Study of Different Faults and Disturbances in Algerian Power System

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Abstract: - Given that electrical energy is very difficult to store, a permanent balance between production and consumption is vital. Generators, loads and the electrical networks which connect them have mechanical and/or electrical inertias which complicate the maintaining of a balance guaranteeing relatively constant frequency and voltage. A severe fault may cause loss of synchronism of a small number of generators. And it may make many generators out of service resulting in wide area blackout. Through this study we have come to know the exact adjusting of all the protection equipment in a way so that the duration of fixing is always less than the limit value which causes the loss of the power plant and thus, the whole network. This Study discusses the electrical interconnection between the Maghreb countries" Algeria, Tunisia, Morocco" and Europe via the line "Morocco-Spain". And that any deficiency in power of the Algerian network will be compensated directly from the Tunisian and Moroccan network this is the main benefit of this interconnection is the possibility to transfer excess power to the neighboring country.

Key-Words: - Power system stability, electric generators, loss of synchronism, protection, short circuit

1 Introduction

Power system interconnection is a well established practice for a variety of technical and economical reasons. Several interconnected networks exist worldwide for a number of factors. Some of these networks cross international boundaries.

When confronted with a power variation, the electrical system normally resumes a stable state after a few oscillations.

However in certain cases the oscillating state can diverge, and studies are then required to avoid this phenomenon and guarantee the stability of the electrical network.

These studies are of particular importance in the case of industrial networks which contain one or more generator sets and motors.

In this paper we describe a real study carried out on the level of study department and forecast of the NATIONAL COMPANY OF ELECTRICITY AND GAS – SONELGAZ which includes the Algerian national dispatching. The purpose of this paper is the simulation of the loss of one or more combined cycle power plant and the simulation of different short circuits on the lines close to all power plants connected to the 400 kV interconnected network for 2009 to determine the stability of the Algerian network. [1] [2] [3]

2 Power system interconnection

The topology of the interconnected system is based on connecting a set of distinct networks; these links can be interconnected across the world, an impressive number of electrical systems that can exchange all sorts of information across lines interconnection.

The interconnection networks allows the mutualisation of reserves and secure a better maintenance of the frequency with lower cost and more availability of immediate assistance in case of difficulty in one or other of the networks involved in the interconnection. Two separate networks can be interconnected for several reasons:

- ✓ The share of power reserves.
- ✓ Joint exploitation of resources.
- ✓ Get credit of commercial advantages.

• Improving safety and quality. For a better analysis and understanding. The future of Mediterranean electric network was taken as an example. The main reasons that have engendered these connections: The safety and network security and continuity of service (reliability).

• Trade exchanges.

Fig. 1. Present state of the interconnection network.

UCTE: Union for the Coordination of electricity transfer: it handles the guaranteeing of safety and security of the network and provide an electricity market.

- The five blocs are:

1. UCTE 1: It contains 18 European countries such as: Spain, France, Portugal, Belgium, and Denmark .
2. UCTE 2: it contains: Bosnia, la Greece and Bulgaria, etc
3. Turkey.
4. SEMB: South-Eastern part of Mediterranean Block. It leaves Libya to Syria and contains Lebanon recently.
5. SWMB: South-Western part of Mediterranean Block. It contains: Morocco, Algeria and Tunisia.

- Existing lines between the Mediterranean countries.

- Spain - Morocco: line 400 kV in 1997.
- Morocco - Algeria: two lines 220 kV in 1988 and 1992.
- Tunisia - Algeria: four lines: two of 90 kV in 1952 and 1956, one 220 kV and one of 150 kV in 1984.
- Tunisia - Libya: project of execution of a double line of 220 kV in 2003.
- Libya - Egypt : one double of 220 kV in 1998
- Egypt - Jordan : line 400 kV in 1997
- Syria - Jordan : line 400 kV in 2001
- Turkey - Bulgaria: two lines 400 kV in 2002 [7][8][9].

3 Development of the Mediterranean Interconnection Network

In the field of electrical interconnection, major projects have been completed or are underway. It should allow the creation of a Mediterranean power, and at the same time improving the reliability of electrical systems.

