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Experimental study on impact of high voltage power transmission lines on silicon photovoltaics using artificial neural network

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The recent trend of renewable energy has positioned solar cells as an excellent choice for energy production in today's world. However, the performance of silicon photovoltaic (PV) panels can be influenced by various environmental factors such as humidity, light, rusting, temperature fluctuations and rain, etc. This study aims to investigate the potential impact of high voltage power transmission lines (HVTL) on the performance of solar cells at different distances from two high voltage levels (220 and 500 KV). In fact, HVTLs generate electromagnetic (EM) waves which may affect the power production and photocurrent density of solar cells. To analyze this impact, a real-time experimental setup of PV panel is developed (using both monocrystalline and polycrystalline solar cells), located in the vicinity of 220 and 500 KV HVTLs. In order to conduct this study systematically, the impact of HVTL on solar panel is being measured by varying the distance between the HVTL and the solar panels. However, it is important to understand that the obtained experimental values alone are insufficient for comprehensive verification under various conditions. To address this limitation, an Artificial Neural Network (ANN) is employed to generate HVTL impact curves for PV panels (particularly of voltage and current values) which are impractical to obtain experimentally. The inclusion of ANN approach enhances the understanding of the HVTL impact on solar cell performance across a wide range of conditions. Overall, this work presents the impact study of HVTL on two different types of solar cells at different distances from HVTL for two HV levels (i.e., 220 and 500 KV) and the comparison study of HVTL impact on both monocrystalline and polycrystalline solar cells.

KEYWORDS

transmission lines, electromagnetic waves, high voltage, photovoltaics, artificial neural network-ANN

1 Introduction

The recent geo-economic conditions have argued the world to replace conventional energy resources with clean and green energy sources such as wind, solar, ocean power, bio energy and many others. Among these options, solar energy production is particularly attractive and popular due to its availability, simplicity, low maintenance cost, and long lifespan (Waleed et al., 2019; Hu, 2023; Osman et al., 2023; Usman et al., 2023). At the country level, people are encouraged to construct and implement grid-connected and standalone photovoltaic (PV) systems to meet their energy needs in order to reduce the dependency on conventional energy resources.

In addition to that, the recent technological advancements in solar energy have revolutionized the era of renewable energy and researchers are employing various materials in PV panels to further enhance the performance of the solar panels (Waleed and Fan, 2017; Pescetelli et al., 2022; Vimala et al., 2023). Moreover, the evolutions in PV systems control such as maximum power point tracking (MPPT), thermal management of panels and inclusion of AI technologies are further enhancing the performance of solar energy (Javed et al., 2019; 2020; Bollipo et al., 2021; Abdallah et al., 2022). Overall, this may be deduced from the above stated that all these developments have encouraged the adoption and utilization of solar energy among the public.

Apart from the benefits, the PV performance can be impacted by environmental and surrounding factors (Maghami et al., 2016; Elshazly et al., 2021; Kaewpraek et al., 2021; Dawood et al., 2023). For instance, in (Daher et al., 2018; Dhimish, 2020), researchers investigated the effect of seasonal temperature variations on PV modules. The study concluded that solar irregularities caused by climate change can affect the efficiency of PV modules and temperature changes due to solar irradiation have a great impact on degradation of solar cell (Magare et al., 2022). Later, some authors (Das, 2019; Giyantara et al., 2021; Ekinici et al., 2022; Vengatesh Ramamurthi and Rajan Samuel Nadar, 2022) have focused primarily on environmental aspects, such as the effect of partial shading, rusting, angle of incidence for PV modules and dust on panels, yielding various conclusions/theories.

Furthermore, the performance of solar cells may also be impacted by magnetic fields surrounding the solar panels. For instance, in (Zerbo et al., 2012; 2017), researchers examined the impact of the magnetic field on PV cells and found through experimentation that the electromagnetic (EM) waves transmitted or received by Amplitude Modulated and Frequency Modulated radio antennas have a negligible effect on the behavior of the PV panel. However, the electric field generated by these communication systems does have a strong influence on the electronic parameters of the solar cell. The investigation in (Fathabadi, 2018a) explored the influence of magnetic field and doping (density, materials) on the J-V characteristics of solar cell while considering shunt and series connected resistances. The results of the study indicated that an increase in magnetic field strength resulted in higher shunt, series, and short-circuited current values across all levels of doping. Few more studies have also described the possible impact of magnetic fields on the performance degradation of PV panels (Combari et al., 2017; Sourabié et al., 2017; Ndeto et al., 2020; Panmuang and Photong, 2021; Wu et al., 2023). Previous studies investigated the effect of constant magnetic field

