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FUZZY LOGIC CONTROL TO PROCESS CHANGE IRRADIATION AND TEMPERATURE IN THE SOLAR CELL BY CONTROLLING FOR MAXIMUM POWER POINT

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Abstract: This paper presents intelligent control methods to get the maximum power point (MPPT) to be a photovoltaic system that operates with high efficiency when weather conditions change as well as fluctuations in temperatures resulting from sunlight. The proposed method of controlling by fuzzy control techniques is applied with a Direct current to Direct current (DC-DC) converter device. The important steps of the control unit for integrated design. The photovoltaic system, which was designed by Matlab / Simulink, was implemented with simulations of autonomous water pumping techniques. Comparison of results with simulations without MPPT control. We have noticed that the system in the case of using the MPPT that was used in the fuzzy logic unit gave high efficiency for the energy production from the solar cell the crucial control unit steps for integrated design. Simulated autonomous water pumping methods were used to implement the Matlab/Simulink-designed photovoltaic system. Results comparison with simulations lacking MPPT control. We have observed that the system provided great efficiency for the energy generation from the solar cell in the event of using the MPPT that was used in the fuzzy logic unit.

Keyword: *Fuzzy Logic;* direct current to direct current *(DC-DC) converter; Photovoltaic; Matlab /Simulink; efficiency*

1. Introduction

The sun is the largest source of energy and covers all parts of the world. Solar energy reaching the Earth is estimated at 3.9 x 1025 per year, more than nine thousand increased demand for electrical energy [1]. There are a number of ways to use this energy to be electrical energy using solar panels. As well as, solar energy is one of the important sources for solving electrical energy problems (remote place, especially in remote areas, as it is supportive of technology in the modern era, instead of pure and clean energy. Solar cells produce electrical energy directly from sunlight [2]. The efficiency of solar cells be described by three factors: (the solar panels we get from the market range between 7-14% [3]. the efficiency of the inverter device (94-99%) and control of PV array (M.P.P.T) efficiency (more than 98.5% [4][5]. That is a very difficult job to enhance the operation of PV panels and the IGBT switch is based on control. Therefore, an improvement on an MPPT algorithm is simple and less expensive [5]. MPPT algorithms are very important for the solar panel in terms of the non-linear characteristic of the current -

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voltage and its energy and point to be generated at a maximum[6]. The effects of this point directly on temperature and solar radiation. These conditions change during the changes resulting from the day compared to the night, as well as in terms of the seasons of the year and sudden weather conditions. The resulting tracking through the control is with high accuracy to obtain the maximum point and according to the conditions and changes in the climate to obtain the maximum power [7]. Many [MPPT] algorithms have been mentioned in several papers. The methods used and the methods have complexity, in terms of accuracy, response to conditions in a time period, cost, maintenance & installation with regard to the technical aspect. We note, many methods have been changed because they are very complex and costly[8]. These results in the MPPT algorithm being simple, low cost, and better performance compared to other methods. This paper proposes, a Fuzzy Logic Controller based MPPT algorithm augmented by a controller through the program MATLAB. The Fuzzy - Logic controller is designed to control voltage changes for PV through electronic boosters. Fuzzy Logic MPPT's algorithms are divided into 48 bases. View the design results.

2. System Components

Figure 1& figure 2 Refers to the components &design of the system that have been proposed. Solar panels group and its inputs solar radiation (E) in a unit of measurement W/m2 and cell temperature (Tc) in degrees Celsius for energy production. Generated current (IPV) and the generated voltage (VPV) as well as obtained an error signal (E). Error and Error Integration is used as input signals for the Fuzzy Logic Controller and for the VREF block. $Ke, Kde, and\ Kz$ are information-dependent FLC tuning information. The mass parameters of the FLC, the reference voltage ($VREF$), are employed as the mass reference of the Fuzzy control of logical[9]. Obtaining an error signal for FLC to compare the voltage generated by VREF and the output voltage from photovoltaic cells (VPV). Then, a cycle is designed by FLC to operate. The feed is supplied through the duty cycle to the PWM signal generator and then to the control to change AC to DC. The boost transformer is planned to control for voltage on terminal input, not in the voltage terminal output. In the array of solar panels, the output value depends $on\ Isc, Voc, Impp, Vmpp$ on $I-V$ and $P-V$ diagrams and curves.