- Since 1997, a submarine cable connects morocco to Spain.
- Maghreb interconnections are existents or are underway.
- Algeria and Tunisia carry out trade exchanges ever since a long time ago..
- Egypt and Libya have established interconnection in 1998.
- The link between the Tunisian and Libyan networks is serviceable since 2001.
- New possibilities of interconnection between the countries in the North and South are presently under study.

The growing interconnection is an element that accentuates competition, thus leading to lower prices and, moreover, opens up many opportunities for exchanges that are in line for a better use of generating facilities.

There is a remarkable complementarity in energy between the Southern and Northern Mediterranean, but it will not be into effect until the development of these "links" to increase the exchange capacity. This includes the establishment of a truly unique network Egypt-Libya-Tunisia-Algeria-Morocco, but also new interconnections by submarine cables between North Africa and southern Europe.

3.1 Presentation

The interconnected networks in the Maghreb, made by electric systems in Morocco, Algeria and Tunisia are interconnected with those of Europe (UCTE System).

The interconnections between Europe and North Africa on the one hand and those in North Africa on the other hand are formed by :

1. Interconnection between Morocco and Spanish networks consists of two 400 kV lines aero - underground, underwater ac Melloussa (Morocco) – Puerto DE La Cruez (Spain): commissioning respectively August 6, 1997 and June2006.

This route is the interconnection between networks Maghreb (Morocco- Algeria-Tunisia) and European (UCTEsystem)

2. The interconnection between the Algerian and Moroccan networks consists of 220 KV lines

Ghazaouet (Algeria)-Oujda (Morocco) and Tlemcen (Algeria) - Oujda (Morocco): Commissioning respectively June 15, 1988 and 16 January 1992 . and the new 400kV double line Boussidi Sid Ali (Algeria)-Bourdim(Morocco).
3. Interconnexion between Tunisian and Algerian networks is formed by lines Tajerouine (Tunisia)-El Aouinet (Algeria) in 220 kV Metlaoui (Tunisia) – Djebel onk (Algeria) in 150 kV and Tajerouine - El Aouinet and Fernan (Tunisia) - El Kala (Algeria) in 90kV.

3.2 Normal operation

In normal operation, networks Maghreb (ONE SONELGAZ and STEG) and European (UCTE network) are interconnected and operate synchronously. The energy exchange between different networks will be either in programmed mode or non-programmed. Compensation for energy will be done bilaterally and is basically in accordance to contracts or agreements established between different pairs of partners: Spain - Morocco, Morocco-Algeria and Algeria-Tunisia [10].

4 The Study and Analysis of Operation of 400 kV Network

4.1 The SICRE Simulator

The operational planning and operation of electric power systems give rise to numerous control problems distributed among several operational levels and extended along different time frames. It can therefore be easily understood that the control of electric power systems constitutes an attractive field for the application of simulation techniques in the time domain.

SICRE consists of a set of functions of simulation and analysis able to represent the dynamic behaviour of power systems, over different time scales and both in normal and emergency conditions. The main scope of SICRE is to provide a large number of users with a set of tools useful for analysis and control and for training. The package is complete from the viewpoint of the components that are modelled with a high degree of detail, efficient from the viewpoint of the algorithms and based on the most modem SW/HW technologies.

4.2 Simulation Functions of SICRE

SICRE provides the user with three types of simulation functions:
1. Simulation of all the dynamics mentioned before, with an integration step suitable for following electromechanical transients, and taking into account all the components, modelled in high detail, involved in the system dynamics, such as:

- generators,
- primary and secondary voltage controllers,
- frequency controllers and supply systems of the units and their regulators,
- load-frequency controller,
- static and dynamic loads,
- tap changers on load and their controllers,
- HVDC model,
- Very detailed models of the main protections of lines, transformers and generators.

