ISSN 2319 – 7757 EISSN 2319 – 7765

Indian Journal of Engineering

Simulation based measurement of three phase active, reactive and apparent power by Two Wattmeter Method with LabVIEW

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Received 19 March; accepted 21 April; published online 01 May; printed 16 May 2013

ABSTRACT

Generally single phase a.c power consume in domestic electrical appliances i.e fans, freeze, washing machines and three phase power consume by bulk consumers like as industries, institutions, shopping malls etc. Study of three phase power is a part of basic Electrical Engineering course which is mandatory for all discipline students to aware the idea of types of a.c active, reactive and apparent power which is in all Technical Universities in India and abroad. This topic is also a part of in Laboratory of their curriculum. Three phase power can be measured by different methods which are one wattmeter, two wattmeter and three wattmeter methods. In these, two wattmeter is cost effective, time saving measurement of three phase power. Software based Practical are less costly than hardware base practical and also have a provision to change the circuit parameters as they need compared to hardware based results, which is better understanding of students in learning concepts of Basic Electrical Engineering course. Today Software based different Laboratory experiments can be performed by the student with a single place which impacts on flexible learning of students and under-standing abilities. In this paper we are measuring entire a.c power by simulating in Laboratory Virtual Instrument Engineering Workbench (LabVIEW) software. LabVIEW uses graphical language which allows a natural, error free result & user-friendly interaction.

Keywords: Basic Electrical Engineering, Laboratory, LabVIEW, Three Phase Power, Simulation, Software, Wattmeter.

1. INTRODUCTION

Basic Electrical Engineering is one of the tough subjects being taught to the first year students in different technical Universities curriculum in India and abroad. Course comprises the following units: Basic Fundamental of Electrical Engineering, D.C Network Theory, Sinusoidal steady state analysis of A.C. circuits, Measuring Instruments, Basic of Power System, Transformer and A.C and D.C Machines with Laboratory. R-L-C Series and Parallel circuit at resonance is a part of Sinusoidal steady state analysis of A.C. circuits Laboratory Experiments have been simulated using LabVIEW software. In this series Electrical Machines experiments are simulated with LabVIEW under graduate Electrical Engineering (Rana, 2010). The fundamental equations of a Transformer, D.C machines and Induction motor and equivalent circuits have been imposed into the LabVIEW for Simulation purpose (Stephen, 2005), (Elliott, 2007). The concept for the use of LabVIEW software in Engineering education is recognized internationally but the complete Lab Experiments of Electrical Machines course has been implemented in LabVIEW based upon the exact ratings and on-ground machines parameters as a pioneer and novel research at RCET (Basher, 2005; Nunnally, 1996). Simulation of Synchronous machines have already been implemented in LabVIEW (Usama, 2008), Other programming tools like MAT-LAB, PSCAD and SkyLab etc. are also used for Laboratory experiments simulation purpose but due to strong graphical user interface LabVIEW is preferred on all others (Krishnan, 1988). Some experiments on verification of d.c network theorems (Ashok, 2012) and analysis of series, parallel resonance Curve (Ashok, 2013) of Basic Electrical Engineering course which has been recently simulated. In this paper we will discuss the measurement of three phase power by using two wattmeter method and it simulated in LabVIEW.

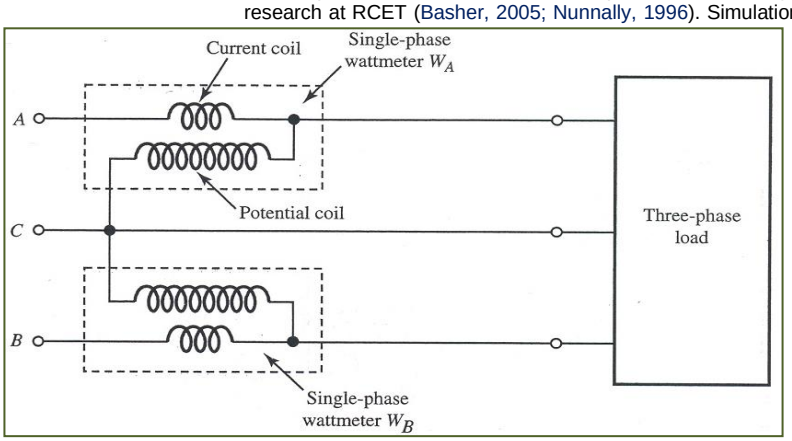

Figure 1
Circuit Diagram for Three Phase Power Measurement

2. ABOUT THE SOFTWARE

Laboratory Virtual Instrument Engineering Workbench (LabVIEW) which is a graphical user friendly Language which is totally based upon icons/buttons instead of programming codes and code paragraph. This software has the ability to build user defined interface with set of objects and graphical tools. These programs are labeled as Virtual Instruments(VIs,) owing to their operational replica of physical instruments, like oscilloscopes, multi-meters ,mathematical tools etc. A Virtual Instrument is the combination two panel generally

