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icse@bwu.edu.ly

Analysis of Load flow network of alsraj 30 KV Power System using ETAP

Abdulwahid. A. khalleefah

Higher Institute of Science and Technology Alasabaa, Alasabaa, Libya
Crossponding author: abdalwahdabrahym@gmail.com

Abstract: Abstract: The purpose of this research is to analyze the load flow network of the Alsraj 30 KV Power System using ETAP software.

In this study, the load flow analysis of the Alsraj 30 KV Power System is conducted using the ETAP software. Load flow calculations are performed to determine the voltage magnitudes and angles at different nodes, as well as the active and reactive power flows in the network.

The load flow analysis of the Alsraj 30 KV Power System reveals the voltage profiles and power flow patterns within the network. The analysis provides valuable insights into the system's performance, identifying potential areas of concern such as voltage drops, overloads, and reactive power issues. The findings help in assessing the system's stability, reliability, and efficiency, facilitating the identification of necessary corrective measures and improvements.

Keywords: (load flow analysis, ETAP)

Introduction

Power consumption is an essential resource that is integral to our modern lifestyles. Consumer demand for power significantly exceeds the current generation capacity, resulting in an imbalance.

Load flow analysis using specialized software provides accurate and highly reliable results. This study effectively utilizes the Electrical Transient Analyzer Program (ETAP) to analyze the load flow within an electrical network..[1]

The primary goal of the load flow analysis is to identify potential issues, such as: Unacceptable voltage conditions, overloading of electrical facilities, decreasing system reliability, Failure to meet performance criteria for the transmission system. By conducting this analysis, the aim is to proactively detect any problems within the power network that could lead to suboptimal performance or failures. [2].

Load flow analysis provides crucial information, including the nodal voltages, phase angles, and power flows through the transmission lines connected to all the buses in the power system. It is an essential tool for conducting various numerical and algebraic analyses on a power system.

Some of the key analyses that can be performed using load flow studies include, Computing load flows under normal operating conditions, Evaluating load flows under abnormal or contingency scenarios .In summary, load flow analysis is an indispensable technique for thoroughly understanding the performance and behavior of a power system under different operating conditions. [3] The load flow solution is a crucial component in the design of new power systems as well as in planning the expansion of existing systems to accommodate increased load demand. Design new power systems effectively, ensuring the system can meet the expected load requirements. Plan the expansion of current power systems to increase the overall load-serving capacity. This helps prepare the network to handle higher future demands. [4].

Flow Calculation Methods

Four methods of load flow calculations: Newton-Raphson, Adaptive Newton-Raphson, Accelerated Gauss-Seidel, and Fast Decoupled. All four diverse ways of measuring load flow have various convergence requirements that each should be. to produce optimal results and fewer errors in a given situation. Any of these methods can be chosen depending on the topology of the structure, type of generation, loading status, and the initial value of the bus voltages[5].

Newton-Raphson Method

The Newton-Raphson (N-R) approach has robust convergence properties, although it requires higher computational and storage requirements. However, the use of sparsity techniques and ordered elimination has contributed to its widespread acceptance. It remains an effective load-flow algorithm for large-scale power systems and optimization problems, even in today's setting.

Compared to the Gauss-Seidel process, the N-R method typically requires a smaller number of iterations to converge, as long as the initial estimate is reasonably close to the final solution. This holds true even as the size of the system increases.[6]

The Newton-Raphson (N-R) load flow method often utilizes the Gauss-Seidel process to obtain reasonable initial voltage estimates as the starting point. These initial voltage values are then used as inputs to the N-R system. The real power (P) is measured at each bus, except the swing bus, and the reactive power (Q) is measured wherever it is defined. These power values are then used to apply the Newton-Raphson technique to solve the load flow equations.[7].

