Enhancement Voltage Stability of the Iraqi Power Grid Using Shunt FACTs Devices

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ABSTRACT

Due to raise in demand, the transmission system becomes more exhausted, which in turn, forces the system to be more susceptible to voltage instability. The aim of this research is to study the enhancement in voltage stability margin by installation the SVC which is represented as Static of VAR Compensator or STATCOM that is represented as Static of Synchronous Compensator. Voltage stabilization dilemma considers an essential issue in the electric networks which may lead to a voltage collapse in electric power networks.

L-index has been used to predict and identify points of breakdown voltages in the power system with sufficient accuracy. L -index has been employed due to its accuracy and effectiveness in the computing voltage collapse points for different load buses with sufficient precision at a short circuit and also at various loads situations. Voltage stability index has been tested on the 9-wscc test system and 14-IEEE test system .Then it has been applied to the Iraqi national grid 400 kV.

A shunt facts(SVC or STATCOM) devices are installed individually at the weak bus bar based on Voltage Stability Index(L indicator) detection, The simulation results are first obtained for an uncompensated system, and the voltage profiles are studied. The results so obtained are compared with the results obtained after compensating the system with SVC and STATCOM to show the voltage stability margin enhancement. The outcomes acquired after simulation demonstrate the performances of shunt fact devices (SVC and STATCOM) when connected to a system Subjected to 3-phase short circuit fault at different locations. All the simulation results have been carried out using MATLAB version 7.10 and Power System Analysis Toolbox (PSAT) package.

Keywords: voltage stability, voltage collapse, voltage stability indices, L indicator, MATLAB and Power System Analysis Toolbox (PSAT).

INTRODUCTION

Voltage stability is related to the ability of power systems to maintain allowable voltage levels at all load buses under normal condition and after being subjected to small disturbances. Recently, the aspect of voltage stability has become an increasingly essential in the planning and operation of the power systems.

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The increasing in demand, makes a stressed in transmission system, which consequently, makes the power system more susceptible to voltage instability. one of most sensible matter, is the voltage instability in the electric power networks. The interconnectivity and inherent complexity imposes a power system to run nearer to it is stability limits, incorporated with the added donation to system instability by inconvenient feed of a reactive power which subsequently results a voltage collapse [1].

Voltage collapse is an operation in which the presence of consecutive events in a large area of electrical system together with voltage instability may lead to the status of inadmissible low voltage situation in the network. Load rising can prompt supernumerary request of reactive power; electrical system will appear voltage instability [2].

As the load diversified, the requirement of the reactive power for transmission system also varies. Transmission of reactive power results to increased losses in the transmission system, decrease in the real power transmitted, and changes in voltage amplitude at the end of transmission lines. It is therefore necessary to provide reactive power compensation at the right location in the power system, in order to enhance power transfer capability of transmission lines, reduce losses and improve voltage stability [3].

Moreover, it is essential to ascertain the position for locating of these controllers because of their so effective costs. In this study, it was suggested to distinguish the appropriate position for compensator to enhance the voltage stability in an electrical power system not just in normal loading situation as well as in maximum loading status [4].

The raised interest in facts controllers is basically due to two causes. Firstly, the late evolution in the high power electronics has made facts controllers effective in terms of cost and secondly, raised loading of electrical power systems, incorporated with disarrangement of power industry, induces the utilization of power flow regulate as an extremely cost-effective technique of dispatching determined power transactions[3].

In this work, proposed L-indicator to find the best location of facts (SVC & STATCOM) devices.

Stationary synchronous compensator (STATCOM)

STATCOM consider as stationary synchronous generator served like a shunt-installed stationary VAR compensator which it is inductive or capacitive yield current may be adjusted autonomous of the voltage of AC system. It supplies support in voltage by absorbing or generating reactive power at the position of ordinary coupling without the requirement of huge external capacitor banks or reactors.

At the point as the voltage of electrical system is minimal the STATCOM inserts quantities of a reactive power to while at the moment as voltage is raising it acquires a reactive power. These quantities of reactive power are injected from a Converter of Voltage Source (VSC) that is installed at a coupling transformer on it is secondary side as shown in Figure (1).

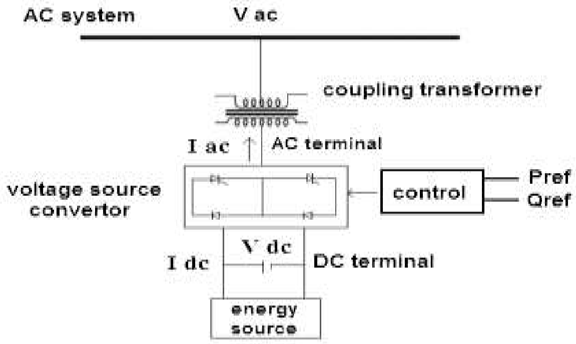


Figure (1): STATCOM Simplified diagram [1]

Stationary VAR compensator (SVC)

Stationary VAR device are employed through the usefulness of the application in the transmission for specific aims. An ordinarily aim is commonly for voltage quicker regulate at most vulnerable sites of the electrical network. Incorporations can be located in a line ends sites or at midpoint of the transmission interconnections.

Static VAR Compensator is shunt installed static absorbers/ generators whose outputs are diversified in order to control power system voltages. The quite simple structure of SVC, it is installed like construction of Controlled Reactor Thyristor Fixed a Capacitor (FC-TCR), Figure (2) shows configuration of SVC device.

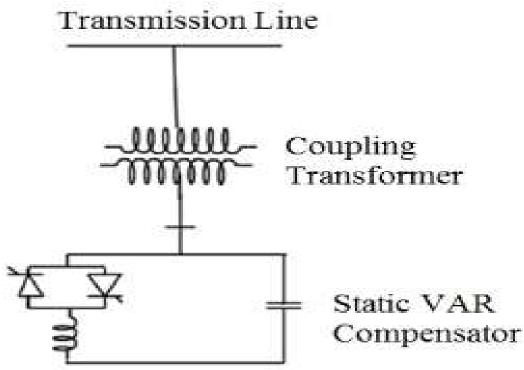


Figure (2): configuration of SVC

Index Formulation

In (2001) Nair N.K.C. and Huang G.M. suggested a new voltage stability indicator, which is dubbed as L- index. L-index is a perfect voltage stability index and it is values change between one (breakdown voltage) and zero (no load). Furthermore, it can be utilized as a quantitative measure to evaluate the margin of voltage stability against operating point.It is based on load flow analysis [5].

The L-index computation for a multi-bus power System is briefly examined below. The relation between current and voltage may be introduced by the subsequent expression:

$$=Y \quad \ldots (1)$$

Assume a power network that contain m of buses in which exist n generators.

All load buses is brought to the top and mark them as α_L and append the PV buses and mark them as α_G.
i.e., αG={ +1, n_L+2, n_L+3……n-1, n} and αL={1,2,3,……,n_L}, where is the load buses number. By separating generator (PV) buses from the load (PQ) buses, Equation (1) may write as [6].

$$\left[{}_{L} \right] = \left[\quad \right] \left[{}_{L} \right] \qquad \ldots (2)$$

Rearranging the previous equation we obtain:

$$\left[{}_{L} \right] = H \left[{}_{L} \right] = \left[{}_{LL} \quad {}_{LG} \right] \left[{}_{L} \right] \qquad \ldots (3)$$

: refer to voltages and currents at load buses.
: refer to voltages and currents at the generator buses.
K : are matrices subsets of the hybrid H matrix. Matrix- H is created from the Y-matrix by using a partial inversion theory (the unknown vector of voltages V_L of the load buses are substituted with their currents I_L).

This exemplification may then be employed to define indicator of the voltage stability at a load bus, called L which is obtained by .

$$\left| - \right| \qquad \ldots (4)$$

Where

=-Σ

Method 1: $L_j = \left| 1 \quad \Sigma_i \right|$ … (5)

: Load buses set.
: Generator buses set.
: Generator bus i Voltage.
: load bus j Voltage.

The term V_{oj} is illustrative of an equivalent generator including the significant addition from all the generators. The L indicator may furthermore be expressed and derived in the power terms such as the Upcoming.

Method 2: $L_j = \left| \; \right|$ … (6)

Where

= +

* signalizes the complex of conjugate of the vector

$$= \left(\Sigma \right) V \qquad \ldots (7)$$

=

S symbolizes significant addition of an others load in the power system to the indicator. The complex expression of power component estimated at the node j in fact, the sub matrix F_{Lj} or is the most essential portion in the L is computed from the matrix.

Figure (3) shows the procedure for computing L-index.

