Estimation Scheme of 22 kV Overhead Lines Power System using ANN

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Abstract

Designing 22kV overhead lines is a task for experienced engineers and the process is very complex and time-consuming due to the many standards involved. Then, this article presents an artificial neural network (ANN) that can be applied to the design of 22 kV overhead lines. It helps to identify the main material lists and quantities needed in the installation and used in the project cost. The design input data are 1) Transformer rating 2) Total distance of the extended distribution line 3) The number of cable right angle points in the system does not require a brick extension line. The outputs of the ANN are the main material lists and the data used to train the ANN comes from the PEA installation standard. Tested by a PEA engineer, satisfactory results were obtained using an accurate and less time-consuming method than usual.

Keywords: distribution line; artificial neural network; overhead line

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1. Introduction

Due to the economics growth in present day make the demand of electrical energy increasing and need to expand the electrical distribution system more widely especially the 22kV distribution system, which is the most cover areas in Thailand. The design and estimation need for experience engineer and time consuming process.

From literature review found that no have any program are used to help engineer for estimate equipment and cost for 22 kV distribution line just have program for estimate cost that user must input equipment list that are used in PEA only [1]. An idea about program used for equipment estimation present in [2] use Artificial Neural Network (ANN) to estimate equipment in low-voltage electrical system in building that does not include transformer and 22 kV distribution line. ANN has the ability to digest large amount of data, memorize the training data and the performance of parallel computing, which is also input all at once, it can give you an answer faster than other methods [3]. And ANN can learn new more information that means we can use the knowledge from expert to teach ANN in computer to make a smarter computer [2]. Therefore this paper presents the use of ANN to help in materials estimation in 22 kV overhead lines.

Nomenclature

ANN	artificial neural network
SAC	spaced aerial cable
P	number of concrete pole
D	expanding distance of distribution system [m]
R	number of right angle of cable path
L	number of line post insulator
S	number of suspension insulator

2. Equipment used in 22 kV overhead line

This information is based on PEA standards [4].

Cable

Usually as Spaced Aerial Cable (SAC) which available in three size 50, 95 and 185 mm^2 chosen according to transformer sizes. The length of cable used to be three time of expanding distance of distribution system.

Concrete pole 12 m

Calculated from expanding distance of distribution system, distance between each pole should less than 40 m that can calculate as equation 1.

$$P = \frac{D}{40} + 1 + R \qquad (1)$$

where P is number of concrete pole, D is expanding distance of distribution system [m], and R is number of right angle of cable path.

Line post insulator and suspension insulator

Line post insulator are used for support cable without any tension it is located on every pole except on the last pole of system that have tension and for suspension insulator are used for support cable with tension along with cable length it is located on first pole, last pole and pole at right angle can calculate as equation 2 and 3.

$$L = [(P-1)\times 3] \quad (2)$$

$$S = 27 + (R\times 18) \quad (3)$$

where L is number of line post insulator, S is number of suspension insulator, P is number of all poles, and R is number of right angle.

Fig. 1. Line post and suspension insulator

Cross-arm concrete

Cross-arm is used for support or suspense the insulator and other equipment cross-arm that commonly used in 22 kV overhead line are available in three sizes as follow: 1) Length 2500 mm is used for insulator, 2) Length 3200 mm is used for surge arrestor and dropout fuse in transformer platform and 3) Length 3450 mm is the large one used for support transformer in transformer platform

Transformer installation

It can be installed in three difference way depend on size of transformer and a suitable installation site as follows: 1) Hanging on single pole is used for 30 kVA single phase transformer and 50-160 kVA three phase transformer, 2) Platform used for three phase transformer rated less than 1000 kVA and 3) Concrete foundation used for three phase transformer rated 315 - 2000 kVA.

Dropout fuse

PEA has set standard for choosing dropout fuse that according to the size of transformer that can search by reference [4].

Fig. 2. Dropout fuse

3. Artificial Neural Network (ANN) and its Application

This paper use MATLAB for creating and training ANN with 3 inputs as follows: 1) Rated of transformer, 2) Distance system of expansion, and 3) Number of right angle. The ANN output has 9 outputs as follow: 1) Length of cable, 2) Size of cable, 3) Number of concrete pole, 4) Number of line post insulator, 5) Number of suspension insulator, 6) Number of cross-arm 2500 mm, 7) Number of cross-arm 3200 mm, 8) Number of cross-arm 3450 mm, and 9) Rated of dropout fuse. The structure of ANN has 20 neural in hidden layer and 9 neural in output layer as Fig.3.

