International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
Foundation of Computer Science FCS, New York, USA
Volume 6– No. 6, December 2013 – www.ijais.org

Improving the Performance of a Real High Voltage Network in the Casablanca Region

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ABSTRACT

In this paper, it proposes to develop the application to calculate the Load flow in order to control the violation of nodal voltages limits of the network and the exceeding in power limit of transport lines. This method is applied to a real grid with 24 nodes in Casablanca. We have expanded our work by detecting the critical node and injecting FACTS to keep the network in good operating conditions.

Keywords

load flow, Newton-Raphson, static compensator of reactive power, FACTS Transmission System Alternating Current.

1. INTRODUCTION

The growing development of the Moroccan industrial sector, the evolution of the national electricity grid and rural electrification rate reached 97.4 in 2011 thanks to new strategies for design and operation. And later fast growth in demand for electrical energy which required the entry into service of new power plants and energy exchange between neighboring countries by international interconnections hence the need to strengthen the transmission system while respecting safety regulations in force.

This growing demand for energy and structural complexity are based on current problems in online conduct which leads to the weakening of the power grids and subsequently unable to maintain their stability.

The compensation of reactive power for holding the voltage and enhancing transmission capacity of the lines have become indispensable for the maintenance of the stability of the network, so the transmission systems are used to improve the stability of the grids, to increase transmission capacity of transport lines and to damp the oscillations of power. These devices operate on the voltage and / or impedance of the line by injecting the necessary amount of active power and / or reactive. FACTS are divided into 3 types:

Parallel FACTS: The idea is to provide or absorb reactive power to alter the natural characteristics of the lines in order to make them more compatible with the load. In steady state, the reactive compensation is used to maintain the voltage at the nodes. In transient state, the shunt devices provide a dynamic voltage control to improve transient stability and to damp the power oscillations. Some models of parallel FACTS are the SVC (Static VAR Compensator), TSC (Thyristor Switched Capacitor) and STATCOM (Static Compensator).

Serial FACTS: These devices are the evolutions of serial fixed capacitor. They usually act by inserting a capacitive voltage on the transport line which compensates for the inductive voltage drop. They also modify the effective reactance of the line. The inserted voltage is proportional and perpendicular to the current flowing in the line. Types of series FACTS are TCSC (Thyristor Controlled Series Capacitors) and SSSC (Static Synchronous Series Compensator)

Hybrid FACTS : Hybrid FACTS devices can act on one of the three parameters determining the power transmitted in a line (voltage, impedance and angle) by a combination of both types of devices (shunt and series), it is possible to obtain hybrid devices able to control simultaneously all different variables mentioned above. The main types are the UPFC (Unified Power Flow Controller), the IPFC (Interline Power Flow Controller) and TCPAR (Thyristor Controlled Phase Angle Regulator) [1].

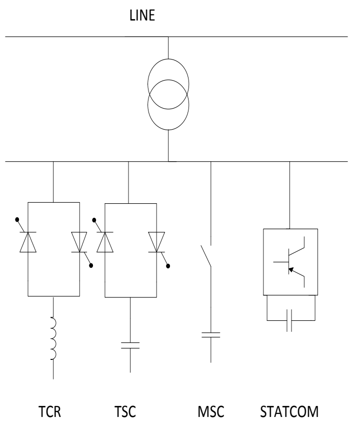

Fig1: parallel FACTS

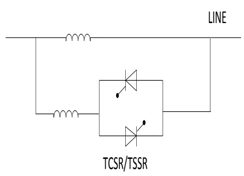

Fig2: serial FACTS TCSR

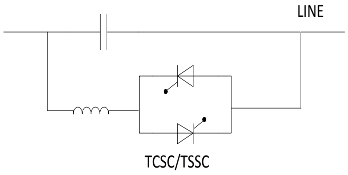

Fig 3: series FACTS TCSC

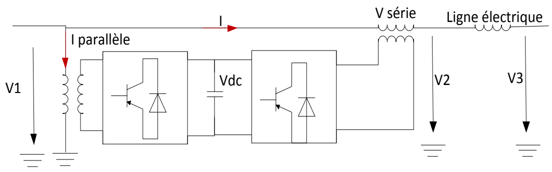

Fig4: hybrid FACTS UPFC

2. PRESENTATION OF THE NETWORK OF THE REGION OF CASABLANCA

The transmission and subtransmission system 225kV is represented by the network shown in Figure 5, the network composes of 24 nodes with 6 nodes generation, the other nodes are loads (system data are from the year 2012).

