CHAPTER 5

THE STUDY RESULTS

This thesis used computer software for create model of allocating reactive power has two models artificial neural network model for five-bus sample system and artificial neural network model for 21-bus system in central I of electricite du Lao (EDL) in Lao PDR system or (EDL21-bus system). Furthermore, using modified Y-bus matrix for five-bus sample system and EDL 21-bus system.

The result of forecasting from two models artificial neural network model will be to get the annualize value, after that, taken the results of computation from Y- bus matrix to compare using absolute percentage error (APE) by the equation 5.1.

$$APE = \left(\left| \frac{L_a - L_f}{L_a} \right| \right) \times 100 \tag{5.1}$$

Where L_a – Actual computation from Y- Bus Matrix

L_f – Value forecast from Artificial Neural Network

After that, taken value for found the mean absolute percentage error (MAPE) shown in equation 5.2.

$$MAPE = \frac{\sum_{i=1}^{n} APE}{n} \tag{5.2}$$

Where n - number of reactive power

$i = 1,2,3.....n$

5.1 Result of Using Artificial Neural Network

The result of allocating reactive power using artificial neural network model for five-bus sample system and artificial neural network model for EDL 21-bus system. For testing performance of artificial neural network, the data 24 hours that have never been trained are used as input for testing. It can be observed that the developed, artificial neural network can allocate reactive power transfer between generators and load with very good accuracy.

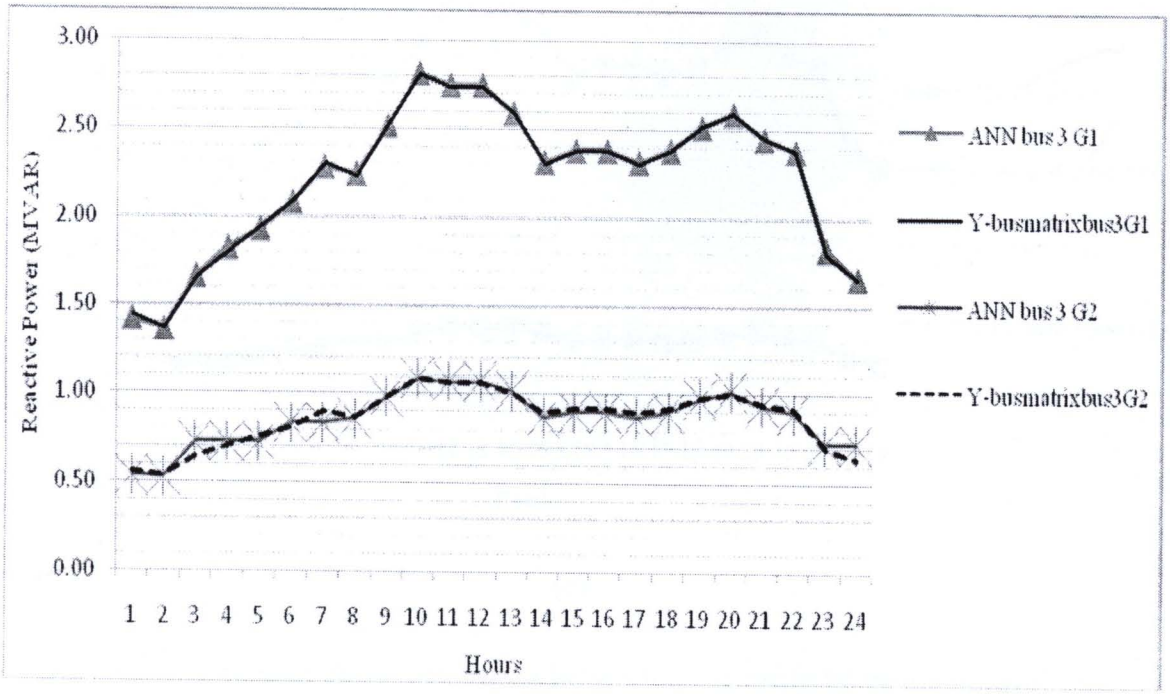
5.2 Compared Result between Using Artificial Neural Network with Using Y-Bus Matrix Method for Five-bus Sample System

The error of the result of allocating reactive power using artificial neural network model for five-bus sample systems compare with result modified Y- bus matrix for five-bus sample systems is shown in table 5.1 and figure 5.1.

Table 5.1 Percentage error of allocating reactive power using artificial neural network for five-bus sample system

Reactive power at bus 3(%)						Reactive power at bus 4(%)						Reactive power at bus 5(%)					
APEG1		APEG2		MAPE		APEG1		APEG2		MAPE		APEG1		APEG2		MAPE	
Max	Min	Max	Min	G1	G2	Max	Min	Max	Min	G1	G2	Max	Min	Max	Min	G1	G2
1.294	0.066	7.950	0.128	0.433	2.588	5.247	0.004	2.422	0.004	0.831	0.302	11.983	0.035	2.369	0.025	2.812	0.813

From the table 5.1 to show the APE of allocating reactive power using artificial neural network for five-bus sample systems, that minimum value is 0.004 to 0.128 % it's very small, while, maximum value is 5.247 to 11.983 % and MAPE is 0.302 to 2.812 %.



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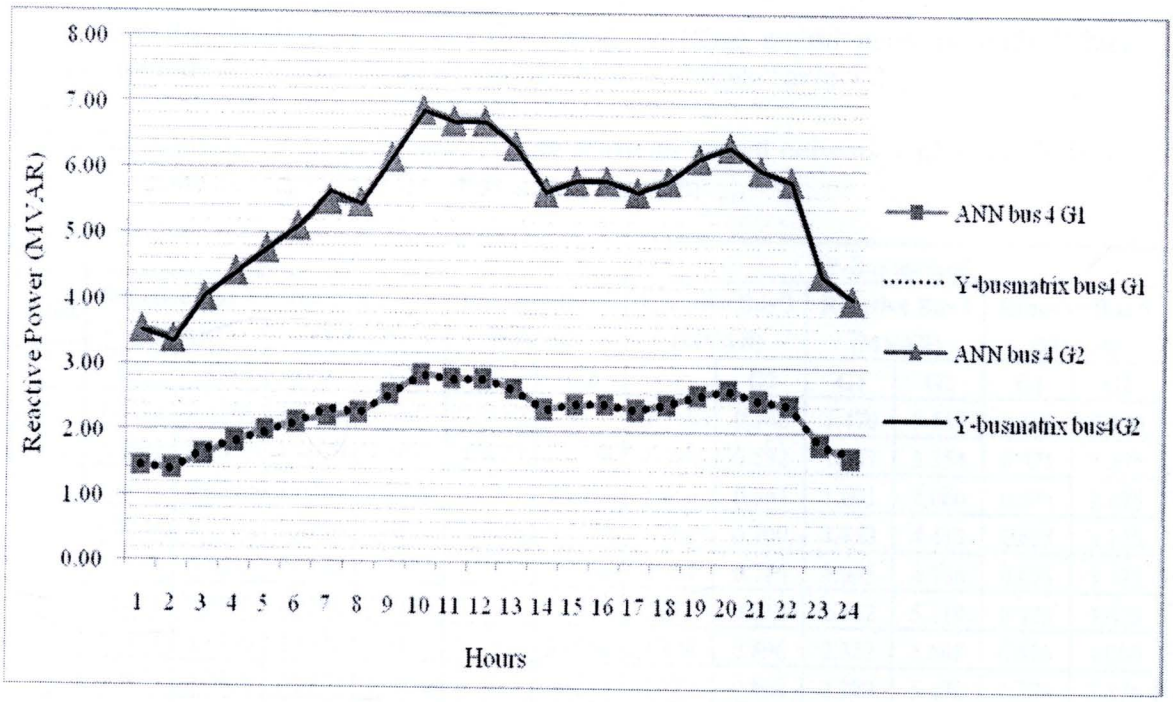

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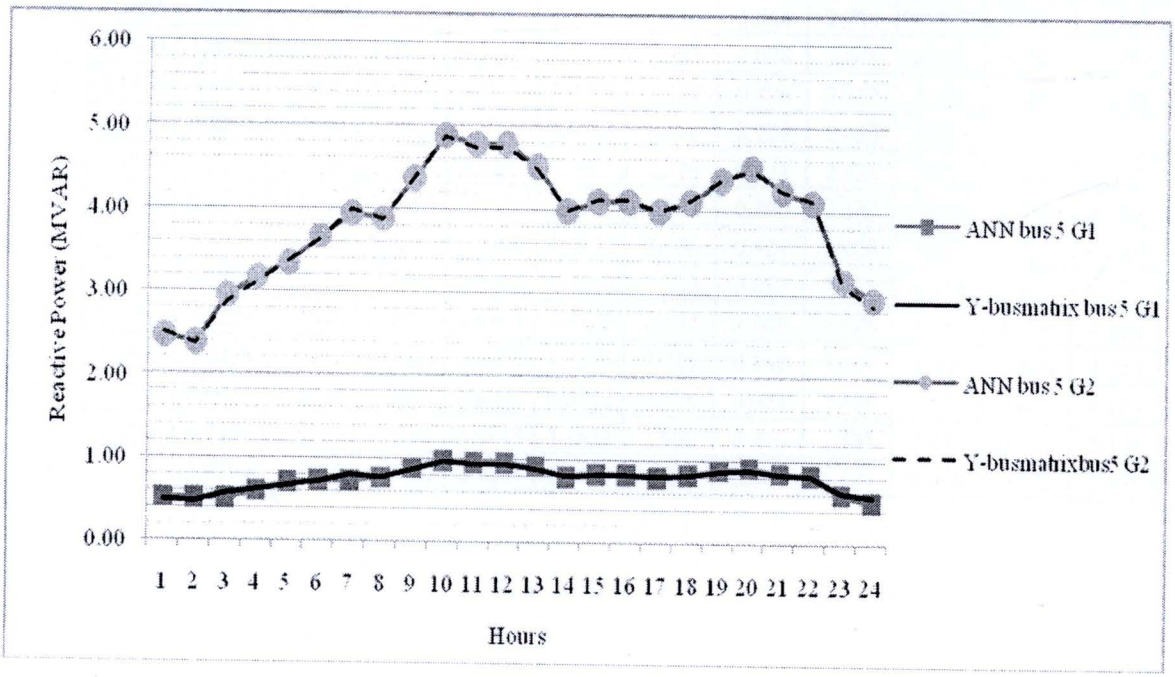


(c)

Figure 5.1 Compared daily load curves between using artificial neural network and using Y- bus matrix method of five-bus sample system

For the detail of Compared by using artificial neural network with Y-bus matrix method of five-bus sample system which is shown Table 5.2.

Table 5.2 Compared result between using artificial neural network with using Y-bus matrix method for five-bus sample system

Hours	ANN						Y-Bus method					
	Reactive Bus 3 (MVAR)		Reactive Bus 4 (MVAR)		Reactive Bus 5 (MVAR)		Reactive Bus 3 (MVAR)		Reactive Bus 4 (MVAR)		Reactive Bus 5 (MVAR)	
	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
1	1.4222	0.5385	1.4502	3.5343	0.5110	2.4537	1.440	0.560	1.470	3.530	0.500	2.500
2	1.3622	0.5303	1.4079	3.3875	0.5027	2.3744	1.368	0.532	1.397	3.354	0.475	2.375
3	1.6631	0.7292	1.6285	4.0320	0.5061	2.9431	1.656	0.644	1.691	4.060	0.575	2.875
4	1.8233	0.7300	1.8276	4.4196	0.5948	3.1658	1.800	0.700	1.838	4.413	0.625	3.125
5	1.9291	0.7281	2.0038	4.7653	0.7071	3.3426	1.944	0.756	1.985	4.766	0.675	3.375
6	2.0814	0.8380	2.1286	5.1112	0.7200	3.6608	2.088	0.812	2.132	5.119	0.725	3.625
7	2.0814	0.8380	2.1286	5.1112	0.7200	3.6608	2.304	0.896	2.352	5.648	0.800	4.000
8	2.2423	0.8608	2.2773	5.4833	0.7656	3.8775	2.232	0.868	2.279	5.472	0.775	3.875
9	2.5146	0.9854	2.5726	6.1684	0.8801	4.3714	2.520	0.980	2.573	6.178	0.875	4.375
10	2.8126	1.0906	2.8692	6.8925	0.9745	4.8823	2.808	1.092	2.867	6.884	0.975	4.875
11	2.7450	1.0734	2.8069	6.7253	0.9585	4.7797	2.736	1.064	2.793	6.707	0.950	4.750
12	2.7450	1.0734	2.8069	6.7253	0.9585	4.7797	2.736	1.064	2.793	6.707	0.950	4.750
13	2.5903	1.0224	2.6538	6.3523	0.9100	4.5179	2.592	1.008	2.646	6.354	0.900	4.500
14	2.3128	0.8763	2.3493	5.6584	0.7929	3.9795	2.304	0.896	2.352	5.648	0.800	4.000
15	2.3788	0.9051	2.4204	5.8265	0.8206	4.0953	2.376	0.924	2.426	5.825	0.825	4.125
16	2.3788	0.9051	2.4204	5.8265	0.8206	4.0953	2.376	0.924	2.426	5.825	0.825	4.125
17	2.3128	0.8763	2.3493	5.6584	0.7929	3.9795	2.304	0.896	2.352	5.648	0.800	4.000
18	2.3788	0.9051	2.4204	5.8265	0.8206	4.0953	2.376	0.924	2.426	5.825	0.825	4.125
19	2.5146	0.9854	2.5726	6.1684	0.8801	4.3714	2.520	0.980	2.573	6.178	0.875	4.375
20	2.5903	1.0224	2.6538	6.3523	0.9100	4.5179	2.592	1.008	2.646	6.354	0.900	4.500
21	2.4446	0.9439	2.4942	5.9942	0.8497	4.2275	2.448	0.952	2.499	6.001	0.850	4.250
22	2.3788	0.9051	2.4204	5.8265	0.8206	4.0953	2.376	0.924	2.426	5.825	0.825	4.125
23	1.8233	0.7300	1.8276	4.4196	0.5948	3.1658	1.800	0.700	1.838	4.413	0.625	3.125
24	1.6631	0.7292	1.6285	4.0320	0.5061	2.9431	1.656	0.644	1.691	4.060	0.575	2.875

