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Improving Voltage Stability in Kurdistan Power System in Areas with Deficit Power Production by Rescheduling the Active Power Based on PSS/E Simulation

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ABSTRACT

This paper aims to improve the voltage profile using the Static Synchronous Compensator (STATCOM) in the power system in the Kurdistan Region for all weak buses. Power System Simulation studied it for Engineers (PSS\E) software version 33.0 to apply the Newton-Raphson (NR) method. All bus voltages were recorded and compared with the Kurdistan region grid index (0.95≤V ≤1.05), simulating the power system and finding the optimal size and suitable location of Static Synchronous Compensator (STATCOM)for bus voltage improvement at the weakest buses. It shows that Soran and New Koya substations are the best placement for adding STATCOM with the sizes 20 MVAR and 40 MVAR. After adding STATCOM with the sizes [20MVAR and 40MVAR] at Soran to the test, it is seen that the total average change in voltage profile for the system improved results in about 17.34 % in average per unit change for the 28 weakest buses, which provides a good improvement in stability. Also, the system's total active power loss reduced from 123.8 MW without STATCOM to 102.8 MW with STATCOM. The results are encouraging for applying the approach to the power system. This approach stands out due to all bus voltages are within acceptable ranges.

Keywords: Voltage Stability Improvement (VSI), Static Synchronous Compensator (STATCOM), PSS®E simulation, Kurdistan Region Power System.

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تحسين استقرار الجهد في نظام الطاقة الكردستاني في المناطق التي تعاني من عجز في إنتاج الطاقة من خلال إعادة جدولة الطاقة النشطة على أساس محاكاة PSS/E

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الخلاصة

يهدف هذا البحث إلى تحسين ملف الجهد باستخدام المعوض المتزامن الثابت (STATCOM) في نظام الطاقة في إقليم كوردستان لجميع الحافلات الضعيفة. تمت دراستها بواسطة برنامج Power System Simulation for Engineers (PSS \ E) الإصدار 33.0 لتطبيق طريقة Newton–Raphson (NR). تم تسجيل جميع الفولتية للحافلات ومقارنتها بمؤشر شبكة إقليم كردستان ($1.05 \geq V \geq 0.95$) الذي يحاكي نظام الطاقة وإيجاد الحجم الأمثل والموقع المناسب للمعوض المتزامن الثابت (STATCOM) لتحسين جهد الناقل في أضعف الحافلات. يظهر أن محطتي Soran و New Koya هما أفضل مكان لإضافة STATCOM بأحجام 20MVAR و 40MVAR. بعد إضافة STATCOM بأحجام [20MVAR و 40MVAR] في Soran للاختبار. يُلاحظ أن متوسط التغيير الإجمالي في ملف الجهد للنظام أدى إلى تحسين حوالي 17.34٪ في المتوسط لكل وحدة تغيير لأضعف 28 ناقلًا مما يوفر تحسنًا جيدًا في الاستقرار. أيضًا ، انخفض إجمالي فقد الطاقة النشطة للنظام من 123.8 ميجاوات بدون STATCOM إلى 102.8 ميجاوات مع STATCOM. النتائج مشجعة لتطبيق النهج على نظام الطاقة. ما يميز هذه الطريقة هو أن جميع الفولتية للحافلات تقع ضمن الحدود المسموح بها.

الكلمات المفتاحية: تحسين استقرار الجهد (VSI) ، المعوض المتزامن الثابت (STATCOM) ،محاكاة PSS®E ، نظام طاقة إقليم كوردستان.

1. INTRODUCTION

Recently, progress in improving the performance of power systems worldwide has been directed toward using advanced control technologies such as the Flexible AC Transmission System (FACTS). Electric power systems transmit and distribute electricity over long distances from power generating stations to consumers, which are typically very large, capital-intensive investments of intricately interconnected parts like power transformers, overhead conductors, underground cables, and generators **(Kishore et al., 2010).** Due to the economic crisis many developing nations, including Kurdistan, are experiencing, constructing new power plants and transmission lines to provide a reliable, secure, and high-quality electrical supply may go very slowly **(Kamarposhti and Lesani, 2011)**. Because they contain several generating units and transmission links, electrical power systems are complicated **(Baghaee et al., 2008)**. The utilities run the generating units and transmission links at maximum capacity due to the rising daily demand for electricity **(Joshi et al., 2016)**. This lessens the bus voltage stability of the power supply. The transmission network's voltage stability is increased using the Flexible AC Transmission System (FACTS), which regulates the network's active and reactive power flow **(Shah et al., 2021)**. FACTS devices like the Static Synchronous Compensator STATCOM regulate line power flow, bus voltage

magnitudes, and angles **(Simeon et al., 2014)**. FACTS, or flexible ac transmission systems, were created to increase transmission capacity across lengthy ac lines and improve the performance of weak ac systems. The three power system states of steady, transient, and post-transient steady state apply to FACTS controllers. The active and reactive power and voltage magnitude can be controlled using FACTS devices **(Yu et al., 2000)**. The enhancement of voltage stability, oscillation damping (dynamic stability), and transient stability are all examples of dynamic applications of FACTS controllers **(Mitra and Venayagamoorthy, 2009; Baghaee et al., 2009)**. The Facts controller may control shunt impedance, series impedance, voltage, current, and phase angle **(Naveh et al., 2009)**. The following are the justifications for employing FACTS **(Singh, 2006)**:

a) to give more effective control than standard control.
b) to increase control reaction time quickly.
c) to create dependable and responsive control.
d) to minimize total system losses
e) to operate more cost-effectively than constructing a power plant or transmission network.

The 132 kV Kurdistan power network can be used as a case study in this work to examine the impact of using STATCOM on enhancing power system performance. The 132 kV electrical grid in the Kurdistan region will be used as a case study for this work's use of Static Synchronous Compensator STATCOM, a FACTS device, for the performance enhancement of the power system. Static Synchronous Compensator STATCOM is essential for maintaining voltage, compensating for reactive power, enhancing power factor, and raising the voltage on the load buses, along with other things **(Salih et al., 2022; Islam et al., 2013)**. Using the Newton Raphson approach, STATCOM was inserted in the 132Kv Kurdistan power system to ensure stability in the voltage profile of the buses**(Thasnas and Siritaratiwat, 2015; Furukakoi 2016)**. It is proposed that the Soran and New Koya substations are the optimal locations for installing STATCOM with 20MVAR and 40MVAR. It can be seen that the system's overall average change in voltage profile results in an average per-unit change for the 28 weakest buses of approximately 18.465%, which provides a good improvement in stability **(Azeez and Abdelfattah, 2020; Rasool et al., 2021)**. Additionally, with STATCOM the system's overall reactive power losses reduced from 880.4MVAR without STATCOM to 730.4MVAR with STATCOM **(Abido, 2009; Ining, 2021)**.

2. METHODOLOGY

2.1 Simulation by using PSS®E

Voltage stability phenomena are simulated and studied using the PSS®E application. The objective is to showcase how interdependent parts might risk the voltage stability of a system. The software PSS®E-Newton-Raphson load flow technique is used to get voltage profile results on systems without fact (STATCOM) type. Power transmission and distribution grid analysis are two of the most common applications of PSS®E. To enhance the voltage profile, reduced power loss, and minimize system costs, STATCOM is incorporated into the power system network **(Azeez and Abdelfattah, 2020). T**he single-line diagram of the Kurdistan power system is shown in **Figs. 1, 2 and 4.** While **Fig. 3** shows the flowchart of the proposed approach.