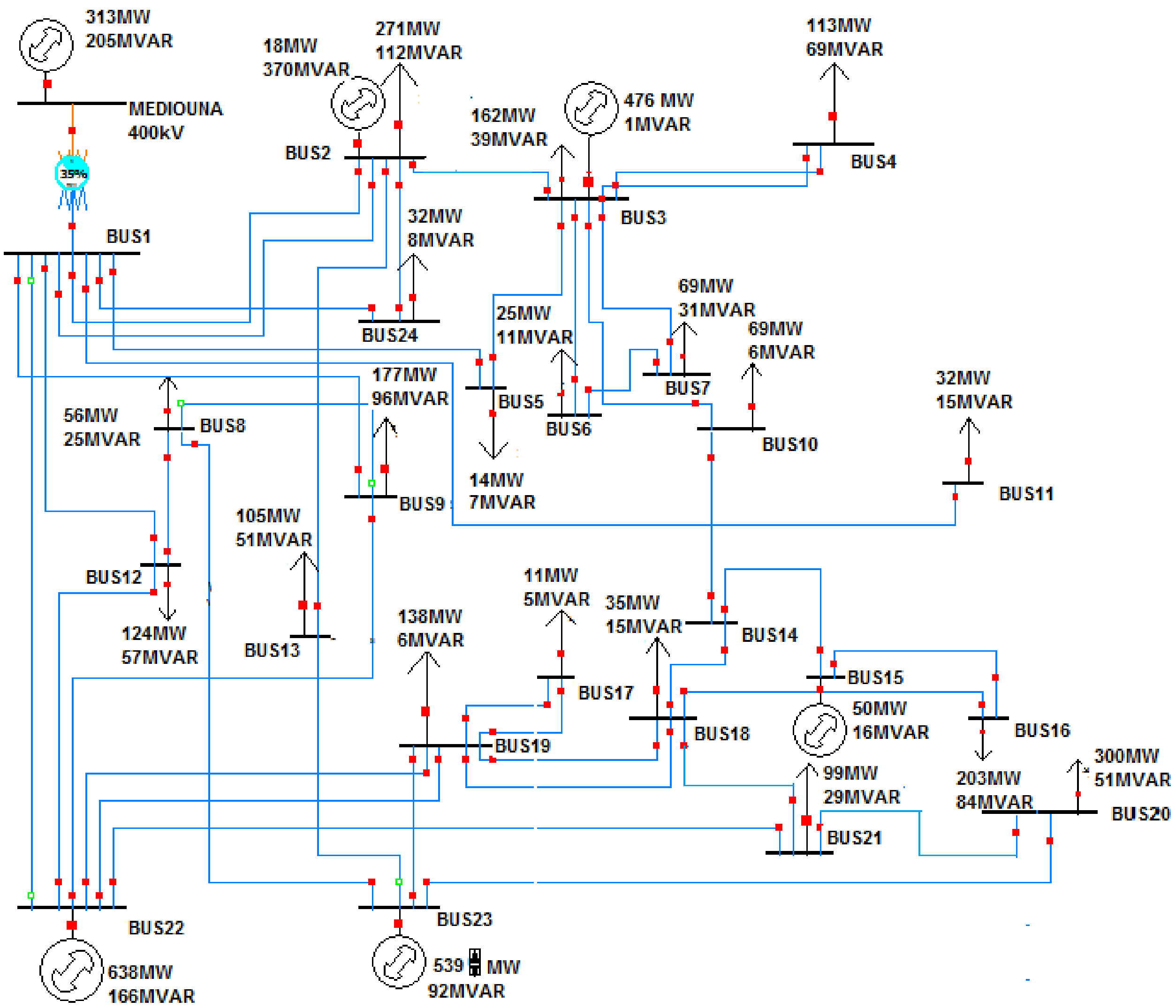

Fig 5 :Network 225kV of the region of Casablanca

International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
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3. RESAULT OF LOAD FLOW

The results of the calculation of load were calculated by the Newton-Raphson method.

