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Examination of the Change in the Power Factor Due to Loading Effect

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Abstract— *Research work is carried out to examination of the change in the power factor due to loading effect. In this experiment, we are taking different values of inductance, one range of capacitor and two ranges of resistance and their total impedance is calculated. The calculated theoretical and practical values of power factor on the basis of different combination loads. Pure sinusoidal sine waves are displayed in computer through sound card and calculate the load phase angle between the fundamental components of the load voltage and current.*

Keywords— *Active power, impedance, signal processing technique, power factor.*

I. Introduction

In electrical engineering, power factor plays a prominent role in our society [1]. Power factor is a significant element in power system which is defined as the angle difference between voltages and currents that produces power fluctuation between sources and loads [2]. This current and voltages are sensed by using instrument transformers like current transformer and voltage transformer. Poor power factor costs our community in increased electricity charges and unnecessary effect in the system and poor power quality [3]. The actual amount of power being used or dissipated in a circuit is called true power. Reactive loads such as inductors and capacitors make up what is called reactive power. The linear combination of true power and reactive power is called apparent power. Power system loads consist of resistive, inductive, and capacitive loads. Examples of resistive loads are incandescent lighting and electric heaters. Inductive loads are induction motors, transformers, and reactors and capacitive loads are capacitors, variable or fixed capacitor banks, motor starting capacitors, generators, and synchronous motors [4], [5].

Power factor may also be defined as the ratio of active power to the apparent power. Power factors range from zero (0) to unity (1) with a typical power factor being between 0.8 and also equal to unity. The power factor can also be leading or lagging depending on whether the load is usually capacitive or inductive in nature. If the circuit is inductive, the current is lags behind the voltage and the power factor is called lagging power factor and if the circuit is capacitive then current leads to voltage and power factor is said to be leading power factor. The result of lagging power factor increases the power losses in the power system. The reactive power is compensated by real power by using suitable value of capacitors [6-11].

The research work is carried out to analyzed the power factor due to loading effect i.e keeping capacitance and resistance are constant due to changing the value of inductances on the designed power system. Signal processing technique is used to calculate the effect of the impedance (Z) and calculation of power factor.

II. Methodology

The purposed research work can be explained in the form of different steps AC power supply stabilization with sensing circuit (i.e voltage and current), different combination of load section, step down voltage transformer (PT) and current transformer (CT) and the sound card with signal processing unit. In this experiment firstly input voltage is applied to power stabilization with sensing circuit the drop in input voltage caused by the fluctuations are stabilized by the PIC based microcontroller and other peripheral devices. The output from the AC power stabilization with sensing circuit is applied to the load (RLC) which consists of series combinations of RLC (resistor-inductor-capacitor). We have taken different values of inductances, one range of capacitance, two different ranges of resistance. The output from the load is applied to the step down voltage transformer. Voltage transformer and current transformer are used for measurement of the load voltage and current. Sinusoidal sine waves are displayed in computer through sound card and calculate the load phase angle between the fundamental components of the load voltage and current.

TABLE I. Different combinations of load LC with resistor 36Ω

S. No.	R(Ω)	L(mH)	C(µF)
1	36	1232.0	2.5
2	36	1073.0	2.5
3	36	873.0	2.5
4	36	729.0	2.5
5	36	590.6	2.5
6	36	470.2	2.5
7	36	363.0	2.5
8	36	269.1	2.5

TABLE II Different combinations of load LC with resistor 124Ω

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

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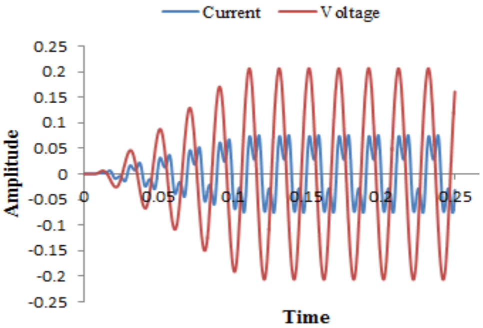
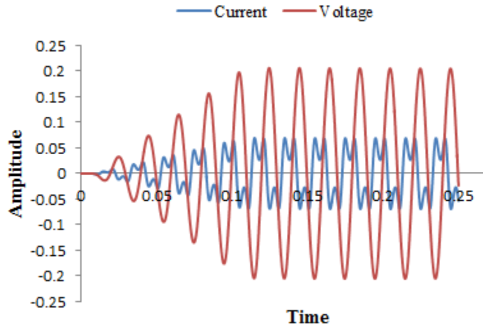
In table I shows the value of resistance and capacitor are constant due to variation of value of inductances. In table II, shows the constant value of resistance, eight values of inductor and the constant value of capacitor.

