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**Electronics
Electrical Power
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ELECTRICAL POWER ENGINEERING

Load Flow Analysis of Myanmar Electric Power System

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Abstract— This paper presents a unified Newton-Raphson method to solve power flow problem with shunt capacitors. Capacitor are used in the transmission or distribution line to increase line load ability and to get the optimum voltage level at a bus. Matlab load flow analysis program is applied to obtain the results which can be used to assist the decision maker in optimum value of capacitance which gives maximum power transfer and minimum losses at acceptable voltage level. The proposed method has been tested with the network of Myanmar electric power system including 65 buses and 59 branches with impedances specified in per unit on a 100 MVA base specified generation and load condition and line to line voltage of 230 kV as bases.

Keywords— Load flow, Newton-Raphson method, Matlab program, shunt capacitor

I. INTRODUCTION

The main function of a power system is to serve the need of real and reactive power as demanded by various connected load in the network. Catering for a given set of busbar loads requires a power flow study that determines the steady state solution of the network. The quantities obtained from a power flow study are voltage magnitudes and phase angles at the load buses, and reactive powers and voltage phase angles at the generating buses, active and reactive power flows in the transmission lines and system loss.

If we know how the overall losses occur, we can take steps to minimize them. Active power losses can be determined by various methods. It can simply be computed as I^2R . The power loss in a line can also be calculated by taking the algebraic sum of the total power flows in either direction and the total loss would be the sum of all the line losses.

The losses on the system network can be controlled by the modified program to the original Newton-Raphson algorithm by means of the two methods.

- (1) the change of transformer tap settings
- (2) addition of different values of capacitor banks to control reactive power distribution

In this paper, only addition of shunt capacitor bank will be discussed.

II. METHODOLOGY

A. Newton-Raphson Load flow

The complex power at bus i is:

$$P_i = \sum_{j=1}^N |V_i| |V_j| |Y_{ij}| \cos(\theta_{ij} - \delta_i + \delta_j) \quad (1)$$

$$Q_i = - \sum_{j=1}^N |V_i| |V_j| |Y_{ij}| \sin(\theta_{ij} - \delta_i + \delta_j) \quad (2)$$

Where V (voltage), P (real power) and Q (reactive power) terms are given in per unit and δ (phase angle) terms are in radians. This equation shows that the real and reactive powers at every bus except the slack bus can be expressed as a function of voltage magnitude and phase angles.

Flow diagram of Newton-Raphson load flow algorithm is shown in Fig 1.

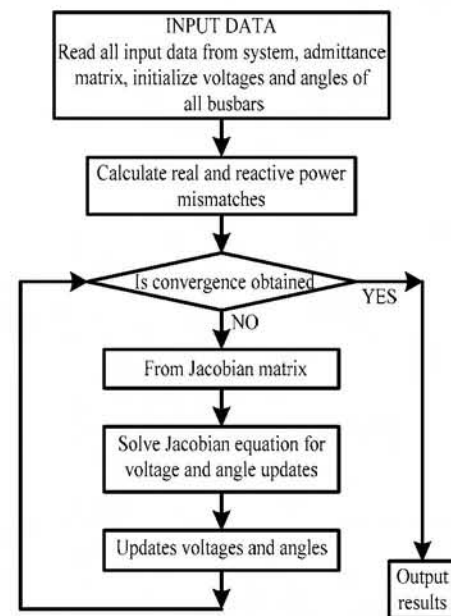


Fig. 1 Flow diagram of the basic Newton-Raphson load flow algorithm

B. Application of Shunt Capacitor Bank

Shunt capacitors are primarily used to improve the power factor in transmission and distribution networks, resulting in improved voltage regulation, reduced network losses, and efficient capacity utilization. Improved transmission voltage regulation can be obtained during heavy power transfer conditions when the system consumes a large amount of reactive power that must be replaced by compensation. At the line surge impedance loading level, the shunt capacitor would decrease the line losses by more than 35%.

Fig. 2 shows the effect of adding a shunt capacitor bank to a power system bus. The system is represented by its Thevenin Equivalent at the node, where the capacitor will be

applied by closing the switch. With the switch open, the node voltage V_t is equal to the Thevenin voltage E_{th} .

