IMPROVING TRANSIENT STABILITY IN CASE OF FAULTS IN HADITHA - QAIM LINE

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Abstract

Iraqi National Super Grid suffers from out of synchronism of the system due to short circuit in the lines. The main goal of this work is to study the effect of optimum generation and reconfiguration of some transmission paths on transient stability improvement for Iraqi Network in case of short circuit in Haditha-Qaim line because it is one of the wrest lines. A programmable package build under Matlab5.3 was used to determine synchronous machines rotor angles as an indicator of transient stability. Sad Al-Mosul, Haditha and Nasiriya power plant were chosen to notice the situation of stability.
Keywords- Power Losses, Transient Stability, Stability, Reconfiguration.

تحسين الاستقرارية العابرة في حالة الخلل في خط حديثة – ألقائم

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الخلاصة

تعاني شبكة الضغط الفائق في العراق من مشكلة خروج المنظومة عن التزامن وذلك عند حدوث دائرة قصر في احد خطوط الشبكة. يهدف هذا البحث إلى دراسة تأثير التوليد الأمثل وتأثير إعادة تشكيل بعض مسارات الخطوط في تحسين الاستقرارية العابرة في شبكة الضغط الفائق وذلك عند حدوث دائرة قصر في خط حديثة – القائم لأنه يعتبر أحد أضعف الخطوط في المنظومة. تم استخدام برنامج جاهز بلغة Matlab5.3 لحساب زوايا دوار المكائن التزامنية كمؤشر لحالة الاستقرارية.تم اختيار محطات توليد سد الموصل، حديثة و الناصرية لملاحظة أستقرارية المنظومة.

Introduction

Power System Stability

The importance of power system stability is increasingly becoming one of the most limiting factors for system performance. By the stability of a power systems we mean the ability of the system to remain in operating equilibrium, or synchronism, while disturbances occur on the system(Kundur2004). There are three types of stability namely, steady-stat, dynamic, and transient stability.

1) Steady-State stability: refer to the stability of a power system subject to small and gradual changes in load and the system remains stable with conventional excitation and governor controls.

2) Dynamic-Stability: refer to the stability of a power system subject to a relatively small and sudden disturbances .The system can be described by linear differential equation, and the system can be stabilized by a linear and continuous supplementary stability control.
3) Transient stability T.S : refer to the stability of power system subject to a sudden and sever disturbance beyond the capability of the linear and continuous supplementary stability control, and the system may lose its stability at the first swing unless a more effective countermeasure is taken, usually of the discrete type, such as dynamic resistance braking or fast valving for the electric energy surplus area, or load shedding for electric energy deficient area. For T.S analysis and control design, the power system must be described by non linear differential equations. T.S concern with the matter of maintaining synchronism among all generators when the power system is suddenly subjected to sever disturbances such as faults or short circuits caused by lightning strikes, the sudden removal from the transmission system of a generator and/or a line, and any sever shock to the system due to a switching operation. Because of the severity and suddenness of the disturbance, the analysis of transient stability is focused on the first few seconds, or even the first few cycles, following the fault occurrence or switching operation (Shin2004),(Selman2005).
First swing analysis is another name that is applied to transient stability studies. If the generators can get through it without losing synchronism, it is said to be transient stable. On the other hand, if the generators losses its synchronism and can not get through the first swing, it is said to be transient unstable. There is a critical angle within which the fault must be cleared if the system is to remain stable(Demetrios2005) .

The Transient Stability calculations were carried out using the step by step modified Euler iterative solution of the differential equations describing machines second and total solution time period of 1.5 second. The programmable package performs transient calculations with different behaviors of the system.
The solution took into account a time step of 0.05 types of faults at any point on the system with 0.15 second clearing time (tc). Rotor angles were taken as an indicator of transient stability.

Iraqi National Network

Iraqi national super grid contains19 busbar,27 transmission lines and six generating sets of various types units, thermal and hydro turbine kinds, with different capabilities of MW and MVAR generation and absorption as shown in **Figure 1.**Using the load data collected on 2/1/2003 in **Appendix A**, the system line data as shown in **Appendix B** which can be obtained from the Iraqi Control Center (Afaneen2004).

