EXPERIMENTAL RIG FOR TESTING VOLTAGE OPTIMISER

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Introduction. In the UK, almost all domestic appliances are designed to work under the voltage at 220~230V. However, the voltage distributed to individual homes is normally above 230V due to the transmission and distribution. In some places near substation, the mains voltage is even higher than 240V. The overrated voltage level not only reduces the life time of the appliances but also increases the power consumption of the appliances. Hence, a new technology called voltage optimisation (VO) [1]comes into practice to overcome this voltage issues. The basic principle is to apply different circuitry with transformer to control and optimise the voltage level. By adopting this technology, it is claimed that the power consumption of the whole house can be saved and the electricity bill is therefore reduced. Massive home owners' surveys are conducted to investigate the exact saving; however this approach tends to be time-consuming and not cost-effective. In this research, test rig and load bank are set up to estimate power reduction to avoid expensive surveys cost through laboratory experiments.

The objective of this work is to establish a complete data acquisition system to obtain the detailed input and output parameters, namely instantaneous voltage and current values, during the operation of the voltage optimiser and investigate the functionality of the voltage optimiser.

Data Acquisition System (DAQ). Two sets of accurate measuring systems are implemented in this work to analyse the operation precisely and compare with each other. The first set of measurement is based on WT3000 Power Analysermanufactured by Yokogawa, which was calibrated at the time of purchase. It is exactly accurate on all values related to power measurements with errors less than 0.2% and able to conduct harmonics analysis as well.The drawback of the power analyser is that it is only possible to log the measurements in relatively low frequency under 1Hz. Therefore, the transient and instantaneous values of voltage and current may not be able to be captured. Another set of the system aims to acquire the instantaneous values of voltage and current at high frequency from 50Hz to 100Hz. The essential hardware in this system is the National Instruments PXIe-1082 chassis with PXIe-635, which is X series multifunction DAQ. In this work, this DAQ device is configured as multiple analog inputs to acquire the voltage and current data gathered from the transducers. The data is then transferred and processed simultaneously. The software is built in Labview to process power calculation and display the measurements along with calculation results both graphically and numerically.

Load Bank. In order to investigate the performance of the voltage controller under different load condition, a high current (up to 32A) load bank including resistors, capacitors and inductors is set up for the test. Two fans are also mounted near to the resistors for cooling purposes. All the loads are mounted inside the aluminum frame with mesh covering for isolation purpose and can be connected through the sockets on the side panel. The details of components inside the load bank are presented in Table.1

Table 1 - Load bank

Name	Numbers	Specification
Resistors	12	22 Ohm, 1500 W
Capacitors	12	50 µF, 450 V, AC
Inductors	3	50-70 mH, 10A, adjustable
Fans	2	14 inches, for cooling

Additional type of load used in the test is centrifugal fans driven by Siemens three phase squirrel cage induction motors. Two identical fans REM 48-0200-2D-07 produced by Nicotra-Gebhardt Ltd aredeployed for experiments. For single phase application, the stator windings of the motors are Δ connected. One of the phases is connected to the Live, another one is connected to the Neutral. The third phase is connected through 30 µF capacitor to the Neutral. With all those components ready, mixed load can be also generated by combining them together.

Tests. The test system is illustrated in Fig. 1.

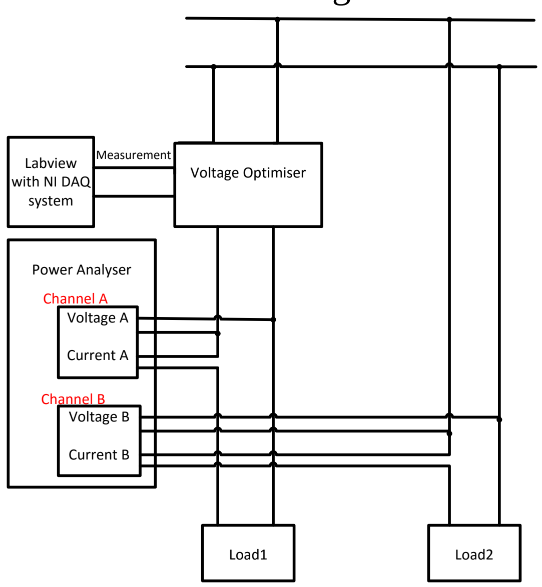

Figure1 – Overview of the test system

Two identical loads are applied in the entire test. One is connected to the voltage optimiser under optimised voltage while another is connected directly to the mains. TheDAQ device from NI collects the raw measurement signals and transmits them to the PC for display and data storing in relatively high frequency 100 KHz and log the data in both high (1 KHz)and low rate (0.5 Hz). The power analyser is also connected to both loads to measure the voltages and currents along with the displayed power consumption values including the active power, reactive power, apparent power and the power factor and logs the data in low rate (0.5 Hz).In addition, the harmonic analysis can be provided by the power analyser simultaneously. The data recorded is imported into MATLAB for further analysis.