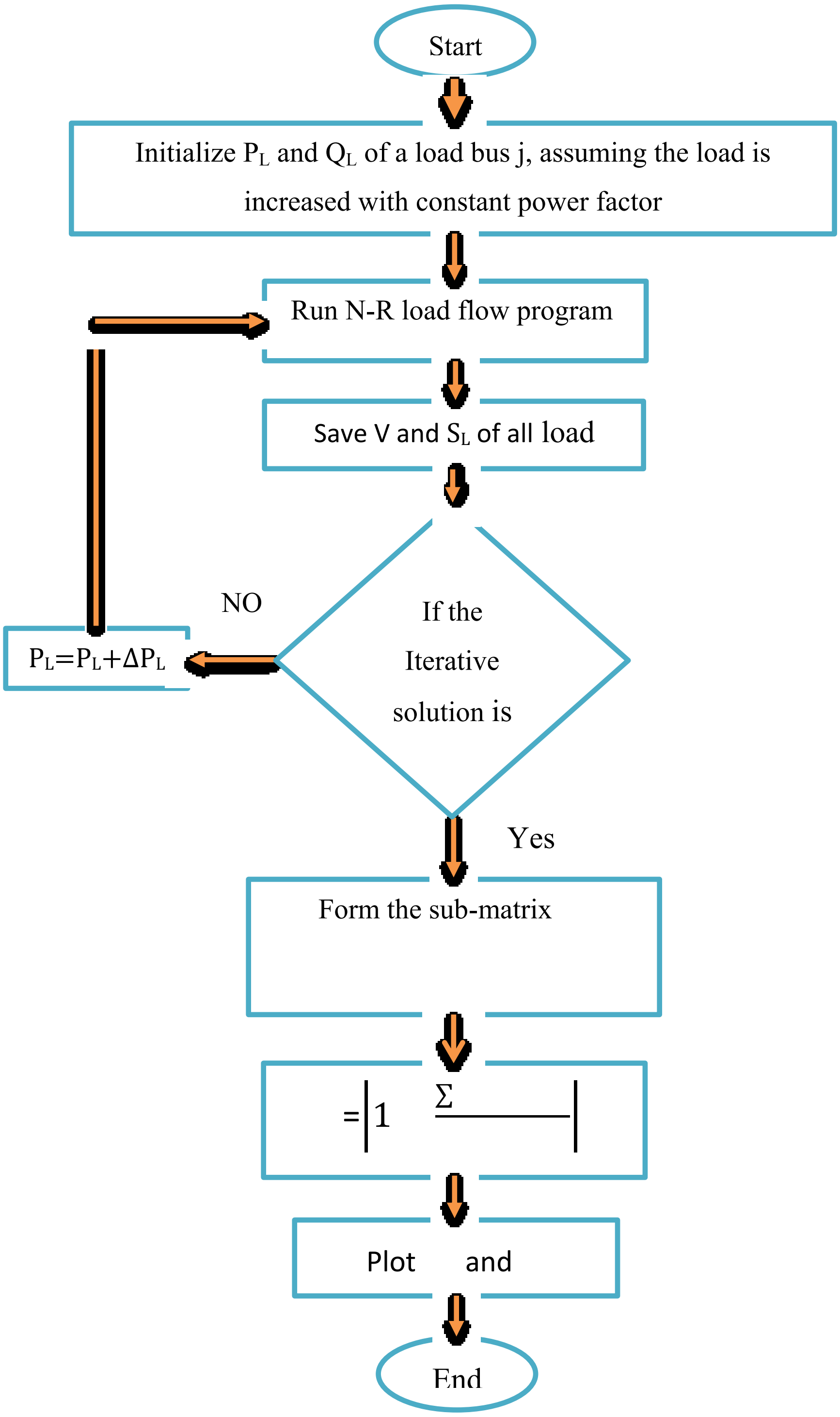


Figure (3): Flow chart of the L indicator calculation and plotting

Test System

The effectiveness of the proposed method has been tested on WSCC 9-bus system, IEEE 14-bus system and Iraqi electrical which they illustrated as shown below.

WSCC 9-Bus Test System

Western System Coordinate Council (WSCC 9-Bus System)[7]which is utilized for carrying out the MATLAB simulation is appeared in Figure (4).WSCC 9-Bus System comprises of 9 buses, 3-machine and 3 transformers. The transmission lines connected the three generation buses and three load buses While, the buses4, 7 & 9 have no generator or loads.

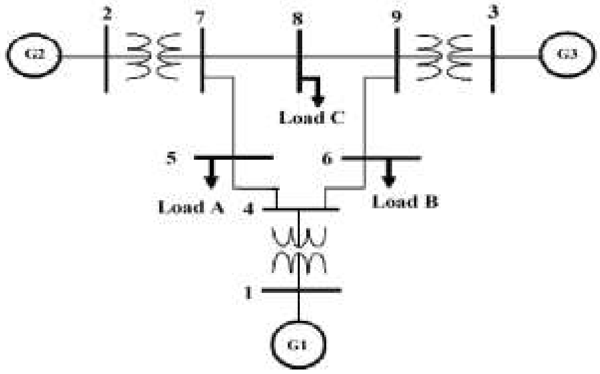


Figure (4): The one line diagram of the WSCC 9-bus system.

The IEEE 14-Bus Test System

The IEEE 14 bus system[8]consists of 9 load buses (14, 13, 12, 11, 10,9,7,5 and 4, generator buses (bus no. 8, 6, 2, 3, and 1) and 20 transmission lines, , in which 3 lines (5-6 , 4-9 and 4-7) are with tap changing transformers. The single line diagram for the IEEE 14 bus test system is shown in the Figure (5).

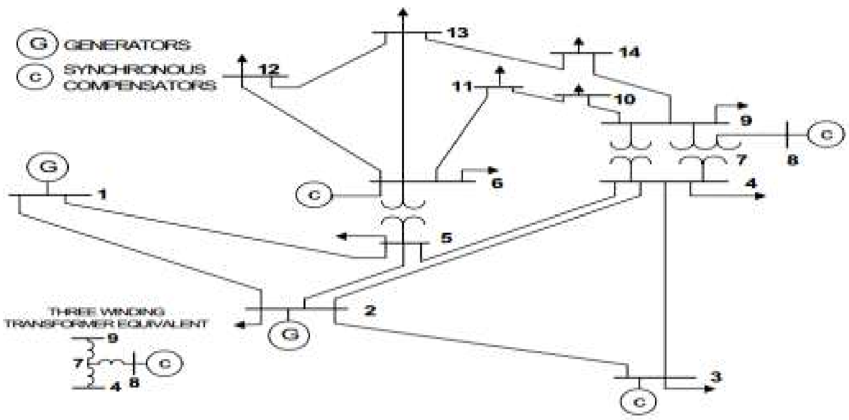


Figure (5): The one line diagram of the IEEE 14-bus test sy

The Iraqi Electrical Network

The Iraqi Electrical Network [9] has thirty nine overhead transmission lines400 kV and twenty four buses**,** eleven generating buses and thirteen load buses. The single line diagram for the system is shown in the Figure (6). Transmission lines are represented by nominal π sections and Loads by static admittance. The slack bus here is MUSP station.

All Iraqi national network data are displayed in per-unit referred to a popular base voltage of 400 kV and popular base power of 100 MVA. The formulation of the bus admittance matrix (Y) is gained from the lines data and buses data of the network. Then this matrix is reduced by the new rearrangement of the lines data to produce the load bus admittance matrix. The model corresponding data is given in appendix A where tables (A-1) and (A-2) represented line data and bus data respectively. Iraqi grid of 132 kV is not taken in our research and our work is limited to 400 kV network.

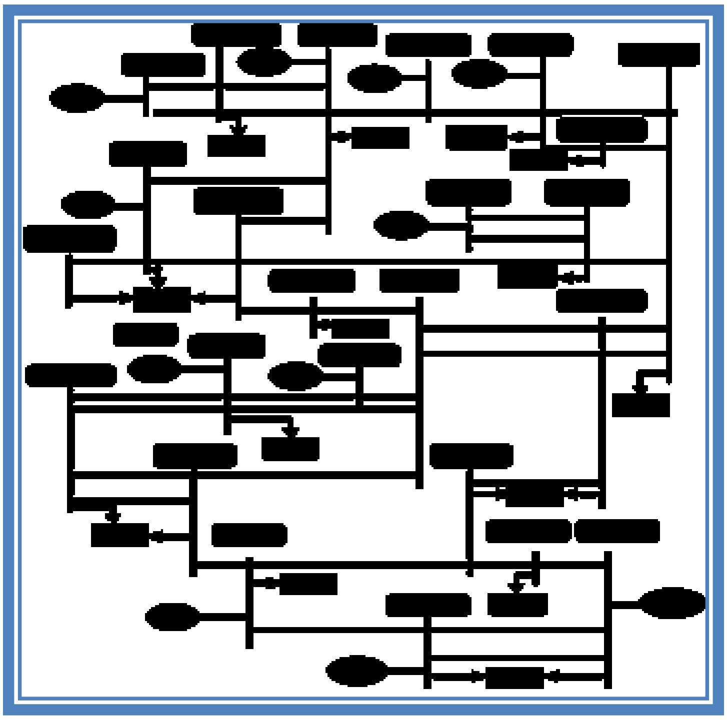


Figure (6): One line diagram of the Iraqi (400 KV) power system

Simulation and Results

The simulation outcomes have been done by employing MATLAB version (7.10) for detect the weakest load bus and plotting bus loading versus L-index and voltages of the load buses**.** The PSAT package was used in representing the shunt fact devices impact on voltage stability during the fault conditions.

Part A: Detect the Weakest Load Bus Using L-indicator

The value of the L-index which is determined the voltage collapse point is specified by raising the bus loading on each load buses individually from zero to its break down point and maintain the load at the remaining load buses at their constant values. The load buses increment takes into consideration a constant power factor.