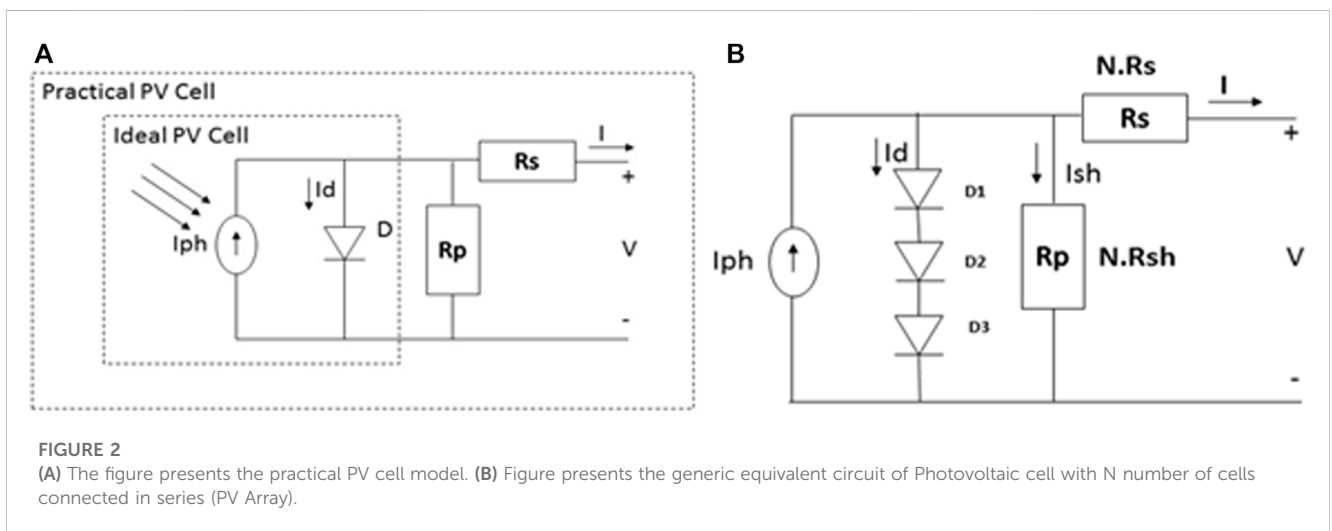
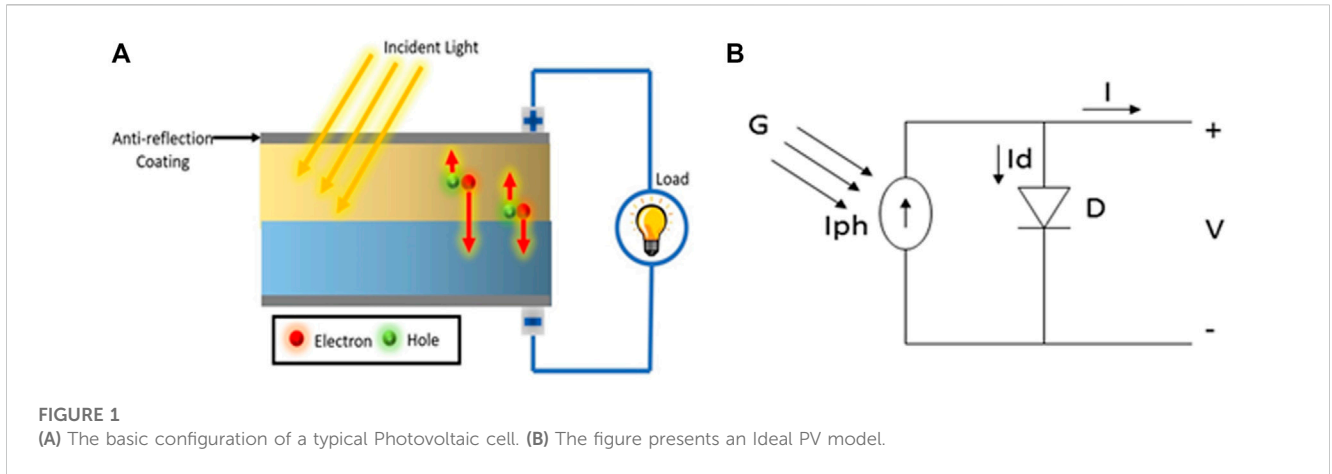
to measure the minority charge carrier mobilization in hetero-junction bipolar transistor. The relationship between magnetic field intensity, mobilization of electrons and change in current caused by magnetic field is established based on magneto-transport theory. The results suggested that there is a relation in magnetic field and base current. In the work (Zoungrana et al., 2012), researchers proposed a method to measure all recombinational parameters of bi-facial solar cell-based PV module under constant magnetic field applied parallel to PN junction surface. The monochromatic light is used for illumination of Bi-facial cell and continuity equation is used to express the photonic current and other associated recombinational parameters. The researchers obtained all recombinational parameters by investigating the effect of magnetic field on short circuited photonic current. The authors in (Sourabié et al., 2017) presented a theoretical representation stating that the inclination angle (θ) of the magnetic field affects the output of polycrystalline SI PV cells. Their research concluded that the PV cell output increases as the inclination angle (θ) increases from 0 to 90°. The result expressed that increase in MF increase the induced photonic current in organic material and decrease the photonic current in solar cells.

This is worth mentioning that previously reported works are more concerned about the impact study of environmental factors and magnetic fields on the performance of solar cells; however, the very least attention has been given to HVTL impact on solar panels. A few works in literature have tried to observe the HVTL effect on the solar cells (Fathabadi, 2018b; Raza et al., 2019) and presented the performance degradation of panels with HVTL. For instance, the study by (Fathabadi, 2018b) concludes that the high voltage power transmission lines generate Electromagnetic Waves (EM), which consist of an electric field resulting from the voltage of the transmission lines. This electric field does not affect the power production of PV panels located near the transmission lines. However, the EM waves also have a magnetic field caused by the current in the transmission lines, and this magnetic field significantly impacts the power production of PV panels situated near high-voltage (HV) transmission lines.

This work is aimed at finding the impact of high voltage power transmission lines on the solar cells (monocrystalline and polycrystalline type) performance by varying the distance between HVTL and solar panels. The collected experimental data provides insights into the effects of HVTLs on both types of solar cell, enabling a comparison between monocrystalline and polycrystalline technologies. This study further examines the influence of the electric field and magnetic field by HVTL on energy production of different PV panels under two different high voltage levels (500 and 220 KV) of transmission lines, utilizing real-time experimental values. Nonetheless, relying solely on these experimental values for comprehensive verification across diverse conditions is inadequate. To handle this challenge, this work employs an Artificial Neural Network (ANN) to acquire complete time-dependent profiles of photovoltaic (PV) panels, especially for voltage and current values that are impractical to obtain experimentally.

2 PV arrays and PV cells

To convert light energy into electrical energy, the devices used are called solar or PV cells. Figure 1A shows the basic construction of PV cell with connected load, whereas Figure 1B represents the ideal PV equivalent model. It is important to understand the basics of PV cells



in order to explain this work theoretically. The conversion of light energy from the Sun into electrical energy is achieved through photovoltaic generation, which relies on the photovoltaic effect. Commercially two categories of PV cells are available in the market: thin film devices and silicon crystalline material-based devices. The crystalline based PV cell category is further divided into two types: mono and multi crystalline material. Both above-mentioned technologies are considered more reliable and efficient to use for commercial purposes. Although the manufacturing cost of single crystalline material is high as compared to multi-crystalline material, but the researchers and market trends show that the efficiency of single crystal-based material is high as compared to multi-crystal-based system (Saive, 2021).

The mathematical equation for ideal diode model is written as:

$$I_d = I_o \left(\frac{qV_d}{e a K T} - 1 \right) \tag{1}$$

In this equation.

- i_d is diode current
- q is charge of electron equal to 1.602×10^{-19}
- K is constant equal to $1.380 \times 10^{-23} J/K$

- T : Temperature (Kalvin)
- a is constant varies from one to two
- i_o is reverse saturation current.

So, the Shockley equation or diode current equation with thermal voltage term can be written as

$$I_{shokly} = I_o \left(e^{\frac{V_d}{aV_{ther}}} - 1 \right) \tag{2}$$

The practical model of a PV cell is explained in Figure 2A and the mathematical equation of current flow toward the load (by considering the photonic current and series, shunt resistance) is provided below in Equation 3. Whereas Figure 2B shows the generic equivalent circuit of Photovoltaic cell with N number of cells connected in series (Solar cell array design handbook, 1982).

$$I_{load} = I_{ph} - I_o \left(e^{\left(\frac{V_d + IR_{se}}{aV_{th}} \right)} - 1 \right) - \left(\frac{V_d + IR_{se}}{R_p} \right) \tag{3}$$

I_{ph} depends upon several factors including.