Results. The voltage optimiser applied in this experiment is one of the voltage optimiser available in the market and bought for research purpose. 4 types of load, namely resistive, resistive-capacitive, resistive-inductive, motor load with parallel resistor, are tested during the whole experiments. The results measured by power analyser are shown in Fig. 2 and 3.

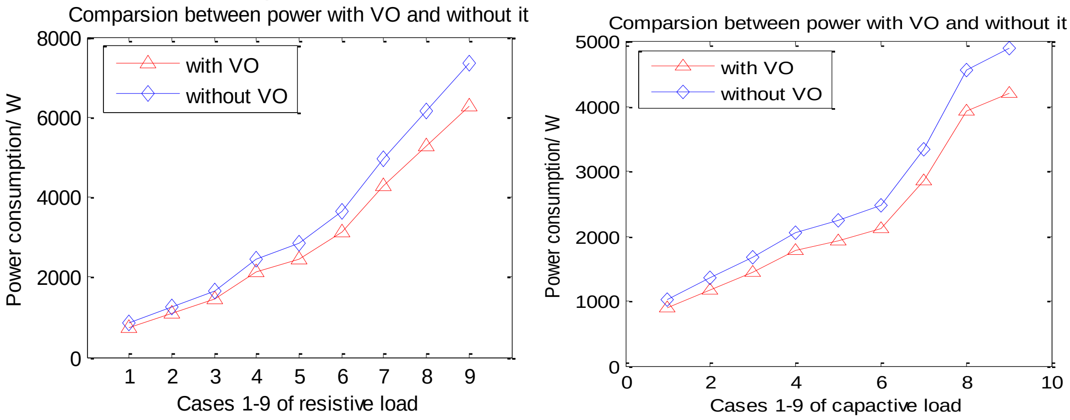

Figure 2 – Test results of resistive and resistive- capacitive load

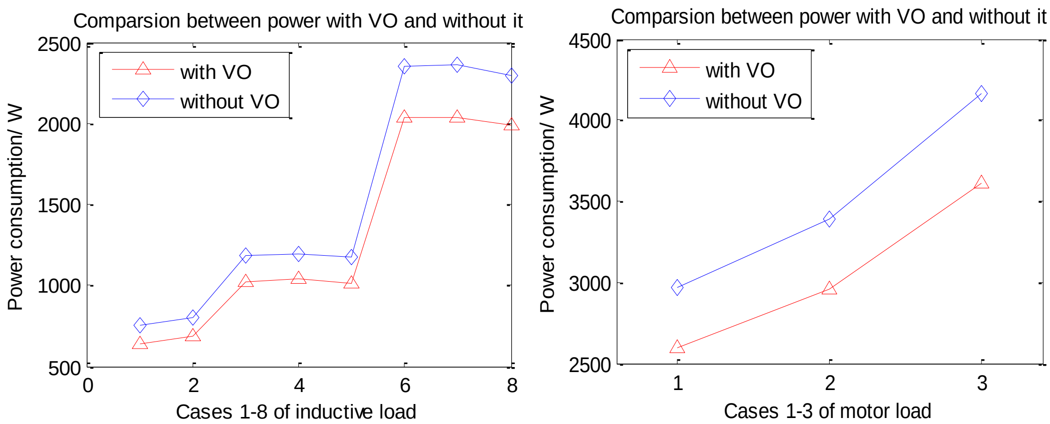

Figure3 – Test results of inductive-resistive and motor load

The loads tested range from 600W to 6000W in terms of power rating. The results clearly show that the power saving is achieved for all the experiments from low power rating to high power rating for all types of loads. The power saving is namely, 13.7% for resistive load, 13.9% for resistive-capacitive load, 14.0% for resistive-inductive load and 12.9 % for motor load. The efficiency of the voltage optimiser depends on the power losses within the optimizer.

Conclusions. Therefore, it can be concluded that the voltage optimisation technology proves to be able to reduce power consumption for different loads and the saving for the voltage optimiser in this experiment is from 12.9% to 14.0%. It should be emphasized that power saving doesn't prove directly energy saving which is more complicated function depending on particularity of energy consumption.

References

1. [Електронний ресурс]: E-fficient Energy Syatems LTD – Електрон. дані. – UK, 2013. – Режим доступу: http://www.e-fficientenergy.co.uk/what-is-voltage-optimisation.html