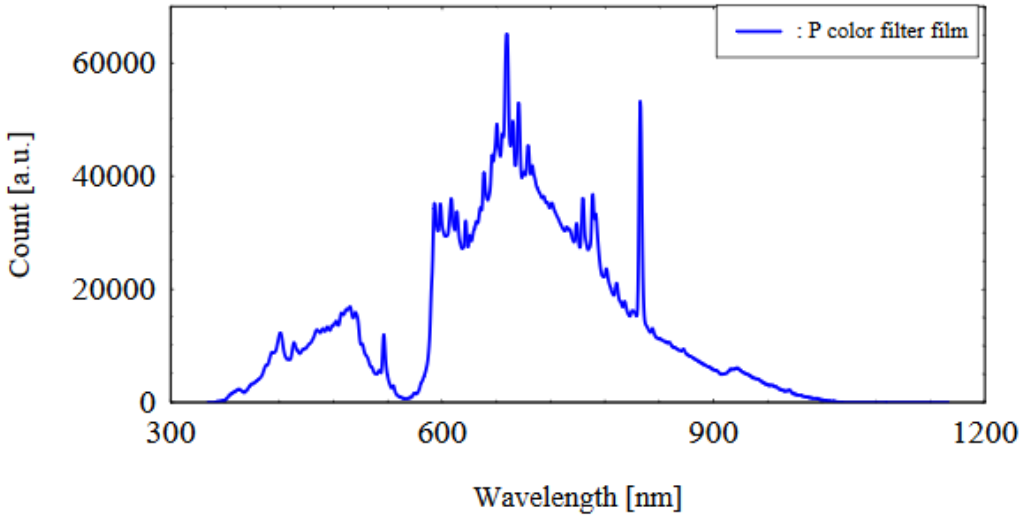
- The three components of the spectrum help to investigate the spectrums.
- The vertical coordinates are the photon count, and the horizontal coordinates are the wavelength *(λ)*.
- Having a look on figure, it can be said that middle part of the spectrum of O-marked color filter film is wider than the spectrum of the K-indicated color filter film, which can influence the maximum power point values.
- The other important observation is in the zero part of the spectrum.
- The O-marked color filter film contains zero count in the middle part of the spectrum.