Iraqi electrical network suffered from serious problems. A great damage happened to the Iraqi power system at all levels, the generation, the transmission and the distribution. There are tow dangerous regions , Baiji and Haditha because the loss of Baigi or Haditha busbars cause Sad Al -Mosul to separate from the network, leaving it with high generation and low loading, and causing the instability of the bus. While the separation of Haditha causes the losses of large amount of power feeding the middle area , and forcing the network to overcome this loss from Sad Al -Mosul. This lead Sad Al-Mosul to swing highly reaching the instability.

Improving the Stability.

The following steps were tried by (Afaneen 2004) to overcome this problem:

1 Recovery of damaged transmission line.

Those are (Mosul – Kirkuk line, one of the double lines of Sad Al Mousil – Baiji, one of the double lines of Hartha- Khour Al-Zubair ……etc). **Table 1**, represents the type of stability and the critical clearing time(Tcr) for each step of generating units cancellation with and without the recovery of the separated transmission lines (T.L).

Although the installation of the recovered transmission lines will lead to improvement in the power flow in the north and middle regions, they did not affect the stability situation of the network.

Increasing the generating power of the generating units.٢ 3.

As shown in **Table 2**, increasing the generating power has no effects on the stability of the system when removing Haditha.

The Effect of Optimum Power Generation on Transient Stability

Three buses(Sad Al-Mosul, Haditha and Nasiriya) power plants were chosen to study the effect of three phase fault in the middle of the line Haditha-Qaim. The system is unstable in case of ordinary load flow because SDM plant is out of synchronism. The system becomes more stable (but still unstable)with optimum power generation using the data of optimum power generation in **Appendix C** (Samir2007).

1 Stability improvement calculations for Sad Al-Mosul

The difference in the rotor angle for the swing curve in case of ordinary generation as shown in **Figure 2**= 330-20 =310degree.

The difference in case of optimum generation as shown in **Figure 3** = 100-5= 95degree.

The stability improvement between ordinary and optimum generation= $\frac{310-95}{310} = 69.35\%$

2 Stability improvement calculations for Haditha

The difference in the rotor angle for the swing curve in case of ordinary generation as shown in Fig4= 15-(-75)=90degree.

The difference in case of optimum generation as shown in **Figure5** = 10-(-15.5)=25.5degree.

The stability improvement between ordinary and optimum generation= $\frac{90-25.5}{90} = 71.6\%$

3 Stability improvement calculations for Nasiriya

The difference in the rotor angle for the swing curve in case of ordinary generation as shown in **Figure 6**= 10-(-85)=95degree.

The difference in case of optimum generation as shown in **Figure 7** = 7.5-(-22.5)=30degree.

The stability improvement between ordinary and optimum generation= $\frac{95-30}{95} = 68.4\%$

The Effect of Paths Reconfiguration on Transient Stability

As shown before the network is the unstable, during both ordinary and optimal load flows, in case of three phase fault in the Haditha-Qaim because this fault will lead Sad Al-Mosul bus to swing away from the stability and cause instability of the system. To overcome this problem a new configuration of the network will solve this problem. If the radial path (Baiji-Haditha-Qaim) as shown in **Figure(1)** is changed to a loop path (Baiji-Qaim-Haditha-Baghdad East-Baiji), the system becomes stable for both ordinary and OPF as shown in swing curves **Figures (8-13).**

Stability Improvement Calculations

The improvement calculations are done in procedure similar to that in 4.1, 4.2 & 4.3.

In case of ordinary generation, the improvements in stability using the new configuration are equal to 96.4%, 63.8% and 59.6% for Sad Al-Mosul, Haditha and Nasiriya respectively with respect to ordinary generation without new configuration as shown in **Figures8, 9 & 10**.

In case of optimum generation, the improvements in stability using the new configuration are equal to 97.4%, 67.9% and 50.8% for Sad Al-Mosul, Haditha and Nasiriya respectively with respect to optimum generation without new configuration as shown in **Figures11, 12 & 13** .

Conclusion

1) Comparison between stability with optimum generation and ordinary generation according to the rotor time angle curve indicates that transient stability is much better with optimum generation.

2) In case of 3-phase fault in the middle of line Haditha-Qaim, transient stability can be enhanced using optimum generation but the system remains unstable.

3) The system becomes stable if a new configuration is used.