- Irradiance level
- Spectrum of light

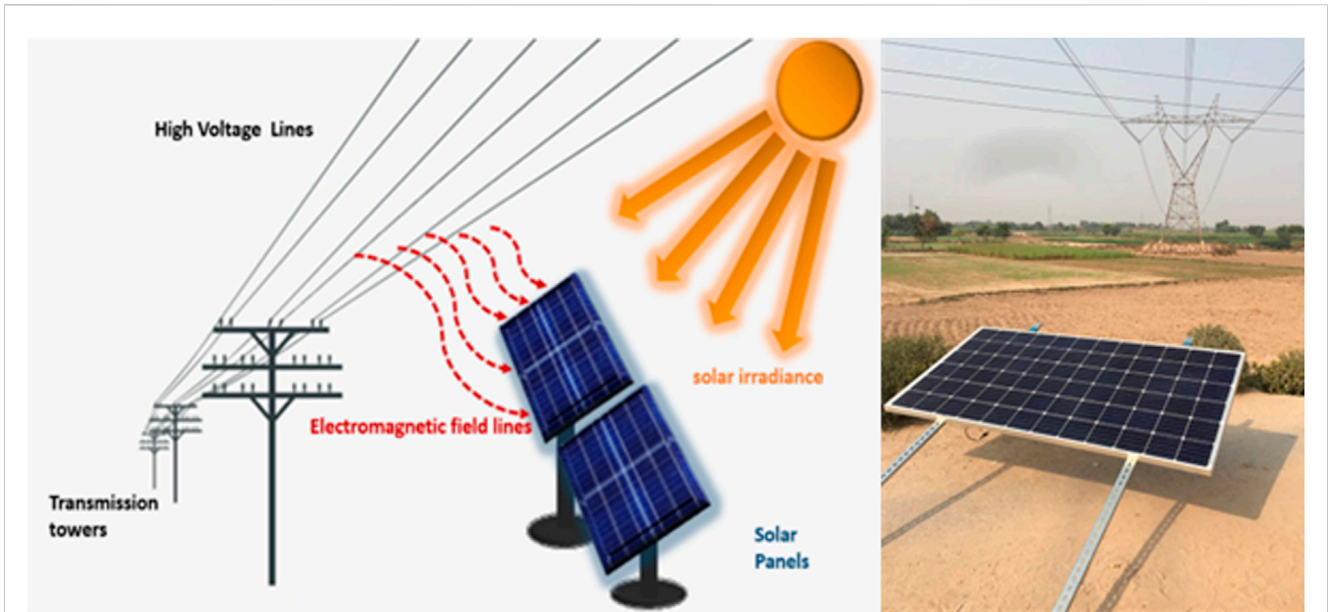


FIGURE 3 The schematic and real-time diagram depicting the experimental setup as developed in this work to perform the HV impact study.

TABLE 1 Properties of monocrystalline PV panel.

Name	Rating
Rated Power	290 W
Open circuit Voltage	44.9 V
Short circuit current	8.47 A
Maximum Power Current	7.97 A
Maximum Power Voltage	38.4 V

TABLE 2 Properties of polycrystalline PV panel.

Name	Rating
Rated Power	335 W
Open circuit Voltage	46.92 V
Short circuit current	9.25 A
Maximum Power Current	8.64 A
Maximum Power Voltage	40.38 V

- Cell characteristics/Quality of material

The short-circuited current of the PV cell is a direct measurement of the photon current, and the change of temperature has no significant impact on the value of I_{ph} . In Equation 3, the R_p represents the shunt resistance which is used to model the leakage current of the cell. The Value of shunt resistance is typically high; if, R_p value is low it represents the defected cell and it has severe effect on module efficiency for low value of

irradiance. In addition to that, the I-V and P-V characteristics describe the relationship of PV cell's "open-circuited voltages and short-circuited current" and "power of the PV array with open-circuited voltages" respectively, at different values of temperature and irradiance level (single mode as well as array connected mode of PV cells). To understand working principle of PV cells, two key design aspects must be under consideration, the open circuit potential difference V_{oc} and the short-circuit i_{sc} value of current. To evaluate the value of open-circuited voltage, value of circuit load current tends to zero and the equation for load current is rearranged as

$$0 = I_{ph} - I_o \left(e^{\left(\frac{V_{oc}}{aV_{th}}\right)} - 1 \right) \tag{4}$$

$$\frac{I_{ph}}{I_o} = \left(e^{\left(\frac{V_{oc}}{aV_{th}}\right)} - 1 \right) \tag{5}$$

Taking \ln on both side of the equation provides the value of V_{oc} as follows:

$$V_{oc} = aV_{Th} \left(\frac{I_{ph}}{I_o} + 1 \right) \tag{6}$$

The open circuit voltages exhibit a strong dependence on temperature, as indicated by Eq. 6, and the relationship between the open circuit voltages and temperature is inversely proportional (Al-naser et al., 2013).

3 Experimental setup

Figure 3 presents the schematic diagram of the experimental setup as established in this work to understand the impact of EM waves from HVTL on the PV cells. The image also presents the real time image of the experimental setup, which is composed of

TABLE 3 Monocrystalline PV parameters at different distances under 220 KV HVTL.

Distance y (ft)	Magnetic field B (uT)	Electric field E (V/m)	PV current (A)	PV voltage V load(V)	PV power P load(W)
0	11.49	1102	2.02	40.3	81.41
30	6.20	543	2.18	40.1	87.42
50	5.64	376	2.23	40.4	90.09
70	5.25	83	2.59	40.3	104.4
90	3.62	52	2.94	39.2	113.48
110	2.95	46	2.88	39.5	113.7
130	2.03	41	3.02	39.0	117.7

TABLE 4 Polycrystalline PV parameters at different distances under 220 KV HVTL.

Distance y (ft)	Magnetic field B (uT)	Electric field E (V/m)	PV current (A)	PV voltage Vload (V)	PV power P load(W)
0	11.49	1102	2.32	39.8	92.37
30	6.20	543	2.50	38.9	97.25
50	5.64	376	2.71	39.6	107.3
70	5.25	83	2.86	39.0	111.5
90	3.62	52	3.34	39.0	130.3
110	2.95	46	3.72	38.7	143.9
130	2.03	41	3.80	38.6	146.7

TABLE 5 Monocrystalline PV parameters at different distances under 500 KV HVTL.

Distance y (ft)	Magnetic field B (uT)	Electric field E (V/m)	PV current	PV voltage Vload (V)	PV power P load(W)
0	7.87	1230	1.68	32.1	53.928
30	6.12	818	1.69	32	54.08
50	6.06	648	1.69	32.3	54.587
70	5.59	620	1.73	33.6	58.128
90	3.34	610	1.72	34	58.48
110	2.07	474	1.73	33.9	58.647
130	1.69	218	1.73	34.1	58.993

an adjustable height assembly of solar panel placed in the vicinity of HVTL. In this study, the two different types of PV panels (monocrystalline and polycrystalline) are being used because mostly commercial PV installations contain these two types only. However, monocrystalline solar plates are considered more efficient because they are a single source of silicon crystal. To create the unique cell shape, square silicon wafers are used to produce mono panels, with their corners trimmed off. The rating of monocrystalline solar panel used in this experiment is given below in [Table 1](#).

In addition to that, the properties of polycrystalline panel used in the experiment are provided below in [Table 2](#). Moreover, both

different types of PV panels have been studied under the impact of two various HVTL levels, i.e., 220 and 500 KV.

