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To Analysis the Effect of Combination Load on the Power Factor

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Abstract*— Research work is carried out to investigate the Power factor variation due to change in the load of a power system has to be considered before it can be implemented.In this paper to investigate the effect of impedance on the power factor of designed system. Combinations of the load inductive, capacitive and resistive are taken in the experiment. Different values of the inductance are taken from 269.1mH to 1232.0mH with resistance 124Ω and capacitance 2.5µF. From the analysis it is observed that the current through the load is inversely proportional to the values of inductance and similar in the case for power factor. The minimum and maximum values of power factor obtained are 0.104and 0.1478 respectively.

***Keywords*— Power factor, load effect, impedance, microcontroller, power system.**

I. INTRODUCTION

All power factor is the relation between current and voltage and thus in generally there is the phases difference between voltage and current [1], [2], [3]. In the capacitive circuit the current leads the voltage thus the power factor is said to be leading and the inductive circuit the current lagging voltage thus the power factor is lagging. The cosine of the angle between current and voltage is called power factor [4], [5], [6]. Power factor is a measurement of how effectively electrical power is being used. The higher the power factor, the more effectively electrical power is being used [7]. Low power factors affect efficiencies and costs for both the electrical power industry and the consumers [8], [9], [10]. In addition to the increased operating costs, reactive power can require the use of wiring, switches, circuit breakers, transformers and transmission lines with higher current capacities, this requires larger, more expensive power plant equipment, transmission lines, transformers, switches, etc. than would be necessary for only real power delivered [11], [12].

The research work is carried out to investigate the effect of impedance i.e. change in the inductance keeping resistance and capacitance are constant on the designed power system. Signal processing technique is used to evaluate the effect of the impedance and calculation of power factor.

II. CAUSE OF LOW POWER FACTOR

Low power factor is undesirable from economic point of view. Normally, the power factor is lower than 0.8 for the whole load on the supply system by following the causes of low power factor [5]:

- AC motors are of induction type (1 phase and 3 phase induction motors) which have low lagging power factor. These motors work at a power factor which is extremely small on light load (0.2 to 0.3) and increases to 0.8 or 0.9 at full load.
- Arc lamps, electric discharge lamps and industrial heating furnaces operate at low lagging power factor.
- The load on the power system is varying; being high during morning and evening and low at other times. During low load period, supply voltage is increased which increases the magnetization current. This results in the decreased power factor.

III. METHODOLOGY

The purposed research work can be explained in the form of block diagram as shown in Fig. 1. It comprises of six blocks: voltage and current sensing circuit, power stabilization, variable loads section, load voltage & current measurement, sound card, signal system and processing unit. Input is applied to the system and its voltage and current are mearsured using the first block. The elevation or drop in the input voltage caused by the fluctuations are stablized by the stablization block consists of microcontroller and other peripehals devices. The microcontroller used in the circuit is PIC16F72 and the volatge stablization is done using MOSFET IC P90NF03L with other peripehal devices. The output from the stablization block is applied to the load. Load consists of series combinations of resistor, capacitor and inductor.

Different combinations of impedance are taken shown in Table I. Load current and voltage for different combinations is measured using CT and load voltage measurement block. Further these signals are stored and processed in PC through sound card. Since the value of output load voltage is in tens of Volts, thus cannot be directly applied to the sound card, a circuit is developed to bring down the amplitude of the output voltage from volts to millivolts shown in Fig. 2.