Case 1: WSCC 9-Bus Test System

The simulation result of raising apparent power at a power factor of 0.74 at each load buses individually from zero to the collapse point against the L-index indicates that bus 6 is the most valuable load bus because it has the lowest maximum loading point. To specify the weakest load bus or the most valuable load bus, the indicator curves obtained are plotted together and are shown in Figure (7-a). The validity of the L indicator has been verified by comparing the simulated results for buses 5, 6 and 8 of this test system with those obtained from reference [10] as shown in Figure (7-b), where very close results have been obtained. Figure (8) show that, the effect of changing the load power factor on the resulting L-indicator for the weakest load bus (bus 6).From the Figure (8) it can be noted that the load bus become weakest when the power factor decreases.

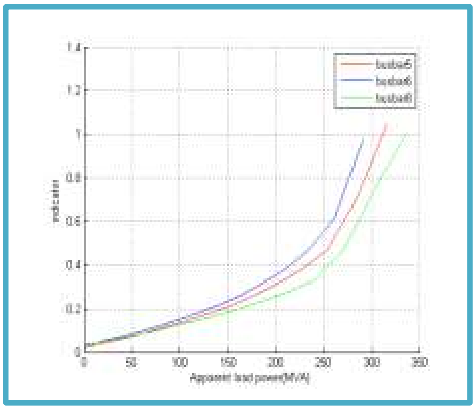


Figure (7-a): Values of Indicator curves of 5, 6 and 8 load buses with individual increased loading

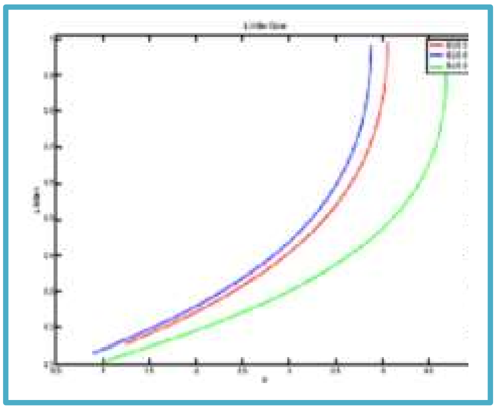


Figure (7-b): Values of Indicator curves of 5, 6 and 8 load buses with individual increased loading

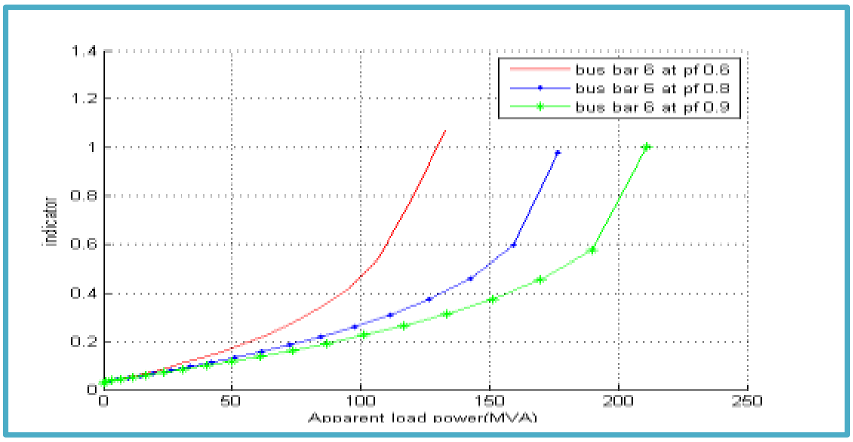


Figure (8): Values of Indicator at bus 6 with increased loading at different power factor

Case 2: The IEEE 14-Bus Test System

The simulation result of raising apparent power at a power factor of 0.86 at each load buses individually from zero to the collapse point against the L-index indicates that bus 14 is the most valuable load bus because it has the lowest maximum loading point. To specify the weakest load bus or the most valuable load bus, the indicator curves obtained are plotted together and are shown in Figure (9).

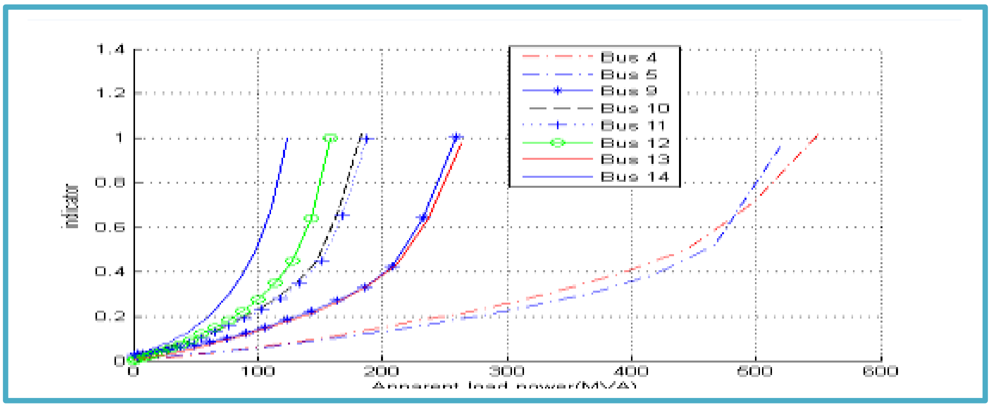


Figure (9): Values of Indicator curves of all load buses with individual increased loading

Case 3: The Iraqi Electrical Network

The simulation result of raising apparent power at a power factor of 0.86 at each load buses individually from zero to the collapse point against the L-index indicates that buses 20, 23 and 24 are the most valuable load buses because they have the lowest maximum loading point. Figure (10) represented the plotting of all load buses together to their respective voltage collapse point to specify the most valuable load bus. The result gained indicates that bus 20 is the most valuable load bus because it has the lowest maximum loading point as indicated in reference [11].Figure (11) represented the plotting of the most weak load buses 20, 21 and 24 together with respect to their voltage collapse point to specify the weakest load buses.

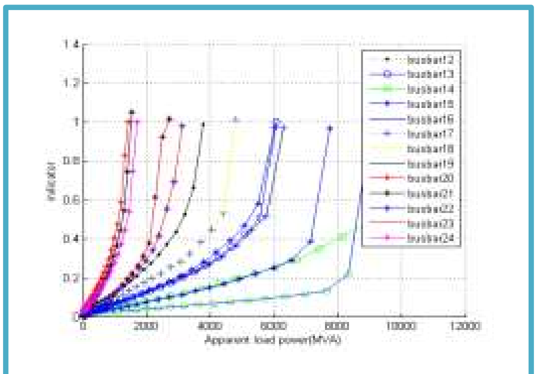


Figure (10): Values of Indicator and voltage at all load buses with individual increased loading

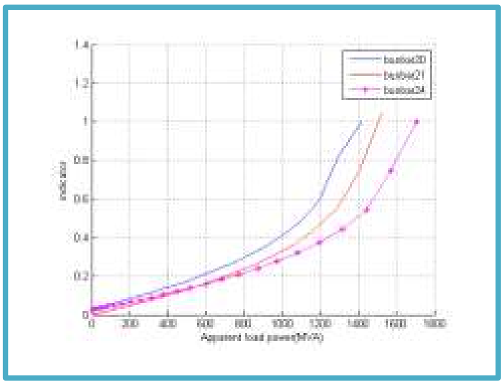


Figure (11): Values of Indicator and voltage at the weakest load buses with individual increased loading

Part B: Enhance Voltage Stability Using SVC and STATCOM

To enhance voltage stability, a shunt fact devices SVC and STATCOM is installed at position of the weakest load bus bar (the most valuable load bus) specified by the L-index detection under 3-phase short circuit fault**.** The value of fault impedance Z_f in simulation process it is taken to be equal to0.001 and the voltage levels should not exceed or dropped below 10% of it is original values. For all the fault conditions in this research it was assumed a permanent fault that it is procedure as the following.

1.The system is in a pre-fault steady state.
2.A fault occurs at $t = t_f$ sec.
3.The fault is removed by opening the breakers of the faulted line at $t = t_c$ sec.
4.The system is in a post-fault state (the system is in new configuration).

Case 1: WSCC 9-Bus Test System

The best location of SVC and STATCOM in order to improve the voltage stability of the system is identified using L – indicator. The SVC and STATCOM devices will be installed at the weakest bus.The weakest bus of 9-bus test system is identified as bus 6. The system voltage profile is tested by applying a three phase to ground fault on a selected bus.

❖ **SVC or STATCOM are connected at bus 6 (**weakest load bus)

• **Fault near Bus 7**

Three phase to ground fault occurs near bus7, the faulted line 4 will be removed to clear the fault at t_c =1.12.