To investigate the effect of electromagnetic field (developed by HVTL), Mono crystalline and poly crystalline panels are fixed together by adjustable supporting structure (to vary the distance between panels and HVTL). Initially the experimentation is performed for 500 KV and later for 220 KV. Under 500 KV, the values of electromagnetic fields are observed by electromagnetic radiation meter and field strength is altered by moving the panels upwards/downwards (the distance is varied between 0 and 130 ft). Electromagnetic radiation meters are accurate devices which are globally used for the precise

TABLE 6 Polycrystalline PV parameters at different distances under 500 KV HVTL.

Distance y (ft)	Magnetic field B (uT)	Electric field E (V/m)	PV current (A)	PV voltage Vload (V)	PV power P load(W)
0	7.87	1230	1.73	34.3	59.339
30	6.12	818	1.74	34.6	60.204
50	6.06	648	1.75	34.6	60.55
70	5.59	620	1.75	35.3	61.775
90	3.34	610	1.75	35.4	61.95
110	2.07	474	1.76	35.4	62.304
130	1.69	218	1.77	35.2	62.304

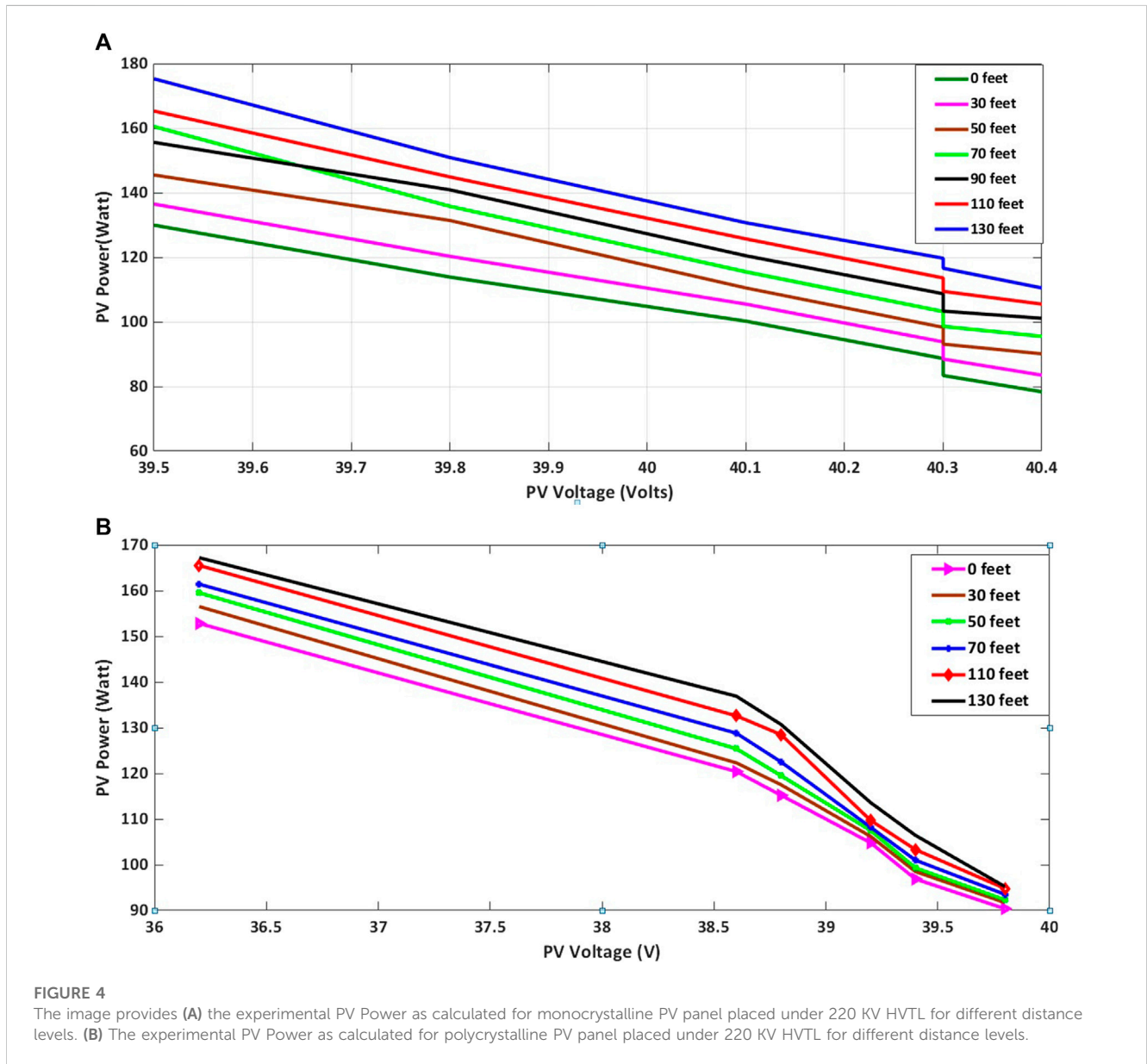


FIGURE 4 The image provides (A) the experimental PV Power as calculated for monocrystalline PV panel placed under 220 KV HVTL for different distance levels. (B) The experimental PV Power as calculated for polycrystalline PV panel placed under 220 KV HVTL for different distance levels.

