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Simulation of Dye Synthesized Solar Cell using Artificial Neural Network

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Abstract*: The primary goal of present examination is to foresee every day worldwide solar cell efficiency in view of meteorological factors, utilizing distinctive counterfeit neural system (ANN) procedures. In the present examination we report the impact of Dye Synthesized solar cell. A three-layer artificial neural network (ANN) model was developed to predict the efficiency of Dye Synthesized solar cell based on 100 experimental sets. In the present examination we report the impact of Dye Synthesized solar cell. The effect of operational parameters such as short circuit current (Jsc),Open circuit voltage(Voc),Fill factor(FF) were studied to optimize the conditions to check the efficiency of Dye Synthesized solar cell. Experimental results showed that the ANN model was able to predict adsorption efficiency with a tangent sigmoid transfer function (tansig) at hidden layer with 20 neurons and a linear transfer function (purelin) at output layer. The Levenberg–Marquardt algorithm (LMA) was used with a minimum mean squared error (MSE) of 0.00350141. The linear regression between the network outputs and the corresponding targets were proven to be satisfactory with a correlation coefficient of about 0.9993 for six model variables used in this study.

***Keywords* : ANN, Dye Synthesized solar cell, Mean-Square error, Simulation**

I. INTRODUCTION

A solar cell has gotten expanding interest since it is a quaternary semiconducting compound. A Dye Synthesized solar cell is an ease solar cell having a place with the gathering of thin film solar cells. It depends on a semiconductor shaped between a photograph sensitized anode and an electrolyte. This solar cell is easy to make utilizing ordinary move printing strategies, is semi-adaptable and semi-straightforward which offers an assortment of employments not appropriate to glass-based frameworks, and a large portion of the materials utilized are low-cost. By surpassing this solar cell in MATLAB, we predicated result eagerly energizes with the test results. To get a productive solar cell we measure the working of the ANN model as to mean square mistake (MSE) and the relationship coefficient between expected yield and yield given by the system. Results attest the security of Dye Synthesized solar cell.

Among the standard physical parameters, the vitality protection is the one checked and controlled generally in present day, nearby and all the part reaching standard human life. There exist collections of vitality holding devices which have progressed over various long periods of innovative work. In this present work we picked the solar cell named as dye synthesized in light of the fact that dye synthesized is a promising material for ease thin film solar cells, in perspective on its proper band gap and huge maintenance coefficient.

Mozhgan Hosseinnezhad applied Artificial Intelligence approach in design of dye sensitized solar cells. He has explored investigated association between development parameters with cell performance. Predicted stochastically control transformation productivity and toughness of DSSCs. Discovered conditions required to expand both change productivity and durability.Realized DSSCs proposed by the model with greatest potential attributes [1]. M. A. Behrangv utilized Multi-layer perceptron (MLP) and outspread premise work (RBF) neural systems are connected for every day GSR demonstrating dependent on six proposed combinations. The correlation of got results from ANNs and diverse regular GSR forecast (CGSRP) models indicates generally excellent upgrades [2]. Carlos J. P. Monteiro reasons that most dyes demonstrated great energy coordinating between energized state energies and the TiO_2 conduction band. The viable separation between the porphyrin center and the TiO_2 surface has key significance in cell efficiencies [3]. Slawomir Kula observed that the photovoltaic gadgets dependent on TiO_2 sharpened with the acquired particles showed low control transformation efficiency, which was the most noteworthy for the gadget containing the balanced atom with bithiophene structure [4].

II. COMPUTATIONAL TOOL

A neural system is a figuring model whose layered structure takes after the organized structure of neurons, with layers of associated nodes Artificial Neural Network (ANN) is a bio-charged processing structure which has various applications in the enhanced fields, for instance, characteristic science. In the scenery of the widespread investigation of ANN as respects to the materials science, the present paper reports the prediction of dye synthesized solar cell utilizing ANN. Techniques Used with Neural Networks:

- Supervised Learning
- Classification
- Regression
- Pattern cognition
- Unsupervised Learning

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III. ANN MODELING OF DYE SYNTHESIZED SOLAR CELL

Table- I: Experimental Results of dye synthesized solar cell

Name of the Solar Cell	Input Values			Experimental Results	Predicted Results using ANN
	J_{sc} (mA cm^{-2})	V_{oc} (mV)	FF	η (%)	η (%)
DYE SYNTHESIZED solar cell [Material used: TiO_2]	700	13	63.5	5.85	5.90574
	730	14.08	66.35	6.87	6.863658
	638	20.07	52.8	6.8	6.911473
	627	23.65	53.3	7.95	7.944104
	624	27.32	51.6	8.84	8.844838
	753	10.28	69	5.34	5.355474
	850	10.9	69	6.4	6.393007
	590	29.66	39	6.75	6.747456
	650	22.25	42	6.14	6.107475
	580	15.08	51	4.47	4.457269

