A Research and Solution Proposal for Reactive Power Problems in North Cyprus Industries

Özgür C. Özerdem[1] Samet Biricik[2]

Near East University, Nicosia, North Cyprus
[1]oozerdem@neu.edu.tr, [2]sbiricik@neu.edu.tr

Abstract

Quality of electrical energy is an important issue which has to be considered carefully. This paper examined the basic power quality problems and made a comparative study on the solutions of one of the most important power quality problem "compensation of reactive power" in Northern Cyprus. In this study conversional methods are used. For analyzing Reactive Power problems, Bozkaya Mine company power systems are investigated as a pilot case of reactive power problems in North Cyprus.

1. Introduction

Identifying problems in an electrical network before any extensive damage occurs is advisable for any power system. Monitoring of power quality is not necessary for the accurate operation of sensitive equipment; it also serves in identification of unnecessary energy losses in a power system which leads to minimizing the expenditures, especially for mines. The power quality problems occur due to different reasons. Voltage sags are generally caused by faults (short circuit) on the system [1]. Overloads can be another cause although it can be termed as being an under voltage phenomenon or a voltage step the other causes of sags also occur when large motors start [2]. Motors have the undesirable effect of drawing several times their full load current while starting. This high reactive current (5-7 times of rated current) from the supply during the starting process lost for about 30 cycles. This sudden rise of current flow through the network impedance results in the voltage sag at the terminal bus. The sag magnitude mainly depends on the starting motors power rating the network impedance and the system source strength [3]. Voltage sag (dip) is a power quality problem that is prevalent in any power system. It is said to be one of the main problems of power quality. It is a decrease of the RMS voltage or current to between 0.9 and 0.1 per unit (pu) at the power frequency for a duration of ½ a cycle to 1 minute [4]. Phase jumps occur due to the difference of X/R ratio the source and that of the faulted feeder [5].

AC electrical machines and other inductive loads used in industry draw reactive power from the line. The reactive power causes overloading effects on the line, circuit breakers, transformers, relays and insulations. Reactive power cannot be transformed into mechanical power. In addition, the reactive power also increases the dimension of cables used in the transmission line. Therefore, the structure of all equipments used in the line has to be strong enough to carry the huge weight of the cables. Therefore, the cost of the system is increased, and the efficiency of the system is reduced. To reduce the cost and to improve the efficiency, the reactive power drawn from the line has to be decreased by supplying it from some other source.

This paper presents common power quality problems prevalent in Northern Cyprus due to Reactive Power.

2. Measurement of Power Quality

The Data given in this study was measured with "C.A. 8335 Qualistar Plus", three phase electrical network analyzer using the *DataWiever®* Software given in figure 1. They were measured from 05th of December 2008. Although all waveforms were recorded, there were complications with current waveforms. The C.A.8335 Qualistar Plus measures current waveforms by sampling voltage induced by current transformers (CTs) that have a ratio of 6500/5. The big drives for the motor have circuit breaker (CB) panels from which drive protection is implemented each panel has two CTs of its own; one for the drive over current protection and the other for the display for panel monitoring facilities. These CTs themselves have ratio of 200/5 each. The C.A. 8335 was connected after one of these CTs. Again in terms of monitoring purposes on the CB panels, Voltage Transformers (VTs) use the C.A. 8335.

Fig. 1. The C.A.8335 Qualistar

3. Collected Data before Compensation

The following Current wave forms were recorded due to motors starting. Figure 2 show the results in current magnitude, during induction motor starting before compensation.

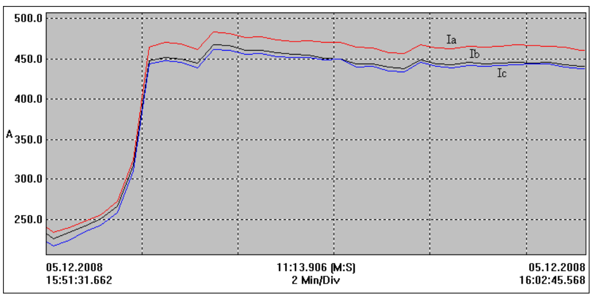

Fig. 2. I_{rms} of phases before compensation

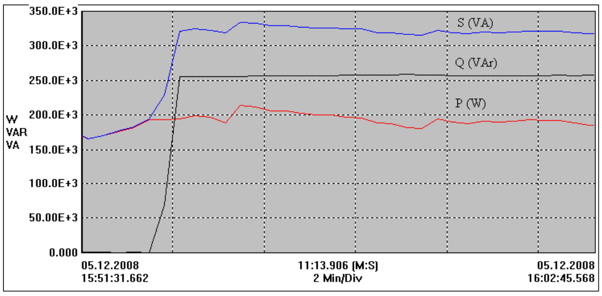

Fig. 3. Total power analyzing before compensation

Figure 3 shows Active power (P) analysis shows that the total active power is 200 kW .The total reactive power (Q) is 260 kVAr. and Apparent power (S) reaches 325 kVA when inductive loads are applied to the power system before compensation. Power factor was 0.56 as given in figure 4, which is not an acceptable level.