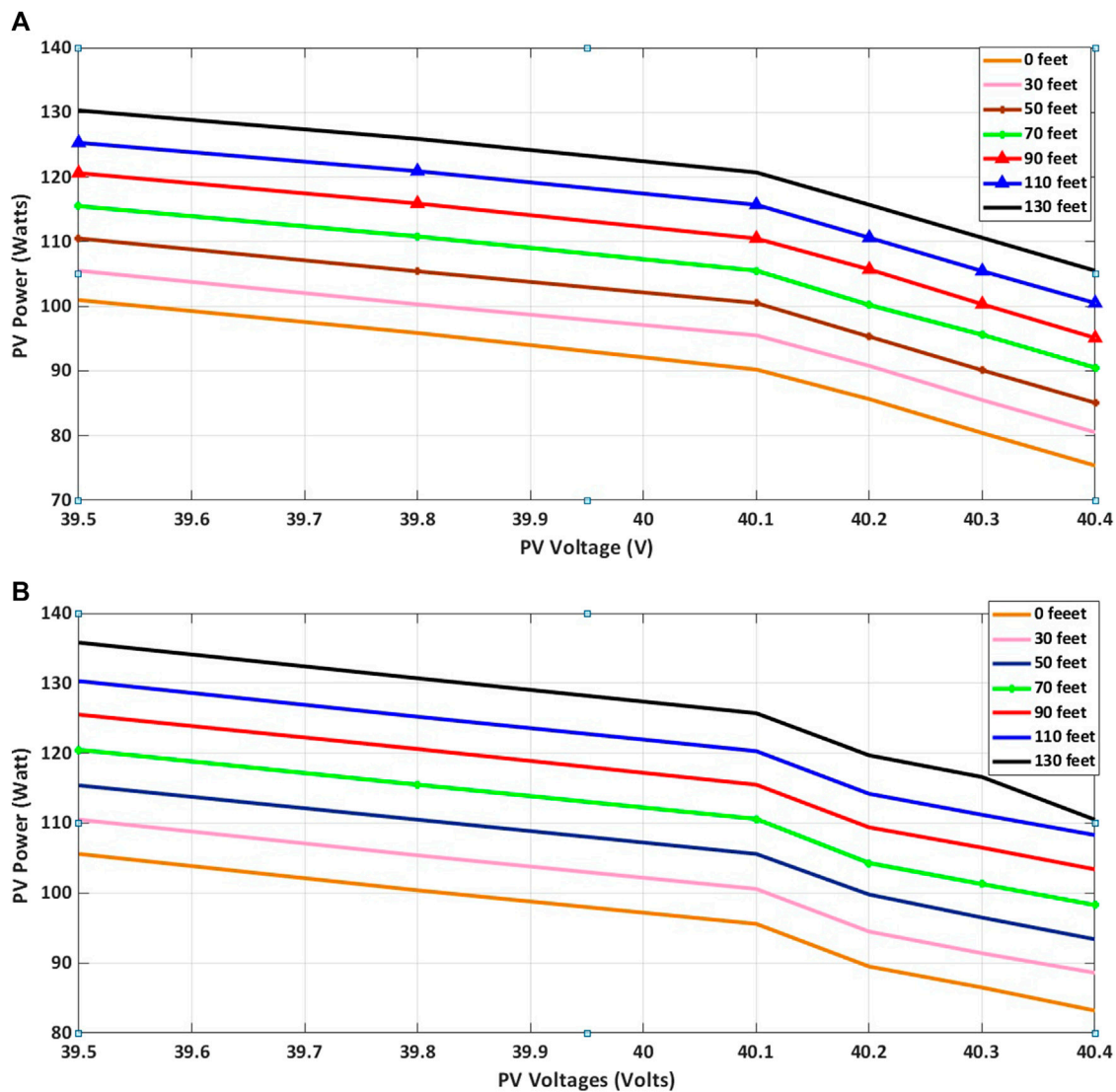


FIGURE 5 The image provides (A) the experimental PV Power as calculated for monocrystalline PV panel placed under 500 KV HVTL for different distance levels. (B) The experimental PV Power as calculated for polycrystalline PV panel placed under 500 KV HVTL for different distance levels.

measurement of electromagnetic (EM) waves, electric and magnetic fields associated with these EM waves. Moreover, this may measure electromagnetic fields which are being emitted from high voltage transmission lines, electrical wiring, and equipment, etc. It is worth mentioning that, at the center of transmission line, the value of electromagnetic field is maximum and is less on the sides of HVTL. Therefore, in this work, the maximum value of electromagnetic field available at center of HVTL has been chosen for further studies. It is further observed that the magnetic field (MF) strength starts reducing if we move the panel away from the HVTL and increases on moving closer to HVTL.

In this experiment, five DC loads of 100 W are connected in series with the PV panels and values of current, voltage and power are being recorded simultaneously. An ammeter is connected in series and a voltmeter in parallel across the loads to measure the current and voltage values and to calculate the power. The

measurements are being taken simultaneously along with variations in the experimental setup (distance change of both types of solar panels from the HVTL).

Later, the same experimental setup is being tested under the 220 KV HVTL and the same experiment is replicated by varying the distance from the transmission line in increments of 20 feet. However, it is observed during the experiment, the practical measurements obtained from photovoltaic (PV) panel (by varying distances from the main transmission lines) have certain limitations. For instance, due to the dependency on sunlight irradiance, it is challenging to capture values at 0 V or discrete voltage levels in this experimental setup. Therefore, this significant challenge is being handled by utilizing an Artificial Neural Network (ANN), which allows for the generation of a complete Power vs. voltage curve for the PV panels. An ANN function is like the human brain and consists of

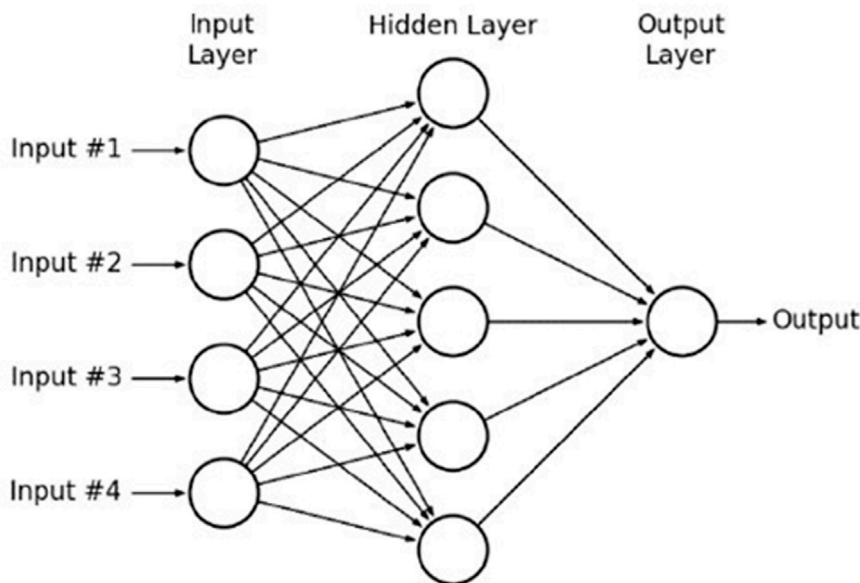
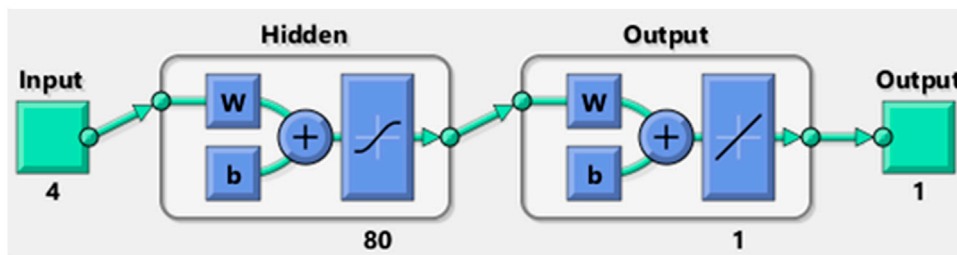


FIGURE 6
The Simulink model of ANN explaining layers in neural network.

three layers: the input layer, hidden layer, and output layer. The input layer serves as a receptor for commands or a database, while the hidden layer evaluates the data. The output layer acts as a neuron transmitter. The processing in the hidden layer occurs through iterations known as epochs, and there can be any number of hidden layers. The ANN can operate using feedforward and feed backward methods, but in this case, the feedforward method is employed. In this work, the ANN takes the experimental data as input and generates the impact plots for the conditions which are not possible to attain through experimental setup.

