Effect of Impedance Load on the Power Factor of Microcontroller Based Power System

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Abstract—Power system designs require considering various parameters effecting power factor. The research work is carried out to study and analyze the effect of impedance with varying inductance on the power factor of designed system. Eight different values of the inductance are taken from 269.1 mH to 1232.0 mH with capacitance of 50 µF and resistance 124 Ω. From the analysis it is observed that the current through the load is inversely proportional to the values of inductance and similar is the case for power factor. The minimum and maximum values of power factor obtained are 0.358 and 0.987 respectively.

Index Terms—Active Power, impedance, power factor.

I. INTRODUCTION

Most electrical loads do not consume only active power and but also reactive power. The higher the reactive power transported by the distribution network to cover the load requirement, the lower will be the power factor [1-2]. In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy losses in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor [3-6].

Power factor may be defined as the ratio of active power and apparent power. In an AC circuit, there is generally a phase difference △ between voltage and current is called the power factor of the ac circuit [7-8]. It is a measure of how the current is being capable to convert into useful work output and a good indicator on the effect of the load current on the efficiency of the supply system [9]. Power triangle is shown in Figure 1.

\[
\text{Power Factor} = \frac{\text{Active Power (WATTS)}}{\text{Apparent Power (VA)}}
\]

Figure 1: Power Triangle [10].

Power Factor gives a measure of how effective the real power utilization of the system is. It is a measure of distortion of the line voltage and the line current and the phase shift between them [11]. 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.

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

II. EFFECT OF ELECTRIC LOADS ON POWER FACTOR

There are three types of electric loads on power factor such as resistive, capacitive, inductive loads. In resistive load the voltage and current peaks coincide with each other and therefore in phase and the power factor is unity. The unit of resistance is referred as ohm (Ω) [12]. Inductive loads require a magnetic field to operate with an inductive load the current waveform is lagging behind the voltage waveform [13-15]. Therefore, the voltage and current peaks are not in phase. The unit of Inductive is called Henrys (H) [12]. The capacitor current leads (instead of lags) the voltage because of the time it takes for the dielectric material to charge up to full voltage from the charging current. Therefore, it is said that the current in a capacitor leads the voltage [3] [16-17]. The units of capacitance are called Farads (F) [18-19].

III. METHODOLOGY

The proposed research work can be explained in this form of block diagram shown in Figure 2. It comprises of six blocks: voltage and current sensing circuit, power stabilization, variable loads section, load voltage & current measurement, sound card, and signal storage and processing unit.

Figure 2: Schematics of the complete block diagram of the system.
Input is applied to the system and its voltage and current are measured using the first block. The elevation or drop in the input voltage caused by the fluctuations are stabilized by the stabilization block consists of microcontroller and driver circuitry. The controller used in the circuit is PIC16F72 and the voltage stabilization is done using MOSFET IC P90NF03L with other peripheral devices. The output from the stabilization block is applied to the load. Load consists of series with other peripheral devices. The output from the stabilization is done using MOSFET IC P90NF03L circuitry. The controller used in the circuit is PIC16F72 and stabilization block consists of microcontroller and driver input voltage caused by the fluctuations are stabilized by the means using the first block. The elevation or drop in the measurement block. Further these signals are stored and processed in PC using Gold wave software. The sampling rate and duration of measurement are kept at value of 16000 and 1 sec respectively.

Figure 3: Voltage step-down circuit to input signal to PC.

If the inductor are varying then loads obtained the output pulses of pure sinusoidal sine wave are display in computer through sound card and calculate the load phase angle, φ_L.

Table 1: Different combinations of load RLC

<table>
<thead>
<tr>
<th>S. No</th>
<th>R (ohm)</th>
<th>L (mH)</th>
<th>C (µF)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>124</td>
<td>1232.0</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>124</td>
<td>1073.0</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>124</td>
<td>873.0</td>
<td>50</td>
</tr>
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<td>4</td>
<td>124</td>
<td>729.0</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>124</td>
<td>590.6</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>124</td>
<td>470.2</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>124</td>
<td>363.0</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>124</td>
<td>269.1</td>
<td>50</td>
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</table>

Table 2: Calculation of power factor

<table>
<thead>
<tr>
<th>S. No</th>
<th>Impedance Z</th>
<th>P.F. Theoretical</th>
<th>P.F. Practical</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>346.3</td>
<td>0.358</td>
<td>0.358</td>
<td>1.000</td>
</tr>
<tr>
<td>2</td>
<td>300.2</td>
<td>0.413</td>
<td>0.422</td>
<td>0.978</td>
</tr>
<tr>
<td>3</td>
<td>244.4</td>
<td>0.507</td>
<td>0.515</td>
<td>0.984</td>
</tr>
<tr>
<td>4</td>
<td>206.8</td>
<td>0.599</td>
<td>0.587</td>
<td>1.020</td>
</tr>
<tr>
<td>5</td>
<td>173.9</td>
<td>0.713</td>
<td>0.707</td>
<td>1.008</td>
</tr>
<tr>
<td>6</td>
<td>149.8</td>
<td>0.828</td>
<td>0.819</td>
<td>1.010</td>
</tr>
<tr>
<td>7</td>
<td>133.8</td>
<td>0.926</td>
<td>0.891</td>
<td>1.039</td>
</tr>
<tr>
<td>8</td>
<td>125.7</td>
<td>0.986</td>
<td>0.987</td>
<td>0.998</td>
</tr>
</tbody>
</table>

The calculated theoretical and practical values are plotted in Figure 5 with different impedance values. As the values of the impedance is decreased i.e. variation in the value of inductance from Henry (H) to mH, the power factor value rises giving minimum and maximum values of 0.358 and 0.987 respectively. There is also some difference in theoretical and practical calculated values are seen in the plot for certain combinations which may arise due to leakage of the inductive or capacitive components.
Figure 4 (a-h): Load current voltage recorded at 16,000 sampling rate for eight different values of inductance.
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V. CONCLUSION

The research work is carried out to study and analyze the effect of the variation in the load on power factor. Eight different combinations of the load are taken with different values of inductance keeping resistance and capacitance constant. Load current and voltages were recorded from all the combinations. Form the investigations it is observed 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.

REFERENCES