5.3 Compared Result between Using Artificial Neural Network with Using Y- Bus Matrix Method for EDL21-bus System

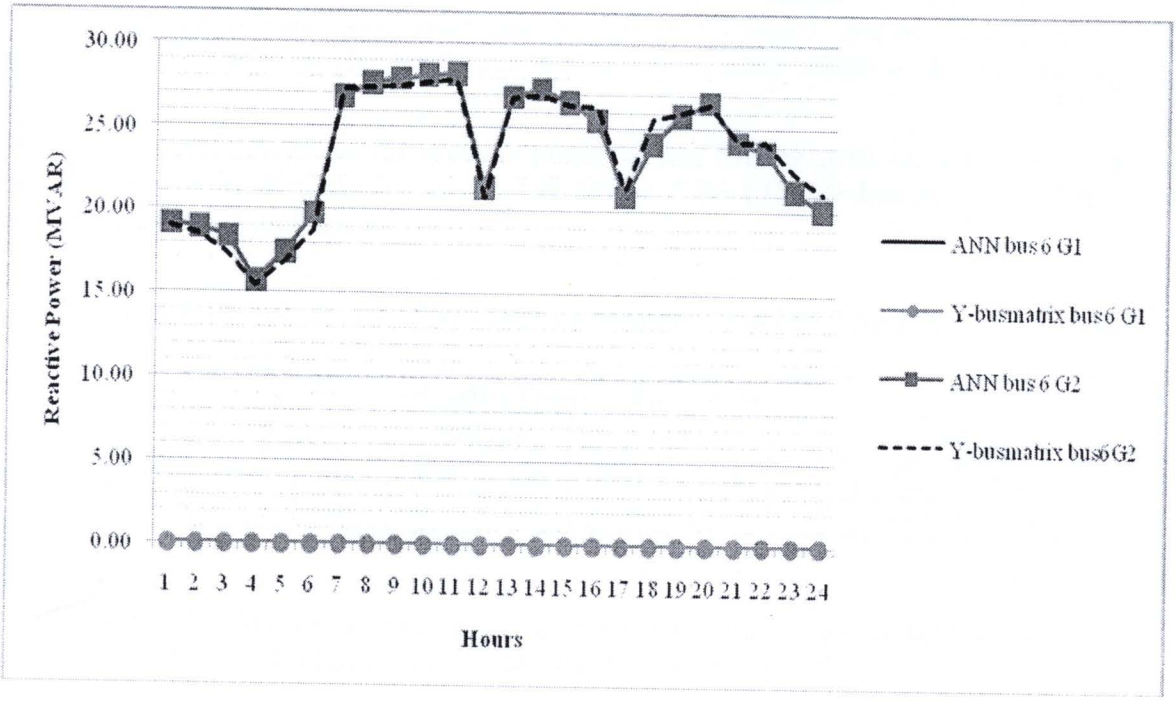
The error of the result of allocating reactive power using artificial neural network model for EDL21-bus system compare with result Y- bus matrix method for EDL 21-bus system.

For the result of allocating reactive power at bus 6 using artificial neural network compare with result Y- bus matrix at bus 6 for EDL 21-bus system which is shown in table 5.3 and figure 5.2.

Table 5.3 Percentage error of allocating reactive power at bus 6 for EDL 21-bus system

Reactive Power at Bus 6 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
0.000	0.000	5.918	0.037	0.000	0.000	0.000	0.000	0.000	2.272	0.000	0.000

The APE shown in table 5.3, there are minimum value is 0.00 to 0.037 %, maximum value is 3.60 to 14.50 % and MAPE is 0.00 to 2.272 %.



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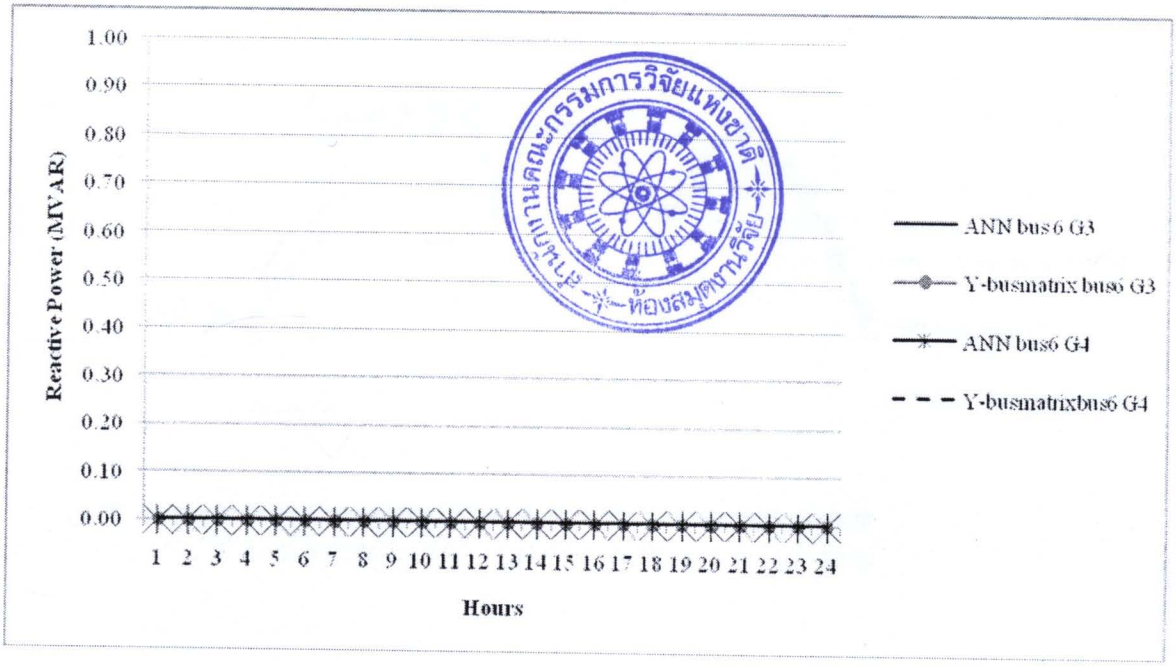


(b)

Figure 5.2 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 6 for EDL 21-bus system

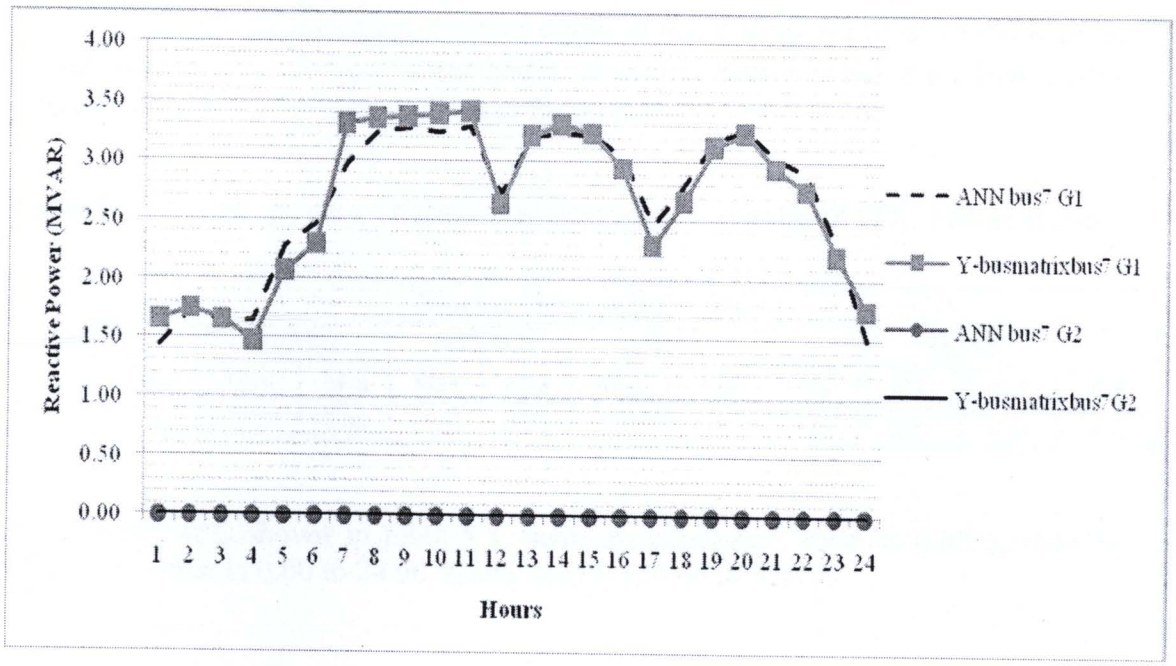
For the detail of Compared by using artificial neural network with Y-bus matrix method at bus 6,bus7,bus8,bus10,bus11,bus12,bus13, bus14, bus15, bus16, bus17, bus18, bus19, bus20, bus21 for EDL 21-bus system which is shown appendix C.

The result of allocating reactive power at bus 7 using artificial neural network model compare with result Y- bus matrix at bus 7 for EDL 21-bus system which is shown in table 5.4 and figure 5.3.

Table 5.4 Percentage error of allocating reactive power at bus 7 for EDL 21-bus system

Reactive Power at Bus 7 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
14.04	0.01	0.00	0.00	17.52	0.52	23.81	0.75	4.99	0.00	10.64	12.75

The APE shown in table 5.4, there are minimum value is 0.00 to 0.01 %, maximum value is 14.04 to 23.81 % and MAPE is 0.00 to 12.75 %.



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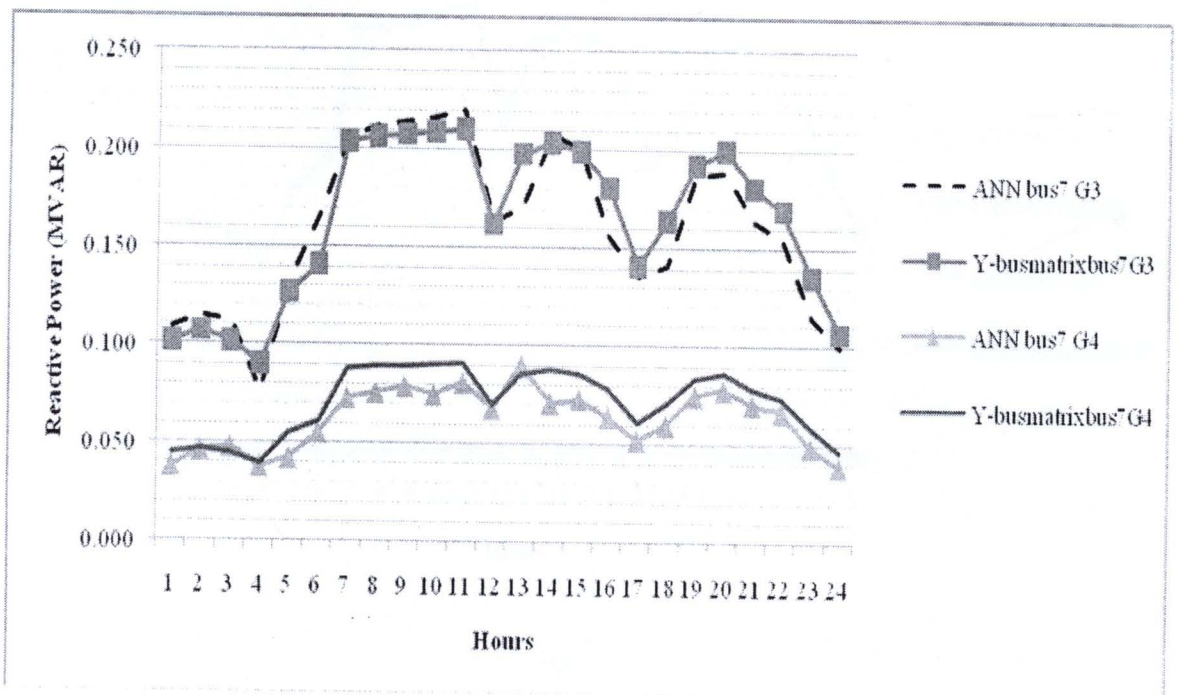


(b)