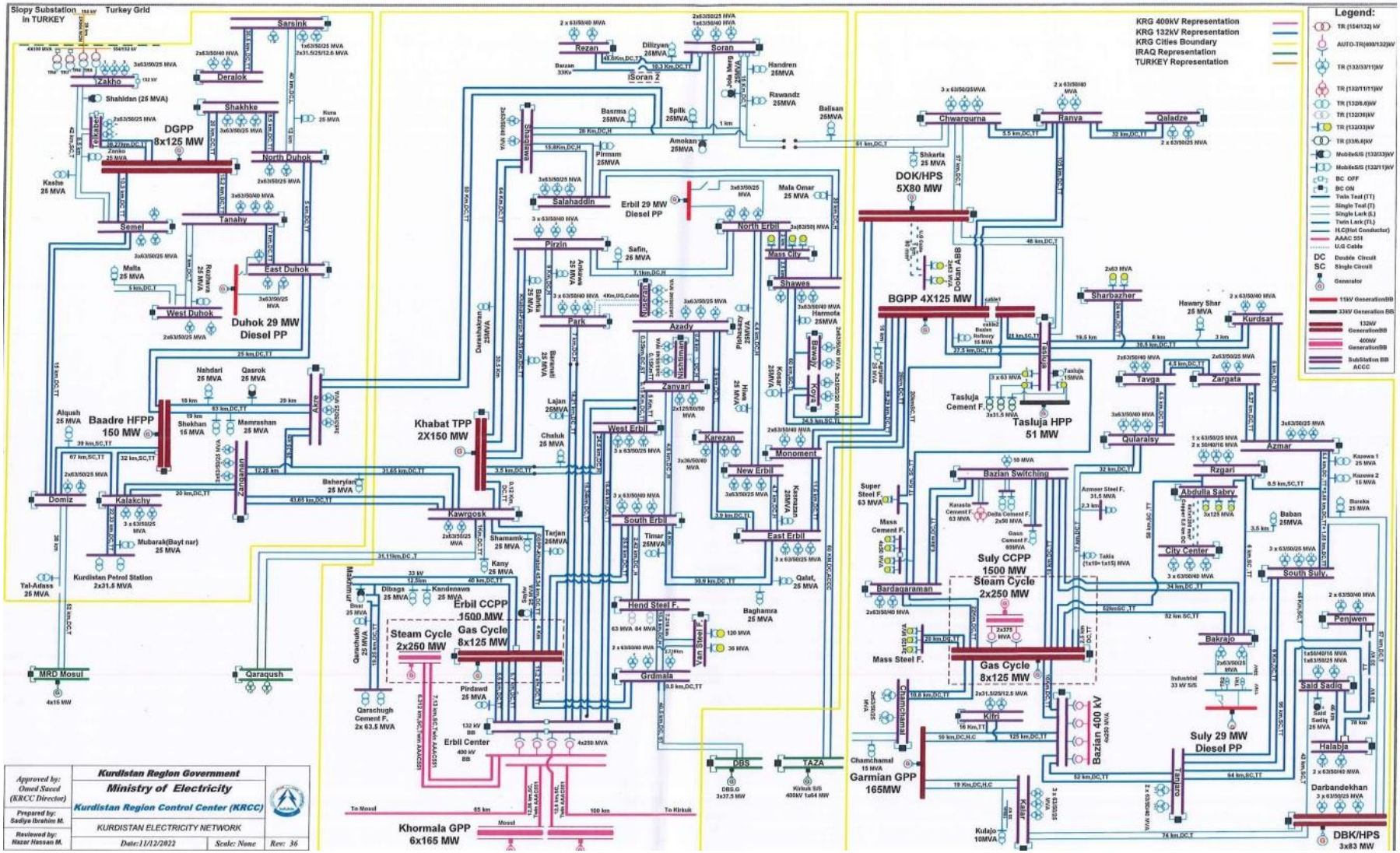

Figure 1. KRG Network Single Line Diagram

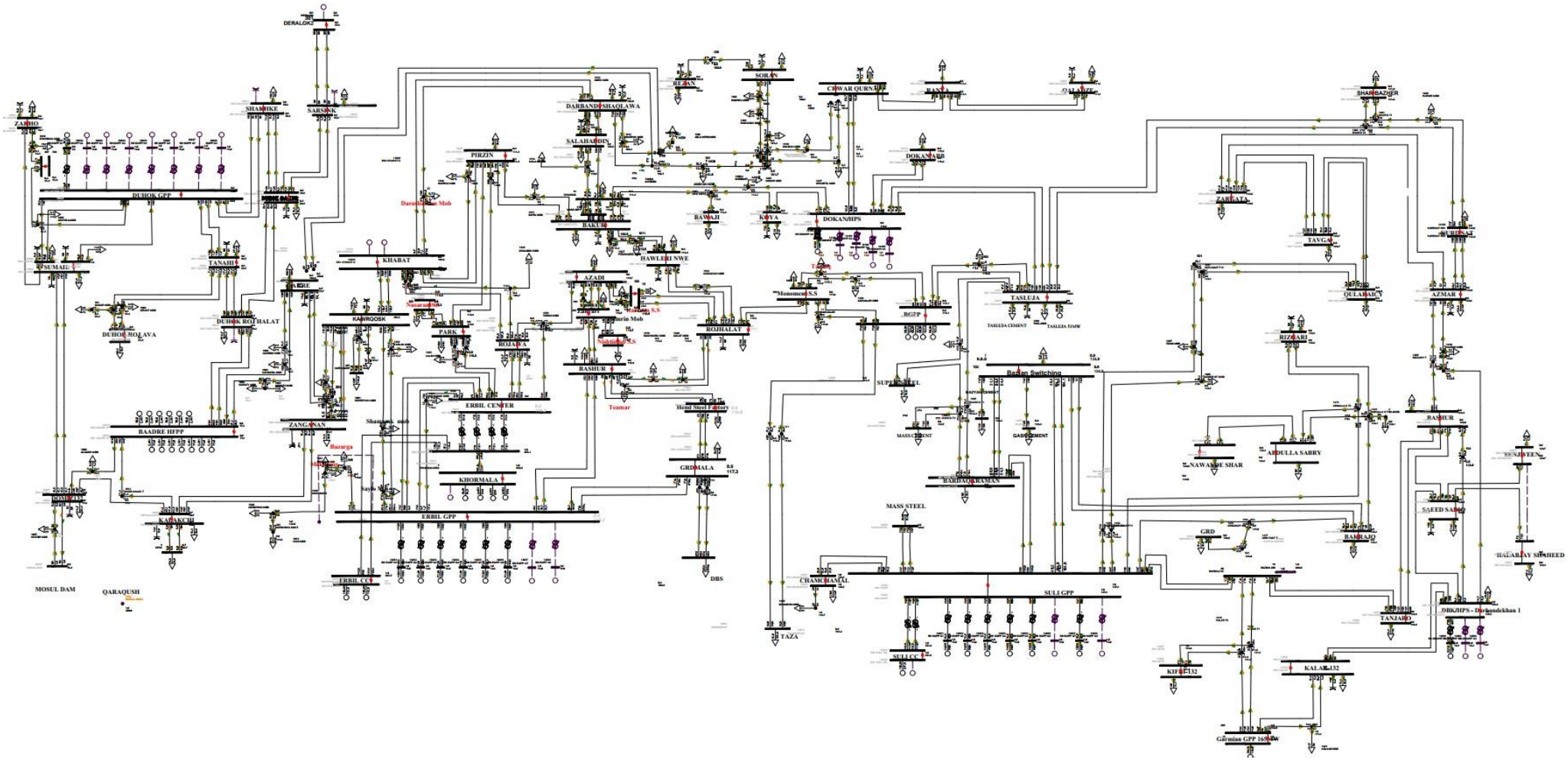

Figure 2. PSS®E Simulation Model of Kurdistan Region Network

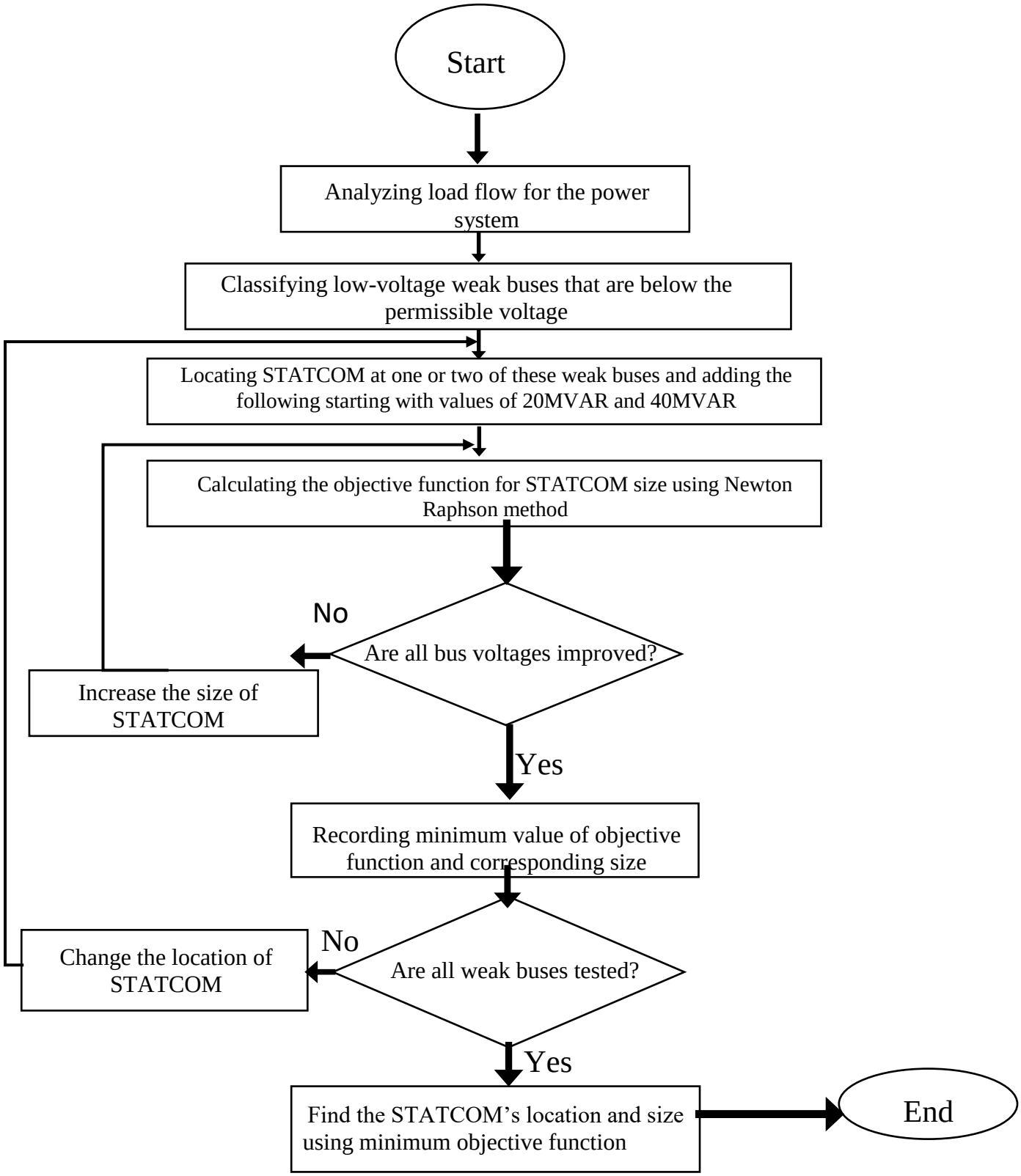

Figure 3. Flow Chart for Optimal Size and Location of STATCOM

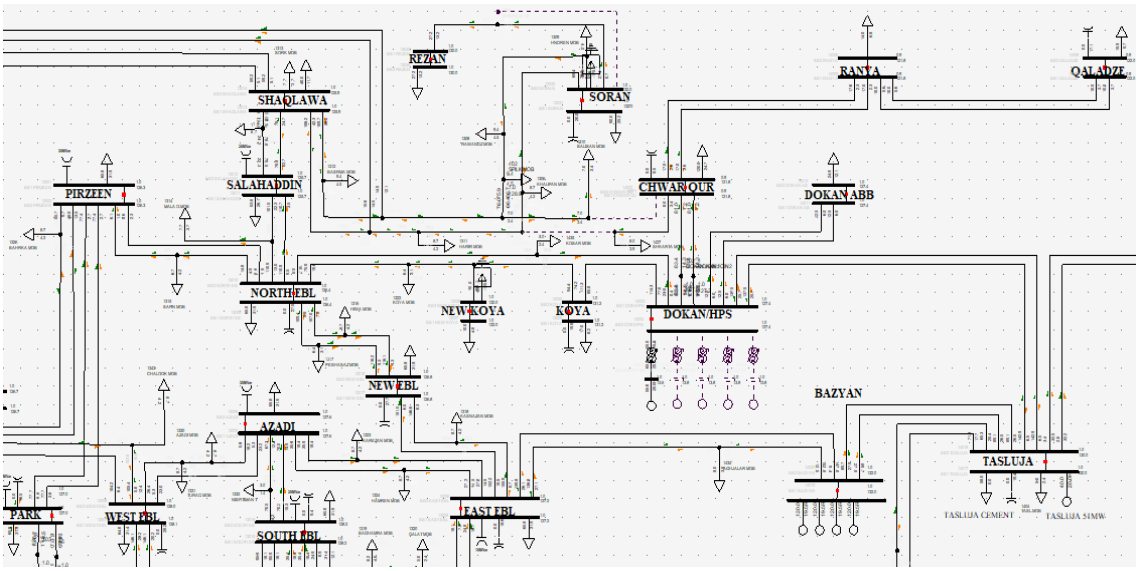

Figure 4. PSS®E Simulation Model of Kurdistan Region Network with STATCOM at Soran &New Koya

2.2. Newton Raphson Method for Load Flow

Power flow analysis is one of the most important topics in power system studies **(Milano, 2008)**. Due to its benefits and precision, Newton Raphson is the most practical approach for load flow **(Salih, 2022)**. The main responsibility of operating a power system is to solve the power flow problem **(Amin, 2019; Acha and Kazemtabrizi, 2013)**. The following equations demonstrate the Newton-Raphson load flow method **(Okakwu et al., 2017)**.

$$Ii=\Sigma YijVjnj=1 \quad (1)$$

where Ii is the current injected into the bus i, writing the polar form equation

$$Ii=\Sigma|Yij||Vj|\angle\theta ij+\delta jnj=1 \quad (2)$$

The current in terms of active and reactive power at bus i:

$$Ii=Pi-jQiVi* \quad (3)$$

From these two above equations, it can be reached to:

$$Pi-jQi=|Vi|\angle-\delta i\Sigma|Yij||Vj|\angle(\theta ij+\delta j)nj=1 \quad (4)$$

By separating real and imaginary parts

$$Pi=\Sigma|Yij||Vj||Vi|\cos(\theta ij-\delta i+\delta j)=1 \quad (5)$$

$$Qi=\Sigma|Yij||Vj||Vi|\sin(\theta ij-\delta i+\delta j)nj=1 \quad (6)$$

These two equations can be rewritten as:

$$\begin{bmatrix} \frac{\partial P_2^{(k)}}{\partial \delta_2} \cdots\cdots \frac{\partial P_2^{(k)}}{\partial \delta_n} \\ \vdots \quad\quad \vdots \\ \frac{\partial P_n^{(k)}}{\partial \delta_2} \cdots\cdots \frac{\partial P_n^{(k)}}{\partial \delta_n} \\ \hline \frac{\partial Q_2^{(k)}}{\partial \delta_2} \cdots\cdots \frac{\partial Q_2^{(k)}}{\partial \delta_n} \\ \vdots \quad\quad \vdots \\ \frac{\partial Q_n^{(k)}}{\partial \delta_2} \cdots\cdots \frac{\partial Q_2^{(k)}}{\partial \delta_2} \end{bmatrix} \begin{bmatrix} \frac{\partial P_2^{(k)}}{\partial |V_2|} \cdots\cdots \frac{\partial P_2^{(k)}}{\partial |V_n|} \\ \vdots \quad\quad \vdots \\ \frac{\partial P_n^{(k)}}{\partial \delta_2} \cdots\cdots \frac{\partial P_2^{(k)}}{\partial \delta_2} \\ \hline \frac{\partial Q_2^{(k)}}{\partial |V_2|} \cdots\cdots \frac{\partial Q_2^{(k)}}{\partial |V_n|} \\ \vdots \quad\quad \vdots \\ \frac{\partial Q_n^{(k)}}{\partial |V_2|} \cdots\cdots \frac{\partial Q_n^{(k)}}{\partial |V_n|} \end{bmatrix} \quad (7)$$

This matrix can be written as:

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & J_2 \\ J_3 & J_4 \end{bmatrix} \quad (8)$$

where J_1, J_2, J_3, and J_4 are Jacobian submatrices.

For J_1 diagonal element:

$$\partial Pi \partial \delta i = \Sigma |Vi| nj = 1 j \neq i |Vj| |Yij| \sin(\theta ij - \delta i + \delta j) \quad (9)$$

For J_1 off-diagonal element:

$$\partial Pi \partial \delta i = -|Vi| |Vj| |Yij| \sin(\theta i - \delta i + \delta j), j \neq i \quad (10)$$

For J_2 diagonal element:

$$\partial Pi \partial |Vi| = 2|Vi| |Yij| \cos\theta ij + \Sigma |Vj| |Yij| \mathrm{Cos}(\theta ij - \delta i + \delta j) nj = 1 j \neq i \quad (11)$$

For J_2 off-diagonal element:

$$\partial Pi \partial |Vj| = |Vi| |Yij| \cos(\theta ij - \delta i + \delta j), j \neq i \quad (12)$$

For J_3 diagonal element:

$$\partial Qi \partial \delta i = \Sigma |Vi| nj = 1 j \neq i |Vj| |Yij| \cos(\theta ij - \delta i + \delta j) \quad (13)$$

For J_3 off-diagonal element:

$$\partial Qi \partial \delta i = -|Vi| |Vj| |Yij| \cos(\theta ij - \delta i + \delta j), j \neq i \quad (14)$$

For J_4 diagonal element:

$$\partial Qi \partial |Vi| = -2|Vi| |Yii| \sin\theta ii - \Sigma |Vj| |Yij| \sin(\theta ij - \delta i + \delta j) nj = 1 j \neq i \quad (15)$$

For J_4 off-diagonal element

$$\partial Qi \partial |Vi| = -|Vi| |Vj| |Yij| \sin(\theta ij - \delta i + \delta j), j \neq i \quad (16)$$

The difference between scheduled and calculated values are $\Delta P1(k)$ and $\Delta PQ1(k)$

$$\Delta(k) = Pisch - Pi(k) \quad (17)$$

$$\Delta(k) = Qisch - Qi(k) \quad (18)$$

The solution for the new values of the voltage and angle are:

$$|Vi|(k+1) = |Vi|(k) + \Delta |Vi|(k) \quad (19)$$

$(k+1)=\delta i(k)+\Delta\delta i(k)$ (20)

2.3. Static Synchronous Compensator (Statcom)

The STATCOM static synchronous generator can be used as a static var compensator when it is shunt-connected, and capacitive or inductive output current can be adjusted independently of the AC system voltage **(Singh, 2006; Anitha and Arul, 2014)**. It is a controlling device that can supply or drain reactive power to an electrical network and, when coupled with a power source, can also act as a source of active power**. Fig. 5** depicts a streamlined STATCOM model comprising a coupling transformer, a VSI, and a DC capacitor **(El-Moursi and Sharaf, 2005).**

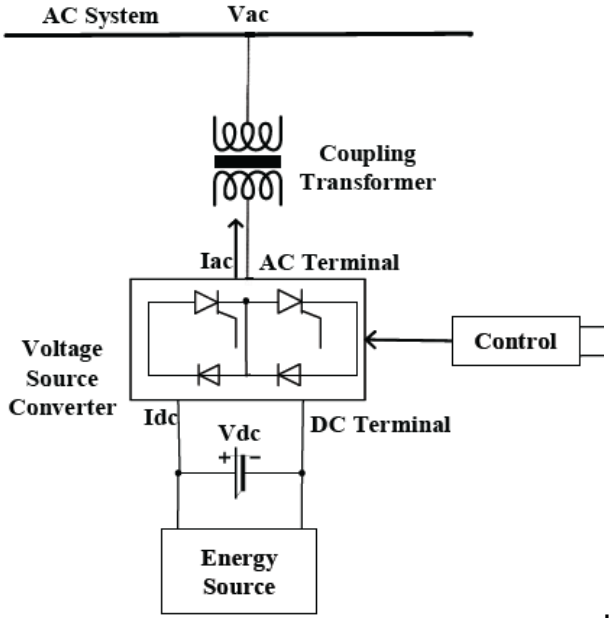

Figure 5. Basic components of STATCOM

The STATCOM output voltage amplitude or the voltage source inverter voltage relative to the AC system voltage can control the reactive power exchange between the STATCOM and the AC system **(El-Moursi and Sharaf, 2005)**. Control of the inverter output voltage, on the other hand, may consequence in the supply or removal of active power from the AC system **(Usha and Kumar, 2013; Rasool et al., 2022).** Regulation of the amplitude STATCOM output voltage may lead to one of the following conditions: injection of reactive power into the AC system**(Sagara et al., 2016),** absorption of reactive power from the AC system, or non-injection or permeability of reactive power from the AC system**(Musunuri and Dehnavi, 2010; Kumar et al., 2013)**. The STATCOM provides reactive current if its output voltage exceeds the AC system voltage at the connection point. However, it absorbs reactive power if its amplitude exceeds the AC system voltage **(Ahmad, 2013; Hossain et al., 2014)**. Connecting a suitable energy storage device across the DC capacitor can raise the active power **(Hossain et al., 2014; Devalkumar and Vyas, 2020)**. A few of STATCOM's important purposes are dampening power system oscillation, enhancing the transient stability margin and steady-state power transfer capacity, reducing temporary overvoltage, and effective voltage regulation and control **(Masood et al., 2010)**.