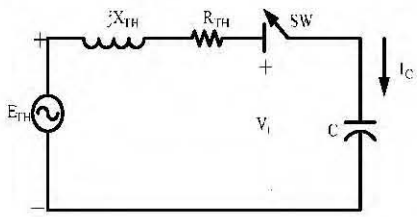


Fig. 2 Effect of adding shunt capacitor to a power system bus

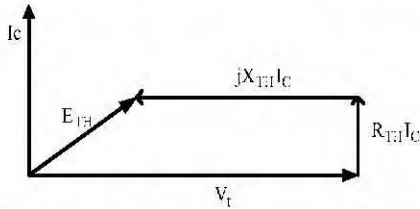


Fig. 3 Phasor diagram when adding a shunt capacitor to a power system bus

From the power flow standpoint, the addition of a shunt capacitor bank to a load bus corresponds to the addition of a negative reactive load. The power flow program computes the increase in bus voltage magnitude along with the small change in phase angle.

The additional capacitor is modeled with the susceptance B . Given a required reactive power injection of Q , the susceptance B can be calculated from $Q = V^2 B$. V is the initial voltage of the bus where the shunt capacitor needs to be installed.

The addition of capacitor bank changes the bus admittance matrix. However, it will only affect the element of the diagonal admittance matrix of the bus where the capacitor is added.

III. RESULTS AND DISCUSSION

A. Preparation of Data

The data bases are from Myanmar Electric Power Enterprise, Ministry of Electric Power (2), which is recorded in July, 2007. The steps in the collection of data are a single line diagram of the system, capacity of all generators at the power stations, load value. Assuming a balance three phase system, the transmission system is represented by its positive-phase-sequence network of linear lumped series and shunt branches. The line impedances and shunt admittance in per unit values are then found, including transformer impedances, shunt capacitor ratings and transformer tapings.

All voltages and line parameters (i.e. resistance, reactance, and susceptance) are converted into per unit quantities. Use three phase volt-ampere of 100 MVA and line to line voltage of 230 kV as bases.

Real and reactive powers are given in actual values (MW or Mvar).