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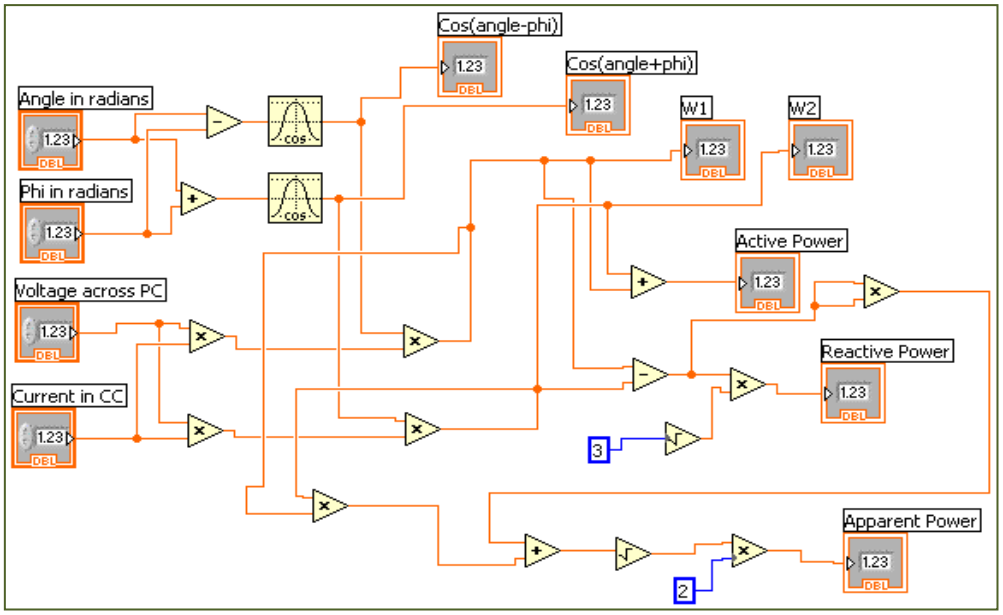

Figure 2
Black Diagram

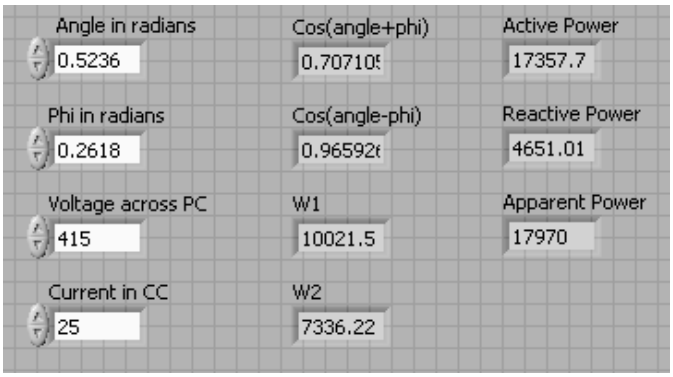

Figure 3
Front Panel

known as windows.

- Front panel or window
- Block diagram window

All control and indicator are the part of Front panel window and their Icon and connector pane lies in a Block diagram window.

3. SIMULATION WITH LabVIEW

The two-wattmeter method, when applied to the balance load, yields interesting results. Considering either balanced star or delta connected loads with the aids of corresponding diagram shown in figure 1. It is well known that the angle between V_{AC} and I_A should be (30 - Φ) degree and in between V_{BC} and I_B should be (30 + Φ) , where Φ is the load power factor angle or the angle associated with the load impedance.

Thus we have
$W_A = V_{AC}\ I_A \cos(30 - \Phi)$
$W_A = V_{BC}\ I_B \cos(30 + \Phi)$
It can also be written as

$W_A = V\ I \cos(30 - \Phi)$ (1)
$W_B = V\ I \cos(30 + \Phi)$ (2)

Where V and I are the magnitudes of line-to-line voltage and line current respectively. Addition of equation (1) and equation (2) represent the total power consumed by the load either it is connected in a star manner or delta manner. Active power , Reactive power and Apparent power can be measured with the help of two wattmeter readings i.e
Active power:

$P = W_A + W_B = \sqrt{3}\ V\ I\ \cos\phi$ Watts

Reactive Power:

$Q = \sqrt{3}\ (W_A - W_B) = \sqrt{3}\ V\ I\ \sin\phi$ Volt-Amp-Reactive

Apparent power:

$S = 2\{(W_A - W_B)^2 + 2 W_A W_B\}^{1/2} = \sqrt{3}\ V\ I$ Volt-Amp.

Our aim is to measure the three phase active, reactive, apparent power with the help of two wattmeter method and it is simulated in LabVIEW with two different windows one is its block diagram window shown in figure 2 and results are indicated in front panel window shown in figure 3.

4. CONCLUSION

The idea of Basic Electrical Engineering Lab experiments Simulation using LabVIEW software is being successfully put into operation at RGEC, Meerut, India in the Department Electrical Engineering which results in outstanding feedback of students Lab work evaluation. The same idea can also be extended for other courses in future like as Control System, Network System, and Electrical Machines etc. Software is a little bit tough to do work on LabVIEW for first year under Graduate technical students but basic idea can be given to them in which how to operate a LabVIEW, how to work in two windows i.e block diagram window and front panel window and how to use basic tools of the software. In lab session's hardware based practical can be performed physically and check their different results after simulation of their circuits in LabVIEW. The Simulation performed during this research work can also utilized as on-line experiments performance with in campus and abroad. Practically the following data is taken,

Voltage across pressure coil, V = 415 Volts
Current in a current coil, I = 25 Amperes
Value of 30 degree in radians = 0.5236
Power factor angle, Φ = 0.2618

Then all three powers are measured by simulation process which are shown in figure 3. These powers are,

Active power, P = 17357.7 W
Reactive power, Q = 4651.01 VAR
Apparent power, S = 17970 VA

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