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A Detailed Study for Load Flow Analysis in Distributed Power System

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ABSTRACT

Load flow (LF) is one of the most important parts to study and analyze power system operation. In this research paper, a detailed study for load flow analysis in distributed power system (DPS) is presented. A case study of modeling and simulation of the actual power distribution network is implemented with the electrical transient analyzer program (ETAP) software (version no: 12.6). Furthermore, a comparison of common load flow techniques of power distribution is presented. In this assessment, numerical and practical methods including Newton-Raphson (NR), Fast Decoupled (FD), and Accelerated Gauss-Seidel (AGS) are provided and compared. The results (total generation, loading, demand, system losses, and critical report of load flow) are obtained and analyzed. This paper focuses on the detailed assessment and monitoring by using the most modern ETAP software, from high voltage substation (HVS) to the loads. The capability and effectiveness of load flow assessment are demonstrated according to the simulation results obtained with ETAP by applying it to the actual distributed power system of Tehran metro (subway). Once the modeling is performed in ETAP for complete power system, it might be highly beneficial for converting conventional grid into smart grid.

Article Info

***Keywords*:**
ETAP, Distributed Power System
Load Flow Analysis, Tehran Metro.

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NOMENCLATURES

AC	*Alternating current*	***VT***	*Transpose of V*
B	*Susceptance (℧)*	***Vi***	*Voltage at node i (V)*
DC	*Direct current*	$\|V\|$	*Voltage Magnitude*
G	*Conductance (℧)*	***Y***	*Admittance (℧)*
I	*Current (A)*	***i, j and k***	*Indices of buses*
I*	*Conjugate of I*	δ	*Phase angle of voltage (degree, rad)*
J	*Jacobian matrix*	Δ	*Mismatch*
n	*Number of branch (i, k)*	***P.U***	*Per unit*
P	*Active power (kW)*	***kVA***	*Kilo volt ampere*
Q	*Reactive power (kVAr)*	***kVAr***	*Kilo var*
PV	*Generator bus*	r_i	*Repair time*
PQ	*Load bus*		
S	*Apparent power (kVA)*	***List of abbreviation***	
V	*Voltage (V)*	***RS***	*Rectifier Substation*
V*	*Conjugate of V*	***LPS***	*Lighting and Power Substation*
λ_s	*Failure rate*	***HVS***	*High Voltage Substation*
r_s	*Average outage duration*	***P.F***	*Power Factor*
U_s	*Average annual outage time*	***ASAI***	*Average service availability index*

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I. Introduction

A. Background

Nowadays, load flow (LF) is one of the important tools utilized by electrical experts for planning and control, to determine the best operation for distributed power systems (DPSs) and the exchange of power between utility companies. In the last decades, electrical engineers have been dealing with power system studies by using new software tools. Recent advances in electrical engineering sciences have brought a revolution in the field of electrical engineering after the development of powerful computer based software [1-4].

Load flow methods might take a long time to be calculated; therefore, it prevents achieving an accurate result for a load flow solution because of continuous changes in power demand and generation. The principal information obtained from a load flow analysis is the magnitude and phase angle of the voltage at each bus, and the real and reactive load flowing in each line [5, 6]. Commercial power systems are usually too complex to allow handing solutions for the load flow. Large-scale digital computers have replaced analogous methods with numerical solutions. Besides, in order to the load flow analysis; computer programs perform related calculations such as short-circuit fault assessment, stability studies with focus on transient and steady-state, unit commitment and economic dispatch [7]. Maintaining a high level of system security is one of the more important aspects of power systems that should be noted as well as the economic operation of these systems [8].

B. Literature Review

In recent years, many researchers have proposed different approaches to analysis, simulation and modeling in the field of power systems and metro structures. Some recently published papers and literature reviews can be found in [9-12]; the most important factors of metro tunnels safety and importance of safety and security to improve the more comfortable services in metro tunnel and subway stations is explained in [13]; in the reference [14], the criteria and rules for design of metro path is dedicated; in the paper [15], the authors presented a review of probabilistic load flow in power systems; the reference [16] deals with an analytical methodology for assessment of smart monitoring impact on future electric power distribution system. In the paper [17, 18], a new prediction model is introduced based on hybrid forecast engine and new feature selection; [19] proposes a new forecast approach based on combination of a neural network with a meta-heuristic algorithm as the hybrid forecasting engine. NR load flow with consideration of the fuzzy load and in the presence of the distributed generations in distribution network is presented in [20].

