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Transient Stability Enhancement and Critical Clearing Time Improvement for Kurdistan Region Network using Fact Configuration

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ABSTRACT

The Electrical power system has become vast and more complex, so it is subjected to sudden changes in load levels. Stability is an important concept which determines the stable operation of the power system. Transient stability analysis has become one of the significant studies in the power system to ensure the system stability to withstand a considerable disturbance. The effect of temporary occurrence can lead to malfunction of electronic control equipment. The application of flexible AC transmission systems (FACTS) devices in the transmission system have introduced several changes in the power system. These changes have a significant impact on the power system protection, due to differences inline impedance, line current and voltage. On the distance relaying protection system to identify essential issues that protection engineers need to consider during the stages of design and operation of the protection system. Transient analysis can be conducted using a simulation software package. One of the commercial simulation software package used by industry worldwide is Siemens Power System Simulation for Engineering (PSS/E). The object of this work is to improve the Transient stability and to clear critical fault times of the Kurdistan Region Government (KRG) network by using optimal FACTS devices in different optimal locations under fault conditions.

Keywords: TS, CCT, FACT Devices, SVC, UPFC

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تعزيز الاستقرار العابرة وتحسين وقت التبادل النقدي لشبكة اقليم الكوردستان باستخدام تشكيلات الحقائق

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الخلاصة

أصبح نظام الطاقة الكهربائية ضخمًا وأكثر تعقيدًا ، لذلك يتعرض لتغيرات مفاجئة في مستويات الحمل. الاستقرار هو مفهوم مهم يحدد التشغيل المستقر لنظام الطاقة. أصبح تحليل الاستقرار العابر أحد التحليلات الرئيسية في نظام الطاقة لضمان استقرار النظام لتحمل أي إزعاج كبير. تأثير حدوث عابر يمكن أن يؤدي إلى خلل في معدات التحكم الإلكترونية. أحدث تطبيق أنظمة نقل التيار المتردد المرنة (FACTS) في نظام النقل العديد من التغييرات في نظام الطاقة. هذه التغييرات لها تأثير كبير على حماية نظام الطاقة ، بسبب التغيرات في مقاومة الخط ، خط التيار والجهد. على نظام حماية ترحيل المسافة من أجل تحديد القضايا الهامة التي يحتاج مهندسو الحماية إلى مراعاتها خلال مراحل تصميم وتشغيل نظام الحماية. يمكن إجراء تحليل عابر باستخدام حزمة برامج المحاكاة. واحدة من حزمة برامج المحاكاة التجارية التي تستخدمها الصناعة في جميع أنحاء العالم هي Siemens Power System Simulation for Engineering (PSS / E). الهدف من هذا العمل هو تحسين الاستقرار العابر ومسح أوقات الخلل الحرجة لشبكة حكومة إقليم كوردستان (KRG) عن طريق استخدام أجهزة FACTS المثلى في مواقع أمثلية مختلفة تحت ظروف الخلل.

الكلمات الرئيسية : الاستقرار العابر ، وقت التخليص الحرج ، أجهزة خط نقل التيار المتردد المرنة ، معوض VAR الإحصائي ، وحدة تحكم موحدة لتدفق الطاقة.

ABBREVIATION

CCT - Critical Clearing Time
FACTS – Flexible Alternating Current Transmission System
FCT – Fast clearing time
KRG – Kurdistan Region Government
SVC - Statistic VAR Compensator
TSA – Transient Stability Analysis
UPFC – Unified Power Flow Controller

1. INTRODUCTION

Generally, Electrical strength system is commonly nonlinear system and a compound network, consists of three essential stages which are generation, transmission and distribution substations. The exporter central part is generation stations that transmit the electricity to the load. As a reference of growing power requesting, in transmission line sometimes may be loaded more than lines capacity at construction. Generation stage, on the electric power network, is the primary point of the power system for using synchronous generators to product electrical voltages. After production for increasing voltage using the set up a transformer before transferring it to minimizing the current in the lines in order to minimize the losses in the transmission lines. After the transmission, the voltage is stepped down using step down transformers that are distributed consequently. An unexpected massive disturbance contains faults, clearing of faults, surprising load changes and persistent or uncontrollable tripping of lines and generators.

The transient stability is happening when the maximum power is transferred during the system when there is not any loss of balance under slight disturbance. Many factors causing transient stability like the strength of the transmission network within the system in and the times to adjacent systems working units, containing inertia of the rotating parts, the electrical properties such as magnetic saturation characteristics of the stator and rotor. Critical clearing time CCT is a significant parameter in TSA of the power system. When the maximum permissible time through the fault when occurring in power system before losing the synchronous is called CCT. The (FCT) fault clearing time is putting randomness in the system. The KRG 400KV and 132kV grid networks as shows in **Fig.1** last updated and approved from MOE, faced with series of defiance like voltage instability, long transmission lines, the environment of transmission lines, high power losses.

The reason for this paper is to improve transient stability and critical fault clearing time in the KRG network by using FACTs devices by using PSS/E software when it was licensed by the government. In FACTs Devices, we choose (SVC and UPFC) as the best solution in our network for now to increase power transfer capability**.**

(To'aima et al., 2015)he investigated that STATCOM was planned to increase the apparent power loss and explain voltage fall issue of the IEEE 5bus standard system, the result has been done by using less possible size of the reactive power injected or absorbed by the STATCOM devices, while sustaining the stability limits in order to decrease the projected installation cost of STATCOM devices. (Hassan et al., 2019) The purpose of this study is to sustain sufficient power for higher heavy loads where possible and accurate amount of load shedding while keeping the load under the accessible power threshold. The main duties are saved ultimately without any disturbance likely. The output solves the efficiency and practicality of the applied method for probable uses in power systems.