4 Results and discussion

This section presents experimental results taken at field level of 220 KV and 500 KV transmission lines with two different types of PV panels. In this proposed configuration, both monocrystalline and polycrystalline photovoltaic (PV) panels have been employed to understand the HVTL impact on both types. The panels are positioned beneath 220 KV and 500 KV transmission lines, at varying distances ranging from 0 m to 130 feet, with intervals of 20–30 feet. The voltage and power

readings are recorded at each interval, ensuring consistent weather conditions. The corresponding power and voltage values for different distances are presented in the tables (Tables 3–6) and figures (Figures 4, 5) as provided below. Tables 3,4 present the variations of voltage, current and power as obtained from the PV panels of monocrystalline and polycrystalline respectively, placed under 220 KV HVTL. The tables also provide the values of magnetic and electric fields, calculated by the electromagnetic detector at different distances between HVTL and PV panels. It is evident from the data that electromagnetic fields strength increases on moving closer to HVTL and decreases on moving away from the HVTL. The measured results enlisted in Tables 3,4 have been depicted graphically in Figure 4. This can be easily observed from Figure 4 that PV output power of both types of panels drop on moving the panels closer to the HVTL and increases on moving away from the HVTL under standard test conditions (STC). However, the drop of power is more noticeable in polycrystalline PV panels as compared to monocrystalline due to their least efficiency as compared to monocrystalline panels. In fact, the impact of HVTL on solar panels leads to a decrease in power production and this can be explained in two ways. Firstly, it reduces the photocurrent density, resulting in a decrease in the

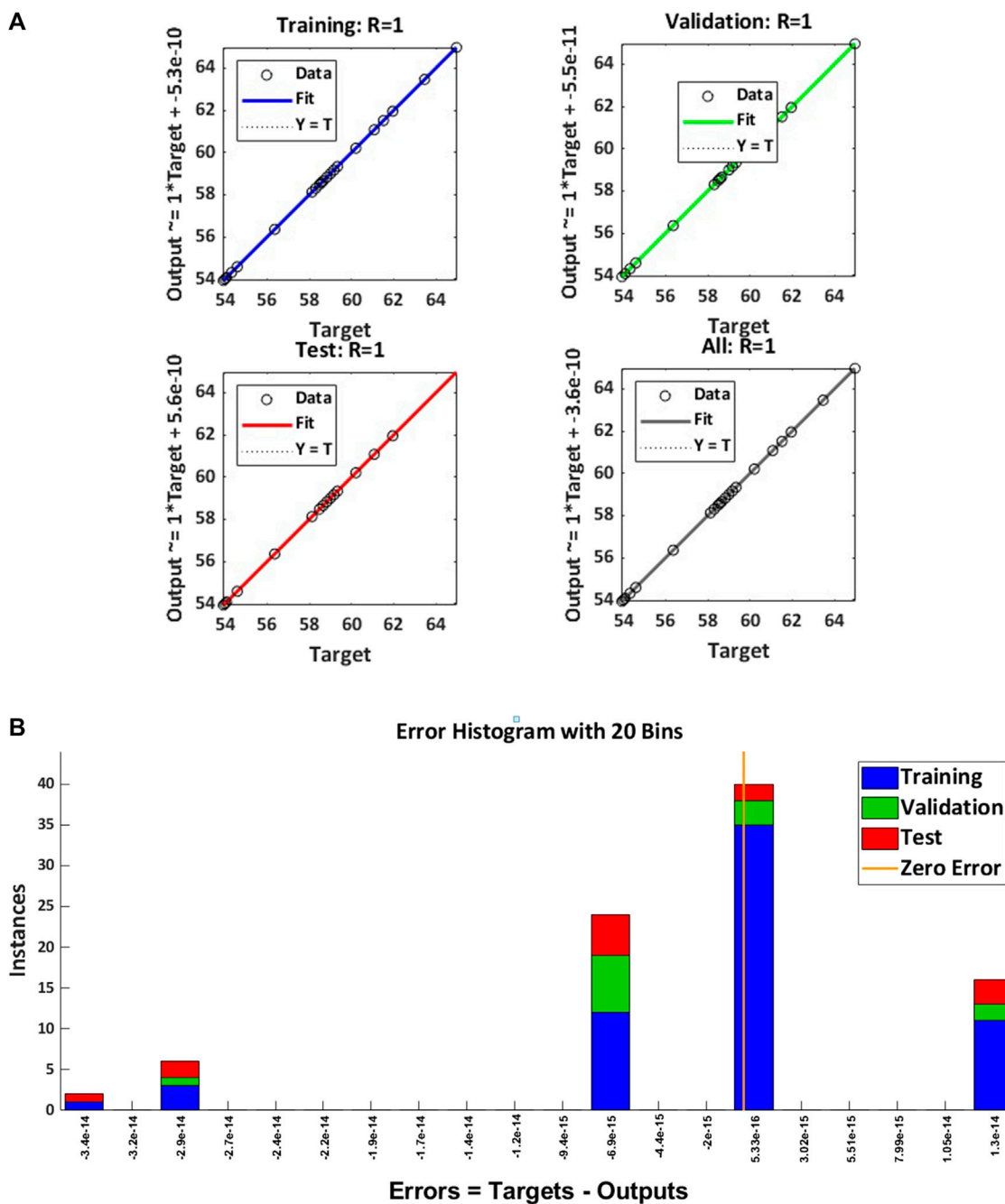


FIGURE 7
 (A) Artificial Neural Network: Training, testing and target value of data. (B) The error Histogram with 20 Bins.

power output of PV panels. Secondly, it diminishes the incident light energy absorbed by PV cells, particularly the partially circularly polarized light (PCPL).

After that, the PV parametric studies have been repeated for both types of PV panels under 500 KV HTL. The corresponding results have been tabulated in [Tables 5, 6](#). The increase in HVTL level increases the electromagnetic field strength and thus decreases the power more drastically as compared to 220 KV transmission line. The corresponding results have been plotted and displayed in [Figure 5](#) for different distance levels. Moreover,

the decay of output power is more rapid in polycrystalline as compared to monocrystalline on moving the panels closer to transmission lines. Moreover, it was observed that in the electromagnetic field developed by HVTL, the magnetic field shows noticeable impact on the generated power from PV panels and the generated power reduces on making PV panel closer to the HVTL due to increase in magnetic field strength. Whereas the electric field generated by HVTL shows no noticeable impact on the performance of PV ([Fathabadi, 2018b](#)).

