LABORATORY VOLTAGE FLUCTUATION SIMULATOR

Jan Šlezingr

Doctoral Degree Programme (3), FEEC BUT

E-mail: xslezi01@stud.feec.vutbr.cz

Supervised by: Jiří Drápela

E-mail: drapela@feec.vutbr.cz

Abstract: The voltage fluctuation simulator was designed for power quality laboratory. It is a physical model of the electrical appliance connected to the electrical system with sine-voltage power supply. The appliance current-time characteristic gives rise to the voltage fluctuation, which causes luminous flux flickering. The electrical system model consist stepped adjustable impedance with inductive characteristic. The appliance consists of load impedance which is switched by Solid State Relay. The switching is controlled by NI-USB 6009 card. The control software, developed in LabView, allows changing frequency and pulsing duty factor. Connected light source allows direct observe luminous flux fluctuation, caused by voltage variation. Both voltage variation and luminous flux fluctuation are measured by NI-USB-6009 card with photo-transducer and voltage isolated transducer. This system is used as the laboratory task for students.

Keywords: Voltage fluctuation, LabView, Light flicker

1. INTRODUCTION

The Power Quality and Low-frequency Electromagnetic Compatibility issue is closely linked to the operation of Electrical Networks. The aim of this project is to create a new laboratory task for effective and simple demonstration of light flicker phenomena.

The task principle is to generate voltage fluctuations as they are actually incurred, not by generate in power supply. The students can cause observe the causes of voltage fluctuation and its propagation and its direct impact on the light sources

2. SOURCES OF VOLTAGE FLUCTUATIONS

The primary cause of voltage changes is the time variability of the reactive power component of fluctuating loads. Such loads include, for example, arc furnaces, rolling mill drives, main winders, etc. – in general, loads with a high rate of change of power with respect to the short-circuit capacity at the point of connection to the supply.

It is very important to note that small power loads such as starting of induction motors, welders, boilers, power regulators, electric saws and hammers, pumps and compressors, cranes, elevators etc. can also be the sources of flicker.

Other causes are capacitor switching and on-load transformer tap changers, which can change the inductive component of the source impedance.[1]

Variations in generation capacity of, for example, wind turbines can also have an effect. In some cases, voltage fluctuations can be caused by low frequency voltage interharmonics.[2]

3. LABORATORY TASK DESCRIPTION

The laboratory task is called „Light flicker caused by voltage fluctuation“, and will serve for demonstration a flicker origin and its propagation in the electrical system. The task is located in the power quality laboratory.

The task consists of the following basic parts:

- the power supply of sinusoidal voltage of 230 V 50 Hz (network)
- the electrical system model
- the appliance model with a fluctuating load
- the flickermeter
- the reference light source and other types of light sources
- the luminous flux indicator (objective flickermeter)

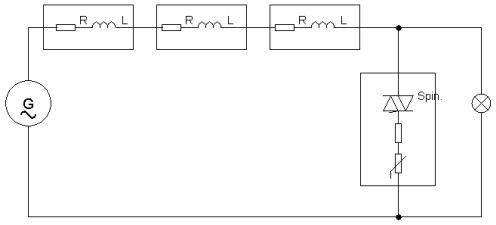

Fig. 1: Task function scheme

3.1. THE TASK PRICIPLE

The AC power supply feeds the model with a fluctuating load. The load current will flow through the electrical system model and causes the voltage drop. Students will be watching how the voltage fluctuations level depends on:

- electrical distance from the source flicker
- the size of load and switching frequency

On the connected light source can be assessed subjective flicker perception, arising from various light sources (incandescent, discharge, LED). A photocell is used for measure and analyzes the generated luminous flux.

3.2. ELECTRIC SYSTEM MODEL

Electric system model consists of three identical modules which can be connected in series. Total line drop can reach up to 7.7 % in nominal current 1 A.

Each module has adjustable impedance in three stages. The impedance consist of inductance 1 mH and resistance 0.1 Ohm in series.

Each modules is stored in a separate plastic box, number of stages is selected by rotary switch. Modules are interconnected by safety measuring leads.