Table1: Results of load flow

Calcul du load flow par newton raphson

Bus No	V pu	Angle Degree	Injection MW	Injection MVar	Generation MW	Generation Mvar	Load MW	Load MVar
1	1.0000	0.0000	199.158	242.490	199.158	242.490	0.000	0.000
2	1.0040	-0.7571	-253.100	256.068	18.000	368.468	271.100	112.400
3	1.0000	0.2572	348.500	196.069	474.000	234.569	125.500	38.500
4	0.9708	-1.5326	-113.200	-69.100	0.000	0.000	113.200	69.100
5	0.9996	0.1642	-14.000	-7.000	0.000	-0.000	14.000	7.000
6	0.9990	0.1632	-25.000	-11.000	0.000	0.000	25.000	11.000
7	0.9982	0.0985	-68.600	-30.600	0.000	0.000	68.600	30.600
8	0.9293	4.0896	-55.600	-25.200	0.000	0.000	55.600	25.200
9	0.8498	-0.0464	-176.700	-96.400	0.000	0.000	176.700	96.400
10	0.9258	0.8332	-60.000	-6.300	0.000	0.000	60.000	6.300
11	0.9841	-1.0319	-32.000	-15.400	0.000	-0.000	32.000	15.400
12	0.9446	2.4775	-124.400	-57.400	0.000	0.000	124.400	57.400
13	1.0003	-1.0642	-105.100	-51.100	0.000	0.000	105.100	51.100
14	0.8736	3.6224	0.000	0.000	0.000	0.000	0.000	0.000
15	0.8643	3.5253	49.800	15.309	49.800	15.309	0.000	0.000
16	0.8257	1.7127	-202.700	-83.600	0.000	0.000	202.700	83.600
17	0.8929	12.6324	-10.500	-5.200	0.000	-0.000	10.500	5.200
18	0.8592	7.3107	-35.300	-14.500	0.000	0.000	35.300	14.500
19	0.8933	12.6711	-137.800	-5.500	0.000	0.000	137.800	5.500
20	0.7447	-4.9408	-300.200	-51.100	0.000	0.000	300.200	51.100
21	0.8169	3.8645	-99.300	-29.100	0.000	0.000	99.300	29.100
22	0.9040	13.8610	660.000	171.937	660.000	171.937	0.000	0.000
23	0.9049	15.6583	660.000	87.620	660.000	87.620	0.000	0.000
24	1.0028	-0.6325	-32.000	-8.300	0.000	-0.000	32.000	8.300
Total			71.958	402.694	2060.958	1120.394	1989.000	717.700

International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
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Powers transited through transport lines are as follows:

Table2: Parameters and transited power of transport lines

Line	From Bus N°	To Bus N°	R (pu)	X(pu)	C(pu)	S Lim (MVA)	S Tansit (MVA)
L1	2	1	0.00193	0.01185	0.20039	301.0	135.1
L2	2	1	0.00193	0.01185	0.20039	301.0	135.1
L3	1	5	0.00300	0.01699	0.02763	301.0	39.5
L4	9	1	0.01985	0.12774	0.03706	301.0	117.2
L5	1	11	0.01774	0.06392	0.12352	187.0	36.1
L6	12	1	0.00373	0.02406	0.03817	301.0	285
L7	1	24	0.00166	0.01106	0.02138	301.0	119.6
L8	3	2	0.00336	0.01692	0.02863	301.0	46.1
L9	13	2	0.00086	0.00554	0.00954	350.0	117.3
L10	2	24	0.00047	0.00316	0.00611	301.0	95.8
L11	3	4	0.01053	0.06778	0.11400	350.0	74.9
L12	3	4	0.01280	0.05515	0.09200	301.0	61.8
L13	3	5	0.00097	0.00548	0.02900	301.0	31.1
L14	3	6	0.00047	0.00316	0.00477	301.0	60.9
L15	7	6	0.00059	0.00395	0.00636	301.0	33.6
L16	3	7	0.00121	0.00780	0.01272	301.0	41.6
L17	12	8	0.00227	0.01517	0.02449	301.0	183.6
L18	23	8	0.01427	0.07747	0.20517	350.0	218.4
L19	9	23	0.01427	0.07747	0.13000	350.0	159.8
L20	3	10	0.01481	0.06044	0.10338	301.0	114.3
L21	14	10	0.01304	0.05333	0.09065	301.0	119.6
L22	22	12	0.02153	0.13837	0.22266	350.0	125.8
L23	15	14	0.00390	0.01511	0.02400	218.0	52.3
L24	14	18	0.01779	0.05584	0.09100	162.0	89.2
L25	15	16	0.01073	0.04156	0.06700	218.0	94.5
L26	16	18	0.00801	0.05341	0.08028	301.0	136.9
L27	19	17	0.00160	0.01106	0.01749	301.0	5.9
L28	19	17	0.00160	0.01106	0.01749	301.0	5.9
L29	19	18	0.00696	0.04480	0.07500	301.0	169.7
L30	19	18	0.01003	0.04410	0.07101	226.0	170.1
L31	21	18	0.01695	0.05546	0.08931	187.0	97.4
L32	22	19	0.00251	0.01618	0.02600	350.0	117.7
L33	23	19	0.00258	0.01659	0.02704	350.0	114.8
L34	23	19	0.00258	0.1576	0.22139	350.0	272.1
L35	21	20	0.02127	0.07376	0.12100	226.0	135.5
L36	23	20	0.02264	0.14571	0.23538	350.0	169
L37	21	22	0.01360	0.08754	0.14200	350.0	160

Limit of the voltages of nodes and transmissible power :

- The limit of 225 KV voltage is between 202.5 kV and 245 kV that to say is between 0.9 and 1.05 pu.
- The limit of transited power in the lines is 0,7 S_{limite} lines.

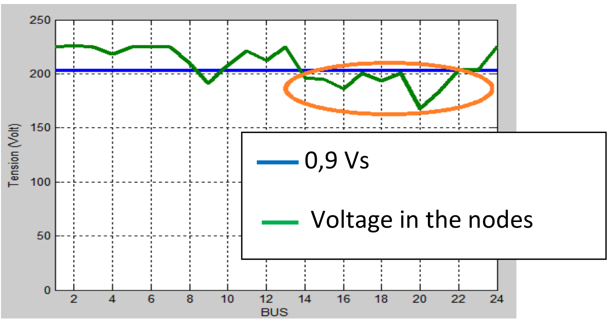

Fig6 : Curve with overruns voltage in the Bus

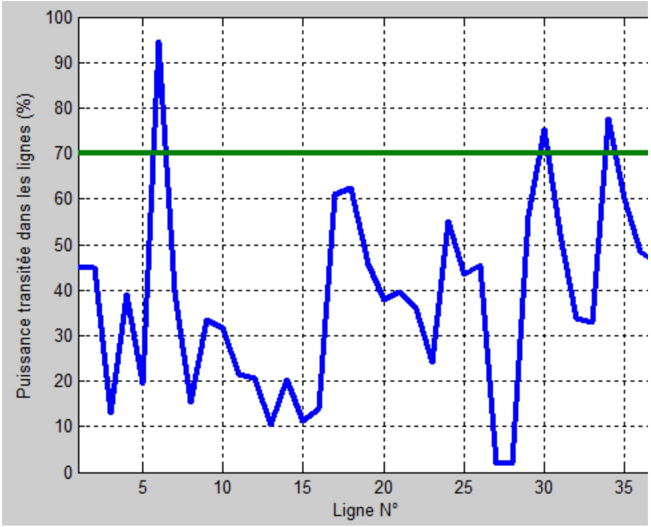

Fig7: Overtaking curve with 70% of the power limit on lines

Interpretations: The lot of voltage drops that exceed the limit tolerated on busbar 225kV particular on nodes 14, 15, 16, 17, 18, 19 and 20.