For optimal power system operation, electrical generation should follow electrical load demand. So, short term load forecast (STLF) has been proposed by researchers to tackle the mentioned problem. So, the paper [21] proposes a new prediction model for small scale load prediction. The paper [22] used new algorithm to optimal sizing and sitting of distributed generation in power system. The particle swarm optimization (PSO) based fuzzy stochastic long-term model for deployment of distributed energy resources in distribution systems with several objectives is proposed in [23]; the summary explanation of the basic equation of the load flow problems are described in [3, 24, 25]. The reference [26] proposes a novel method to deal with the energy minimization; in the paper [27] the wavelet decomposition combined with adaptive neuro-fuzzy inference system is used for short term wind power forecasting.

C. Motivation and Main Contribution

In this paper, we focus on the effective usage of the ETAP software for load flow analysis and modeling in the distributed power system of Tehran metro. The results comprise large distributed power systems emanating from high voltage (H.V.), medium voltage (M.V.), and low voltage (L.V.) networks, equipment and loads; the data used for the assessment objective are in the form of one line diagrams of the complete and actual power grid of Tehran metro starting from HVS and power transformer at the grid up to the loads. The ratings of all the components of the power system network are taken as they actually exist. Also, the transformers, circuit breakers (C.B.) and load switch (L.S.), conductor's cables, distribution system and DC components are also simulated according to the actual ratings by electrical transient analyzer program software, and this innovative concept deals with 63kV, 20kV, 0.75kV and 0.4kV network simulations with the ETAP software.

D. Paper Structure

The rest of the paper is organized as follows: in section 2, the fundamental theories of the proposed method are introduced. Section 3 describes a case study analysis approach to the distributed power system of Tehran metro in detail. In Section 4, the prediction results are given. The conclusions are presented in Section 5.

II. MATERIALS AND METHOD

In section 2, three common load flow methods are explained.

A. Bus Classifications

According to the references [25, 28-30], bus is a point or node in which one or many transmission lines, loads and generators are connected. Traditionally, in a power system study, every bus is associated with four quantities: active power (P), reactive power (Q), magnitude of voltage (|V|), and phase angle of voltage (δ). In addition, buses are divided into three important categories including: 1) slack bus, 2) generator (PV) bus, and 3) load (PQ) bus. These categories are shown in Table I.

TABLE I
BUS CLASSIFICATION

Type of Bus	**Variables**			
	P	**Q**	**V**	**δ**
Slack	Unknown	Unknown	Known	Known
(PV)	Known	Unknown	Known	Unknown
(PQ)	Known	Known	Unknown	Unknown

B. Load Flow Calculation Methods

In the past three decades, various numerical analysis methods have been applied for solving load flow analysis problems. The most commonly used iterative methods are the GS, NR, and FD methods [5, 31]. According to the reference [5], the first step in performing a load flow assessment is to form the Y-bus admittance using the transmission line and the transformer input data. The nodal equation for a power system network using Y-bus can be written as follows:

$$I = Y_{Bus} V \qquad (1)$$

The nodal formula can be expressed in a generalized form for an n bus system.

$$I_i = \sum_{j=1}^{n} Y_{ij} V_j \quad ; \quad \text{for } i = 1, 2, 3, \dots, n \qquad (2)$$

The complex power delivered to bus i is given by:

$$P_i + jQ_i = V_i I_i^* \qquad (3)$$

$$I_i = \frac{P_i - jQ_i}{V_i^*} \qquad (4)$$

Substituting for Ii in terms of Pi and Qi, the formula is given as:

$$\frac{P_i - jQ_i}{V_i^*} = V_i \sum_{j=1}^{n} Y_{ij} - \sum_{j=1}^{n} Y_{ij} V_j \quad ; \quad j \neq i \qquad (5)$$

