ECAI 2015 - International Conference – 7th Edition
Electronics, Computers and Artificial Intelligence
25 June -27 June, 2015, Bucharest, ROMÂNIA

Electrical Power Analysis Learning And Implementation In One2One Project

Luminita Mirela CONSTANTINESCU[a)], Yannick VILLENEUVE [b)]
a) Dept. of Electronics, Computers and Electrical Engineering
University of Pitesti, no.1, Targu din Vale, Arges, 110040,
Pitesti, Romania
luminita.constantinescu@upit.ro
b) Dept. of Industrial Maintenance and Engineering Sciences
Lycée NEWTON ENREA, no. 1, place Jules Verne, 92110, CLICHY
Paris, France
yannick.villeneuve@ac-versailles.fr

Abstract – **This paper presents a didactical project for vocational education in electrical field under the European Longlife Learning Programme - Transfer of innovation - with the title "one2one - One Teacher and One Student working with ProjectX [1], [2]". The ProjectX is an innovative methodological guidebook for the student to carry out a concrete work, one to one with the tutor, in which theory and practice are both thoroughly integrated and is related to the real workplace [1], [2]. In the theoretical part, students will learn about the key elements of an electrical installation that refers to: the main types of loads, the electrical system capacity, the cables choice, checking the protection of electrical equipment, protection of persons, power factor and harmonics. They will also know the parameters for estimating main characteristics of electrical networks. After learning and testing, the students will perform the practice that has as main objective the achievement of energy assessments. At the end of this *ProjectX*, students will be able to realise a preventive or corrective maintenance for best energy efficiency, with high technical and economic impacts. The Project developed by France partner was evaluated by Romania partner, in order to improve its quality and transferability. In these conditions the project facilitates the exchange of ERASMUS mobility for students and teachers.**

Keywords-component: vocational education; electrical power analysis; practical activities; ProjectX

I. INTRODUCTION

To make better the pedagogical activity – method of teaching at schools – several partners of the *InnMain association* [1], [2], have developed what they call “ProjectX”.

A ProjectX is a tool used to allow teacher’s individual observation to each singular student, and respect their own individual learning rhythms, [1], [2].

Through theoretical knowledges and their associated practical activities to acquire skills in several fields (electronics and telecommunications, electrotechnics, welding, maintenance, Heating, Ventilation and Air Conditioning (HVAC) etc.) each student working with a ProjectX is the protagonist of self-learning.

To build each ProjectX (total of 21 from 7 partners / 3 ProjectX each) each writer had to focus on the Learning Outcomes according to the EQF and the ECVET credit system, which will admit the mobility of students and teachers between the organizations that have ProjectX [1], [2], [3].

Concerning France partner, he worked on 3 projectX in relation with industrial world: PX019: Industrial Risk Analysis, PX020: Electrical Power analysis, PX021: Wiring of an asynchronous motor starter.

PX020: Electrical Power analysis is the subject of this paper.

Because a bad power quality can cause technological damage (defects and deterioration of product quality, reduced productivity, irregularity of the technological process) and Electromagnetic damage (increase in energy losses, damage to electrical equipment, disruptions in automation, communication etc.), we have to take it into account.

The student will have to estimate the main characteristics of the electricity network by using a power quality tool.

With this assessment, preventive or corrective maintenance could be done to reach the best energy efficiency.

II. PROJECT DESCRIPTION

In the frame of *One2One* was design and promote one ProjectX related to the electrical power analysis.

978-1-4673-6647-2/15/$31.00 ©2015 IEEE

This section describes the main theoretical and practical aspects related to the study of the electricity network and makes an energy assessment.

A. Theoretical Knowledge

For the determination of a declared power demand which establishes the contract for the supply of energy, the rating of the MV/LV transformer, levels of load current at each distribution panel is necessary the examination of actual values of apparent-power required by each electrical consumer [4], [5], [6].

1) Study the types of Loads and verify electrical system capacity

Main loads in the industries one of the most common loads is the induction motor (Figure 1). It's important to know what kind of power is written on the descriptive plate for connected it to a corresponding energy network, less damage and what the dual voltage is. Connecting an induction motor (with Delta connexion) to a higher voltage will result in a high starting current, extreme heat will be generated, and the switch gear, cables, fuses, and transformers may also be faulty [7], [8].

