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Tct Configuration Technique For Shade Dispersion Of Pvarray System Under Non-Uniformirradiation: Experimental Study

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Abstract:An experimental evaluation of the solar photovoltaic (PV) system's depletion under the weather.investigating how blurring affects the PV system with different solar radiation levels four PV solar module panels (20W, Manf: Usha Solar) subject to parallel (SP) weather are used in this investigation—cross-sectional rate-arrested (TCT) and forecast. To evaluate the PV system's performance under artificial lighting fixtures, the test set includes electrical performance rating devices with a variable load. Furthermore, performance comparisons between PV modules programmed into the SP and TCT modified PV modules were conducted under the shading I-II test case.A thorough examination is aided by the anomalous behaviour of the current-voltage (V-V) and power-voltage (P-V) curves when numerous power points, such as local maximum power points (LMPP) and ground mass points (GMPPT), are present. Furthermore, performance indicator measures such as GMPP power, low power loss, and fill factor (FF) were evaluated under both PV power assumptions in distinct shadow scenarios.

Keywords: Solar energy, series-parallel connection. Total-cross-tied connection, power losses, power, fill factor

I. INTRODUCTION

Because of communication and transportation networks, among other things, the use of electricity is steadily increasing. Fossil fuels like petrol, diesel and petrol are used to generate a significant portion of the energy. It is common knowledge that scientists are working hard to find new alternative energy sources because fossil fuels are becoming scarce and have a limited capacity for storage. Renewable energy sources, such as photovoltaics, wind turbines, biofuel, etc., are becoming more and more popular these days because of their benefits.

In particular, because using a solar PV system doesn't require any sophisticated skills, it is more acceptable in society. Due to its environmentally beneficial character, the solar photovoltaic system is now the most practical technique for generating electricity in both residential and commercial settings. One of the main concerns regarding the decline in PV system performance is the fluctuation of sun irradiation potential and/or its irregularity with regard to time. Many researchers are currently looking at ways to improve PV system performance while taking into account the current geographic circumstances. Due to a number of factors, including high-rise commercial structures like shopping centres, hospitals, and corporate offices, the shadowing effectismost noticeable in both rural and urban regions. The primary sources of partial shadowing conditions (PSCs), which directly lower PV system performance, are present in all of these shadow test situations.Numerous sophisticated techniques exist to lessen the effects of shadowing, but according to recent research from the years 2013–2020, reconfiguring PV modules in PV array schemes is one of the best options available in the current situation.

In actuality, the PV array system experiences varying degrees of irradiation during PSCs. Many peaks of high-power points, such as local and global power points (LMPP& GMPP), arise in the indirect environment of PV and IV signals as a result of this irregular radiation exposure to the PV list. To identify the ideal configuration based on performance measurement tests, extensive comparative studies of several configurations were carried out. Usually, solar modules are installed in a sequence of interlocking modes to meet the demand for loading power.Because of the dimmingof one or more panels, the PV array output powerdecreases. The authors have prepared a completecross-tied (TCT) link between the PV series' modules. In essence, a number of tests were conducted to compare the outcomes, including power loss, FF location, and GMPP preparation for both under the four categories of blurring cases: long length (LW), narrow wide (NW), short wide (SW), and short narrow (SN). The experimental analysis discovered local and GMPPs, which were then verified under simulated settings using the MATLAB/Simulink model (Rani et al., 2013).The authors examined the MATLAB/Simulink experimental investigations that sought to attain MPP throughout theBridge-link (BL), TCT, and series PV modules (SP), and it is clear that the TCT suspension is superior to the other two (Koray, 2014). The series and related connections of the PV array under three dimming circumstances were studied by the authors. A comparatively different loss (MML) and a modest number of GMPPs were obtained with the corresponding link created using FF (Vijaylekshmy, et al., 2014). Based on higher power, better FF, and low power coal, the authors have discovered methods to improve PSC the impacts of name distribution on the TCT PV panel link and puzzle connection (Bai et al., 2015).The authors have suggested a number of PV installation methods, including bridge-link (BL), honey-comb (HC), series-parallel (SP), TCT, and a novel suspension of the list. According to Malathy and Ramaprabha (2015), the "new" suspension has a better response than others, and the 6x6 PV size is ideal for test research under PSCs. Because of the shadow on the PV list to be examined in the preparation of SP, HC, BL, TCT, and Su-Do-Ku, the writers perceive the passing of clouds. SuDo-Ku's modified TCT (RTCT) suspension puzzle performs better when compared to the regular TCT pattern (Vijaylekshmy et al., 2015a).Su-Do-Ku suspension connections to PV panels exhibit superior results in terms of high FF, low power loss, and a small number of -MPP (smooth PV curve), according to the authors' investigation of TCT suspension, hybrid SPTCT, and Su-Do-Ku (Vijaylekshmy et al., 2015b). For a variety of shading conditions, including SW, LW, SN, and LN, the authors transformed the normal TCT suspension into a Magic Square (MS) problem. They discovered that MS suspensions perform best in all shading scenarios (Samikannu et al., 2016). When a PV panel is properly connected to a specific compound under investigation, the panels' regular SP and TCT connections and juxtaposition under partial blurring provide findings and demonstrateThe authors examined the SP, BL, and TCT configurations and contrasted the shadow dispersion scheme (SDS) for PV array electrical connection under LN and SW shadow connection. They discovered that SDS produced the best outcomes out of all configurations (Satpathy et al., 2017). The authors evaluated the PV system's performance to determine the model's effects and confirmed the model's dependability using MATLAB/Simulink modelling (Lamri et al., 2018).

