DOI: 10.17265/2161-623X/2014.11.008

Journal of Mechanics Engineering and Automation 4 (2014) 914-918

Basic Concepts for Alternating Current through Educational Videos

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Received: August 20, 2014 / Accepted: September 12, 2014 / Published: November 25, 2014.

Abstract: This article highlights the importance of complementing classes through educational videos, especially in disciplines exclusively with lectures. This proposition is exemplified through basic concepts in alternating current for both single-phase and three-phase circuits, which are critical in the formation of electrical engineers, mechanics, chemists, etc. The main objective of conducting educational videos is to make learning more attractive and stimulate interest in acquiring the knowledge of certain topics, given their importance in professional life in different engineering areas. The videos, filmed in laboratory and of short duration, aim to complement and consolidate the content taught in the classroom lectures.

Key words: Audiovisual, alternating current circuits, electrotechnical, engineering education, educational videos.

1. Introduction

In disciplines that basic concepts of electricity are addressed: single-phase and three-phase circuits; production, transmission and electric power use; physical principles and main applications of transformers; electrical induction machines, asynchronous and direct current; basics concepts of electrical installations and protection devices, only through lectures, the loss of quality in the assimilation of these content is inevitable.

There are teachers who try projection of figures or pictures in order to facilitate understanding of the content and, in some cases, it has been an effective strategy.

However, the ideal is to have physical space, equipment, teaching and technical staffs so that students can, by conducting appropriately designed experiments, verify and consolidate the theoretical content.

Thus, by prioritizing the undergraduate activities and aware of the need for students to have a basic quality knowledge of alternating current circuits, the way we found to minimize such loss was the production of educational videos with experiments demonstration in electrotechnical.

Thus, we have been achieving objectives such as:

• Increase students interest in complementary and consolidate the content taught in lectures. The motivating and investigative characters cause them to question and seek answers in a dynamic and interactive manner, encouraging discussions in the classroom and thus increasing the student-teacher interaction;

• Flexibility in access, videos as instructional materials (lecture notes and other texts) are available via the Internet.

The production of educational videos can be helpful in teaching, research and extension areas, aiming to transmit information dynamically, enabling real laboratory experiments, that are not always produced when desire can be disseminated to all concerned.

In Refs. [1-8], there are important comments and analysis on the use of educational videos and how the

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recordings should be made with quality and precision, so they are well explained without lighting and frameworks issues.

The paper is organized as follows: Section 2 contains the titles and brief descriptions of the videos produced to date; Section 3 describes how the videos were produced; Section 4 comments the receptivity of the videos and reproduces some of the comments posted by those who have watched the videos; and Section 5 presents our considerations on the importance of developing instructional video to disclose knowledge and motivate learning.

2. Elaborated Educational Videos

From scripts previously designed for carrying out the experimental tests, we enable the filming of the topics listed below, mentioning succinctly their contents:

(1) Obtaining characteristic curve of dipoles (6'58"): voltmeter-ammeter method to obtain the characteristic curves of linear and nonlinear resistive dipoles;

(2) Concept of effective value (3'53"): experimental realization of the concept of effective value for a sinusoidal waveform;

(3) RC (resistor and capacitor) series circuit (4'02"): analysis of current electrical behavior against voltage in an RC series circuit connected to a sinusoidal voltage source;

(4) RL (resistor and inductor) series circuit (4'28"): analysis of current electrical behavior against voltage in an RL series circuit connected to a sinusoidal voltage source;

(5) RLC (resistor, inductor and capacitor) series circuit (4'27"): analysis of current electrical behavior against voltage in a RLC series circuit connected to a sinusoidal voltage source;

(6) Three-phase load in unbalanced star (3'00"): importance of neutral conductor in a three-phase load in unbalanced star;

(7) Three-phase voltages (3'02"): practice finding of the relationship between line voltage and phase in a three-phase electric power system;

(8) Power factor correction (4'48"): importance of improving the power factor in a single-phase induction motor by connecting capacitors in parallel;