III. Result and Discussion

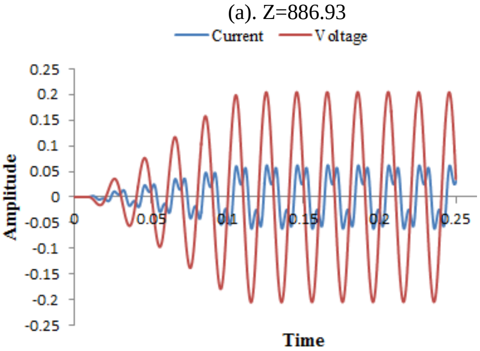
Experimental results are obtained from the different combination of loads (LC with resistor 36Ω and LC with resistor 124Ω) on the microcontroller based power system. Investigations of the change in the power factor due to loading effect has been evaluated and analyzed. Calculations of the power factor are carried out using signal system and processing unit. Figure 1(a-h) represents the segmented output voltage and current waveforms for different combinations of the load with duration of 0.3s.



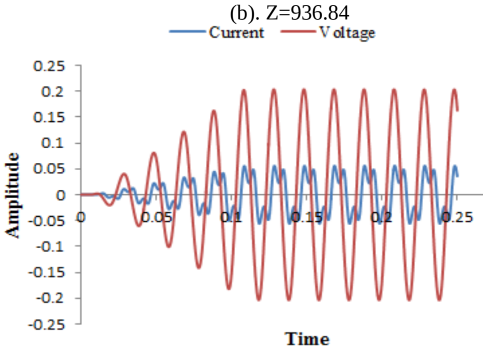
(a). Z=886.93



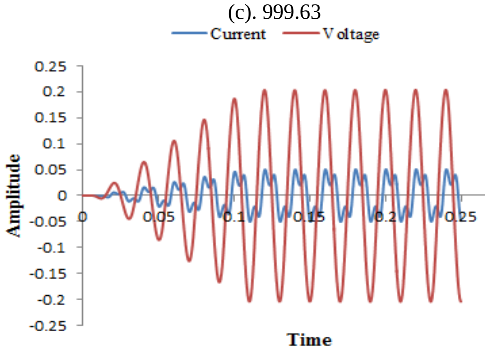
(b). Z=936.84



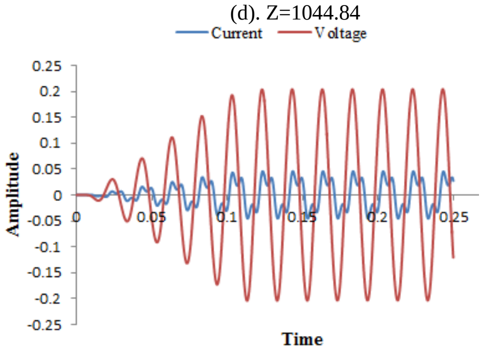
(c). 999.63



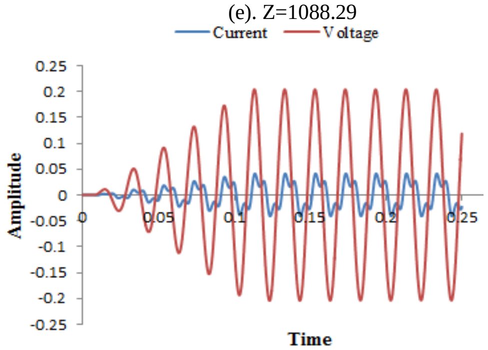
(d). Z=1044.84



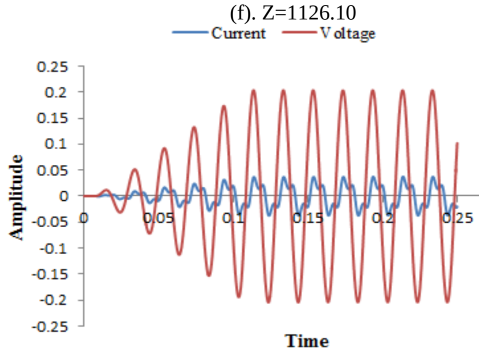
(e). Z=1088.29



(f). Z=1126.10



(g). Z=1159.76



(h). Z=1189.24

Fig. 1(a-h). Signal for output current and voltage are recorded at 16,000 sampling rate for eight different values of inductance, keeping resistance (36Ω) and capacitor are constant.