3.3. FLUCTUATING LOAD MODEL – FLICKER ORIGIN

A resistance load fast switching leads to the current fluctuation and then to the line impedance voltage drop. It leads to the voltage fluctuation, which increase with electrical distance from the power supply.

The power supply terminal voltage is invariable, the largest voltage fluctuation is on the load terminal. The load resistor is switched by Solid state relay, i.e. semiconductor contactless relay

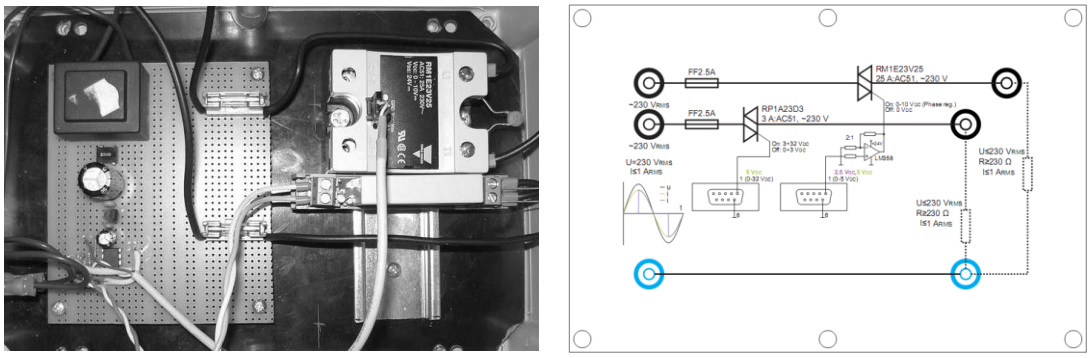

Fig. 2: Actual implementation of the model (left), front panel of the model (right)

The load model has embedded two semiconductor contactless relays, type RP1A23D3 and type RM1E23V25.

First relay is RP1A23D3 type, AC Solid state relay for PCB mounting. The basic parameters are:

- Zero switching or instant-on
- Rated operational current: 3 A_{RMS}
- Rated operational voltage: Up to 480 V_{RMS}
- Control voltage: 3 to 32 VDC* / 16 to 32 V_{AC}

Second relay is RM1E23V25, analog switching relay (phase-angle control) for resistive and slightly inductive load applications. The basic parameters are:

- Phase angle control principle
- Rated operational voltage: 230 V_{AC}
- Blocking voltage: 650 Vp
- Control input: 0-10 V_{DC}

Each other relay has separated power contacts and control input, each is possible used independently of the other.

The load resistor consists of adjustable resistor 0...250 Ohms. Therefore it is possible to switch current in the range of 0.5 to 1.5 A. The fixed resistor do not allow cross-circuit current above 1.5 A (Maximum allowable model current).

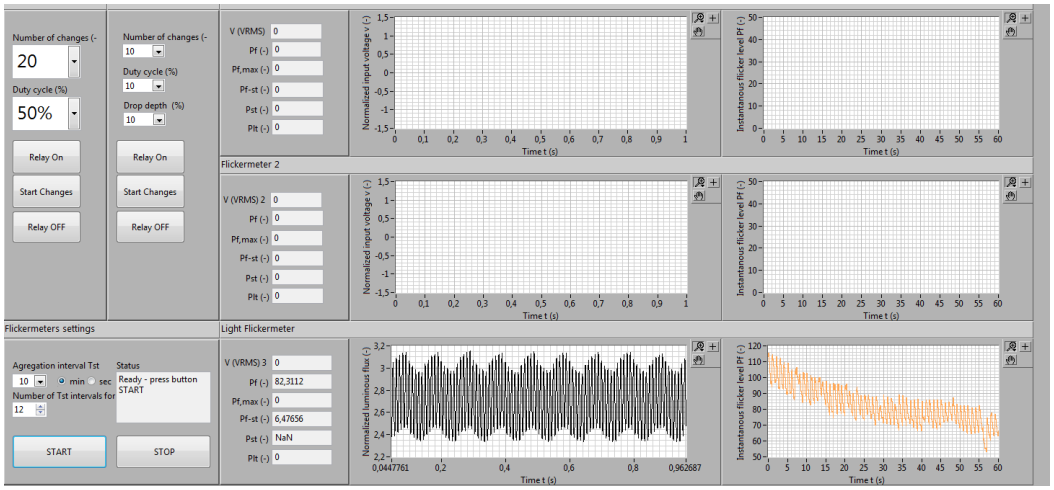

Fig. 3: Control and measurement software

Relay control

Solid state relay is controlled by voltage 0-10 V, which is galvanically isolated from the switching circuit. Control voltage is generated using a multi-card NI USB-6009, which will be connected to a computer via USB. At the same time, this card will serve as the flicker-meter and light flickermeter measuring card.