On the other hand, according to the reference [32], complex power injection of the system is given by:

$$S_i = S_{Gi} - S_{Di} = \text{Generation} - \text{Load} \qquad (6)$$

$$S_i = \sum_{k}^{n} S_{ik} \qquad (7)$$

Where in the equations (6) and (7); k = 1, 2,…,n ; i = 1, 2,…,n

Similarly, the phasor of current injections are given by:

$$I_i = I_{Gi} - I_{Di} = \sum_{k}^{n} Y_{ik} V_{ik} \qquad (8)$$

$$S_i = V_i I_i^* = V_i \sum_{k}^{n} Y_{ik}^* V_k^* \qquad (9)$$

$$S_i = \sum_{k}^{n} |V_i||V_k| e^{j\delta ik} (G_{ik} - jB_{ik}) \qquad (10)$$

Where: Vk = |Vk| eiδik ; δik = δi – δk ; Yik = Gik + jBik

Breaking the complex of load flow formulation into real and imaginary parts are given by:

$$S_i = P_i + jQ_i = \sum_{k}^{n} |V_i||V_k| \, e^{j\delta ik} (G_{ik} - jB_{ik}) \qquad (11)$$

$$P_i = \sum_{k}^{n} |V_i||V_k| \, [G_{ik} \cos(\delta_{ik}) + B_{ik} \sin(\delta_{ik})] \qquad (12)$$

$$Q_i = \sum_{k}^{n} |V_i||V_k| \, [G_{ik} \cos(\delta_{ik}) - B_{ik} \sin(\delta_{ik})] \qquad (13)$$

These three equations (11, 12, and 13) utilize iterative techniques to solve load flow problems. Therefore, they are necessary to review the general forms of the various solution methods: NR, FD and AGS load flow.

1. Newton-Raphson Method

The NR method formulates and iteratively solves the following load flow equation:

$$\begin{vmatrix} \Delta P \\ \Delta Q \end{vmatrix} = \begin{vmatrix} J1 & J2 \\ J3 & J4 \end{vmatrix} \begin{vmatrix} \Delta \delta \\ \Delta V \end{vmatrix} \qquad (14)$$

Where: J1, J2, J3 and J4 are the Jacobian matrix elements. P and Q are the specified bus real and reactive power mismatch vectors between the specified value and the calculated value, respectively. ΔV and Δδ represent bus voltage magnitude and angle vectors in an incremental form; and J1 through J4 are called Jacobian matrices [28, 30, 33, 34].

2. *Fast-Decoupled Method*

The FD method is derived from the NR method. It takes in the fact that a small change in the bus voltage magnitude does not vary the real power at the bus extremely, and likewise, for a small change in the phase angle of the bus voltage, the reactive power does not change much. So the equation of load flow from the NR method can be simplified into two separate decoupled sets of power equations, which can be solved iteratively [28, 30, 33, 34]:

$$\begin{aligned} |\Delta P| &= |J1||\Delta\delta| \\ |\Delta Q| &= |J3||\Delta V| \end{aligned} \tag{15}$$

It has to mention that compared to the NR method, the FD method reduces the storage of computer memory by almost half. It also solves the load flow equations by taking significantly less computer time than that required by the NR method, since the Jacobian matrices are constant [28, 30, 33, 34].

3. *Accelerated Gauss-Seidel Method*

From the system nodal voltage equation:

$$|I| = |Y_{Bus}||V| \tag{16}$$

The AGS method derives the following load flow equation and solves it iteratively:

$$|P + jQ| = |V^T||Y_{Bus}^* V^*| \tag{17}$$

Where in the equation (17), P and Q are the specified bus real and reactive power vectors, V is the bus voltage vector; YBUS is the system admittance matrix. YBUS* and V* are the conjugates of YBUS and V, respectively; VT is defined as the transpose of V [28, 30, 33, 34].