(9) Electric motors (5'01"): emphasis on training of rotating magnetic field that guides the operation principle of induction and three-phase synchronous motors;

(10) Determination of resistance value (5'37"): highlighted connections of a voltmeter and an ammeter in relation to a resistor to obtain the respective value;

(11) Effective value (2'54"): determining the effective value of a sinusoidal wave;

(12) Electric capacitor (2'21"): it is highlighted the current lag in relation to voltage, caused by a capacitor connected to a sinusoidal voltage source;

(13) Electric behavior of an inductor (2'32"): it is highlighted the current lag in relation to voltage, caused by an inductor connected to a sinusoidal voltage source;

(14) Electrical behavior of inductor and capacitor in series (2'47"): analysis of the variation of current lag in relation to voltage, caused by a capacitor and an inductor connected in series to a sinusoidal voltage source with adjustable frequency;

(15) Magnetic fields (7'12"): different experiments related to magnetic fields highlight the induction phenomenon (Faraday’s law of induction);

(16) Residential electrical connections (3'00"): addresses the residential connections in electricity distribution;

(17) Simple switch (2'43"): it is highlighted the correct connection of the simple switch used to trigger one or more fixtures from a single location;

(18) Parallel switch (3'17"): it is highlighted the correct connection of parallel switches used to trigger two or more fixtures from two locations;

(19) Intermediate switch (4'05"): it is highlighted the correct connection of the intermediate switch with parallel-type switches used to trigger one or more fixtures from three or more locations;

(20) Direct current motor-operation (5'19"): presentation of a device to trigger a direct current motor with starting current limitation and protective mechanism against excessive acceleration;

(21) Induction motor-principle of operation (5'05"): it is presented the working principle of a three-phase induction motor through simple assembly;

(22) Induction motor-operation-star-triangle switch (5'05"): explanation of the role of a star-triangle switch in a three-phase induction motor;

(23) Transformer-principle of operation (5'10"): the working principle of a transformer is presented through simple assemblies;

(24) Improved power factor (3'08"): we can see the benefits of improved power factor through capacitors in parallel connection to a single-phase induction motor;

(25) Polarity of transformers (2'53"): easy method to identify the polarities of the terminals in a single-phase transformer;

(26) Brazilian Standard 14136 (NBR14136) switches and plugs (2'40"): description of the switches standardized by ABNT (Brazilian Association of Technical Standards);

(27) Single phase transformers in parallel (3'41"): a practical way of associating two single-phase transformers in parallel;

(28) Obtaining active and reactive powers on a three-phase motor (2'53"): easy procedure to obtain three-phase active and reactive power on a three-phase induction motor;

Note: the brackets information, for example, (5'01") for electric motors video, corresponds to the duration in minutes and seconds. The filming done so far totalizes 1 h 48 min 20 s.

As can be seen, the videos produced are of short duration (up to 7 min.) and to ease access, they are available on YouTube (www.youtube.com) for being a popular site of videos, and they can be located using the acronyms ET016, ET616, UNICAMP or FEEC.

3. Methodology

The equipment used in the initial filming was a Nikon CoolPix 7600 7.1 megapixels Digital Camera and currently, we use a camcorder with high definition resolution, resulting in better picture quality and sound, for example, in the video behavior electric of RLC series circuit.

Aiming to facilitate the topics understanding, in some of the videos we added figures, electric diagrams and formulas, both during and after their shoot.

The final edit of the video was done with Windows Movie Maker, which shows educational videos can be possible at low cost.

4. Results

The receptivity of these videos can be accessed through the amount of views presented in Table 1 (by December 2013), surpassing a total of 654,000 related videos, the site of educational content (https://www.youtube.com/user/gilmarbarreto/). There were 1,080,515 views, as well as several publications in national and international conferences and the preparation of a textbook for a course in alternating current circuits [9-13].

This initiative has been rewarding due to the significant amount of comments on the videos content and also their didactic presentation, which has been a constant on incoming messages, some of which we reproduce below:

“I am an electronics technician; I find it very interesting these matters, congratulations for the explanation, teacher!”

“Excellent video, Greetings from Colombia!”