For dye synthesized solar cell, we consider the following parameters or experimental data as an input to the neural - Synthesis method such as short circuit current (Jsc),Open circuit voltage(Voc),Fill factor(FF) and the output of the neural network contains efficiency. The Table I below shows the experimental results for dye synthesized solar cell.

To model the efficiency of dye synthesized solar cell, we have employed artificial neural network (ANN). The ANN prompts streamlined game plans in some progressing nonlinear issues. For the present assessment, normal feed-forward ANN is used. The framework contains input layer and yield layer.

IV. WORKING MODEL

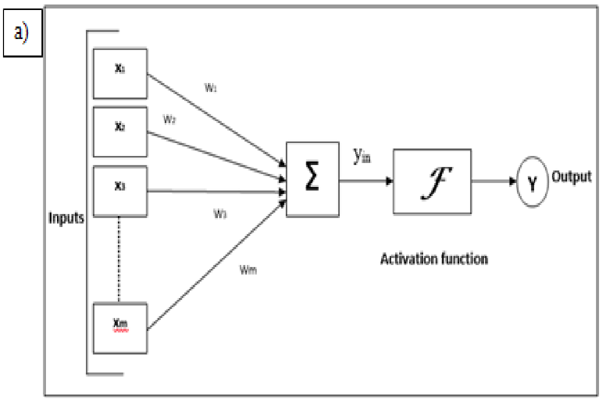

Fig. 1.Model of Artificial Neural Network. *(a)*

Figure 1 (a) represent Model of Artificial Neural Network. Figure 1 (b) represents the working model of dye synthesized Solar Cell using ANN. In MATLAB we have used the dye synthesized material to find the efficiency of corresponding solar cell with the help of ANN. By applying multiple hidden neurons in ANN we get the approximate results. To train the data we applied the specified measured inputs and outputs.

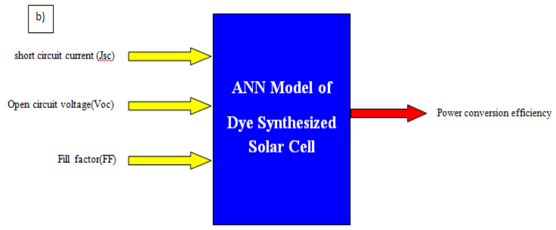

Fig. 2.Working model of DYE SYNTHESIZED solar cell using ANN *(b)*

The Levenberg-Marquardt feed-forward algorithm is used to train the present architecture. The short circuit current (Jsc), Open circuit voltage (Voc),Fill factor(FF) of DYE SYNTHESIZED solar cell is considered as inputs to the network, whereas efficiency is considered as the output of the network. By measuring the performance of the ANN model dye synthesized solar cell in terms of mean square error (MSE) and the correlation coefficient. The MSE is defined as,

$$\text{MSE} = \frac{1}{n}\sum_{i=1}^{n}\left(Y_i - \hat{Y}_i\right)^2 \qquad (1)$$

where Y_i is an actual value of the i^{th} observation and $\hat{Y}_i$represents the predicted value of the i^{th} observation. The difference $(Y_i - \hat{Y}_i)$ is termed as an error. The correlation coefficient between X and Y is,

$$r = \frac{\sum_{i=1}^{n}(X_i-\bar{X})\,(Y_i-\bar{Y}_i)}{\sqrt{\sum_{i=1}^{n}(X_i-\bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i-\bar{Y}_i)^2}} \qquad (2)$$

Where $\bar{X}$and $\bar{Y}$ denotes the arithmetic mean of the X and Y respectively.

Validation vectors are utilized to quit preparing early if the system execution on the approval vectors neglects to improve or continues as before formax_fail epochs in succession. Test vectors are utilized as a further watch that the system is summing up well, but don't have any impact on training.

Training on numerous times will produce various outcomes because of various introductory conditions and inspecting.