It has to mention that ETAP software is able to calculate and analyze the reliability in power system; therefore, to show the capability of the ETAP software, it can be considered a sample reliability index over the optimization process. For instance, Based on the element data and the configurat on of the general feeder [35], a set of traditional analysis formulas for calculating the basic load-point indices of load-point failure rate λs , average outage duration rs and average annual outage time Us for load point S of a general feeder is as follows:

$$\lambda_s = \sum_{i\epsilon s} (\lambda_i' + \lambda_i'') \tag{18}$$

$$U_s = \sum_{i\epsilon s} (\lambda_i' r_i' + \lambda_i'' r_i'') \tag{19}$$

Where λ_i' is defined as a failure rate of the failed component i (occur/year); λ_i'' is defined as a maintenance outage rate of the component i (occur/year); r_i' is defined as a repair time of the failed component i (hour); r_i'' is defined as a maintenance outage time of the component i (hour). The average service availability index (ASAI) of the system can be calculated using the following formula:

$$\mathrm{ASAI} = \frac{8760 \sum_i N_i - \sum_i N_i U_i}{8760 \sum_i N_i} \tag{20}$$

$$r_s = \frac{U_s}{\lambda_s} \tag{21}$$

Here: N_i is the number of a customer in the load point i and U_i is the average annual outage time at the load point i.

Table II shows a representative sample of the load point reliability indices where the indices are equal to the calculation results of literature [36].

TABLE II
LOAD-POINT INDICES

Load point (i)	**Failure rate (occur/year)**	**Outage duration (hour)**	**Unavailability (hour/year)**
1	0.3304	2.7416	0.8164
10	0.3596	2.2434	0.8065
20	3.4740	4.1916	14.5736
25	3.4770	5.0218	17.4596
35	3.6499	4.2299	15.439

III. CASE STUDY

According to the paper [37], line 2 of Tehran metro was supplied from three high voltage substations (HVS) and also it consists of 154 main feeders. All HVSs in the power network of Tehran metro include 63/20KV and gas insulated substation (GIS) type. Each station of Tehran metro has two lighting and power substations (LPS). The LPSs supply electric power for every component, equipment and loads. The LPS is situated at each substation platform. Besides, rectifier substation (RS) converts AC to DC power to supply electric energy for traction motors of trains.

Most of the stations on line 2 of Tehran metro have one RS. Each RS is capable to convert 20KV (AC) to 750V (DC) using diode rectifiers.

Single line diagrams of the power distribution network of

Tehran metro in the form of ETAP is displayed in Fig 1. As can be seen from the Fig. 1, HVSs are situated on the top, LPS and loads at the middle, and RS and loads at the bottom.