3. RESULTS AND ANALYSIS

3.1. Case One

The results of the voltage profile, as shown in **Table 1.** after the simulation for the system was run at normal load, suggest that there is under voltage at BB1 SORAN voltage bus bar (0.7556p.u.). HARIR MOB (0.7834p.u.) changed to (1.0 and 0.9653 p.u.), respectively, by adding 20MVAR STATCOM at Soran -substation. However, adding (20MVAR STATCOM at Soran & 20MVAR STATCOM at New Koya) will further modify the voltage profile, changing it to (1.0 and 0.9694) p.u, as illustrated in **Figs. 6 and 7.**

Table 1. Voltage without STATCOM, with STATCOM (20MVAR) at SORAN and with STATCOM (20MVAR Soran & 20MVAR New Koya)

No.	Bus Name	Voltage(p.u) Without STATCOM	Voltage(p.u) With STATCOM at Soran	Voltage(p.u) With STATCOM at Soran & New Koya
1	KPS2	0.8258	0.9499	0.9579
2	Qasar Mob.	0.7665	0.9425	0.9516
3	Deralok	0.7778	0.955	0.9641
4	Spilk Mob	0.7702	0.9736	0.9764
5	Bsheryan Mob	0.8532	0.9498	0.9572
6	Qasrok Mob	0.7842	0.9445	0.9522
7	Nahadra Mob	0.7814	0.9472	0.9556
8	Mahat1 Mob	0.7813	0.9452	0.9534
9	Alqush Mob	0.7786	0.9474	0.9562
10	Khatir Mob	0.7727	0.9443	0.9533
11	Zakho U.Mob	0.7575	0.9392	0.9485
12	Shahidan Mob	0.755	0.9378	0.9472
13	New Koya T	0.8937	0.9325	0.9984
14	Akre T2	0.7881	0.9588	0.9637
15	Soran T2	0.7727	0.9711	0.9743
16	Soran T1	0.7741	0.9747	0.9776
17	Khalifan Mob	0.7675	0.982	0.984
18	Rawandz Mob	0.7651	0.9807	0.9827
19	Hndren Mob	0.7563	0.9981	0.9983
20	Balisan Mob	0.7699	0.969	0.9721
21	Harir Mob	0.7834	0.9653	0.9694
22	Basrma Mob	0.7964	0.9549	0.9603
23	BB1 Rezan	0.7337	0.9847	0.9847
24	BB2 Rezan	0.7337	0.9847	0.9847
25	BB1 Koya	0.8959	0.9325	0.9941
26	BB2 Koya	0.8959	0.9325	0.9941
27	BB1 Soran	0.7556	1	1
28	BB2 Soran	0.7556	1	1

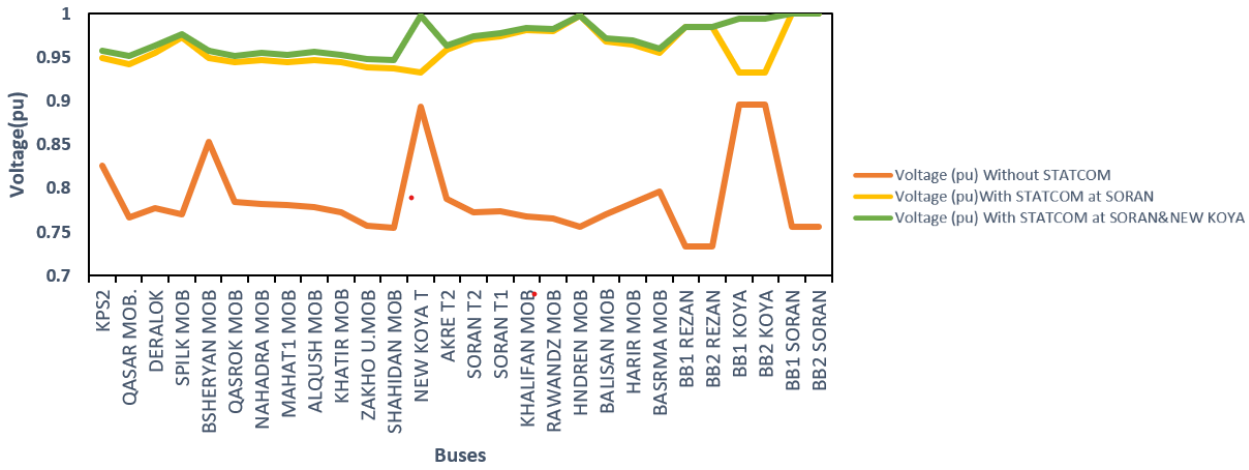

Figure 6. Low voltage buses without STATCOM, with STATCOM (20MVAR) at Soran and with STATCOM (20 MVAR Soran & 20 MVAR New Koya)

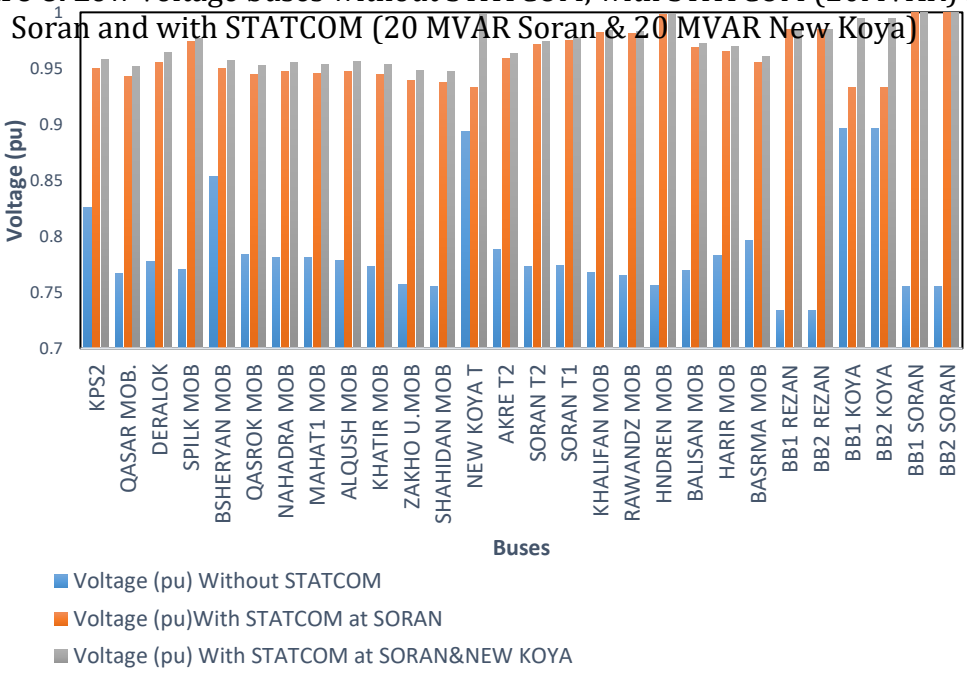

Figure 7. Low voltage buses without STATCOM, with STATCOM (20MVAR) at Soran and with STATCOM (20MVAR Soran& 20MVAR New Koya)

3.2. Case Two

The results of the voltage profile, as shown in **Table 2.** after the simulation for the system was run at normal load, indicate that there is under voltage at BB1 SORAN voltage bus bar (0.7556p.u) and HARIR MOB (0.7834p.u), which were changed to (1.0 and 0.9653p.u) respectively by adding 40MVAR STATCOM at Soran -substation. However, by including (40MVAR STATCOM at Soran & 40MVAR STATCOM at New Koya), the voltage profile will also be modified to (1.0 and 0.9694) p.u, as shown in **Figs. 8 and 9**.

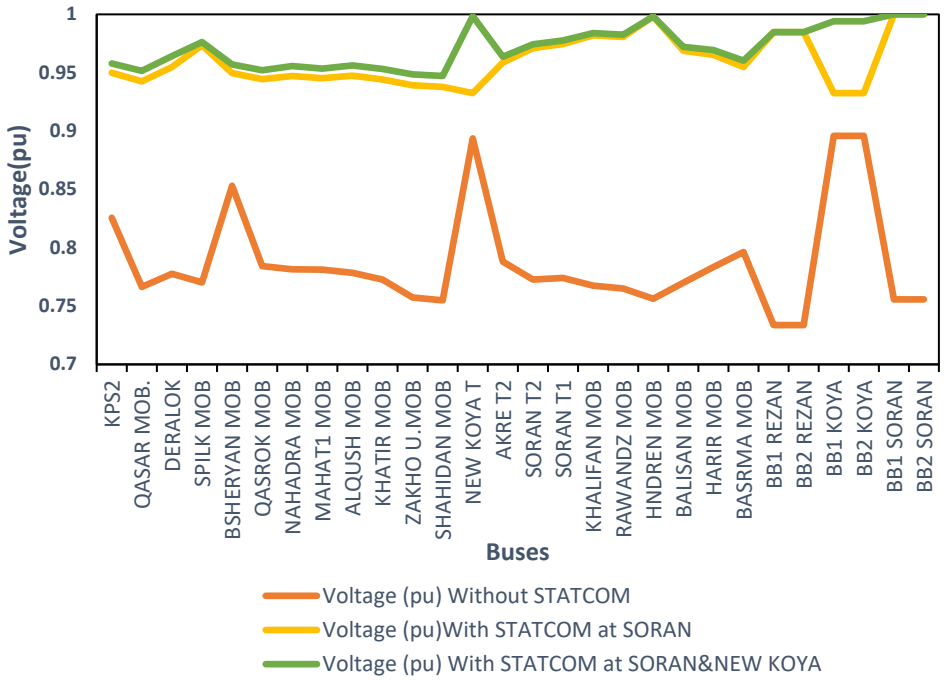

Figure 8. Low voltage buses without STATCOM, with STATCOM (40MVAR) at Soran and with STATCOM (40MVAR Soran& 40MVAR New Koya)

Table 2. Voltage without STATCOM, with STATCOM (40MVAR) at SORAN and with STATCOM (40MVAR Soran & 40MVAR New Koya)

No.	Bus Name	Voltage (p.u) Without STATCOM	Voltage (p.u) With STATCOM at Soran	Voltage (p.u) With STATCOM at Soran &New Koya
1	KPS2	0.8258	0.9498	0.9579
2	Qasar Mob.	0.7665	0.9424	0.9515
3	Deralok	0.7778	0.9549	0.964
4	Spilk Mob	0.7702	0.9736	0.9764
5	Bsheryan Mob	0.8532	0.9498	0.9572
6	Qasrok Mob	0.7842	0.9444	0.9521
7	Nahadra Mob	0.7814	0.9471	0.9555
8	Mahat1 Mob	0.7813	0.9452	0.9533
9	Alqush Mob	0.7786	0.9474	0.9561
10	Khatir Mob	0.7727	0.9442	0.9533
11	Zakho U.Mob	0.7575	0.9391	0.9485
12	Shahidan Mob	0.755	0.9377	0.9472
13	New Koya T	0.8937	0.9325	0.9984
14	Akre T2	0.7881	0.9588	0.9637
15	Soran T2	0.7727	0.9711	0.9742
16	Soran T1	0.7741	0.9747	0.9776
17	Khalifan Mob	0.7675	0.982	0.984
18	Rawandz Mob	0.7651	0.9807	0.9827
19	Hndren Mob	0.7563	0.9981	0.9983
20	Balisan Mob	0.7699	0.969	0.9721

21	Harir Mob	0.7834	0.9653	0.9694
22	Basrma Mob	0.7964	0.9548	0.9603
23	BB1 Rezan	0.7337	0.9847	0.9847
24	BB2 Rezan	0.7337	0.9847	0.9847
25	BB1 Koya	0.8959	0.9325	0.9941
26	BB2 Koya	0.8959	0.9325	0.9941
27	BB1 Soran	0.7556	1	1
28	BB2 Soran	0.7556	1	1

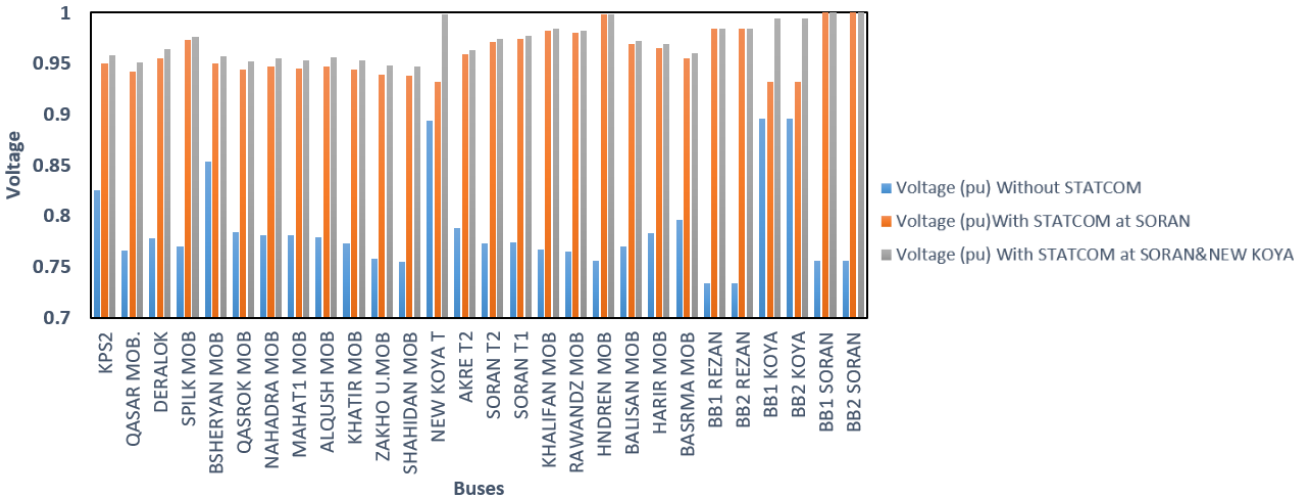

Figure 9. Low voltage buses without STATCOM, with STATCOM(40MVAR) at Soran and with STATCOM (40MVAR Soran and 40MVAR New Koya)

A comparison of all cases without STATCOM with STATCOM (20 and 40 MVAR) at Soran is shown in **Table 3** and **Fig. 10.** A comparison of all cases without STATCOM, with STATCOM (20 and 40 MVAR) at Soran&New Koya is shown in **Table 4** and **Fig 11.**

Table 3. Comparison (20 and 40) MVAR at Soran bus voltage (p.u)

No.	Bus Name	Voltage (p.u) Without STATCOM	Voltage (p.u) With STATCOM at Soran 20 MVAR	Voltage (p.u) With STATCOM at Soran 40 MVAR
1	KPS2	0.8258	0.9499	0.9498
2	QASAR MOB.	0.7665	0.9425	0.9424
3	DERALOK	0.7778	0.955	0.9549
4	SPILK MOB	0.7702	0.9736	0.9736
5	BSHERYAN MOB	0.8532	0.9498	0.9498
6	QASROK MOB	0.7842	0.9445	0.9444
7	NAHADRA MOB	0.7814	0.9472	0.9471
8	MAHAT1 MOB	0.7813	0.9452	0.9452
9	ALQUSH MOB	0.7786	0.9474	0.9474
10	KHATIR MOB	0.7727	0.9443	0.9442

