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# Numerical and Selective Method of Reactive Energy Compensation of Limete Substation Feeders

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**Abstract**— *In this article, we proceed to the numerical and selective method of reactive energy compensation of feeders of the Limete substation that have a bad power factor, that is to say a cosine lower than 0.8. We notice that some feeders of the Limete substation have cosine values equal to 0.5. In this article, we propose to bring all feeders to an identical power factor of 0.8; is an important solution in the stable operation of the industrial power network. This will improve the quality of electrical power supplied by the Limete substation, in terms of supply voltage of the industrial area.*

**Keywords**— *Selective, Reactive energy compensation, Feeders, Limete Substation.*

## I. INTRODUCTION

Distributors and users of electrical energy have always been confronted with a number of difficulties inherent to service continuity, power transmission efficiency, voltage amplitude variations, as well as other phenomena such as rapid voltage fluctuations and voltage imbalances.

It is certain that most of the electrical receivers, in the industry, the tertiary sector and even in the domestic sector, are distorting loads (non-linear). They absorb non-sinusoidal currents and these, given the impedances of the circuits, distort the voltage sine wave. However, we are witnessing a regular increase, on the part of the users, of the harmonic and unbalance rates of the currents, as well as an important consumption of the reactive power [1-3].

These elements allow to improve the stability of the system, to control the power transits, to manage the reactive power exchanges in real time and consequently an efficient operation of the networks by continuous and fast action on the various parameters of the network (phase shift, voltage, impedance). The disturbances caused by the growth of reactive power demand have an impact on the stability of an electrical network. The consequences can be very serious, even leading to the collapse of the network [4-10].

A good power factor makes it possible to optimize an electrical installation and brings advantages on the suppression of the invoicing of reactive energy, the reduction of the subscribed power, the limitation of the losses of active energy in cables taking into account the reduction of the intensity conveyed in the installation, the improvement the level of voltage at the end of line, the contribution of additional available power at the level of the power transformers if the compensation is carried out with the secondary [10-12]. A good power factor makes it possible to optimize an electrical installation and brings advantages on the suppression of the invoicing of reactive energy, the reduction of the subscribed power, the limitation of the losses of active energy in cables taking into account the reduction of the intensity conveyed in the installation, the improvement the level of voltage at the end of line, the contribution of additional available power at the level of the power transformers if the compensation is carried out with the secondary. The receivers consuming the most reactive energy are, low load motors, welding machines, arc and induction furnaces and power rectifiers. In the case of no harmonics cosφ is equal to the power factor.

In this article, we propose to bring all feeders to an identical power factor of 0.8; is an important solution in the stable operation of the industrial power network. This will improve the quality of electrical power supplied by the Limete substation, in terms of supply voltage of the industrial area.

## II. ELECTRICAL PARAMETER EQUATIONS

Alternating current electrical networks provide the apparent power in (kVA) which corresponds to the power demand.

$$s = \sqrt{3}\,UI = \sqrt{P^2 + Q^2} \qquad (1)$$

This energy can be broken down into two forms of energy (Figure 1):

Active power in (kW): transformed into mechanical power (work) and heat (loss).

$$P = \sqrt{3}\,UI\,cos\varphi \qquad (2)$$

Reactive power in (kVAr): used to create magnetic fields.

$$Q = \sqrt{3}\,UI\,sin\varphi \qquad (3)$$

Reactive power consumers are asynchronous motors, transformers, inductors (fluorescent tube ballasts) and static converters (rectifiers).

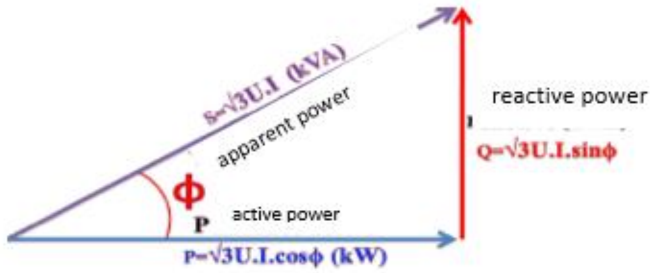


Figure 1: Vector composition of active, reactive and apparent powers

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By definition, the power factor, otherwise known as the cosφ of an electrical device, is equal to the ratio of active power P(kW) to apparent power S (kVA) and can vary from 0 to 1.

$$FP = cos\varphi = \frac{\text{P(kW)}}{\text{S (kVA)}} \quad (4)$$

Energy metering devices record active and reactive energy consumption. Electricity suppliers generally include the term tanφ on their bill.

$$tan\varphi = \frac{\text{q(kVAr)}}{\text{P (kW)}} = \frac{E_r(kVArh)}{E_a(kWh)} \quad (5)$$

The tanφ is the quotient between the reactive energy $E_r(kVArh)$ and the active energy $E_a(kWh)$ consumed during the same period.