(Abd Al Hassan and Tuaimah, 2020)Investigates one of the most promising FACTS devices, UPFC is used to achieve the fundamentals (voltage regulation, reactive power and power flow controller) to make the system more efficient and reliable. The result can show the number of UPFC is increase with increase load at (15% and 20%) because one UPFC cannot reduce from overload in lines so by using tow unit of UPFC device in different position can improve maximum load ability and minimum line losses.

The motivation behind this paper is to survey and improve the voltage profile in weak buses on the KRG network by using SVC (Reactive Power Control) (**Husein and AbdulFatah, 2016)**. This investigation is about improvements of enactment are planned applied on the interconnected 400kV, 50Hz Kurdistan and Iraq power systems using ±500kV, 300MW HVDC link.

(Roberts et al., 2015) In this investigative show, the approximation of the (CCT) is resulting from the direct strategies of stability of the energy system. This Equation is designed to combine as many possible characteristics of transient stability analysis as possible, like different fault areas and different network circumstances after the failure. The objective of this calculation is to resolve trends instability (in terms of CCT) of energy systems under the system parameter change.

(Mohammed, 2019) Is considered the essential (critical) clearing time of synchronous machines in the power systems, when the non-salient pole and salient poles of synchronous machine model are using mathematical equations in power system. CCT compared two models with various cases.

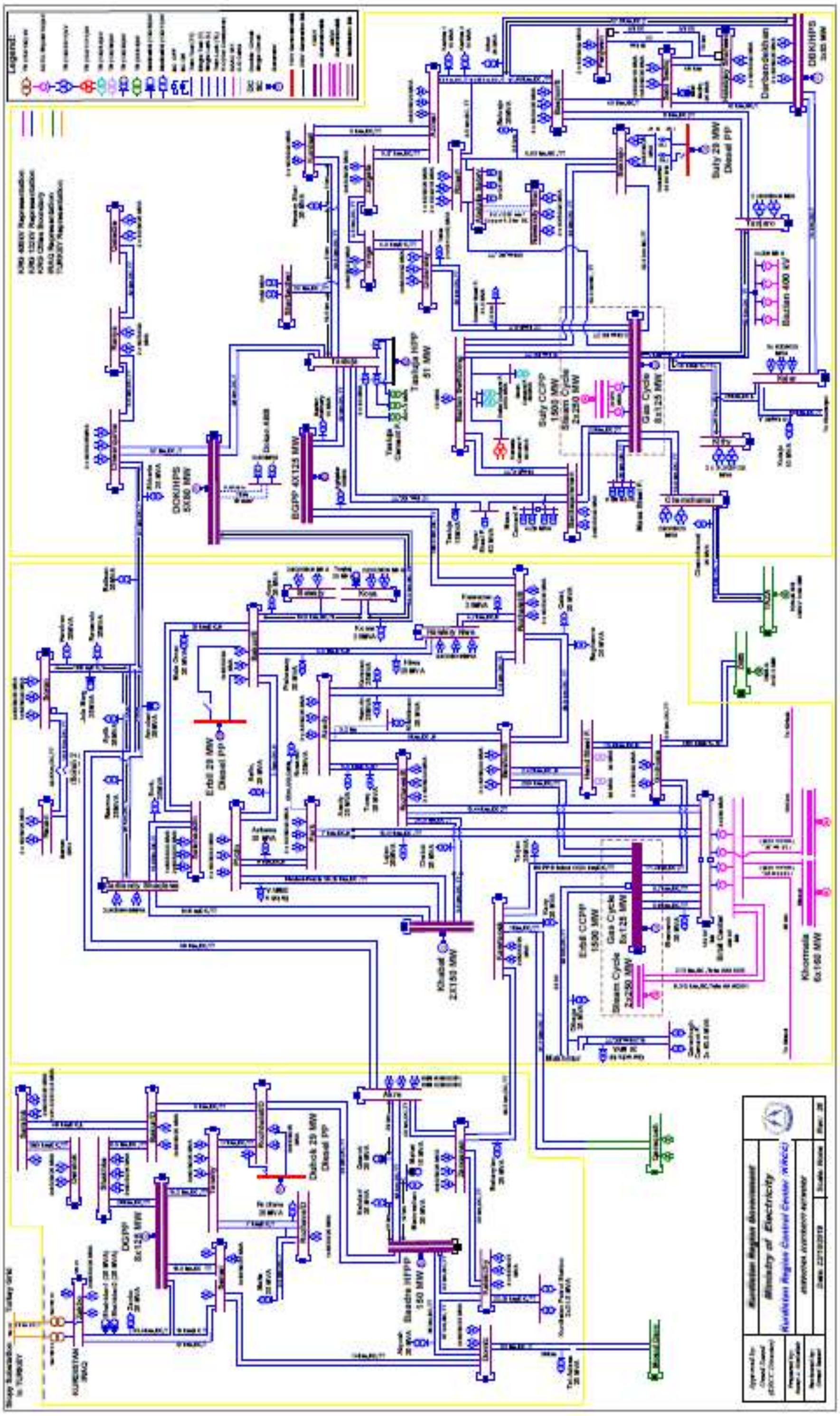

Figure 1 .KRG Network Single Line Diagram.

2. METHODOLOGY

2.1 Power System Stability

When there is a physical disturbance in an electrical power system returning to operating condition without losing equilibrium is called power system stability **(Kundur et al., 1994).** It means the power system overall connected. In the practical group of generators connected when one of them is losing the synchronism the system not lose the stability.

Power system stability is classified into three types (steady state, dynamic and capable of a power system to transfer from point to another under the case of small load variation is steady state, transient) stability; dynamic stability is a type of rotor angle stability to discuss the stability when there is a significant disturbance.

2.2 TRANSIENT STABILITY

The capability of a power system to preserve of synchronism when it causes the transient fault is called transient stability; this disturbance is caused an epic trip of generators, rotor angles by nonlinear power angle linkage. The significant disruption causing loss of load and loss of generation units for returning to steady-state may be losing some generation units. **(Sutter et al., 2015)**

In KRG network case the system was stable, but when there is a bus fault, or one transmission line is out of work it makes the network unstable and the CCT change according to of type of responsibilities such as clearing in the result section. For simulating power system stability and output file, we can use PSS/E software.

