–KEM Scientific, Inc.
Instruments for Science from Scientists

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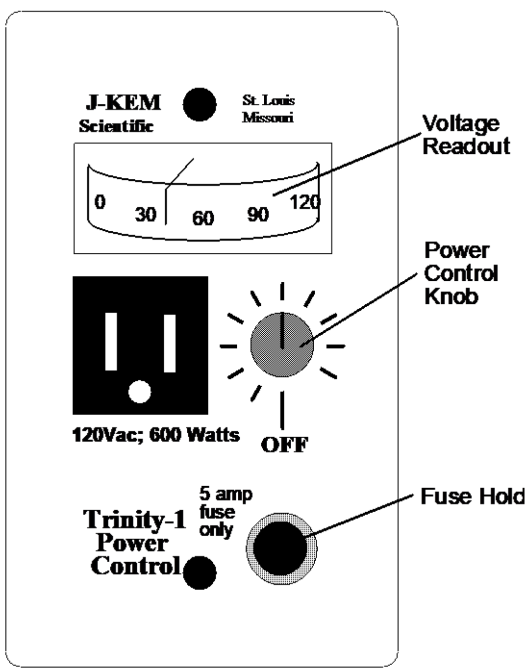
The Trinity-1M and 1P power controllers are panel mount units that must be installed in a standard duplex receptacle junction box. This unit must be installed by a qualified electrician.



- The Trinity Power Controller is a solid state version of a variac. This unit controls power by varying the voltage at the receptacle depending on the position of the Power Control Knob set by the User. As the Power Control Knob is turned in a clockwise direction, the voltage present at the power outlet increases. The voltage at the power outlet is shown on the Voltage Readout meter.

- The Trinity Power Controller is capable of delivering 5 amps at its full range of voltages.

- The fuses used with this unit are standard 5 x 20mm fuses. **Only 5 amp fuses should be used with this unit.** Fuses larger than 5 amps may result in a fire hazard.

- If you need assistance, call J-KEM's Engineering department.

Theory of Operation

The way power is regulated by J-KEM's Trinity Power Controller is shown in the figures below and should be understood since it influences the types of instruments that can be used. It should be noted that virtually all types of heaters and motors are compatible with the Trinity controller, the only exceptions are motors that use a capacitive starting mechanism and ultra low resistance heaters such as Nichrome wire in oil baths. The discussion that follows is not a rigorous treatment of power regulation and some compromises are made to keep the explanation simple. There are 2 ways to regulate 120 volt AC power. The first is to regulate the peak amplitude of the waveform (i.e., the peak voltage), which is how a variac works, the second is to regulate the percent of the waveform that's actually used, which is how the Trinity controller works. The waveform of "normal" 120 volt AC power is shown in Figure 1. The key features of Figure 1 are that AC power is a perfect sine wave with a frequency of 60 Hz and peak amplitudes of +120 volts and -120 volts for the positive and negative half waves, respectively. The power of a 120 VAC wave is linearly proportional to the shaded area enclosed by the sine wave.

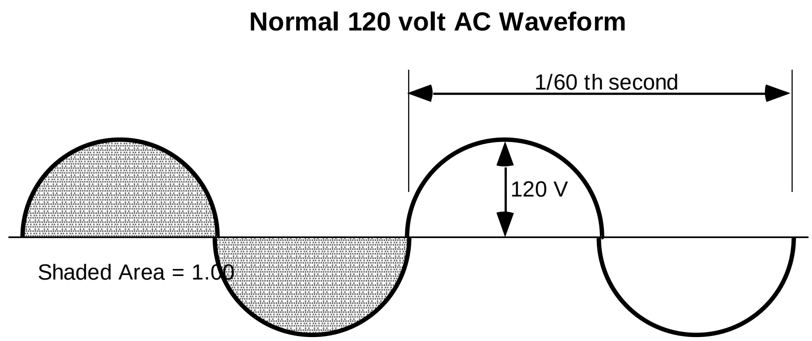


Figure 1

A variac regulates power by limiting the amplitude of the voltage sine wave as is shown in Figure 2. By restricting the maximum voltage of the sine wave a variac limits the area under the curve which is equivalent to limiting the power contained in a single sine wave. Figure 2 shows the case for a power reduction of 50%. The important feature to remember about Figure 2 is that the peak voltage is 60 volts.