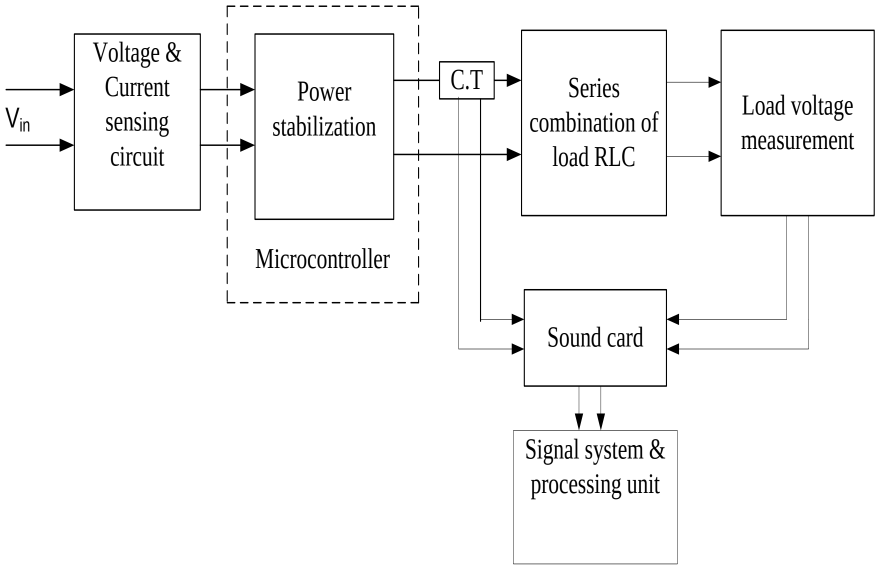


Fig. 1 Block diagram of the system

We take the eight different values of the inductance 1232mH to 269.1mH, keeping resistance and capacitance are constant with sampling rate and duration of measurement are kept at value of 16000 and 1 s respectively. These signals are recorded in the PC using Goldwave software. Calculations of the power factor are carried out using signal system and processing unit.

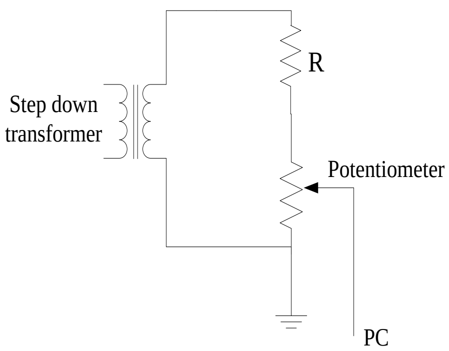


Fig. 2 Voltage step-down circuit to input signal to PC

TABLE I
DIFFERENT COMBINATIONS OF LOAD RLC

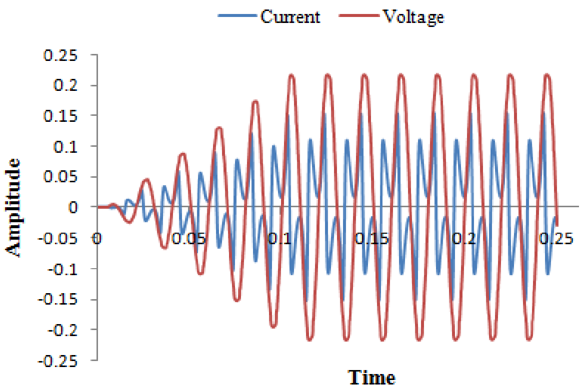
S. No.	R(Ω)	L(mH)	C(µF)
1	124	1232.0	2.5
2	124	1073.0	2.5
3	124	873.0	2.5
4	124	729.0	2.5
5	124	590.6	2.5
6	124	470.2	2.5
7	124	363.0	2.5
8	124	269.1	2.5

IV. RESULT AND DISCUSSION

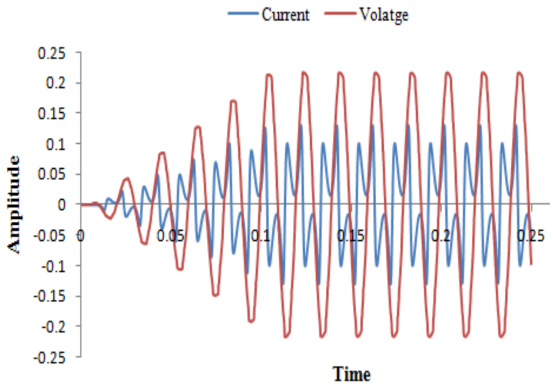
Investigations of the change in the power factor due to loading effect has been evaluated and analyzed. Calculations of the power factor are carried out using signal system and processing unit. Various combinations of load i.e. inductive, capacitive and resistive are shown in Table I and their total impedance is calculated using following formula:

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad (1)$$

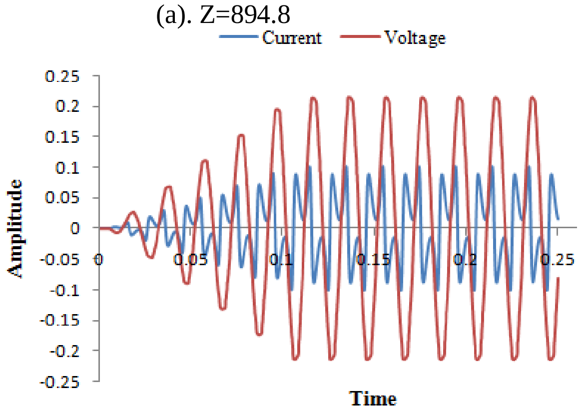
where $X_L = 2\pi fL$ and $X_C = \dfrac{1}{2\pi fC}$



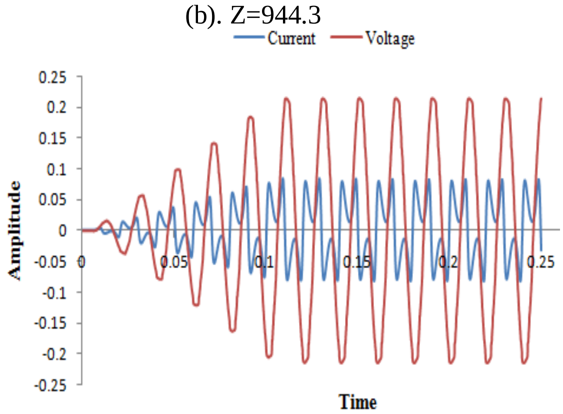
(a). Z=894.8



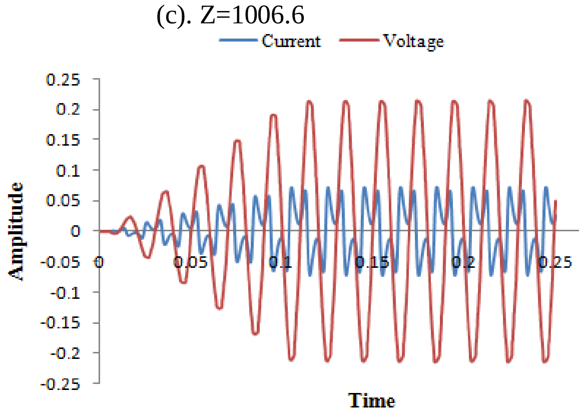
(b). Z=944.3



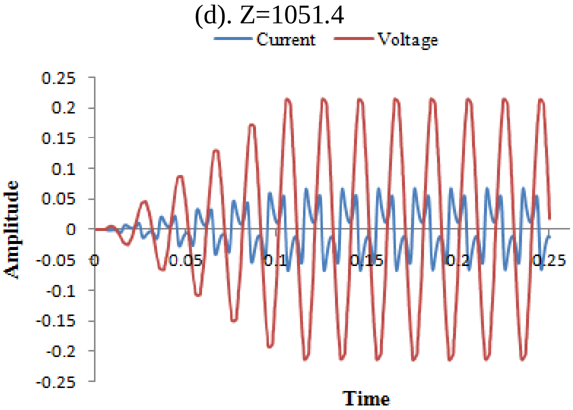
(c). Z=1006.6



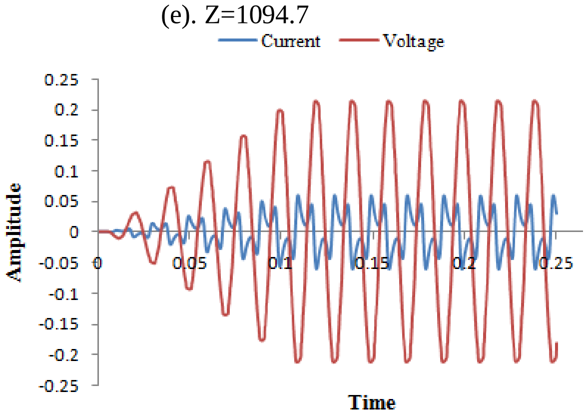
(d). Z=1051.4



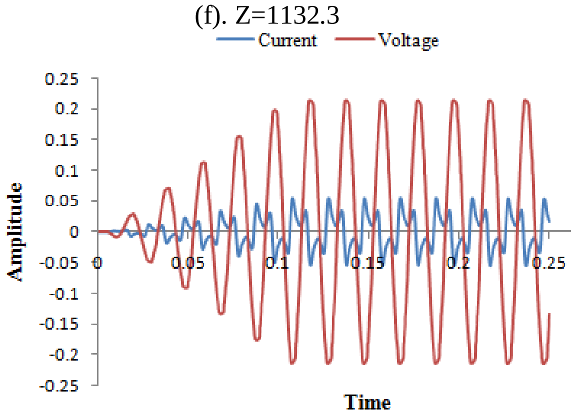
(e). Z=1094.7



(f). Z=1132.3



(g). Z=1165.8



(h). Z=1195.1

Fig. 3(a-h) Signal for output current and voltage are recorded at 16,000 sampling rate for eight different values of inductance, keeping resistance (124Ω) and capacitor (2.5μF) are constant

Load voltage and current through it are segmented for 0.25 s for eight combinations of impedance are shown in Fig. 3(a) to Fig. 3(h). From these plots it can be analysed that inductance shows a prominent effect on the amplitude of the current but as far as voltage is concerned its amplitude remains constant for all the combinations of the load. Current amplitude is inversely proportional to the magnitude of the inductor. Theoretical values of the power factor were calculated using following formula given below with all the values of the inductor, capacitor and resistor taken in the experiment.

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right) \quad (2)$$

$$P.F. = \cos\phi$$