2. Simulation only of slow transients (long-term dynamics), supposing already damped faster phenomena such as electromechanical transients, with an integration step suitable for following long-term dynamics. This simulation function, if running on modern work-stations of medium quality, should permit real time simulation even for large power systems.
3. A combination of the two functions above illustrated, that means the function 1. during the interval immediately following perturbations and the function 2) when the electromechanical transients have damped out. The commutation between the two functions can be automatic on the basis of suitable criteria or forced by the user in run-time. This last function allows the user to analyse the system behaviour for long periods and for a cascade of events in sequence. [5]

5 Network Configuration

For 2009, it was considered the network to which are added the works for winter 2009.

Table 1: Maximum powers called for 2009[4].

Year	power (MW)
2009	7300

To determine the stability of generators connected to the Algerian network 400 kV for the peak winter 2009; we use the software SICRE and the following simulations were carried out: [11][13][14]
• Loss of one or more combined cycle power plant
• Different short circuits on the lines close to all power plants connected to the 400 kV.

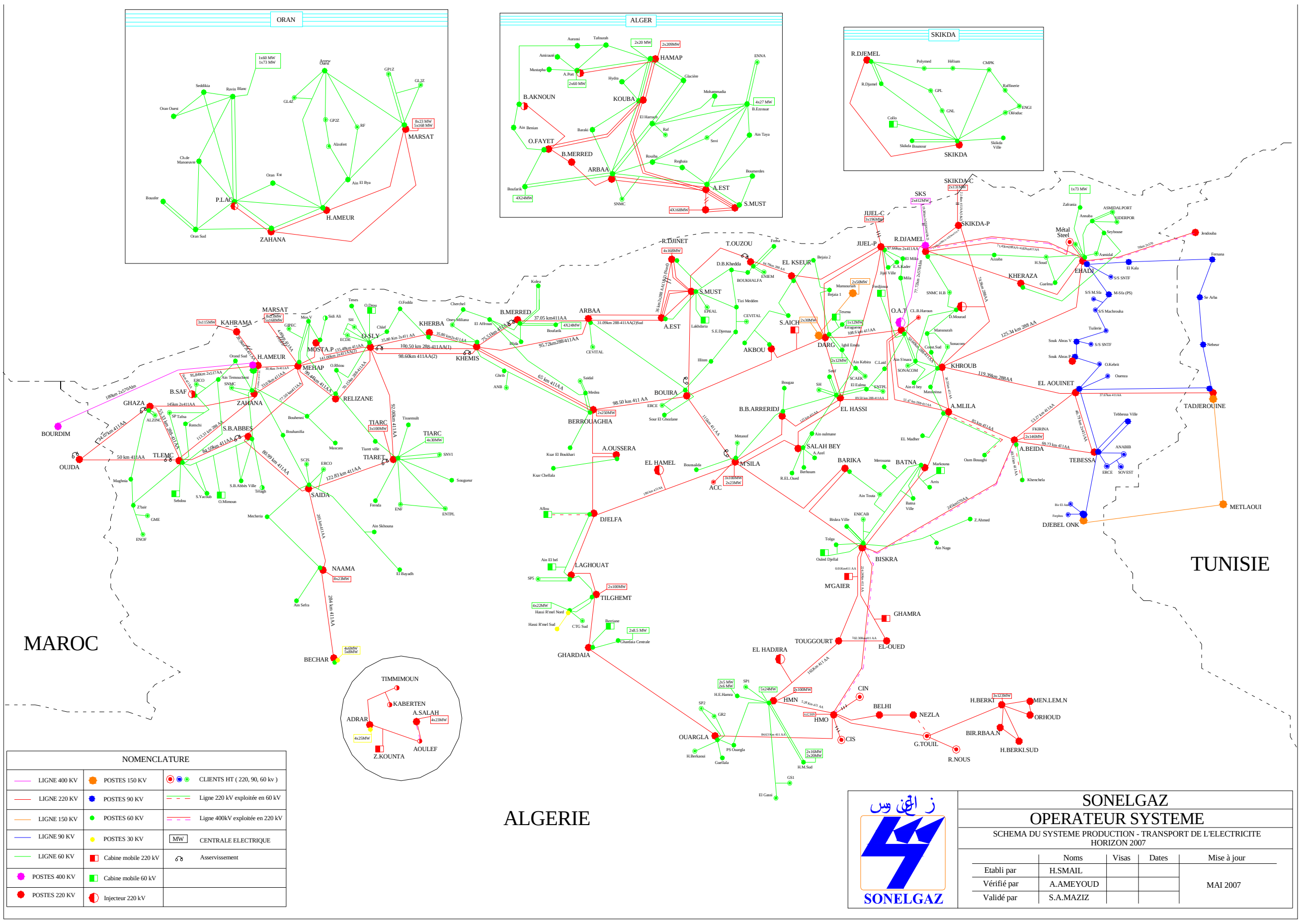

Fig. 2. Algerian Network Map [4].