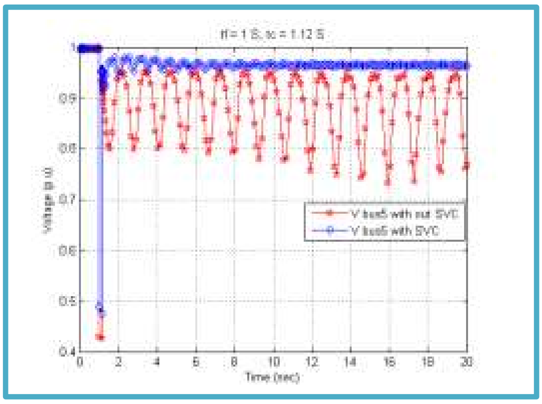


Figure (12a): Voltage of bus 5with and without SVC

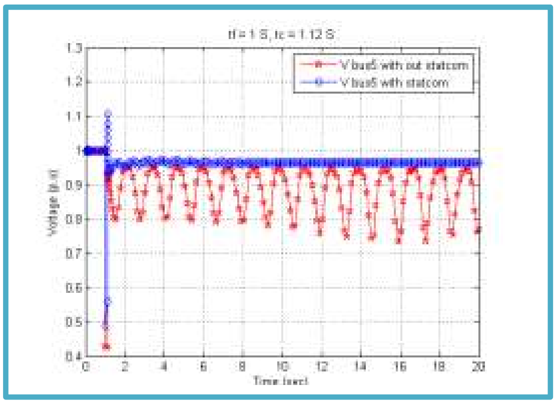


Figure (13 a): Voltage of bus 5 with and without STATCOM

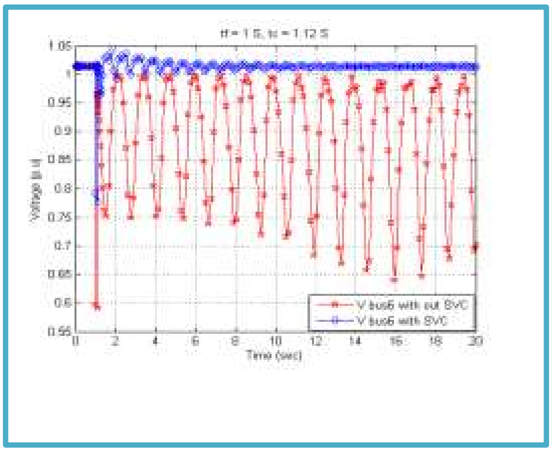


Figure (12b): Voltage of bus 6 with and without SVC Figure

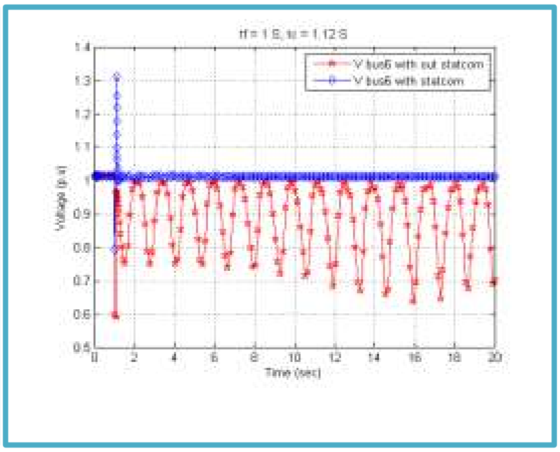
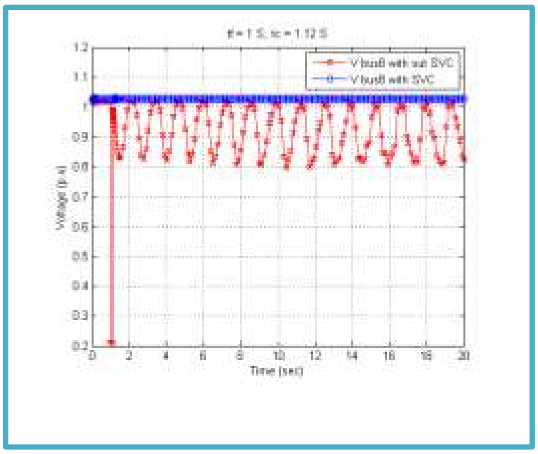


Figure (13b): Voltage of bus 6 with and without STATCOM



(12 c): Voltage of bus^ with and without SVC

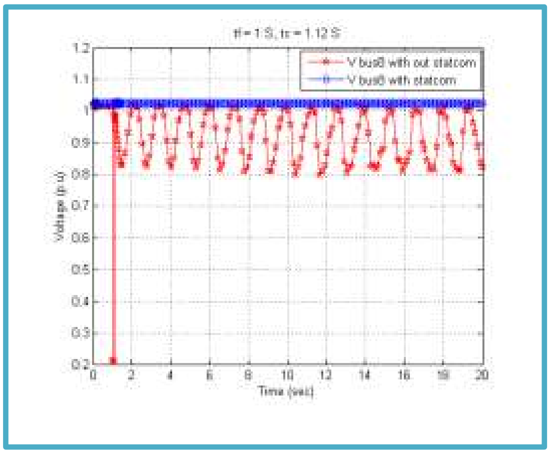


Figure (13 c): Voltage of bus8 with and without STATCOM

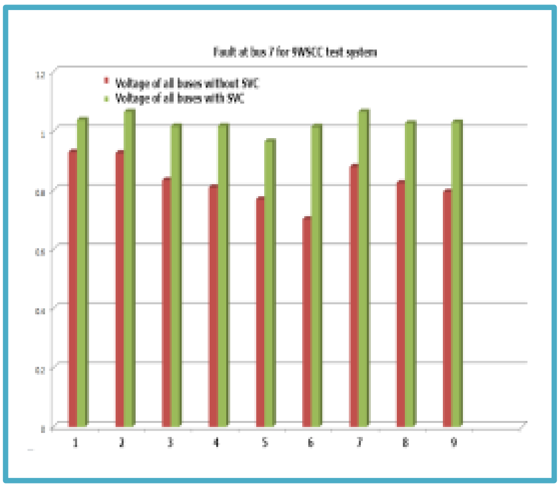


Figure (12d): Voltage of all buses with and without SVC (when a fault occurs near bus 7)

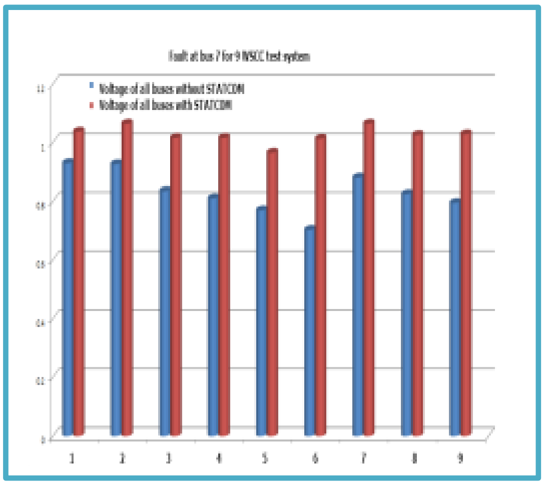


Figure (13 d): Voltage of all buses with and without STATCOM (when a fault occurs near bus 7)

- **Fault near Bus 4**

Three phase to ground fault occurs near bus4, the faulted line 5will be removed to clear the fault at t_c=1.3 sec.