11	ZAKHO U.MOB	0.7575	0.9392	0.9391
12	SHAHIDAN MOB	0.755	0.9378	0.9377
13	NEW KOYA T	0.8937	0.9325	0.9325
14	AKRE T2	0.7881	0.9588	0.9588
15	SORAN T2	0.7727	0.9711	0.9711
16	SORAN T1	0.7741	0.9747	0.9747
17	KHALIFAN MOB	0.7675	0.982	0.982
18	RAWANDZ MOB	0.7651	0.9807	0.9807
19	HNDREN MOB	0.7563	0.9981	0.9981
20	BALISAN MOB	0.7699	0.969	0.969
21	HARIR MOB	0.7834	0.9653	0.9653
22	BASRMA MOB	0.7964	0.9549	0.9548
23	BB1 REZAN	0.7337	0.9847	0.9847
24	BB2 REZAN	0.7337	0.9847	0.9847
25	BB1 KOYA	0.8959	0.9325	0.9325
26	BB2 KOYA	0.8959	0.9325	0.9325
27	BB1 SORAN	0.7556	1	1
28	BB2 SORAN	0.7556	1	1
29	%Average	78.721%	96.064%	96.060%

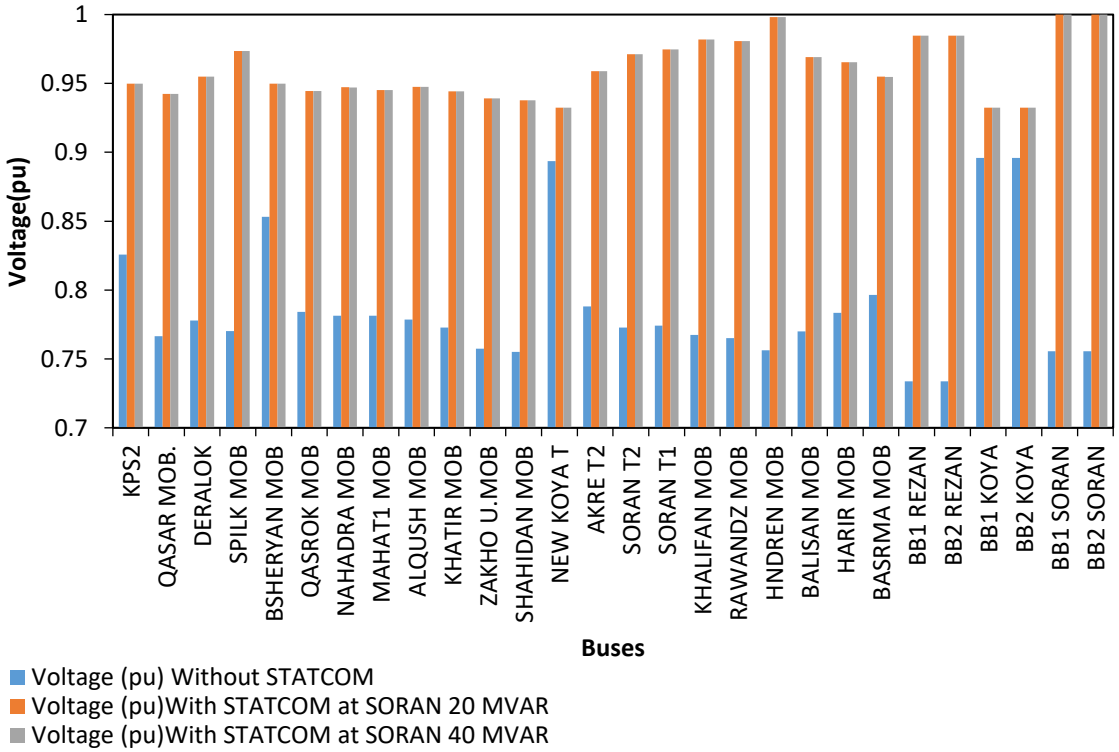

Figure 10. Low voltage buses without STATCOM, with STATCOM (20MVAR and 40MVAR) at Soran

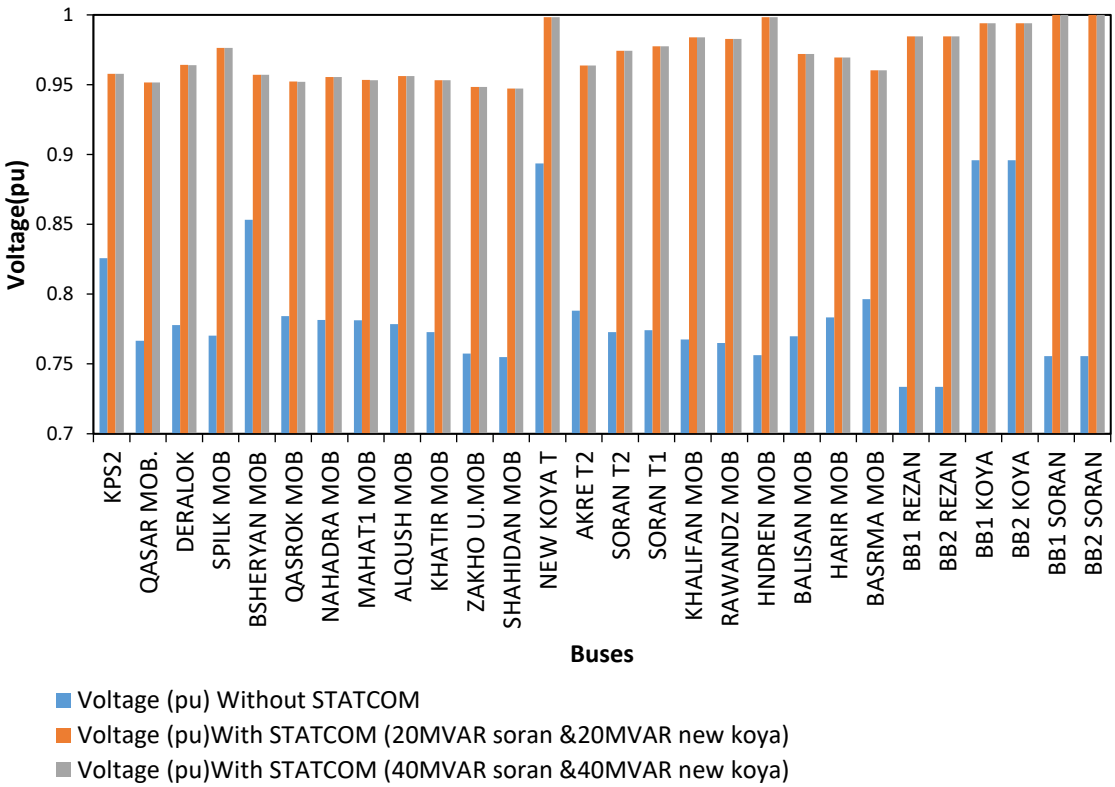

Figure 11. Low voltage buses without STATCOM, with STATCOM (20MVAR Soran& 20MVAR Newkoya), with STATCOM (40MVAR Soran& 40MVAR Newkoya)

Table 4. Comparison (20 and 40) Mvar at Soran&New Koya bus voltages

No.	Bus Name	Voltage(p.u) Without STATCOM	Voltage (p.u) With STATCOM at Soran&Newkoya 20 MVAR	Voltage (p.u) With STATCOM at Soran&Newkoya 40 MVAR
1	KPS2	0.8258	0.9579	0.9579
2	QASAR MOB.	0.7665	0.9516	0.9515
3	DERALOK	0.7778	0.9641	0.964
4	SPILK MOB	0.7702	0.9764	0.9764
5	BSHERYAN MOB	0.8532	0.9572	0.9572
6	QASROK MOB	0.7842	0.9522	0.9521
7	NAHADRA MOB	0.7814	0.9556	0.9555
8	MAHAT1 MOB	0.7813	0.9534	0.9533
9	ALQUSH MOB	0.7786	0.9562	0.9561
10	KHATIR MOB	0.7727	0.9533	0.9533
11	ZAKHO U.MOB	0.7575	0.9485	0.9485
12	SHAHIDAN MOB	0.755	0.9472	0.9472
13	NEW KOYA T	0.8937	0.9984	0.9984
14	AKRE T2	0.7881	0.9637	0.9637
15	SORAN T2	0.7727	0.9743	0.9742

16	SORAN T1	0.7741	0.9776	0.9776
17	KHALIFAN MOB	0.7675	0.984	0.984
18	RAWANDZ MOB	0.7651	0.9827	0.9827
19	HNDREN MOB	0.7563	0.9983	0.9983
20	BALISAN MOB	0.7699	0.9721	0.9721
21	HARIR MOB	0.7834	0.9694	0.9694
22	BASRMA MOB	0.7964	0.9603	0.9603
23	BB1 REZAN	0.7337	0.9847	0.9847
24	BB2 REZAN	0.7337	0.9847	0.9847
25	BB1 KOYA	0.8959	0.9941	0.9941
26	BB2 KOYA	0.8959	0.9941	0.9941
27	BB1 SORAN	0.7557	1	1
28	BB2 SORAN	0.7556	1	1
29	%Average	78.721%	97.186%	97.183%

3.2. Power Losses for Kurdistan Region 132 kV, 50 Hz Power System

Although the STATCOM is mostly used to reduce active and reactive power losses in transmission lines in the electrical system. To see the STATCOM effect on the system, the 132 kV Kurdistan power system is used as an example. The summary of the test result is shown in **Figs. 12 and 13**. Total active losses and Reactive total losses are shown in **Table 5.**

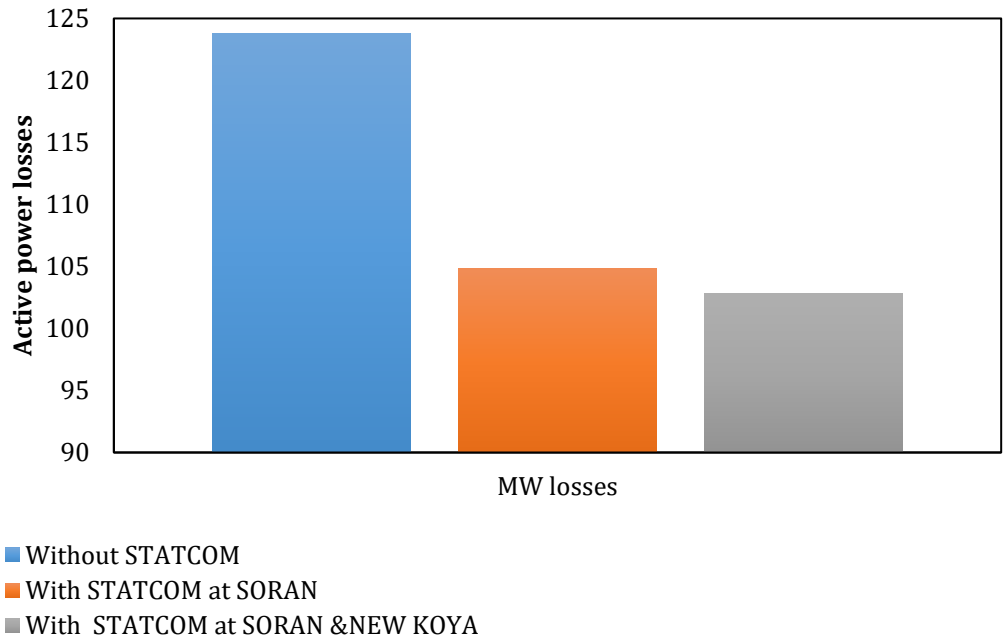

Figure 12. Total Active power losses with STATCOM

Table 5. Power flow losses with and without STATCOM

Power losses	Without STATCOM	With STATCOM at SORAN	With STATCOM at SORAN & NEW KOYA
MW losses	123.8	104.8	102.8
MVAR losses	880.4	744.8	730.4

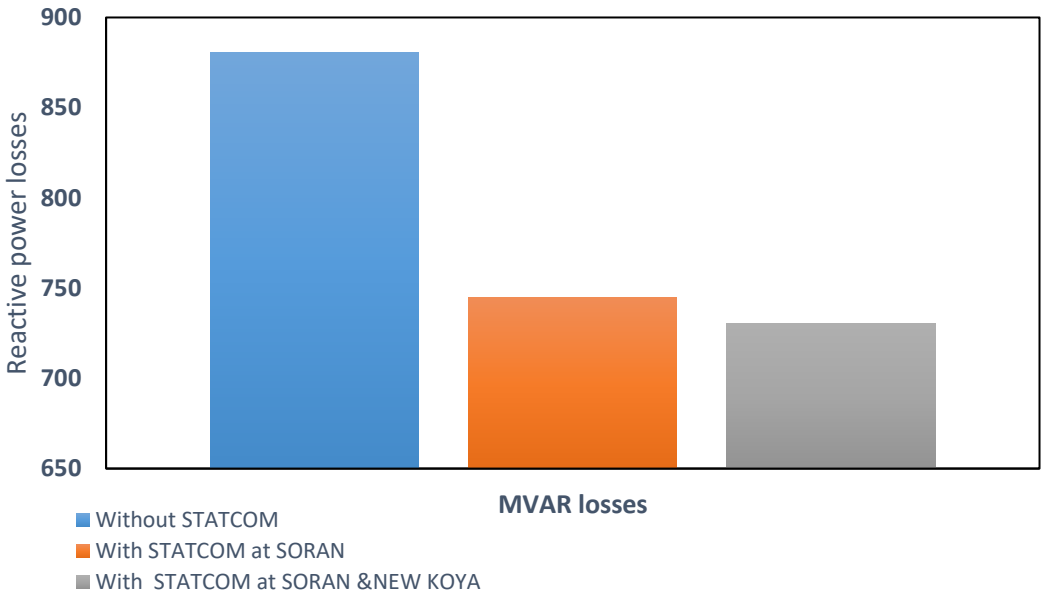

Figure 13. Total Reactive power losses with STATCOM

4. CONCLUSIONS

In this work, a Static Synchronous Compensator STATCOM has been proposed to improve the voltage profile of the power system. The main feature of STATCOM is the compensation of reactive power, one of the efficient ways by which improved and cost-effective performance of power systems. It can be guaranteed to have quick-acting compensating devices that can increase the system's stability. In this work, the performance improvement of power system networks has been examined for the Weakest buses in the power system of the 132kv Kurdistan Region. The study modeled and simulated PSS/E software with and without STATCOM, and all the modeling and simulation were carried out in the environment. The simulation results, graphs, and bar chart confirmed that STATCOM could improve the power system voltage stability. After adding STATCOM with the size [20 and 40MVAR] at Soran and New Koya to the test. It is seen that the total average change in voltage profile for the system improved results in about 18.465 % in average per unit change for the 28 weakest buses, which provides a good improvement in stability. Also, the system's total active power loss reduced from 123.8 MW without STATCOM to 102.8 MW with STATCOM. For future work, it is advisable to rely on other types of FACTS devices and compare them.

Nomenclature

symbol	description	symbol	description
I	Current (A)	FACTS	Flexible Alternating Current Transmission System
J	Jacobian	KR	Kurdistan Region
P	Power (W)	NR	Newton-Raphson
V	Voltage (V)	PSS®E Software	Power System Simulator for Engineering
δ	angle	STATCOM	Static Synchronous Compensator
		VSI	Voltage Stability Improvement

REFERENCES

Abido, M.A., 2009. Power system stability enhancement using FACTS controllers: A review. *The arabian journal for science and engineering*, *34*(1B), pp. 153-172.