At connecting an induction motor (with Star connexion) to a lower voltage, the most probable scenario is that the motor will stall, because it cannot produce sufficient torque to drive the load, this will likely result in too early failure of the motor [7], [8].

As well, it's important to know the advantages the star-delta starting, as the immense reduction in the starting current of the motor, which will result in a important cost saving on cables, transformers and switch gear [7], [8].

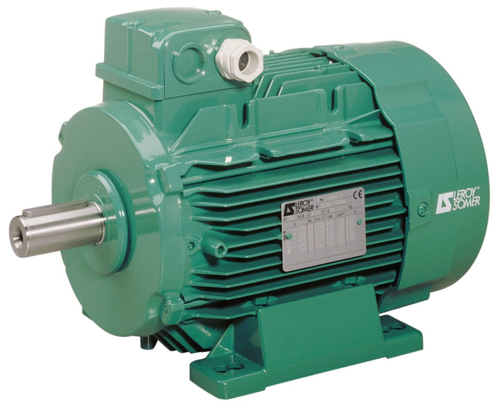

Fig. 1. Induction motor

Other loads may be lamps (incandescent, conventional or halogen) and resistive-type heating appliances. The current demand is obtained from the nominal power P_n, the voltage U and for each kind of single-phase or three-phase network type.

For a good calculation of the maximum power and apparent-power requests actually needed to dimension the installation, the factor of maximum utilization (k_u) and the factor of simultaneity (k_s) are necessarily also.

2) Cable choice

Here, the most important aspect is to know the several criterias involved in the determination of the cross sectional area for a cable (the rated current, an ambient air temperature equal to 35 °C and 3 loaded conductors).

3) Checking the protection of electrical equipment

As shown in Figure 2, the circuit-breaker/ disconnector is the single element of switchgear capable, of at the same time, satisfying all the basic functions required in an electrical installation.

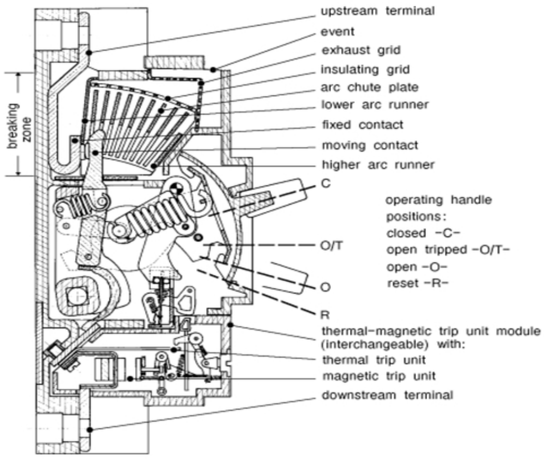

Fig. 2. Circuit –Breaker [9]

The fundamental characteristics of a circuit-breaker are the rated voltage, U_e, the rated current, I_n, the tripping-current-level adjustment areas for overload protection, I_r, and for short-circuit protection, I_m, and the short-circuit current breaking rating, I_{cu} [10].

For this circuit-breaker is most important to know the tripping curve (Figure 3), delay-tripping curve, discrimination (selectivity) of cascading circuit breakers, discrimination based on current level, discrimination based on stepped time delay.

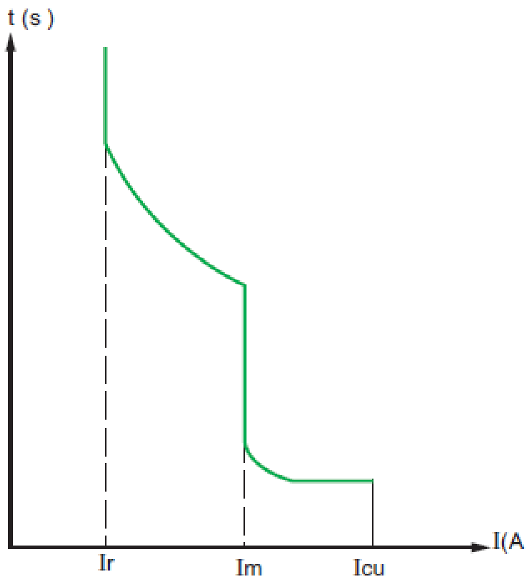

Fig. 3. Tripping curve [4]

4) Protection of persons

The accidents that may occur in electrical labs can be electrocution and electrical burns. These can be produced by direct contact (when a person coming into contact with a conductor which is live in normal circumstances) and indirect contact (when a person coming into contact with an exposed conductive-part which is not normally alive, but has become alive accidentally).