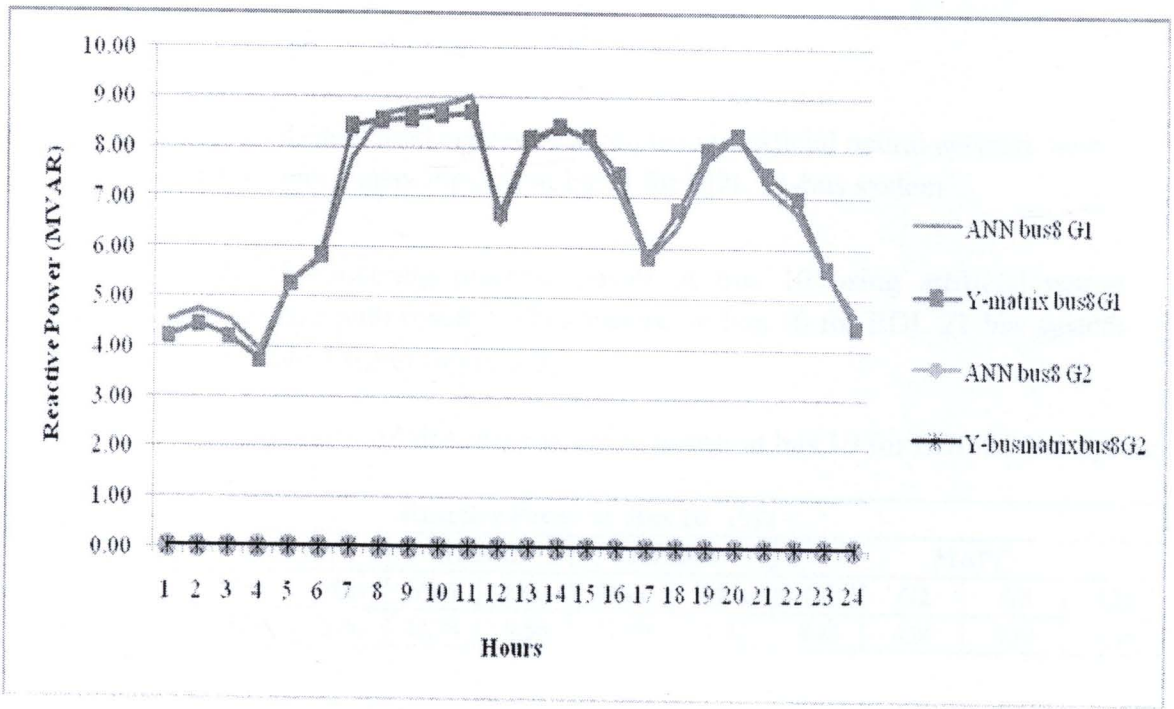
Figure 5.3 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 7 for EDL 21-bus system

The result of allocating reactive power at bus 8 using artificial neural network model compare with result Y- bus matrix of reactive power at bus 8 for EDL 21-bus system which is shown in table 5.5 and figure 5.4.

Table 5.5 Percentage error of allocating reactive power at bus 8 EDL 21-bus system

Reactive Power at Bus 8 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
7.88	0.18	0.00	0.00	15.37	0.05	24.90	0.04	3.28	0.00	6.81	9.41

The APE shown in table 5.5, there are minimum value is 0.00 to 0.04 %, maximum value is 0.00 to 24.90 % and MAPE is 0.00 to 9.41 %.



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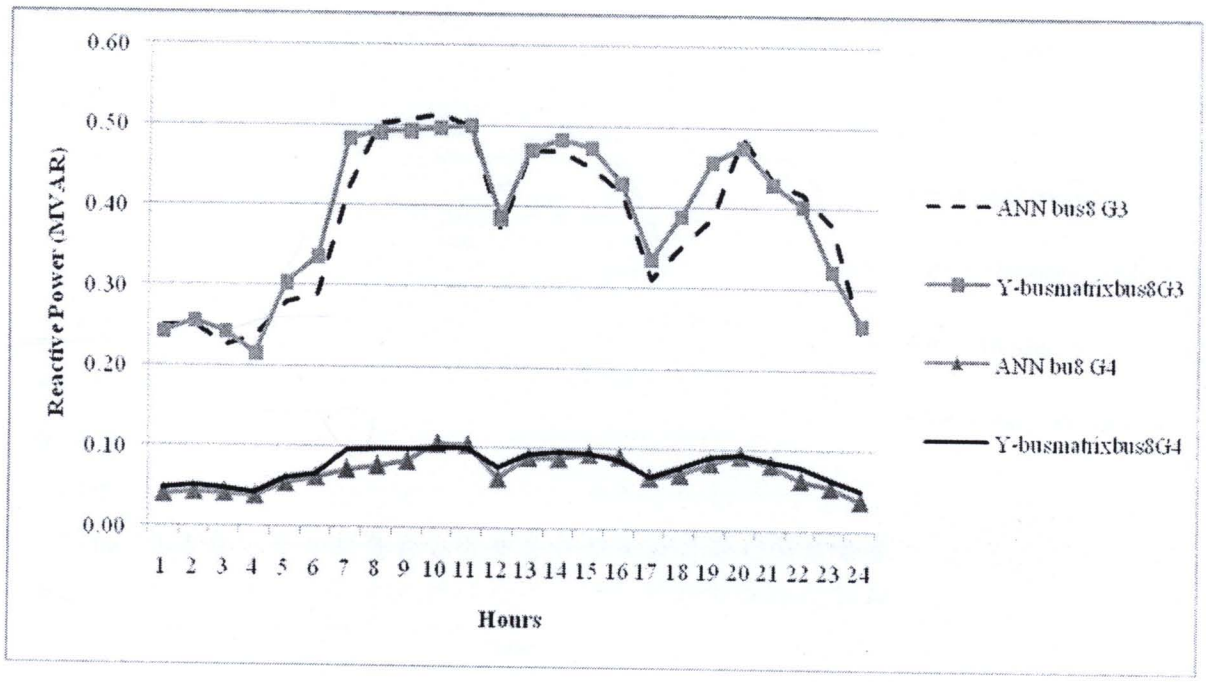


(b)

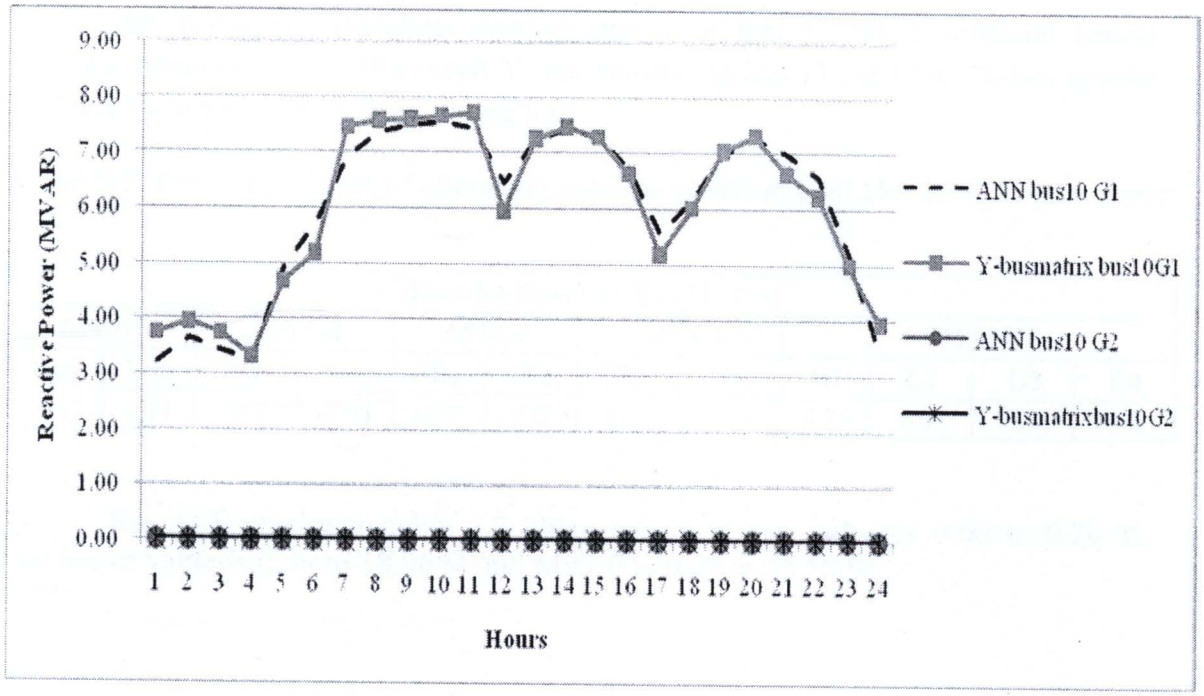
Figure 5.4 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 8 for EDL 21-bus system

The result of allocating reactive power at bus 10 using artificial neural network model compare with result Y- bus matrix at bus 10 for EDL 21-bus system which is shown in table 5.6 and figure 5.5.

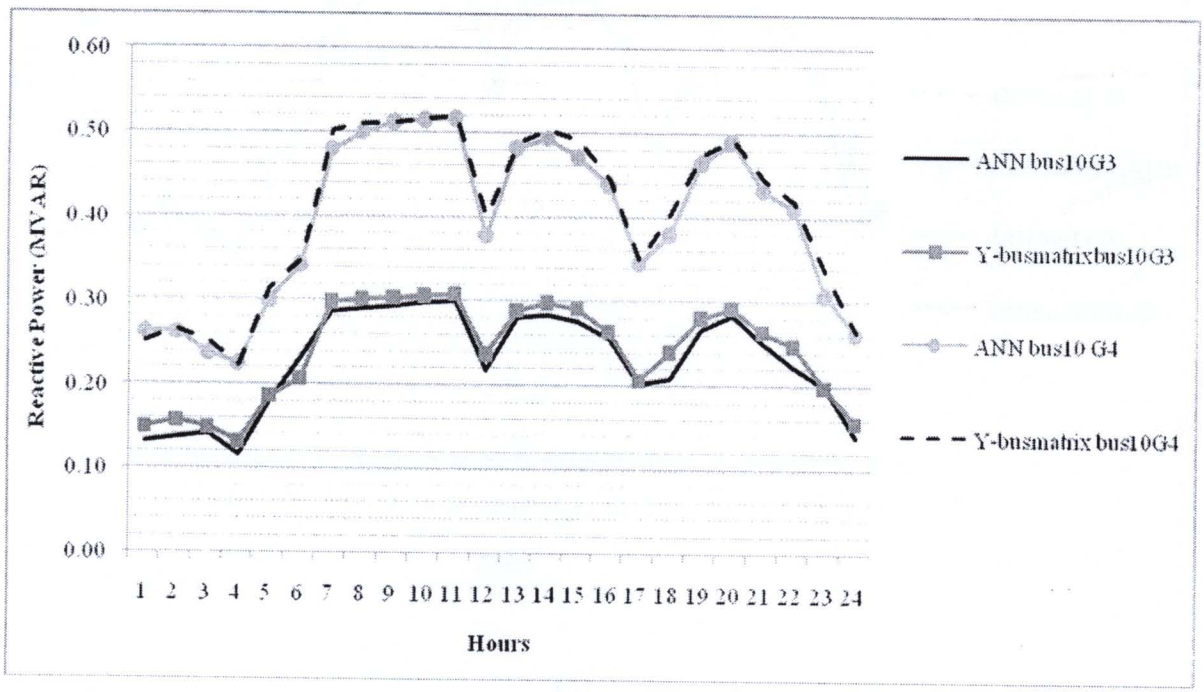
Table 5.6 Percentage error of allocating reactive power at bus 10 for EDL 21-bus system

Reactive Power at Bus 10 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
13.67	0.31	0.00	0.00	15.74	0.86	19.90	1.34	4.88	0.00	9.34	8.45

The APE shown in table 5.6, there are minimum value is 0.00 to 0.31 %, maximum value is 0.00 to 19.90 % and MAPE is 0.00 to 9.34 %.



(a)



(b)

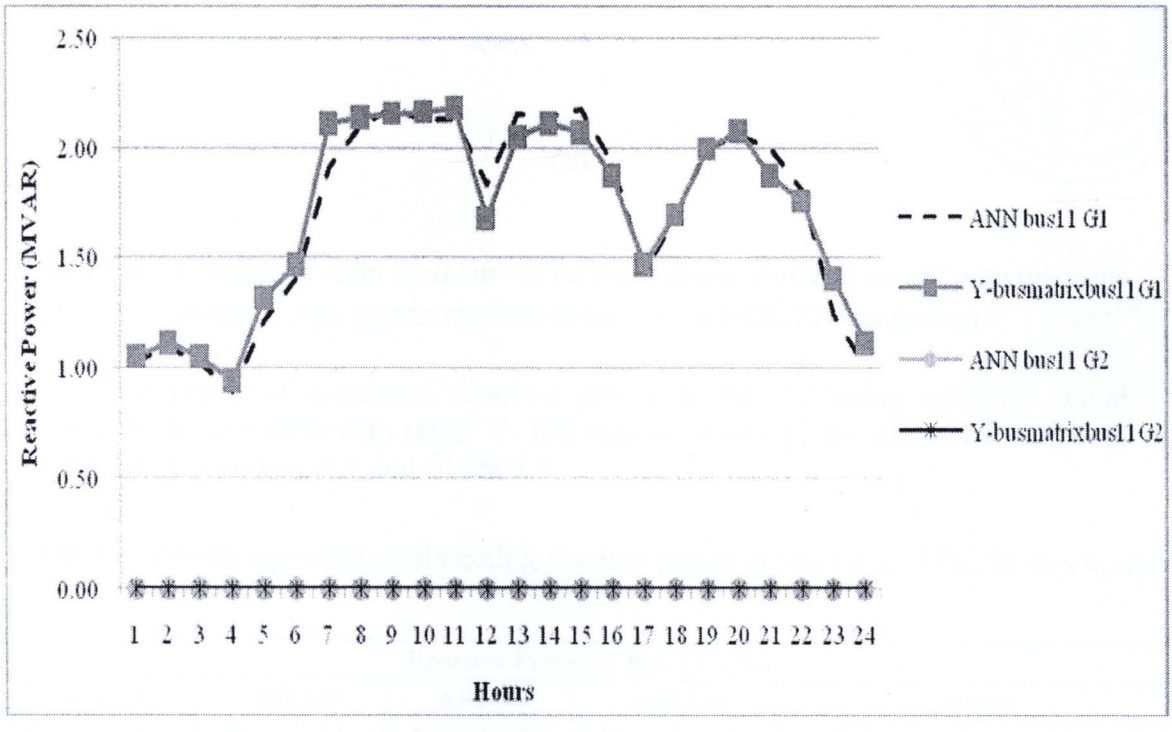
Figure 5.5 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 10 for EDL 21-bus system

The result of allocating reactive power at bus 11 using artificial neural network model compare with result Y- bus matrix at bus 11 for EDL 21-bus system which is shown in table 5.7 and figure 5.6.