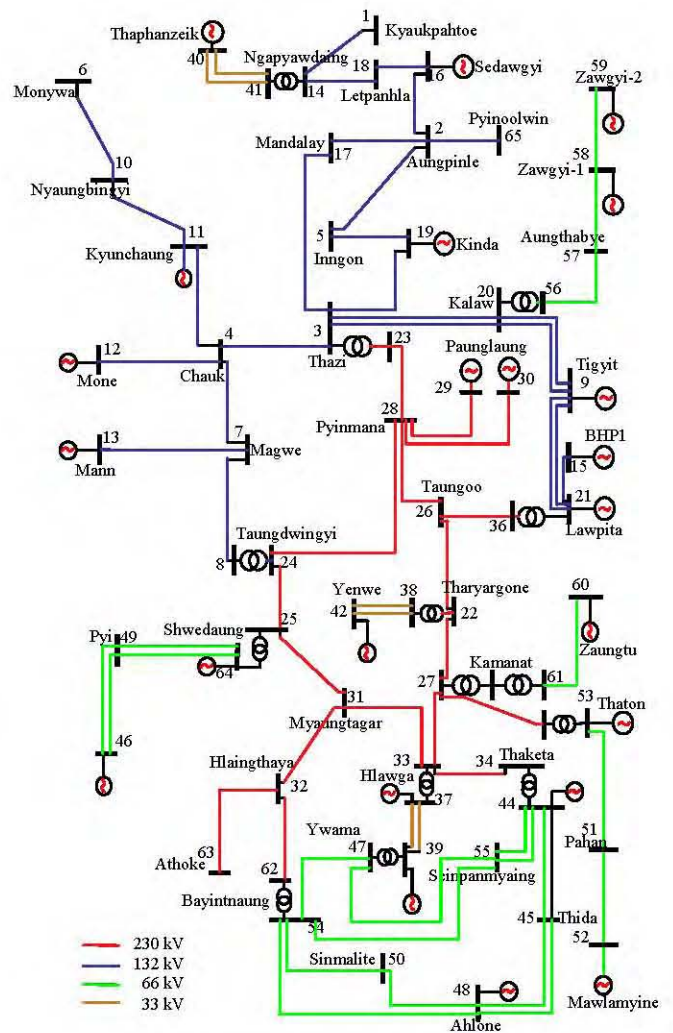


Fig. 4 One line diagram of Myanmar National Grid System

B. Procedure of Matlab Input File

1. Launch Matlab program and open an M-file that will serve as input file.
2. Specify some program parameters: basemva=100; accuracy = 0.001, maxiter =100;
3. Input *busdata* matrix that has the number of rows (equals system buses) and 11 columns. Column 1 is the bus number. Column 2 is designated for bus code where code 0, 1, and 2 are used to specify load buses, slack bus, and voltagecontrolled bus respectively. For slack bus, voltage and phase angle will be specified. For load buses, real and reactive powers are entered in positive megawatts and megavars. It is important to specify initial bus voltage and phase angle. If they are not given enter a flat start ($V=1$, $\delta=0$). Finally, voltage magnitude, real power generation, minimum, and maximum limits of the megavars are specified for voltage-controlled buses. Column 3 and 4 are reserved for voltage magnitude and phase angle. Column 5 and 6 are load MW and Mvar in order. Column 7 and 8 are used to specify generated MW and Mvar respectively. Column 9 and 10 are denoted for generation unit minimum and maximum limits of

Mvar. The last column is used to specify positive injected Mvar of shunt capacitors.

4. Transmission line parameters are entered in *linedata* matrix which consists of six columns. Columns 1 and 2 are reserved for line bus numbers. Columns 3 through 5 are used for line resistance, reactance, and one-half of the total line charging susceptance. The last column has the value of 1 for transmission line or transformer tap setting.

5. The following developed functions shown in Table 2 will be used in sequence to compute and display power flow solution in Matlab work space:

TABLE I
GENERATION DATA

bus no.	name	base KV	rated capacity (MVA)	no of unit	power factor	actual capacity (MW)	remark
9	Tigit	132	75	2	0.8	60	1 is out of service
			22.5	3	0.8		
			29.41	3	0.85		
			25	2	0.8		
			15.5	2	0.9		
			13.88	2	0.9		
			35	2	0.85		
			31	6	0.9		
			85	2	0.85		
			85	2	0.85		
			43.05	3	0.8		
			25,28.3	3	0.8		
			12.5	3	0.8		
			18	1	0.85		
11	Kyunchaung	132	23.9	4	0.8	30	1 is out of service
			24.75,	2	0.8		
			30.7				
			43.05	4	0.8		
			7.5	2	0.8		
			6	3	0.8		
			7	3	0.9		
			7	2	0.9		
			12.5	2	0.8		
			25	3	0.8		
12	Mone	132	43.05	4	0.8	72	1 is out of service
			7.5	2	0.8		
			6	3	0.8		
			7	3	0.9		
			7	2	0.9		
			12.5	2	0.8		
13	Mann	132	25	3	0.8	3.8	of service
			7	3	0.9		
			7	2	0.9		
			12.5	2	0.8		
15	BHP	132	25	3	0.8	20	out of service
			7	3	0.9		
16	Sedawgyi	132	7	3	0.9	14	service
			7	2	0.9		
19	Kinda	132	7	3	0.9	11	1 is out of service
			7	2	0.9		
21	Lawpita	132	7	3	0.9	9	out of service
			7	2	0.9		
29	Paunglaung1	230	7	3	0.9	20	of service
			7	2	0.9		
30	Paunglaung2	230	7	3	0.9	14	service
			7	2	0.9		
37	Hlawga	33	7	3	0.9	11	1 is out of service
			7	2	0.9		
39	Ywama	33	7	3	0.9	9	out of service
			7	2	0.9		
40	Thapanzeik	33	7	3	0.9	11	1 is out of service
			7	2	0.9		
42	Yenew	33	7	3	0.9	9	out of service
			7	2	0.9		
44	Thaketa	66	7	3	0.9	11	1 is out of service
			7	2	0.9		
46	Myanaung	66	7	3	0.9	9	out of service
			7	2	0.9		

C. Results

The power flow program computes the voltage magnitude and angle at each bus in a power system under balanced three phase steady state conditions. Once they are calculated, real and reactive power flows for all line interconnecting the

buses, as well as each line losses and the total losses in the whole system are also provided.