Then the voltages, line admissions and real and reactive forces are represented for polar form representation as

$$I_i = \sum_{j=1}^{n} |Y_{ij}|\,|V_{ij}| < \theta_{ij} + \delta_j \qquad (1)$$

The real and reactive power at bus i is

$$P_i - jQ_i = V_i^* I_i \qquad (2)$$

Substituting for Ii in the equation gives

$$P_i - jQ_i = |V_I| < -\delta_i \sum_{j=1}^{n} |Y_{ij}|\,|V_{ij}| < \theta_{ij} + \delta_j \qquad (3)$$

The real and imaginary parts are separated:

$$P_i = \sum_{j=1}^{n} |V_i|\,|V_j||Y_{ij}| \cos(\theta_{ij} - \delta_i + \delta_j) \qquad (4)$$

$$Q_i = \sum_{j=1}^{n} |V_i|\,|V_j||Y_{ij}| \sin(\theta_{ij} - \delta_i + \delta_j) \qquad (5)$$

The load flow equations using Newton-Raphson techniques can therefore be written as:

$$\begin{bmatrix} \Delta P_2^{(K)} \\ \cdot \\ \cdot \\ \cdot \\ \frac{\Delta P_n^{(K)}}{\Delta Q_2^{(K)}} \\ \cdot \\ \cdot \\ \cdot \\ \Delta Q_n^{(K)} \end{bmatrix} \begin{bmatrix} \frac{\partial P_2^{(K)}}{\partial \delta_2} & . \; . \; . & \frac{\partial P_2^{(K)}}{\partial \delta_2} \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \frac{\frac{\Delta P_n^{(K)}}{\partial \delta_2}}{\frac{\partial Q_2^{(K)}}{\partial \delta_n}} & . \; . \; . & \frac{\frac{\Delta P_n^{(K)}}{\partial \delta_2}}{\frac{\partial Q_2^{(K)}}{\partial \delta_n}} \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \frac{\partial Q_n^{(K)}}{\partial \delta_2} & . \; . \; . & \frac{\partial Q_n^{(K)}}{\partial \delta_2} \end{bmatrix} \begin{bmatrix} \frac{\partial P_2^{(K)}}{\partial V_2} & . \; . \; . & \frac{\partial P_2^{(K)}}{\partial V_2} \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \frac{\frac{\Delta P_n^{(K)}}{\partial V_2}}{\frac{\partial Q_2^{(K)}}{\partial V_n}} & . \; . \; . & \frac{\frac{\Delta P_n^{(K)}}{\partial V_2}}{\frac{\partial Q_2^{(K)}}{\partial V_n}} \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \frac{\partial Q_n^{(K)}}{\partial V_2} & . \; . \; . & \frac{\partial Q_n^{(K)}}{\partial V_2} \end{bmatrix} \begin{bmatrix} \Delta P_2^{(K)} \\ \cdot \\ \cdot \\ \cdot \\ \frac{\Delta P_n^{(K)}}{\Delta V_2^{(K)}} \\ \cdot \\ \cdot \\ \cdot \\ \Delta V_n^{(K)} \end{bmatrix}$$

In a compact form, it can be written as:

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & J_3 \\ J_2 & J_4 \end{bmatrix} \begin{bmatrix} \Delta Q \\ \Delta |V| \end{bmatrix} \qquad (6)$$

The difference between the schedule and calculated values known as power residuals for the terms ΔPi(k) and ΔQi(k) is represented as:

$$\Delta P_i^{(k)} = P_i^{sch} - P_i^{k} \quad (7)$$

$$\Delta Q_i^{(k)} = Q_i^{sch} - Q_i^{k} \quad (8)$$

The new estimates for bus voltage are :

$$\delta^{(k+1)} = \delta_i^{(k)} + \Delta\delta_i^{(k)} \quad (9)$$

$$\left|V^{(k+1)}\right| = \left|V_i^{(k)}\right| + \Delta\left|V_i^{(k)}\right| \quad (10)$$

Power Flow Analysis using ETAP Software:

ETAP is an analyzer program that contains documentation elements and task-oriented program modules. It utilizes the Newton-Raphson method to analyze the load flow. ETAP operates faster than real-time and produces accurate, precise, and reliable outcomes. The analysis provides steady-state characteristic data such as active power, reactive power, voltage magnitude, voltage phase angles, system losses, and power consumption.