Table II below shows the Network performance for different numbers of hidden neurons

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Table- II: Network performance for different number of hidden neurons

No. of Hidden Neurons	% of Training	% of Validation	% of Testing	Dataset	Correlation coefficient	Average correlation coefficient
5	70%	5%	25%	Training	0.99849	0.99823
				Validation	0.99764	
				Testing	0.99715	
10	80%	15%	5%	Training	0.99946	0.99936
				Validation	0.9986	
				Testing	0.99987	
15	70%	15%	15%	Training	0.99921	0.99911
				Validation	0.99908	
				Testing	0.9987	
20	80%	10%	10%	Training	0.99983	0.9993
				Validation	0.99929	
				Testing	0.99548	
25	90%	5%	5%	Training	0.99967	0.9996
				Validation	0.99903	
				Testing	0.99662	
30	90%	5%	5%	Training	0.99992	0.9998
				Validation	0.99924	
				Testing	0.99921	

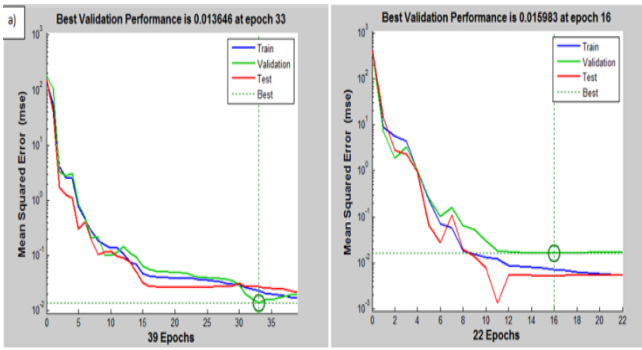

Fig. 2. Performance of ANN model of Dye Synthesized solar cell. By changing the values of hidden neuron i.e.5,10 for mean square error of network provided by the network *(a)*

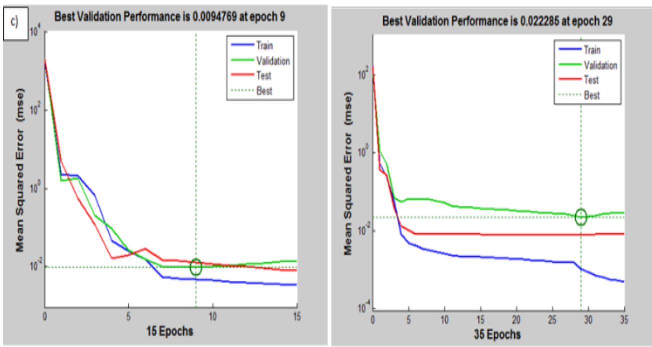

Fig. 2. Performance of ANN model of Dye Synthesized solar cell. By changing the values of hidden neuron i.e.25,30 for mean square error of network provided by the network *(c)*

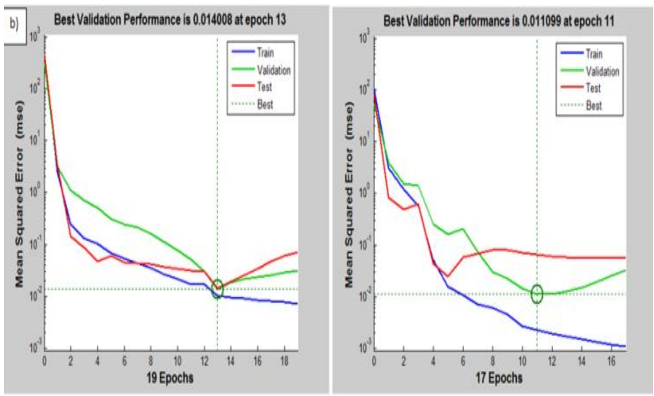

Fig. 2. Performance of ANN model of Dye Synthesized solar cell. By changing the values of hidden neuron i.e.15,20 for mean square error of network provided by the network *(b)*

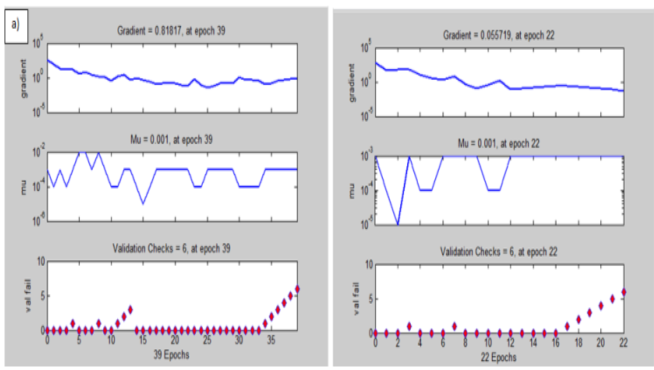

Fig. 3. Performance of ANN model of Dye Synthesized solar cell. By changing the values of hidden neuron i.e.5,10 for gradient, mu (), and validation checks parameters of the network *(a)*