$$\text{System Losses} = \text{Total Losses} \times \frac{100}{\text{Total Generation}}$$

$$= 47.765 \times \frac{100}{1025.906} = 4.622\%$$

TABLE II
MATLAB DEVELOPED FUNCTIONS

Function	Description
lfybus	From the bus admittance matrix
lfnewton	Load flow solution by Newton-Raphson method
busout	Prints the power flow solution on the screen
lineflow	Computes and displays the line flow and losses

In the load flow program, the voltage magnitude is set to 1.0 per unit and the specified voltage variation limit is $\pm 5\%$. So the voltage magnitude must be in the range of 1.05 per unit to 0.95 per unit. Table III shows the weak points in the system that has the voltage magnitude under 0.95.

TABLE III
WEAK POINTS IN THE SYSTEM

Bus No.	Name	Voltage Magnitude (per unit)
1	Kyaukpahtoe	0.938
2	Aungpinlae	0.914
6	Monywa	0.846
10	Nyaungbingyi	0.853
14	Ngapyawdaing(123kV)	0.941
17	Mandalay	0.905
18	Letpanhla	0.944
41	Ngapyawdaing(33kV)	0.881
57	Aungthabye	0.930
65	Pyinoolwin	0.910

D. Compensation of Shunt Capacitor Bank

Aungpinlae, bus 2, is chosen as an example. The digital load flow print of Aungpinlae shows a voltage at bus 2 of 0.914 per unit. When the voltage of bus 2 is specified to be 0.953 per unit, the required reactive power generation is found to be 27 Mvar. The flow of real and reactive power determined by the computer in the lines connected to bus 2, Aungpinlae, with and without the added capacitors is shown in Fig. 5.

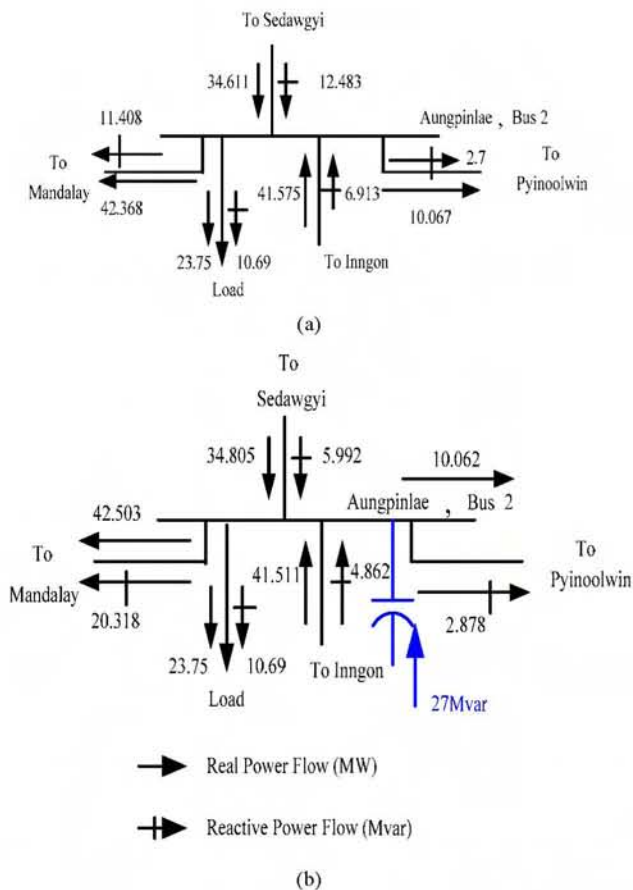


Fig 5. Flow of P and Q at Bus 2 of the Myanmar Electric Power System (a) as found in original load flow study and (b) with capacitor added at Bus 2 to raise the voltage to 0.953 per unit

The same load flow program can be used to determine the amount of reactive power which must be supplied by capacitors at bus to raise the voltage to any specified value. Optimum values of the required reactive compensation are shown in Table VI.

TABLE 4
REQUIRED INJECTED Q FOR WEAK POINTS

Bus No.	Injected Mvar
2	27
5	6
6	8
10	8
17	30
41	15
57	15
65	15

Fig. 6 shows comparison for the level of each bus voltage magnitude with and without injection of Mvar. Optimum value of required reactive compensation gives minimum losses at acceptable voltage level.