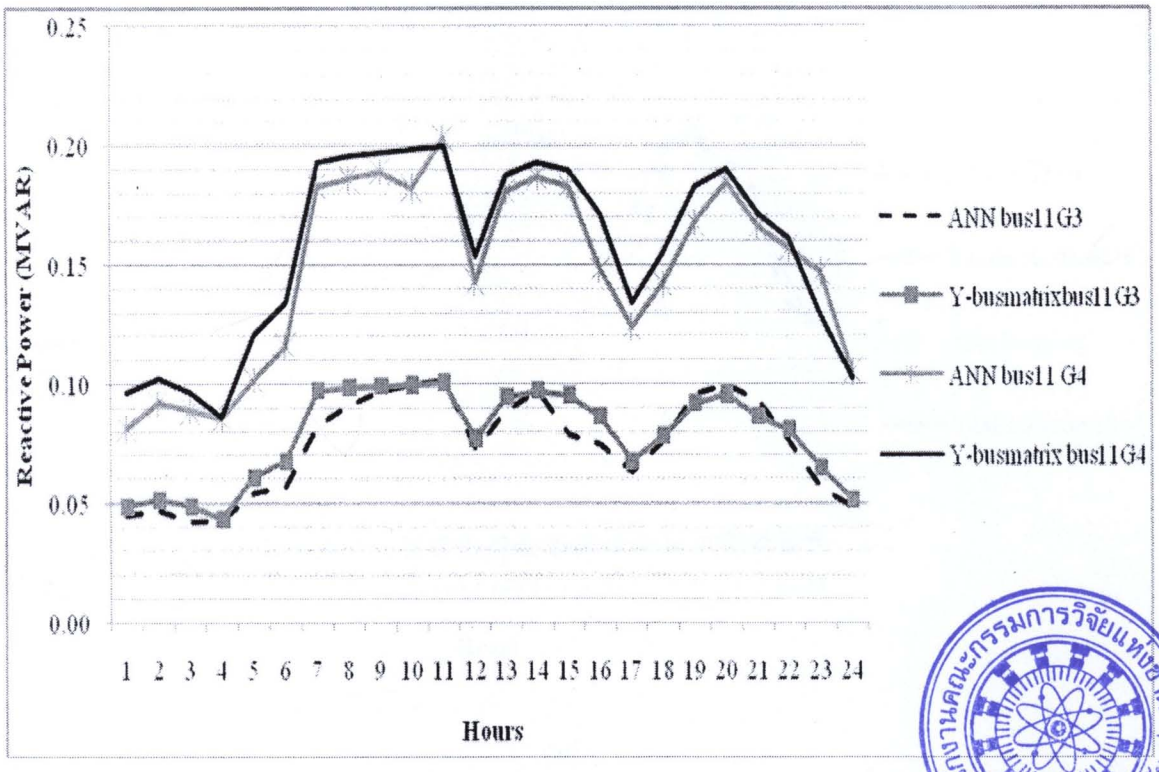
Table 5.7 Percentage error of allocating reactive power at bus11for EDL 21-bus system

Reactive Power at Bus 11 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
11.90	0.14	0.00	0.00	19.95	0.12	18.96	0.79	4.25	0.00	10.53	8.02

The APE shown in table 5.7, there are minimum value is 0.00 to 0.79 %, maximum value is 0.00 to 18.96 % and MAPE is 0.00 to 10.53 %.



(a)



(b)

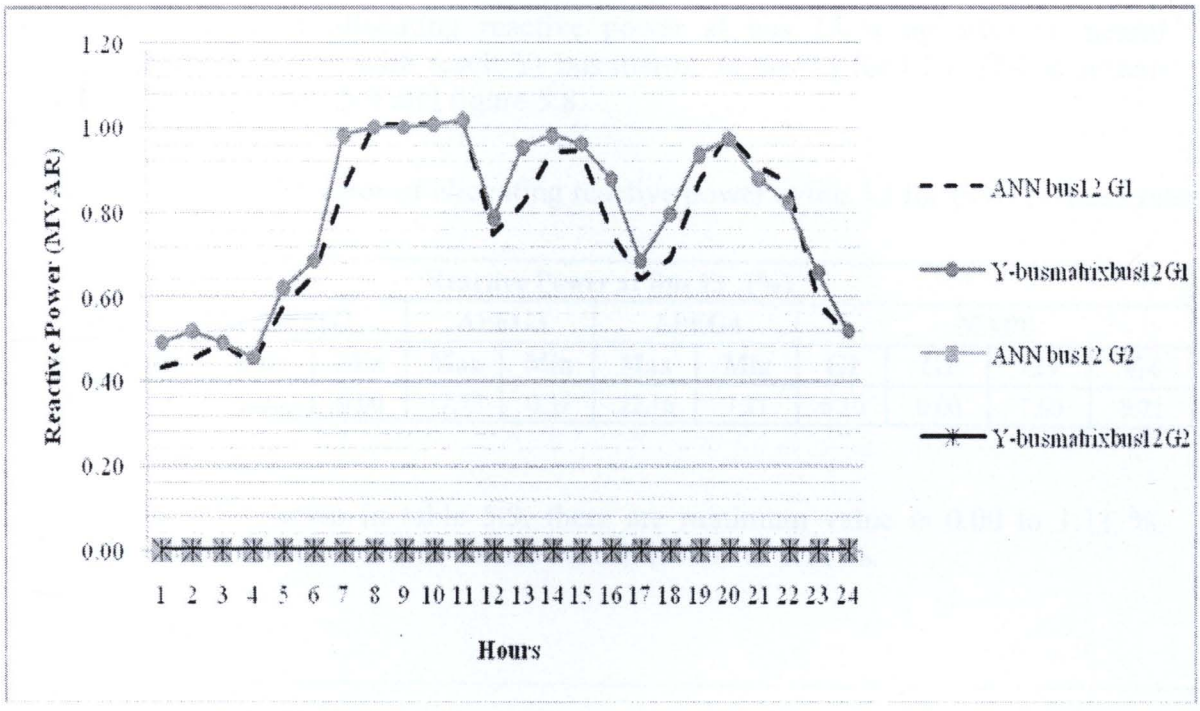
Figure 5.6 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 11 for EDL 21-bus system

The result of allocating reactive power at bus 12 using artificial neural network model compare with result Y- bus matrix at bus 12 for EDL 21-bus system which is shown in table 5.8 and figure 5.7.

Table 5.8 Percentage error of allocating reactive power at bus 12 for EDL 21-bus system

Reactive Power at Bus 12 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
18.16	0.20	0.00	0.00	15.00	1.69	25.00	1.22	6.91	0.00	6.50	10.77

The APE shown in table 5.13, there are minimum value is 0.00 to 1.69 %, maximum value is 0.00 to 25.00 % and MAPE is 0.00 to 10.77 %.



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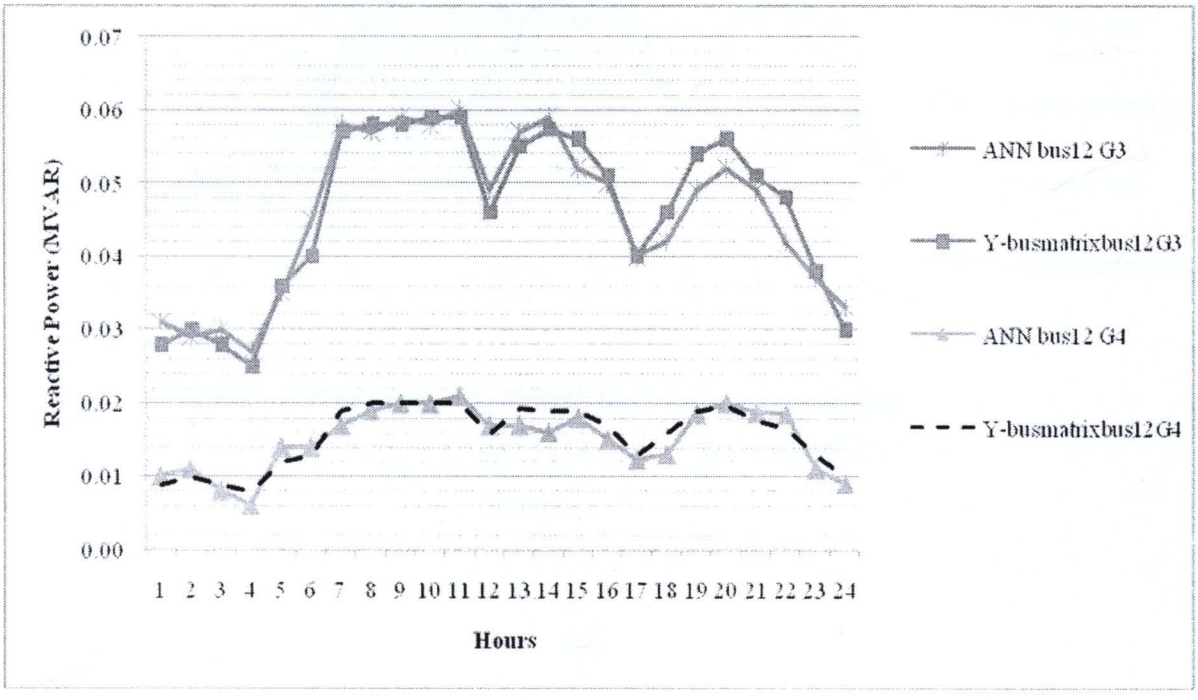


(b)

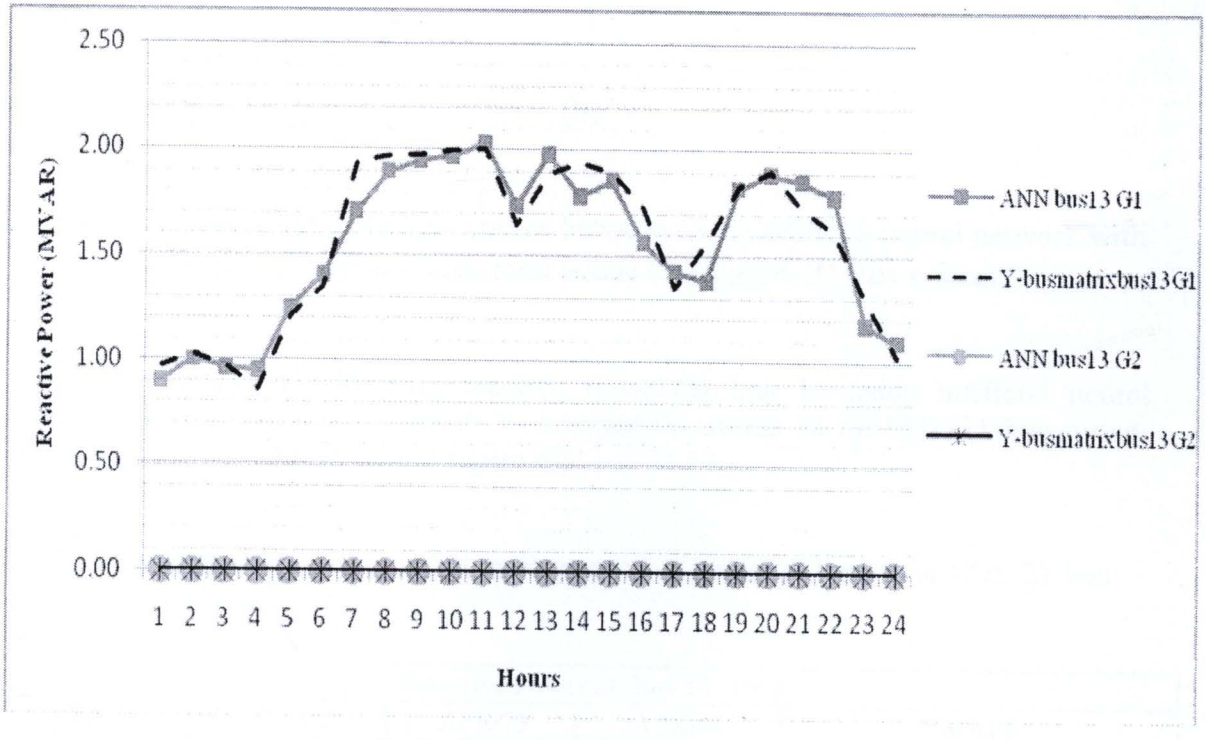
Figure 5.7 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 12 for EDL 21-bus system

The result of allocating reactive power at bus 13 using artificial neural network model compare with result Y- bus matrix at bus 13 for EDL 21-bus system which is shown in table 5.9 and figure 5.8.