2.1. Current Photovoltaic and Voltage Photovoltaic Curves

A paper has been proposed, using the PV array module that it has used regardless of the characteristics shown in Table (1). PV cells do not contain losses or current leakage to the ground, for so note that the resistance (Rs) = zero and the parallel resistance (Rsh). Note that[9][10]. the proposed design method was not a PV panel, the rate of Rs, Rsh was not optimal according to the above for designing a typical solar panel, a value of Rs 1.234 Ohms, and Rsh 10851 Ohms is set [10].

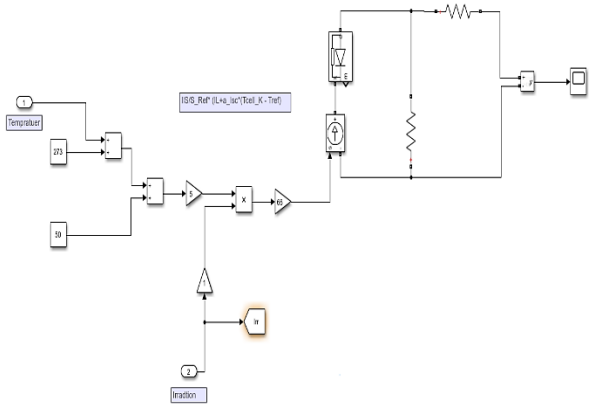


Figure 1. Solar cell Simulink

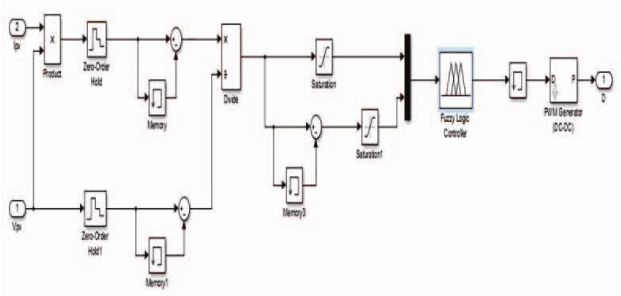


Figure 2. fuzzy logic controller (PWM)

Table 1. first table. Electrical performance under test

Characteristic	Value
Rated Power (Pmax)	55 W +15% -5%
Open- Circuit-Voltage (Voc)	21.8 V
Short - Current- Current (Isc)	3.32 A
Maximum - Power- Voltage (Vpp)	17.5V
Max - Power – Current (Ipp)	3.12 A
Temperature- coefficient of Voc	8.22 x 10^{-2} /0C
Temperature – coefficient of Isc .	34 x 10^{-3} A/0C
Nap	1
Ness	2

Generated power from characteristic of current and voltage of the PV be expressed by irradiation& temperature generate current fountain and a component as shown in Fig. 3. In commend to get a demand power, the PV array is connected in shunt and connected series, which unitized the form of the module a PV array[11]. Current proved is suitable to the PV energy, photons that on the PV cell (***IPh***).

According to Kirchhoff's Law (KCL) in Figure 2, we can express the current produced by the solar p

Figure .2 fuzzy logic controller

$$IPV = IPh - ID \quad (1)$$

The radiation state as well as the temperature determine the value of IPh. The equation for IPh can be expressed as:

$$IPh = \left(ISC + \alpha\,(Tc - Tref)\right)\lambda\, ref \quad (2)$$

It can be seen at the same time, ID is the diode current and the exponential function.

$$I = \frac{I\,[exp\,(q(VPV + RsIPV)) - 1]}{A\,K\,Tc} \quad (3)$$

The saturation current of the solar cells[12]. which shows the degree of influence of temperature and the exponential function, is called. The equation for Is is:

$$Is = IRs\left(\frac{Tc}{T_{ref}}\right)\exp\left[\frac{qEg\left(\frac{1}{T_{ref}} - \frac{1}{Tc}\right)}{KA}\right] \quad (4)$$

The reverse saturation current IRS, as well as an exponential function.

$$IRs = \frac{Isc}{exp\left(\frac{qvoc}{AKTc}\right) - 1} \quad (5)$$

It should be noted that current $IRsh$ is a current that flows into Current passes through a resistance connected in parallel[13]. it according to the current – equation by using the Kof voltage formal from Figure .2. Equation to the h that is [14]:

$$IRsh = \frac{VPV + RSIPV}{Rsh} \quad (6)$$

Then, Equation. Re-written to get a new and distinctive formula:

Of IPV as shown:

$$IPV = IPh - IS\left[\exp\left(\frac{q(VPV + RsIPV)}{A\,K\,Tc}\right) - 1\right] - \frac{VPV + RSIPV}{Rsh} \quad (7)$$

$$IPV = NpIph - NpI\left[\left[exp\left[\left(\frac{q\left(\frac{VPV}{Ns} + \frac{RsIPV}{Np}\right)\right)}{(A\,K\,Tc)}\right)\right] - 1\right] - \frac{\left(\frac{NpVPV}{Ns}\right) + (RsIPV)}{Rsh} \quad (8)$$

Where,

IPV: The output current of solar panel (A)

VPV: $The\ output\ voltage\ of\ solar\ panel\ (V)$

ISC: $Short\ circuit\ current\ (A)$

VOC: $Open\ circuit\ voltage\ (V)$

α: $Temperature\ coefficient\ (V\ /\ °C)$

Tc: $Solar\ panel\ temperature\ (K)$

$Tref$: $Solar\ panel\ reference\ temperature\ (K)$

λ: $Irradiance\ (W\ /\ m2)$

λref: $Reference\ Irradiance\ (W\ /\ m2)$

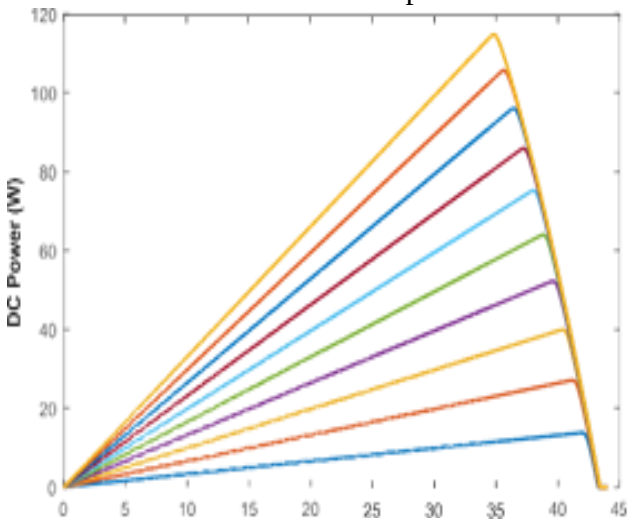
K: $Boltzman's\ contant\ (1.38\ \times\ 10-23)$

A: $Ideality\ factor$

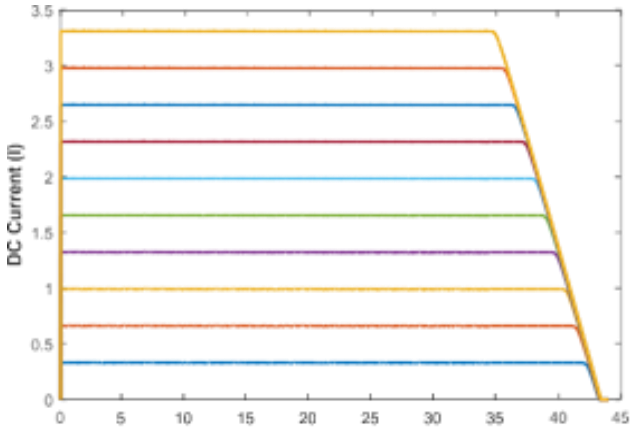
q: $Elementary\ charge\ (1.6\ \times\ 10-19\ C)$

Eg: $Band\ gap\ energy\ of\ the\ semiconductor\ (eV)$

From the equations shown above, a solar panel can be designed using Matlab as indicated in Figure .3. And the details shown in Table No. 1 for the solar cell[13]. From the voltage and current characteristic of the photovoltaic



(a) *D*c voltage



(b) *D*c voltage

Figure 3. (a) Relationship between Current &Voltage & (b) relationship between Power &Voltage attribute, of PV cell modules for $E = 100 - 1000W/m2\ and\ TC = 299\ K$.

panel[14]. the value of the series resistance Rs can be observed as a field in the field of the voltage source and a field of parallel resistanceRsh.

changes in the weather conditions and is surprising every day. Any changes that occur affect the shape of the I-V curve as well as

voltage[15]. MPP and power. Therefore, advanced technology was applied to solve this issue. Its ways are to use the fuzzy control. The fuzzy logic control has a merit its ability to be suitable with non-linear models. Fuzzy give an interactive language strategy[16].