6 Results of the Simulations

6.1 Loss of one or more Combined Cycle

6.1.1 Normal Situation

In normal situation, the network operates without constraints.

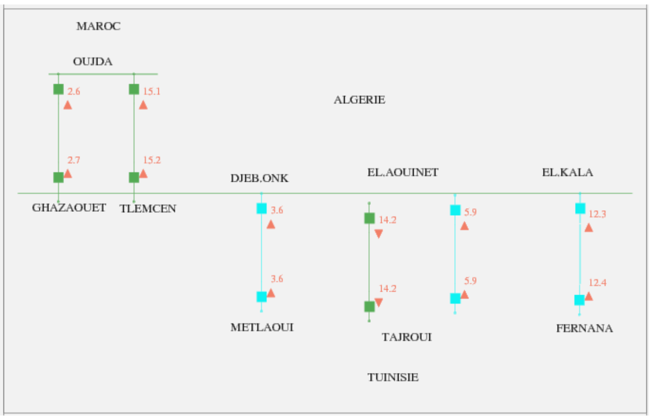

Fig. 3. Active transits on the interconnection lines Algeria –Morocco and Algeria-Tunisia (normal situation)

6.1.2 Loss of a Combined Cycle (400MW) at the Power Plant of SKH

Active transits on the interconnection lines Algeria-Tunisia and Algeria-Morocco are presented on the following figure:

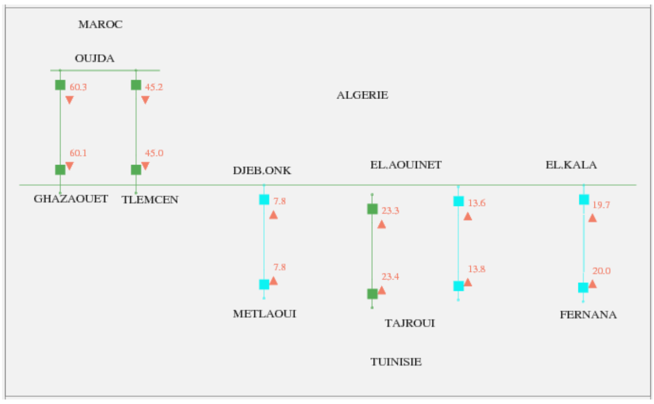

Fig. 4. Active transits on the interconnection lines Algeria-Tunisia and Algeria-Morocco (Loss of a CC 400MW)

After the loss of the group, transits on the interconnection lines with Morocco pass from 18MW (Algeria→Morocco).to105MW (Morocco→ Algeria)
Transits on interconnection line with Tunisia pass from 8MW(Tunisia→Algeria) to 64 MW (Tunisia→Algeria). The rest (222MW) is offset by production groups of Algeria (primary setting).

6.1.3 Loss of two combined cycle (800MW) the first CC at the power plant SKS and the second CC at the power plant SKH

After the loss of two groups, transits on the interconnection lines with Morocco pass from 18MW (Algeria→Morocco).to 205MW (Morocco→ Algeria)
Transits on interconnection line with Tunisia pass From 8MW(Tunisia→Algeria) to 140 MW (Tunisia→Algeria); The rest (445MW) is offset by production groups of Algeria (primary setting). Active transits on the interconnection lines Algeria-Tunisia and Algeria-Morocco are presented on the following figure:

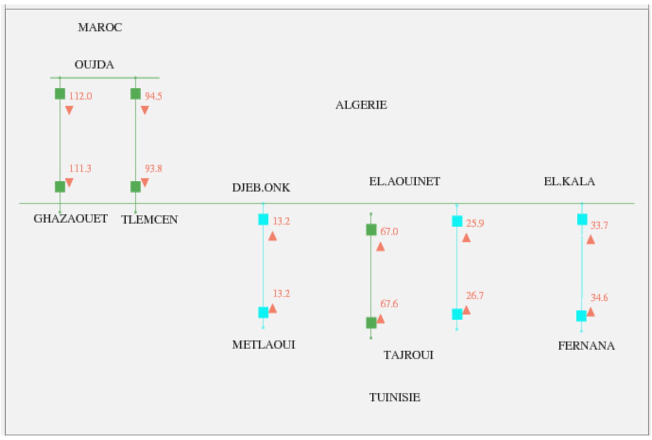

Fig. 5. Active transits on the interconnection lines Algeria-Tunisia and Algeria-Morocco (Loss of two CC 800MW)

6.2 Short circuits on the lines close to all power plants connected to the 400 kV interconnected network

We use the software SICRE and the following simulations were carried out: [6][12]
• First case: The short circuit that causes the loss of synchronism.
• Second case: The short circuit that does not cause loss of synchronism.

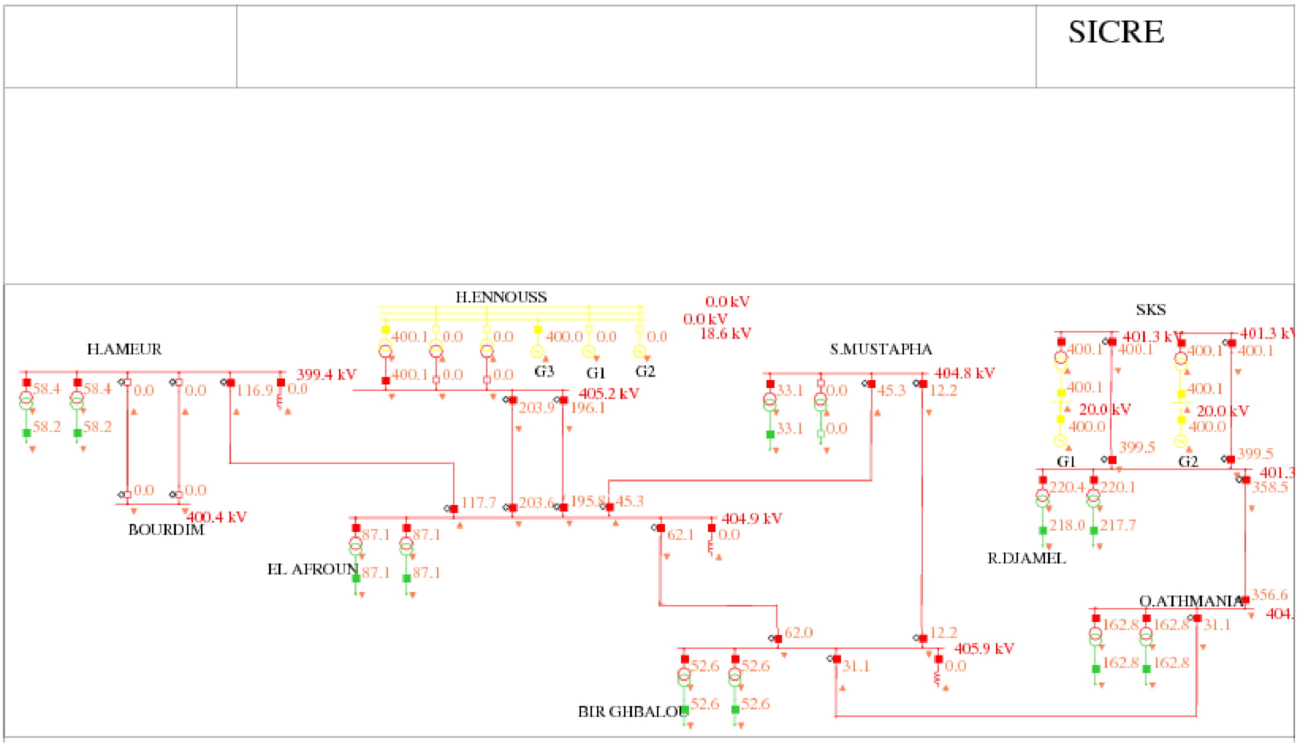

Fig. 6. Voltages at substations 400 kV and active transits on the lines 400 kV (year 2009).

