

## GC-10 : PARALLEL PATH ISOLATOR

### Background Information:

Trailing cables are used in the mining industry to supply power to electrical equipment. Standards enforced by regulatory authorities vary; however, they usually require ground conductors in trailing cables to be monitored. The purpose in monitoring a ground conductor is to ensure a path exists for ground-fault current when a ground-fault occurs. An adequate ground-fault path is necessary to prevent personnel exposure to hazardous voltages and to allow ground-fault equipment to operate reliably. Ensuring an adequate ground-fault path occasionally requires the use of ground-wire devices. Parallel path isolators are ground-wire devices that allow ground conductors to be reliably monitored when:

- trailing-cable-fed equipment is in contact with the earth. If a ground path through earth parallels the ground conductor in a trailing cable, and if the resistance of the ground path through earth is less than the trip resistance of the ground-conductor monitor, the ground-conductor monitor will not detect an open ground conductor. A parallel path isolator between the power-center ground and the cable ground allows a groundconductor monitor to ignore the parallel path and monitor only the cable ground conductor.
- two or more pieces of trailing-cable-fed equipment are fed from the same power center. Trailing cable ground conductors are paralleled if equipment frames touch or are connected through earth. The ground path through a parallel cable can prevent a ground-conductor monitor from detecting an open ground conductor. Parallel path isolators between the power-center ground and the cable grounds allow ground conductor monitors to ignore parallel paths and monitor only their respective cable ground conductors.
- stray dc current from traction equipment or from cathodic protection flows in cable grounds. When trailing-cable-fed equipment is in contact with the earth, stray dc current can interfere with ground-conductor monitoring. A parallel path isolator between the power-center ground and the cable ground eliminates stray dc current in the cable ground conductor.
- voltages are induced in ground conductors. Asymmetrical power cables can have voltages induced in their ground conductors when load currents flow in their phase conductors—personnel have reported electric-shock sensations and intermachine arcing. Ground-conductor monitors are designed to tolerate induction in ground-check loops; however, it has been shown that the energy released is sufficient to ignite explosive methane-air mixtures when equipment frames touch or when an equipment frame touches an overhead mesh. Parallel path isolators between the power-center ground and the cable grounds eliminate low-voltage arcing.

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### PPI Design Requirements:

A parallel path isolator is a device in series with a ground conductor at the location where the downstream ground conductor is to be monitored. All four conditions discussed in BACKGROUND INFORMATION will be satisfied if the parallel path isolator prevents current from low-voltage sources from flowing in the downstream ground conductor. In order to maintain the integrity of the ground, a parallel path isolator must:

- have a continuous rating greater than 5 A—resistance-grounded systems over 5 A are tripping-type systems,
- have a short time rating adequate to survive the ground-fault current for an interval longer than that required for the ground fault to clear—most systems have grounding resistors with let-through currents less than 25 A and most ground faults are cleared in less than 2 seconds.
- have a short-circuit rating greater than the cable ground conductors,
- not significantly limit ground-fault current—this would lower the ground-fault tripping ratio, and
- be fail safe—any component failure must allow the device to continue to operate properly or the device must fail in short.

### PPI-600V:

The PPI-600V incorporates back-to-back SCR's with redundant gating circuits that begin to conduct when the voltage across the device exceeds 12 V. With one gate drive failed open, each SCR is guaranteed to fire at 35 Vac on a 5-A system so that a 10:1 tripping ratio will not be compromised. On 600-V systems, NGR's rarely exceed 15 A; however, parallel gate drives driven from a full-voltage fault on a 25-A system will not exceed the SCR's peak gate current rating of 4 A. Peak power ratings of the gating components are never achieved.

The SCR's used in the PPI-600V have a one-cycle surge rating of 15 kA and an  $I^2t$  for fusing of 935,000 A<sup>2</sup>sec. In destructive testing at Littelfuse Startco, a PPI-600V survived 10 seconds at 2.5 kA and it failed in short in 2.5 seconds at 5 kA—this exceeds the short-circuit rating of a 2/0 insulated copper conductor. The short-circuit failure mode is desired in the event of a two-phase-to-ground fault on opposite sides of a PPI-600V. If a failed PPI-600V is in service, symptoms will include nuisance ground-check monitor tripping but ground-conductor continuity and safety will be maintained. Each SCR package rating is  $80 \times 10^6$  A<sup>2</sup>sec which is more than 80 x the fusing  $I^2t$ .

For systems above 600 V use a V131DA40 MOV across the PPI-600V to limit the voltage until the SCR fires. The combination of a PPI-600V and a V131DA40 is adequate for systems above 600 V provided the NGR let-through current is less than 140 A continuous. For NGR let-through current above 140 A, a conservative time rating is given by the formula:  $(t = 25,000 / \text{NGR current})$ .