2.2. Rated Reference Voltage Based on The Photovoltaic Module Fuzzy Logic Controller

A wide field of fuzzy logic controller was used earlier and the fuzzy logic could deal with the error from the input inaccuracy[17]. does not need precise arithmetical modeling, and is good enough to deal with non-linearity. The member command is used, as indicated in Figure 4, for programming each integer in a language can specify the number as well as the membership duty to be a precise control, but it is different from 6 to 7 [18]. In this paper, the 7-stage fuzzy technique was used: one Nb (large negative), four two Nm (medium negative), three Ns (small negative), four Ze (zero), 5 Ps (small positive), 6 Pm (medium positive), 7Pb (large) positive). The values of A, B, and C depend on the value of each variable entry. There are cases, the function of the member cannot be the same. or its shape can be made as optimal as possible to get a good result and accuracy.

Table 2. Rules of fuzzy function

e\ de	NB1	NM2	NS3	ZE4	PS5	PM6	PB7
NB1	NB1	NB1	NB1	NB1	NM2	NS3	ZE4
NM2	NB1	NB1	NB1	NM2	NS3	ZE4	PS5
NS3	NB1	NB1	NM2	NS3	ZE4	PS5	PM6
ZE4	NB1	NM2	NS3	ZE4	PS5	PM6	PB7
PS5	NM2	NS3	ZE4	PS5	PM6	PB7	PB7
PM6	NS3	ZE4	PS5	PM6	PB7	PB7	PB7
PB7	ZE4	PS5	PM6	PB1	PB7	PB7	PB7

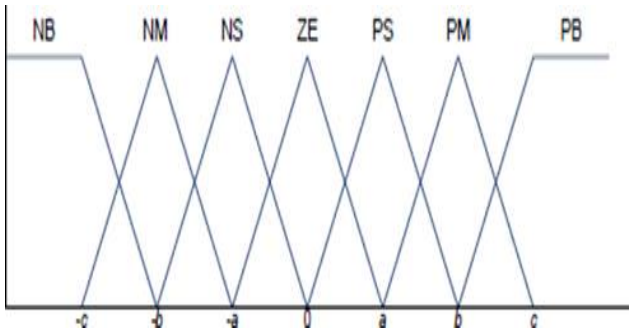
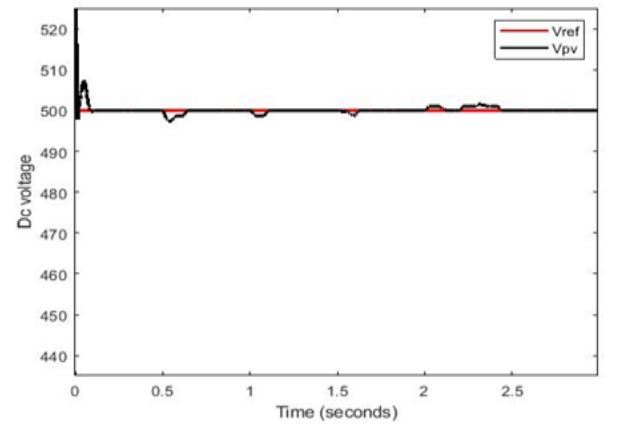


Figure 4. Membership of fuzzy function

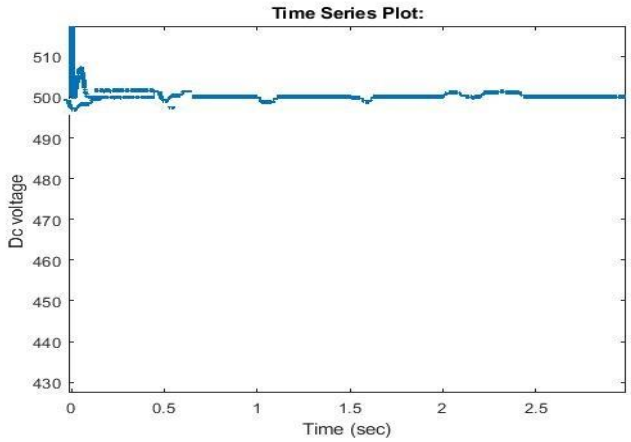
After a step that has been completed, the last step is to fix the harmonic in the control unit. This step is the process of converting the input into numbers[19]. There are several methods for this process. The error was calculated by the current and solar panel voltage as shown:

$$error = I + V\frac{dI}{dV} \quad (9)$$

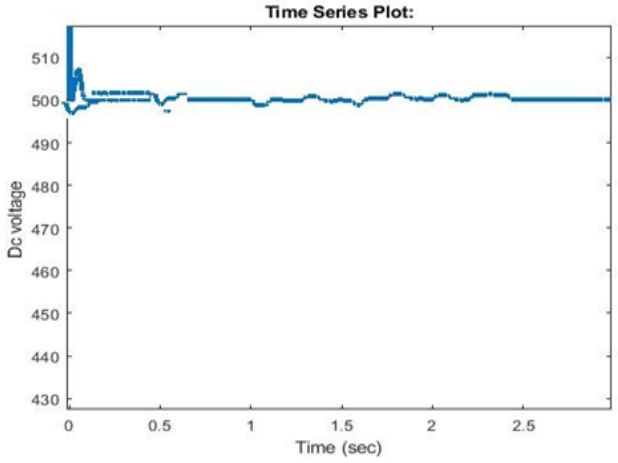
Input of integer element divide into error & change of error is input to fuzzy logic controller[20]. Through the fuzzy logic controller, as mentioned earlier, and setting errors, changing the error, as well as the output, it is Could reasonably be expected should get those reference voltage ($VREF$) so as to acquire the most extreme control fuzzy logic controller to MPPT sun based cell Modules. The examination may be settled on for those values created toward the fluffy rationale controller ($VREF$) through those present voltage yields of the sun-oriented panel, which prompts a lapse. This yields lapse and the subordinate of the slip would inputs of the fluffy rationale controller{Formatting Citation}.The destination of the controller is to design those modes of operation of the support converter in this way that the yield voltage of the sun-oriented board may be the same concerning illustration the reference voltage worth. On the other hand, the support converter drives the sun-based board to process A DC voltage of the same quality as the



(a)



(b)



(c)

Figure 5. System reactions will (a) seclusion phase, (b) Postponed furthermore (c) quickly repaired in the radiation level from 750 W/m2 will 1000 W/m2 toward 299 k.

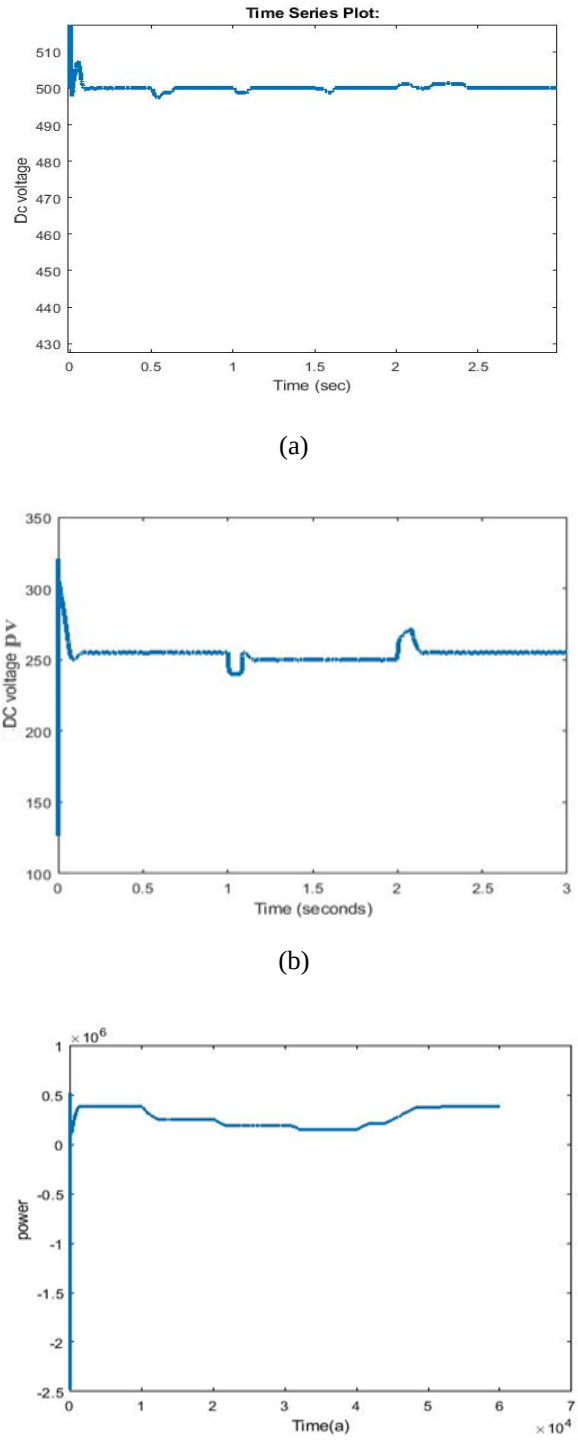
reference voltage; therefore, the greater force will be created. Suggested support converter the circlet is made up for exchanging spurs, inductance, and Furthermore capacitors, associated with an altered 51-ohm load.