The degree of danger for the person is a function of the value the current, the parts of the body through which the current passes (the body resistance), and the duration of current flow.

The pathophysiological effects of an electric current through the human body are: electrical shocks, burns and skin metallization, peripheral muscle paralysis, heart fibrillation.

The protection of persons against electric shock in LV installations must be provided in concordance with appropriate national standards statutory regulations, codes of practice and official guidebooks. It is necessary to know the inferior limit of DC or AC dangerous current, the pathophysiological effects curves and the current threshold for irreversible effects like in Figure 4.

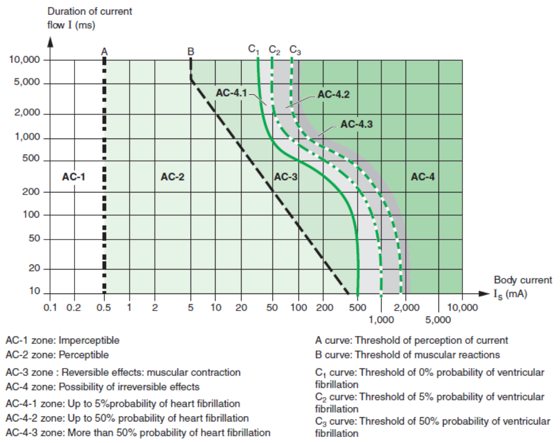

Fig. 4. Areas time/current of repercussions of AC current on human body when passing from left hand to feet [4]

Will be studied the measures of protection against direct or indirect contact. At indirect contact will be learned protection device (for TT, TN or IT system) and residual current devices.

5) Power factor

This is an indicator of the standard of design and management of an electrical installation. The Power Factor is the ratio of the active power, P to the apparent power, S. The value of power factor ranges from 0 to 1. A low power factor means that the apparent power is big, so the electrical equipment rating is bigger than for a power factor close to unity, for a transmission of a specified active power to the electrical consumer. The reactive power is bigger than active power.

From the expression of active power, at constant voltage, the current drawn from the network, at the same power, is even greater when the power factor is low. Accordingly, loss of power transmission line and voltage loss line are the largest since the current is higher. For this reason, practical aims receivers operation with a high power factor, as to obtain a current as small (voltage and constant power).

In the industrial activities, some types of equipments are requiring reactive power, such as: induction motors, transformers, reactors, lamps, heaters. Increasing the power factor of an installation requires, in principle, a group of capacitors which acts as a source of reactive energy. This presents a number of technical and economic advantages, especially in the reduction of electricity bills, in some cases.

6) Harmonics

The harmonics in electrical systems means that current and voltage are deformed and diverge from sinusoidal waveforms.

All non-sinusoidal periodic functions can be represented as the series made up of: a DC component, a sinusoidal term at the fundamental frequency and harmonics whose frequencies are whole multiples of the fundamental frequency (the Fourier theorem).

To manage harmonics is necessary because harmonics flowing in distribution networks can cause the deterioration of the standard of electrical power and decreased of the efficiency of the system [4], [5], [6].

The harmonics may be caused by the non-linear magnetizing impedances of transformers, reactors, fluorescent lamp ballasts, some power electronic devices.

The indicators used to quantify and assess the harmonic distortion in current and voltage waveforms, are: power factor, crest factor, harmonic spectrum and root mean square (r.m.s.) value [4], [5], [6].

Harmonic measurement in electrical networks is carried out preventively or in view of corrective action.