From the output waveforms of current and voltage the practical value of the power factor were obtained. Both theoretical and practical calculated values of power factor are shown in Table II. Also the error calculated by dividing theoretical and practical calculated values is shown. The calculated theoretical and practical values are plotted in Fig. 4 with different impedance values. As the values of the impedance is increased i.e. variation in the value of inductance from Henry (H) to mH, the power factor value falls giving maximum and minimum values of 0.1478 and 0.104 respectively. Least error in the power factor was observed in the power system.

TABLE II
CALCULATION OF THEORETICAL AND PRACTICAL VALUE OF POWER FACTOR

S. No.	Impedance Z(Ω)	P.F. Theoretical	P.F. Practical	Error
1	894.8	0.1384	0.1478	0.9364
2	944.3	0.1311	0.1391	0.9424
3	1006.6	0.123	0.1305	0.9425
4	1051.4	0.1178	0.1218	0.9671
5	1094.7	0.1131	0.1150	0.9834
6	1132.3	0.1094	0.1110	0.9855
7	1165.8	0.1062	0.104	1.0211
8	1195.1	0.1036	0.104	0.9961

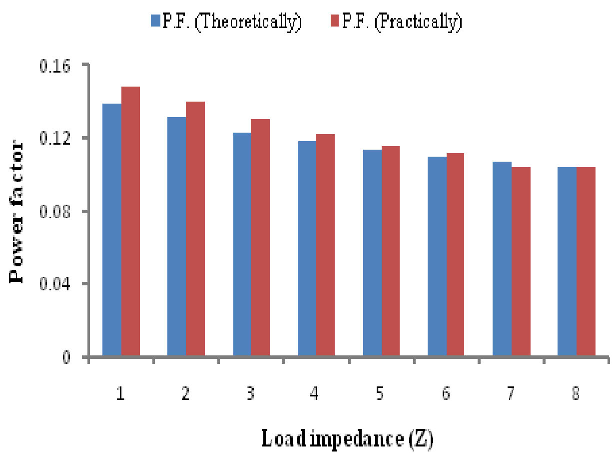


Fig. 4 Calculated theoretical and practical value of power factor for different impedance value

V. Conclusions

Research work was carried out to analyse the effect of impedance variation on the power factor. Various combinations of inductance, capacitance and resistance were taken to form different load condition in the load. Current and voltages were recorded from all the combinations at 16,000 sampling. It is observed form the investigations that the amplitude of the current in the load is inversely proportional to the inductance and also the power factor is inversely proportional to it.

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