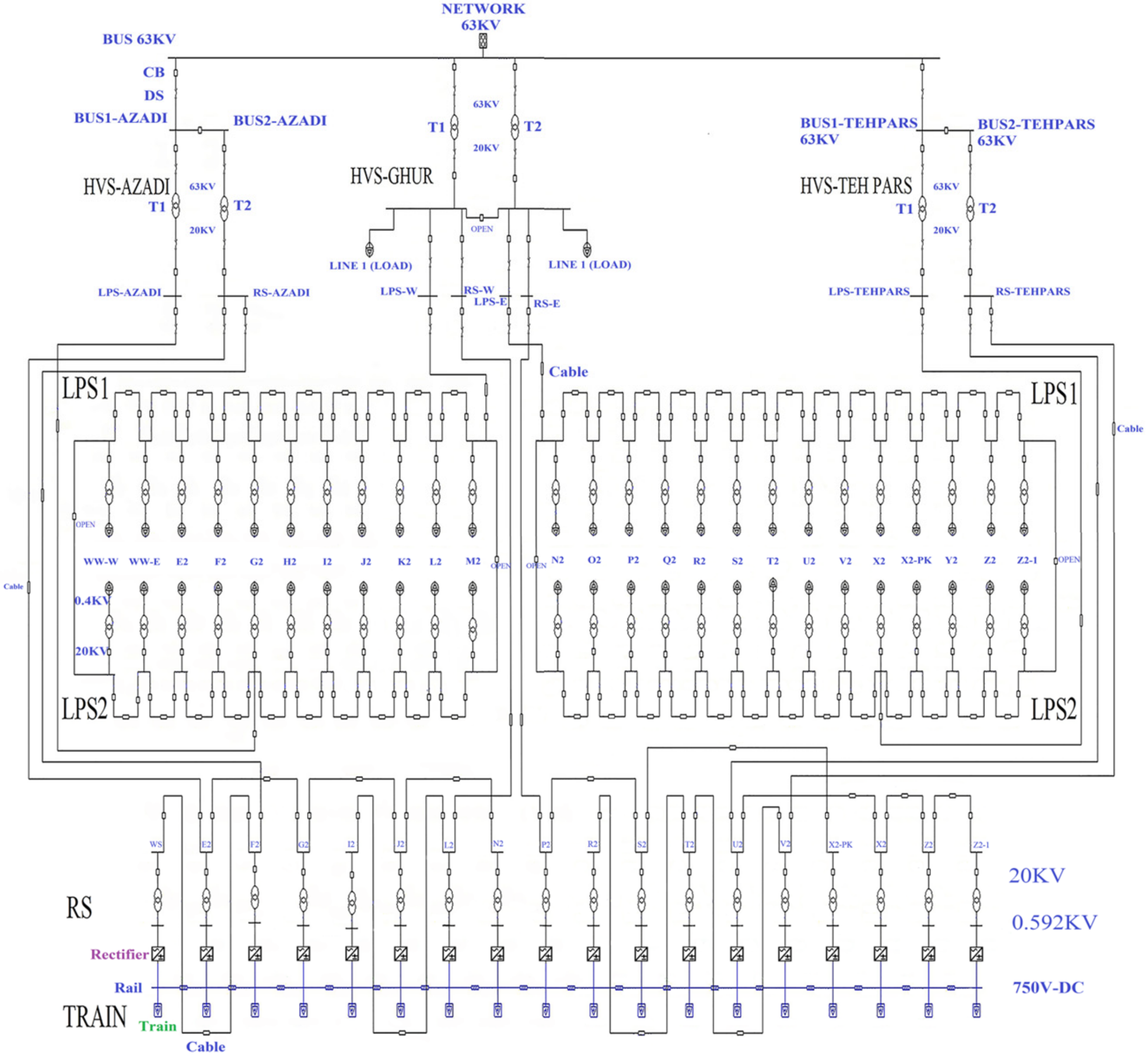

Fig 1.Single line diagram of the power distribution system of Tehran metro (Line 2) in the form of ETAP

According to the monthly report (July 2017) from power distribution unit of Tehran metro, the total consumption for LPSs and RSs (active and reactive) are measured, and these informational data are presented in Table III and Table IV, respectively.

For the implementation of the simulation, the values used to compare the three methods of load flow are shown in Table V.