Measurement devices, like portable instruments (oscilloscope, digital analyser), give instantaneous and average information concerning harmonics. Instantaneous values are used for analysis of disturbances linked to harmonics. Average values are used for Power Quality evaluation [4], [5], [6].

Main effects of harmonics in electrical installations can be [4], [5], [6]: resonance, increased losses, overload of electrical equipment, interference affecting sensitive loads, economic impact.

B. Practice

After checking the students' theoretical knowledge through a test (answer a multiple choice or "fill-in-the-bubbles"), they will make the practice of the project.

The objective of the practice is to make an energy assessment.

1) To discover the electrical blueprint with its characteristics

Each student ask the teacher electrical blueprint of the whole place, complete with wiring diagram. It could be a single line instead of drawing 3 separate lines for three phases. He do the inventory of the machines connected to the grid and their main features.

2) To check the protection of persons

According to the electrical blueprint of the whole installation, each student may determine the ground fault protection system used. He focus on the devices able to assume this protection. He choose a safety measurement protocol to measure the earth/ground resistance and continuity. He choose a safety measurement protocol to test the efficiency of the residual current devices.

3) To check the protection of goods

Each student choose a safety measurement protocol to measure the current of each machine in the technical laboratory with the correct tool. Each machine has to be ran at its nominal features. The results will be put in a table (Machine – current – type of protection – size of protection). Highlight the potential discordance between size of protection and the real current.

4) To prepare the audit of quantity and quality electrical energy

According to the manual of the network analyzer, the student choose a safety measurement protocol to perform the audit of quantity and quality electrical energy (A, V, cos phi, harmonics, kWh ...). He choose also the place to do it.

5) To do the energy measurement

According to step 4, Use the *Analyzer* and its accessories only as specified in the User's Manual.

6) To conclude about the energy assessment

By using the previous results, assess the energy network in term of: consumption, reactive power (cos phi), harmonics. If possible analyse the Power purchase agreement or an electrical bill.

III. Learning Outcomes Of The Project

To be easily integrated in VET system of different European countries, in this ProjectX were presented, besides detailed description of theoretical and practical activities, a list of knowledge, skills and competences acquired after project completion for some learning outcomes, as:

A. Compare an electrical installation to the IEC international standards

1) Knowledge:

- knows what is an electrical blueprint and wiring diagram;
- knows the protection principles for electrical safety (electric shock, protection against thermal effects, protection against overcurrent.. [4], [5], [6]);
- knows how to select and erect electrical equipment (common rules, wiring system, earthing arrangements, protective conductors).

2) Skills:

- able to find the electrical box of a workplace, of a machine;
- must be able to know the voltage and type of the power supply;
- must be able to recognize the ground system;
- must be able to read the main characteristics of the circuits.

B. Assess the electric safety and availability of an electrical installation

1) Knowledge:

- knows the necessary occupational safety especially for electrical measurements;
- knows the various measuring instruments and their intended purpose;
- can explain the different measurement protocol;
- can explain the measurement process of the different instruments and their proper storage;
- knows the verification of measuring instruments.

2) Skills:

- checks the measuring instruments on their function and accuracy;
- can check the Earth & Ground Resistance and continuity;
- can check residual current protection devices;
- draws up a results chart.

3) Competences:

- must be able to select the right instruments;
- must be able to validate the size of protection devices;
- must be able to validate the efficiency and correct working order.

C. Generate an electrical audit of a 3 phase power supply

1) Knowledge:

- knows the necessary occupational safety especially for electrical measurements;
- knows the various measuring instruments and their intended purpose;
- can explain the different measurement protocol;
- can explain the measurement process of the different instruments and their proper storage;

- knows the verification of measuring instruments;
- knows the influence of power factor , harmonics onto energy efficiency.

2) *Skills:*

- checks the measuring instruments on their function and accuracy;
- prepares the clamps for measuring with the power analyser;
- can set up the measurement tools;
- draws up a results chart.

3) *Competences:*

- must be able to select the right instruments;
- must be able to setup a tool for the correct objectives;
- must be able to validate the efficiency of the electricity network or initiate appropriate activities to improve the network.

IV. The Tested Of The ProjectX

This ProjectX was tested "One2One" by students and teachers of Electrical Engineering of University of Pitesti - Romanian partner project.