6.2.1 Short-circuit on the Line 400 kV SK.Skikda - Ramdane Djamel

6.2.1.1 First Case

A three-phase short circuit on the 400 kV line SKS-R. Djamel close to the power plant SKS during 0.16s with disabling protection.

This fault causes the loss of synchronism of the interconnected system to 1.720s after application of the fault.

Series of loss of synchronism:

- at 1.720s loss of Group 1 of the power plant SKS.
- at 1.720s loss of Group 2 of the power plant SKS.

To avoid loss of synchronism, it is necessary that the response time of the protections for the elimination of the fault is less than 160 ms.

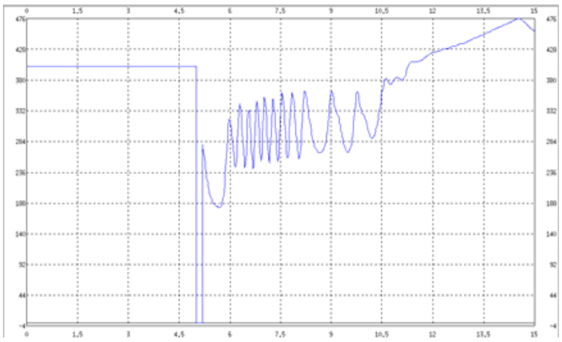

Fig. 7. Voltage at the level of SKS group 1 substation 400 kV.

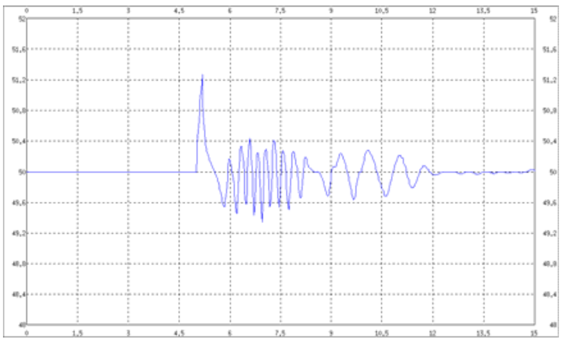

Fig. 8. Frequency at the level of SKS group 1 substation 400 kV.

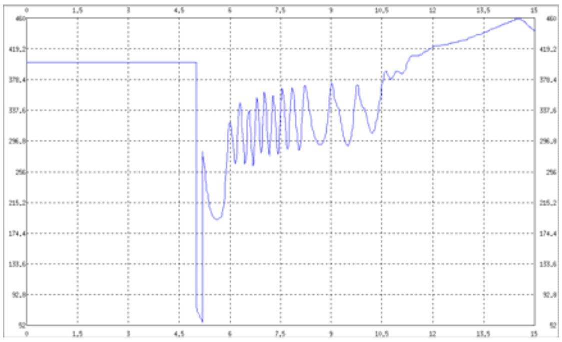

Fig. 9. Voltage at the level of SKS group 2 substation 400 kV.

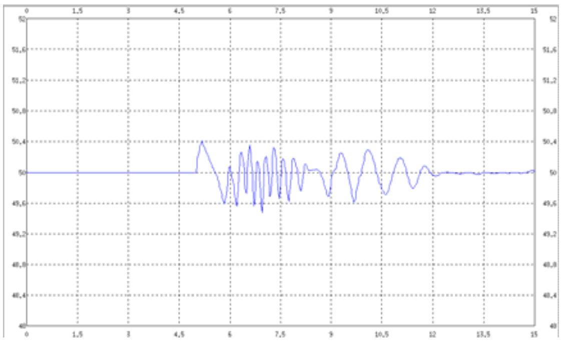

Fig. 10. Frequency at the level of SKS group 2 substation 400 kV.