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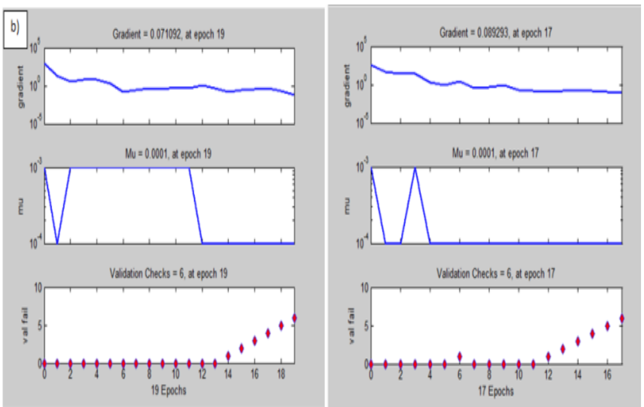

Fig. 3. Performance of ANN model of Dye Synthesized solar cell. By changing the values of hidden neuron i.e.15,20 for gradient, mu (), and validation checks parameters of the network *(b)*

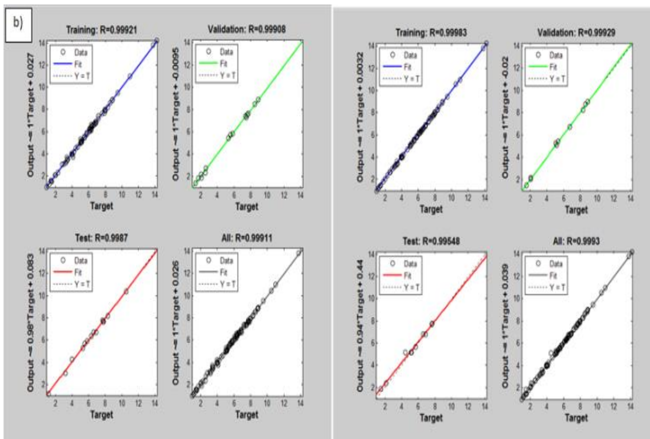

Fig. 4. Performance of ANN model of Dye Synthesized solar cell. By changing the values of hidden neuron i.e.15,20 for the correlation coefficient of the output *(b)*

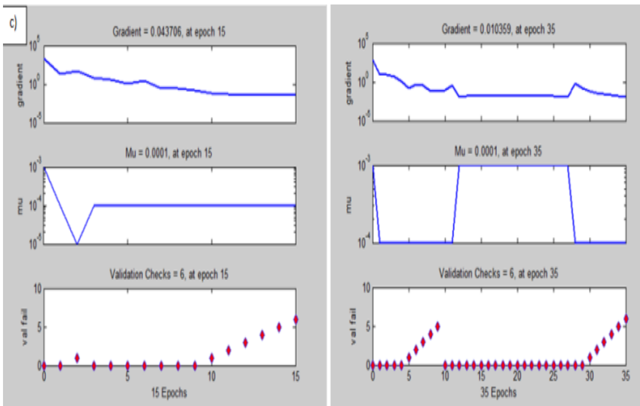

Fig. 3. Performance of ANN model of Dye Synthesized solar cell. By changing the values of hidden neuron i.e.25,30 for gradient, mu (), and validation checks parameters of the network *(c)*

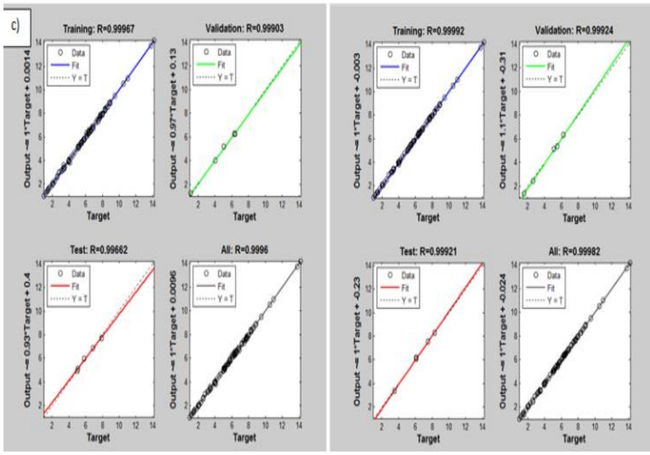

Fig. 4. Performance of ANN model of Dye Synthesized solar cell. By changing the values of hidden neuron i.e. 25,30 for the correlation coefficient of the output *(c)*