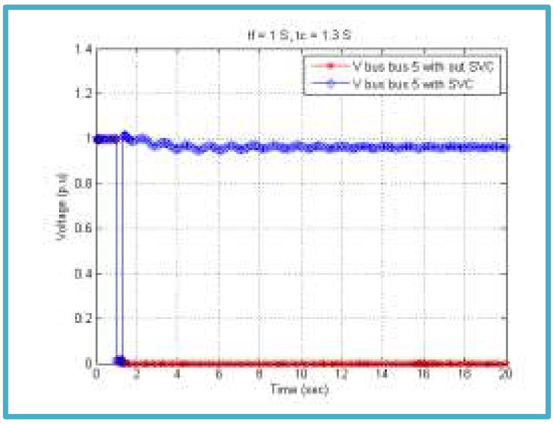


Figure (14 a): Voltage of bus 5 with and without SVC at t_c=1.3

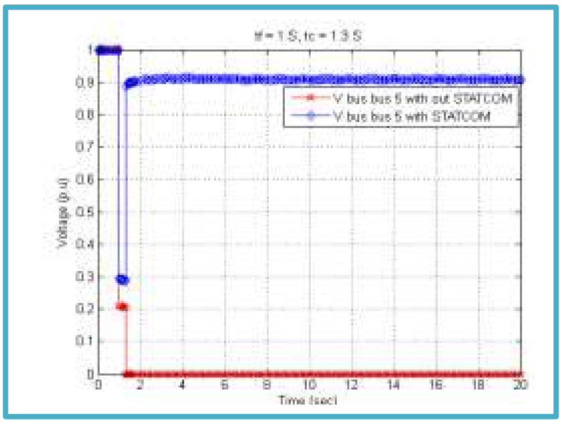


Figure (15 a): Voltage of bus٥ with and without STATCOM

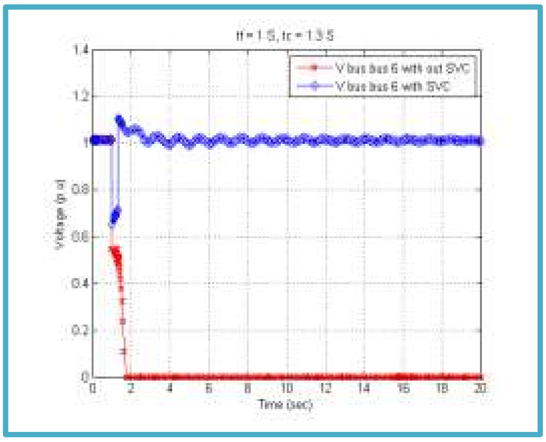


Figure (14 b): Voltage of bus ٦ with and without SVC at t_c=1.3

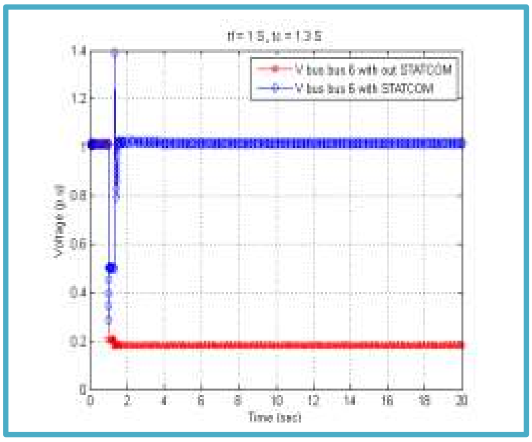


Figure (15 b): Voltage of bus ٦ with and without STATCOM

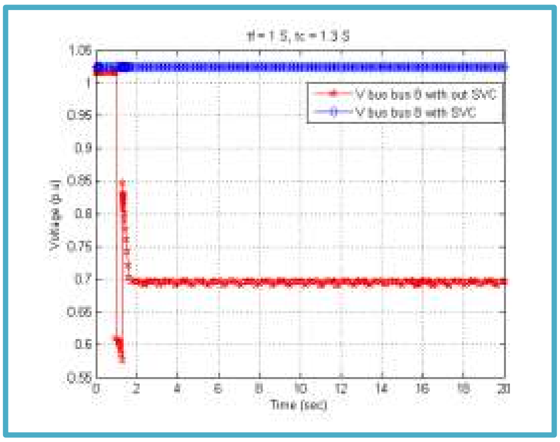


Figure (14 c): Voltage of bus٨ with and without SVC at t_c=1.3

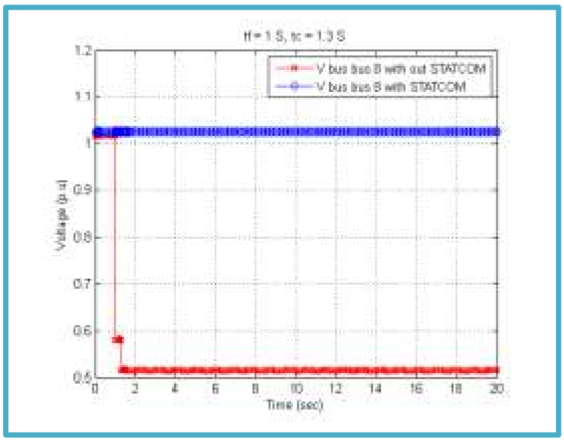


Figure (15c): Voltage of bus٨ with and without STATCOM

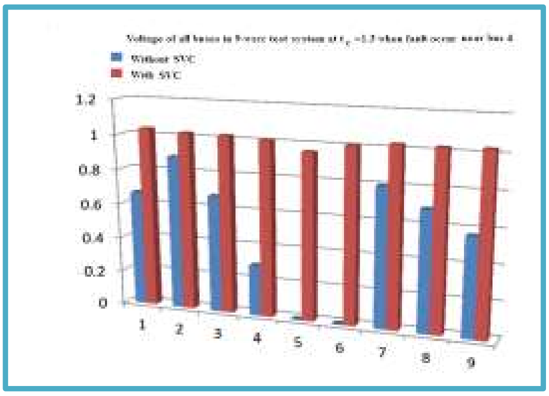


Figure (14 d): Voltage of all buses with and without SVC

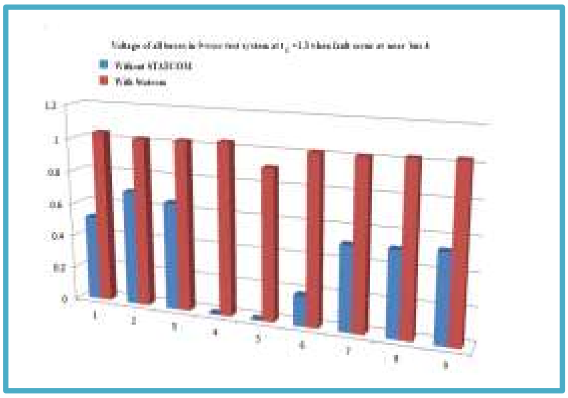


Figure (15 d): Voltage of all buses with and without STATCOM

Figures from (12a) to (13d) at t_c=1.12 sec. showed the improvement in voltage profile after connecting the SVC or STATCOM and the effect of these facts on the damping of the voltage oscillation that happened after the fault.

Increasing of the t_c =1.3 sec. as in Figures from (14a) to (15d), causes a reduced in voltage magnitude and the system is unstable and tend to collapse before connecting the SVC or STATCOM, while the system become stable after connected these facts devices.

The SVC or STATCOM not only improved the voltage stability at the installed location but even on the other network buses as indicated in Figures (12d),(13d),(14d) and (15d) because STATCOM is a controlled reactive power source and it provides voltage support by generating or absorbing reactive power while, SVC is a shunt connected static VAR generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specified parameters of the electrical power (typically bus voltage).

Case 2: IEEE 14-Bus Test System
The SVC and STATCOM devices will be installed at the weakest bus. The weakest bus of 14-bus test system is identified as bus 14. The system voltage profile is tested by applying a three phase to ground fault on buses.

❖ **SVC or STATCOM are connected at bus 14** (weakest load bus)
- **Fault near Bus 13**