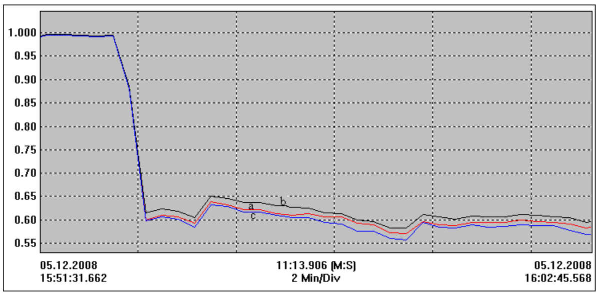

Fig. 4. Power factor of phases before compensation

4. Power Factor Correction with Mechanical Switched Capacitors

Capacitors are practical and economical power factor improvement devices. As stated previously, all inductive loads produce inductive reactive power. Capacitors on the other hand produce capacitive reactive power, which is the exact complement of inductive reactive power. In this instance, the current peak occurs before the voltage peak, leading by a phase angle of 90 degrees. Careful selection of capacitance is required, to cancel out totally the inductive reactive power. The system is build practically as seen in Figure 5.

Fig. 5.Mechanical switched compensation system

The required system of reactive power compensation is designed for Bozkaya Mine Company as seen in Figure 6.

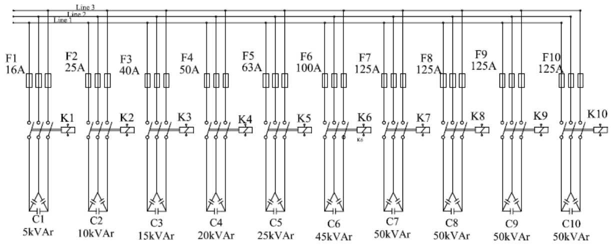

Fig. 6. Manage project diagram

Figure 7 show the results in current magnitude, after compensation.

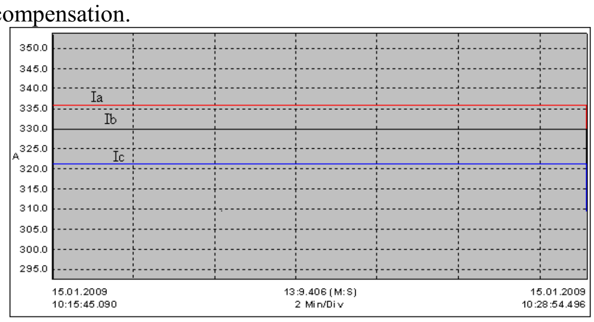

Fig. 7. I_{rms} of phases after compensation

Power analysis after compensation shows that the average total active power (P) is 200 kW. Apparent power (S) reaches 200,06 kVA when inductive and capacitive loads are applied to power system, as shown in figure 8.

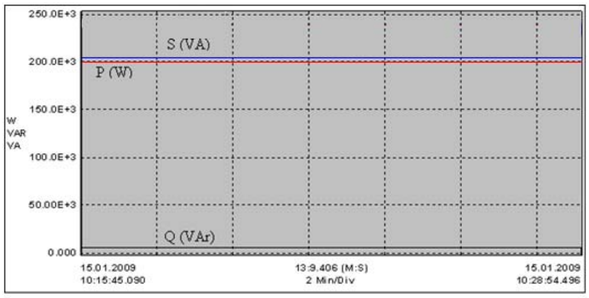

Fig. 8.Power Analysis of phases after compensation

Figure 8 also shows the measured total reactive power (Q) of phases. It can be seen that reactive power compensation works fine in steady state. The reactive power of each line is quite close to zero point the deviation approximately 5 kVAr. Figure 9 shows power factor of phases during compensation.

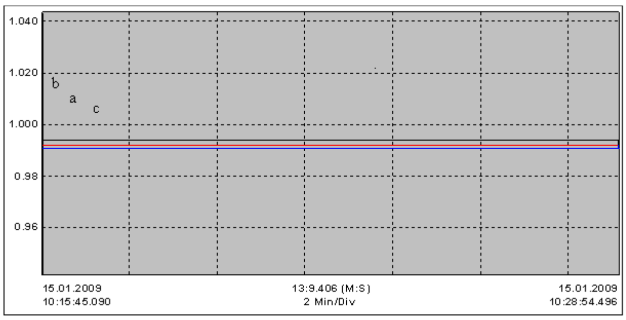

Fig. 9.Power factor of phases during compensation

5. STATCOM Simulation with MATLAB

The system was simulated for the reactive power compensation using the MATLAB. For this a power system similar to the case analyzed practically was modeled and simulated. The MATLAB model is given in figure 10.