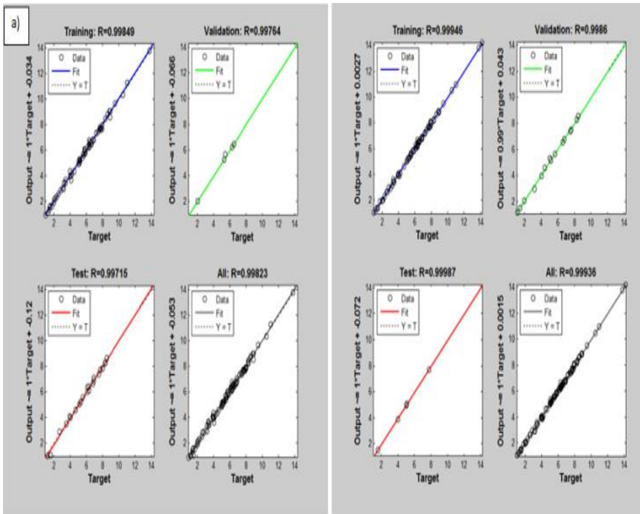

Fig. 4. Performance of ANN model of Dye Synthesized solar cell. By changing the values of hidden neuron i.e.5,10 for the correlation coefficient of the output *(a)*

V. PERFORMANCE MEASUREMENT OF ANN MODEL

Figure 4 presents the performance of ANN model of Dye Synthesized solar cell. Figure 2 (a,b,c) represents correlation coefficient of the output provided by the network. This is also called the Regression. Regression is a statistical metric used in finance, investment and other disciplines to determine the power of the connection between one dependent variable and a number of other factors.

When hidden neuron value is'5' then the correlation coefficient for training data set is (i. e. 0.99849), whereas for validation dataset, it becomes 0.99764 i.e. approximately equal to 1 and for testing dataset it to becomes 0.99715. The overall correlation coefficient of the output and provided by the network is equal to 0.99823. When hidden neuron value is'10' then the correlation coefficient for training data set is 0.99946, whereas for validation dataset, it becomes approximately 0.9986 and for testing dataset it becomes 0.99987. The overall correlation coefficient of the output and provided by the network is equal to 0.99936.

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When hidden neuron value is'15' then the correlation coefficient for training data set is 0.99921 whereas for validation dataset, it becomes approximately 0.99908 and for testing dataset it becomes 0.9987. The overall correlation coefficient of the output and provided by the network is equal to 0.99911. When hidden neuron value is'20' then the correlation coefficient for training data set is 0.99983, whereas for validation dataset, it becomes 0.99929 and for testing dataset it becomes 0.99548. The overall correlation coefficient of the output and provided by the network is equal to 0.9993. When hidden neuron value is'25' then the correlation coefficient for training data set is 0.99967, whereas for validation dataset, it becomes 0.99903 and for testing dataset it becomes 0.99662. The overall correlation coefficient of the output and provided by the network is equal to 0.9996. When hidden neuron value is'30' then the correlation coefficient for training data set is 0.99992, whereas for validation dataset, it becomes 0.99924 and for testing dataset it becomes 0.99921. The overall correlation coefficient of the output and provided by the network is equal to 0.99982.

The mean-square error and mu () of the network have value 0.0001 which is very small, and confirms the effectiveness of ANN in modeling Dye Synthesized solar cell.

Following graph shows that the optimized results of Dye Synthesized solar cell found at '20' hidden neurons.