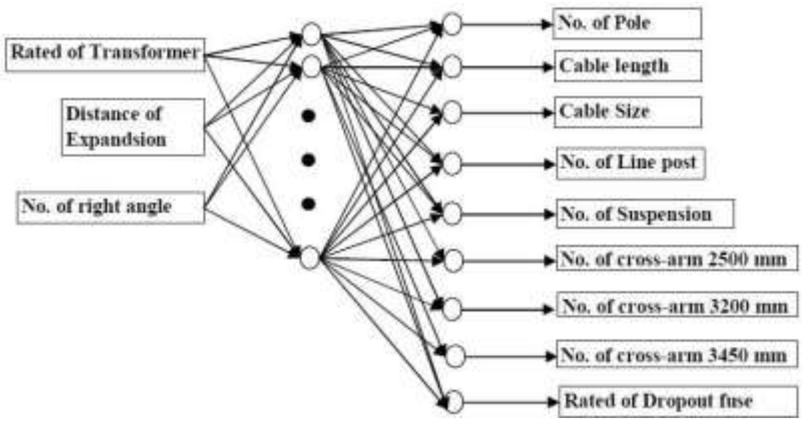

Fig. 3. ANN Structure

Providing the data for training ANN by designing the 22kV overhead line according to PEA standard by distance 40 to 1000 m. use all rated of transformer available in market and right angle from 0-5 point example in table 1 which show only some of all training data in Fig.4 show decreasing of error during training. And for more convenient use of the program we use Graphic User Interface (GUI) as Fig.5

Table 1. Example of training data

input							Output				
Rated of Transformer [kVA]	Distance of expandsion system [m]	No. of right angle	Cable length [m]	Cable size [Sqmm]	No of pole	No. of Line post	No. of Suspension	No. of cross-arm 2500 mm	No. of cross-arm 3200 mm	No. of cross-arm 3450 mm	Rated dropout fuse [A]
30	40	0	120	50	2	3	27	4	0	0	2
30	80	0	240	50	3	6	27	5	0	0	2
30	120	1	360	50	5	12	45	10	0	0	2
500	400	0	1200	185	13	36	27	15	2	2	20
500	440	1	1320	185	15	42	45	20	2	2	20
500	480	2	1440	185	17	48	63	25	2	2	20
2000	920	1	2760	185	25	72	45	30	0	0	65
2000	960	2	2880	185	27	78	63	33	0	0	65
2000	1000	3	3000	185	29	84	81	38	0	0	65