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Table (1)The stability situation during the recovery of the separated transmission lines

The separated bus-bar	The system stability	Tcr(sec)with the recovery of T.Ls
Baiji	Unstable	٠.٠٠١٢٣١٢
Sad Al-Mosul	Stable	٠.٦٩٤٧٠٢١
Haditha	Unstable	٠.٠٠١٢٣٠٦
Mussayab	Stable	٠.٧٧٧٠٢٤٩
Nasiriya	Stable	٠.٤٠٥٦٤٠٥
Hartha	Stable	٠.٥١٠٤٢٥٣

Table (2)The stability situation after increasing generated power of the generating bus-bar

The separated bus-bar	The generated power(Mw)	The system stability	Tcr(sec)
Baiji	٨٠٠	Stable	٠.٦١٥٢١٠١
Sad Al-Mosul	٨٠٠	Stable	٠.٦٨٠٢٤٥٧
Haditha	٦٠٠	Unstable	٠.٠٠١٢٣١٥
Mussayab	١٠٠٠	Stable	٠.٥٥٥٥٩١٤
Nasiriya	٧٥٠	Stable	٠.٤٦٥٢٥٩٢
Hartha	٧٠٠	Stable	٠.٢٤٤٨٤٤٩٦

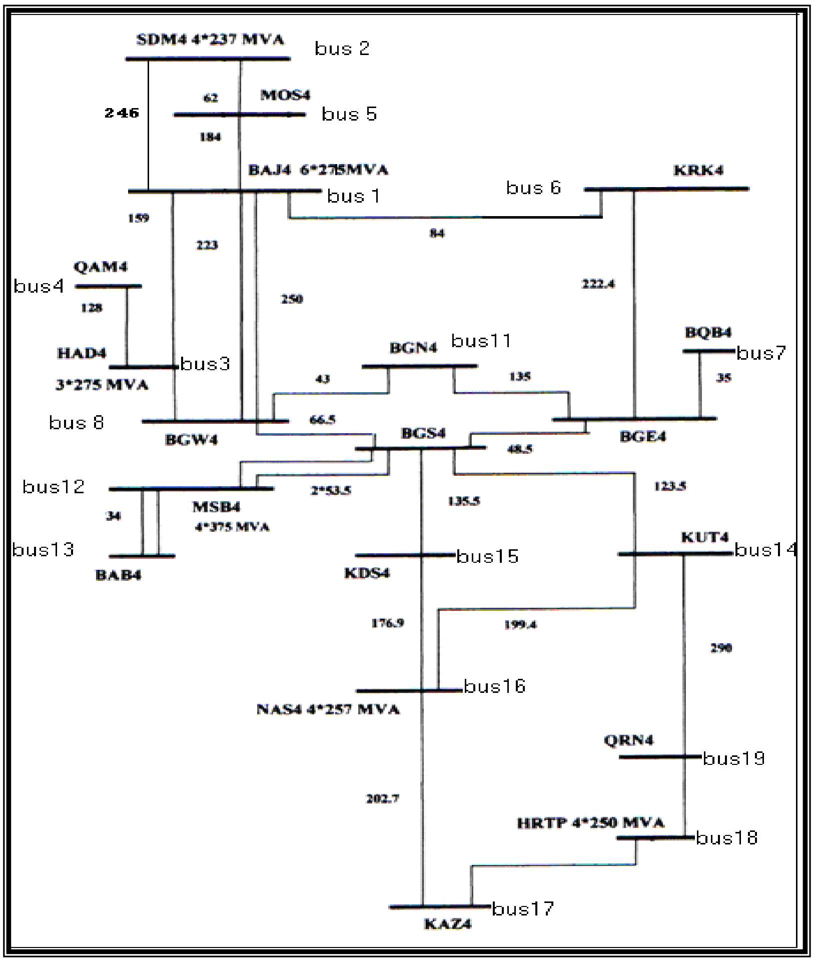


Figure (1) Iraqi National Super Grid

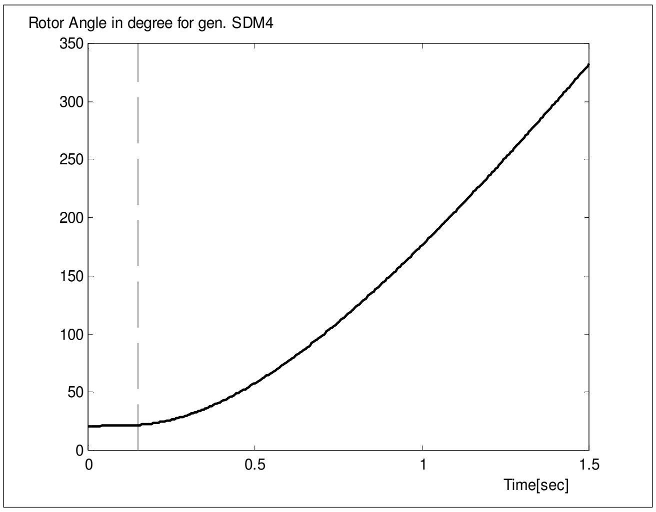


Figure 2: Swing Curve for (Sad Al-Mosul) Generator with ordinary power generation