The scheme of this study is divided into asSection I description of the paper. The notablepoints of study are given in Section II. Section IIIbriefs the novelty of the work done in the paper. In sectionIV, the results and discussion are summarized, and sectionV concludes the paper.

I.I.Novelty of Work

In this paper, the hypothetical investigation is performed to estimate I–V and P–V bends of 2x2 size PV system by showing PSCs impact.The important points of the present study aresummarized as,

- To study the experimental comparison of SP-TCT configuration, two types of shading casesused.

- Experimental results are useful for estimating the performance of PV systems under PSCs.

II.PV SYSTEM TECHNOLOGYAND EXPERIMENTAL SETUP

More PV module systems must be added in series and parallel to provide power support to the load due to the solar PV system's lower conversion efficiency from solar light intensity into electrical energy.The PV module's technical balancing circuit is shown in Fig. 1 as

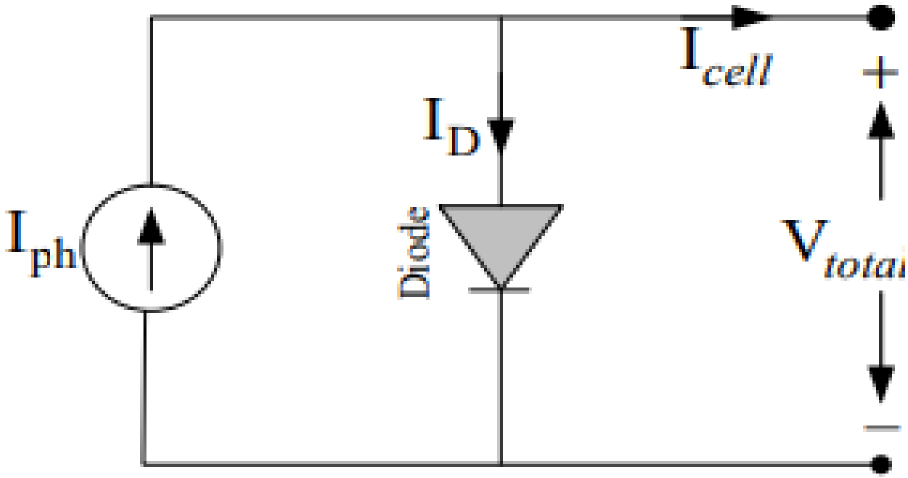


Figure 1: Illustrative diagram of PV system

The deliberated current of solar cell (cell I) is given in Eq. (1) and (2) as

$I_{cell} = I_{ph} - I_D$ (1)

$$I_{cell} = I_{ph} - I_o\left(\exp^{\left(\frac{qV_C}{AkT_C}\right)} - 1\right) \quad (2)$$

Where, I_{ph} : cell photocurrent (A),

I_D : diodecurrent (A), I_o : Reverse saturation current (A),

q :charge of electron (Coulomb), VC : cell voltage (V),

A :ideality factor, k : Boltzmann's constant (J/K),

T_C : cell temperature (^oC).