Acha, E., and Kazemtabrizi, B., 2013. A new STATCOM model for power flows using the Newton–Raphson method. *IEEE Transactions on Power Systems*, *28*(3), pp. 2455-2465. Doi:10.1109/TPWRS.2012.2237186

Ahmad, A., Shehzad, A., and Shrivastava, V.B., 2013. Power quality improvement using STATCOM in IEEE 30 bus system. *addvance in electronic and electric engineering*, *3*(6). pp. 727-732

Amin, D.H., 2019. Enhancement of Voltage Stability by Using SVC for 30-Bus Power System. *Kurdistan Journal of Applied Research*, *4*(2), pp.128-136. Doi:10.24017/science.2019.2.14

Anitha, C., and Arul, P., 2014, March. Enhancement of voltage stability in transmission system using SSSC. In *2014 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2014]* (pp. 30-33). IEEE. Doi:10.1109/ICCPCT.2014.7054785

Azeez, T.T., and Abdelfattah, A.A., 2020. Transient stability enhancement and critical clearing time improvement for kurdistan region network using fact configuration. *Journal of Engineering*, *26*(10), pp. 50-65. Doi:10.31026/j.eng.2020.10.04

Baghaee, H.R., Mirsalim, M., Kashefi-Kaviani, A., and Gharehpetian, G.B., 2009. Optimal allocation of multi-type FACTS devices to improve security and reduce the losses and fault level using multi-objective particle swarm optimization. *International Review of Electrical Engineering*, *4*(6).pp. 1326-1335.

Baghaee, H.R., Vahidi, B., Jazebi, S., Gharehpetian, G.B., and Kashefi, A., 2008, October. Power system security improvement by using differential evolution algorithm based FACTS allocation. In *2008 Joint International Conference on Power System Technology and IEEE Power India Conference* (pp. 1-6). IEEE Doi:10.1109/ICPST.2008.4745275

Devalkumar, M., and Vyas, S.R., 2020. Voltage Stability Improvement by using STATCOM. *International Research Journal of Engineering and Technology (IRJET)*, *7*(3), pp. 4209-4212.

El-Moursi, M.S., and Sharaf, A.M., 2005. Novel controllers for the 48-pulse VSC STATCOM and SSSC for voltage regulation and reactive power compensation. *IEEE Transactions on Power systems*, *20*(4), pp. 1985-1997. Doi:10.1109/TPWRS.2005.856996

Furukakoi, M., Senjyu, T., and Funabashi, T., 2016, May. Voltage stability improvement of power system using a shunt capacitor. In *Proceedings of the International Conference on Renewable Energies and Power Quality* (pp. 339-344). Doi:10.24084/repqj14.311

Hossain, S., Khan, A.R., and Noor, J.E., 2014. Design of STATCOM for power system stability improvement. *Global J. Res. Eng*, *14*(2), pp. 1-6.

Ining, A.M., Leh, N.A.M., Hamid, S.A., and Muhammad, Z., 2021, December. A Study on Voltage Stability Improvement using STATCOM and UPFC. In *2021 IEEE 9th Conference on Systems, Process and Control (ICSPC 2021)* (pp. 34-39). IEEE. Doi:10.1109/ICSPC53359.2021.9689145

Islam, M.N., Kabir, M.A., and Kazushige, Y., 2013. Design and simulation of STATCOM to improve power quality. *International Journal of Innovation and Applied Studies*, *3*(3), pp. 871-878.

Joshi, B.S., Mahela, O.P., and Ola, S.R., 2016. Reactive power flow control using Static VAR Compensator to improve voltage stability in transmission system, in 2016 International Conference on Recent Advances and Innovations in Engineering (ICRAIE). Doi: 10.1109/ICRAIE.2016.7939504

Kamarposhti, M.A., and Lesani, H., 2011. Effects of STATCOM, TCSC, SSSC and UPFC on static voltage stability. *Electrical Engineering*, *93*, pp. 33-42. Doi:10.1007/s00202-010-0187-x

Kumar, K.K., SharathBabu, V., HariBabu, M., and Bhaskar, R., 2013. Performance comparison of SVC and SSSC with POD controller for Power System Stability. *IOSR Journal of Electrical and Electronics Engineering*, *6*(2), pp.28-37.

Kishore, P.V., Reddy, S.R., and Kishore, P.V., 2010. modeling and simulation of thirty bus system with DSTATCOM for power quality improvement. *International Journal of Engineering Science and Technology*, *2*(9), pp. 4560-4569.

Milano, F., 2008. Continuous Newton's method for power flow analysis. *IEEE transactions on power systems*, *24*(1), pp. 50-57. DOI:10.1109/TPWRS.2008.2004820

Mitra, P., and Venayagamoorthy, G.K., 2009. An adaptive control strategy for DSTATCOM applications in an electric ship power system. *IEEE Transactions on power electronics*, *25*(1), pp. 95-104. DOI: 10.1109/TPEL.2009.2024152

Masood, T., Aggarwal, R.K., Qureshi, S.A., and Khan, R.A.J., 2010, March. STATCOM model against SVC control model performance analyses technique by MATLAB. In *International Conference on Renewable Energies and Power Quality,* 1(8), pp. 1314-1321. DOI:10.24084/REPQJ08.655

Musunuri, S., and Dehnavi, G., 2010, September. Comparison of STATCOM, SVC, TCSC, and SSSC performance in steady state voltage stability improvement. In *North American Power Symposium 2010* (pp. 1-7). IEEE. Doi:10.1109/NAPS.2010.5618971

Naveh, M.H., Rakhshani, E., and Heidari, R., 2009, March. Application of linear observer on control of subsynchronous oscillations using TCSC. In *2009 International Conference on Power Engineering, Energy and Electrical Drives* (pp. 540-545). IEEE. Doi:10.1109/POWERENG.2009.4915187

Okakwu, I.K., Ogujor, E.A., and Oriaifo, P.A., 2017. Load flow assessment of the Nigeria 330-kV power system. *American Journal of Electrical and Electronic Engineering*, *5*(4), pp.159-165. Doi:10.12691/AJEEE-5-4-6

Rasool, A.A., Abbas, N.M., and Sheikhyounis, K., 2022. Determination of Optimal Size and Location of Static Synchronous Compensator For Power System Bus Voltage Improvement and Loss Reduction Using Whale Optimization Algorithm. *Eastern-European Journal of Enterprise Technologies*, *1*(8), p.115. Doi:10.15587/11729-14061.12022.251760

Rasool, A.A., Abbas, N.M., and Sheikhyounis, K., 2021. Contingency Analysis and Ranking of Kurdistan Region Power System Using Voltage Performance Index. *UKH Journal of Science and Engineering*, *5*(1), pp. 73-79. Doi:10.25079/ukhjse.v5n1y2021.pp73-79

Sagara, M., Furukakoi, M., Senjyu, T., Danish, M.S.S., and Funabashi, T., 2016, October. Voltage stability improvement to power systems with energy storage systems. In *2016 17th International Conference on Harmonics and Quality of Power (ICHQP)* (pp. 7-10). IEEE. Doi:10.1109/ICHQP.2016.7783463

Simeon, M., Tita, W.S., Isaiah, A.A., Ajisegiri, E.S.A., and Joseph, O.A., 2014. Power system's voltage stability improvement using static var compensator. *International Journal of Emerging Technology and Advanced Engineering*, *4*(1), pp. 2250-2459.

Shah, S.O., Arshad, A., and Alam, S., 2021, April. Reactive power compensation utilizing FACTS devices. In *2021 International conference on emerging power technologies (ICEPT)* (pp. 1-6). IEEE. Doi:10.1109/ICEPT51706.2021.9435455

Singh, S.N., 2006. Flexible AC Transmission Systems (FACTS) controllers: an overview. *International journal of energy technology and policy*, *4*(3-4), pp. 236-254. Doi:10.1504/IJETP.2006.009973

Salih, T.K.M., Hussain, Z.S., and Ahmed, F.S., 2022. Voltage Profile Enhancing Using HVDC for 132KV Power System: Kurdistan Case Study. *Journal of Engineering*, *28*(1), pp. 52-64. Doi:10.31026/j.eng.2022.01.04

Salih, T.K.M., Hussain, Z., and Ismail, S.Y., 2022. Impact of High Voltage Direct Current Link on Transmission Line in Kurdistan Power System. *Journal of Engineering*, *28*(3), pp. 46-59. Doi:10.31026/j.eng.2022.03.04

Thasnas, N., and Siritaratiwat, A., 2015. Static voltage stability margin Enhancement using shunt capacitor, SVC and STATCOM. *Applied Mechanics and Materials*, *781*, pp. 288-291. DoiI:10.4028/www.scientific.net/AMM.781.288

Usha, N., and Kumar, M.V., 2013. Enhancement of power quality in thirty bus system using ZSI based STATCOM. *Int. Journal of Modern Engineering Research*, *3*(2), pp. 773-778.

Yu, Y., Jianye, C., and Yingduo, H., 2000, July. STATCOM modeling and analysis in damping power system oscillations. In *Collection of Technical Papers. 35th Intersociety Energy Conversion Engineering Conference and Exhibit (IECEC)(Cat. No. 00CH37022)* (Vol. 2, pp. 756-762). IEEE. Doi:10.1109/IECEC.2000.870871

APPENDIX

A. Load Flow Analysis Before Compensation (without STATCOM)

```
                    SIEMENS POWER TECHNOLOGIES INTERNATIONAL

                50000 BUS POWER SYSTEM SIMULATOR--PSS(R)E-33.5.2

                    INITIATED ON MON, JAN 23 2023  12:47


SWING BUS SUMMARY:
   BUS# X-- NAME --X BASKV      PGEN     PMAX    PMIN      QGEN     QMAX    QMIN
  13051 BB EGPP G1  15.000     119.8    125.0    30.0      71.4     72.0   -40.0



BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)      BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)
      1 DOKAN JOIN2 132.00    1 0.9080 119.85         2 BKJMOB      132.00   14 0.9710
128.18
      3 KPS2        132.00    1 0.8258 109.00         4 JOINT1      132.00    1 0.7671
101.26
      5             132.00    1 0.9108 120.22         6             132.00    1 0.9639
127.24
    101 QASAR MOB.  132.00   10 0.7665 101.18       102 DOKAN JOIN1 132.00    1 0.9080
119.85
    103             132.00    1 0.9182 121.20       104             132.00    1 0.9620
126.98
    201 DERALOK     132.00   10 0.7778 102.67       202             132.00    1 0.8768
115.74
```

301	DERALOK2	132.00	10	0.7778	102.67	302		132.00	1	0.8765	115.70
401	QERCHWG SMNT	132.00	1	0.9292	122.66	402	SPILK MOB	132.00	1	0.7702	101.67
501		132.00	14	0.9740	128.56	1001	BSHERYAN MOB	132.00	10	0.8532	112.62
1002	QASROK MOB	132.00	10	0.7842	103.51	1003	NAHADRA MOB	132.00	10	0.7814	103.14
1004	MAHAT1 MOB	132.00	10	0.7813	103.14	1005	MAHAT2 MOB	132.00	10	0.7813	103.13
1006	ALQUSH MOB	132.00	10	0.7786	102.77	1007	KHATIR MOB	132.00	10	0.7727	102.00
1008	WEAST MOB	132.00	10	0.7672	101.27	1009	ZAKHO U.MOB	132.00	10	0.7575	99.99
1010	SHAHIDAN MOB	132.00	10	0.7550	99.662	1012	BADR-KALAK T	132.00	10	0.8037	106.09
1013	QARAQUSH T	132.00	10	0.8737	115.33	1301	NEW KOYA T	132.00	13	0.8937	117.97
1302	AKRE T2	132.00	13	0.7881	104.03	1303	AKRE T1	132.00	13	0.7891	104.16
1304	SORAN T2	132.00	13	0.7727	102.00	1305	SORAN T1	132.00	13	0.7741	102.18
1306	KHALIFAN MOB	132.00	13	0.7675	101.32	1308	RAWANDZ MOB	132.00	13	0.7651	101.00
1309	HNDREN MOB	132.00	13	0.7563	99.829	1310	BALISAN MOB	132.00	13	0.7699	101.63
1311	HARIR MOB	132.00	13	0.7834	103.41	1312	BASRMA MOB	132.00	13	0.7964	105.12
1313	SORK MOB	132.00	13	0.8308	109.67	1314	MALA O.MOB	132.00	13	0.8670	114.45
1315	SAFIN MOB	132.00	13	0.8857	116.91	1316	HIWA MOB	132.00	13	0.8905	117.55
1317	PESHASAZ MOB	132.00	13	0.8926	117.83	1318	KASNAZAN MOB	132.00	13	0.9016	119.01
1319	BAGHAMRA MOB	132.00	13	0.9178	121.15	1320	QALAT MOB	132.00	13	0.9107	120.22
1322	KOYA MOB	132.00	13	0.8925	117.81	1323	KAREZAN MOB	132.00	13	0.9102	120.15
1324	HAMREN MOB	132.00	13	0.9102	120.15	1326	BAHRKA MOB	132.00	13	0.8849	116.81
1330	AZADI MOB	132.00	13	0.9152	120.81	1331	TURAQ MOB	132.00	13	0.9172	121.07
1332	NISHTIMAN T	132.00	13	0.9172	121.07	1340	QERCHWG MOB	132.00	13	0.9325	123.09
1341	DEBAGAH MO	132.00	13	0.9329	123.14	1343	CHALOOK MOB	132.00	13	0.8787	115.99
1345	LAJAN MOB	132.00	13	0.9216	121.65	1350	SOR-REZA T2	132.00	13	0.7520	99.259
1351	SMAMAMK MOB	132.00	13	0.9508	125.50	1354	TARJAN MOB	132.00	13	0.9147	120.75
1401	SHAR B T1	132.00	14	0.9677	127.73	1402	SHAR B T2	132.00	14	0.9678	127.75
1403	SHERKUZH MOB	132.00	14	0.9643	127.29	1404	TASL.MOB	132.00	14	0.9759	128.82
1405	MASS C T1	132.00	14	0.9770	128.96	1406	MASS C T2	132.00	14	0.9769	128.95
1407	TAKIA MOB	132.00	14	0.9768	128.94	1408	AZMER SF MOB	132.00	14	0.9688	127.89
1409	RIZGARY T	132.00	14	0.9670	127.64	1410	KAZIWA MOB	132.00	14	0.9638	127.23
1411	KIFRI T2	132.00	14	0.9826	129.70	1412	KIFRI T1	132.00	14	0.9821	129.64
1413	ABDULLA S T1	132.00	14	0.9717	128.27	1415	ABDULLA S T2	132.00	14	0.9731	128.45
1416	GRD-BAZY CE	132.00	14	0.9747	128.66	1417	GRD FACT T	132.00	14	0.9742	128.59
1418	KALAR T2	132.00	14	0.9656	127.46	1419	KALAR T1	132.00	14	0.9557	126.16
1420	KALAR T22	132.00	14	0.9572	126.35	1421	KULAJO MOB	132.00	14	0.9545	126.00