The lines MEDIOUNA - OULADHADDOU; SIDI BENNOUR - GHANEM2; GHANEM - Official Journal LASFAR2, have exceeded over 70% of the power limit.

Checking the safety rule: In the operation of an electrical system, we are reminded that it is possible at any time that the network or production groups trigger, hence the necessity for the other intact lines can support the failure at some level, by making triggers of the lines, it was found that the onset of the line number 22 and line number 18 causes blackout whence the non-compliance of the rule N-1 [2], [3].

To limit the overtaking power transport lines and to restore the rule of security N-1, we opt for the installation of FACTS on the line number 36.

It has conducted in parallel a technical-economic study for the choice of the appropriate FACTS device and therefore its contribution to the maintenance of the stability and the good performance of the network. In principle, the TCSC (Thyristor Controlled Series Capacitors) and a capacitor battery are able to overcome these different abnormalities of the network namely by the voltage setting, the distribution of power flow, the improvement of the stability and mitigation of power oscillations while minimizing the cost of investment comparing to the UPFC [1], [4], [5].

Table3: selection criteria of FACTS

Device	Control of power flow	Voltage Control	transient stability	static stability
SVC	+	+++	+	++
STATCOM	+	+++	++	++
TCSC	++	+	+++	++
UPFC	+++	+++	+++	+++

So it inserts a TCSC in the line number 36 with parameter compensation by 30%, and capacitor batteries of 14 MVAR in bus number 20 [1], [6], [7].