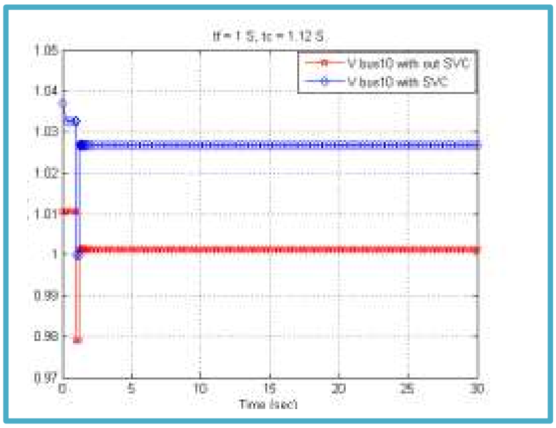


Figure (16 a): Voltage of bus ١٠ with and without SVC

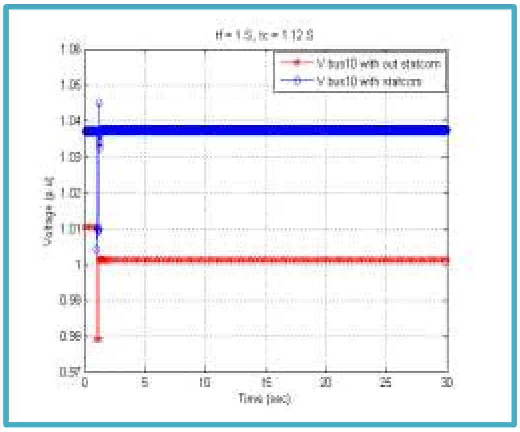


Figure (17 a): Voltage of bus ١0 with and without STATCOM

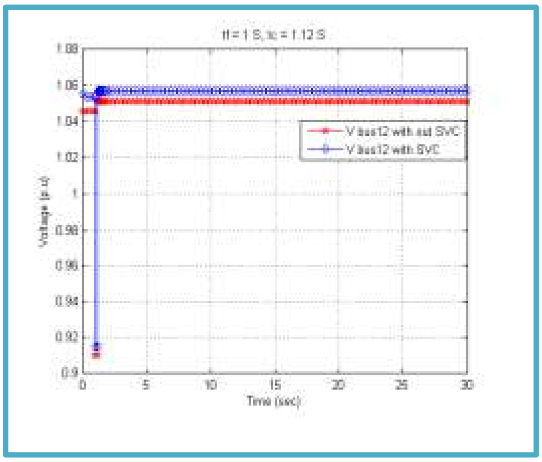


Figure (16 b): Voltage of bus ١٢ with and without SVC

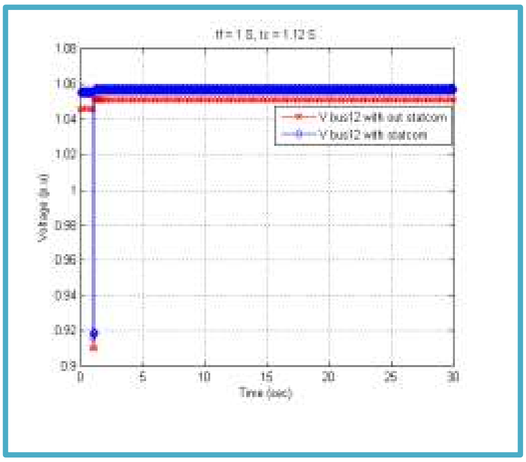


Figure (17 b): Voltage of bus ١2 with and without STATCOM

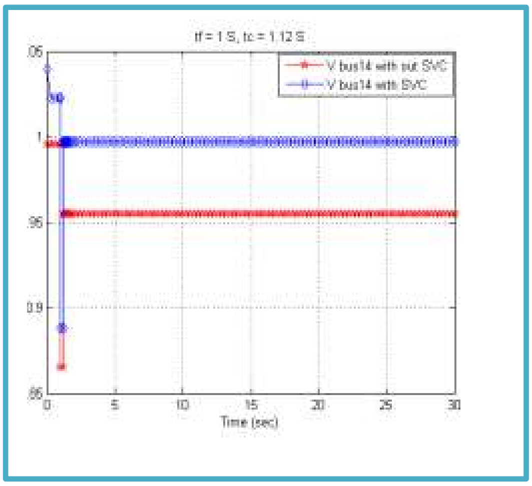


Figure (16 c): Voltage of bus ۱4 with and without SVC

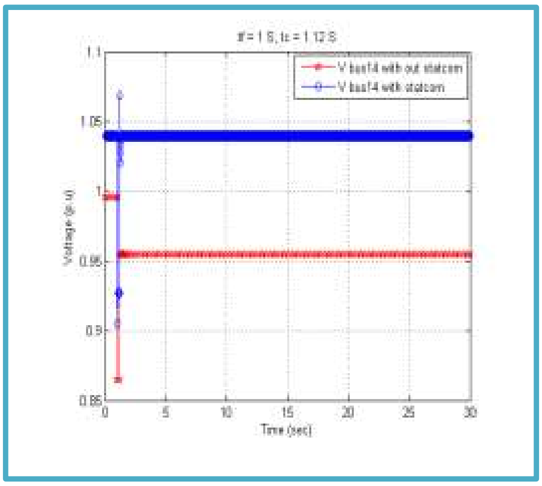


Figure (17 c): Voltage of bus ۱4 with and without STATCOM

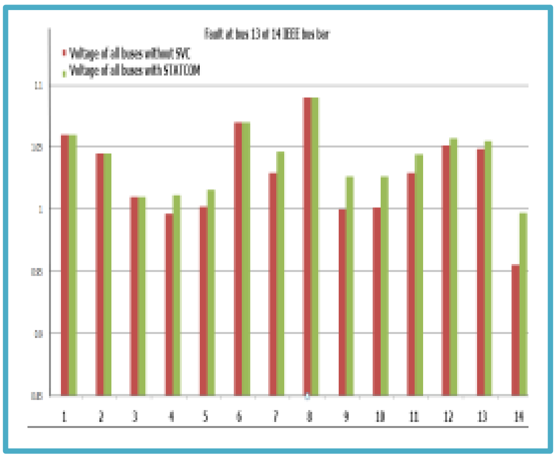


Figure (16 d): Voltage of all buses with and without SVC (when a fault occurs near bus13)

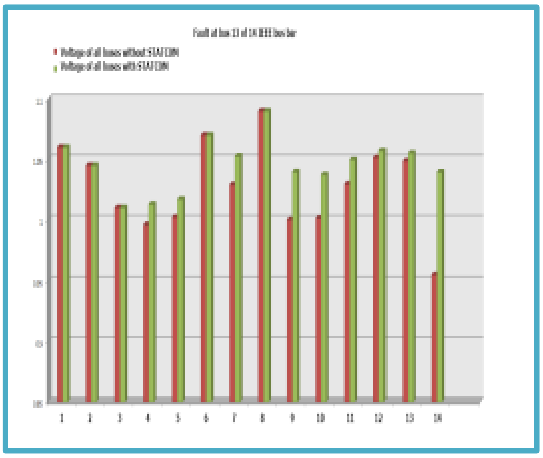


Figure (17 d): Voltage of all buses with and without STATCOM (when a fault occurs nearbus13)

- **Fault near Bus 6**

Three phase to ground fault occurs near bus 6, the faulted line 5will be removed to clear the fault at t_c=1.12 sec, then the installation of STATCOM and SVC has been compared on the same curve.

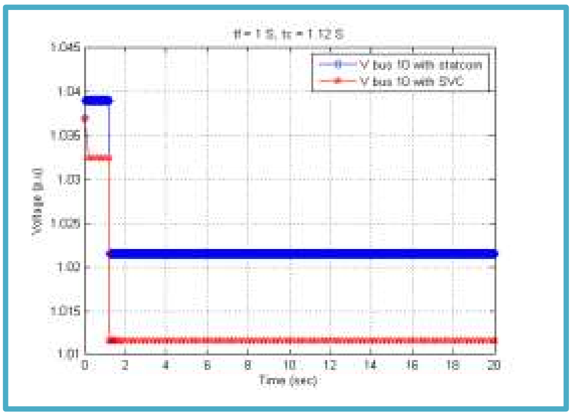
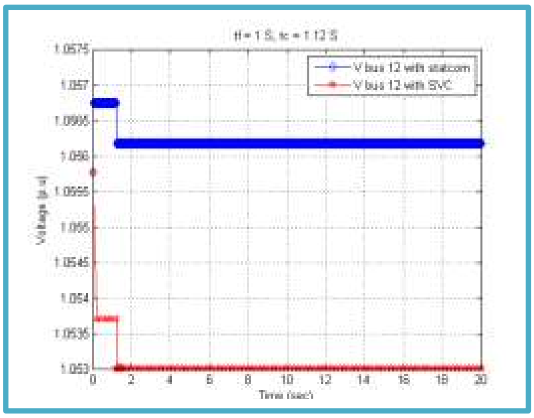


Figure (18): Voltage of bus ١٠ with STATCOM and with SVC



Figue (19): Voltage of bus 12 with STATCOM and with SVC

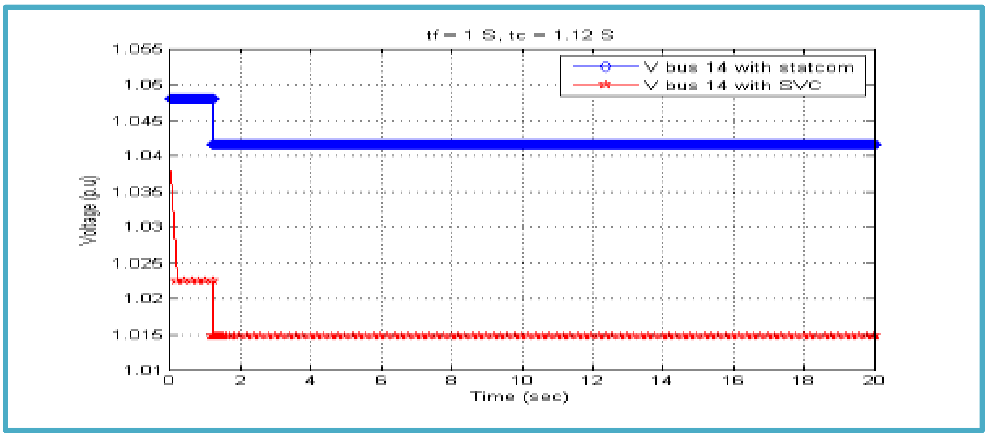


Figure (20): Voltage of bus 14with STATCOM and with SVC

At three phase to ground fault condition, Figures from (16a) to(17d) at t_c=1.12 sec. showed the improvement in voltage profile after connecting the SVC or STATCOM. Here also SVC or STATCOM not only improved the voltage stability at the installed location but even on the other network buses as indicated in figures (16d) and (17d). Figures from (18) to(20) prove that the STATCOM is more effective as compared to SVC for voltage stability improvement.

Case 3: Iraqi Electrical Network

The SVC and STATCOM devices will be installed at the weakest bus. The weakest bus of Iraqi national grid is identified as bus 20. The system voltage profile is tested by applying a three phase to ground fault on buses.

❖ **SVC or STATCOM are connected at bus 20 (**weakest load bus)

- **Fault near bus 3**

Three phase to ground fault occurs near bus 3, the faulted line 8 will be removed to clear the fault at t_c=1.366 sec.