3.4. FLICKER MEASUREMENT

The voltage fluctuation is measured by voltage transducer LV25-P. Galvanically isolated signal is routed to the measuring card NI-USB-6009 and then processed by digital flickermeter developed in LabView. For the purposes of task already programmed digital flikermeter based on the IEC 61000-4-15 standard is used.

Luminous flux measurement

A simple photodiode BPW 21, adapted on eye spectral perception connected to the trans–impendance amplifier LMV793, will be used for a real luminous flux measurement. Amplifier output is routed to the NI USB-6009 card. Then is processed by Light-Flickermeter [4].

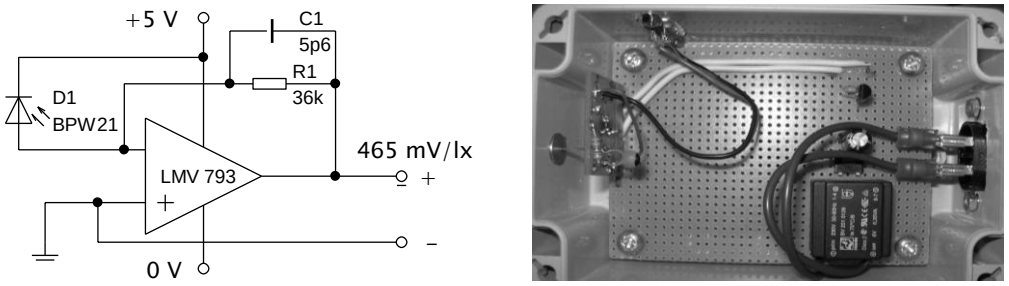

Fig. 4: Transimpedance amplifier circuit scheme (left), actual implementation of the photohead (right)

4. CONCLUSION

The laboratory task with voltage fluctuation simulator will improve the laboratory teaching in Power Quality Laboratory. Students will be able to understand flicker origin and its propagation in electrical network. Laboratory task is very friendly and error-proof. Students can play with, and gain their experience with electrical energy and physical phenomena. The advantage is also possibility of task extension and modification and compatibility with others tasks and devices in Power Quality Laboratory. It is possible to develop for individual projects and theses of students.

ACKNOWLEDGEMENTS

This paper contains the results of research works funded from project of specific research program of Brno University of Technology No. FEKT-S-11-19.

REFERENCES

[1] EN 61000-4-15:1997. Electromagnetic compatibility (EMC). Part 4: Testing and measurement techniques. Section 15: Flickermeter. Functional and design specifications.

[2] Zbigniew Hanzelka; Andrzej Bień; Guide to Quality of Electrical Supply for Industrial Installations, Part 5, Flicker and Voltage Fluctuations, ‘Power Quality’ Working Group WG2, 2000.

[3] EN 61000-2-2 2nd ed.:2002. Electromagnetic Compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalizing in public low-voltage power supply systems

[4] DRÁPELA, J.; ŠLEZINGR, J. A Light - flickermeter - Part I: Design. In Proccedings of the 11th International Scientific Conference Electric Power Engineering 2010. 1. Brno, BrnoUniversity of Technology, FEEC, DEPE. 2010. p.453-458. ISBN978-80-214-4094-4.

[5] DRÁPELA, J.; ŠLEZINGR, J. A Light - flickermeter - Part II: Realization and Verification. In Proccedings of the 11th International Scientific Conference Electric Power Engineering 2010. 1. Brno, Brno University of Technology, FEEC, DEPE. 2010. p.459-464. ISBN978-80-214-4094-4.