Table 5.9 Percentage error of allocating reactive power at bus 13 for EDL 21-bus system

Reactive Power at Bus 13 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
13.25	0.60	0.00	0.00	17.73	0.37	22.16	1.11	6.10	0.00	7.60	9.71

The APE shown in table 5.9, there are minimum value is 0.00 to 1.11 %, maximum value is 0.00 to 22.16 % and MAPE is 0.00 to 9.71 %.



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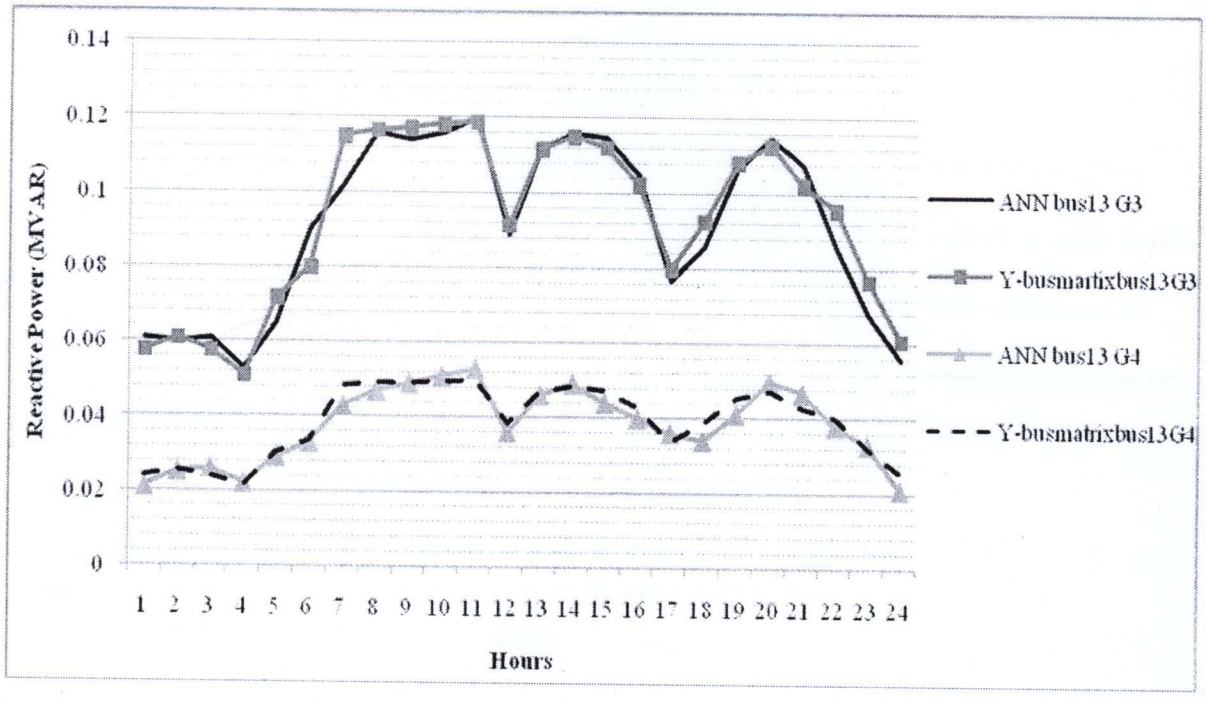


(b)

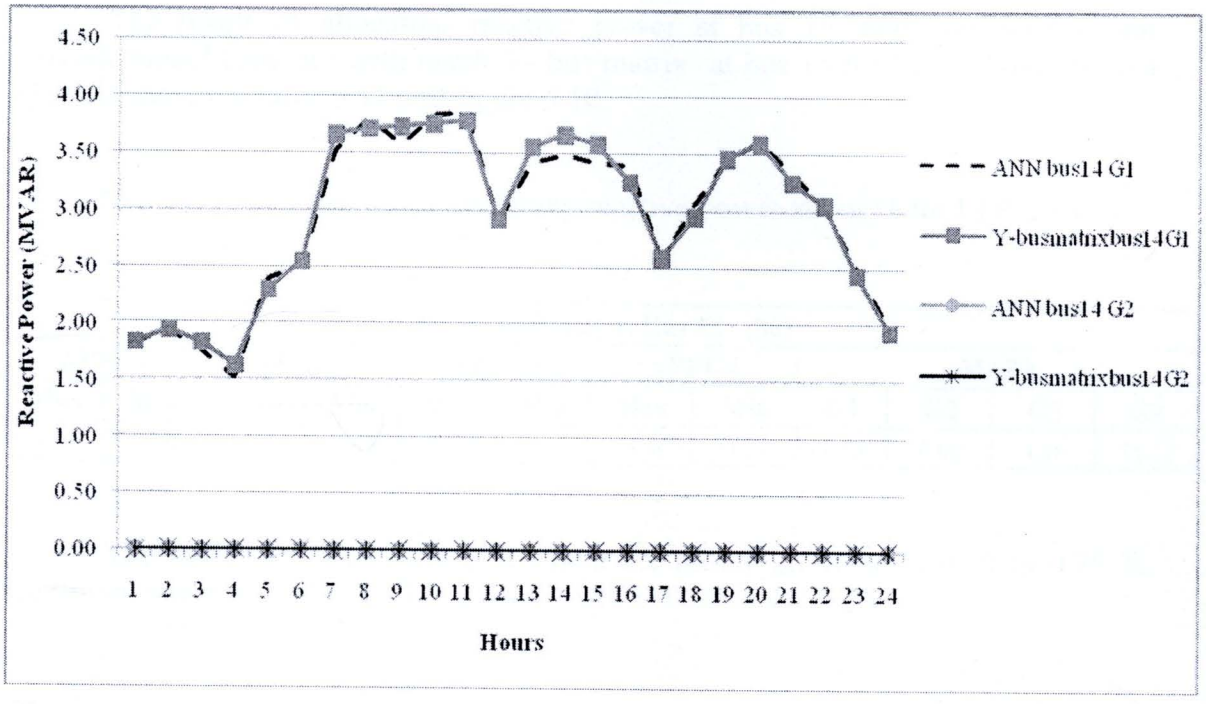
Figure 5.8 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 13 for EDL 21-bus system

The result of allocating reactive power at bus 14 using artificial neural network model compare with result Y- bus matrix at bus 14 for EDL 21-bus system which is shown in table 5.10 and figure 5.9.

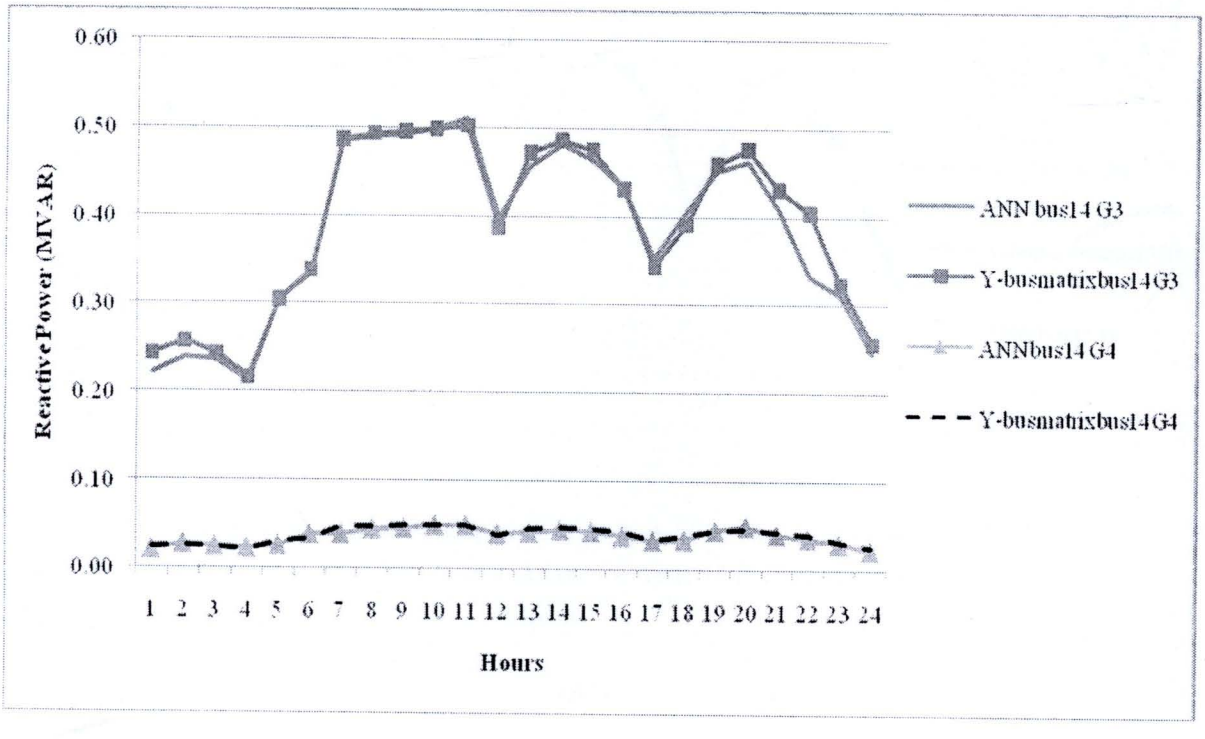
Table 5.10 Percentage error of allocating reactive power at bus14 for EDL 21-bus system

Reactive Power at Bus 14 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
6.90	0.05	0.00	0.00	28.56	0.29	21.10	0.11	2.63	0.00	8.70	8.75

The APE shown in table 5.10, there are minimum value is 0.00 to 0.29 %, maximum value is 0.00 to 28.56 % and MAPE is 0.00 to 8.75 %.



(a)



(b)

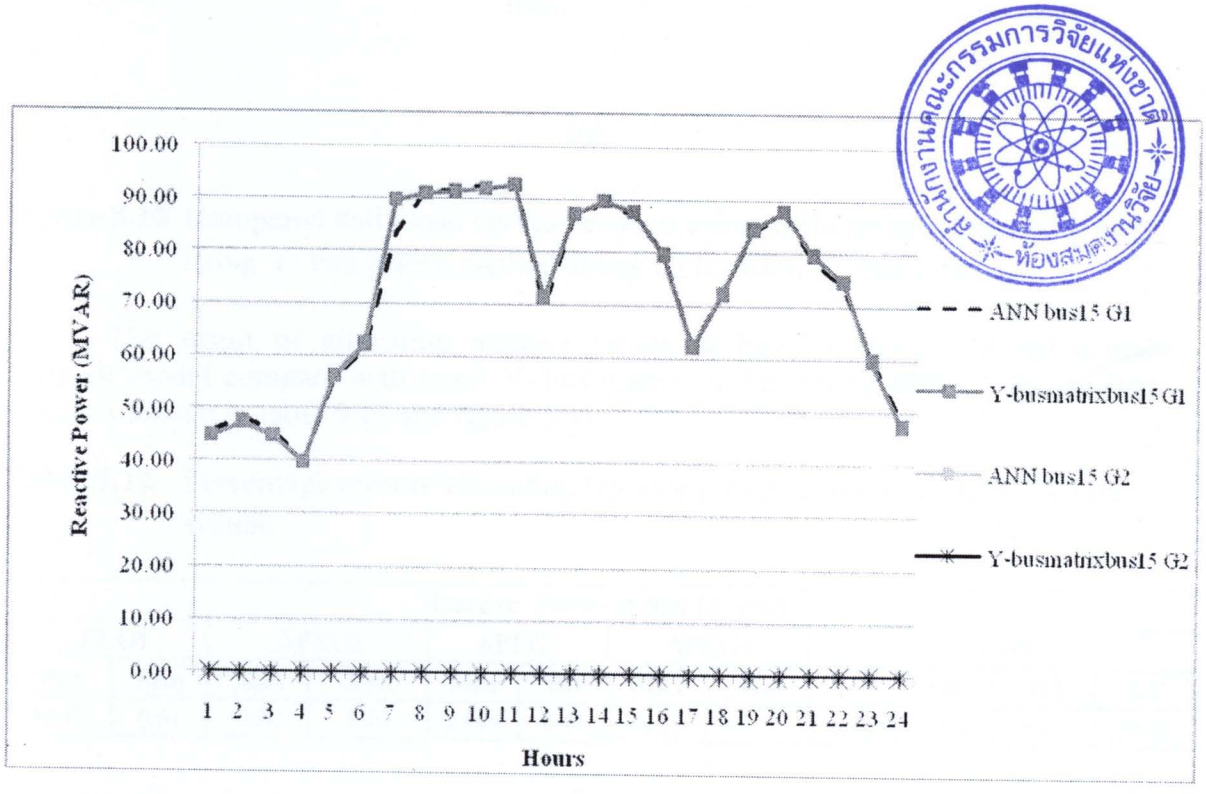
Figure 5.9 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 14 for EDL 21-bus system

The result of allocating reactive power at bus 15 using artificial neural network model compare with result Y- bus matrix at bus 15 for EDL 21-bus system which is shown in table 5.11 and figure 5.10.