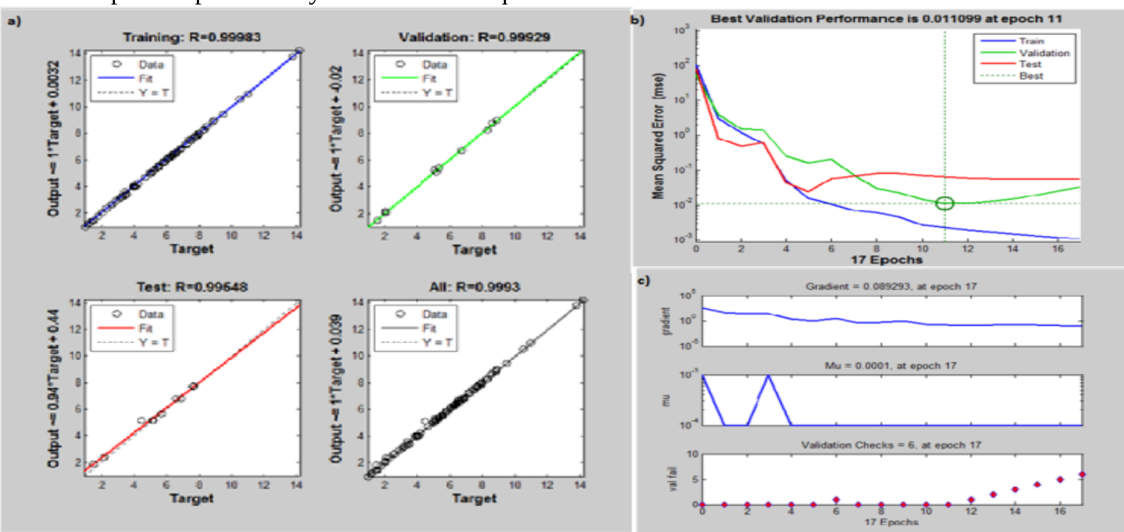

Fig. 5. Performance of ANN model with '20' hidden neuron value of DYE SYNTHESIZED solar cell. (a) correlation coefficient of the output provided by the network; (b) mean square error of network; (c) gradient, mu (μ), and validation checks parameters of the network

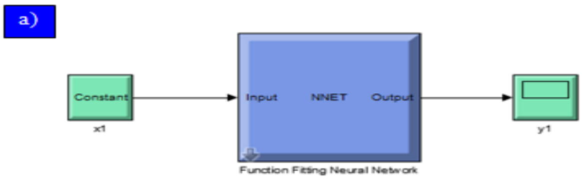

Fig. 6. Simulink diagram of the ANN model of the Dye Synthesized solar cell at hidden neurons equal to 20 presents the input and output mapping of the network. ***(a)***

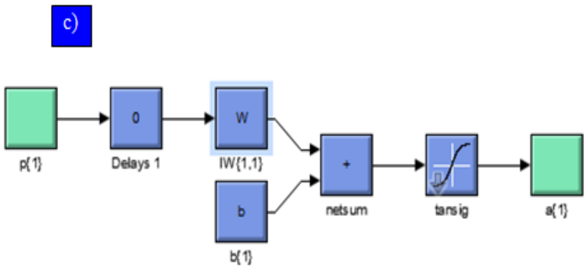

Fig. 6 Simulink diagram of the ANN model of the Dye Synthesized solar cell at hidden neurons equal to 20 reveals detail the structure of the hidden layer1. ***(c)***

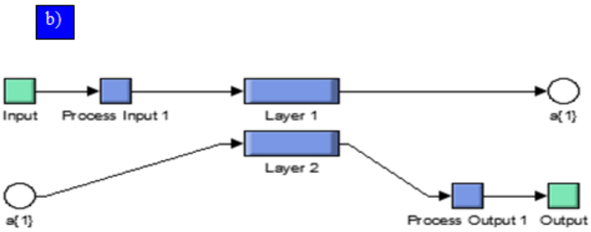

Fig. 6. Simulink diagram of the ANN model of the Dye Synthesized solar cell at hidden neurons equal to 20 depicts general structure of hidden layer and an output layerof the model. ***(b)***

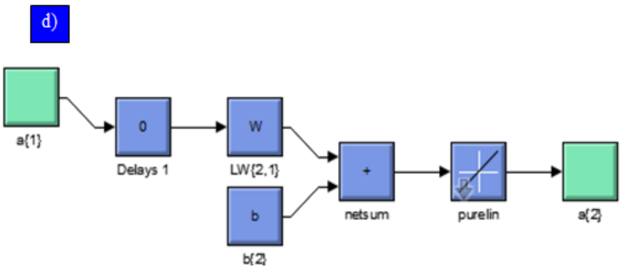

Fig. 6. Simulink diagram of the ANN model of the Dye Synthesized solar cell at hidden neurons equal to 20 depicts general structure of hidden layer and an output layer 2 of the model. ***(d)***