2. 2.1 Swing Equation

(Kundur et al., 1994)From SMIB the mathematical equations must be as:

$$\boldsymbol{M \frac{d^2\delta}{dt^2} + D\frac{d\delta}{dt} = P_{mech} - P_{elec}}\mathbf{h} \tag{1}$$

When
M = inertia constant
D = damping constant
Pmech = mechanical power source
Pelec = electrical power product

From the equivalent circuit the equations will be as:

$$\boldsymbol{P_e = \frac{E' E_g}{X_T} \sin\delta = P_{max} \sin\delta} \tag{2}$$

The swing equation can be written as:

$$\frac{2H}{\omega_0}\frac{d^2\delta}{dt^2} = P_m - P_{max}\sin\delta \tag{3}$$

2.2.2 Critical Clearing Time Calculatin

The estimation stability in (CCT) is a critical component to preserve the stability of the power system. The maximum duration for occurring fault in a power system is called significant clearing time (CCT) when it sets randomly, if the time for CCT is less than the time for clearing fault CFT, it causes the loss of stability. The primary purpose is to calculate protection characteristics when required in power system. **(Kundur et al., 1994)**

$$M \frac{d^2\delta}{dt^2} = P_s - P_e \tag{4}$$

When the fault occurs $P_e = 0$ hence the equation will be as:

$$M \frac{d^2\delta}{dt^2} = P_s \tag{5}$$

$$\frac{2H}{\omega_s} \frac{d^2\delta}{dt^2} = P_s \tag{5a}$$

$$\frac{d^2\delta}{dt^2} = \frac{\omega_s}{2H} P_s \tag{5b}$$

$$\frac{d\delta}{dt} = \int_0^t \frac{\omega_s}{2H} P_s \, dt = \frac{\omega_s}{2H} P_s t \tag{6}$$

$$\delta = \int_0^t \frac{\omega_s}{2H} P_s \, dt = \frac{\omega_s}{4H} P_s t^2 + \delta \tag{7}$$

Let $\delta = \delta_c$ and $t = t_c$ so:

$$\delta_c - \delta_0 = \frac{\omega_s}{4H} P_s t^2 \tag{8}$$

At last

$$t_c = \sqrt{\frac{2H(\delta_c - \delta_0)}{\pi f P_s}} \tag{9}$$

2.3 fact Devices

The flexible AC transmission system is a static device construct with the growing abilities of power electronic ingredient. Equipment’s with high power level can change with various voltage scales. The comprehensive at initial points for network elements preferring the reactive power the parameters of the power system. The FACT devices are mainly classified:

1. Series controllers like Thyristor Controlled Series Capacitor (TCSC), Thyristor and Static Synchronous Series Compensator (SSSC).

2. Shunt controllers like Static VAR Compensator (SVC), and Static Synchronous Compensator (STATCOM).

3. Combined series-series controllers

4. Mixed series-shunt controllers like Interline Power Flow Controller (IPFC), Unified Power Flow Controller (UPFC).

The main application of FACT devices is used for controlling power flow, compensating reactive power by increasing the ability of transmission lines, improving and conditioning power stability and quality, controlling of voltage stability, modification of sparks. Also, FACT devices having many advantages in transmission power system are summarized as follows:

1. Increasing transmission lines loading capacity.
2. Reactive power Decrease.
3. Decrease the spark voltage.
4. Damping of power pulses.
5. Stability system, ensuring.
6. Accessibility and Security.
7. Unwavering quality and economy activity.

2.3.1 (SVC) Static VAR Compensator

Shunt controller’s electrical equipment, Static VAR Compensator (SVC) is the oldest type generating of the FACT device family, which is designed for refining fast-acting reactive power on a high-voltage electricity transmission line. SVC is an application using for voltage regulation, dynamic stability, damping Oscillations, and reducing voltage drop. SVC is most widely installed equipment's form FACT devices in the world which can be capable of supplying reactive power in the system for improving voltage stability. It connected to the transmission system directly for controlling voltage at weak buses occasionally it connected with the control of the transmission system as shown in **Fig 2. (Khoa et al., 2017)**

The modelling for SVC may be as (TCR-FC). In power system load is changed from time to time so that it causes confusion in the system, causing voltage instability. The essential appearances for SVC are voltage regulator and VAR switch mode. It's a stator device. Leading and lagging are terming for connecting SVC shunt devices. Worked on Voltage Profile Improvement of KR Power Network Using Reactive Power Control the result was improving stability of the system instantaneously. **(Husein and AbdulFatah, 2016)**

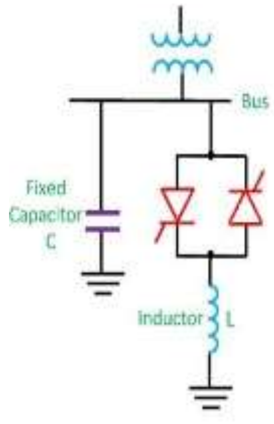

Figure 2. Static VAR compensator (SVC) model.

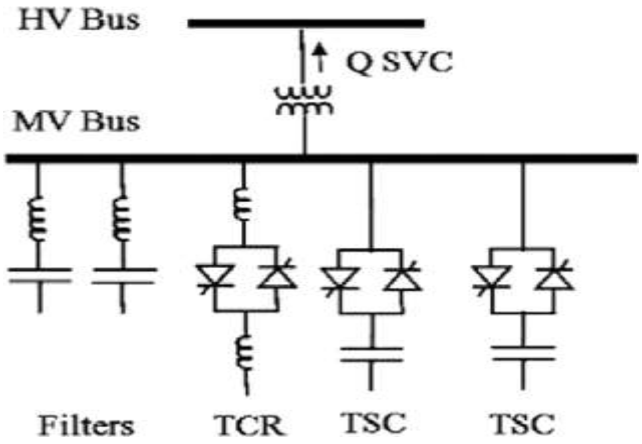

Figure 3. Static VAR compensator (SVC).