The solar PV array and the performance measurement system make up the two primary sections of the installed experimental setup. The PV array in the first segment is made up of 2x2 PV modules that are connected by TCT and SP. The performance measuring system is in charge of the second segment. To monitor the voltage and current in real time for performance analysis, two multimeters are utilised with a resistive load. By observing the I-V and P-V curves, the performance index of the installed system is calculated to demonstrate the influence on voltage and current. Table 1 lists all of the auxiliary components that make up the experimental setup along with their specifications and uses. The experimental setup is displayed in Fig. 2 as

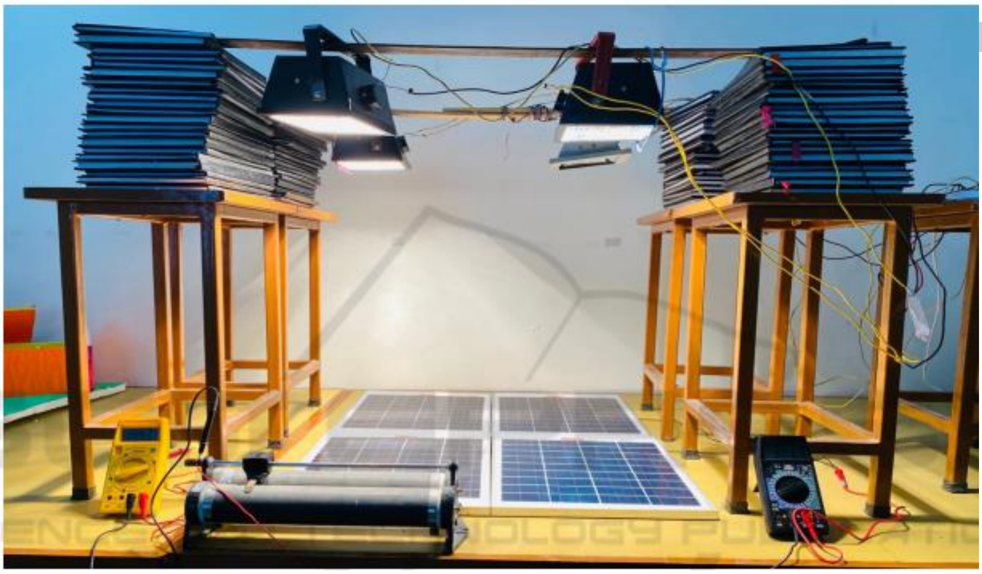


Figure 2: Experimental system for study

Table 1: Provision and role of supportive parts of Laboratory setup

Segment	Parts	Provision	Role
• Solar PV array(2x2)	• PV array system	• Power: 20 W • O. C. voltage: 21.997 V • S. C. current: 1.2586 A • Impp: 1.12A, Vmpp: 18V • PV module no.: 4 (2x2 array) • Cell technology: Poly-Si • Dimension (mm): 356×490×25 • Manf.: USHA SHRIRAM Technologies (Model NO: US 20/12V)	• 2x2 size PV array is used to design SP, TCT configurations for performance investigation is carried out shadow test cases.
	• Artificial solar lamp	• Total number of lamps- 4(2x2) • Light intensity 50- 650W/m2	• Solar lamp for light intensity to perform study
• Performance measurement system	• Multi-meter used as ammeter	• Number of ammeter: 1 • Measurement range: 0.01 to 10A DC • Mastech Technology	• Measurement of voltage ofSP,TCTconfigurations under different test cases.
	• Multi-meter used as voltmeter	• No. of voltmeter: 1 • Measurement range: 0.1 to 250V DC • Mastech Technology	• Measurement of current of SP, TCT configurations under different test cases.
	Decade resistive load	• Number of resistive load:2 • Range: 0.1 to 250 ohm	• Variable load (decade resistive box) is used to characterize the solar PV system from 0 Ω to maximum required load accordingly.

III.PV ARRAY CONFIGURATIONS AND SHADING ANALYSIS

The technical arrangement of PV modules are shown primarily in SP to achieve maximum current and voltage values. But due to climatic challenges TCT configuration is introduced for performance investigation under shading cases.