ETAP monitors the system network accurately and generates a detailed and organized representation of the output results. The obtained results from the analysis help to assess the system voltage profile, phase angles, transformer loadings, system losses, and the contribution of the optimization technique (PFI plant) in system improvement [8].

5. Data Required for Load-Flow Analysis

Data Required for Load-Flow Analysis

The following steps are implemented in the collection of system data for load flow analysis:

- Draw a single-line diagram of the system.
- Enter all data from the General Electricity Company and it consists of the following Two 30/220 transformers, twenty five 30/11 transformers, twenty five transport buses, Forty cable lines, and twenty five loads.
- Node or bus self-admittances are found, using the nodal analysis.
- Run it through as a suitable Mathematical iterative model.
- Obtaining the appropriate information and statistics required from the ETAP program reports.

The details of the equipment are provided in Table 1, Single line diagram of the network is shown in Figure1.

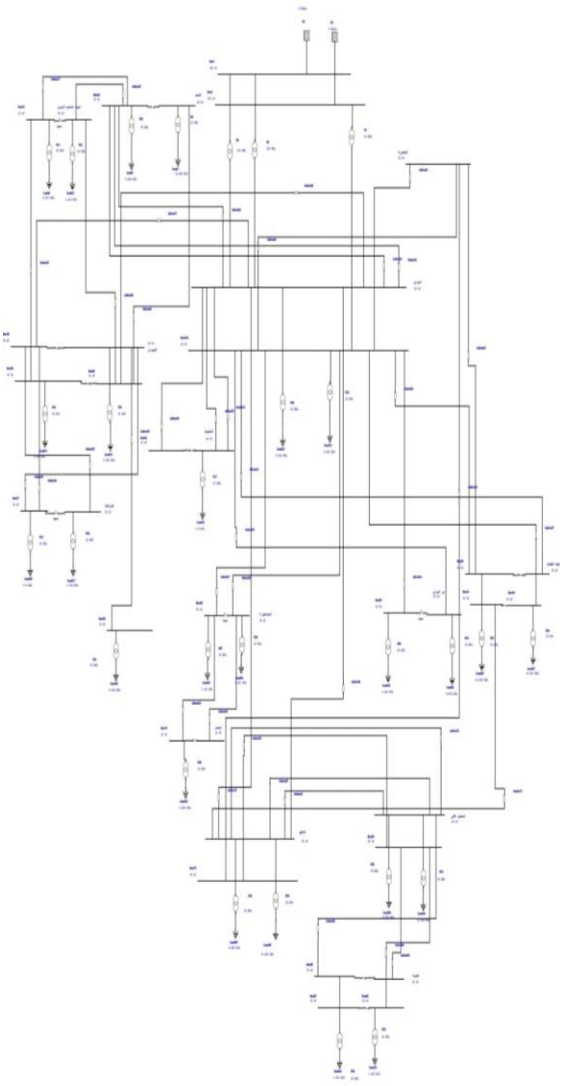

figure 1

Table 1 Transformer input data

Component	Type	Rating	Prim	Sec
Power Transformer	T1(2-winding)	63MVA	220 KV	30 KVA
	T2(2-winding)	100 MVA	220 KV	30 KVA
	T3(2-winding)	100 MVA	220 KV	30KVA
	T4-T28 (2-winding)	20 MVA	30 KV	11KVA

Table 2 Input data of all the cable

Name	Length (m)	T (°C)	Resistance	Impedance
Cable 1-2	2300	75	0.02830	0.11670
Cable 3-36-40	3700	75	0.0435	0.0600
Cable4-5-6	2000	75	0.0283	0.1167
Cable7-8	600	75	0.0283	0.1167
Cable 9-10	2700	75	0.0435	0.0600
Cable 11-12-13	950	75	0.0283	0.1300
Cable 14-15-16	3200	75	0.0870	0.1450
Cable17	3410	75	0.0870	0.1450
Cable18	2900	75	0.0830	0.1167
Cable19-20-22	4560	75	0.0870	0.1200
Cable21	2100	75		0.1200
Cable23-24	4000	75	0.0283	0.1167
Cable 25-26	2330	75	0.0283	0.1167
Cable27-28-37-38-39	1500	75	0.0283	0.1167
Cable 29-31-32-33	2500	75	0.0870	0.1200
Cable 30-35	4250	75	0.0435	0.0600