TABLE III
LPS INFORMATION DATA

Station	LPS	kW.h	kVAr.h	% P.F
WWW	LPS1	13200	12600	0.723355544
	LPS2	88800	58200	0.836371791
WWE	LPS1	104400	46800	0.912509325
	LPS2	79200	59400	0.801123211
E2	LPS1	134400	87600	0.837759372
	LPS2	164400	105000	0.842773779
F2	LPS1	75000	62400	0.768725123
	LPS2	79800	46800	0.862600381
G2	LPS1	82200	52800	0.841377961
	LPS2	48600	43800	0.742837965
H2	LPS1	98400	59200	0.856877624
	LPS2	65600	42400	0.839844835
I2	LPS1	70200	63600	0.741085436
	LPS2	66600	54600	0.773336106
J2	LPS1	77400	71400	0.735021854
	LPS2	50400	49800	0.711328201
K2	LPS1	81000	100800	0.626391108
	LPS2	39000	54600	0.581238194
L2	LPS1	63600	90600	0.574553174
	LPS2	85800	96600	0.664075548
M2	LPS1	104400	88200	0.763885626
	LPS2	105000	87000	0.770021561
N2	LPS1	28800	36400	0.620482186
	LPS2	123600	90000	0.808396555
O2	LPS1	55200	57600	0.691905363
	LPS2	121200	94200	0.789562641
P2	LPS1	135600	80400	0.860167816
	LPS2	51600	23400	0.910728795
Q2	LPS1	36400	27200	0.801055097
	LPS2	22400	34800	0.541245989
R2	LPS1	145200	108600	0.800793475
	LPS2	38400	24000	0.847998304
S2	LPS1	159000	114600	0.811243918
	LPS2	41400	39000	0.727890219
T2	LPS1	156000	112200	0.811830358
	LPS2	28200	20400	0.810224411
U2	LPS1	154200	115800	0.799626479
	LPS2	36000	32400	0.743294146
V2	LPS1	165600	119400	0.811143955
	LPS2	6600	8400	0.617821552
X2	LPS1	53200	26000	0.898443585
	LPS2	143600	40400	0.962629097
Y2	LPS1	143272	93292	0.838001817
	LPS2	44745	7474	0.986334879
Z2	LPS1	58039	20151	0.944680879
	LPS2	120184	54718	0.910112674
Z2-1	LPS1	24256	43823	0.484267581
	LPS2	21265	24960	0.648515545
X2-PK	LPS1	78400	36800	0.905236944
	LPS2	44400	26000	0.862931791

TABLE IV
RS INFORMATION DATA

Station - RS	kW.h	kVAr.h	% P.F
WW	38000	7000	0.983453189
E2	258000	35000	0.990923419
F2	305000	51000	0.986306385
G2	365000	69000	0.982596814
I2	389000	69000	0.984630287
J2	313000	55000	0.984910009
L2	408000	72000	0.984783559
N2	291000	46000	0.987735429
P2	365000	62000	0.985878152
R2	292000	51000	0.985087696
S2	293000	47000	0.987377466
T2	222000	32000	0.98977037
U2	198000	28000	0.990148533
V2	195000	23000	0.993115797
X2	236000	30000	0.992017044
Y2	198000	51000	0.96839174
Z2	207000	51000	0.970964612
Z2-1	217000	54000	0.970404983

TABLE V
THE VALUES OF LOAD FLOW METHODS

Method	Max Iteration	Precision	Accel Factor
NR	10	0.0001	-
FD	99	0.0001	-
AGS	2000	0.00001	1.45

IV. RESULTS OF LOAD FLOW ANALYSIS

Using NR load flow method, branch losses summary report on transformers and cables are shown in Table VI and Table VII, respectively.

As can be seen from Tables VI and VII, the total amount of losses from transformers and cables are 1354.6 (kW) and 13854.1 (kVar).

TABLE VI
BRANCH LOSSES SUMMARY REPORT ON TRANSFORMERS

ID	Lossess (kW)	Lossess (kvar)	ID	Lossess (kW)	Lossess (kvar)
T1-GHOR	37.6	1689.8	T74	11.5	17.2
T2-GHOR	43.1	1938.6	T76	14.6	87.6
T56	15.2	53.3	T77	7.6	26.4
T1-AZADI	13.9	624.8	T80	5.9	8.8
T1-TEHPARS	30.8	1385.2	T79	14.9	52.2
T58	21.3	128.0	T78	10.6	15.9
T2-AZADI	32.1	1443.1	T75	1.7	2.5
T2-TEHPARS	30.9	1388.8	T69	10.8	16.2
T1	0.1	1.4	T66	13.9	48.6
T4	11.0	133.4	T65	12.7	76.0
T5	13.2	160.7	T2	15.7	54.9
T6	19.2	233.1	T29	17.1	102.7
T7	21.1	256.0	T30	14.5	50.9
T8	14.4	175.4	T31	12.6	44.0
T9	23.5	284.8	T32	12.4	43.4
T10	12.4	151.0	T34	11.1	38.8
T11	19.0	231.0	T35	13.4	46.8
T12	12.9	156.2	T36	12.8	76.7
T59	8.5	29.9	T37	16.8	58.6
T60	8.0	28.1	T39	13.6	81.5
T13	12.4	150.3	T41	8.7	13.0
T14	7.3	88.5	T42	9.8	34.4
T15	5.6	67.6	T43	15.8	94.7
T16	6.0	72.7	T44	8.2	12.3
T17	7.5	91.6	T45	19.1	114.6
T18	5.6	68.3	T46	20.7	124.4
T19	6.3	76.4	T47	19.5	117.1
T20	7.1	86.4	T49	20.2	121.4
T61	8.9	31.3	T50	21.1	126.4
T62	11.1	38.7	T51	10.9	16.4
T63	8.3	29.2	T52	9.5	33.1
T64	9.1	31.9	T53	18.8	112.9
T67	15.8	94.6	T54	13.9	48.7
T71	7.8	11.7	T55	10.4	15.5
T70	8.4	12.6	T68	15.3	91.8
T72	11.3	16.9	T83	4.0	6.0
T73	7.6	11.5	T84	0.0	0.0