In our transmission line network, we suggest to use shunt fact devices SVC for improving voltage stability, voltage collapse and reactive power for increasing, transmitting power capacity, oscillation and damping by contingent on the optimal sites.

SVC is separated in two quantities one is static VAR generator the second is static VAR absorber when the output may be capacitive or inductive current to keep and regulate factors of electrical power system, especially the bus voltage, in general, is thyristor Controlled Reactor (TCR) for retaining reactive power and thyristor Switched Capacitor (TSC) for reactive power supplying as shown in figure (3). The basic idea of working SVC controlling system is (a) reactive power generation for (capacitive SVC) to low voltage; (b) reactive power absorbs for (inductive SVC) for high voltage. (Virk and Garg, 2013)

$$I_{SVC} = jB_{SVC}V_m \quad (10)$$

The reactive power injected at bus m

$$Q_{SVC} = Q_m = I_{SVC}V_m = -B_{SVC}{V_m}^2 \quad (11)$$

The susceptance B_{SVC} Equivalent equation is given by:

$$B_{SVC} = \frac{1}{X_c X_L}\frac{X_C - X_L[2(\pi-\alpha_{SVC}) + \sin 2\alpha_{SVC}]}{\pi} \quad (11a)$$

The two thyristors is firing angle αSVC

$X_L = wL$

$$X_C = \frac{1}{WC}$$

2.3.2 UPFC (Unified Power Flow Controller)

The UPFC is a device of the second generation of FACT devices which can use simultaneously for controlling several line parameters for power flow, such as (line impedance, voltage and phase angle). It was produced by combining two types of fact devices: The Static Synchronous Compensator (STATCOM) and the Static Synchronous Series Compensator (SSSC) as shown in **Fig.4 so** that the UPFC is the best type between other FACT devices because it works as a shunt transformer by connecting to the transmission line system for improving steady-state stability, transient stability and increasing voltage stability. (Sebastian and Sajith, 2014). The fundamental principle of working UPFC is to controlling area time of dynamic compensation on AC transmission line when producing multi-functionality for improving problems in the power line system.

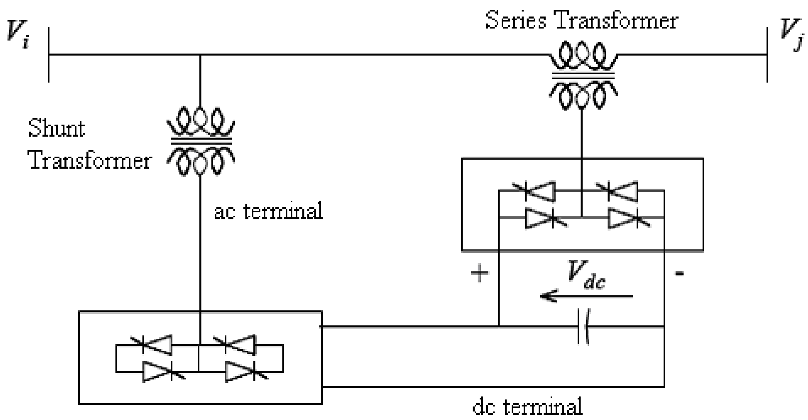

Figure 4. UPFC Control Model.

3. RESULTS and Discussion

TRANSIENT STABILITY IMPROVEMENT MODELS

In KRG network model, power flow. When it results from PSS/E software by using fixed slope decoupled Newton –Raphson. All bus Data of the system showing in Appendix A

WING BUS SUMMARY:

BUS#	X-- NAME --X	BASKV	PGEN	PMAX	PMIN	QGEN	QMAX	QMIN
13051	BB EGPP G1	15.000	119.3	125.0	30.0	47.1	72.0	-40.0

3.1 WITHOUT FACT DEVICES

For calculating transient stability in PSS/E first of all, we must convert the system to Dynamic system the process for converting the system to dynamic system for measuring CCT is in many steps when the system convert to dynamic we just putting the model of generators in our network we are using(GENROU) model and Exciter current model (SEXS) as shown in table (1) after that running the transient stability reading CCT, after that, we create three-phase fault in the system and reading CCT if the system remains stable we it means we do not have any problem, but if the order is not firm we must return back to dynamic data and changing the system till we get stability in the network this prose is shown in a flowchart in **Fig. 5**

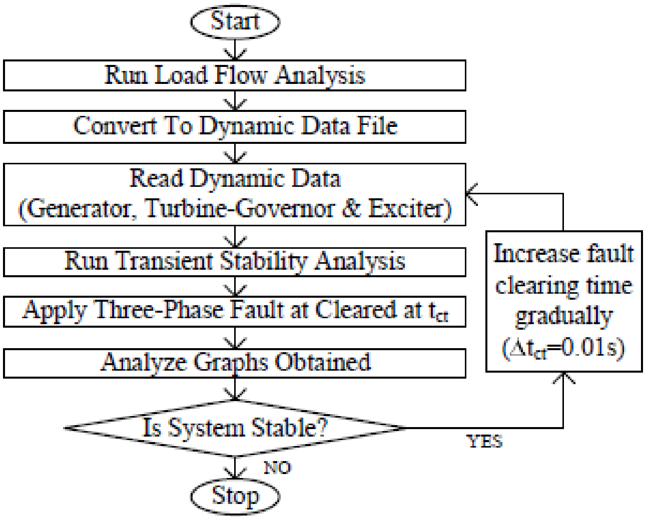

Figure 5. Flowchart of Transient Stability Analysis in PSS/E.

Table 1. GENROU model Data Inputting and SEXS model data.