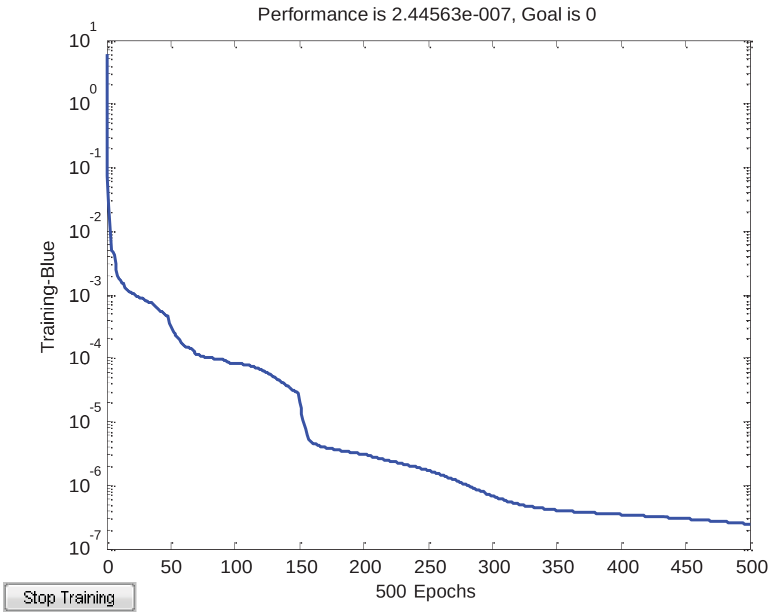

Fig. 4. Decreasing of error during training

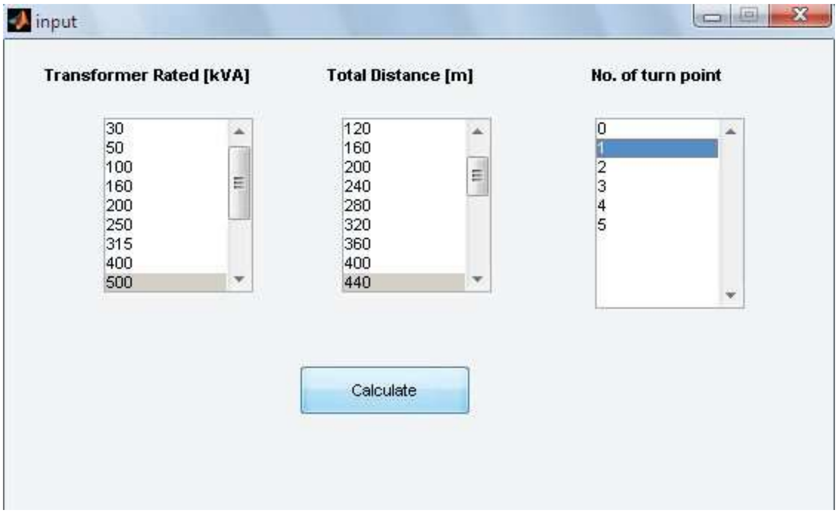

Fig.5. Program with GUI

4. Testing Results

After training the ANN, it should be tested by entering all of possible input 2100 cases example in Table 2 and check the output have some error or not.

Table 2. Example of Input data for test the program

Item	Rated of transformer	Distance system of expansion	Number of right angle
1	30	40	0
2	30	40	1
3	30	40	2
…	…	…	…
1049	315	1000	4
1050	315	1000	5
1051	400	40	0
…	…	…	…
2098	2000	1000	3
2099	2000	1000	4
2100	2000	1000	5

The testing result found that ANN can give the answer in all case without any error that mean ANN can learn and memorized the equipment estimation of designing 22 kV overhead line as required. The efficiency of this method verified by PEA engineers, they compare the program with conventional manual method and found that this program can give accurate and rapid answer.

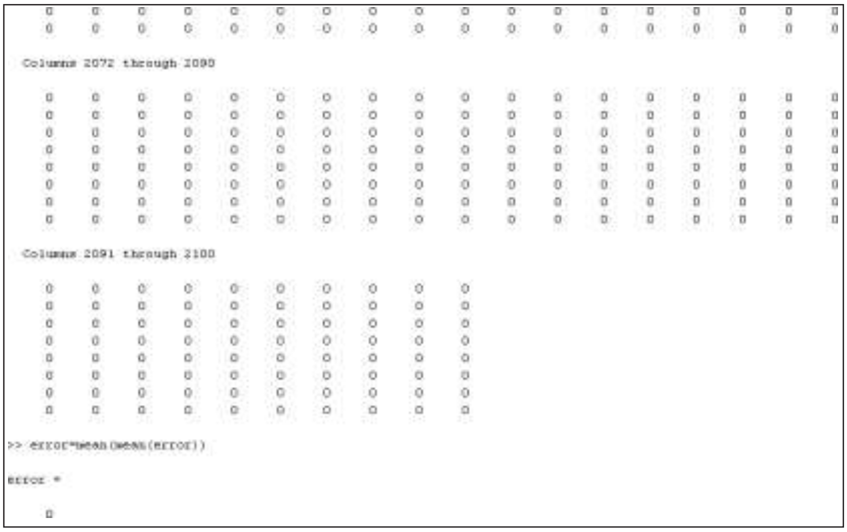

Fig. 6. Error of answer from ANN

5. Conclusion

The 22 kV distribution system with overhead line is the most widely used in Thailand. This system will be expanded according to economic growth. The design and estimation need for experience engineer and time-consuming process. Then this paper proposes the application of ANN to learn and memorized the design and estimation in 22 kV overhead line according PEA standard for save time in designing process and help someone who less experience can preliminary design and estimation the system. The input to ANN are rated of transformer, distance of system expansion, number of right angle that input via GUI and output are list and amount of equipment need for installation. From testing found that this program gives accurate and rapid answer.

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