Table 5.11 Percentage error of allocating reactive power at bus15 for EDL 21-bus system

Reactive Power at Bus 15 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
7.13	0.18	0.00	0.00	27.17	0.06	24.56	0.75	1.15	0.00	3.46	11.12

The APE shown in table 5.11, there are minimum value is 0.00 to 0.75 %, maximum value is 0.00 to 27.17 % and MAPE is 0.00 to 11.12 %.



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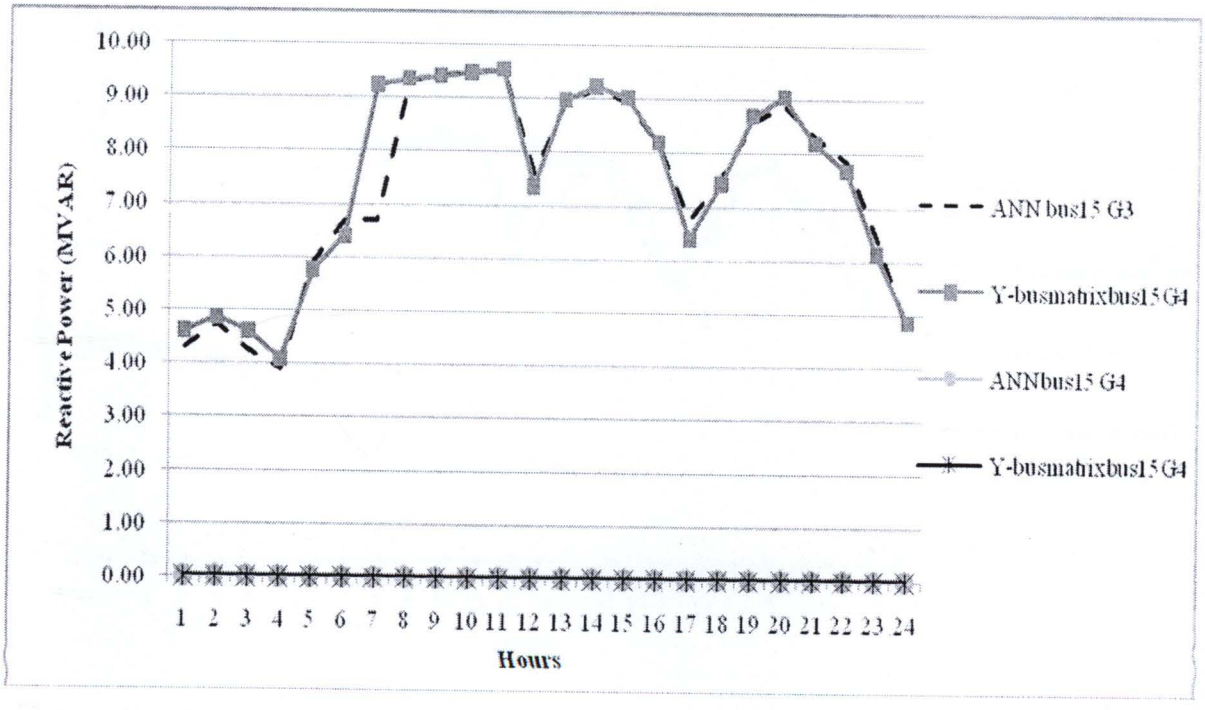


(b)

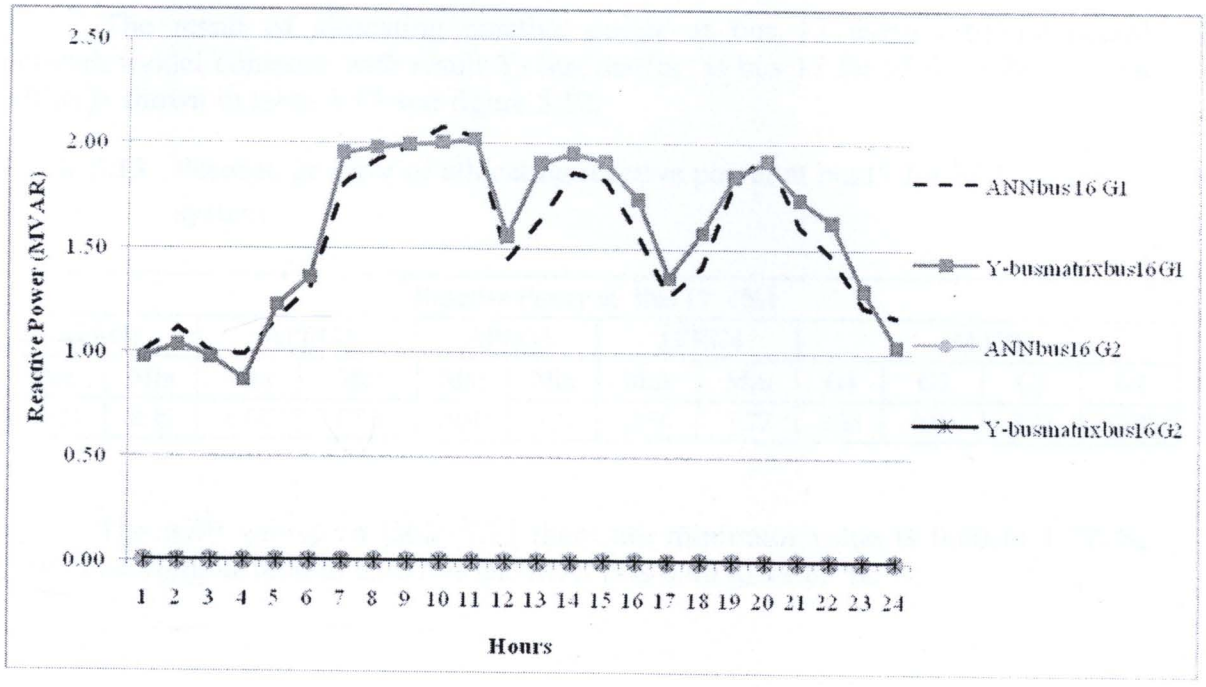
Figure 5.10 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 15 for EDL 21-bus system

The result of allocating reactive power at bus 16 using artificial neural network model compare with result Y- bus matrix at bus 16 for EDL 21-bus system which is shown in table 5.12 and figure 5.11.

Table 5.12 Percentage error of allocating reactive power at bus16 for EDL 21-bus system

Reactive Power at Bus 16 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
14.17	0.61	0.00	0.00	14.04	0.41	22.22	0.11	6.22	0.00	6.81	10.40

The APE shown in table 5.12 there are minimum value is 0.00 to 0.61 %, maximum value is 0.00 to 22.22 % and MAPE is 0.00 to 10.40 %.



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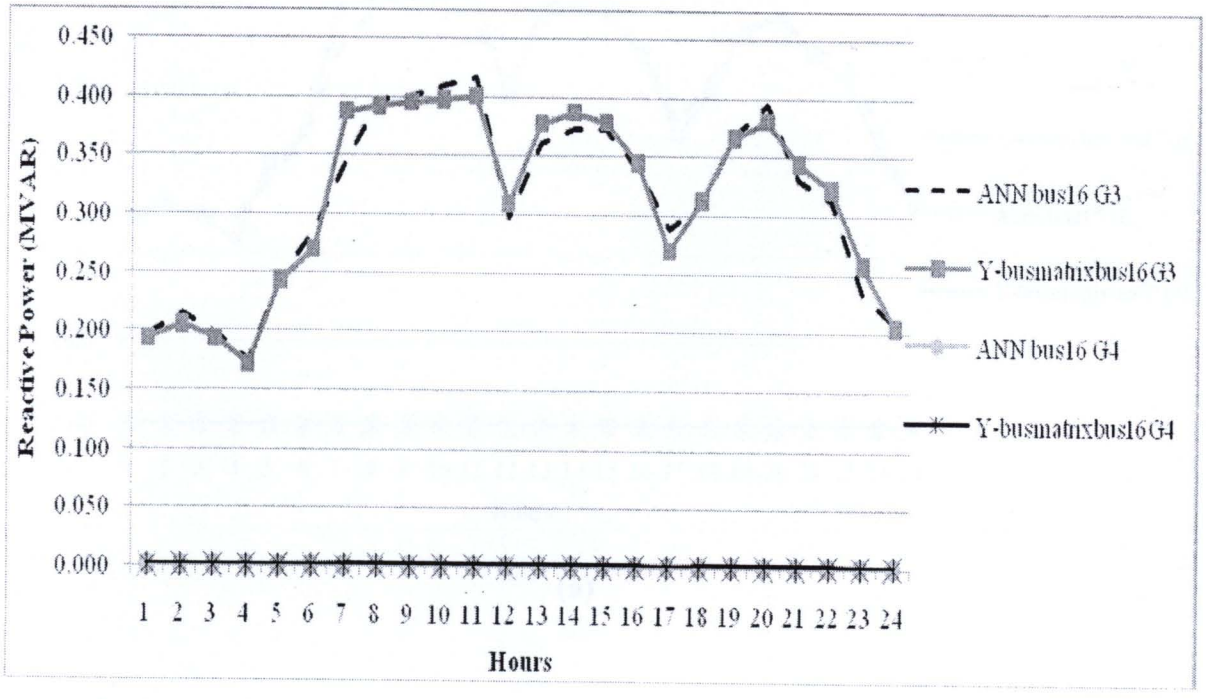


(b)

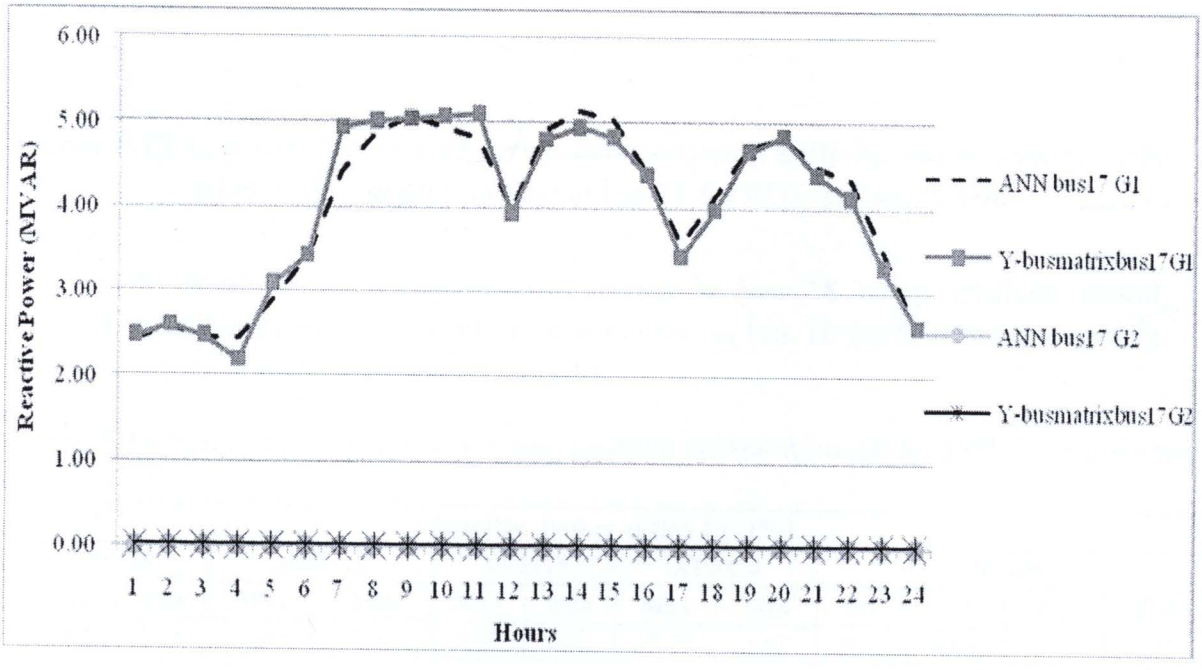
Figure 5.11 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 16 for EDL 21-bus system

The result of allocating reactive power at bus 17 using artificial neural network model compare with result Y- bus matrix at bus 17 for EDL 21-bus system which is shown in table 5.13 and figure 5.12.