In contrast to cosφ, it is easy to see that the value of tanφ must be as small as possible in order to have the minimum reactive energy consumption. The cosφ and the tanφ are linked by the following relation:

$$FP = cos\varphi = \frac{1}{\sqrt{1 + (tan\varphi)^2}} \quad (6)$$

The active, reactive, and apparent currents, as well as the phase shift, are related by the following relations:

$$I_t = \sqrt{{I_a}^2 + {I_r}^2} \quad (7)$$

$$I_a = I_t \, cos\varphi \quad (8)$$

$$I_r = I_t \, sin\varphi \quad (9)$$

With Ia: the active current, Ir the reactive current and It the total apparent current.

## III. APPLICATION A LA SOUS-STATION LIMETE

### *III.1 Données techniques des feeders*

#### *III.1.1 Feeders à compenser*

| F | cos | sin | tg | P (kW) |
|---|---|---|---|---|
| F61 | 0.5 | 0.86 | 1.73 | 1313.07 |
| F74 | 0.5 | 0.86 | 1.73 | 1341.615 |
| F63A | 0.5 | 0.86 | 1.73 | 1353.033 |
| F72A | 0.5 | 0.86 | 1.73 | 1084.71 |
| F72B | 0.5 | 0.86 | 1.73 | 1301.652 |

#### *III.1.2 Feeders non à compenser*

| F | cos | sin | tg | P (kW) | | |
|---|---|---|---|---|---|---|
| F69 | 0.8 | 0.59 | 0.74 | 1826.88 | 1331.85 | 2272.08 |
| F71 | 0.8 | 0.59 | 0.74 | 1370.16 | 1010.49 | 1702.47716 |
| F67 | 0.8 | 0.59 | 0.74 | 310.569 | 229.045 | 385.894695 |
| F76 | 0.8 | 0.59 | 0.74 | 1187.472 | 875.176 | 1475.48139 |
| F68 | 0.8 | 0.86 | 0.74 | 730.752 | 538.929 | 907.78 |
| F61B | 0.8 | 0.59 | 0.74 | 1872.552 | 1381.007 | 2326.72115 |
| F63B | 0.8 | 0.59 | 0.74 | 1324.488 | 976.809 | 1645.7291 |
| F73 | 0.8 | 0.59 | 0.74 | 1452.369 | 1071.122 | 1804.62685 |
| F65A | 0.8 | 0.59 | 0.74 | 1297.084 | 956.6 | 1611.67939 |
| F70 | 0.8 | 0.59 | 0.74 | 1004.784 | 741.028 | 1248.48443 |
| F60 | 0.8 | 0.59 | 0.74 | 858.633 | 633.242 | 1066.88615 |
| F64 | 0.8 | 0.59 | 1.73 | 1516.31 | 1118.278 | 1884.07582 |
| F72C | 0.8 | 0.86 | 1.73 | 610.863 | 1050.68436 | 1215.35642 |

### *III.2 Résultat de la compensation des feeders*

Figure (2) shows the variation of the reactive power to be compensated in the network as a function of the active power of the network. We can see that the reactive power of the network increases when its active power increases.

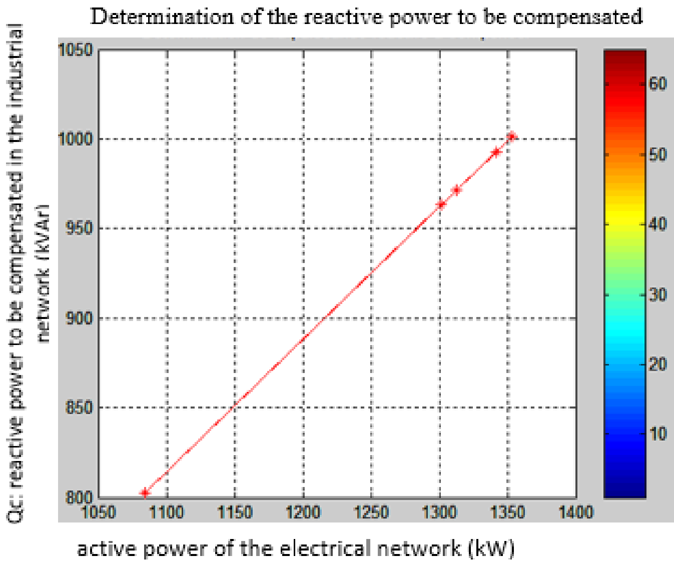


Figure 2 : Determination of the reactive power to be compensated

In Figure 2, we have presented the variation of the reactive power as a function of the reactivated power to be eliminated for different values of Q.

