



# Power Factor Correction

An Online Continuing Education Course for Engineers

**Course Number: E-3096**

**Credit: 3 Hours / 3 PDH / 3 CPD**

# Power Factor Correction

<b>Table of Contents</b>	<b>Page</b>
<b>1. Introduction</b>	<b>4</b>
<b>2. First, Consider a DC Circuit</b>	<b>4</b>
<b>3. Reactance</b>	<b>8</b>
<b>4. Demand</b>	<b>12</b>
<b>5. A Parallel LC Circuit</b>	<b>14</b>
<b>6. A Closer to Real World Example</b>	<b>15</b>
<b>7. Industrial World Considerations</b>	<b>18</b>
<b>8. So, How Do We Pay to Run This Motor?</b>	<b>20</b>
<b>9. Power Factor Correcting a Single Motor</b>	<b>20</b>
<b>10. Power Factor Correction by Adding a Fixed Capacitor</b>	<b>22</b>
<b>11. A Better, and Still Inexpensive, Way</b>	<b>23</b>
<b>12. A Completely Automatic System</b>	<b>25</b>
<b>13. How to Apply Power Factor Correction at Your Facility</b>	<b>25</b>
<b>14. Conclusions</b>	<b>26</b>

<b>List of Illustrations</b>	<b>Page</b>
<b>Figure 2.1 Simple DC Circuit</b>	<b>5</b>
<b>Figure 2.2 Waveforms of Voltage and Current in a Resistive Circuit</b>	<b>5</b>
<b>Figure 2.3 Vector Diagram of Voltage and Current for a Resistive Circuit</b>	<b>6</b>
<b>Figure 2.4 Waveforms of Voltage, Current, and Power for a Resistive Circuit</b>	<b>6</b>
<b>Figure 2.5 DC Circuit Showing Line Resistance</b>	<b>7</b>
<b>Figure 2.6 Resistive Circuit with an AC Source</b>	<b>7</b>
<b>Figure 3.1 Inductive Circuit</b>	<b>8</b>
<b>Figure 3.2 Waveforms of Voltage and Current in a Pure Inductive Circuit</b>	<b>9</b>
<b>Figure 3.3 Voltage, Current, and Power Flow for the Circuit of Figure 3.1</b>	<b>9</b>
<b>Figure 3.4 Vector Diagram for an Inductive Circuit</b>	<b>10</b>
<b>Figure 3.4 Simple Capacitive Circuit</b>	<b>10</b>
<b>Figure 3.5 Waveforms of Voltage and Current for a Capacitor</b>	<b>11</b>
<b>Figure 3.6 Graph of Voltage, Current, and Power for a Capacitor</b>	<b>11</b>
<b>Figure 4.1 Resistor – Inductor Series Circuit</b>	<b>12</b>
<b>Figure 4.2 Graph of Voltage and Current lagging Voltage by <math>45^\circ</math></b>	<b>13</b>
<b>Figure 4.3 Waveforms of Voltage, Current, and Power in an RL Circuit</b>	<b>13</b>
<b>Figure 4.4 Vector Diagram Showing the Current Lagging the Voltage by <math>45^\circ</math></b>	<b>14</b>
<b>Figure 5.1 Parallel Inductor Capacitor Circuit</b>	<b>14</b>
<b>Figure 5.2 Waveforms of the Voltage and Currents in an LC Circuit</b>	<b>15</b>