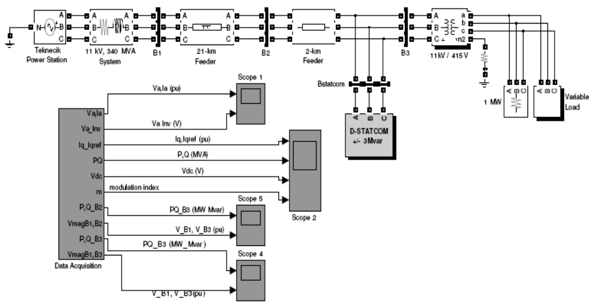

Fig. 10. MATLAB model with STATCOM

The figure 11 gives the active and reactive power graphs before STATCOM application and figure 12 after STATCOM application.

Capacitor banks can help the motor to get back to the normal speed after starting. However, the capacitor banks are usually switched by mechanical contactor. A STATCOM, in Contrast can provide power support immediately in changing load. This power support includes both and reactive power. Although the STATCOM is usually supposed to provide reactive power support, cause an active power flow from the converter to the network. In the converter control system, a PLL works on the positive sequence component of the ac side bus flux.

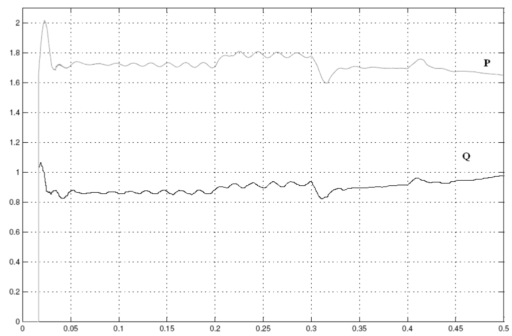

Fig. 11. Reactive(Q) and Active (P) powers without STATCOM

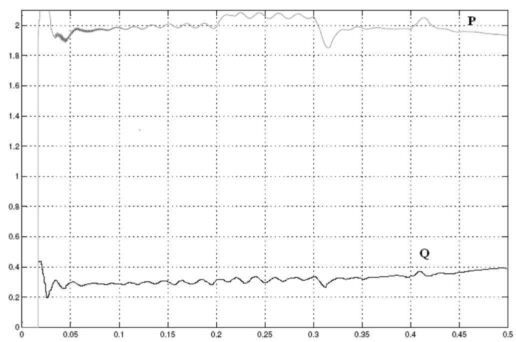

Fig. 12. Reactive (Q) and Active (P) powers with STATCOM

6. Conclusions

In North Cyprus, the demand of electrical energy keeps increasing. For this reason, electric energy prices increase. But in recent decades, the quality and price of electric energy should be in optimum level.

In power systems, active power should be supported by reactive power for power system requirements. Reactive power is due to loaded generators and transmission lines. The technique of reactive power generation at load side is called Compensation. Unfortunately, electrical energy authorities in TRNC (Turkish Republic of Northern Cyprus) did not set rules or regulations for compensation. As a result of this, voltage drop, harmonics, over voltage, noises and unnecessary reactive power on lines often occur. In fact, these cause lack of quality on electricity. This work represents pilot design to overcome these problems in industries.

As a proposed solution, mechanical switched capacitors are used. After the system was integrated to Bozkaya Ltd, the measurements were repeated. Figure 8 showing reactive power was reduced. Therefore, power factor increased up to 0.99, as shown in figure 9, which meets the international standard.

By doing required regulations in Northern Cyprus and applying similar projects to other industrial areas, the energy efficiency could increase which will support economy.

7. References

[1] Dugan R.C., McGranaghan M.F., Santoso S., Beaty H. W., '*'Electrical Power Systems Quality*'', McGraw-Hill Companies, Inc., New York 2003M.

[2] Mansoor A., Collin E. R., Morgan R. L., *''Effect of Unsymmetrical Voltage Sags on Adjustable Speed Drive,''* Textile, Fiber, and Film Industry Technical Conference, 1997, IEEE 1997 Annual, 1997

[3] J. Wu, T. Saha, "Simulation of Power Quality Problems on a University Distribution system", Power Engineering Society Summer Meeting, 2000. IEEE, Volume: 4, 2000, Pages: 2326-2331 vol. 4

[4] IEEE Standards Board, "IEEE std 1159-1995, IEEE Recommended Practice for Monitoring Electric Power Quality", IEEE, Inc., New York June 1995

[5] H. J. Bollen, P. Wang, N. Jenkins, "Analysis and Consequences of the phase jump Associated With A Voltage Sag ", Power System Computation Conference, Dresden, Germany, August 1996

[6] Samet Biricik, "A Research and Solution Proposal for Reactive Power Problems in North Cyprus Industries", Master thesis, Near East Univ., Nicosia, Turkish republic of Northern Cyprus, 2009.

[7] Ö. C. Özerdem, S. Biricik, "Development of a Solution for Reactive Power Problems in North Cyprus Industries," EMO Bilim Journal of the Chamber of Electrical Engineers, vol.2, Pages: 48-50, Turkish Republic of Northern Cyprus, August 2009.