First, the students received the Student's Guide and then go to learn (20 hours, according to the necessary time learning theory).

After checking the students' theoretical knowledge through a test, they made the practice of the project (15 hours).

The teachers presented of the students some instruments, such as PowerQ Plus MI 2392 [11] and the Fluke 1625 Earth/Ground Tester [12] (Figure 5.a and b).

a.

b.

Fig. 5. PowerQ Plus MI 2392(a) and the Fluke 1625 Earth/Ground Tester (b)

The PowerQ Plus is a portable multifunction instrument for measurement and evaluations of three-phase power systems. The Fluke 1625 Earth/Ground Tester tests the resistances of individual ground connections.

The students make an energy assessment. They quantify the energy consumption for each machine in the school laboratory. They check quality of service compliance and validate incoming power quality at the service entrance. They validated the protection device. Students have followed all the steps provided in the Guide - Practice and completed the work practice.

After an internal assessment, the conclusions of students and teachers are:

- The presentation of the project is clear for what it's contains. The short presentation of the project is good and necessary in the electricity networks to reach the best efficiency. The connection between the title and content is ensured by questions that rise the curiosity to scroll through the project.
- The theoretical knowledge is very complex, but is presented gradual, logically and very complete. The references are very good and updated material for study.
- The questions of the tests are very clear, the answers are easy to find in theory, after study.
- The practice is very clear and interesting activity.

The students were impressed by attending project that was tested. They learned new things about the electricity, electrical power and on analysis of certain measuring instruments used in practice. They have acquired new abilities and skills.

V. Conclusion

In this paper were presented a series of theoretical and practical activities useful for VET, in order to improve general knowledge about electrical power analysis.

The project has a logical structure, a gradual introduction of elements of electrical components that takes into account its compound, protection of

Compounds equipment, but also personnel protection serves. It highlights the parameters required to estimate the main characteristics of a grid.

The project can be approached by students from vocational school. The students at UPIT encountered in their curriculum many similarities with the projects' content. By completing the project they will be able to achieve a preventive or corrective maintenance for increased energy efficiency, increased technical and economic impact.

The project is very complex, excellent and facilitates the exchange of ERASMUS mobility for students and teachers in a high grade of quality, in accord with the European Strategy 2020.

ACKNOWLEDGMENT

This paper is part of the project "One teacher and one student working with ProjectX", project code 2013-1-ES1-LEO01-66485, acronym "One2One", funded with support from the European Commission, through Leonardo da Vinci, Transfer of Innovation program.

DISCLAIMER

This project has been funded with support from the European Commission.

This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

REFERENCES

[1] ProjectX, "Guidelines for making ProjectX", Lifelong Learning Programm "One teacher and one student working with ProjectX", project code 2013-1-ES1-LEO01-66485, acronym "One2one", projectxone2one.eu

[2] www.innmain.eu , InnMain

[3] I. Bostan, R. Beloiu, and N. Bizon, "Learning Digital Frequency Dividers Through Practical Laboratory Activities", Procedia - Social and Behavioral Sciences, vol. 180, 5 May 2015, pp. 1014-1021

[4] Schneider Electric, "Electrical Installation guide 2015", http://www.schneider-electric.com/ww/en/ , www.schneider-electric.com.au

[5] Schneider Electric, "Electrical Installation guide", www.voltimum.pt

[6] Schneider Electric, "Electrical Installation guide", www.electrical-installation.org

[7] Henk de Swardt, "Star Delta Starting and Dual Voltage Motors Explained" Rev. 08, Date: 10/2007, Martinhusen&Coutts, http://www.mandc.co.za/

[8] Henk de Swardt, "Star Delta Starting and Dual Voltage Motors Explained" Rev. 08, Date: 10/2007, Martinhusen&Coutts, www.readbag.com

[9] Low Voltage Circuit Breakers, http://engineering.electrical-equipment.org/electrical-distribution/

[10] electrical-engineering-portal.com

[11] Metrel, http://www.metrel.si/products/power-quality-analysis/

[12] Fluke, http://en-us.fluke.com/products/earth-ground/