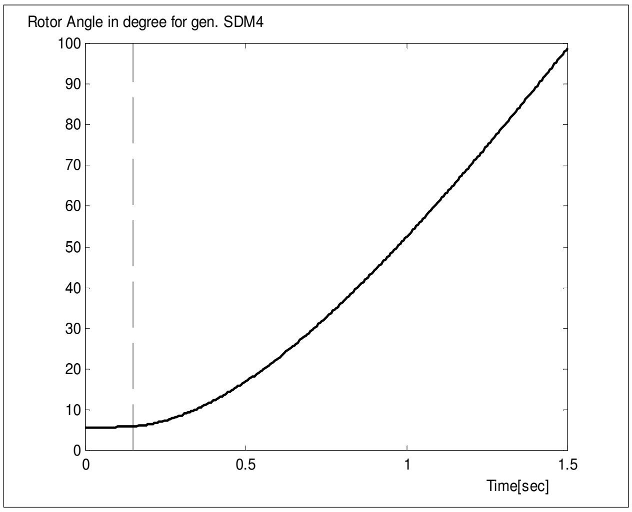


Figure 3: Swing Curve for (Sad Al-Mosul) Generator with OPF

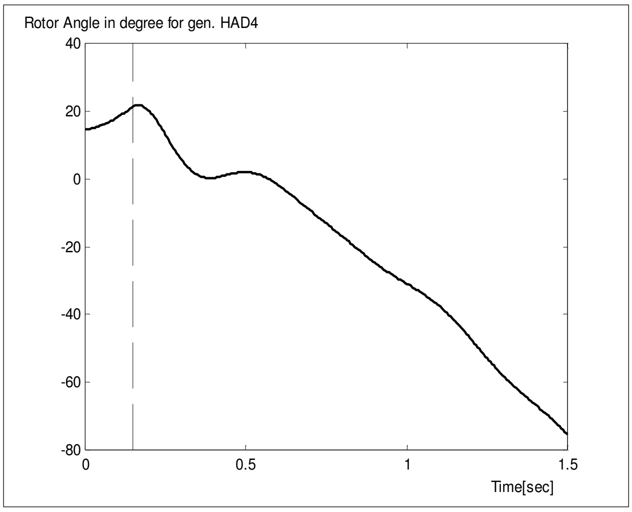


Figure 4: Swing Curve for (Haditha) Generator with ordinary power generation

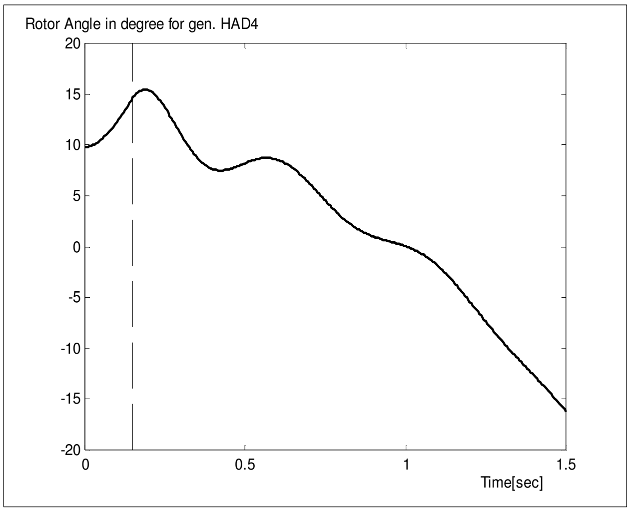


