**Pulsed Modulated Injection Theory (PMI)**

PMI uses all 3 (proportional, integral, derivative) functions of a PID Control algorithm to open and close 1 of 2 relays housed within the CPU-1000. The control can choose to use PMI on either a pump (PMIp) terminals 26, 27 & 28 or a valve (PMIv) terminals 15 & 16.

In the example of a pump, the PMI logic will determine how long the pump needs to be ON for and how long to be OFF for to maintain adequate injection rates to stabilize the target temperature in the mixed (radiant) heat emitter. In the case of pump injection, the pump is being held on (pulsed on) e.g. full speed, for a calculated period of time and then held off (pulsed off) e.g. zero speed, for again a calculated period of time.  The ON pulse and the OFF pulse, time is continuously being monitored and compensated for by the Controls internal algorithm using PID application theory.

> **\* It is important to view this as a long on pulse or off pulse as opposed to a rapid series of pulses.  The duration of each pulse will likely be several seconds or even minutes before the beginning of a new cycle length.  It is also important to recognize that this control principle cycles the device on and off more frequently than is customary.  This has been taken into consideration and several safety features are built into the Control to alleviate any potential adverse effects on the Control, the electrical environment, pump motors and valve coils.**

**A. Typical Short Cycle Runtime**



PMI - Theoretical Representation
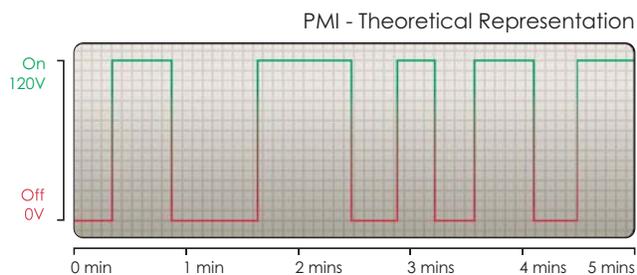
**B. Typical Long Cycle Runtime**



Pulsed Modulated Injection Theory (PMI)
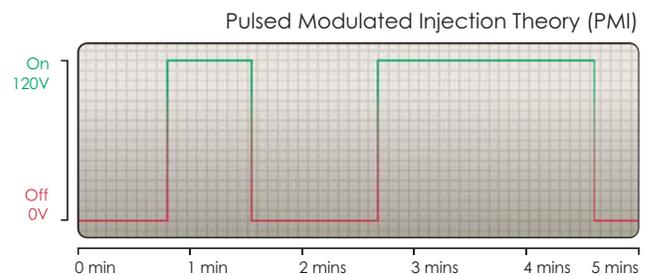
**\* In both examples, actual cycle time may be longer or shorter then shown**

In the case of PMIv or valve injection the theory is exactly the same.  With regard to the slower and varying response time of the valve the control PID will compensate and respond with timing changes accordingly.

HBX has tested this injection principle both in the lab and in extensive customer site locations with a variety of manufacturers' valves and pumps with exceptional control characteristics and no detrimental effects on either valve motors/coils or pump motors etc.

The main advantages to employing this control strategy with mixing are:

**i.** Single Phase pumps up to 10 amps (1HP, 120VAC) can be used for injection

**ii.** Extra Controls do not need to be wired into the main Control

**iii.** The option exists for future mechanical system upgrades or modifications without changing your primary controller

**iv.** Greater injection control using valves

⚠️ **PMIp is not recommended with split-phase motors. Premature failure of the start winding and/or centrifugal starting contacts may occur.**