Preparing the Experiment – Rest of the Colour Filter Films

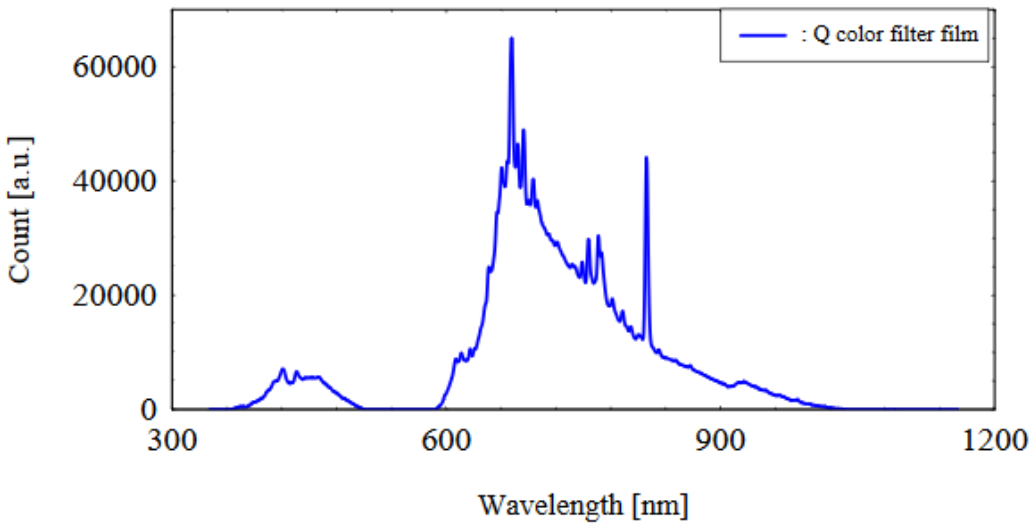


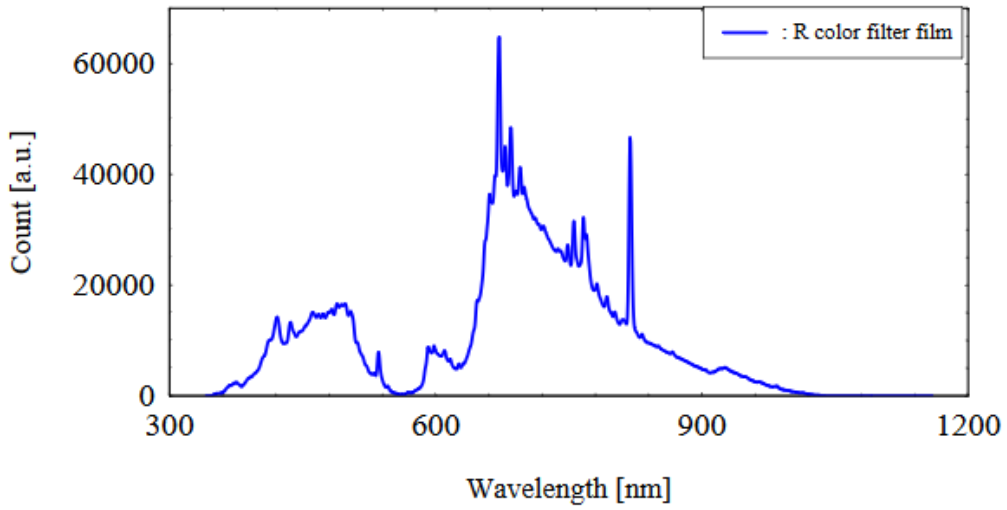


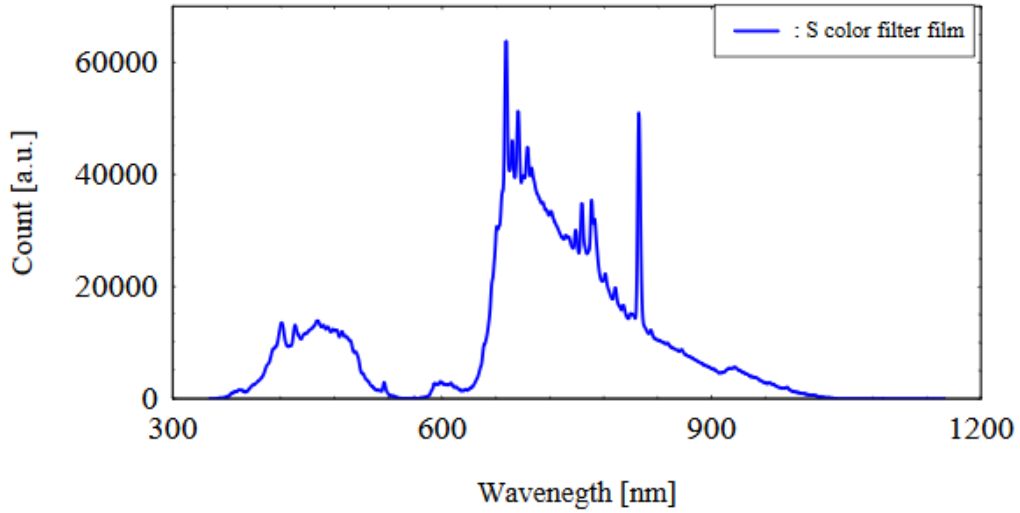




Preparing the Experiment – Rest of the Colour Filter Films

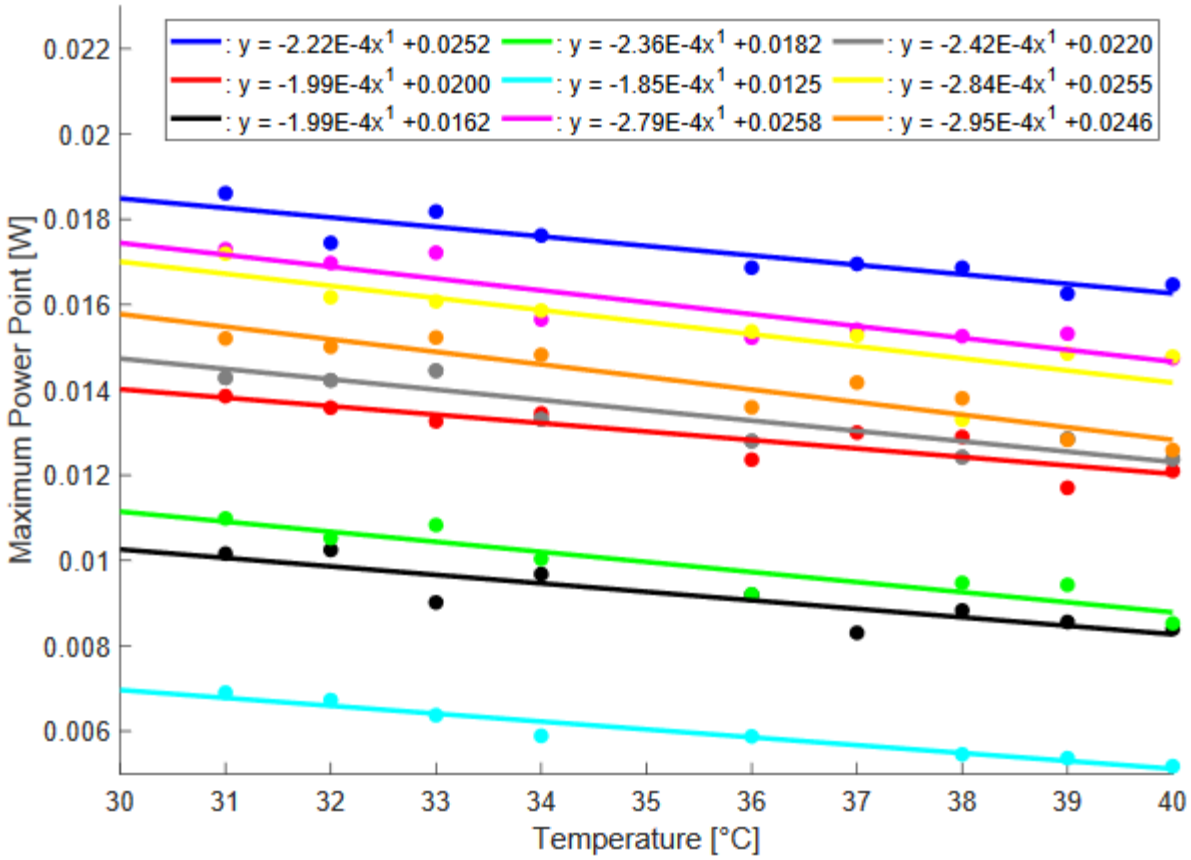






Analysing the Results

Analysing the Results – Maximum Power Point



Maximum power point points based on the cell temperature in the range of 31 °C – 40 °C in case of different colour filter films

Letter sign of the Colour Filter Film	max. dev.	r^2	σ_a	σ_b
K	$5.97 \cdot 10^{-4}$	0.834	$3.75 \cdot 10^{-5}$	$1.34 \cdot 10^{-3}$
P	$6.80 \cdot 10^{-4}$	0.829	$4.78 \cdot 10^{-5}$	$1.71 \cdot 10^{-3}$
R	$1.44 \cdot 10^{-3}$	0.691	$7.17 \cdot 10^{-5}$	$2.56 \cdot 10^{-3}$
S	$4.61 \cdot 10^{-4}$	0.883	$4.06 \cdot 10^{-5}$	$1.45 \cdot 10^{-3}$
Q	$4.43 \cdot 10^{-4}$	0.898	$3.33 \cdot 10^{-5}$	$1.20 \cdot 10^{-3}$
L	$5.24 \cdot 10^{-4}$	0.777	$4.02 \cdot 10^{-5}$	$1.44 \cdot 10^{-3}$
N	$5.23 \cdot 10^{-4}$	0.853	$4.00 \cdot 10^{-5}$	$1.42 \cdot 10^{-3}$
M	$6.47 \cdot 10^{-4}$	0.764	$4.19 \cdot 10^{-5}$	$1.49 \cdot 10^{-3}$
O	$3.36 \cdot 10^{-4}$	0.946	$1.81 \cdot 10^{-5}$	$6.41 \cdot 10^{-4}$