Figure 5: Swing Curve for (Haditha) Generator with OPF

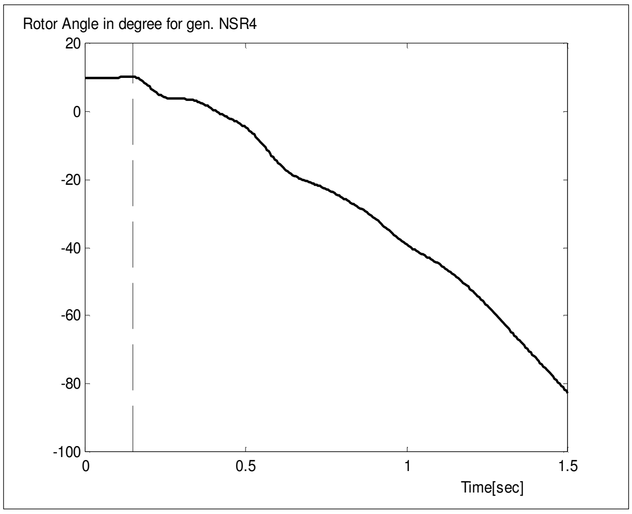


Figure 6: Swing Curve for (Nasiriya) Generator

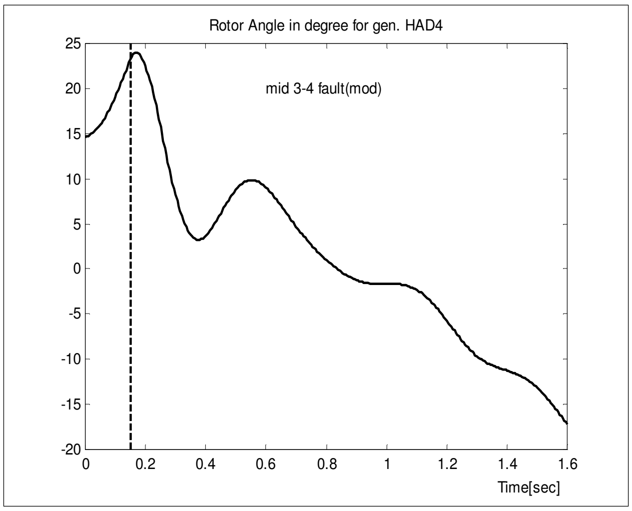
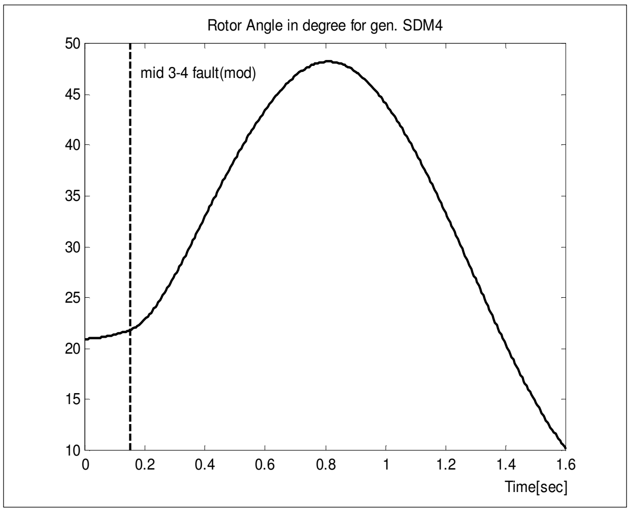