6.2.1.2 Second Case

A three-phase short circuit on the 400 kV line SKS-R. Djamel close to the power plant SKS during 0.15s with disabling protection.

This fault does not cause loss of synchronism of the interconnected system.

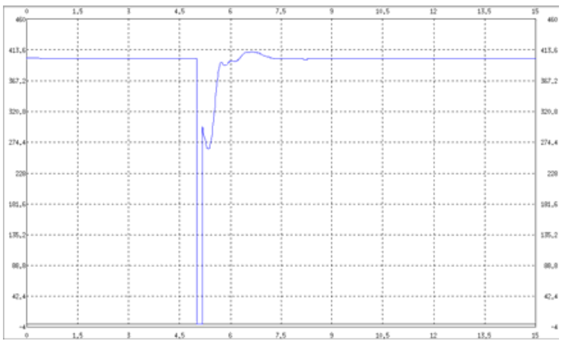

Fig. 11. Voltage at the level of SKS group 1 substation 400 kV.

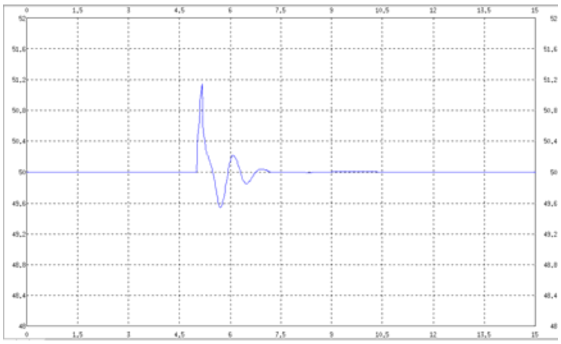

Fig. 12. Frequency at the level of SKS group 1 substation 400 kV.

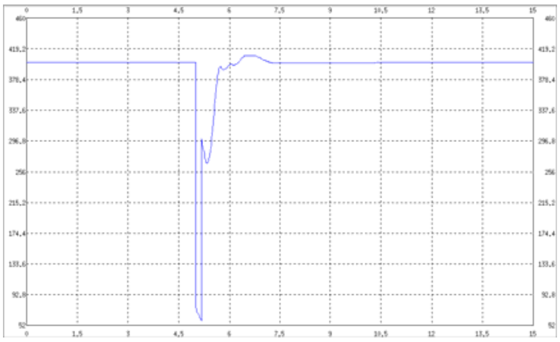

Fig. 13. Voltage at the level of SKS group 2 substation 400 kV.

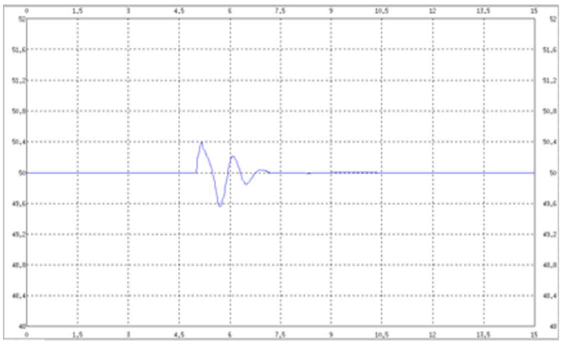

Fig. 14. Frequency at the level of SKS group 2 substation 400 kV.

6.2.2 Short-circuit on the Line 400 kV SK.Hadjrat Ennous - El Afroun

6.2.2.1 First Case

A three-phase short circuit on the 400 kV line Group 3 SKH-El Afroun close to the power plant SKH during 0.20s with disabling protection.

This fault causes the loss of synchronism of the interconnected system to 0.860s after application of the fault.

Series of loss of synchronism:

• at 0.860s loss of Group 3 of the power plant SKH.

To avoid loss of synchronism, it is necessary that the response time of the protections for the elimination of the fault is less than 200 ms.

