PRECISION
POWER LABS

IntegraPower™ Energy Saving Motor Controller
Technology Overview

Introduction

Precision Power Lab’s IntegraPower unit is an energy optimization device that uses solid state switching devices to precisely control the voltage and current provided to an inductive load. The device makes use of a method originally proposed by a NASA scientist by the name of Frank Nola in the late 1970s. Since that time, improvements in technology have allowed the development of increasingly more sophisticated controllers, but all of them operate under essentially the same principles.

Background

Before beginning to explain the operation of the IntegraPower controller, a certain amount of background knowledge is required to understand the fundamental operation of the device. This paper will make frequent use of terms associated with the device and its operation that may be unfamiliar to an individual with limited experience in the motor control industry. To establish a framework to build upon, the following background information is provided. Readers already familiar with the basic terms and concepts of motor control may want to skip to the ***Principles of Operation*** section.

Motor Controllers

A motor controller in its most basic form is nothing more than a switch that, when shut, allows the motor to operate, and when open, prevents the motor from operating. From this basic idea, many advancements and additions can be made. Motor controllers exist that operate based on a time schedule, a variety of temperature and/or pressure signals, remote operation signals, or a myriad of other possible configurations. The IntegraPower device is a motor controller that turns the motor on and off 120 times per second based on 20 external inputs and dozens of internal calculations. By precisely controlling the timing of these switches, considerable energy savings can be realized when compared to conventional products.

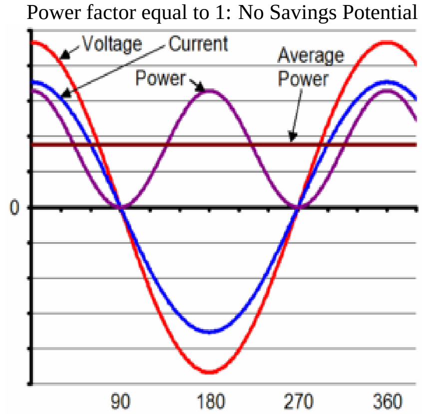
Phase Angle

Phase angle is the term used to describe the relationship between the voltage and current waveforms. Power provided from the electric utility is in the form of an alternating current sine wave. When this voltage is powering a device, the current flowing to that device is normally in the form of a sine wave as well. The nature of a motor is such that there is a phase difference between these two sine waves and that phase difference is the phase angle.

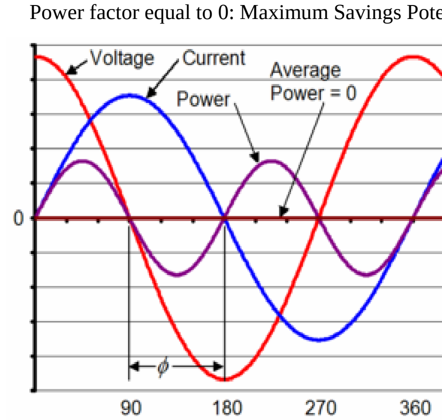
Power Factor

The power factor of a circuit is simply the cosine of the phase angle as described above. The power factor will always be between -1 and 1 and for a circuit where the current and voltage are in phase, the power factor is 1. All applications that the IntegraPower unit will be used on should have a power factor between 0 and 1. These types of loads are referred to as *inductive* loads and will have a current wave form crossing 0 some time *after* the voltage wave does. Loads with a power factor between -1 and 0 are called *capacitive* loads and will have a current waveform crossing 0 some time *before* the voltage does. Loads with a power factor of 1 are referred to as *resistive* loads and will have a current waveform crossing 0 at the *same time* as the voltage does.

Power factor equal to 1: No Savings Potential



Power factor equal to 0: Maximum Savings Potential



Power (Real and Apparent)

Power is the energy used to do work. In an electromechanical device it is a function of the voltage supplied to the load, the current drawn by the load, and the power factor of the circuit the load is part of. Apparent power is simply the voltage supplied to the load multiplied by the current drawn by the load. That means given a 240 volt voltage supply and a 10 amp current draw, the apparent power is 2400 VA or 2.4 kVA. Real power is a function of the actual work being done by the load and is equal to the voltage supplied multiplied by both the current drawn and the net power factor of the circuit. If the above example were on a circuit with a power factor of .8, the real power supplied would be 1920 W or 1.9 kW.

Theory of Operation

The fundamental operation of the IntegraPower controller involves measuring the existing phase angle of the treated circuit and lowering the applied voltage in circumstances where the phase angle is high. There is an inverse relationship between the magnitude of the phase angle and the level of load that the motor is operating under and by reducing the voltage during less than peak loading, a considerable reduction in power consumption can be achieved.

Condition Detection

The core of the IntegraPower controller is a state of the art Digital Signal Processor. This processor contains 16 built- in analog to digital converters which measure the analog voltage and current signals and convert them to digital signals for use by the processor. These signals are then analyzed to determine the precise phase angle, voltage and current levels. These values are sampled over 20,000 times each second allowing the controller to respond to changing conditions in fractions of a second.

Control Functions

The basic control in the IntegraPower unit stops current flow to the load for some period following the zero crossing of the current wave form. The period of time the current is turned off for varies depending on the detected phase angle but is always less than 90 degrees of the current waveform. At startup, the phase angle is measured and if the load is operating out of phase, the delay period is applied. If the measured phase angle with the initial delay period applied is still out of phase, the length of the delay period is increased. This loop is continued until the circuit becomes in phase, or a maximum amount of delay is reached.

Load Response

The circuit response to the applied delay period causes the current and voltage to come more into phase. This results in a smaller phase angle and a higher power factor. In addition to this, because the current is zero during the delay time, the RMS current applied to the load is reduced as well. The result of this is a dramatic reduction in apparent power (KVA) and a marked reduction in real power (KW) consumed by the load. In addition, the load operates at a higher power factor.

Overall Results

The overall effect of operation with the IntegraPower controller installed is an increase in the power factor seen by the supply and a decrease in the power consumed by the load. The precise amount of power savings that is exhibited is highly load and application dependent but has varied from 5% to 35% of the pre-treatment power consumption. The fundamental operation is the same in both single phase and three phase applications, though the higher inherent efficiency of 3 phase systems results in a lower average savings in these applications. The reduced current also results in lower heat loss and less vibration in the load. Though difficult to quantify, this results in increase motor life, in addition to the power savings.