The TCT is modify version of SP configuration after addition of cross-tied between two parallel connected strings. The schematic sketch of both configurations i.e. SP and TCT are shown in Fig. 3 as,

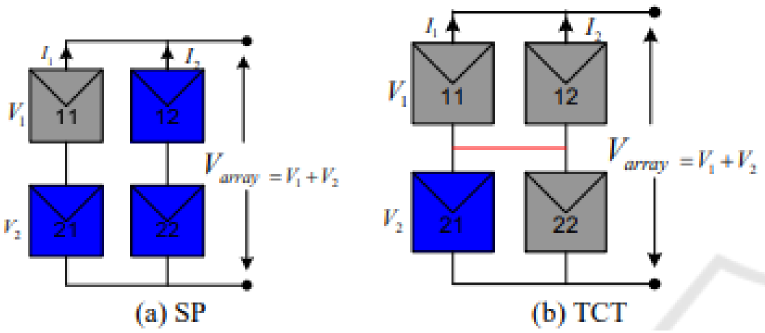


Figure 3: Schematic diagram of PV array configuration with shading patterns

Two shadow test cases are taken for performance analysis such as (i) 3 PV modules- 12, 21, 22 are shaded (ii) Single PV module-21 shaded. The present study briefly reflects the impact of these considered shadow conditions.

In shading case- 1, as the three PV modules at locations 12,21 and 22 receive the low irradiation as 75W/m2 and treated as shaded but one PV module at location 11 receives normal sun irradiation as 266 W/m2 and treated as non- shaded.

The 2x2 size of SP configuration-based PV system generated current for shadow cases(a) and (b) is obtained as,

(a) Current generated for shadow case-(a)

$$\left.\begin{aligned} I_{R1} &= \left(\frac{S}{S_{STC}}\right)I_m + \left(\frac{S}{S_{STC}}\right)I_m = \left(\frac{75}{1000}\right)\times I_m + \left(\frac{266}{1000}\right)I_m = 0.341 I_m \\ I_{R2} &= \left(\frac{266}{1000}\right)\times I_m + \left(\frac{266}{1000}\right)I_m = 0.532 I_m \end{aligned}\right\} (3)$$

(b) Current generated for shadow case-(b)

$$\left.\begin{aligned} I_{R1} &= \left(\frac{S}{S_{STC}}\right)I_m + \left(\frac{S}{S_{STC}}\right)I_m = \left(\frac{75}{1000}\right)\times I_m + \left(\frac{75}{1000}\right)I_m = 0.151 I_m \\ I_{R2} &= \left(\frac{266}{1000}\right)\times I_m + \left(\frac{266}{1000}\right)I_m = 0.532 I_m \end{aligned}\right\} (4)$$

The theoretical values of the voltage and power of the PV array such as SP and TCT adjustment can be similarly tested under similar shading test cases 3 (a) - (b).

IV.RESULTS AND DISCUSSION

The combination of the two configurations as mentioned above in the PV array is configured. In this unusual situation, the features of the V and P-V curve are drawn in the tests. Results are summarized as:

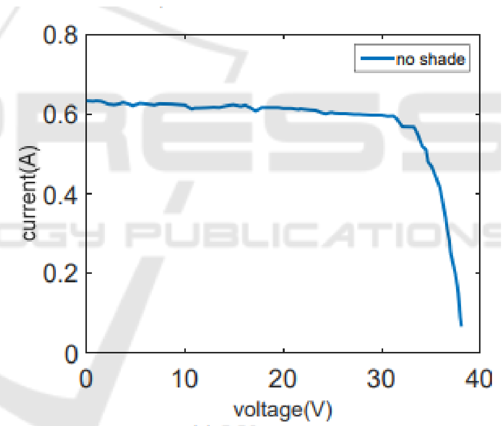
• P-V and I-V curve of SP and TCT PV under under uniform conditions.