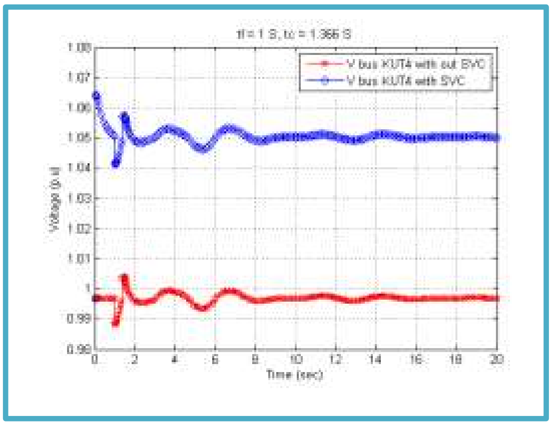


Figure (21 a): Voltage of bus ٢٠ (KUT4) with and without SVC

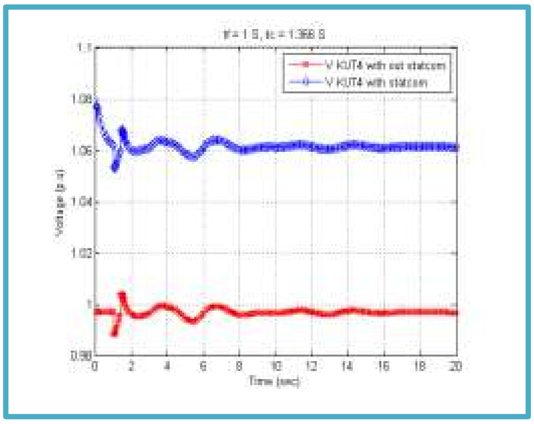


Figure (22a): Voltage of bus ٢٠(KUT4) with and without STATCOM

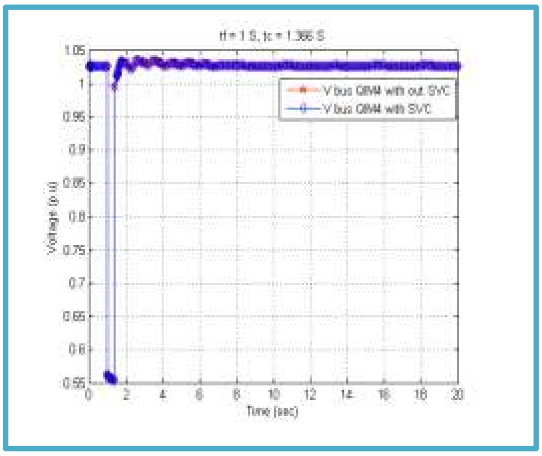


Figure (21 b): Voltage of bus 21(QIM4) with and without SVC

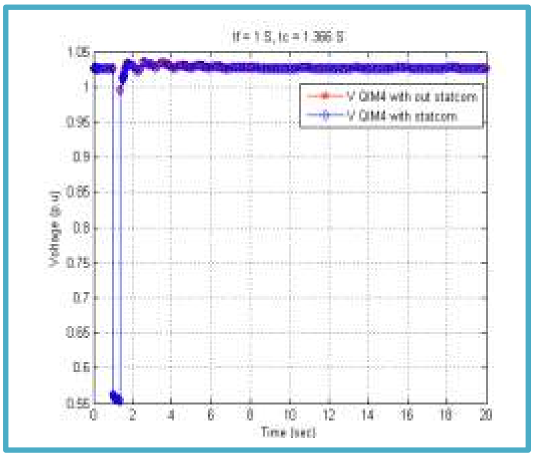


Figure (22 b): Voltage of bus ٢1(QIM4) with and without STATCOM

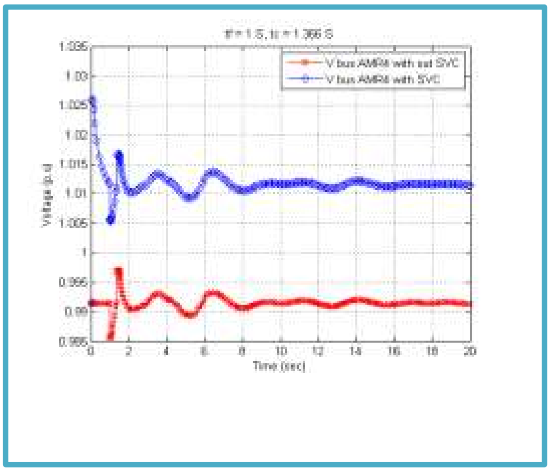


Figure (21 c): Voltage of bus ٢4(AMR4) with and without SVC

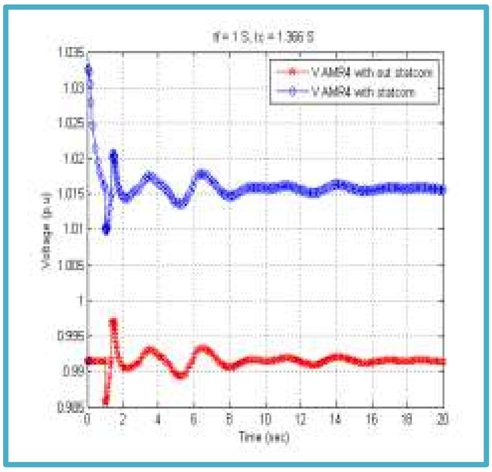


Figure (22 c): Voltage of bus ٢4(AMR4) with and without STATCOM

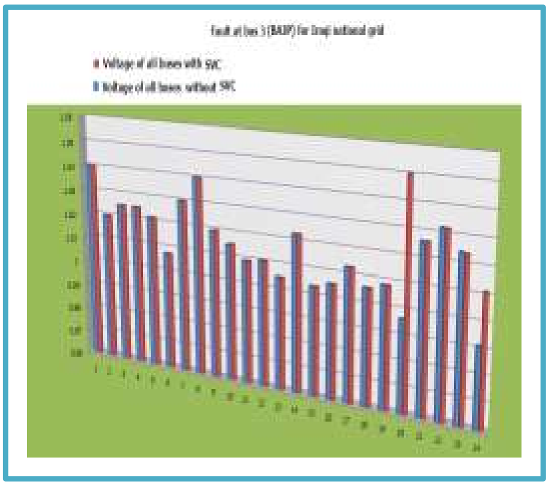


Figure (21 d): Voltage of all buses with and without SVC (when a fault occurs near bus3)

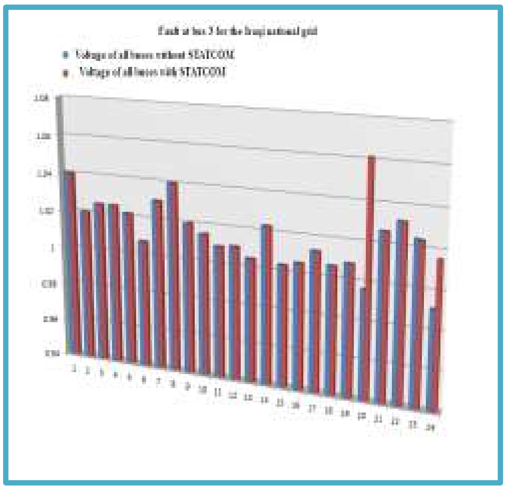


Figure (22 d): Voltage of all buses with and without STATCOM (when a fault occurs near bus3)

- **Fault near Bus 3**

Three phase to ground fault occurs near bus3, the faulted lines 8 and 7will be removed to clear the fault at t_c=2.0859 sec.

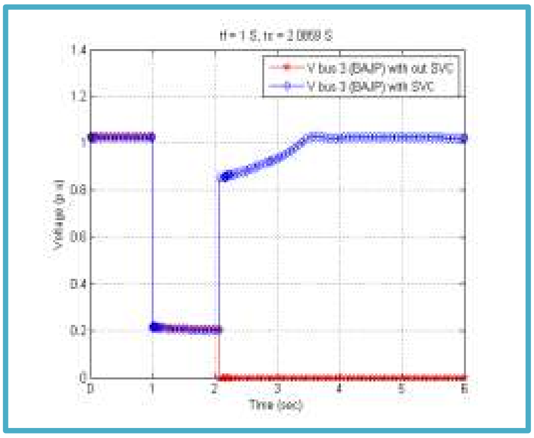


Figure (23 a): Voltage of bus ٣with and without SVC

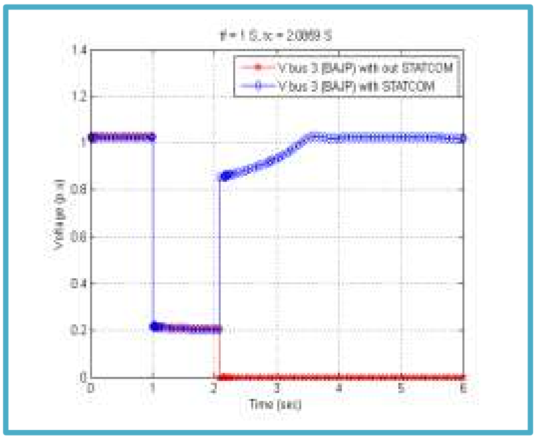


Figure (24a): Voltage of bus ٣with and without STATCOM

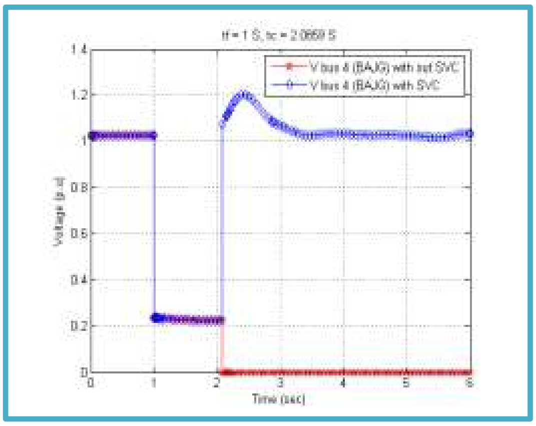


Figure (23 b): Voltage of bus4 with and without SVC

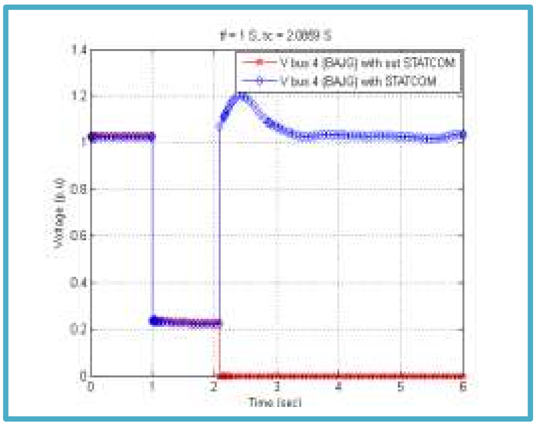
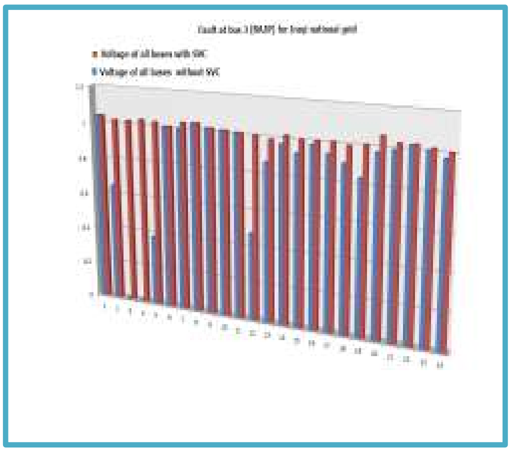