3. Simulink &Result

System confirmation is carried out toward simulating those suggested system utilizing Simulink Matlab., S-function piece. Actuation will be carried Eventually Tom's perusing changing the illumination from 800 W/m2 on 1000 W/m2 utilizing venture information capacity. In this study, a few confirmation arrangements would have actualized with assessing that heartiness. Of the recommended system. Firstly, step, moderate Furthermore, quick transforms in irradiance level starting with 800 W/m2 with 1000 W/m2 at consistent temperature 298 k would connected of the PV module. System confirmation may be finished Toward simulating that recommended system dynamic may be completed Toward progress the illumination from 800 W/m2 to 1000 W/m2 by utilizing a stage enter work. In this proposition, a few actuation arrangements need aid planned on assessing the great state of the suggested framework. Primary, period, moderate Also quick variety clinched alongside irradiances standard starting with 800 W/m2 will 1000 W/m2 at settle temperature 298 k are connected with the sun - powered cell module.

Those fuzzy rationale controllers faultlessly track each progress for radiation Likewise over fig. 5a. The effects indicated that the recommended controller might have been suitableness to moderate Furthermore, quick radiation progress likewise demonstrated over fig. 5b What's more separately. With a stable run through of zero. 43 seconds, the controller here has the capacity will effectively recognize

Furthermore control MPP at startup. Over the same time evolving conditions, the controller might control inside zero. One seconds.



(a)

(b)

(c)

Figure 6. (a)(v) Voltage reference, (b) actual voltage for PV plant, (c) DC supply power.

In the second stage, those recommended strategy is tried by evolving those radiations in the type from claiming straightforward Furthermore moderate transforms starting with 800 W/m2 should 1000 W/m2 et cetera over with 800 W/m2, Anyway, this the long haul those reference current voltage, the real DC voltage (genuine pave yield voltage), What's more note the created energy. Shown On figure 6. Through those results, we note that those suggested controller, those fluffy rationale controller, might be actualized on the MPPT calculation what is more demonstrates helter skelter effectiveness when evolving those radiations.

4. Conclusion

Another thought to MPPT based fuzzy rationale controller brings been indicated in this paper on outline judgment MPPT under variety state. Matlab - Simulink outline of the framework need is conveyed out. The fuzzy rationale controller may be utilized on valuation those reference voltages from claiming sun powered cell module straight with those enter of sun based cell voltage & present. Then, in place on stay with those sun based cell voltages remain with the amount the enter from claiming reference voltage, again, the fuzzy rationale controller will be utilized for support converter. The Outcomes indicate that those summery MPPT has the capacity will recognize What's more compass those MPP for A quick the long run faultlessly under both moderate What's more quick variety to irradiance. The Matlab-Simulink framework requirement outline is shown. The fuzzy rationale controller may be used to evaluate the reference voltages obtained directly from the input of the sun-based cell voltage and current.

Conflict of Interest

The authors guarantee that there is no conflict of interest with the publication of this paper.

Author Contribution Statement

Authors 1, 2 and 3 proposed the research problem. Authors 1 and 3 developed the theory and performed the computations. Authors 1, 2 and 3 verified the analytical methods and investigated [a specific aspect] and supervised the findings of this work. First two authors authors discussed the results and contributed to the final manuscript.

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