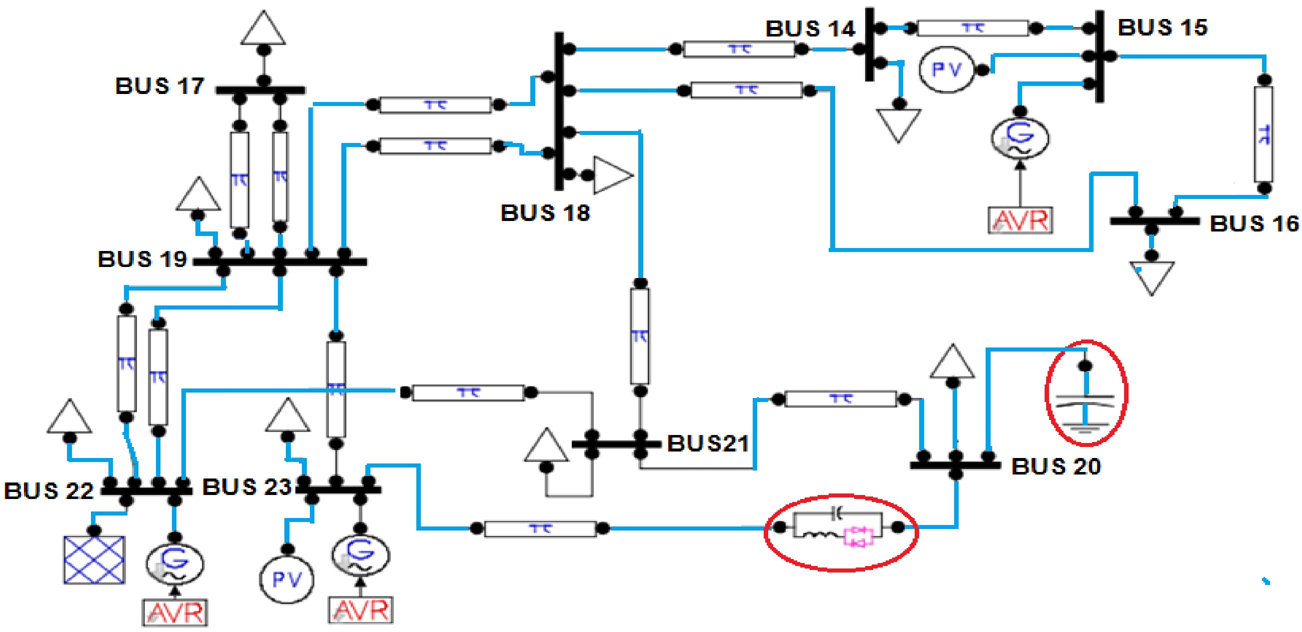

Fig8 : Diagram of the proposed solution in PSAT

International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
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The results obtained before and after the insertion of TCSC and capacitor battery on Bus number 20.

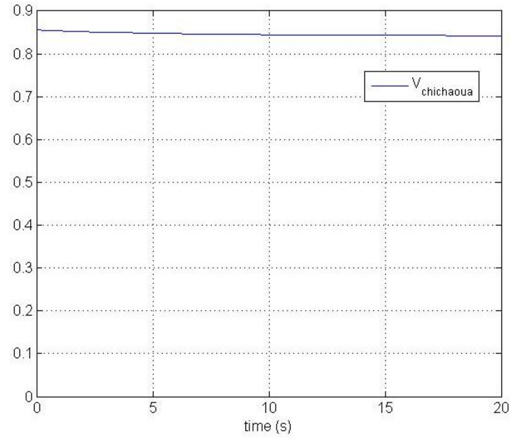

Fig 9: CHICHAOUA bus voltage before correction

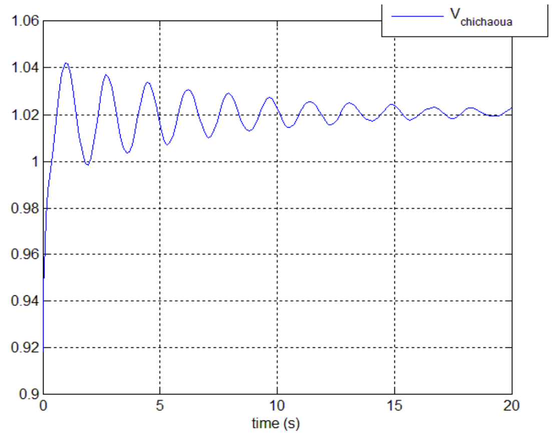

Fig10: CHICHAOUA bus voltage after correction

Fig 11 : PV curve before implantation of the TCSC

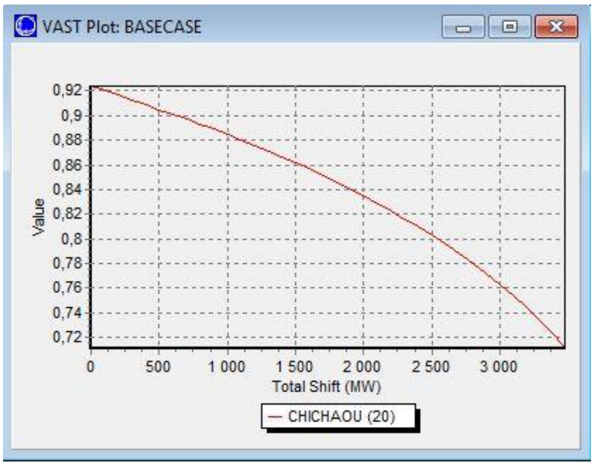

Fig12 : PV curve after implantation of the TCSC

So there is no more voltage drop on the bus or exceeded 70% of the power limit lines.