• Impact on SP and TCT configuration due to shading pattern-1

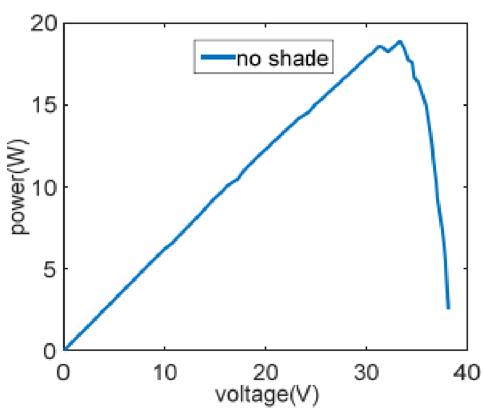
• Impact on SP and TCT configuration due to shading pattern-2

1.1 P-V and I-V Characteristics of SPand TCT Array at No Shade

The complete PV and IV feature of the SP and TCTfixed PV under the uniform distribution of lightintensity of 266 W / m2 is from Fig. 4 (a) - (b). It isevident that the IV and P-V curve is smooth (noGMPP and LMPP).,



(a) I-V curve



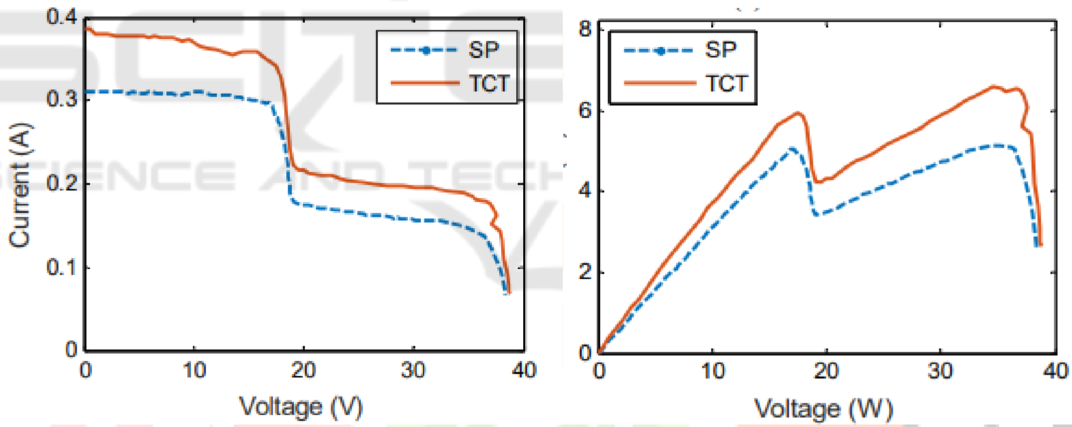
(b) P-curve

Figure 4: Performance characteristics of SP and TCT configurations under ideal conditions

IV.I. Effect of Shadow Pattern-1

The state of PSCs is that they are unable to receive the entire amount of solar radiation when one or more panels in a PV array are shaded. PSCs reduce the output efficiency of the panel and display a dark zone and an increase in the graphical figure of the I-V and P-V curve. They can be caused by overcast weather or by trees and buildings casting shadows over the panel.

Three panels are shaded in this examination, while one panel is exposed to the full sun. The graphical curve in Figure 6 clearly shows the disruption in the panels' working performance caused by the 75W/m2 received by the shaded panel and the 266W/m2 received by the non-shaded panel. The Voc for SP in this shading scenario is 38.3V, while for the TCT arrangement, it is 38.7V. In this scenario, the Vm are 35.2V and 34.6V for SP and TCT, while the power at GMPP for SP is 5.13 W and 7.57 W for TCT. The Isc is 0.31A and 0.38A for SP and TCT, respectively. For SP and TCT, the resulting FF is 0.80 and 0.42, respectively, whereas the misleading power is 0.10 and 0.02 for SP and TCT, respectively.



(a) I-V curve(b) P-V curve

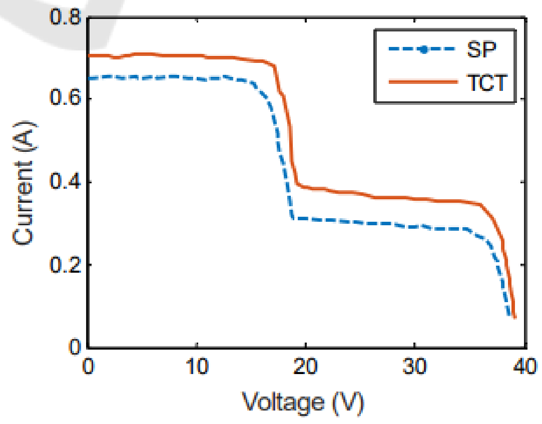
Figure 5: Performance characteristics of SP and TCT configurationsunder shading test case- 1