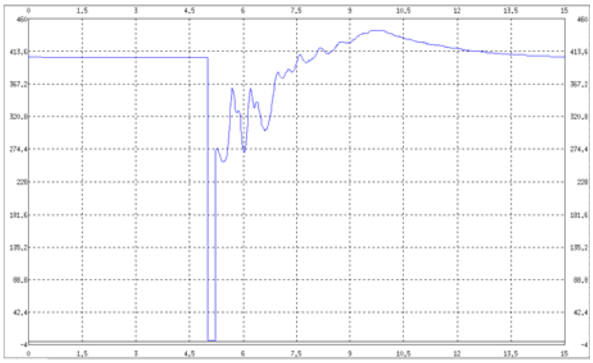

Fig. 15. Voltage at the level of SKH group 3 substation 400 kV.

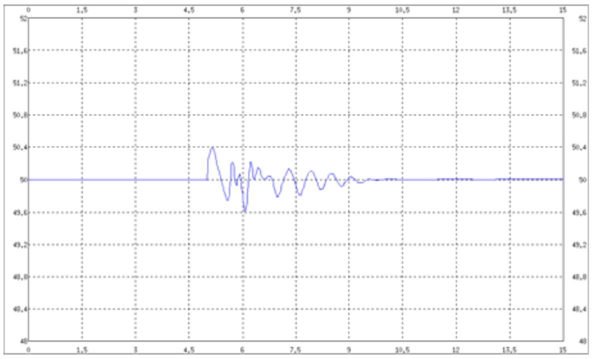

Fig. 16. Frequency at the level of SKH group 3 substation 400 kV.

6.2.2.2 Second Case

A three-phase short circuit on the 400 kV line SKH-

• El Afroun close to the power plant SKH during 0.19s with disabling protection.

This fault does not cause loss of synchronism of the interconnected system.

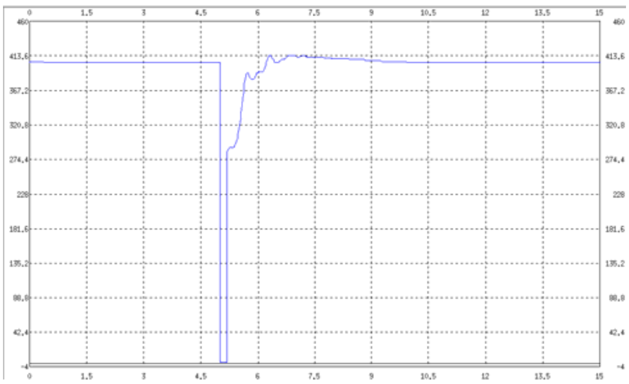

Fig. 17. Voltage at the level of SKH group 3 substation 400 kV.

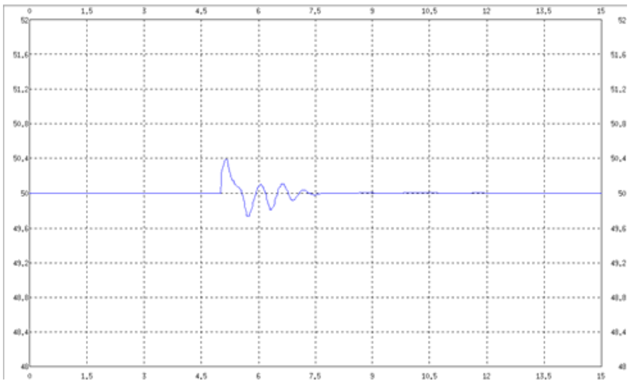

Fig. 18. Frequency at the level of SKH group 3 substation 400 kV.

7 Conclusion

The study of operation of interconnected Algerian network shows that it is sufficiently strengthened to cope with large amplitude disturbances, namely:

• The loss of one or more combined cycle power plant.

The swaying observed in these disturbances is soon damped while the interconnected system keeps up synchronization.

From the simulation results of the loss of synchronism after a three-phase short circuit, we conclude that the zones of protection settings (final disposal of fault) for different power plants connected to the Algerian network 400 kV are:

• 160 ms for the power plant SKS.

• 200 ms for the power plant SKH.

The depasment of this zone could bring back the power plant in the loss of synchronism until the blackout if emergency measures are not taken immediately (ms).

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