Figure 7: Swing Curve for (Nasiriya) Generator

with ordinary power generation

with OPF



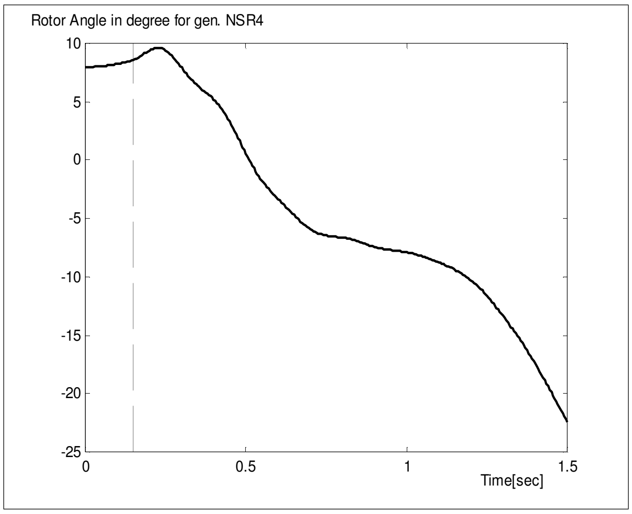
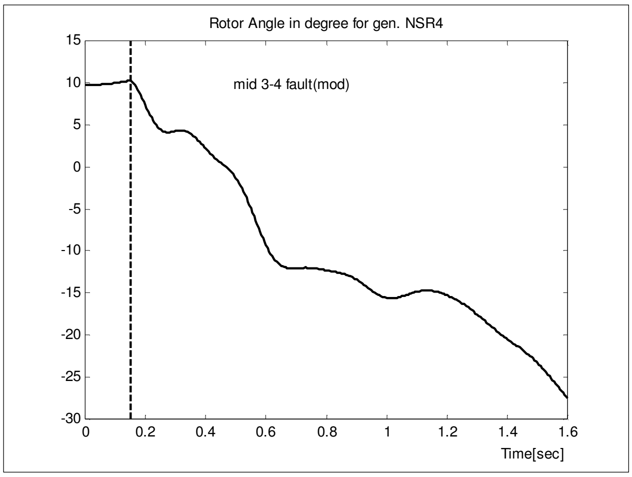


Figure 8: Swing Curve for(Sad Al Mosul) Generator with ordinary generation& new configuration

Figure 9: Swing Curve for (Haditha) Generator with ordinary generation& new configuration



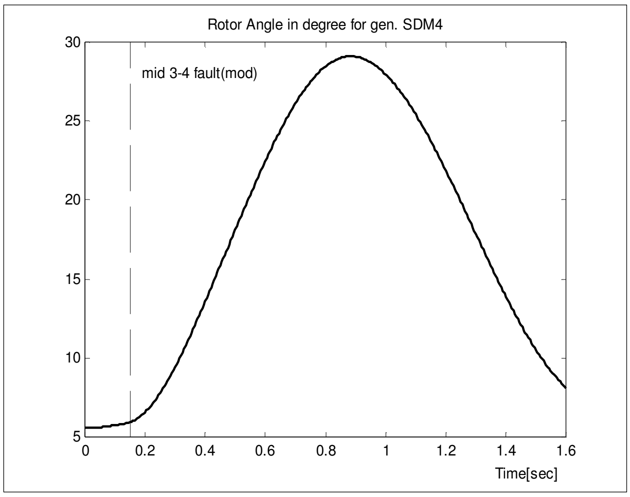


Figure 10: Swing Curve for(Nasiriya) Generator with ordinary generation& new configuration

Figure11: Swing Curve for (Sad Al Mosul) Generator with optimum generation& new configuration

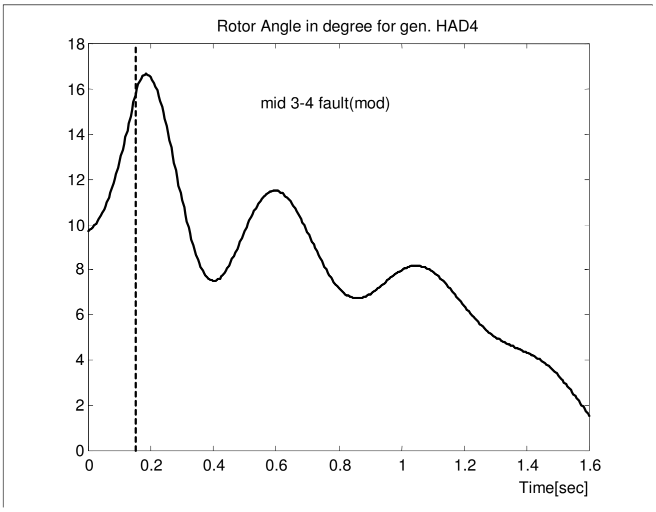


Figure 12: Swing Curve for(Haditha) Generator with optimum generation& new configuration