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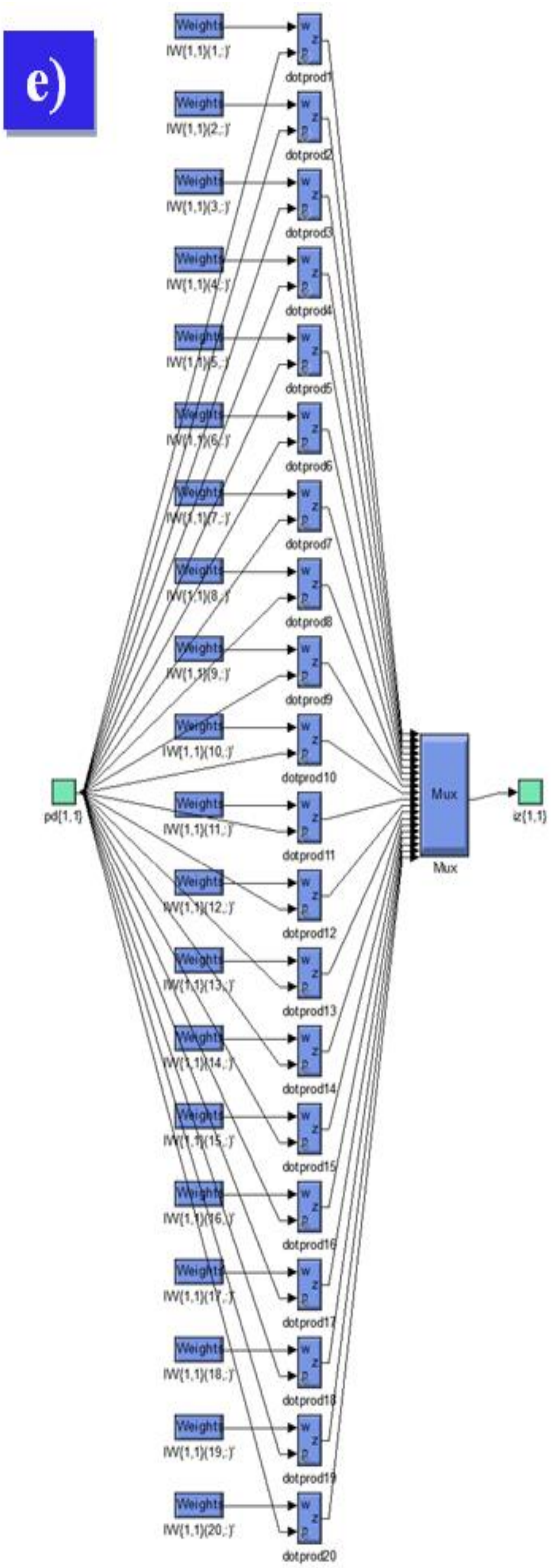

Fig. 6. Simulink diagram of the ANN model of the Dye Synthesized solar cell at hidden neurons equal to 20 exemplifies weights associated with the hidden layer 1 *(e)*

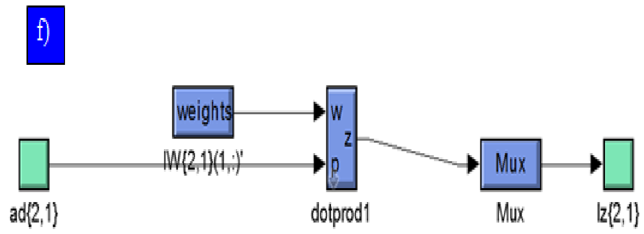

Fig. 6. Simulink diagram of the ANN model of the Dye Synthesized solar cell at hidden neurons equal to 20 exemplifies weights associated with the hidden layer 2 *(f)*

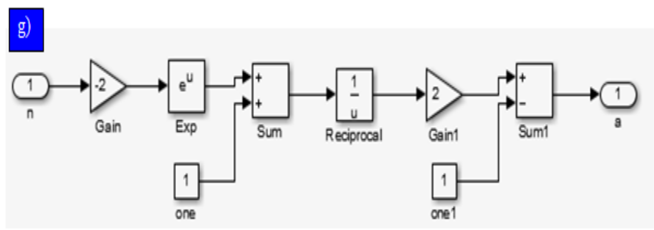

Fig. 6. Simulink diagram of the ANN model of the Dye Synthesized solar cell at hidden neurons equal to 20 consists of the hyperbolic tangent sigmoid transfer function and sums net input function of the Layer 1 *(g)*

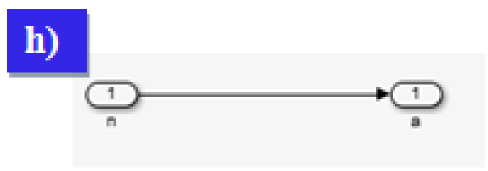

Fig. 6. Simulink diagram of the ANN model of the Dye Synthesized solar cell at hidden neurons equal to 20 consists of the linear transfer function of the Layer 2 *(h)*