Table 2: Performance parameters of SP and TCT configurations under shade pattern-1

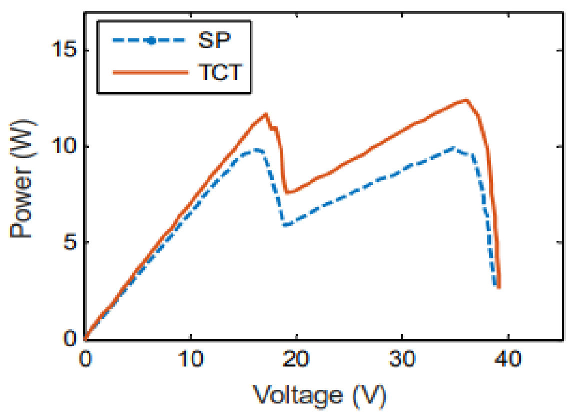
Parameters	SP	TCT
O. C. Voltage (V)	38.3	38.7
S.C current (A)	0.31	0.38
Max voltage (V)	35.2	34.6
Max current (A)	0.14	0.18
Power at GMPP (W)	5.13	7.57
Misleading Power (W)	0.10	0.02
Power loss (W)	12.14	11.31
Fill Factor	0.80	0.42

IV.II. Effect of Shadow Pattern-2

Since three of the panels in this study are exposed to normal radiation while one is shaded, the output of the 2x2 array displays peaks in the graph that demonstrate that the non-shaded portion of the modules absorb 266 W/m2 of radiation, while the shaded panel receives 75 W/m2, as seen in Fig. 6. Because of the darkened panels, less power is created and more power is lost.For SP, the open-circuit voltage (Voc) is 38.6V, while for TCT, it is 39.1V. Additionally, for SP and TCT topologies, the short circuit current (Isc) is measured to be 0.65A and 0.70A, respectively.For SP and TCT systems, the maximum voltage (Vm) produced in this scenario is 36.5V and 36V, respectively. For SP, the observed maximum current (Im) is 0.27A, while for TCT, it is 0.34A. For SP and TCT setups, the power at GMPP is 9.89W and 12.46W, respectively. Better FF values of 0.39 and 0.44 are noted for SP and TCT systems, respectively. For SP and TCT systems, the deceptive power is 0.29W and 0.8W, respectively. For SP and TCT, the power loss (PL) is 7.38W and 6.42W, respectively.



(a) I-V curve



(b) P-V curve

Figure 6: Performance characteristic of SP and TCT configuration undershading test case-2

Table 3: Performance parameters of SP and TCT configurations under shade pattern-2

Parameters	SP	TCT
O. C. voltage (V)	38.6	39.1
S.C current (A)	0.65	0.70
Max voltage (V)	36.5	36
Max current (A)	0.27	0.34
Power at GMPP(W)	9.89	12.46
Misleading Power(W)	0.29	0.8
Power loss	7.38	6.42
Fill Factor(W)	0.39	0.44

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V.CONCLUSIONS

A thorough evaluation of the PSC's influence on the PV modules put together by SP and TCT was provided as part of this experimental investigation. Transparent part-dimensional shading patterns, one shading, a single-panel case with a transparent and shaded case, two three-dimensional panels, and one non-black panel were used in the lengthy studies.

The results show that the display of PV modules in experimental investigations is significantly impacted by blurring.

- According to the aforementioned partial shading circumstance, the TCT-designed PV module performs better than the SP configuration.
- PV modules with SP and TCT configurations both experience power reductions, however TCT performs better than SP.
- According to shade pattern-1, the power reductions for SP and TCT-arranged PV modules are 7.38W and 6.42W, respectively; for shading method-II, they are 12.14W and 11.31W.
- Under shade pattern-1, the calculated FF factors for the SP and TCT configurations are 0.39 and 0.44, respectively. As a whole, TCT has the best performance. Based on the explanation above, it is determined that, under the shading effects 1 and 2 mentioned above, TCT arrangement of panels performs better than SP arrangement.

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