Model GENROU for machine at bus 14081 '1 '

Model CONS | Model ICONS | Model VARS

	Con Value	Con Description
1	1.9000	T'do (> 0)
2	0.0450	T''do (> 0)
3	0.6500	T'qo (> 0)
4	0.0880	T''qo (> 0)
5	6.3300	H, Inertia
6	0.0000	D, Speed Damping
7	1.9900	Xd
8	1.8900	Xq
9	0.1950	X'd
10	0.3850	X'q
11	0.1350	X''d = X''q
12	0.1100	Xl
13	0.0817	S(1.0)
14	0.6474	S(1.2)

Model SEXS for machine at bus 14083 '3 '

Model CONS | Model ICONS | Model VARS

	Con Value	Con Description
1	0.1000	TA/TB
2	10.0000	TB (> 0)
3	100.0000	K
4	0.1000	TE
5	0.0000	EMIN
6	3.0000	EMAX

A- At natural casein our network, the system is stable. I have not any problem, and the critical clearing time CCT 0.2sec as shown in **Fig.6.**

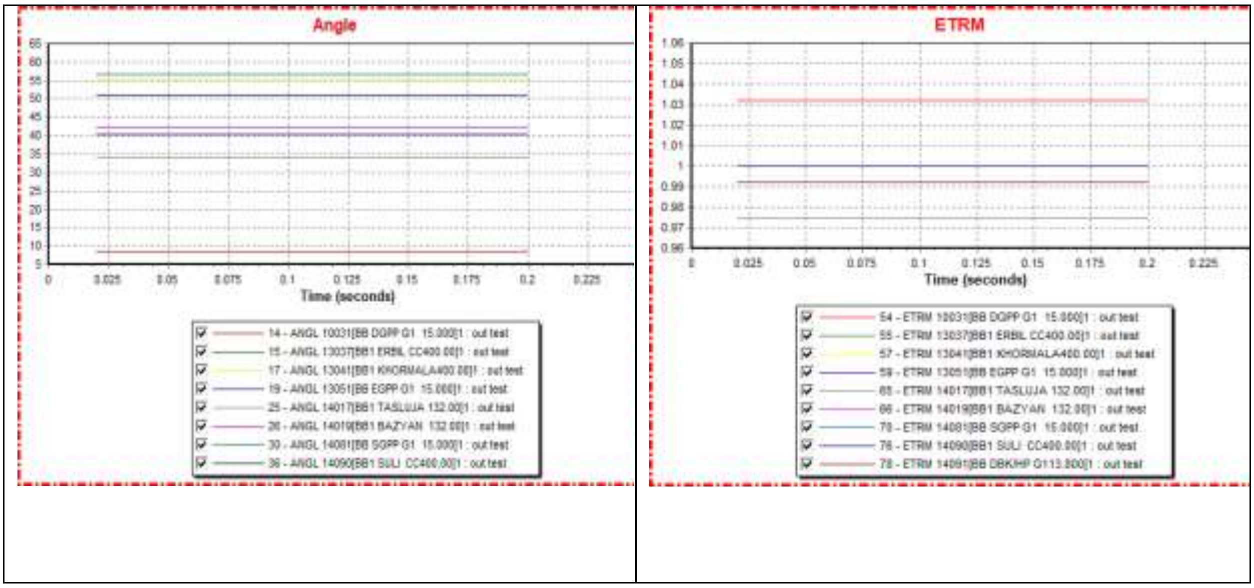

Figure 6. CCT Analyses at normal case.

B-When there is a three-phase fault in one bus such as Soran substation Bus, KRG network it will be out of the stable and the transient stability cannot be stable in one value. Shown in **Fig.7**

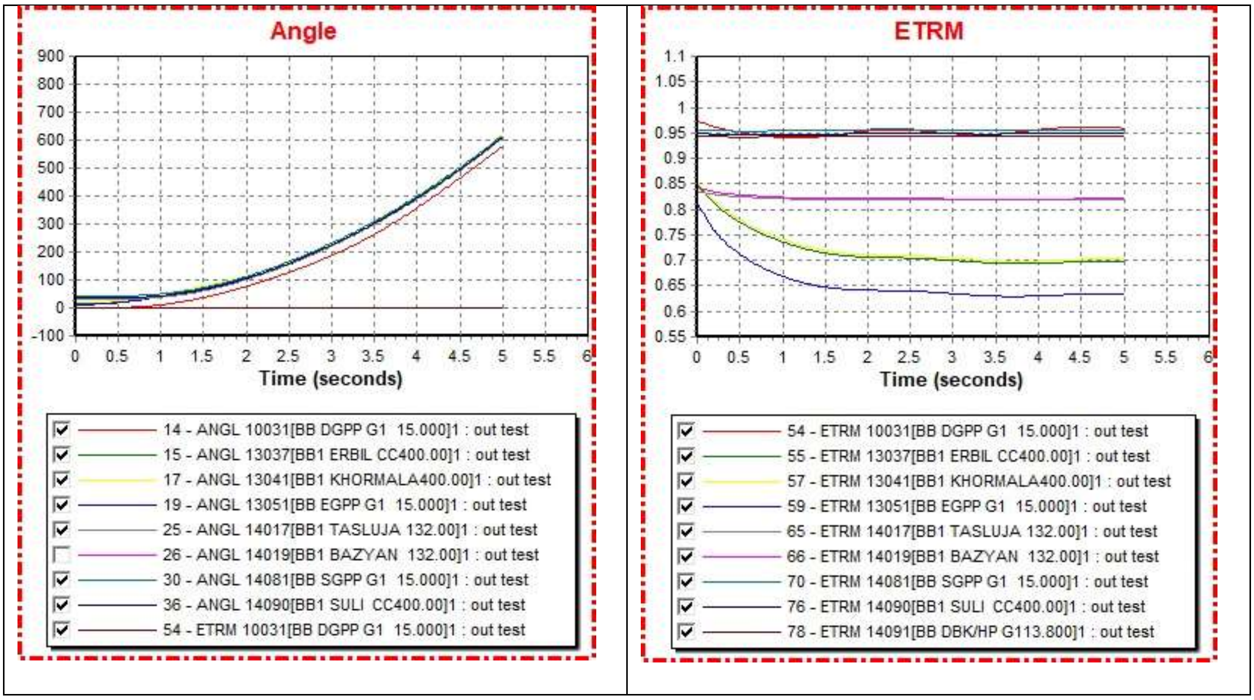

Figure 7. CCT with a fault on Shaqlawa-Soran line.