Table VII shows the summary report of branch losses (Max Loading) in the power distribution network of line 2 of Tehran metro. As can be seen, Table VII shows that the results of three methods are very close together.

In addition, the summary of total generation, loading and demand for maximum loading is shown in Table IX.

TABLE VII
BRANCH LOSSES SUMMARY REPORT ON CABLES

ID	Lossess (kW)	Lossess (kvar)	ID	Lossess (kW)	Lossess (kvar)
Cable1	0.0	0.0	Cable129	9.6	9.6
Cable4	5.4	1.4	Cable140	18.7	18.8
Cable134	28.8	29.0	Cable89	0.6	0.6
Cable138	33.9	34.1	Cable101	2.9	3.0
Cable60	0.1	0.1	Cable90	0.8	0.8
Cable61	1.0	1.0	Cable100	3.8	3.8
Cable3	1.8	1.9	Cable128	2.9	2.9
Cable135	0.0	0.0	Cable91	3.1	3.1
Cable137	1.8	1.8	Cable143	8.6	8.7
Cable62	2.2	2.2	Cable144	16.2	16.3
Cable5	1.8	1.9	Cable99	2.8	2.9
Cable133	14.5	14.6	Cable126	2.5	2.5
Cable63	4.0	4.0	Cable92	5.6	5.7
Cable136	23.5	23.6	Cable98	2.0	2.0
Cable13	3.6	3.6	Cable127	6.5	6.6
Cable64	4.4	4.4	Cable93	7.4	7.4
Cable12	3.2	3.3	Cable97	1.6	1.6
Cable130	5.1	5.1	Cable125	12.0	12.1
Cable65	2.1	2.1	Cable94	11.1	11.1
Cable11	4.1	4.1	Cable96	1.2	1.2
Cable131	3.2	3.2	Cable95	13.1	13.2
Cable66	1.4	1.4	Cable14	0.0	0.0
Cable10	4.6	4.6	Cable9	0.0	0.0
Cable67	0.6	0.6	Cable113	0.2	0.2
Cable17	5.5	5.6	Cable2	0.2	0.2
Cable141	6.7	6.7	Cable6	0.7	0.7
Cable68	0.1	0.1	Cable114	0.6	0.6
Cable139	6.5	6.6	Cable112	0.3	0.3
Cable142	3.1	3.2	Cable124	3.8	3.8
Cable145	26.0	26.2	Cable115	0.4	0.4
Cable104	4.8	4.9	Cable122	0.8	0.8
Cable87	0.0	0.0	Cable111	0.0	0.0
Cable103	3.1	3.2	Cable116	0.0	0.0
Cable88	0.1	0.1	-	-	-
Cable102	3.2	3.2	**Total**	**1354.6**	**13854.1**

TABLE VII
BRANCH LOSSES SUMMARY REPORT (MAX LOADING)

Method	Losses Branch (Transformers, Cables)	
	kW (P)	kVAr (Q)
NR	1354.6	13854.1
FD	1354.7	13854.2
AGS	1354.6	13854.1