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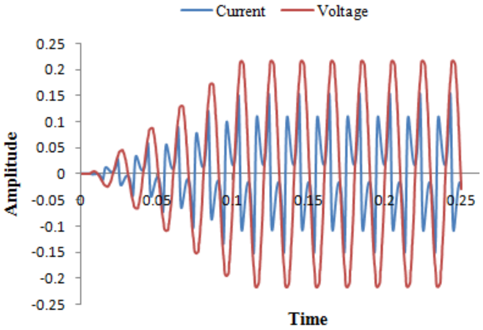
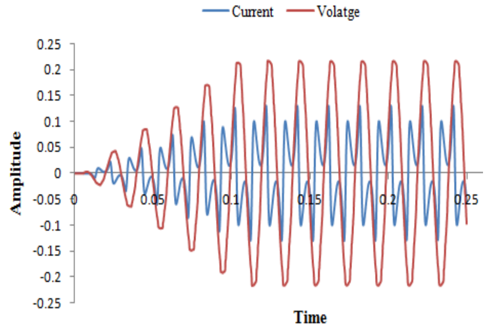
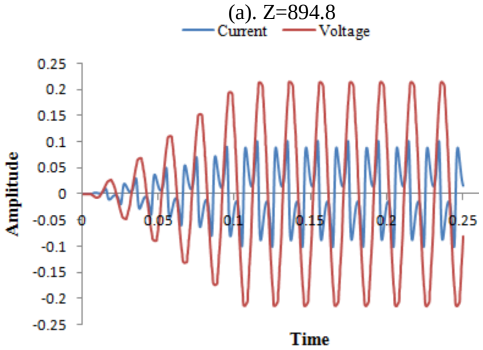


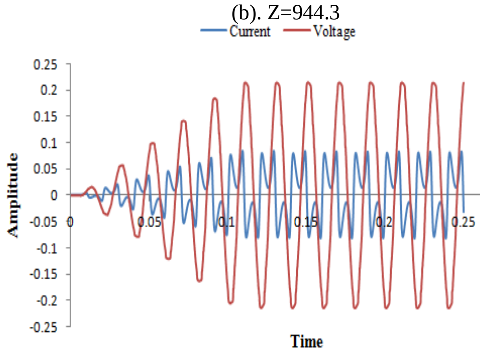
(a). Z=894.8



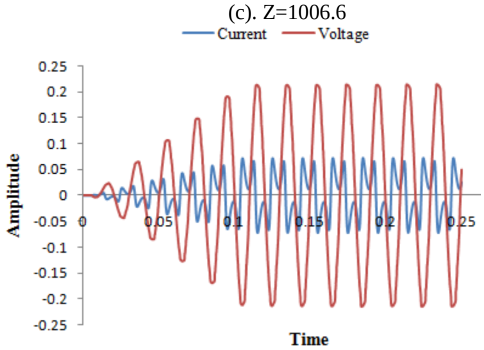
(b). Z=944.3



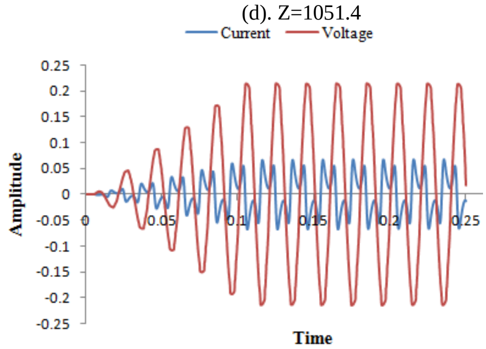
(c). Z=1006.6



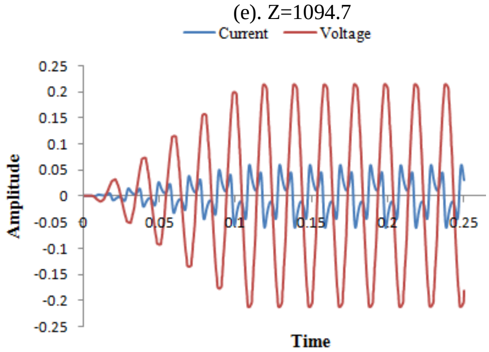
(d). Z=1051.4



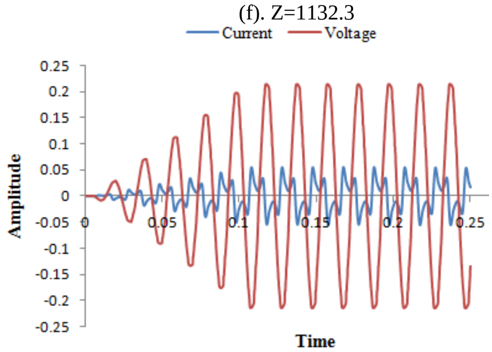
(e). Z=1094.7



(f). Z=1132.3



(g). Z=1165.8



(h). Z=1195.1

Fig. 2(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 are constant.