3.2 WITH FACT DEVICES

A- By connecting SVC

At normal case we have any problem in the KRG network one of them under-voltage, overload, by Connecting SVC in parallel with EGPP bus the result for CCT will be between (0.1-0.25) and the under-voltage of many busses was increased. and the transient stability for calculating CCT is increasing as **Fig.8**

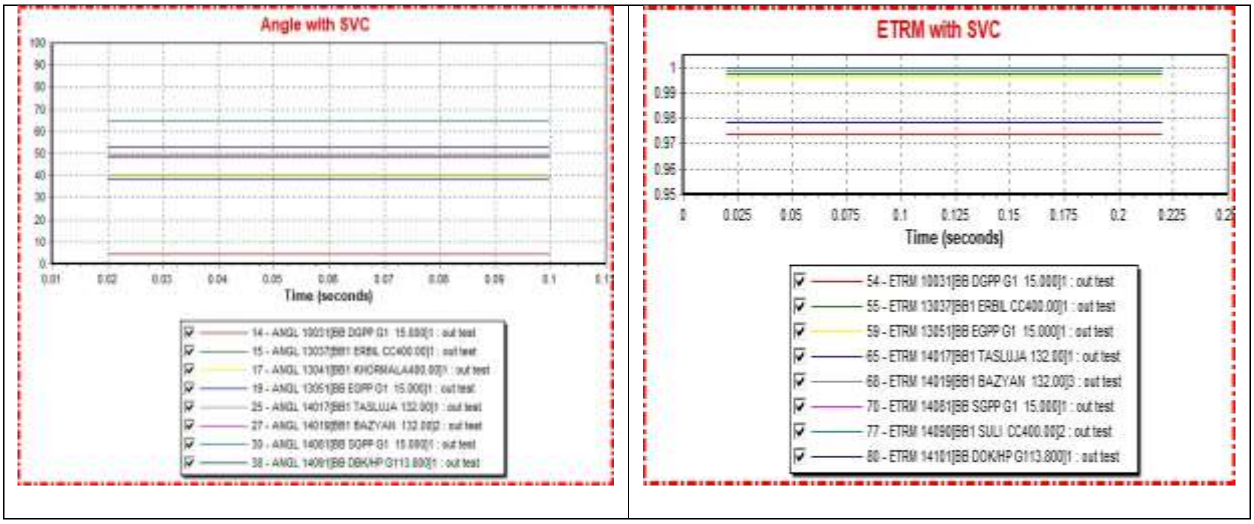

Figure 8. CCT with SVC.

a. By connecting UPFC

Connecting UPFC in series with EGPP bus the result for CCT will be between (0.23-0.45)0.171pu as shown in **Fig.9**

By connecting UPFC in the KRG network many especially in Duhok and Soran area, many problems were solving such (overloading and under voltage) because the voltage in this area is very low it changed from 111Kv to 125Kv.as shown in appendix B.

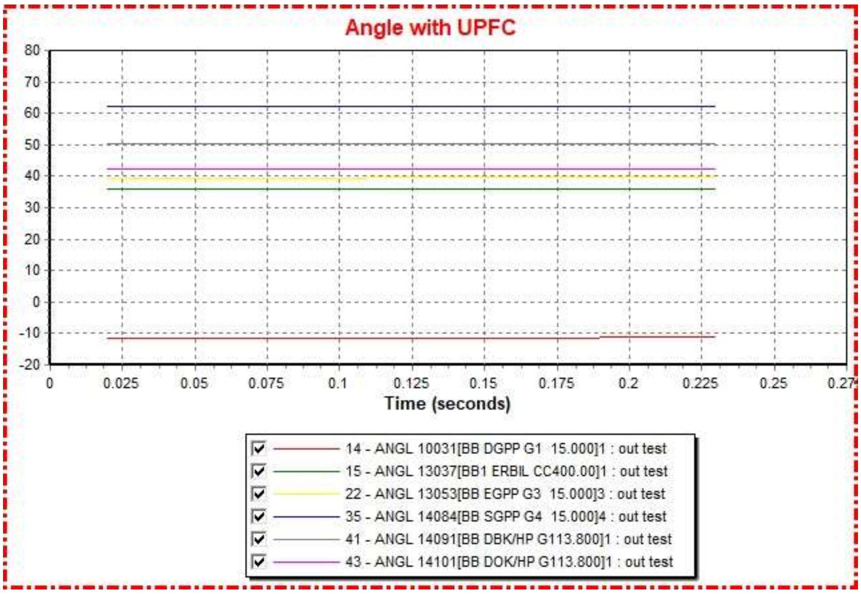

Figure 96. CCT with UPFC.

By this calculation, in result, we occur that connecting UPFC is much better for connecting to our KRG network. In our network having low voltage level in Duhok and Soran area if we using UPFC it will solve this problem and solving many other problems such as transient stability and dynamic stability. Also, SVC is a good compensator for improving our problem but comparing it with UPFC, UPFC is much better, but it's more costing than SVC .as shown in table 2

Table 2: Comparison between SVC and UPFC

FACTS	Power System Stability Enhancement	Load Flow	Voltage Stability	Transient Stability	Dynamic Stability
SVC	Yes	Low	High	Low	Medium
UPFC	Yes	Medium	High	High	Medium

4. CONCLUSION

FACT devices are power electronics based reactive compensators that are connected in a power system and are capable of improving the power system transient performance and the quality of supply. Although individual compensations differ, all the two FACTS devices not only damp the system oscillations of the multi machine system but also reduce the oscillation settling times for generator Emf and rotor angle transient responses. This observation of KRG network is helpful to examine stability improvement in both the cases. This work can be extended to multi-machine system by using other types of FACTS controllers like SVC, UPFC etc.