1425 CHAMCHA MOB 132.00 14 0.9778 129.07 1426 H.SHAR MOB 132.00 14 0.9650 127.38
1427 SHKARTA MOB 132.00 14 0.8579 113.25 1431 SGP-QULR T12132.00 14 0.9670 127.65
1432 SGP-QULR T11132.00 14 0.9835 129.82 1433 SGP-QULR T21132.00 14 0.9840 129.89
1434 AGHJALAR MOB132.00 14 0.9517 125.62 1435 KOSAR MOB 132.00 14 0.8921 117.76
10001 BB1 ZAKHO 132.00 10 0.7544 99.585 10002 BB2 ZAKHO 132.00 10 0.7544 99.586
10003 BB1 SUMAIL 132.00 10 0.7739 102.15 10004 BB2 SUMAIL 132.00 10 0.7674 101.29
10005 BB3 SUMAIL 132.00 10 0.7739 102.15 10006 BB1 FAYDA 132.00 10 0.7755 102.36
10007 BB2 FAYDA 132.00 10 0.7755 102.37 10008 BB1 TANAHI 132.00 10 0.7701 101.65
10009 BB2 TANAHI 132.00 10 0.7701 101.65 10010 BB1 WEST DHK132.00 10 0.7669 101.23
10011 BB2 WEST DHK132.00 10 0.7669 101.23 10012 BB1 EAST DHK132.00 10 0.7755 102.37
10013 BB2 EAST DHK132.00 10 0.7755 102.37 10014 BB1 AKRE 132.00 10 0.7910 104.41
10015 BB2 AKRE 132.00 10 0.7910 104.41 10016 BB1 NORTH DH132.00 10 0.7750 102.30
10017 BB2 NORTH DH132.00 10 0.7750 102.30 10018 BB1 SARSANG 132.00 10 0.7774 102.61
10019 BB2 SARSANG 132.00 10 0.7774 102.61 10020 BB1 SHAKHKE 132.00 10 0.7750 102.30
10021 BB2 SHAKHKE 132.00 10 0.7750 102.30 10022 BB1 KALAKCHI132.00 10 0.8255 108.97
10023 BB2 KALAKCHI132.00 10 0.8255 108.97 10024 BB1 ZANGANAN132.00 10 0.8408 110.98
10025 BB2 ZANGANAN132.00 10 0.8408 110.99 10026 BB1 DUHOK GP132.00 10 0.7738 102.14
10027 BB2 DUHOK GP132.00 10 0.7738 102.14 10028 BB1 BADRE HF132.00 10 0.7814 103.14
10029 BB2 BADRE HF132.00 10 0.7813 103.14 10030 MOSUL DAM 132.00 1 0.7740 102.17
10031 BB DGPP G1 15.000 10 0.8120 12.180 13001 BB1 PIRZEEN 132.00 13 0.8868 117.05
13002 BB2 PIRZEEN 132.00 13 0.8868 117.06 13003 BB1 PARK 132.00 13 0.9006 118.88
13004 BB2 PARK 132.00 13 0.9006 118.89 13005 BB1 AZADI 132.00 13 0.9152 120.80
13006 BB2 AZADI 132.00 13 0.9151 120.80 13007 BB1 WEST EBL132.00 13 0.9181 121.19
13008 BB2 WEST EBL132.00 13 0.9180 121.17 13009 BB1 NORTH EB132.00 13 0.8857 116.91
13010 BB2 NORTH EB132.00 13 0.8856 116.90 13011 BB1 SALAHADD132.00 13 0.8496 112.15
13012 BB2 SALAHADD132.00 13 0.8496 112.14 13013 BB1 SHAQLAWA132.00 13 0.8299 109.55
13014 BB2 SHAQLAWA132.00 13 0.8299 109.55 13015 BB1 SOUTH EB132.00 13 0.9234 121.88
13016 BB2 SOUTH EB132.00 13 0.9232 121.87 13017 BB1 NEW EBL 132.00 13 0.8970 118.40
13018 BB2 NEW EBL 132.00 13 0.8968 118.38 13019 BB1 KHABAT 132.00 13 0.8738 115.34
13020 BB2 KHABAT 132.00 13 0.8738 115.34 13021 BB1 POLTEX 132.00 13 0.9262 122.26
13022 BB2 POLTEX 132.00 13 0.9261 122.25 13023 BB1 QUSHTAPA132.00 13 0.9424 124.39
13024 BB2 QUSHTAPA132.00 13 0.9423 124.39 13025 BB1 EAST EBL132.00 13 0.9082 119.88
13026 BB2 EAST EBL132.00 13 0.9081 119.87 13027 BB1 NEW KOYA132.00 13 0.8936 117.95
13028 BB2 NEW KOYA132.00 13 0.8936 117.95 13029 BB1 KOYA 132.00 13 0.8959 118.25
13030 BB2 KOYA 132.00 13 0.8959 118.25 13031 BB1 SORAN 132.00 13 0.7556 99.746

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  13032 BB2 SORAN   132.00   13 0.7556 99.743     13035 BB1 ERBIL GP132.00   13 0.9520
125.67
  13036 BB2 ERBIL GP132.00   13 0.9515 125.60     13037 BB1 ERBIL CC400.00   13 0.9842
393.66
  13038 BB2 ERBIL CC400.00   13 0.9840 393.58     13039 BB1 ERBIL CE132.00   13 0.9486
125.22
  13040 BB2 ERBIL CE132.00   13 0.9485 125.20     13041 BB1 KHORMALA400.00   13 0.9838
393.53
  13042 BB2 KHORMALA400.00   13 0.9837 393.47     13044 DBS/KIRKUK  132.00    1 0.9334
123.20
  13045 BB1 REZAN   132.00   13 0.7337 96.849     13046 BB2 REZAN   132.00   13 0.7337
96.846
  13051 BB EGPP G1  15.000   13 1.0000 15.000     13052 BB EGPP G2  15.000   13 1.0000
15.000
  13053 BB EGPP G3  15.000   13 1.0000 15.000     13054 BB EGPP G4  15.000   13 1.0000
15.000
  13055 BB EGPP G5  15.000   13 1.0000 15.000     13056 BB EGPP G6  15.000   13 1.0000
15.000
  13059 BB1 KHABAT G132.00   13 0.8734 115.29     13060 BB2 KHABAT G132.00   13 0.8735
115.30
  14001 BB1 CHWAR QU132.00   14 0.8596 113.46     14002 BB2 CHWAR QU132.00   14 0.8595
113.46
  14003 BB1 DOK/HPS 132.00   14 0.9093 120.02     14004 BB2 DOK/HPS 132.00   14 0.9093
120.02
  14005 BB1 RANYA   132.00   14 0.8593 113.43     14006 BB2 RANYA   132.00   14 0.8593
113.43
  14007 BB1 QALADZE 132.00   14 0.8603 113.56     14008 BB2 QALADZE 132.00   14 0.8603
113.56
  14009 BB1 SHARBAZH132.00   14 0.9647 127.34     14010 BB2 SHARBAZH132.00   14 0.9647
127.34
  14011 BB1 DOKAN AB132.00   14 0.9090 119.99     14012 BB2 DOKAN AB132.00   14 0.9090
119.99
  14013 BB1 ZARGATA 132.00   14 0.9634 127.17     14014 BB2 ZARGATA 132.00   14 0.9634
127.17
  14015 BB1 TAVGA   132.00   14 0.9641 127.26     14016 BB2 TAVGA   132.00   14 0.9641
127.26
  14017 BB1 TASLUJA 132.00   14 0.9759 128.82     14018 BB2 TASLUJA 132.00   14 0.9759
128.81
  14019 BB1 BAZYAN  132.00   14 1.0000 132.00     14020 BB2 BAZYAN  132.00   14 0.9998
131.98
  14025 BB2 AZMAR   132.00   14 0.9639 127.24     14026 BB1 AZMAR   132.00   14 0.9639
127.24
  14027 BB2 QULARACY132.00   14 0.9654 127.44     14028 BB1 QULARACY132.00   14 0.9654
127.44
  14030 SUPER STEEL 132.00   14 0.9761 128.84     14032  BB MASS CEM132.00   14 0.9769
128.95
  14035 BB2 PENJWEEN132.00   14 0.9389 123.94     14036 BB1 PENJWEEN132.00   14 0.9389
123.94
  14037 BB1 RIZGARI 132.00   14 0.9725 128.37     14038 BB2 RIZGARI 132.00   14 0.9725
128.37
  14039 BB1 S.SULI  132.00   14 0.9618 126.96     14040 BB2 S.SULI  132.00   14 0.9618
126.96
  14041 BB1 ABDULA S132.00   14 0.9712 128.20     14042 BB2 ABDULA S132.00   14 0.9712
128.20
  14043 BB1 SULI CEN132.00   14 0.9705 128.11     14044 BB2 SULI CEN132.00   14 0.9705
128.11
  14045 BB1 BARD QAR132.00   14 0.9780 129.10     14046 BB2 BARD QAR132.00   14 0.9780
129.10
  14047 BB1 SGPP    132.00   14 0.9850 130.01     14048 BB2 SGPP    132.00   14 0.9851
130.04
  14050 MASS STEEL  132.00   14 0.9840 129.89     14051 BB1 CHAMCHAM132.00   14 0.9802
129.38
  14052 BB2 CHAMCHAM132.00   14 0.9801 129.38     14053 BB1 BAKRAJO 132.00   14 0.9733
128.47
  14054 BB2 BAKRAJO 132.00   14 0.9732 128.47     14055 BB1 S.SADIQ 132.00   14 0.9471
125.02
  14056 BB2 S.SADIQ 132.00   14 0.9471 125.02     14057 BB1 HALABJA 132.00   14 0.9382
123.85
  14058 BB2 HALABJA 132.00   14 0.9382 123.85     14059 BB1 TANJARO 132.00   14 0.9642
127.27
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  14060 BB2 TANJARO 132.00   14 0.9642 127.27     14061 BAZYAN CEMNT132.00   14 0.9745
128.63
  14063 GRD DELTA   132.00   14 0.9738 128.54     14067 BB1 KIFRI   132.00   14 0.9510
125.53
  14068 BB2 KIFRI   132.00   14 0.9510 125.53     14069 BB1 KALAR   132.00   14 0.9546
126.00
  14070 BB2 KALAR   132.00   14 0.9546 126.00     14071 BB1 DBK/ HPS132.00   14 0.9670
127.65
  14072 BB2 DBK/ HPS132.00   14 0.9671 127.65     14074 TAZA/KIRKUK 132.00    1 0.9633
127.16
  14075 GASN        132.00   14 0.9741 128.58     14081 BB SGPP G1  15.000   14 1.0000
15.000
  14082 BB SGPP G2  15.000   14 1.0000 15.000     14083 BB SGPP G3  15.000   14 1.0000
15.000
  14084 BB SGPP G4  15.000   14 1.0000 15.000     14085 BB SGPP G5  15.000   14 1.0000
15.000
  14088 BB SGPP G8  15.000   14 1.0000 15.000     14089 BB2 SULI  CC400.00   14 0.9999
399.96
  14090 BB1 SULI  CC400.00   14 1.0000 400.00     14091 BB DBK/HP G113.800   14 1.0000
13.800
  14092 BB DBK/HP G213.800   14 1.0000 13.800     14101 BB DOK/HP G113.800   14 0.9323
12.865
  14106 KURDSAT BB1 132.00   14 0.9642 127.28     14107 KURDSAT BB2 132.00   14 0.9642
127.27
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B. Load Flow Analysis After Compensation (with STATCOM) at SORAN