Figure 2(a-h) represents the segmented output voltage and current waveforms for different combinations of the load with duration of 0.3s and their total impedance is calculated with all the values of the capacitor, inductor and resistor. Theoretical values of the power factor were calculated. The practical values of the power factor were obtained from the output waveforms of current and voltage. Both calculated theoretical and practical values of power factor are shown in table III and table IV. In Table III, the minimum value of theoretical power factor is 0.030 and corresponding practical power factor is 0.020. The maximum value of theoretical power factor is 0.040 and corresponding practical power factor is 0.030. In Table IV, the minimum value of theoretical power factor is 0.1036 and corresponding practical power factor is 0.104. The maximum value of theoretical power factor is 0.1384 and corresponding practical power factor is 0.1478. The calculated theoretical and practical values of power factor are plotted in figure 3 and figure 4 with different impedance values.

TABLE III. Calculation of theoretical and practical value of PF for load LC with resistor 36 Ω.

S. No	Impedance Z(Ω)	P.F. Theoretical	P.F. Practical
1	886.93	0.040	0.030
2	936.84	0.038	0.030
3	999.63	0.035	0.020
4	1044.84	0.034	0.020
5	1088.29	0.033	0.020
6	1126.10	0.031	0.020
7	1159.76	0.031	0.020
8	1189.24	0.030	0.020

TABLE IV. Calculation of theoretical and practical value of PF for load LC with resistor 124 Ω.

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

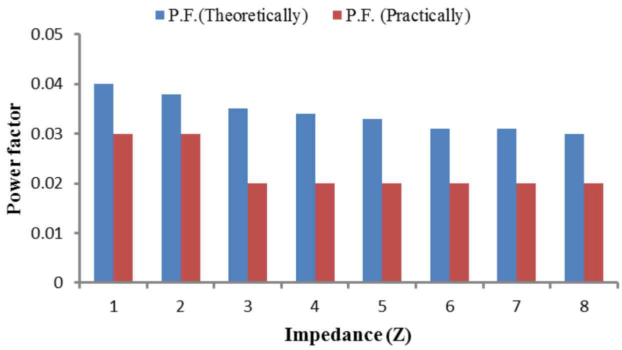


Fig. 3. Theoretical and practical calculated value of power factor for different combinations of impedance (LC with resistor 36 Ω).

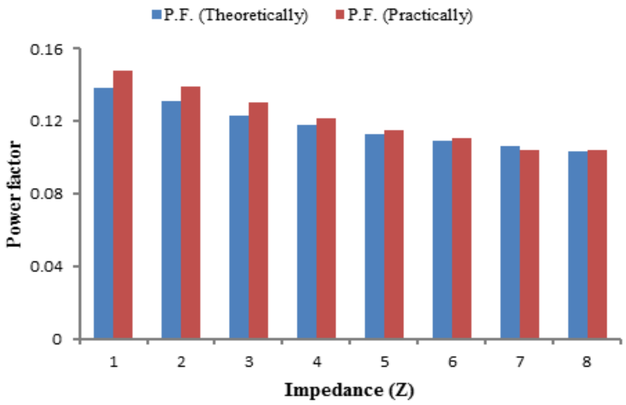


Fig. 4. Calculated the theoretical and practical value of power factor for certain combinations of impedance (LC with resistor 124 Ω).

IV. CONCLUSION

Research work is carried out to examination of the change in the power factor due to loading effect. Calculations of the power factor were carried out using digital signal processing algorithms. Different combinations of loads were investigated for affecting the performance of the system. In RLC load, it was found that taking the capacitance as constant and varying the value of inductance from 269.1mH to 1.232H and resistance as 36Ω and 124Ω resulted in the minimum and maximum value of power factor for resistance of 36Ω as 0.020 and 0.030, for resistance of 124Ω as 0.104 and 0.1478. The estimation of the power factor was taken by recording the voltage and current waveforms at 16,000sa/s at 16-bit quantization and processing using digital signal processing algorithms.

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