Fig.6 (a-h) shows the simulink diagrams of the ANN model of the Dye Synthesized solar cell for hidden neuron equal to 20. Fig. 6 (a) presents the input and output mapping of the ANN model. Fig.6 (b) displays the general structure of hidden layer and output layer of the model. Fig.6 (c) exhibits detail structure of the hidden layer 1. This layer. The above-referred duo works as a transfer function and net input function for hidden layer. Fig. 6 (d) depicts general structure of hidden layer and an output layer 2 of the model. Weights of the hidden layer 1 and 2 are shown in the Fig. 6 (e) and Fig. 6(f) respectively. Fig.6 (e) present the detailed structure of the output layer. This layer consists of the linear transfer function and sums net input function. Fig. 6(g) consists of the hyperbolic tangent sigmoid transfer function and sums net input function of the Layer 1. This functions work as a transfer function and net input function for output layer and corresponding weights of the output layer are shown in the fig. 6 (e). Fig. 6(h) consists of the linear transfer function of the Layer 2.

VI. IMPACT OF HIDDEN NEURONS DYE SYNTHESIZED SOLAR CELL

For different neuron values we found different average errors of Dye Synthesized solar cell. These values are in between -0.3101 to 0.2244.

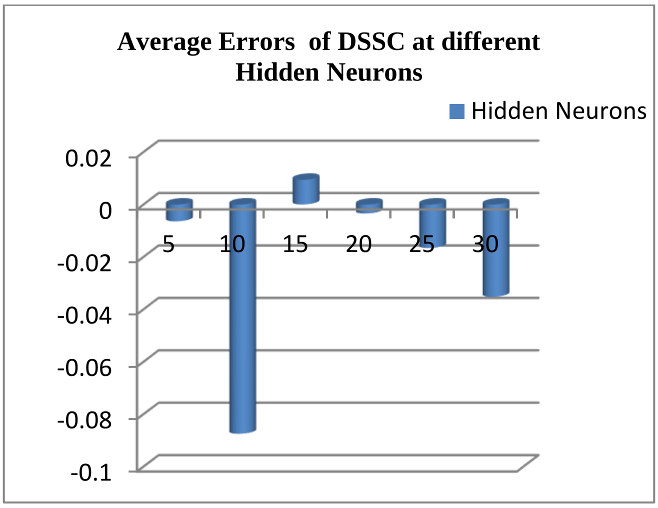

Fig. 7. Error found in different values of hidden neuron

Above graph shows that the negative average error values of Dye Synthesized solar cell found at 5, 10, 15, 20, 25and 30 hidden neurons. When Value of hidden neuron was ‘5’ then average value was -0.006426953. When Value of hidden neuron was ‘10’ then average value was -0.087453247. When Value of hidden neuron was ‘15’ then average value was 0.009414561. When Value of hidden neuron was ‘20’ then average value was -0.003422499. When Value of hidden neuron was ‘25’ then average value was -0.016586192. When Value of hidden neuron was ‘30’ then average value was -0.035176677. So above graph represents the minimum error found at ‘20’ hidden neurons. So this solar cell results are useful for optimization of solar cell parameters.

VII. CONCLUSION

In the present examination, we have effectively displayed the properties of Dye Synthesized solar cell utilizing the artificial neural network (ANN). The current ANN architecture is helpful for software development identified as a smart block for anticipating the characteristics of Dye Synthesized solar cells. For different neuron values we found different average errors of Dye Synthesized solar cell. For the hidden neuron 20 we got the effective result. So, we can conclude that at hidden neuron level '20' the efficiency of Dye Synthesized solar cell is high as compared to other hidden neurons.

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S K Kharade was born in 1989. She received her BCS and MCA in Shivaji University, Kolhapur. Currently she is pursuing her Ph.D in Computer Science. She has published 20+ papers in various conferences and journals. She is working as Assistant Professor in Department of Mathematics, Shivaji University, Kolhapur since 2016

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K G Kharade was born in 1987. He received his B.Sc (Computer Science) and MCA in Shivaji University, Kolhapur. Currently he is pursuing his Ph.D in Computer Science. He has published 25+ papers in various conferences and journals. He is working as Assistant Professor in Department of Computer Science, Shivaji University, Kolhapur since 2012