Cable34	2720	75	0.0870	0.1200

Table 3 Load input data

	KV	MVA	MW	Mvar
Load1	11	1.602	1.362	0.844
Load2	11	1.921	1.633	1.012
Load 3-9-22	11	12.804	10.883	6.745
Load4-25	11	8.003	6.803	4.216
Load 5	11	13.828	11.754	7.284
Load 6	11	8.643	7.347	4.553
Load 7	11	6.402	5.442	3.372
Load 8	11	16.005	13.604	8.431
Load10-18-21-23	11	9.604	8.163	5.059
Load11-12-17-24	11	6.402	5.442	3.372
Load 13	11	7.142	6.071	3.762
Load14	11	9.064	7.704	4.775
Load15	11	1.594	1.355	0.84
Load16-19	11	0.8	0.68	0.422
Load20	11	5.602	4.762	2.951

LOAD FLOW ANALYSIS

Load flow simulations give us result on diagram and generate tabulation reports of calculated bus voltage, its magnitude, angle, currents, and power flow through the electrical network etc. We analyzed the output data for different values of equipment by using ETAP Load Flow Result Analyzer.

When the original condition analyzed we noticed that there is a drop voltage in most of the buses. The calculated voltages shown in the table 4 are not acceptable because of the extra drop voltage in the networks which can be clearly seen from Fig2**.**

Type 4

Bus Number	Bus Type	Nominal Voltage		PF
		%	Angle	
11	Load Bus	94.28	-3.6	82.3
12	Load Bus	94.38	-3.5	81.5
13	Load Bus	94.38	-3.5	83.6
14	Load Bus	94.29	-3.7	83.4
15	Load Bus	94.31	-3.7	83.5
16	Load Bus	94.27	-3.5	83
17	Load Bus	94.47	-3.4	84.6
18	Load Bus	94.48	-3.4	84.6
19	Load Bus	94.53	-3.4	84.7
20	Load Bus	94.45	-3.4	0
21	Load Bus	94.45	-3.5	83.6
22	Load Bus	94.52	-3.5	79.6
23	Load Bus	94.44	-3.6	65.2
24	Load Bus	94.32	-3.3	83.5
25	Load Bus	94.91	-3.4	82
30	Load Bus	94.53	-3.4	82.3
31	Load Bus	94.62	-3.7	82.9
32	Load Bus	94.18	-3.7	83.5
33	Load Bus	94.27	-3.7	79.7