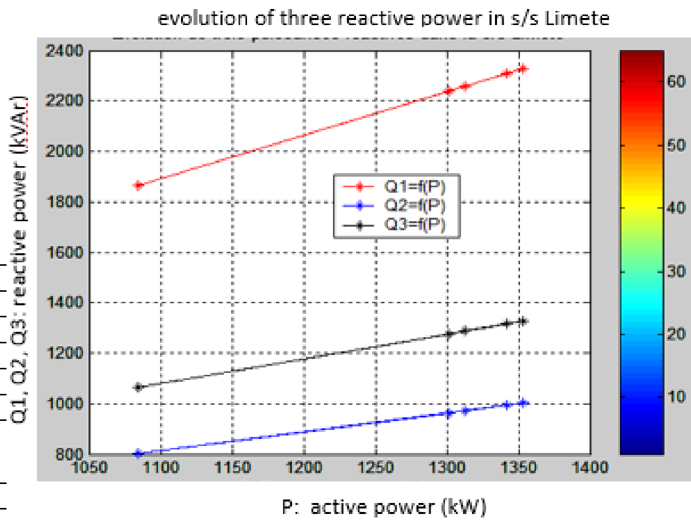


Figure 3 : Determination of the reactive power to be eliminated

In figure (4), the variation of the battery capacity as a function of the compensated reactive power is shown. This variation increases when the power increases.

In figure (5), we have plotted the compensation capacity of the batteries and the capacitor capacity as a function of the compensated reactive power. These capacities increase when the power increases.

Figure 6 shows the evolution of the reactive current as a function of the reactive power of the compensation. We notice that the reactive current increases as the power increases.

The evolution of the pre- and post-compensation load rates as a function of the new load rate is presented in Figure 7. We note that the post-compensation load rate is around 60% comparable to the pre-compensation rate which varies around 80%.

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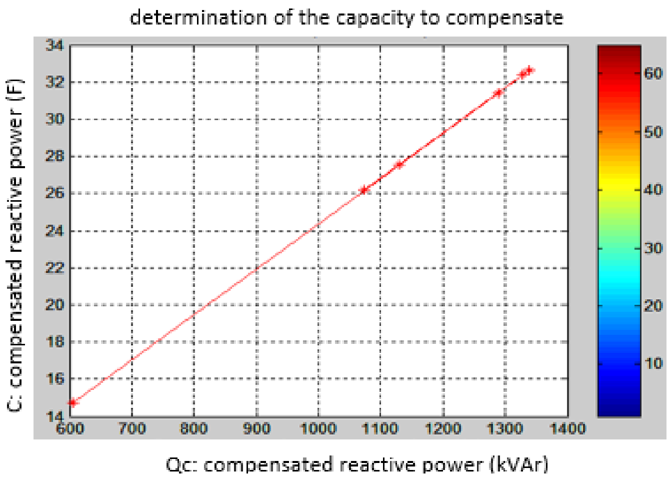