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Appendix

A. Load Flow at normal case and all bus data of KRG Network

SIEMENS POWER TECHNOLOGIES INTERNATIONAL

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

INITIATED ON TUE, DEC 10 2019 10:44

SWING BUS SUMMARY:

BUS#	X-- NAME --X	BASKV	PGEN	PMAX	PMIN	QGEN	QMAX	QMIN
13051	BB EGPP G1	15.000	119.3	125.0	30.0	47.1	72.0	-40.0

BUS#	X-- NAME --X	BASKV	AREA	V(PU)	V(KV)	BUS#	X-- NAME --X	BASKV	AREA	V(PU)	V(KV)
5		132.00	1	0.9420	124.35	8	JOINT AKRE1	132.00	10	0.8699	114.82
10		132.00	13	0.8608	113.62	103		132.00	1	0.9472	125.03
105	JOINT AKRE2	132.00	10	0.8730	115.23	106		132.00	13	0.8678	114.55
107		132.00	13	0.8585	113.33	202		132.00	1	0.9298	122.73
203		132.00	13	0.8706	114.93	302		132.00	1	0.9309	122.87
303		132.00	13	0.8586	113.33	401	QERCHWG SMNT	132.00	1	0.9457	124.84
402	T	132.00	1	0.8586	113.33	502	T MOB	132.00	13	0.8684	114.63
601	T MOB	132.00	13	0.8694	114.76	1011		132.00	13	0.9289	122.61
1301	NEW KOYA T	132.00	13	0.9159	120.89	1302	AKRE T2	132.00	13	0.8686	114.66
1303	AKRE T1	132.00	13	0.8717	115.07	1305	SORAN T1	132.00	13	0.8599	113.51
1306	JOLA MERGMOB	132.00	13	0.8555	112.93	1308	RAWANDZ MOB	132.00	13	0.8547	112.82
1309	HNDREN MOB	132.00	13	0.8485	112.00	1310	BALISAN MOB	132.00	13	0.8572	113.15
1311	EN	132.00	13	0.8600	113.51	1312	BASRMA MOB	132.00	13	0.8744	115.42
1313	SORK MOB	132.00	13	0.8985	118.60	1314	MALA O.MOB	132.00	13	0.9157	120.87
1315	SAFIN MOB	132.00	13	0.9248	122.08	1317	PESHASAZ MOB	132.00	13	0.9283	122.53
1318	KASNAZAN MOB	132.00	13	0.9339	123.28	1319	BAGHAMRA MOB	132.00	13	0.9446	124.68
1320	QALAT MOB	132.00	13	0.9398	124.06	1322	KOYA MOB	132.00	13	0.9163	120.95
1323	KAREZAN MOB	132.00	13	0.9396	124.02	1324	HAMREN MOB	132.00	13	0.9396	124.02
1326	BAHRKA MOB	132.00	13	0.9264	122.29	1330	AZADI MOB	132.00	13	0.9431	124.48
1331	TURAQ MOB	132.00	13	0.9453	124.78	1332	NISHTIMAN T	132.00	13	0.9443	124.65
1340	QERCHWG MOB	132.00	13	0.9492	125.29	1341	DEBAGAH MO	132.00	13	0.9496	125.34
1343	CHALOOK MOB	132.00	13	0.9319	123.00	1345	LAJAN MOB	132.00	13	0.9495	125.33
1419	KALAR T1	132.00	14	0.9408	124.19	1420	KALAR T22	132.00	14	0.9403	124.12
1421	KULAJO MOB	132.00	14	0.9373	123.72	1427	SHKARTA MOB	132.00	14	0.8585	113.32
1435	KOSAR MOB	132.00	14	0.9241	121.98	13001	BB1 PIRZEEN	132.00	13	0.9265	122.30
13002	BB2 PIRZEEN	132.00	13	0.9265	122.30	13003	BB1 PARK	132.00	13	0.9349	123.41
13004	BB2 PARK	132.00	13	0.9349	123.41	13005	BB1 AZADI	132.00	13	0.9430	124.47
13006	BB2 AZADI	132.00	13	0.9429	124.46	13007	BB1 WEST EBL	132.00	13	0.9463	124.91
13008	BB2 WEST EBL	132.00	13	0.9462	124.90	13009	BB1 NORTH EB	132.00	13	0.9245	122.03
13010	BB2 NORTH EB	132.00	13	0.9245	122.03	13011	BB1 SALAHADD	132.00	13	0.9083	119.89
13012	BB2 SALAHADD	132.00	13	0.9083	119.89	13013	BB1 SHAQLAWA	132.00	13	0.8981	118.55
13014	BB2 SHAQLAWA	132.00	13	0.8981	118.55	13015	BB1 SOUTH EB	132.00	13	0.9486	125.21
13016	BB2 SOUTH EB	132.00	13	0.9485	125.20	13017	BB1 NEW EBL	132.00	13	0.9309	122.88
13018	BB2 NEW EBL	132.00	13	0.9308	122.87	13025	BB1 EAST EBL	132.00	13	0.9382	123.84
13026	BB2 EAST EBL	132.00	13	0.9382	123.84	13027	BB1 NEW KOYA	132.00	13	0.9157	120.87
13028	BB2 NEW KOYA	132.00	13	0.9157	120.87	13029	BB1 KOYA	132.00	13	0.9162	120.93
13030	BB2 KOYA	132.00	13	0.9162	120.93	13031	BB1 SORAN	132.00	13	0.8481	111.95
13032	BB2 SORAN	132.00	13	0.8481	111.95	13045	BB1 REZAN	132.00	13	0.8442	111.44
13046	BB2 REZAN	132.00	13	0.8442	111.43	13059	BB1 KHABAT G	132.00	13	0.9285	122.56
13060	BB2 KHABAT G	132.00	13	0.9285	122.57	14001	BB1 CHWAR QU	132.00	14	0.8597	113.48
14002	BB2 CHWAR QU	132.00	14	0.8597	113.48	14003	BB1 DOK/HPS	132.00	14	0.9163	120.95
14004	BB2 DOK/HPS	132.00	14	0.9163	120.95	14005	BB1 RANYA	132.00	14	0.8594	113.44
14006	BB2 RANYA	132.00	14	0.8594	113.44	14007	BB1 QALADZE	132.00	14	0.8600	113.52
14008	BB2 QALADZE	132.00	14	0.8600	113.53	14011	BB1 DOKAN AB	132.00	14	0.9160	120.92
14012	BB2 DOKAN AB	132.00	14	0.9160	120.92	14035	BB2 PENJWEEN	132.00	14	0.9280	122.49
14036	BB1 PENJWEEN	132.00	14	0.9280	122.49	14055	BB1 S.SADIQ	132.00	14	0.9371	123.70
14056	BB2 S.SADIQ	132.00	14	0.9371	123.70	14057	BB1 HALABJA	132.00	14	0.9273	122.40
14058	BB2 HALABJA	132.00	14	0.9273	122.40	14067	BB1 KIFRI	132.00	14	0.9356	123.50
14068	BB2 KIFRI	132.00	14	0.9356	123.50	14069	BB1 KALAR	132.00	14	0.9364	123.61
14070	BB2 KALAR	132.00	14	0.9364	123.61						