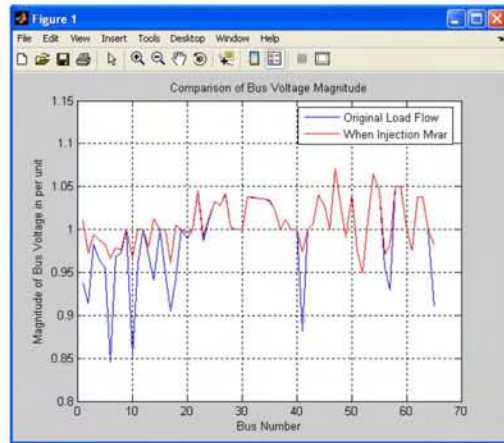


Fig 6. Comparison of bus voltage magnitude

The availability of this thesis results would be helpful to small utilities as electrical power engineers seek to integrate their power system with different types of generation.

IV. CONCLUSION

The quality of electricity is decided by system frequency and voltage. The load for industrial use which is sensitive to system frequency is seriously affected by rising and declining frequency. Therefore, system frequency should be maintained within certain prescribed range. Power system voltage also should be within a prescribed range. System frequency is the same at the entire power system, but voltage can be different at each bus in power system. Therefore, it is necessary to install voltage compensation devices to the points where the voltage is too high or low.

The power system must be able to maintain its stability even under the fluctuation of both active and reactive power. Unlike other types of energy, electricity cannot be conveniently stored in sufficient quantities. Therefore, adequate 'spinning' reserves of active and reactive power should be maintained and appropriately controlled at all times.

The voltage characteristics in normal conditions of major 230 kV substations and 132 kV substations are very low which means out of specified range. Especially, the bus voltages at the Hlawga, Thaketa, Mandalay, Aungpinle, where are in charge of heavy loads in Yangon and Mandalay areas, are expected to be low. The reactive power facilities need to be reinforced in these regions.

For reliable and economical operation of the power system it is necessary to forecast the entire system to get the up-to-date data. The power system operational and technical data are essential for the power system stability.

In developing load flow studies of Myanmar Electric Power System, variations of the main variable parameters such as system base load, day and night peak load and emergency load condition are taken into consideration in determining the optimization of existing system operation and the future expansion of power system planning.

REFERENCES

- [1] William D. Stevenson, JR. 1975. Elements of Power System Analysis. 4th Edition. MC Graw-Hill, Inc.
- [2] Hadi Saadat. 1999. Power System Analysis. Singapore: MC Graw-Hill Companies. Inc.
- [3] J. Arrillage, C. P. Arnold and B.J. Harker. 1983. Computer Modelling of Electrical Power Systems. John Wiley & Sons Ltd.
- [4] Allen J. Wood and Bruce F. Wollenberg. 1996. Power Generation, Operation, and Control. 2nd Edition. United States of America: John Wiley & Sons, Inc.
- [5] Ramasamy Natarajam. 2002. Computer-Aided Power System Analysis. The United States of America. Marcel Dekker, Inc.
- [6] I J Nagrath and D P Kothari. 1994. Power System engineering. Tata Mc Graw-Hill Company Limited.
- [7] Stagg, G.W. and El-Abiad, Ahmed H. 1968. Computer Methods in Power System Analysis. New York. McGraw-Hill Book Company.
- [8] Lukman, D., Blackburn and T.R., Modified Algorithm of Load Flow Simulation For Loss Minimization In Power System. Proceedings of the Australasian Universities Power Engineering Conference (AUPEC'94), Brisbane, Australia. 24-27 September 2000.
- [9] Penny, J. and Lindfield, G. 1995. Numerical methods using MATLAB. Hertfordshire. Ellis Horwood Limited.
- [10] Ray D. Zimmerman, Carlos E. Murillo-Sánchez and Deqiang (David) Gan. 2006. Matpower User's Manual. Ithaca. Power Systems Engineering Research Center (PSERC). School of Electrical Engineering, Cornell University.
- [11] Weedy, B.M. and Cory, B.J. 1998, Electric Power Systems. 4th Edition. West Sussex. John Wiley & Sons.
- [12] Gonen, T. 1988. Modern Power System Analysis. New York. John Wiley and Sons, Inc.