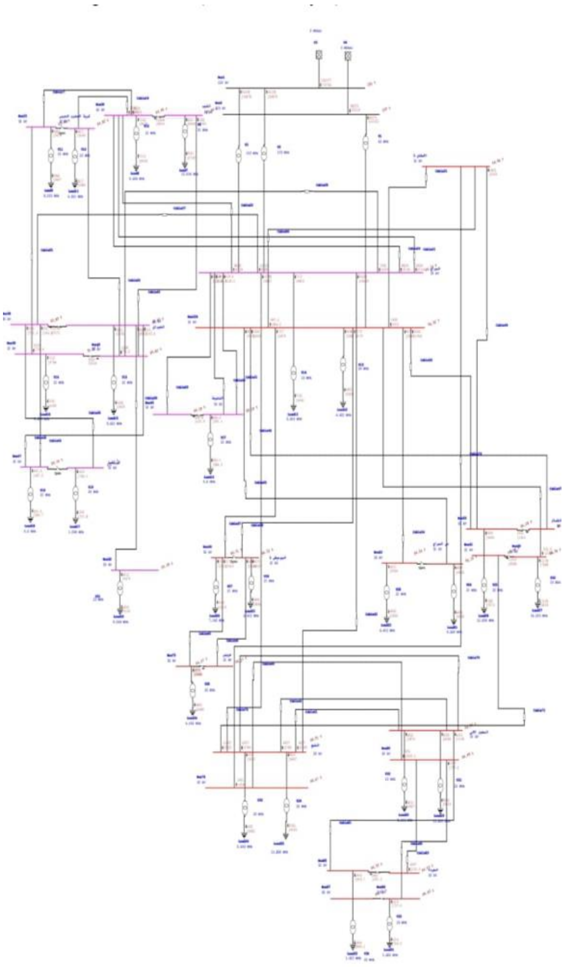

Figure**2**

TABLE 5 shows the Demand and Losses summary report which tells us about the total demand of the system and also about the losses that occurs in a system.

TABLE 5

Type	MW	Mvar
Swing Bus	140.852	107.478
Total Demand	140.852	107.478
Total Losses	1.718	21.25

In this network the max tap of the transformer T1,T2 ,T3 is +1 x 5% . so we put the settings of the transformers tap's as shown in the following table6.

TABLE 6

Transformer	Tap Settings
T1	+5% on the seconder Side
T2	+5% on the seconder Side
T3	+5% on the seconder Side

After running the ETAP the load flow results obtained are shown as shown in the following Fig3.When analyzing the original case, we noticed that there is no voltage drop for the buses

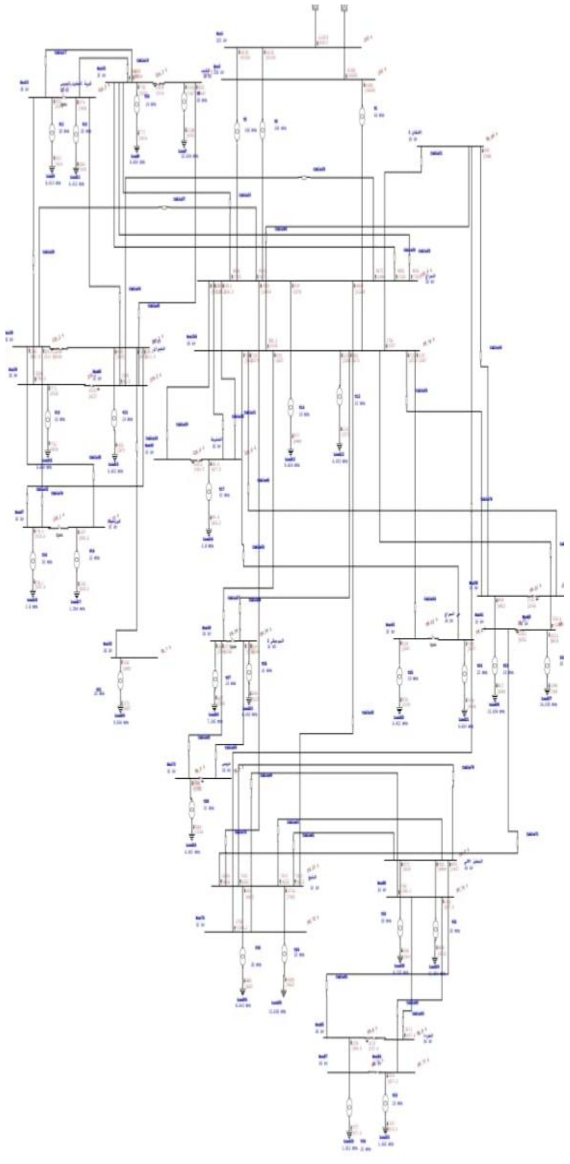

Fig 3

Conclusion

In this research Load flow study using ETAP software is carried out to analyze the system under various conditions. By using ETAP load flow program, it is found that the network of the Alsraj 30 KV Power System experiences many technical problems including: poor power factor, low voltage levels and power losses. And the aim of this load flow studies is to determining the system voltage under various conditions, and to use proper methods that used to maintain the problem of under voltage. And they are useful to determine if system voltages remain within specific limits under various conditions, and whether equipment such as transformers and transmission lines are overloaded.

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