<b>Figure 5.3</b>	<b>Vector Diagram of Voltages and Currents in a Parallel LC Circuit</b>	<b>15</b>
<b>Figure 6.1</b>	<b>Series RL Circuit</b>	<b>16</b>
<b>Figure 6.2</b>	<b>Voltage, Current, and Power Waveforms for an RL Circuit</b>	<b>16</b>
<b>Figure 6.3</b>	<b>Series RL Circuit with Parallel Capacitor</b>	<b>17</b>
<b>Figure 6.4</b>	<b>Currents in a Parallel Power Factor corrected Circuit</b>	<b>17</b>
<b>Figure 6.5</b>	<b>Vector Representation of the Waveforms of Figure 6.4</b>	<b>18</b>
<b>Figure 7.5</b>	<b>Power Vector Diagram for a 100 Horsepower, Three Phase Motor</b>	<b>19</b>
<b>Figure 9.1</b>	<b>Power Factor Correction Added to a 100 Horsepower Motor</b>	<b>21</b>
<b>Figure 9.2</b>	<b>Power Factor Change by Using the Recommended Capacitor for a 100 HP Motor</b>	<b>22</b>
<b>Figure 10.1</b>	<b>Power Vector Diagram for Peak KVA Use for a Typical Factory</b>	<b>23</b>
<b>Figure 11.1</b>	<b>Power Vector Diagram of Factory with Larger Motors Power Factor Corrected</b>	<b>24</b>
<b>Figure 11.2</b>	<b>Power Vector Diagram for factory needing only 100 KVAR to Correct to Unity Power Factor</b>	<b>24</b>
<b>Figure 12.1</b>	<b>A Completely Automatic Power Factor Correction System</b>	<b>25</b>

## 1. Introduction

In today's world, and for most of recorded history, men and women have looked for and sought the most economical way to procure those things that have made or are making their lives more comfortable. Today one of the things that we use a lot is electricity. Because someone uses their time and talents to produce electricity and transport it to our homes and businesses, they expect us to pay for it. This is only fair and right. After all, when we do something that benefits mankind, we expect to get paid for our results. When the cost of electricity is considered, one of the few ways that the residential customer can save on his or her electricity is to turn off the lights or other electrical devices. It is also possible for some residential customers to save by reducing the number of appliances that are turned on at any given time. In other words, the power to the electric hot water heater can be automatically turned off when either the dryer, air conditioner, or other large load is turned on. This has the effect of lowering the peak load delivered to the customer. If the control scheme is chosen correctly, this technique can save some residential customers some money on their electric bills. If you want to see if this can apply to your personal electric bill, the utility's rate schedule for your electric service needs to be obtained and studied to see if it has provisions that can save you money. The rest of this course is concerned with reducing the peak current that flows to larger loads, such as manufacturing facilities, without reducing the actual power usage. This can lead to significant reductions in the power bills of manufacturing plants.

## 2. First, Consider a DC Circuit

To understand the concept and need for power factor correction, we first need to look at basic DC electrical principles. First, we have something called 'voltage,' which is electrical pressure. Then, we need something for this pressure to push, and we call it 'current.' And finally, we need somewhere for this current to flow through, and we call that 'resistance.'

Resistance is a property of materials. The resistance of any piece of material depends upon three things. These are **the length, cross-section area, and material constant called resistivity.** Resistance increases as length increases and decreases as the cross-section area increases. The relationship is:

$$R = (\rho * l) / A$$

Where l is length, A is area, and  $\rho$  is resistivity. For American units, l is in feet, Area is in circular mills (CM), and resistivity is in Ohm-circular feet. For example, **the resistivity of copper is 10.37 CM-ohm feet.** **the resistivity of aluminum is 17.2 CM-ohm feet.** **a circular mill is the area of a circle with a diameter of one mill.**

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

Close this window and click "Add to cart" on the product page.

Figure Number  
resistance (R).  
understanding e.

ent (I), and  
concept in

Ohm's Law says t

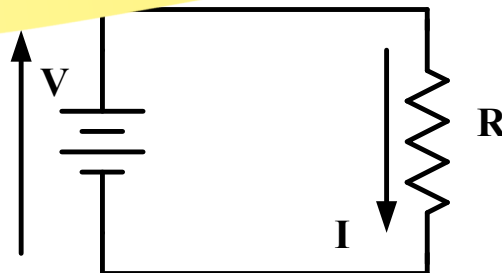


Figure 2.1 Simple DC Circuit