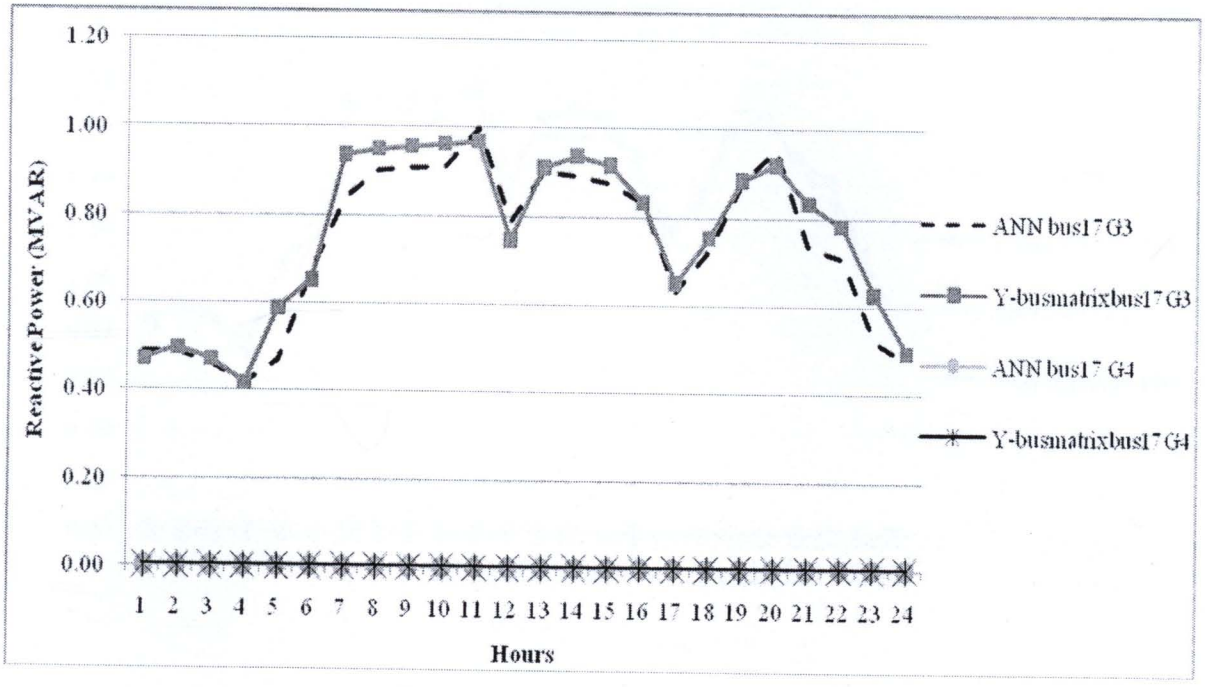
Table 5.13 Percentage error of allocating reactive power at bus17 for EDL 21-bus system

Reactive Power at Bus 17 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
10.93	0.45	0.00	0.00	20.97	0.21	23.07	1.77	3.35	0.00	7.84	12.82

The APE shown in table 5.13 there are minimum value is 0.00 to 1.77 %, maximum value is 0.00 to 23.07 % and MAPE is 0.00 to 12.82 %.



(a)



(b)

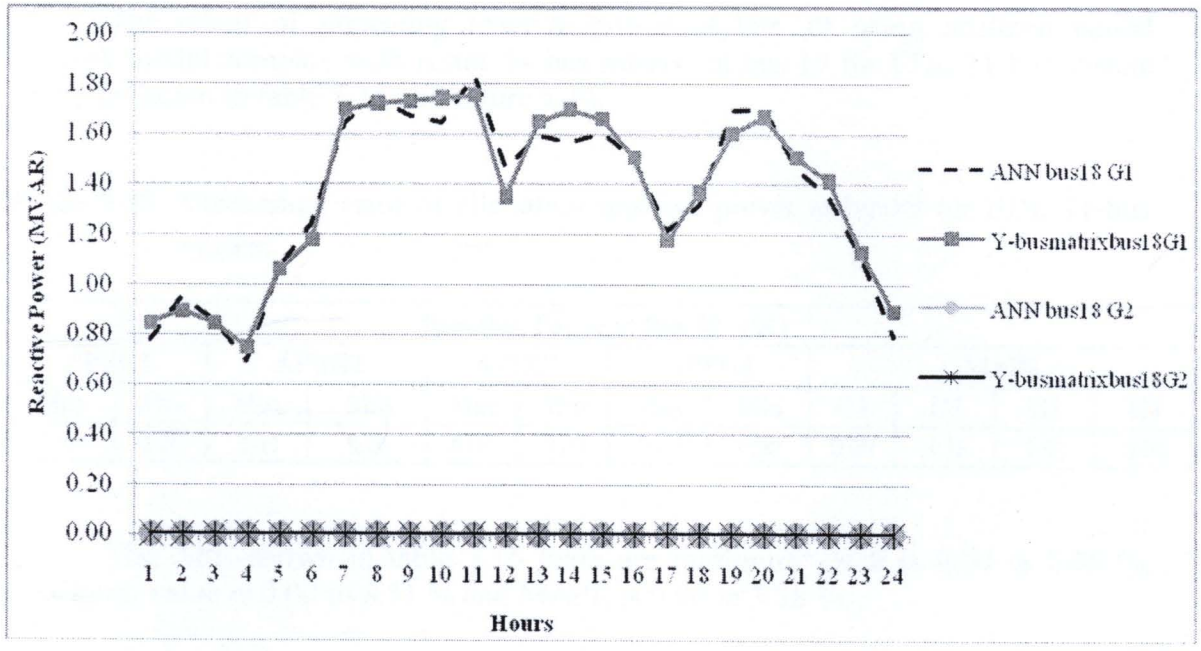
Figure 5.12 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 17 for EDL 21-bus system

The result of allocating reactive power at bus 18 using artificial neural network model compare with result Y- bus matrix at bus 18 for EDL 21-bus system which is shown in table 5.14 and figure 5.13.

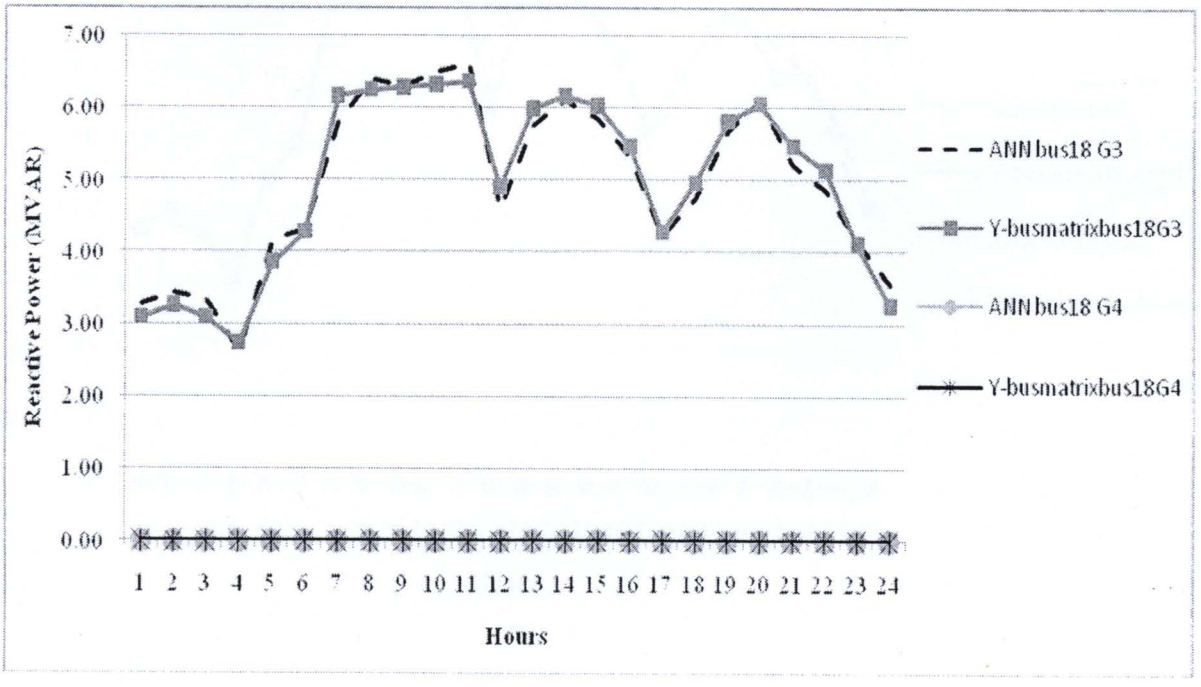
Table 5.14 Percentage error of allocating reactive power at bus18 for EDL 21-bus system

Reactive Power at Bus 18 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
11.43	0.46	0.00	0.00	8.93	0.42	23.22	1.62	4.36	0.00	3.95	8.53

The APE shown in table 5.14 there are minimum value is 0.00 to 1.62 %, maximum value is 0.00 to 23.22 % and MAPE is 0.00 to 8.53 %.



(a)



(b)

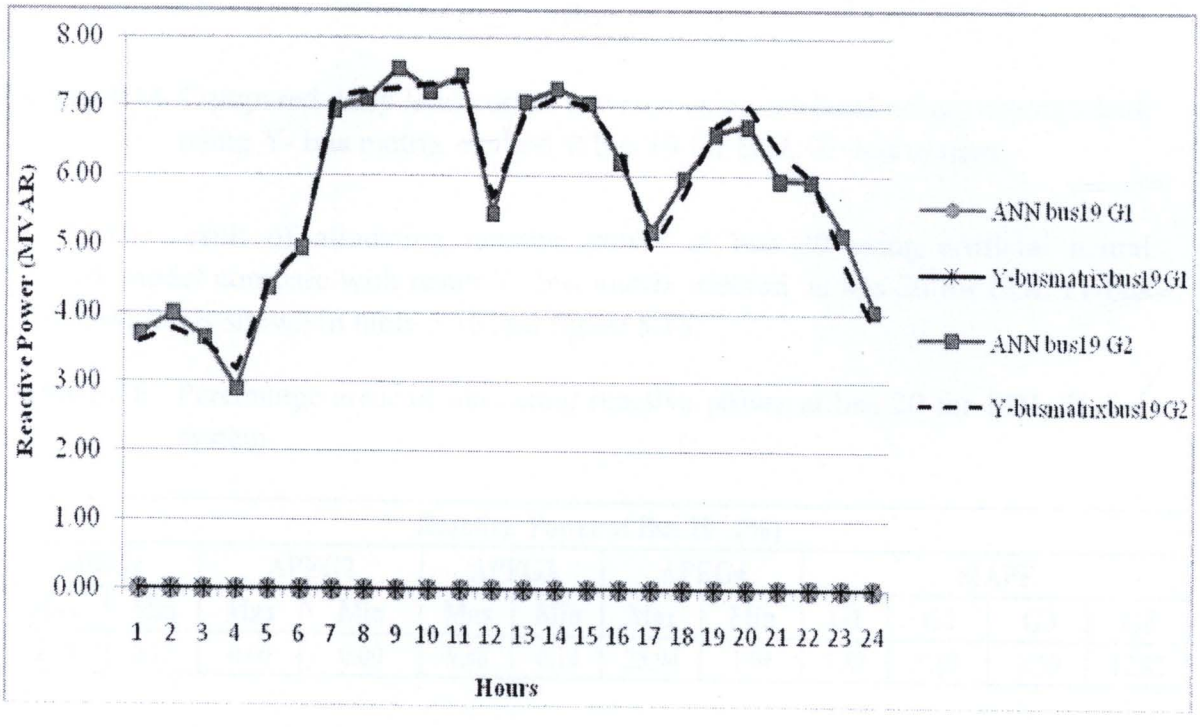
Figure 5.13 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 18 for EDL 21-bus system

The result of allocating reactive power at bus 19 using artificial neural network model compare with result Y- bus matrix at bus 19 for EDL 21-bus system which is shown in table 5.15 and figure 5.14.

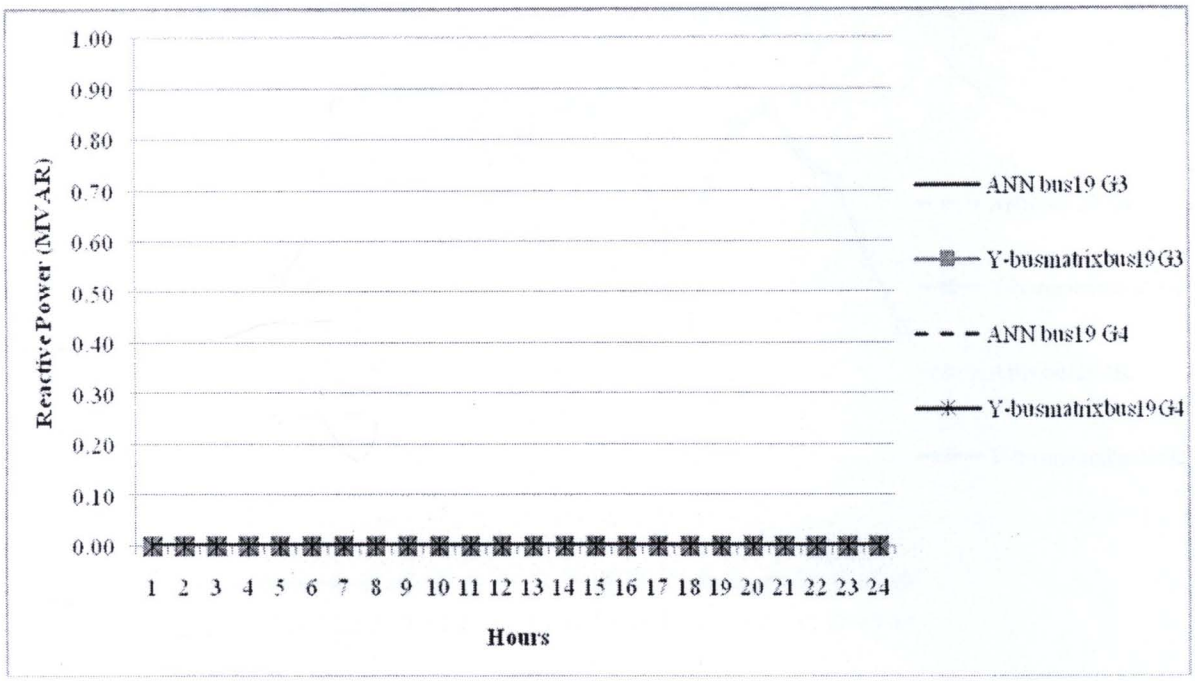
Table 5.15 Percentage error of allocating reactive power at bus19 for EDL 21-bus system

Reactive Power at Bus 19 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
0.00	0.00	8.51	0.06	0.00	0.00	0.00	0.00	0.00	3.38	0.00	0.00

The APE shown in table 5.15 there are minimum value is 0.00 to 0.06 %, maximum value is 0.00 to 8.51 % and MAPE is 0.00 to 3.38 %.



