The basic idea behind the keyword “hybrid” is an intelligent combination of wear-free, microprocessor-controlled, solid-state switches and low power dissipation relay contacts. The Contactron “4 in 1” employs the best features of both of these switching devices.

Contactron “4 in 1” is a reversing motor starter. Motor rotation selection is accomplished by inverting two phases with a set of relay contacts.

In this paper, we will look at only one direction of rotation. Phase reversal is not shown in the circuit diagrams illustrated in this paper.

When the Contactron “4 in 1” is activated in a direction of rotation, a number of internal tests are run. These tests serve to ensure the safe switching function of the Contactron “4 in 1”. If an internal error is recognized during this process, the Contactron “4 in 1” will remain safely switched off. If no problems are detected, start up proceeds and the power is applied to the motor.

The following steps outline the sequence of events that occurs when the Contactron “4 in 1” is activated. This sequence is controlled by the on-board microcontroller in the Contactron “4 in 1”.

Most solid-state switches have energy that can be measured on their output terminals when they are off and must, therefore, have additional protection from this hazard. The reason for this effect is leakage current in the RC element. This problem does not apply to the Contactron “4 in 1” since relay K1 has open contacts upstream of the triacs in both phases of L1 and L2 when it is switched off. Phase L3 is isolated by relay K2. Subsequently, the Contactron “4 in 1” offers efficient protection from shock hazards that is not provided by many other solid-state switching devices.
2. Sequence 1: Both K2 relay contacts close in phase L3 (see Figure 2). These contacts close without current flowing as a motor will not start with only one phase energized. Without any current flow, no arcing occurs on the K2 relay contacts, so this switching operation does not damage or shorten the life of those contacts.

3. Sequence 2: Both K1 relay contacts close in phase L1 and phase L2 (see Figure 3). No motor current is switched at this point since the downstream triacs V1 and V2 and relay K3 are off. No power is provided to the motor.
4. Sequence 3: Triacs V1 and V2 are energized and current flows to the motor, the K3 bypass contacts close and the triacs go into sleep mode. The contacts of relay K3 are not damaged since they were already completely closed when current was transferred to them by the triacs. It should be noted that contact wear is caused primarily by contact chatter at high start power or inductive surge voltage upon shutdown.

An additional consideration is that solid-state switches create a certain amount of power dissipation during continuous operation. This can be calculated by multiplying the residual voltage drop on the semiconductor by the conductor current. Normally this heat energy is dissipated over heat sinks. However, heat sinks have not been integrated into the Contactron “4 in 1”.

Instead, the K3 relay contacts are closed in parallel in phase L1 and phase L2 providing a bypass and eliminating the need for a heat sink. In this operation, only minimum switching power is applied to the K3 contacts, since only the triac’s residual voltage drop needs to be switched.

5. Sequence 4: Once triacs V1 and V2 have been bypassed by the K3 contacts, they are set into sleep mode (see Figure 5). The motor current now flows over the closed relay contacts of relay K3 with minimal power loss. The motor is now receiving full power and should be at its normal operating speed.

Shutdown of the Contactron “4 in 1” occurs in reverse order: triacs V1 and V2 are awakened from sleep mode and the K3 contacts are opened. Momentarily, the motor remains energized. Then triacs V1 and V2 are deactivated and the motor current is switched off, resulting in no contact damage to K3. Finally, all additional relay contacts are opened without any current flow that would cause inductive arcing and damage to those relay contacts.