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BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)      BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)
      1 DOKAN JOIN2 132.00    1 0.9307 122.86         2 BKJMOB      132.00   14 0.9723
128.34
      3 KPS2        132.00    1 0.9499 125.39         4 JOINT1      132.00    1 0.9430
124.48
      5             132.00    1 0.9597 126.68         6             132.00    1 0.9659
127.50
    101 QASAR MOB.  132.00   10 0.9425 124.42       102 DOKAN JOIN1 132.00    1 0.9307
122.86
    103             132.00    1 0.9641 127.26       104             132.00    1 0.9633
127.15
    201 DERALOK     132.00   10 0.9550 126.06       202             132.00    1 0.9532
125.82
    301 DERALOK2    132.00   10 0.9550 126.06       302             132.00    1 0.9529
125.78
    401 QERCHWG SMNT132.00    1 0.9610 126.86       402 SPILK MOB   132.00    1 0.9736
128.52
    501             132.00   14 0.9753 128.74      1001 BSHERYAN MOB132.00   10 0.9498
125.38
   1002 QASROK MOB  132.00   10 0.9445 124.68      1003 NAHADRA MOB 132.00   10 0.9473
125.04
   1004 MAHAT1 MOB  132.00   10 0.9453 124.78      1005 MAHAT2 MOB  132.00   10 0.9452
124.77
   1006 ALQUSH MOB  132.00   10 0.9475 125.07      1007 KHATIR MOB  132.00   10 0.9444
124.66
   1008 WEAST MOB   132.00   10 0.9431 124.49      1009 ZAKHO U.MOB 132.00   10 0.9392
123.98
   1010 SHAHIDAN MOB132.00   10 0.9379 123.80      1012 BADR-KALAK T132.00   10 0.9486
125.21
   1013 QARAQUSH T  132.00   10 0.9528 125.77      1301 NEW KOYA T  132.00   13 0.9325
123.09
   1302 AKRE T2     132.00   13 0.9588 126.57      1303 AKRE T1     132.00   13 0.9610
126.86
   1304 SORAN T2    132.00   13 0.9711 128.19      1305 SORAN T1    132.00   13 0.9747
128.66
   1306 KHALIFAN MOB132.00   13 0.9820 129.62      1308 RAWANDZ MOB 132.00   13 0.9807
129.45
   1309 HNDREN MOB  132.00   13 0.9981 131.75      1310 BALISAN MOB 132.00   13 0.9690
127.91
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1311	HARIR MOB	132.00	13	0.9653	127.42	1312	BASRMA MOB	132.00	13	0.9549	126.04
1313	SORK MOB	132.00	13	0.9463	124.91	1314	MALA O.MOB	132.00	13	0.9439	124.59
1315	SAFIN MOB	132.00	13	0.9466	124.95	1316	HIWA MOB	132.00	13	0.9484	125.19
1317	PESHASAZ MOB	132.00	13	0.9494	125.31	1318	KASNAZAN MOB	132.00	13	0.9533	125.83
1319	BAGHAMRA MOB	132.00	13	0.9618	126.96	1320	QALAT MOB	132.00	13	0.9577	126.42
1322	KOYA MOB	132.00	13	0.9332	123.18	1323	KAREZAN MOB	132.00	13	0.9576	126.40
1324	HAMREN MOB	132.00	13	0.9576	126.40	1326	BAHRKA MOB	132.00	13	0.9479	125.12
1330	AZADI MOB	132.00	13	0.9609	126.83	1331	TURAQ MOB	132.00	13	0.9634	127.17
1332	NISHTIMAN T	132.00	13	0.9619	126.97	1340	QERCHWG MOB	132.00	13	0.9642	127.27
1341	DEBAGAH MO	132.00	13	0.9646	127.32	1343	CHALOOK MOB	132.00	13	0.9533	125.83
1345	LAJAN MOB	132.00	13	0.9659	127.50	1350	SOR-REZA T2	132.00	13	0.9976	131.68
1351	SMAMAMK MOB	132.00	13	0.9821	129.63	1354	TARJAN MOB	132.00	13	0.9671	127.65
1401	SHAR B T1	132.00	14	0.9705	128.10	1402	SHAR B T2	132.00	14	0.9706	128.12
1403	SHERKUZH MOB	132.00	14	0.9662	127.54	1404	TASL.MOB	132.00	14	0.9795	129.30
1405	MASS C T1	132.00	14	0.9799	129.34	1406	MASS C T2	132.00	14	0.9798	129.34
1407	TAKIA MOB	132.00	14	0.9781	129.10	1408	AZMER SF MOB	132.00	14	0.9705	128.10
1409	RIZGARY T	132.00	14	0.9686	127.86	1410	KAZIWA MOB	132.00	14	0.9658	127.49
1411	KIFRI T2	132.00	14	0.9836	129.84	1412	KIFRI T1	132.00	14	0.9832	129.78
1413	ABDULLA S T1	132.00	14	0.9730	128.43	1415	ABDULLA S T2	132.00	14	0.9744	128.62
1416	GRD-BAZY CE	132.00	14	0.9758	128.80	1417	GRD FACT T	132.00	14	0.9753	128.74
1418	KALAR T2	132.00	14	0.9666	127.60	1419	KALAR T1	132.00	14	0.9568	126.29
1420	KALAR T22	132.00	14	0.9583	126.49	1421	KULAJO MOB	132.00	14	0.9556	126.13
1425	CHAMCHA MOB	132.00	14	0.9788	129.20	1426	H.SHAR MOB	132.00	14	0.9674	127.70
1427	SHKARTA MOB	132.00	14	0.8838	116.66	1431	SGP-QULR T12	132.00	14	0.9688	127.88
1432	SGP-QULR T11	132.00	14	0.9846	129.96	1433	SGP-QULR T21	132.00	14	0.9851	130.03
1434	AGHJALAR MOB	132.00	14	0.9708	128.14	1435	KOSAR MOB	132.00	14	0.9470	125.01
10001	BB1 ZAKHO	132.00	10	0.9378	123.79	10002	BB2 ZAKHO	132.00	10	0.9378	123.79
10003	BB1 SUMAIL	132.00	10	0.9477	125.09	10004	BB2 SUMAIL	132.00	10	0.9453	124.78
10005	BB3 SUMAIL	132.00	10	0.9477	125.09	10006	BB1 FAYDA	132.00	10	0.9462	124.90
10007	BB2 FAYDA	132.00	10	0.9462	124.90	10008	BB1 TANAHI	132.00	10	0.9454	124.79
10009	BB2 TANAHI	132.00	10	0.9454	124.80	10010	BB1 WEST DHK	132.00	10	0.9428	124.45
10011	BB2 WEST DHK	132.00	10	0.9428	124.45	10012	BB1 EAST DHK	132.00	10	0.9480	125.13
10013	BB2 EAST DHK	132.00	10	0.9480	125.13	10014	BB1 AKRE	132.00	10	0.9436	124.56
10015	BB2 AKRE	132.00	10	0.9437	124.56	10016	BB1 NORTH DH	132.00	10	0.9487	125.22
10017	BB2 NORTH DH	132.00	10	0.9487	125.23	10018	BB1 SARSANG	132.00	10	0.9545	126.00

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  10019 BB2 SARSANG 132.00   10 0.9545 126.00     10020 BB1 SHAKHKE 132.00   10 0.9495
125.33
  10021 BB2 SHAKHKE 132.00   10 0.9495 125.34     10022 BB1 KALAKCHI132.00   10 0.9496
125.35
  10023 BB2 KALAKCHI132.00   10 0.9496 125.35     10024 BB1 ZANGANAN132.00   10 0.9498
125.38
  10025 BB2 ZANGANAN132.00   10 0.9498 125.37     10026 BB1 DUHOK GP132.00   10 0.9488
125.24
  10027 BB2 DUHOK GP132.00   10 0.9488 125.25     10028 BB1 BADRE HF132.00   10 0.9492
125.30
  10029 BB2 BADRE HF132.00   10 0.9492 125.30     10030  MOSUL DAM  132.00    1 0.9455
124.81
  10031 BB DGPP G1  15.000   10 0.9818 14.727     13001 BB1 PIRZEEN 132.00   13 0.9476
125.08
  13002 BB2 PIRZEEN 132.00   13 0.9476 125.08     13003 BB1 PARK    132.00   13 0.9541
125.94
  13004 BB2 PARK    132.00   13 0.9541 125.94     13005 BB1 AZADI   132.00   13 0.9607
126.82
  13006 BB2 AZADI   132.00   13 0.9607 126.81     13007 BB1 WEST EBL132.00   13 0.9645
127.31
  13008 BB2 WEST EBL132.00   13 0.9644 127.30     13009 BB1 NORTH EB132.00   13 0.9465
124.94
  13010 BB2 NORTH EB132.00   13 0.9465 124.93     13011 BB1 SALAHADD132.00   13 0.9436
124.55
  13012 BB2 SALAHADD132.00   13 0.9436 124.56     13013 BB1 SHAQLAWA132.00   13 0.9467
124.96
  13014 BB2 SHAQLAWA132.00   13 0.9467 124.96     13015 BB1 SOUTH EB132.00   13 0.9653
127.42
  13016 BB2 SOUTH EB132.00   13 0.9653 127.41     13017 BB1 NEW EBL 132.00   13 0.9512
125.55
  13018 BB2 NEW EBL 132.00   13 0.9511 125.55     13019 BB1 KHABAT  132.00   13 0.9529
125.79
  13020 BB2 KHABAT  132.00   13 0.9529 125.79     13021 BB1 POLTEX  132.00   13 0.9671
127.66
  13022 BB2 POLTEX  132.00   13 0.9671 127.66     13023 BB1 QUSHTAPA132.00   13 0.9768
128.93
  13024 BB2 QUSHTAPA132.00   13 0.9767 128.93     13025 BB1 EAST EBL132.00   13 0.9564
126.24
  13026 BB2 EAST EBL132.00   13 0.9564 126.24     13027 BB1 NEW KOYA132.00   13 0.9324
123.07
  13028 BB2 NEW KOYA132.00   13 0.9324 123.07     13029 BB1 KOYA    132.00   13 0.9325
123.09
  13030 BB2 KOYA    132.00   13 0.9325 123.09     13031 BB1 SORAN   132.00   13 1.0000
132.00
  13032 BB2 SORAN   132.00   13 1.0000 132.00     13035 BB1 ERBIL GP132.00   13 0.9826
129.71
  13036 BB2 ERBIL GP132.00   13 0.9824 129.68     13037 BB1 ERBIL CC400.00   13 1.0000
400.00
  13038 BB2 ERBIL CC400.00   13 0.9999 399.96     13039 BB1 ERBIL CE132.00   13 0.9811
129.50
  13040 BB2 ERBIL CE132.00   13 0.9810 129.49     13041 BB1 KHORMALA400.00   13 1.0000
400.00
  13042 BB2 KHORMALA400.00   13 0.9999 399.96     13044 DBS/KIRKUK  132.00    1 0.9682
127.80
  13045 BB1 REZAN   132.00   13 0.9847 129.99     13046 BB2 REZAN   132.00   13 0.9847
129.99
  13051 BB EGPP G1  15.000   13 1.0000 15.000     13052 BB EGPP G2  15.000   13 1.0000
15.000
  13053 BB EGPP G3  15.000   13 1.0000 15.000     13054 BB EGPP G4  15.000   13 1.0000
15.000
  13055 BB EGPP G5  15.000   13 1.0000 15.000     13056 BB EGPP G6  15.000   13 1.0000
15.000
  13059 BB1 KHABAT G132.00   13 0.9527 125.76     13060 BB2 KHABAT G132.00   13 0.9527
125.76
  14001 BB1 CHWAR QU132.00   14 0.8853 116.86     14002 BB2 CHWAR QU132.00   14 0.8853
116.86
  14003 BB1 DOK/HPS 132.00   14 0.9319 123.02     14004 BB2 DOK/HPS 132.00   14 0.9320
123.02
  14005 BB1 RANYA   132.00   14 0.8852 116.84     14006 BB2 RANYA   132.00   14 0.8852
116.84
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14007 BB1 QALADZE 132.00 14 0.8864 117.00 14008 BB2 QALADZE 132.00 14 0.8864 117.00
14009 BB1 SHARBAZH132.00 14 0.9675 127.72 14010 BB2 SHARBAZH132.00 14 0.9675 127.71
14011 BB1 DOKAN AB132.00 14 0.9317 122.99 14012 BB2 DOKAN AB132.00 14 0.9317 122.98
14013 BB1 ZARGATA 132.00 14 0.9654 127.43 14014 BB2 ZARGATA 132.00 14 0.9654 127.43
14015 BB1 TAVGA 132.00 14 0.9659 127.50 14016 BB2 TAVGA 132.00 14 0.9660 127.51
14017 BB1 TASLUJA 132.00 14 0.9797 129.31 14018 BB2 TASLUJA 132.00 14 0.9796 129.31
14019 BB1 BAZYAN 132.00 14 1.0000 132.00 14020 BB2 BAZYAN 132.00 14 0.9999 131.98
14025 BB2 AZMAR 132.00 14 0.9660 127.51 14026 BB1 AZMAR 132.00 14 0.9660 127.51
14027 BB2 QULARACY132.00 14 0.9672 127.67 14028 BB1 QULARACY132.00 14 0.9672 127.67
14030 SUPER STEEL 132.00 14 0.9793 129.27 14032 BB MASS CEM132.00 14 0.9798 129.33
14035 BB2 PENJWEEN132.00 14 0.9401 124.09 14036 BB1 PENJWEEN132.00 14 0.9401 124.09
14037 BB1 RIZGARI 132.00 14 0.9737 128.53 14038 BB2 RIZGARI 132.00 14 0.9737 128.53
14039 BB1 S.SULI 132.00 14 0.9631 127.13 14040 BB2 S.SULI 132.00 14 0.9631 127.13
14041 BB1 ABDULA S132.00 14 0.9725 128.36 14042 BB2 ABDULA S132.00 14 0.9724 128.36
14043 BB1 SULI CEN132.00 14 0.9718 128.28 14044 BB2 SULI CEN132.00 14 0.9718 128.27
14045 BB1 BARD QAR132.00 14 0.9806 129.44 14046 BB2 BARD QAR132.00 14 0.9806 129.44
14047 BB1 SGPP 132.00 14 0.9860 130.15 14048 BB2 SGPP 132.00 14 0.9861 130.17
14050 MASS STEEL 132.00 14 0.9850 130.02 14051 BB1 CHAMCHAM132.00 14 0.9812 129.52
14052 BB2 CHAMCHAM132.00 14 0.9812 129.51 14053 BB1 BAKRAJO 132.00 14 0.9744 128.62
14054 BB2 BAKRAJO 132.00 14 0.9744 128.62 14055 BB1 S.SADIQ 132.00 14 0.9483 125.17
14056 BB2 S.SADIQ 132.00 14 0.9483 125.17 14057 BB1 HALABJA 132.00 14 0.9394 124.00
14058 BB2 HALABJA 132.00 14 0.9394 124.00 14059 BB1 TANJARO 132.00 14 0.9654 127.44
14060 BB2 TANJARO 132.00 14 0.9654 127.44 14061 BAZYAN CEMNT132.00 14 0.9756 128.78
14063 GRD DELTA 132.00 14 0.9749 128.69 14067 BB1 KIFRI 132.00 14 0.9520 125.67
14068 BB2 KIFRI 132.00 14 0.9520 125.67 14069 BB1 KALAR 132.00 14 0.9556 126.14
14070 BB2 KALAR 132.00 14 0.9556 126.14 14071 BB1 DBK/ HPS132.00 14 0.9680 127.77
14072 BB2 DBK/ HPS132.00 14 0.9680 127.78 14074 TAZA/KIRKUK 132.00 1 0.9644 127.30
14075 GASN 132.00 14 0.9752 128.73 14081 BB SGPP G1 15.000 14 1.0000 15.000
14082 BB SGPP G2 15.000 14 1.0000 15.000 14083 BB SGPP G3 15.000 14 1.0000 15.000
14084 BB SGPP G4 15.000 14 1.0000 15.000 14085 BB SGPP G5 15.000 14 1.0000 15.000
14088 BB SGPP G8 15.000 14 1.0000 15.000 14089 BB2 SULI CC400.00 14 0.9999 399.96
14090 BB1 SULI CC400.00 14 1.0000 400.00 14091 BB DBK/HP G113.800 14 1.0000 13.800
14092 BB DBK/HP G213.800 14 1.0000 13.800 14101 BB DOK/HP G113.800 14 0.9545 13.173
14106 KURDSAT BB1 132.00 14 0.9665 127.58 14107 KURDSAT BB2 132.00 14 0.9665 127.58

