EMC Compliance Considerations

1. Transient Absorption

We recommend using 3 high energy MOV's, each connected between each phase and 0V. This should be done as far up the local supply tree as is practicable (ideally immediately downstream of the local cabinet isolator). These will help to absorb any high energy transients which may be present on the 3-phase supply, by clipping or clamping the voltage to a nominal maximum permissible voltage value. If MOV's are used which are rated at 275V rms, the clamping voltage is typically around 700V. It is not unusual for transients up to 20kV to be present in industrial environments. These are usually the cause of switching semiconductor failure due to massive instantaneous current densities creating hot-spots within the semiconductor junctions. Clipping transients to 700V will ensure that all semiconductor junctions are kept within their specified operating conditions. Fig 1 shows the MOV arrangement.

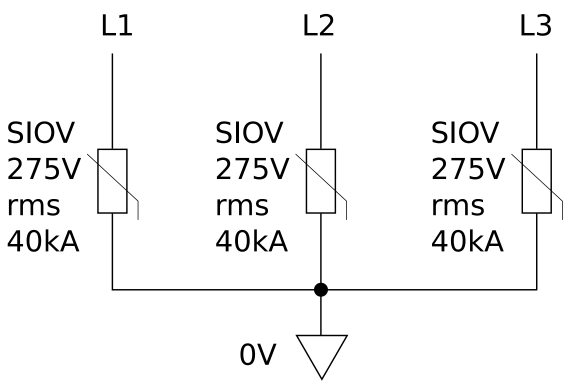

Fig 1.
Transient absorption network

Note that a temperature actuated switch should be used for each MOV, as an end-of-life indicator. MOV's will eventually begin to fail if subjected to particularly dirty supplies. The failure mode presents itself as a temperature rise as the MOV begins to conduct slightly at line voltage, and disspiates heat internally. Temperature is therefore a useful end-of-life indicator.

2. Zero Crossing Detection

There are 3 zero crossing detection circuits located on the HEATWAVE control card. The purpose of these is to provide an active low timing pulse for each phase on the system. The length of this pulse is approximately 50μs. It is generated symmetrically about the actual zero crossing point, meaning that the maximum temporal displacement from nominal zero is 25μs. The timing pulse is generated on each positive going transition of the phase (i.e. once every complete cycle), using an optoisolator to provide an accurate, repeatable timing reference and interface to the 5V logic. Fig 2 shows the zero crossing detection mechanism.

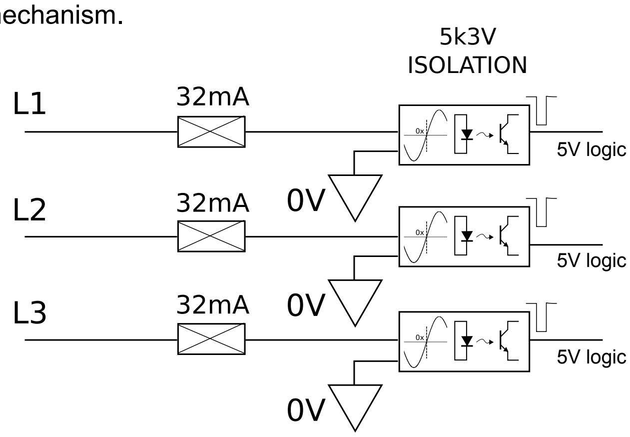

Fig 2.
Zero Crossing Detection

If we zoom in on the region of the zero volt crossing, we can see its correlation to the waveform of the underlying phase voltage. Because each detector has a purely resistive impedance, there are no phase shifts associated with the detection and generation of the timing pulse, and the pulse itself is symmetrical about zero volts as shown in Fig. 3.

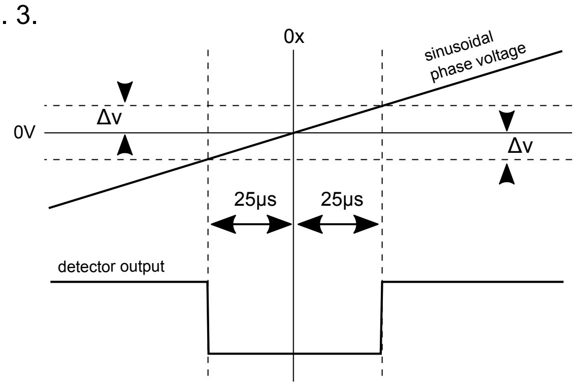

Fig 3.
Detailed view of Zero Crossing Pulse Timing

We can easily calculate Δv, the absolute maximum switching voltage. If the phase frequency is 50Hz, and the line voltage is 240V rms, then the period is 20ms and the peak amplitude of the sine voltage is 340V. Δv then is given by:

$$\Delta v = 340.\ \sin^{-1}\left[\frac{25 \times 10^{-6}\ .\ 2\pi}{20 \times 10^{-3}}\right]$$

$$\Delta v = 2.67 \text{ volts}$$

Since all necessary switching operations are performed within the 50µs pulse width, it follows that all switching must therefore be done at a phase voltage of 2.67 volts or less.

3. Triac Switching Method

Heatwave continuously performs a modulo 100 count of cycles on a reference phase. "On" transition for any given zone will be made during the timing pulse at the start of its respective cycle number. Its "Off" transition will be determined by the setting of the zone (0 to 99%). Thus for each zone, the maximum number of commutations during every 2 seconds (100 cycles at 50Hz) is one "On" and one "Off".

Drive to each Triac is achieved by providing a negative steady-state gate current controlled by the timing logic via optoisolators. This current is switched "On" during the timing pulse at its "On" cycle, and "Off" during the timing pulse of its desired "Off" cycle. The triacs are thus operated in quadrants II and III.

This method of switching is much cleaner than the ubiquitous burst-fire techniques, which commutate every half cycle, giving rise to spurii at every commutation. By comparison a similar system using burst fire would commutate not twice in 2 seconds, but 400 times!

4. Summary

We have had extensive experience with the HEATWAVE system over a period of 15 years since its original development. During that time, we have not witnessed any abnormal behaviour when the system is operated in reasonably close proximity to other control/switchgear or IT equipment. There have been occasions where HEATWAVE has shown susceptibility to EMI, but on each of these occasions analysis showed that some external piece of equipment or some vital suppression mechanism therein had become faulty.

Having put a finite value on the boundary condition for the term "zero volt switching" of 2.67 volts, and taking into account the method of switching and its cleanliness when compared to more traditional burst-fire techniques, we are confident that the HEATWAVE system is fully EMC compliant with 2014/30/EU.