FROM BUS: BUS#	NAME	BASKV	AREA	TO BUS: BUS#	NAME	BASKV	AREA	CKT	LOADING	RATING	PERCENT
14003	BB1 DOK/HPS	132.00	14	14018	BB2 TASLUJA	132.00*	14	1	139.1	123.0	113.1
14003	BB1 DOK/HPS	132.00	14	14018	BB2 TASLUJA	132.00*	14	2	139.1	123.0	113.1
14047	BB1 SGPP	132.00	14	14048	BB2 SGPP	132.00*	14	@1	1098.5	1000.0	109.9

B. When connecting Fact Devices

UPFC (100Mvar Duhok & 150Mvar Soran)

PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E TUE, NOV 26 2019 12:10

AREA TOTALS IN MW/MVAR

X-- AREA --X	FROM GENERATION	FROM IND GENERATN	TO IND MOTORS	TO LOAD	TO BUS SHUNT	TO GNE BUS DEVICES	TO LINE SHUNT	FROM CHARGING	TO LOSSES	NET INTERCHANGE TO TIE LINES	NET INTERCHANGE TO TIES + LOADS	DESIRED NET INT
1	0.0	0.0	0.0	287.2	0.0	0.0	0.0	0.0	4.1	-291.2	-254.1	0.0
	0.0	0.0	0.0	18.0	0.0	0.0	0.0	18.6	17.0	-16.4	1.6	
10	230.0	0.0	0.0	708.0	0.0	0.0	0.0	0.0	19.7	-497.7	-497.7	0.0
DUHOK	46.9	0.0	0.0	305.9	-390.8	0.0	0.0	68.8	117.9	82.8	82.8	
13	1349.3	0.0	0.0	1043.8	0.0	0.0	0.0	0.0	61.0	244.5	202.4	0.0
ERBIL	409.4	0.0	0.0	478.7	-325.5	0.0	0.0	161.4	473.6	-56.0	-76.3	
14	1795.0	0.0	0.0	1216.0	0.0	0.0	0.0	0.0	34.5	544.5	549.4	0.0
SULI	467.0	0.0	0.0	450.5	-116.6	0.0	0.0	123.7	267.3	-10.4	-8.1	
COLUMN	3374.3	0.0	0.0	3255.0	0.0	0.0	0.0	0.0	119.3	0.0	0.0	0.0
TOTALS	923.3	0.0	0.0	1253.0	-832.9	0.0	0.0	372.5	875.8	0.0	0.0	

PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E TUE, NOV 26 2019 12:10

SUBSYSTEM LOADING CHECK (INCLUDED: LINES; BREAKERS AND SWITCHES; TRANSFORMERS) (EXCLUDED: NONE)
MVA LOADINGS ABOVE 100.0 % OF RATING:

FROM BUS: BUS#	NAME	BASKV	AREA	TO BUS: BUS#	NAME	BASKV	AREA	CKT	LOADING	RATING SET A: RATING	RATING SET A: PERCENT	RATING SET B: RATING	RATING SET B: PERCENT	RATING SET C: RATING	RATING SET C: PERCENT
14003	BB1 DOK/HPS	132.00	14	14018	BB2 TASLUJA	132.00*	14	1	143.9	123.0	117.0	--	--	--	--
14003	BB1 DOK/HPS	132.00	14	14018	BB2 TASLUJA	132.00*	14	2	143.9	123.0	117.0	--	--	--	--

PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS(R)E TUE, NOV 26 2019 12:11

BUSES WITH VOLTAGE GREATER THAN 1.0500:

BUS#	NAME	BASKV	AREA	V(PU)	V(KV)	BUS#	NAME	BASKV	AREA	V(PU)	V(KV)

* NONE *

BUSES WITH VOLTAGE LESS THAN 0.9000:

BUS#	NAME	BASKV	AREA	V(PU)	V(KV)	BUS#	NAME	BASKV	AREA	V(PU)	V(KV)
1427	SHKARTA MOB	132.00	14	0.8805	116.23	14001	BB1 CHWAR QU	132.00	14	0.8821	116.43
14002	BB2 CHWAR QU	132.00	14	0.8820	116.43	14005	BB1 RANYA	132.00	14	0.8819	116.41
14006	BB2 RANYA	132.00	14	0.8819	116.41	14007	BB1 QALADZE	132.00	14	0.8831	116.57
14008	BB2 QALADZE	132.00	14	0.8831	116.58						