Table 4 – Result of the calculation of the load flow after correction

Bus Records										
Number	Nom kV	PU Volt	Volt (kV)	Angle (Deg)	Load MW	Load Mvar	Gen MW	Gen Mvar	Switched Sh	Tension adm
1	225	1.01137	227.559	39.68						202.5
2	225	1.01312	227.953	38.82	271.1	112.4	18	369.44		202.5
3	225	1	225	39.37	125.5	38.5	343.62	101.11		202.5
4	225	0.97084	218.439	37.58	113.2	69.1				202.5
5	225	1.00238	225.535	39.42	14	7				202.5
6	225	0.99895	224.764	39.28	25	11				202.5
7	225	0.99822	224.6	39.21	68.6	30.6				202.5
8	225	0.97096	218.466	43	55.6	25.2				202.5
9	225	0.90176	202.895	39.59	176.7	96.4				202.5
10	225	0.9586	215.686	40.32	60	6.3				202.5
11	225	0.99563	224.016	38.67	32	15.4				202.5
12	225	0.97797	220.044	41.71	124.4	57.4				202.5
13	225	1.00941	227.117	38.52	105.1	51.1				202.5
14	225	0.93504	210.384	43.2						202.5
15	225	0.92916	209.062	43.14			49.8	16.2		202.5
16	225	0.90029	202.565	41.69	202.7	83.6				202.5
17	225	0.96901	218.028	50.39	10.5	5.2				202.5
18	225	0.93861	211.187	46.56	35.3	14.5				202.5
19	225	0.9694	218.115	50.42	137.8	5.5				202.5
20	225	0.89708	201.844	44.39	300.2	51.1			14.08	202.5
21	225	0.92359	207.808	45.85	99.3	29.1				202.5
22	225	0.97809	220.071	51.66			660	166.4		202.5
23	225	0.98063	220.641	52.09			660	91.6		202.5
24	225	1.01239	227.789	38.97	32	8.3				202.5

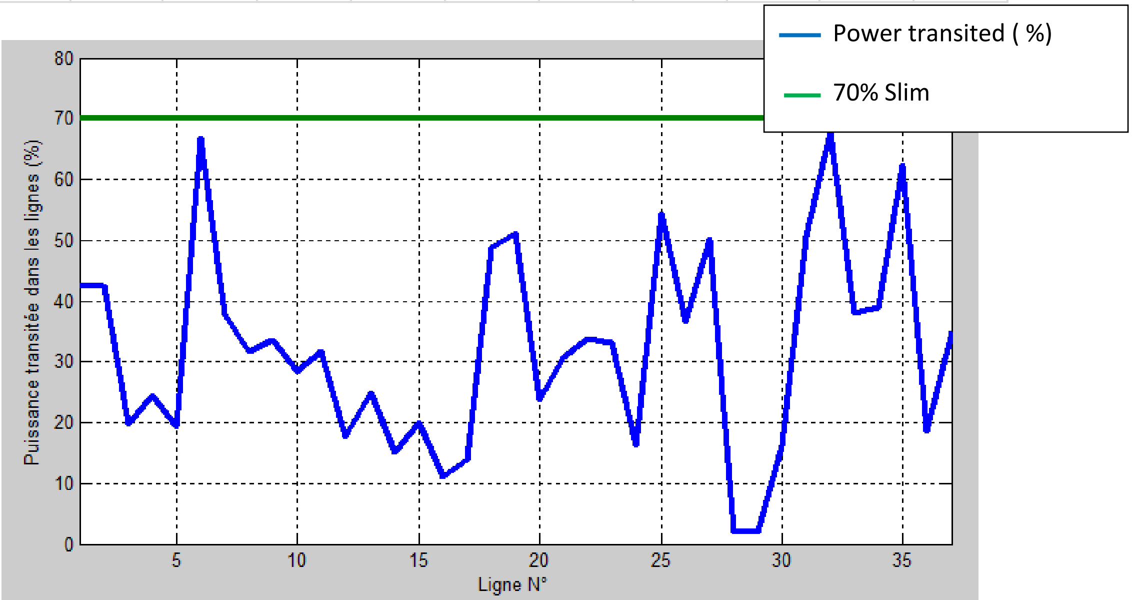

Fig.13- Powers transited through lines after correction

4. CONCLUSION

The introduction of TCSC in the network object of study has allowed us to increase the margin stability of the network, it has allowed us to shift the voltage collapse point to increase the value of reactive power, decrease the apparent reactance of the line and thereafter increasing the transport capacity of the power line and to respect the rule N-1**.**

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