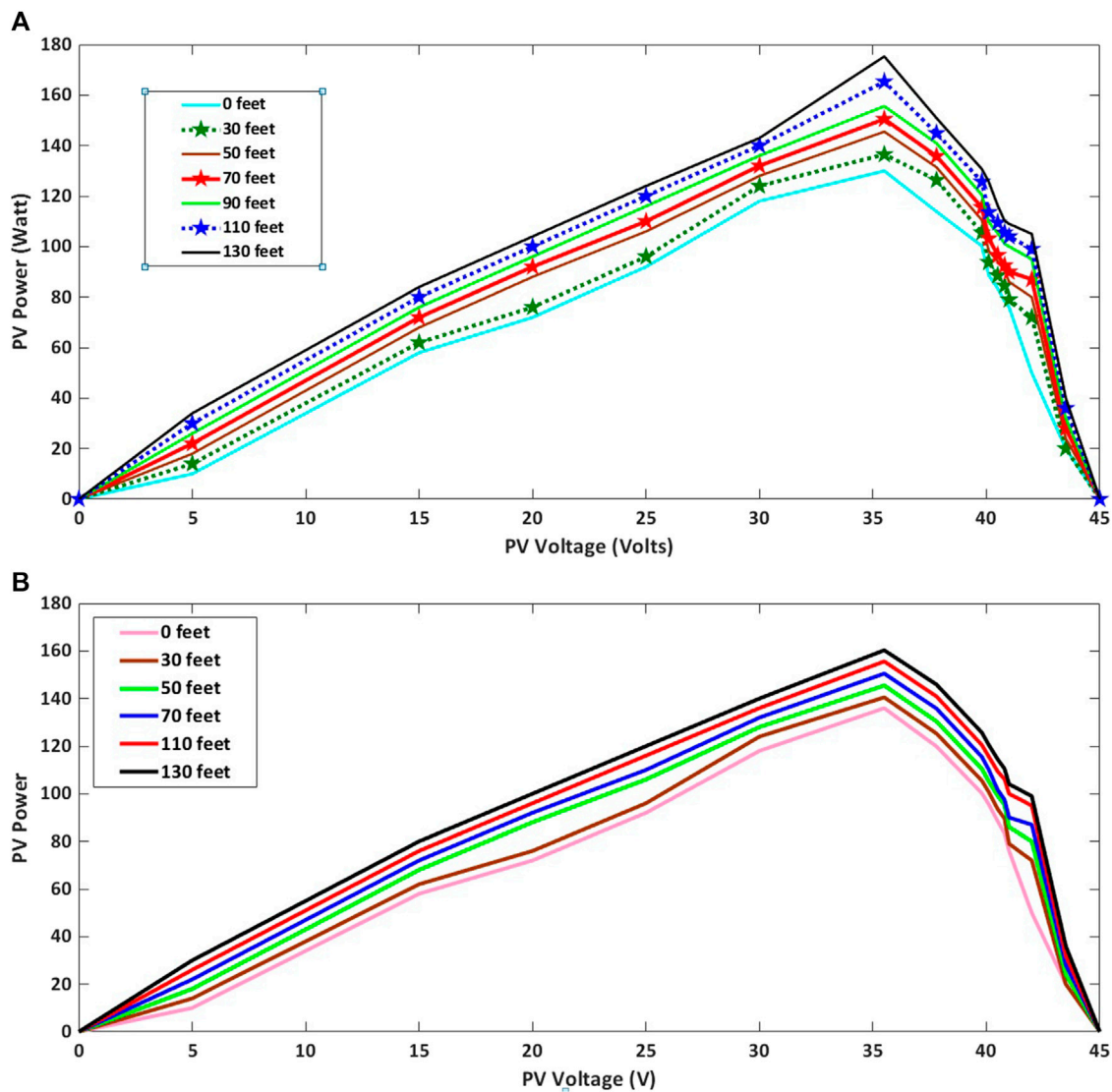


FIGURE 8 (A) The relation curve of PV voltage and power at different distances from 220 KV lines for monocrystalline by applying ANN. (B) The relation curve of PV voltage and power at different distances from 220 KV lines for polycrystalline by applying ANN.

However, it is worth mentioning that the obtained experimental data has certain limitations (for instance, PV power values can be obtained only against a limited voltage range) and cannot provide the complete analysis picture for the extended conditions. Thus, there is dire need to use the obtained experimental data to get broader look of HVTL impact on PV panels via artificial intelligent techniques such as: artificial neural network (ANN). It is also worth noting that to handle the mentioned issue, artificial intelligence technique “artificial neural network using feed forward fitting” is being used in this work. The feedforward architecture of neural network consists of three layers; including input layers, hidden layers, and output layer. The number of inputs and outputs can be arranged according to problem statement. In hidden layers, each neuron has weighted inputs and bias from previous layers, as given in Equation 7. Where M_k^{j-1} represent the input from k nodes, $W_{k,j}$ represents

the link between nodes of all previous layers and node k, and b_j is bias to node (Arce-Medina and Paz-Paredes, 2009).

$$Y_i = \left(\sum_{k=1}^{N_j-1} M_k^{j-1} W_{k,i} - b_k \right) \tag{7}$$

The main Simulink model for ANN is provided in Figure 6. It contains four inputs and one output; whereas the hidden layer of ANN has 80 neurons, which have been used to train the data. The experimental data (enlisted in Tables 3–6) received in experimentation is being used as input to train the model in ANN.

The testing, target and training of data is provided in Figure 7A, where the dot circles represent data and solid line represents fit line. If the data remains on the line, it represents higher accuracy and if the data is below line, it shows errors in the training. Furthermore, the performance function of ANN is Mean Square Error (MSE). In order to train this network, more than a thousand samples are taken