Figure (24 b): Voltage of bus 4with and without STATCOM



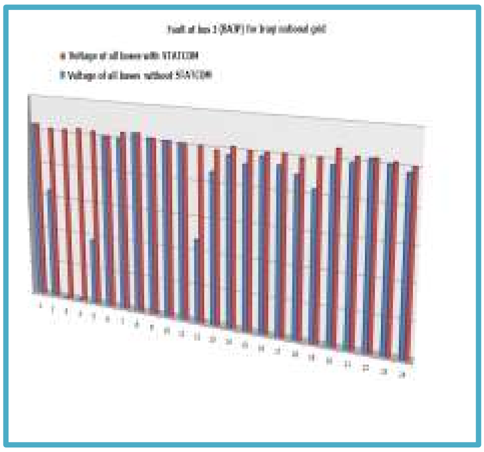


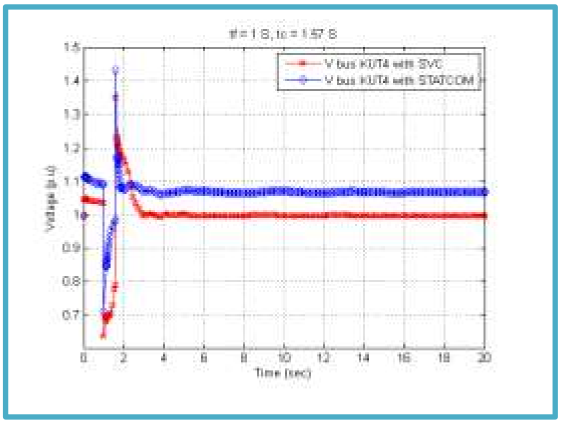
Figure (24 c): Voltage of all buses with and without STATCOM

Figure (23c): Voltage of all buses with and without SVC

In Figures from (23a) to Figure (24c) when three phase to ground fault occurs near bus 3 and the faulted lines 8 and 7 will be removed to clear the fault at t_c= 2.0859 sec. by opening the circuit breaker at the fault location, the system is became unstable and tend to collapse. But the system is stable when the SVC or STATCOM is compensated to the system and the voltage levels will be improved. Furthermore, the SVC or STATCOM not only improved the voltage stability at the location of installation but even on the other network buses as indicated in Figures (23c) and (24c).

- **Fault near bus 11**

Three phase to ground fault occurs near bus 11, the faulted line 20 will be removed to clear the fault at t_c=1.57 sec then the installation of STATCOM and SVC are compare on the same curve.



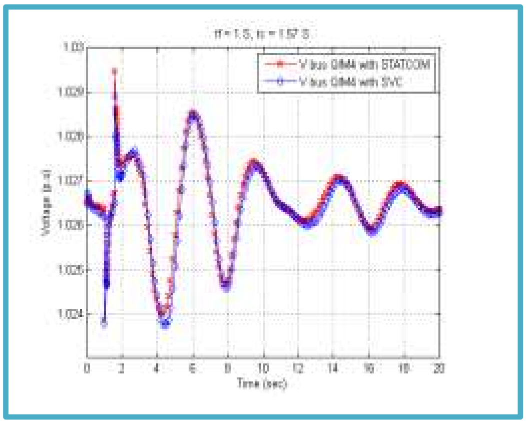


Figure (25): Voltage of bus20(KUT4) with STATCOM and SVC

Figure (26): Voltage of bus 21 (QIM4)with STATCOM and SVC

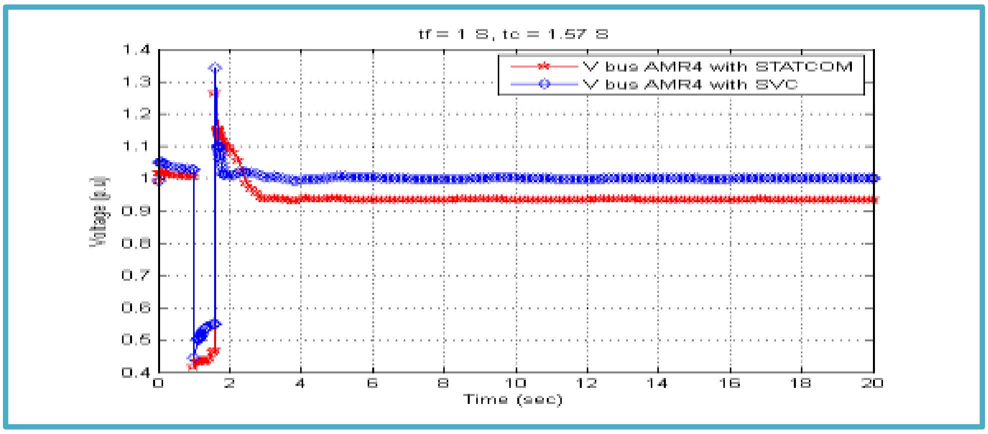


Figure (27): Voltage of bus 24(AMR4) with STATCOM and SVC

Conclusion

- The validation of FACTs controllers to enhance voltage profile is examined. The outcomes show that, the shunt facts SVC and STATCOM have considerable influence in improving the voltage profile under severe faults.
- The best location of shunt fact controller is determined for 9-bus IEEE system, 14-bus IEEE system and for Iraqi National Grid System is based on the L indicator value that identifies the weak bus, this position improves the voltage stability execution of the network when fault occurs.
- From the outcomes, it is deduced that the systems execute better when the FACTS controllers are installed and accomplished enhancement of voltage stability and improvement of voltage profile.
- The simulation result showed that the STATCOM has significant effect in improving the voltage stability than that of the SVC.

Appendix (A): Data of the Iraqi power grid (400 kV) [11]

Table (A-1): Line data for Iraqi power grid (400 kV)

From Bus	To Bus	Line R (pu)	Line X (pu)	Charging (pu)
20	2	0.00144	0.01177	0.36439
20	2	0.00144	0.01177	0.36439
20	3	0.0042	0.03437	1.06426
20	3	0.0042	0.03437	1.06426
3	4	0.00002	0.0002	0.00584
3	13	0.00483	0.04393	1.30165
3	13	0.00496	0.04511	1.33667
3	7	0.00345	0.03132	0.92808
4	5	0.0018	0.01635	0.48447
5	15	0.005114	0.046492	1.377532
5	12	0.004247	0.038612	1.144052
13	14	0.00093	0.00847	0.25099
13	17	0.000616	0.005608	0.166179
13	7	0.00485	0.04405	1.30515
18	19	0.00082	0.00749	0.22181
18	19	0.00082	0.00749	0.22181
18	17	0.000964	0.008772	0.259921
18	1	0.00122	0.01015	0.31897
18	6	0.001094	0.009106	0.286176
18	22	0.00308	0.02795	0.82827
15	14	0.00029	0.00262	0.07763
15	19	0.00043	0.00394	0.11674
15	19	0.00043	0.00394	0.11674
15	12	0.00087	0.00788	0.23348
14	8	0.00015	0.00138	0.04086
14	8	0.00015	0.00138	0.04086
19	23	0.02744	0.22904	0.09156
23	11	0.00432	0.03928	1.1639
23	24	0.00479	0.04354	1.28998
7	16	0.00292	0.02391	0.74035
1	6	0.000125	0.001043	0.032791
1	21	0.00081	0.00673	0.21165
1	21	0.00081	0.00673	0.21165
21	22	0.00233	0.01935	0.60812
21	22	0.00233	0.01935	0.60812
22	11	0.00383	0.03485	1.03256
11	9	0.00439	0.03993	1.18316
24	10	0.0029	0.0264	0.78216
10	9	0.00118	0.01076	0.3187
10	9	0.00118	0.01076	0.3187

Table (A-2): Bus data for Iraqi power grid (400 kV)

Bus Number	Bus Name	Voltage (pu)	PL (MW)	QL (Mvar)	Pg (MW)
1	MUSP	1.0400	199.7795	116.6333	1107.1
2	MMDH	1.0200	0.0000	0.0000	690.10
3	BAJP	1.0250	124.8622	92.2467	406.00
4	BAJG	1.0250	0.0000	0.0000	590.45
5	KRK4	1.0217	129.8567	60.4896	239.87
6	MUSG	1.0400	0.0000	0.0000	369.00
7	HDTH	1.0300	253.054	75.612	202.97
8	QDSG	1.0075	0.0000	0.0000	735.30
9	KAZG	1.0096	566.0419	294.6579	207.58
10	HRTP	1.0150	154.8291	72.1171	332.13
11	NSRP	1.0197	422.8665	198.3219	775.00
12	DYL4	1.0000	83.2415	21.1712	0.0000
13	BGW4	1.0000	576.031	302.4481	0.0000
14	BGN4	1.0000	412.8776	139.1261	0.0000
15	BGE4	1.0000	849.0627	294.6579	0.0000
16	QIM4	1.0000	109.8787	39.3182	0.0000
17	BGC4	1.0000	49.9449	181.4688	0.0000
18	BGS4	1.0000	0.0000	0.0000	0.0000
19	AMN4	1.0000	126.564	56.0014	184.52
20	MSL4	1.0000	649.2833	302.4481	0.0000
21	BAB4	1.0000	307.9934	184.6695	0.0000
22	KDS4	1.0000	213.0981	151.4458	0.0000
23	KUT4	1.0000	259.7134	108.1756	0.0000
24	AMR4	1.0000	311.0221	160.3709	0.0000

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