C. Load Flow Analysis After Compensation (with STATCOM) at SORAN& NEWKOYA

BUS#	X-- NAME --X	BASKV	AREA	V(PU)	V(KV)	BUS#	X-- NAME --X	BASKV	AREA	V(PU)	V(KV)
1	DOKAN JOIN2	132.00	1	0.9639	127.24	2	BKJMOB	132.00	14	0.9741	128.58
3	KPS2	132.00	1	0.9579	126.44	4	JOINT1	132.00	1	0.9520	125.66
5		132.00	1	0.9666	127.59	6		132.00	1	0.9687	127.87
101	QASAR MOB.	132.00	10	0.9515	125.60	102	DOKAN JOIN1	132.00	1	0.9639	127.24
103		132.00	1	0.9703	128.08	104		132.00	1	0.9651	127.39
201	DERALOK	132.00	10	0.9640	127.25	202		132.00	1	0.9600	126.72
301	DERALOK2	132.00	10	0.9640	127.25	302		132.00	1	0.9597	126.68
401	QERCHWG SMNT	132.00	1	0.9644	127.30	402	SPILK MOB	132.00	1	0.9764	128.89
501		132.00	14	0.9773	129.01	1001	BSHERYAN MOB	132.00	10	0.9571	126.34
1002	QASROK MOB	132.00	10	0.9521	125.68	1003	NAHADRA MOB	132.00	10	0.9555	126.13
1004	MAHAT1 MOB	132.00	10	0.9533	125.84	1005	MAHAT2 MOB	132.00	10	0.9533	125.83
1006	ALQUSH MOB	132.00	10	0.9561	126.21	1007	KHATIR MOB	132.00	10	0.9532	125.83
1008	WEAST MOB	132.00	10	0.9520	125.67	1009	ZAKHO U.MOB	132.00	10	0.9484	125.19
1010	SHAHIDAN MOB	132.00	10	0.9471	125.02	1012	BADR-KALAK T	132.00	10	0.9568	126.30
1013	QARAQUSH T	132.00	10	0.9597	126.68	1301	NEW KOYA T	132.00	13	0.9984	131.79
1302	AKRE T2	132.00	13	0.9637	127.20	1303	AKRE T1	132.00	13	0.9657	127.48
1304	SORAN T2	132.00	13	0.9742	128.60	1305	SORAN T1	132.00	13	0.9776	129.04
1306	KHALIFAN MOB	132.00	13	0.9840	129.88	1308	RAWANDZ MOB	132.00	13	0.9827	129.71
1309	HNDREN MOB	132.00	13	0.9983	131.78	1310	BALISAN MOB	132.00	13	0.9721	128.32
1311	HARIR MOB	132.00	13	0.9694	127.96	1312	BASRMA MOB	132.00	13	0.9603	126.76
1313	SORK MOB	132.00	13	0.9537	125.89	1314	MALA O.MOB	132.00	13	0.9541	125.94
1315	SAFIN MOB	132.00	13	0.9573	126.36	1316	HIWA MOB	132.00	13	0.9588	126.56
1317	PESHASAZ MOB	132.00	13	0.9593	126.63	1318	KASNAZAN MOB	132.00	13	0.9617	126.94
1319	BAGHAMRA MOB	132.00	13	0.9680	127.78	1320	QALAT MOB	132.00	13	0.9648	127.35
1322	KOYA MOB	132.00	13	0.9947	131.30	1323	KAREZAN MOB	132.00	13	0.9646	127.33
1324	HAMREN MOB	132.00	13	0.9646	127.33	1326	BAHRKA MOB	132.00	13	0.9570	126.32
1330	AZADI MOB	132.00	13	0.9671	127.65	1331	TURAQ MOB	132.00	13	0.9692	127.93
1332	NISHTIMAN T	132.00	13	0.9680	127.77	1340	QERCHWG MOB	132.00	13	0.9676	127.72
1341	DEBAGAH MO	132.00	13	0.9679	127.77	1343	CHALOOK MOB	132.00	13	0.9600	126.72
1345	LAJAN MOB	132.00	13	0.9718	128.28	1350	SOR-REZA T2	132.00	13	0.9976	131.68
1351	SMAMAMK MOB	132.00	13	0.9854	130.08	1354	TARJAN MOB	132.00	13	0.9720	128.30
1401	SHAR B T1	132.00	14	0.9745	128.64	1402	SHAR B T2	132.00	14	0.9746	128.65

1403 SHERKUZH MOB132.00 14 0.9688 127.89 1404 TASL.MOB 132.00 14 0.9847 129.98
1405 MASS C T1 132.00 14 0.9840 129.89 1406 MASS C T2 132.00 14 0.9840 129.89
1407 TAKIA MOB 132.00 14 0.9799 129.34 1408 AZMER SF MOB132.00 14 0.9728 128.41
1409 RIZGARY T 132.00 14 0.9709 128.16 1410 KAZIWA MOB 132.00 14 0.9687 127.86
1411 KIFRI T2 132.00 14 0.9851 130.04 1412 KIFRI T1 132.00 14 0.9847 129.98
1413 ABDULLA S T1132.00 14 0.9747 128.67 1415 ABDULLA S T2132.00 14 0.9762 128.85
1416 GRD-BAZY CE 132.00 14 0.9773 129.01 1417 GRD FACT T 132.00 14 0.9768 128.94
1418 KALAR T2 132.00 14 0.9681 127.79 1419 KALAR T1 132.00 14 0.9583 126.49
1420 KALAR T22 132.00 14 0.9597 126.68 1421 KULAJO MOB 132.00 14 0.9570 126.33
1425 CHAMCHA MOB 132.00 14 0.9803 129.40 1426 H.SHAR MOB 132.00 14 0.9709 128.17
1427 SHKARTA MOB 132.00 14 0.9211 121.58 1431 SGP-QULR T12132.00 14 0.9712 128.20
1432 SGP-QULR T11132.00 14 0.9861 130.17 1433 SGP-QULR T21132.00 14 0.9866 130.23
1434 AGHJALAR MOB132.00 14 0.9741 128.58 1435 KOSAR MOB 132.00 14 0.9620 126.99
10001 BB1 ZAKHO 132.00 10 0.9471 125.02 10002 BB2 ZAKHO 132.00 10 0.9471 125.02
10003 BB1 SUMAIL 132.00 10 0.9566 126.27 10004 BB2 SUMAIL 132.00 10 0.9544 125.98
10005 BB3 SUMAIL 132.00 10 0.9566 126.27 10006 BB1 FAYDA 132.00 10 0.9551 126.07
10007 BB2 FAYDA 132.00 10 0.9551 126.07 10008 BB1 TANAHI 132.00 10 0.9543 125.97
10009 BB2 TANAHI 132.00 10 0.9543 125.97 10010 BB1 WEST DHK132.00 10 0.9518 125.63
10011 BB2 WEST DHK132.00 10 0.9518 125.63 10012 BB1 EAST DHK132.00 10 0.9567 126.29
10013 BB2 EAST DHK132.00 10 0.9567 126.29 10014 BB1 AKRE 132.00 10 0.9504 125.45
10015 BB2 AKRE 132.00 10 0.9504 125.46 10016 BB1 NORTH DH132.00 10 0.9575 126.39
10017 BB2 NORTH DH132.00 10 0.9575 126.39 10018 BB1 SARSANG 132.00 10 0.9635 127.18
10019 BB2 SARSANG 132.00 10 0.9635 127.18 10020 BB1 SHAKHKE 132.00 10 0.9584 126.51
10021 BB2 SHAKHKE 132.00 10 0.9584 126.51 10022 BB1 KALAKCHI132.00 10 0.9576 126.40
10023 BB2 KALAKCHI132.00 10 0.9576 126.40 10024 BB1 ZANGANAN132.00 10 0.9575 126.38
10025 BB2 ZANGANAN132.00 10 0.9574 126.38 10026 BB1 DUHOK GP132.00 10 0.9577 126.42
10027 BB2 DUHOK GP132.00 10 0.9578 126.43 10028 BB1 BADRE HF132.00 10 0.9578 126.42
10029 BB2 BADRE HF132.00 10 0.9578 126.42 10030 MOSUL DAM 132.00 1 0.9544 125.98
10031 BB DGPP G1 15.000 10 0.9905 14.858 13001 BB1 PIRZEEN 132.00 13 0.9569 126.32
13002 BB2 PIRZEEN 132.00 13 0.9570 126.32 13003 BB1 PARK 132.00 13 0.9619 126.97
13004 BB2 PARK 132.00 13 0.9619 126.97 13005 BB1 AZADI 132.00 13 0.9670 127.64
13006 BB2 AZADI 132.00 13 0.9669 127.63 13007 BB1 WEST EBL132.00 13 0.9701 128.05
13008 BB2 WEST EBL132.00 13 0.9700 128.05 13009 BB1 NORTH EB132.00 13 0.9577 126.41
13010 BB2 NORTH EB132.00 13 0.9577 126.42 13011 BB1 SALAHADD132.00 13 0.9526 125.74
13012 BB2 SALAHADD132.00 13 0.9526 125.75 13013 BB1 SHAQLAWA132.00 13 0.9540 125.93

13014 BB2 SHAQLAWA132.00 13 0.9540 125.93 13015 BB1 SOUTH EB132.00 13 0.9709 128.16
13016 BB2 SOUTH EB132.00 13 0.9708 128.15 13017 BB1 NEW EBL 132.00 13 0.9604 126.77
13018 BB2 NEW EBL 132.00 13 0.9603 126.77 13019 BB1 KHABAT 132.00 13 0.9598 126.69
13020 BB2 KHABAT 132.00 13 0.9598 126.69 13021 BB1 POLTEX 132.00 13 0.9725 128.37
13022 BB2 POLTEX 132.00 13 0.9725 128.36 13023 BB1 QUSHTAPA132.00 13 0.9808 129.46
13024 BB2 QUSHTAPA132.00 13 0.9807 129.46 13025 BB1 EAST EBL132.00 13 0.9638 127.22
13026 BB2 EAST EBL132.00 13 0.9638 127.22 13027 BB1 NEW KOYA132.00 13 1.0000 132.00
13028 BB2 NEW KOYA132.00 13 1.0000 132.00 13029 BB1 KOYA 132.00 13 0.9941 131.22
13030 BB2 KOYA 132.00 13 0.9941 131.22 13031 BB1 SORAN 132.00 13 1.0000 132.00
13032 BB2 SORAN 132.00 13 1.0000 132.00 13035 BB1 ERBIL GP132.00 13 0.9859 130.14
13036 BB2 ERBIL GP132.00 13 0.9857 130.12 13037 BB1 ERBIL CC400.00 13 1.0000 400.00
13038 BB2 ERBIL CC400.00 13 0.9999 399.97 13039 BB1 ERBIL CE132.00 13 0.9846 129.97
13040 BB2 ERBIL CE132.00 13 0.9845 129.96 13041 BB1 KHORMALA400.00 13 1.0000 400.00
13042 BB2 KHORMALA400.00 13 0.9999 399.97 13044 DBS/KIRKUK 132.00 1 0.9722 128.34
13045 BB1 REZAN 132.00 13 0.9847 129.99 13046 BB2 REZAN 132.00 13 0.9847 129.99
13051 BB EGPP G1 15.000 13 1.0000 15.000 13052 BB EGPP G2 15.000 13 1.0000 15.000
13053 BB EGPP G3 15.000 13 1.0000 15.000 13054 BB EGPP G4 15.000 13 1.0000 15.000
13055 BB EGPP G5 15.000 13 1.0000 15.000 13056 BB EGPP G6 15.000 13 1.0000 15.000
13059 BB1 KHABAT G132.00 13 0.9596 126.67 13060 BB2 KHABAT G132.00 13 0.9596 126.67
14001 BB1 CHWAR QU132.00 14 0.9226 121.78 14002 BB2 CHWAR QU132.00 14 0.9225 121.78
14003 BB1 DOK/HPS 132.00 14 0.9650 127.39 14004 BB2 DOK/HPS 132.00 14 0.9651 127.39
14005 BB1 RANYA 132.00 14 0.9225 121.77 14006 BB2 RANYA 132.00 14 0.9225 121.77
14007 BB1 QALADZE 132.00 14 0.9241 121.98 14008 BB2 QALADZE 132.00 14 0.9241 121.98
14009 BB1 SHARBAZH132.00 14 0.9716 128.25 14010 BB2 SHARBAZH132.00 14 0.9716 128.25
14011 BB1 DOKAN AB132.00 14 0.9648 127.36 14012 BB2 DOKAN AB132.00 14 0.9648 127.36
14013 BB1 ZARGATA 132.00 14 0.9682 127.80 14014 BB2 ZARGATA 132.00 14 0.9682 127.80
14015 BB1 TAVGA 132.00 14 0.9686 127.86 14016 BB2 TAVGA 132.00 14 0.9686 127.86
14017 BB1 TASLUJA 132.00 14 0.9850 130.02 14018 BB2 TASLUJA 132.00 14 0.9850 130.02
14019 BB1 BAZYAN 132.00 14 1.0000 132.00 14020 BB2 BAZYAN 132.00 14 0.9999 131.99
14025 BB2 AZMAR 132.00 14 0.9689 127.90 14026 BB1 AZMAR 132.00 14 0.9689 127.90
14027 BB2 QULARACY132.00 14 0.9698 128.01 14028 BB1 QULARACY132.00 14 0.9698 128.01
14030 SUPER STEEL 132.00 14 0.9840 129.89 14032 BB MASS CEM132.00 14 0.9839 129.88
14035 BB2 PENJWEEN132.00 14 0.9418 124.32 14036 BB1 PENJWEEN132.00 14 0.9418 124.32
14037 BB1 RIZGARI 132.00 14 0.9755 128.77 14038 BB2 RIZGARI 132.00 14 0.9755 128.77
14039 BB1 S.SULI 132.00 14 0.9650 127.38 14040 BB2 S.SULI 132.00 14 0.9650 127.38

14041 BB1 ABDULA S132.00 14 0.9742 128.60 14042 BB2 ABDULA S132.00 14 0.9742 128.60
14043 BB1 SULI CEN132.00 14 0.9736 128.51 14044 BB2 SULI CEN132.00 14 0.9736 128.51
14045 BB1 BARD QAR132.00 14 0.9842 129.92 14046 BB2 BARD QAR132.00 14 0.9842 129.92
14047 BB1 SGPP 132.00 14 0.9874 130.34 14048 BB2 SGPP 132.00 14 0.9876 130.36
14050 MASS STEEL 132.00 14 0.9865 130.21 14051 BB1 CHAMCHAM132.00 14 0.9826 129.71
14052 BB2 CHAMCHAM132.00 14 0.9826 129.71 14053 BB1 BAKRAJO 132.00 14 0.9761 128.84
14054 BB2 BAKRAJO 132.00 14 0.9760 128.84 14055 BB1 S.SADIQ 132.00 14 0.9499 125.39
14056 BB2 S.SADIQ 132.00 14 0.9499 125.39 14057 BB1 HALABJA 132.00 14 0.9411 124.23
14058 BB2 HALABJA 132.00 14 0.9411 124.23 14059 BB1 TANJARO 132.00 14 0.9673 127.68
14060 BB2 TANJARO 132.00 14 0.9672 127.68 14061 BAZYAN CEMNT132.00 14 0.9771 128.98
14063 GRD DELTA 132.00 14 0.9764 128.89 14067 BB1 KIFRI 132.00 14 0.9535 125.87
14068 BB2 KIFRI 132.00 14 0.9535 125.87 14069 BB1 KALAR 132.00 14 0.9571 126.33
14070 BB2 KALAR 132.00 14 0.9571 126.33 14071 BB1 DBK/ HPS132.00 14 0.9693 127.95
14072 BB2 DBK/ HPS132.00 14 0.9693 127.95 14074 TAZA/KIRKUK 132.00 1 0.9659 127.50
14075 GASN 132.00 14 0.9768 128.93 14081 BB SGPP G1 15.000 14 1.0000 15.000
14082 BB SGPP G2 15.000 14 1.0000 15.000 14083 BB SGPP G3 15.000 14 1.0000 15.000
14084 BB SGPP G4 15.000 14 1.0000 15.000 14085 BB SGPP G5 15.000 14 1.0000 15.000
14088 BB SGPP G8 15.000 14 1.0000 15.000 14089 BB2 SULI CC400.00 14 0.9999 399.96
14090 BB1 SULI CC400.00 14 1.0000 400.00 14091 BB DBK/HP G113.800 14 1.0000 13.800
14092 BB DBK/HP G213.800 14 1.0000 13.800 14101 BB DOK/HP G113.800 14 0.9871 13.621
14106 KURDSAT BB1 132.00 14 0.9698 128.02 14107 KURDSAT BB2 132.00 14 0.9698 128.01