Figure 4 : Determining the capacity of battery compensations

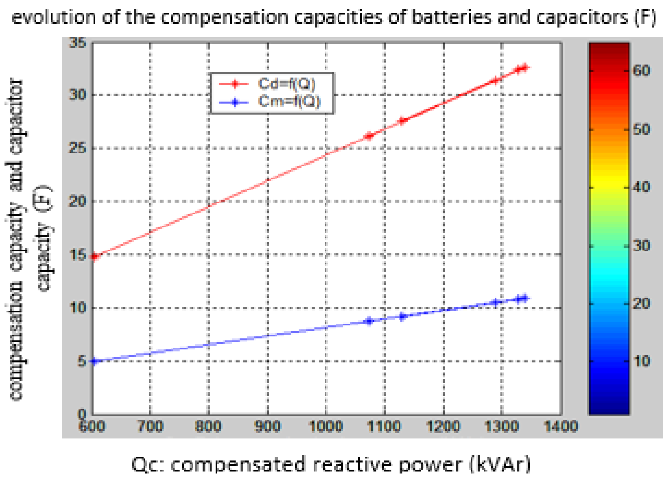


Figure 5 : Determination of the capacitance of compensation capacitors

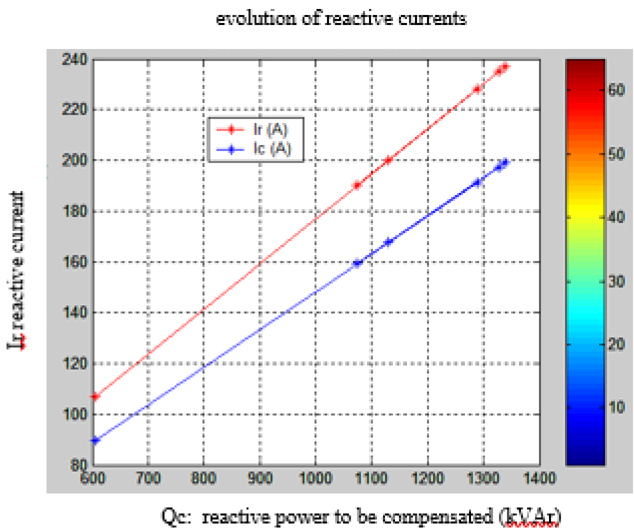


Figure 6 : Determination of the compensation current

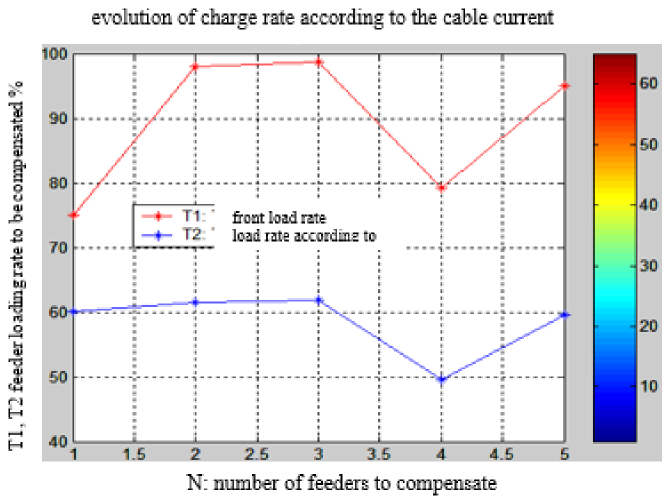


Figure 7 : Determination of the new compensation loading rate

## IV. CONCLUSION

This article was devoted to the simulation of the selective compensation of the reactive power at the feeders of the limete substation. by reducing the power factor by a cosine of 0.8 to the five feeders to be compensated. We found that for each feeder, the charge rate dropped by 15% at the level of the allowable current of the feeders. on the other hand, at the level of the transformer current, the charge rate drops by 3%.

## REFERENCES

[1] Normes IEEE Std 519-1992; IEEE recommended practices and requirements for harmonie control in electrical power systems; 12 April1993, Page(s):15- 99.

[2] Canadian National Power Quality Survey: Frequency of Industrial and Commercial Voltage Sags; D.O Koval, M.B Hughes; IEEE Trans. lnd. Appl., Vol. 33, No. 3, MAY/JUNE 1997, Page(s):622- 627.

[3] Voltage support by distributed static VAr systems (SVS); S. Kincic, X.T. Wan, D.T. McGillis, A. Chandra, Ooi. Boon-Teck, F.D. Galiana,

[4] H. Dutrieux. Méthodes pour la planification pluriannuelle des réseaux de distribution. Application à l'analyse technico-économique des solutions d'intégration des énergies renouvelables intermittentes. Thèse, Ecole Centrale de Lille, Novembre 2015.

[5] M. Stubbe, B. Meyer, and M. Jerosolimski. Outils de simulation dynamique des réseaux électriques. Techniques de l'ingénieur : Réseaux électriques de transport et de répartition, Cahier D(4120), Novembre 1998.

[6] G. Delille. Contribution du Stockage à la Gestion Avancée des Systèmes Électriques. Approches Organisationnelles et Technico-économiques dans les Réseaux de Distribution. Thèse, Ecole Centrale de Lille, Novembre 2010.

[7] Cong, L., Y. Wang et D. J. Hill. 2005. « Transient stability and voltage regulation enhancement via coordinated control of generator excitation and SVC ». International Journal of Electrical Power and Energy Systems, vol. 27, n° 2, p. 121-130.

[8] P. Kundur and a. al., "Definition and classification of power system stability," IEEE Trans. Power Syst., vol. 19 No.2, Mai 2004.

[9] Chang, Y., et Z. Xu. 2007. «A novel SVC supplementary controller based on wide area signais». Electric Power Systems Research, vol. 77, n° 12, p. 1569-74.

[10] Chaudhuri, B., R. Majumder et B. C. Pal. 2004. « Wide-area measurement-based stabilizing control of power system considering signal transmission delay ». IEEE Transactions on Power Systems, vol. 19, n° 4, p. 1971-1979.

[11] A General Circuit Topology of Multilevel Inverter, S. Choi7 J- G-Cho,and GH. Cho, IEEE 22nd Annual Power Electronic Specialist Conference, 199 1, pp.96- 103.

*Volume 7, Issue 4, pp. 1-4, 2023.*
*ISSN (Online): 2456-7361*

[12] Chen, J. Y., T. T. Lie et D. M. Vilathgamuwa. 2004. « Damping of power system oscillations using SSSC in real-time implementation ». International Journal of Electrical Power and Energy Systems, vol. 26, n° 5, p. 357-364.