“Awesome. It is the type of video I like to watch. I recommend bettering the audio next time, including subtitles in Spanish.”

“This video is amazing. I think it should have more of this level.”

“Congratulations, Gilmar! It is easy to learn from your teaching method, thanks for the video.”

Table 1 Number of views until December 2013.

Characteristic curves of dipoles	2,406
Concept of effective value	12,089
RC series circuit	86,214
RL series circuit	13,751
RLC series circuit	38,927
Three-phase load in unbalanced star	16,594
Three-phase voltage	11,331
Power factor correction	23,939
Electric motors	14,310
Determination of dipole resistance value	943
Effective value-experimental procedure	1,409
Electrical behavior of a capacitor	509
Electrical behavior of a RL series circuit	1,293
Electrical behavior of a RLC series circuit	6,146
Magnetic fields	6,278
Residential electrical connections	72,822
Simple switch	35,752
Parallel switch	114,837
Direct current motor-starting protection	7,448
Induction motor-principle of operation	29,209
Induction motor-operation- star-delta-triangle	4,279
Transformer-principle of operation	55,245
Improving power factor	1,078
Polarity of transformers	52,695
ABNT NBR 14136 switches and plugs	1,871
Single-phase transformers in parallel	3,295
Obtaining active and reactive powers on a three-phase motor	494

"Thank you for that tip, it was very good."

"Excellent!!"

"The material will be useful to review the concepts learned in my course."

"Very good teaching. I confess I did not know about that."

"It helped me a lot, it solved several questions. I admire a lot the work of Prof. Barreto. I read his thesis on building an electric vehicle and I confess it was one of the best materials I've ever encountered to date, the details and techniques presented are fantastic."

"I would like to know if I could have access to the course material, as it is essential for my activities at work."

"Very good, this video explains well the motor operation."

"I have never seen a better explanation. For a long time, I have been looking for something that explained in detail the operation of this engine and no material explained in this way."

"I thank you in advance for your attention and take this opportunity to congratulate you for the excellent organization of this material."

We are aware that these videos are being adopted as teaching material in other universities and technical schools, as well as being used in other websites which we have no control of access.

TELEDUC is a web platform for implementation of courses (subjects) on the Internet with the purpose of distance learning and it has helped us in contact with students and the dissemination and use of teaching materials, in addition to regular classes. In Ref. [8], there is a master's thesis in which we analyzed the students' feelings with respect to this tool as didactic support in electrotechnical teaching.

4. Final Consideration

Through the work carried out until now, we found that we can use nonprofessional filming equipment and software easily to manipulate, as is the Windows Movie Maker case to produce excellent results in terms of production of educational videos, thus contributing to the improvement of teaching and knowledge dissemination.

The videos meet students' claim to facilitate electrotechnical theory understanding, since it deals with practical aspects and the subject does not include laboratory classes.

The contribution to teaching and learning through the videos can be seen by an improvement in students' performance on assessments in both test and exercises and comments from several university professors and technical schools that use the videos produced.

The knowledge disseminated is serving our students, and other educational institutions can review many times a particular concept in basic electricity. The videos and their way of dissemination create

conditions for better learning, more quickly and to a greater number of students with the advantage of being able to watch the experiments at any time and review the subject through audiovisual resources.

Other videos will be developed covering topics such as:

- Faraday's law;
- Lenz's law;
- Construction of phasor diagrams;
- Calculation of capacitors for power factor correction;
- Blondel's theorem;
- Measurement of reactive power;
- Safe electrical installation.

We will also remake videos that are not in high resolution, e.g., electrical behavior of RLC series circuit.

The preparation of educational videos by teachers and/or students to disclose knowledge and motivate learning is something that should be encouraged and supported.

Acknowledgments

The authors have relied on the effective support of the School of Electrical and Computer Engineering of University of Campinas, FEEC-UNICAMP that always encouraged us in the development of undergraduate teaching activities. Our gratitude is also to the Student Support Service-SAE, UNICAMP agency that manages the grants work for undergraduate students who have supported us in the preparation of these videos.

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