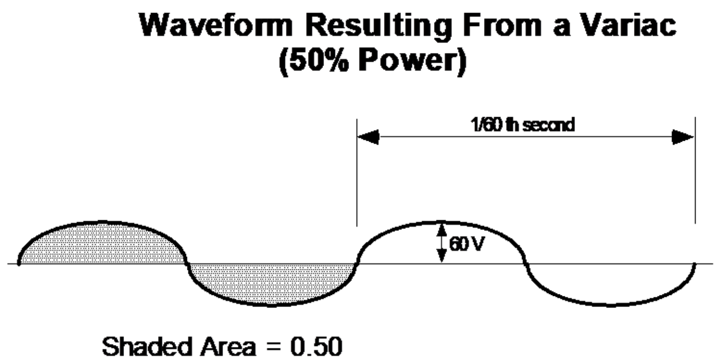


Figure 2

By comparison, J-KEM's Trinity controller regulates power by a completely different mechanism. Rather than limiting the peak voltage, the Trinity controller limits the <u>percent</u> of a "normal" 120 VAC sine wave that's allowed to pass as shown in Figures 3 & 4. For example, Figure 3 shows the resulting waveform when the controller is set to 50% power. To achieve 50% power the first half of both the positive and negative going phases of the sine wave are "cut off" and only the second half of each cycle is allowed to pass. In the case of 25% power (Figure 4), the first 75% of both the positive and negative going halves of the sine waves are "cut off". Since percent power is equal to the shaded area under the curve, the time proportioning of the sine wave shown in Figures 3 & 4 directly controls the amount of power delivered to a heater or motor connected to the Trinity controller.

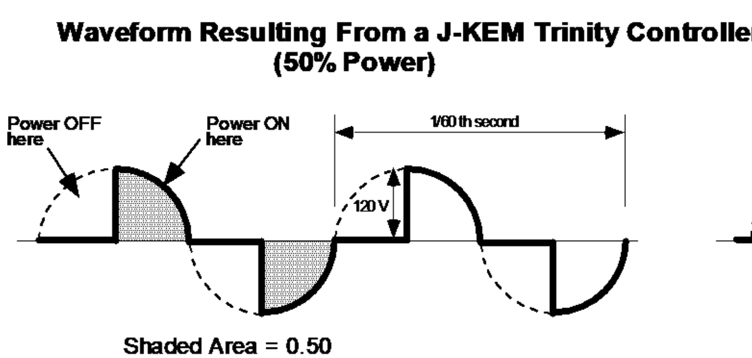


Figure 3

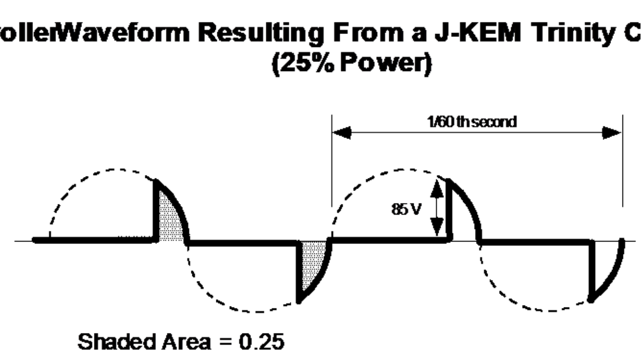


Figure 4

An important feature of the time proportioning mechanism of the Trinity controller is the peak voltage of each half wave cycle and its effect on peak current drawn by an attached electrical device.

Why The Trinity Controller Shouldn't Be Used With Oil Baths

A fundamental equation in electronics is:

V=IR which stand for: Voltage = Current * Resistance **Eq. 1**

As an example, a 100 ml heating mantle has a resistance of 180 ohms. Using equation 1, the peak current when the sine wave is at 120 volts is solved to be 0.67 amps (Eq 2).

120 volts = I * 180 ohms I = 0.67 amps **Eq. 2**

The problem with heating oil baths is that the resistance of the Nichrome wire that is commonly used to heat the oil has extremely low resistance, usually about 4 ohms. The difference between heating an oil bath with a variac and the Trinity controller is seen by solving Equation 1 for the peak voltage generated by a variac at 50% power and the Trinity controller at 50% power.

For a variac at 50% power, peak voltage is 60 volts. (Figure 2)

60 volts = I * 4 ohms I = 15 amps The peak current through the Nichrome wire at 50% power is **15 amps**.

For the Trinity controller at 50% power, peak voltage is 120 volts (Figure 3).

120 volts = I * 4 ohms I = 30 amps The peak current through the Nichrome wire at 50% power is **30 amps**.

The difference between a Trinity controller and a variac, in this case, is that the Trinity controller delivers twice the power of a variac for half the time. In other words, a variac delivers small amounts of power continuously while the Trinity controller delivers larger pulses of power for short durations of time. The only consequence of this is that when the Trinity controller is connected to an oil bath with its low resistance heater, the peak current generated is often large enough to blow the fuse in the controller. For this reason and the safety hazards associated with heating reactions using hot oil,
J-KEM discourages the use of oil baths and recommends the use of heating mantle at a safe and cleaner alternative. The advantages of the Trinity controller's power control mechanism is that it's ideally suited for all resistance heaters (other than oil baths), motor speed control, it's substantially more power efficient, less expensive to implement and smaller than a variac.