(a)



(b)

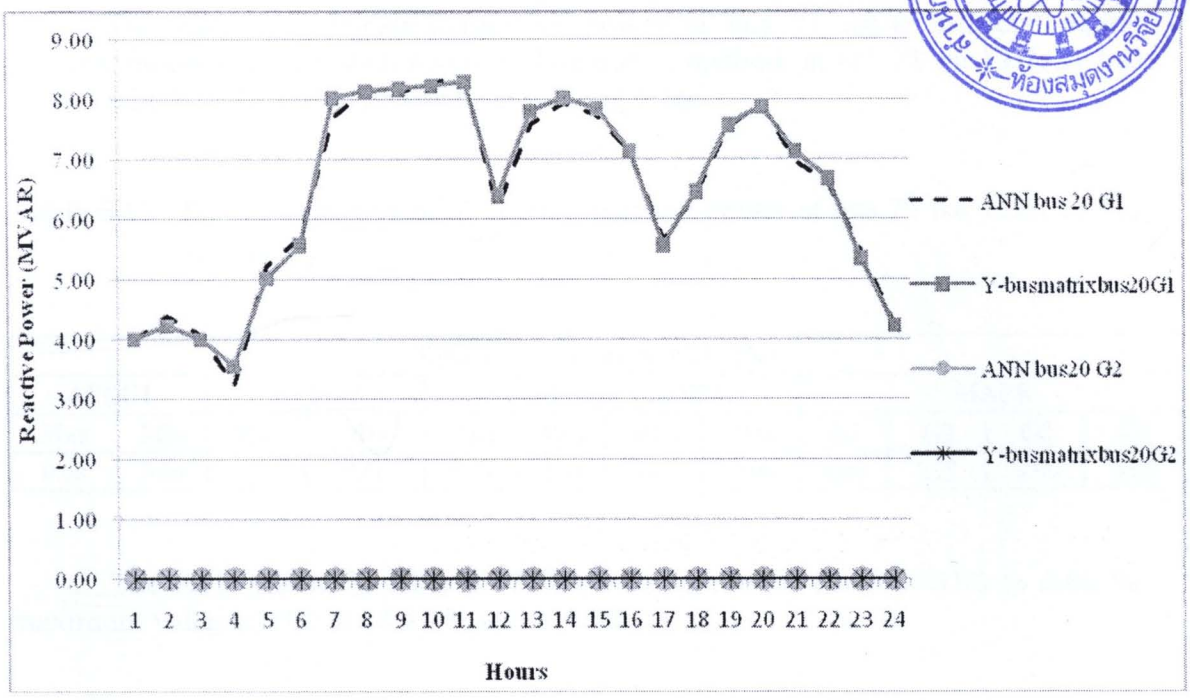
Figure 5.14 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 19 for EDL 21-bus system

The result of allocating reactive power at bus 20 using artificial neural network model compare with result Y- bus matrix method at bus 20 for EDL 21-bus system which is shown in table 5.16 and figure 5.15.

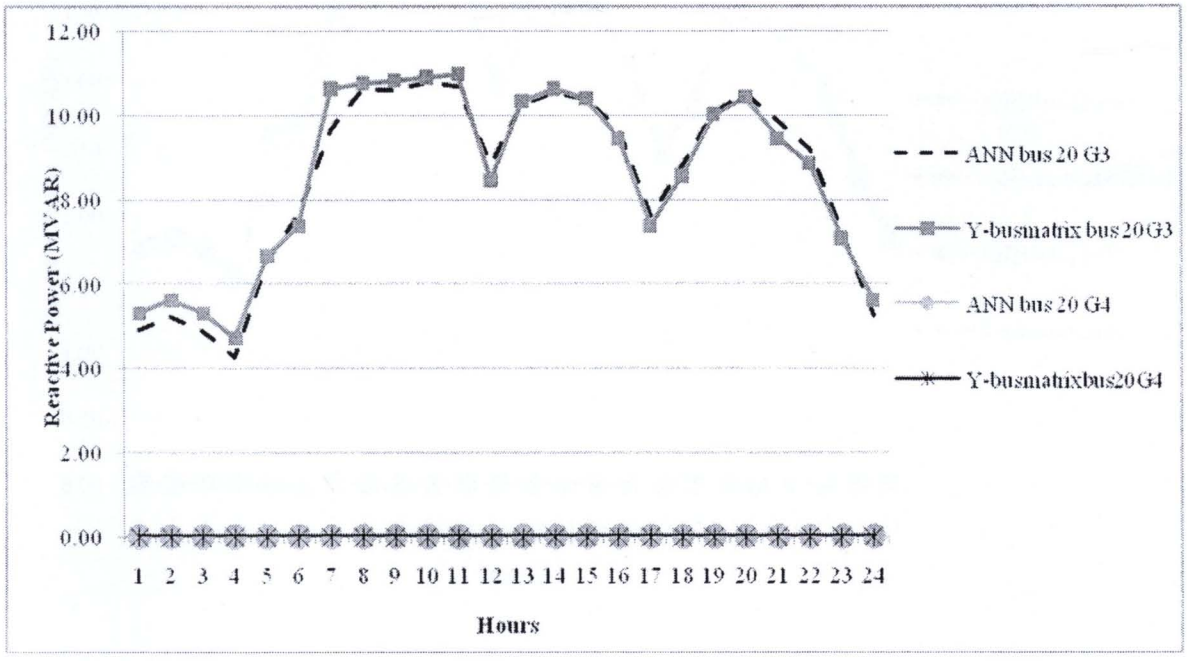
Table 5.16 Percentage error of allocating reactive power at bus 20 for EDL 21-bus system

Reactive Power at Bus 20 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
9.20	0.15	0.00	0.00	9.88	0.14	25.94	1.04	1.87	0.00	3.59	12.82

The APE shown in table 5.16 there are minimum value is 0.00 to 1.04 %, maximum value is 0.00 to 25.94 % and MAPE is 0.00 to 12.82 %.



(a)



(b)

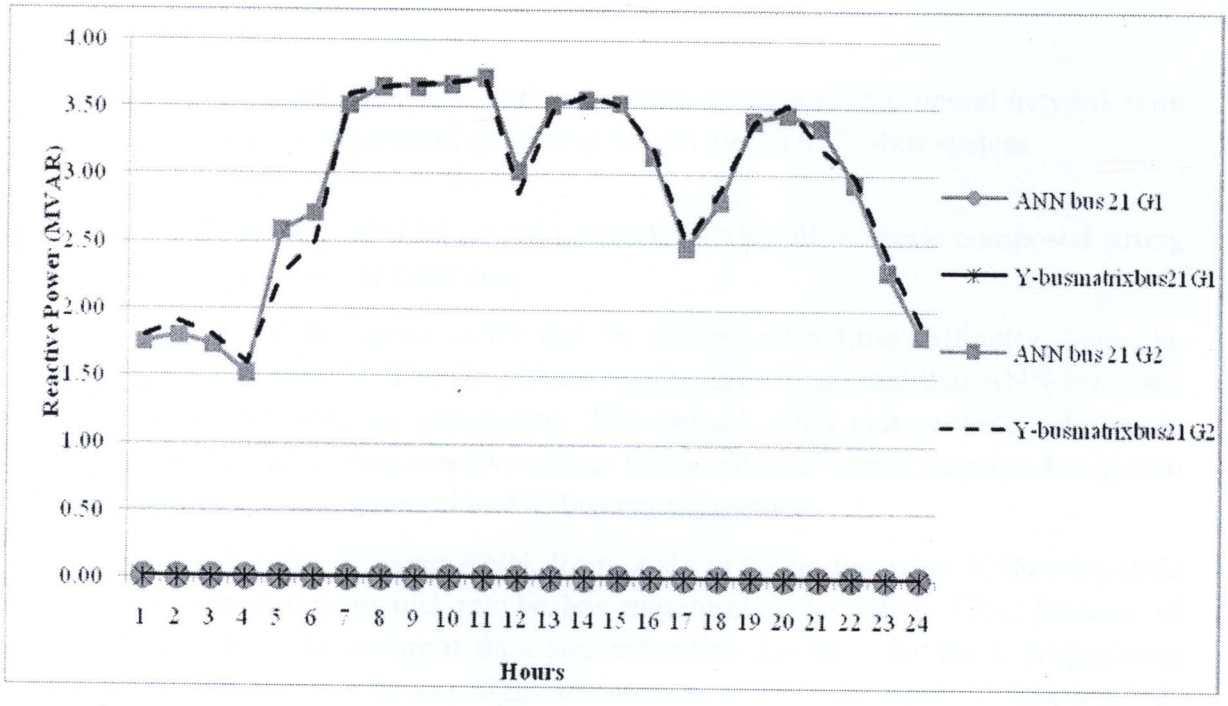
Figure 5.15 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 20 for EDL 21-bus system

The result of allocating reactive power at bus 21 using artificial neural network model compare with result Y- bus matrix method at bus 21 for EDL 21-bus system which is shown in table 5.17 and figure 5.16.

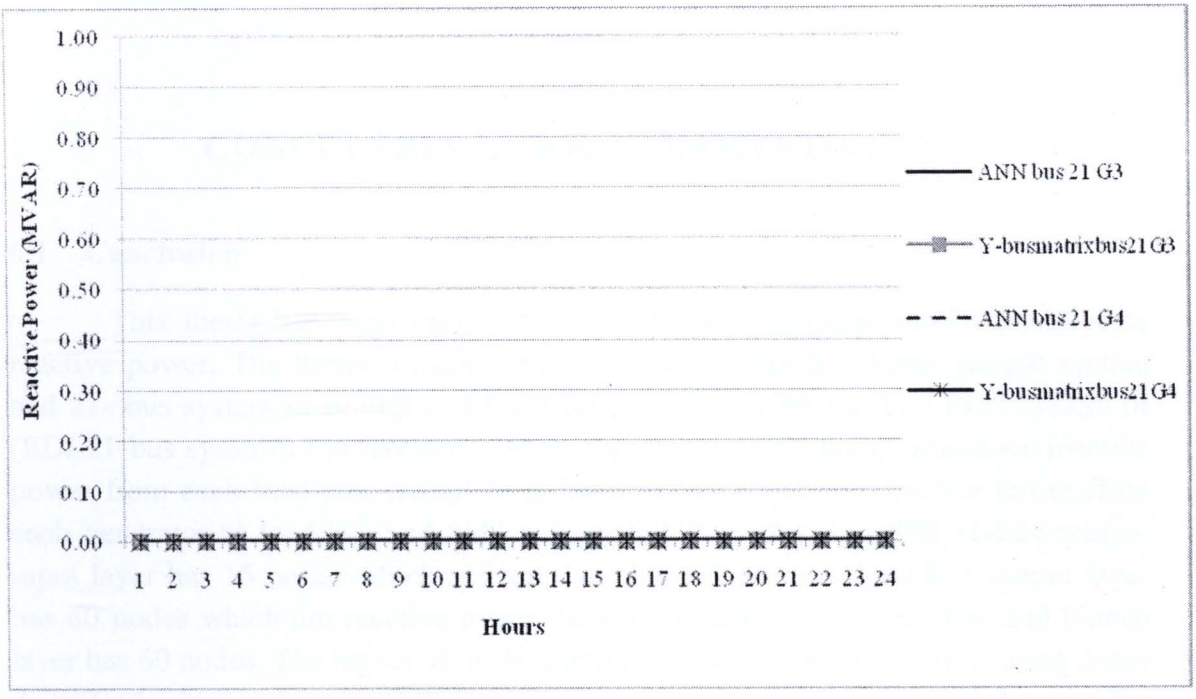
Table 5.17 Percentage error of allocating reactive power at bus 21 for EDL 21-bus system

Reactive Power at Bus 21 (%)											
APEG1		APEG2		APEG3		APEG4		MAPE			
Max	Min	Max	Min	Max	Min	Max	Min	G1	G2	G3	G4
0.00	0.00	14.80	0.00	0.00	0.00	0.00	0.00	0.00	3.21	0.00	0.00

The APE shown in table 5.17 there are minimum value is 0.00 to 0.00 %, maximum value is 0.00 to 14.80 % and MAPE is 0.00 to 3.21 %.



(a)



(b)

Figure 5.16 Compared daily load curves between using artificial neural network with using Y- bus matrix method at bus 21 for EDL 21-bus system

From the using artificial neural network (ANN) all in thesis composed strong point and weak point as the following:

Strong point for using ANN can be trained with little difficulty, once the training data are generated. The simulation results have illustrated that ANN is a good accuracy with simplicity in calculation. The trained ANN can provide solution in good manner. The allocating reactive power using artificial neural network has gotten all characteristics of the conventional Y-bus matrix method.

The weak point of using ANN, from study in thesis for using ANN with large system. The simulation results maybe has maximum error about 13%, because of using ANN it depends on input data and activating function for Back propagation which it has two types as: binary sigmoid function and bipolar sigmoid function. For thesis activating functions for the hidden and output layers are '`tansig`' (bipolar sigmoid function -1, 1) and '`purelin`' (linear function), respectively.