TABLE IX
SUMMARY OF TOTAL GENERATION, LOADING AND DEMAND (MAX. LOADING)

Type	MW (P)	MVAr (Q)	MVA (S)	% P.F
Source	97.824	83.84	128.345	73.22 Lagging
Total Demand	97.824	83.084	128.345	76.22 Lagging
Total Motor Load	86.764	58.037	104.385	83.12 Lagging
Total Static load	9.566	6.878	11.782	81.19 Leading
Apparent Losses	1.495	18.168	-	-

The results of these three load flow methods are almost exactly the same; hence, due to the similarity of the results in each of three load flow simulations, the critical reports of NR load flow are illustrated in Figs 2 and 3 respectively. Fig. 2 shows the amount of under voltage (kV) in different distribution transformers. Fig. 3 shows the percentage of overload on transformers. The marginal and critical voltage drop and overload standard set by utility are 2% and 5 % respectively which are significantly violated here.

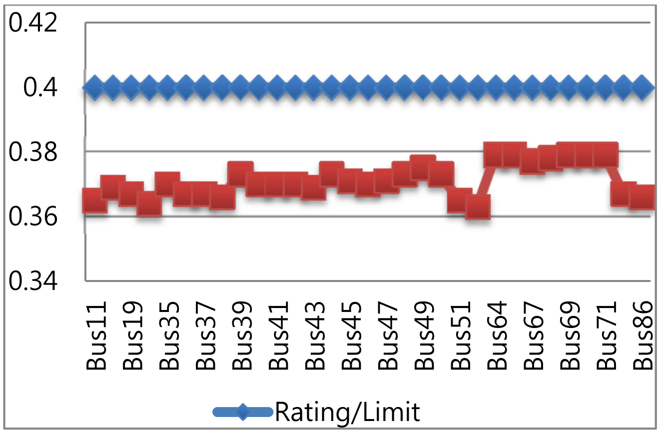

Fig 2. Under voltage (kV) on the buses

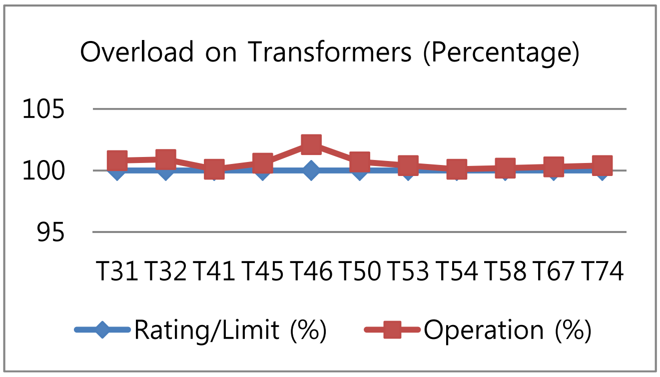

Fig 3. Percentage of overload on transformers

V. CONCLUSION

In this study, a comprehensive study for load flow analysis in distributed power system was presented. Besides, a case study of modelling, simulation, and load flow analysis of the actual distributed power system of Tehran metro (line 2) using ETAP is implemented. In this paper, a comparison of three common load flow techniques including Newton-Raphson, Fast Decoupled, and Accelerated Gauss-Seidel was presented; the numerical methods of load flow were compared; the theoretical and practical approaches of load flow have been learned, compared, and applied to solve the tasks given. The results of load flow assessment (total generation, loading, demand, and power losses) were obtained and analyzed. In addition, a load flow based simulation using ETAP were developed to find out the optimum location of distribution system unit for load profile improvement and minimizing power losses in the test distribution system. In order to improve speed performance and computational accuracy in power system analysis, using powerful software like ETAP is very practical and helpful, and it also offers a better view of the power network. Further research work can be done for finding more powerful methods to solve the power flow equations with more efficiency in terms of time, computer memory storage as well as robustness. In addition, understanding the best way of load flow is economical, and therefore which can be a hot topic for future studies of the power distribution system.

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