Table I: filter Properties of the fitted curve for each colour films

Analysing the Results – Maximum Power Point

Letter sign of the Color Filter Film	"Valley effect" $\Delta\lambda$ [nm]	MPP [from max to low data]
K	0	K
P	17	P
R	32	R
S	41	S
Q	79	Q
L	85	L
N	85	N
M	95	M
O	124	O

Table II: Colour filter films with its valley effect (Δλ) and with the maximum power point values. The highest values is at the top and the lowest is at the bottom.

Evaluation and Investigation of the Results

- However, the quality of the fit is not perfect (it is not $r^2=1$), but it remarkable because most of the color filter films, such as O, Q, S, N, filter foils achieve the $r^2=0.8$ or greater.
- The slope of the fitted curve of the calculated maximum power point shows a slightly decreasing trend in Table I. but taking a deep look at the figure and the table, it can be stated that steepness values are poor values e.g. $a=2.42\cdot10^{-4}$ and $a=-2.95\cdot10^{-4}$ which means that a falls in the order of magnitude of 10^{-4}.

Analysing the Results – Maximum Power Point

Letter sign of the Color Filter Film	"Valley effect" $\Delta\lambda$ [nm]	MPP [from max to low data]
K	0	K
P	17	P
R	32	R
S	41	S
Q	79	Q
L	85	L
N	85	N
M	95	M
O	124	O

Table II: Colour filter films with its valley effect (Δλ) and with the maximum power point values. The highest values is at the top and the lowest is at the bottom.

Evaluation and Investigation of the Results

- According to the spectra of the color filter films the following can be noticeable: the size of the middle part of the spectra can influence the fitted curve for the maximum power point based on the cell temperature.
- For example, the spectrum of K-marked color filter film does not have zero photon count which can cause the highest maximum power point values in the measured temperature range. On the other hand, the O-indicated color filter film has the widest valley effect.
- Comparing the maximum power point values with the color filter films the following can be observed, the middle part of the spectrum influences the maximum power point values and the fitted curve. In other words, the "valley effect" determine the maximum power point values based on the cell temperature. This is proven by measured and evaluated data listed in Table II.

Analysing the Results – Maximum Power Point

Letter sign of the Color Filter Film	"Valley effect" $\Delta\lambda$ [nm]	MPP [from max to low data]
K	0	K
P	17	P
R	32	R
S	41	S
Q	79	Q
L	85	L
N	85	N
M	95	M
O	124	O

Table II: Colour filter films with its valley effect ($\Delta\lambda$) and with the maximum power point values. The highest values is at the top and the lowest is at the bottom.

Evaluation and Investigation of the Results

- The $\Delta\lambda$ is the metric of the "valley effect", which determine the range of the "valley effect". According to the table, inversely order can be seen between the color filter films and the maximum power point values.
- However, it is not sure that it is inversely proportional, the increasing $\Delta\lambda$ causes the decrease of the maximum power point values.
- In other words, the higher the "valley effect" is, the lower the maximum power point will be. So, the more the photon zero counts become, the lower the maximum power point will be.

SUMMARY

Summary

Reference: https://www.solarchoice.net.au/blog/news/is-the-federal-solar-rebate-ending

- Method was developed to adjust the temperature of the DSSC cell using Peltier-generator
- Variable parameters of the experiment were light irradiation and the cell temperature
- Measured electrical response of the DSSC was the maximum power point
- The results were plotted and curve was fitted
- Results were analysed

Thank You for Your Attention!