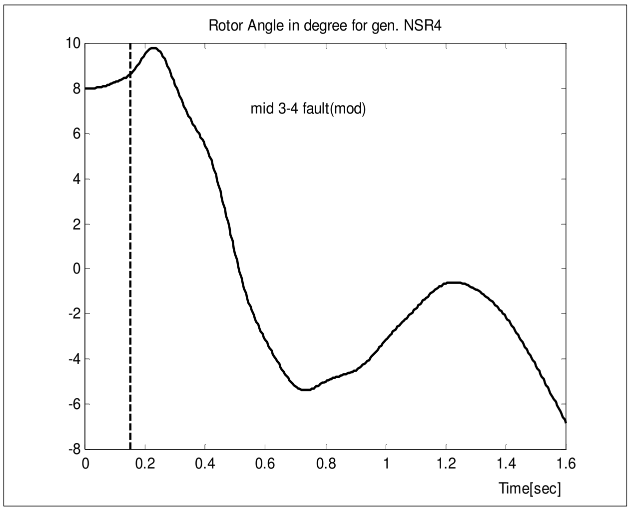


Figure13: Swing Curve for (Nasiriya) Generator with optimum generation& new configuration

Appendix A: INSG System Load Data

Bus Bar Number	Bus Bar Name	Type	Generation		Load	
			MW	M_{VAR}	MW	M_{VAR}
1	BAJ	Slack	570.592	100.4455	200.00	98.00
2	SDM	P,V	700.00	- 23.2248	5.00	2.00
3	HAD	P,V	500.00	- 0.8474	100.00	60.00
4	QAM	P,Q	.00	.00	60.00	40.00
5	MOS	P,Q	.00	.00	300.00	180.00
6	KRK	P,Q	.00	.00	70.00	40.00
7	BQB	P,Q	.00	.00	150.00	80.00
8	BGW	P,Q	.00	.00	500.00	360.00
9	BGE	P,Q	.00	.00	500.00	360.00
10	BGS	P,Q	.00	.00	100.00	50.00
11	BGN	P,Q	.00	.00	300.00	200.00
12	MSB	P,V	600.00	420.6564	120.00	70.00
13	BAB	P,Q	.00	.00	100.00	50.00
14	KUT	P,Q	.00	.00	100.00	60.00
15	KDS	P,Q	.00	.00	200.00	100.00
16	NAS	P,V	650.00	- 69.1434	100.00	54.00
17	KAZ	P,Q	.00	.00	350.00	200.00
18	HRT	P,V	380.00	35.9855	38.00	22.00
19	QRN	P,Q	.00	.00	70.00	30.00
Total			3400.592	463.8716	3363	2056

Appendix B: INSG System Line Data

From	To	R (P.U)	X (P.U)	B (P.U)
BAJ4	SDM4	0.00542	0.0487	1.4384
MOS4	SDM4	0.00143	0.0124	0.36439
MOS4	BAJ4	0.00399	0.03624	1.074
BAJ4	HAD4	0.00364	0.03024	0.8676
QAM4	HAD4	0.0035	0.03	0.7413
BGE4	BQB4	0.00076	0.00689	0.2043
BAJ4	KRK4	0.00182	0.01654	0.49031
BAJ4	BGW4-2	0.0055	0.05004	1.4826
BAJ4	BGW4-1	0.00483	0.04393	1.3017
HAD4	BGW4	0.00483	0.04393	1.3017
BGW4	BGN4	0.00093	0.00847	0.25099
BGN4	BGE4	0.00029	0.00265	0.0788
KRK4	BGE4	0.00481	0.04373	1.29581
BGE4	BGS4	0.00105	0.00955	0.28309
BGW4	BGS4	0.00144	0.0131	0.38816
BGS4	MSB4-1	0.00121	0.0102	0.30944
BGS4	MSB4-2	0.00121	0.0102	0.30944
BAB4	MSB4-1	0.00077	0.00648	0.19666
BAB4	MSB4-2	0.00077	0.00648	0.19666
BGS4	KUT4	0.00245	0.02236	0.6625
BGS4	KDS4	0.00292	0.02659	0.788
KDS4	NSR4	0.00383	0.03486	1.03314
KAZ4	NSR4	0.00439	0.03999	1.1849
KUT4	NSR4	0.00433	0.0394	1.1674
KAZ4	HRT4	0.00119	0.01083	0.32104
QRN4	HRT4	0.0013	0.01182	0.35022
QRN4	KUT4	0.00628	0.05713	1.6927

Appendix C: Optimum Power Generation according to system data load(Samir2007)

Generation bus name	Optimum Generation[Mw]
Baiji	571
Sad Al-Mosul	250
Haditha	350
Mussayab	1000
Nasiriya	500
Hartha	400