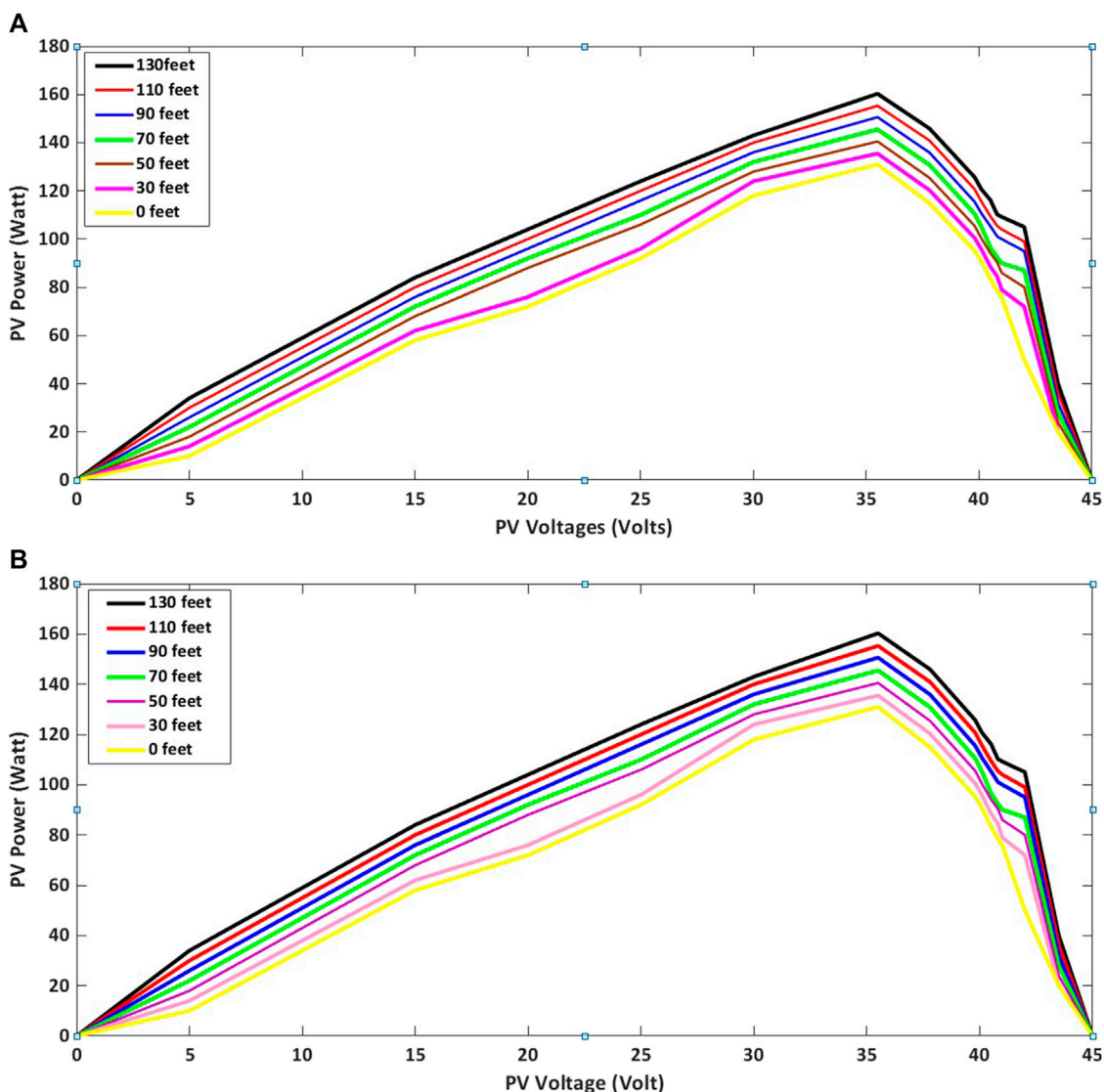


FIGURE 9 (A) PV voltage and Power at different distances from 500 KV lines for monocrystalline material by applying ANN (B) PV voltage and Power at different distances from 500 KV lines for polycrystalline material by applying ANN.

and the corresponding error histogram for this case is provided in Figure 7B. The zero error is equal to zero and other data near to zero represents very few errors in the system.

The experimental results outlined in Figures 4, 5 have been utilized with an Artificial Neural Network to extract the complete waveform of a PV panel to analyze the impact of HVTL at extended range. Due to the limited data range for ANN in this case, a deep learning approach with multiple layers has been employed to achieve accuracy. The error histogram and training data results demonstrate that the data has been effectively trained, resulting in accurate outcomes compared to alternative methods. Figure 8A illustrates the complete waveform of a monocrystalline PV panel at different distance levels (0–130 feet) under the impact of 220 KV lines using ANN. The experimental findings in Figures 4, 5 indicated a limited output range, while the full range (0–45 V) has been obtained

using an artificial neural network (ANN). The graphs in figure demonstrate the accurate tracking of the entire curve, with higher output power observed at greater distances from HV lines and lower output power values closer to HV lines. Figure 8B represents the complete PV panel waveform for polycrystalline solar cell under the impact of 220 KV HVTL using ANN technology. The decay trend of PV output power in case of polycrystalline is like monocrystalline, i.e., decrease in power on moving the panel closer to HVTL. However, the curves at different distances show that the effect of HV lines is higher for polycrystalline panels as compared to monocrystalline panels.

Figure 9A depicts the effect of 500 KV lines on monocrystalline panel through Power-Voltage curve of panel using ANN at different distances. The curves show that the effect of 500 KV lines is higher on monocrystalline panel as compared to 220 KV lines due to

increase in electromagnetic field strength. Figure 9B expresses the impact of 500 KV lines on the extended range of polycrystalline panels using an Artificial Neural Network (ANN). The ANN, based on deep learning, precisely models the entire voltage spectrum and calculates the impact of HVTL at different distance levels. The obtained results as visualized through curves, indicate that as the distance increases between PV panel and HVTL, the output power increases. On the other hand, when the solar panel moves closer to the HV lines, the output power decreases. The results trend obtained through ANN method is like the results as received through experimental setup. The experimental findings further indicate that the HVTL impact on the open circuited voltage and power of solar panels is greater at the 500 KV level as compared to the 220 KV level. This is attributed to the presence of a stronger magnetic field intensity surrounding the solar module. Additionally, the choice of material also plays a role and monocrystalline materials are less impacted by HVTL as compared to polycrystalline materials under both 220 KV and 500 KV voltage levels.

5 Conclusion

This comprehensive study contributes to our understanding of how HVTLs can influence the performance of solar cells, providing valuable information for the development and implementation of solar energy systems in the presence of high voltage power transmission lines. The solar energy has become a popular candidate in the recent world due to its outstanding advantages. However, it has been observed that solar production performance may get impacted with various environmental factors and thus there is utmost need to explore the possible effect of these factors. This research work focuses on investigating the impact of high voltage power transmission lines (HVTL) on solar cells, specifically at two voltage levels: 220 and 500 KV. Additionally, it also presents a comparative analysis of the HVTL impact on both monocrystalline and polycrystalline solar cells at different distance levels between HVTL and solar panels. The study aims to understand how the presence of HVTLs affects the performance of solar cells, considering factors such as power production and photocurrent density. To achieve this, an experimental setup is established, incorporating both monocrystalline and polycrystalline solar cells and is placed in the proximity of 220 and 500 KV HVTLs. The obtained results show that the electromagnetic fields generated by HVTL reduce the output power of solar panels and deteriorates their performance. It is further noticed that the impact of HVTL on solar panels gets stronger on moving the panels closer to the HVTL due to increase in electromagnetic strength of HVTL. Moreover, the 500 KV HVTL impacts more the solar panels as compared to 220 KV HVTL due to stronger EM waves generated by 500 KV. This study is also evaluated by varying the material of panels and concludes that the monocrystalline panels are less affected by HVTL in comparison to polycrystalline due to their higher solar efficiency with reference to polycrystalline panels.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

MJ: Data curation, Formal Analysis, Methodology, Validation, Visualization, Writing–original draft. MH: Software, Validation, Visualization, Writing–review and editing. MU: Investigation, Methodology, Writing–review and editing, Formal Analysis. FA: Investigation, Writing–review and editing, Methodology. MS: Data curation, Writing–original draft, Methodology. WA: Investigation, Writing–review and editing, Project administration. GL: Formal Analysis, Project administration, Writing–review and editing, Resources. AW: Conceptualization, Formal Analysis, Investigation, Project administration, Supervision, Validation, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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