APPLICATION NOTE

EARTH CONTINUITY PILOT VOLTAGES

Electrical Protection Relays

The function of the earth continuity system is to enable SAFE and RELIABLE operation of reticulated mining equipment by ensuring the presence of an adequate earth connection. Earth continuity is typically required in applications where there is a fundamental reliance on the earth return impedance for the electrical safety of the operating equipment.

Earth continuity has a number of functions, all of which involve electrical safety:

1. Active (continuous) monitoring to ensure an in-tact earth connection between starter and load, rapidly disconnecting power if the resistance of the pilot-earth loop becomes excessive. This would occur if a powered disconnect was attempted with a plug/socket arrangement, or in case of excessive cable tension when powering mobile or relocatable equipment.
2. Active (continuous) monitoring to ensure that the return earth resistance is below a nominated threshold during operation and prior to the introduction of power.
    a. This threshold is the primary control for touch potential in an earth fault limited network as mandated for underground applications in NSW.

In order to make the determination that there is an in-tact earth connection, the EC relay must present a signal on a pilot core of the cable returning through the earth core. This DC or high frequency square wave signal is processed by the relay to determine the resistance of the pilot-earth loop. This Pilot-Earth loop resistance in conjunction with the limited Earth Fault current provides the horizontal axis reference of the touch-potential curve (4871.1, section 2.6.2.1) that the installation is exposed to under fault conditions.

In plain terms: **the EC relay and its associated signal contributes to the TOUCH POTENTIAL CONTROL for primary electrical safety**. Please note, the curves below appear in AS/NZS3000 as well as AS/NZS4871, and characterise the fibrillation limit for duration of exposure to a 50Hz touch potential. That is, the vast majority of the population will not suffer lasting physiological effects if the voltage duration of exposure is below this curve set. The curves are well in excess of the threshold of perception, and in some voltage/duration instances will result in painful involuntary muscle response.

There are sometimes supplementary functions of the pilot signal (such as communications), which may or may not affect the overall system design. It is recommended that these signals be understood before utilising in any application.

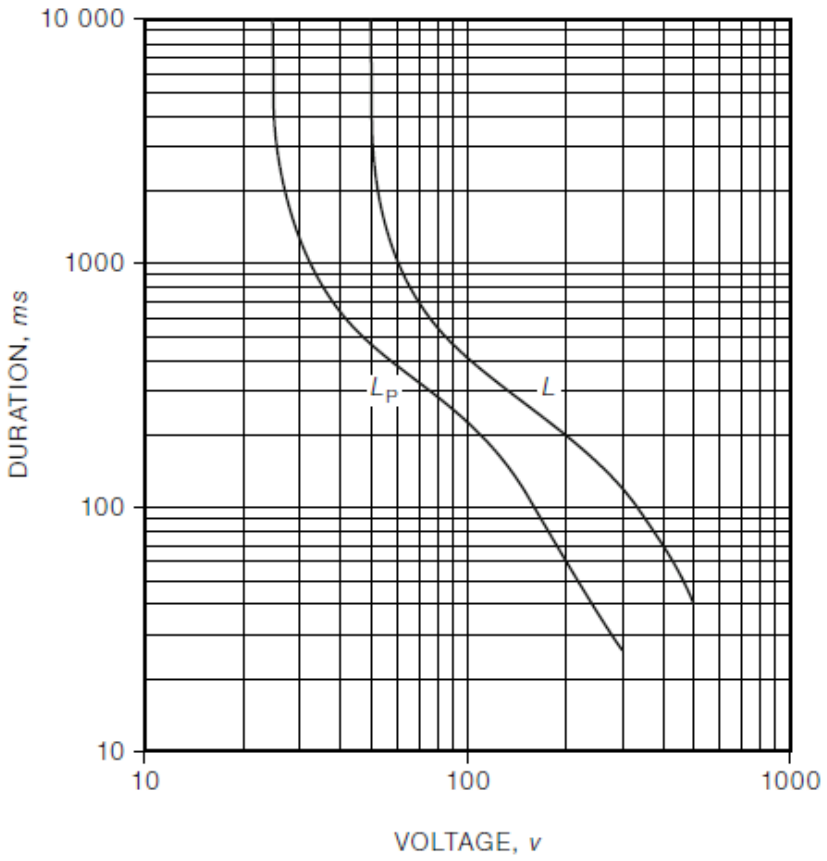
The design of the pilot signal is important.

a. It is designed to be safe in the situation where human contact could be reasonably expected – noting that this does not preclude that the signal may be perceptible. This will be the case where an earth connection is either high-resistance or open altogether.
b. It is also designed to be robust in the presence of electrical interference over long cable runs.

To achieve these goals for the EC signal, there are two important characteristics:

a. The signal remains within the limits for ELV, and where applicable, remains below the appropriate curve of the graph above.
b. The signal current is limited. This is achieved through the substantial series output impedance utilised in the pilot circuit of Ampcontrol relays. This limits the amount of electrical energy that can be delivered from the relay into the pilot circuit. This series impedance explicitly limits body current in the case of direct contact.

Remembering that the most important purpose of the EC system is to ensure electrical safety in the presence of a phase to earth electrical fault, the EC signal plays a pivotal role in ensuring the safe and reliable operation of the electrical system as a whole.



L	for normal conditions	touch voltage limit 50 V
L_P	for wet conditions	touch voltage limit 25 V

NOTE: This curve is derived from AS/NZS 3000 and is based on a typical set of conditions and body resistance values.

Figure 1: MAXIMUM DURATION OF PROSPECTIVE 50 Hz TOUCH VOLTAGE (This image has been taken from AS4871 Section 2.6.2.1)

POTENTIAL FAULTS WITH EARTH CONTINUITY RELAYS

There are a number of faults that can cause an Earth Continuity Relay to trip, including but not limited to:

- Increased Pilot-Earth loop resistance
  - Cable extensions exceed limits
  - Dirty plug pins
  - Old deteriorated cables
- Broken earth supply cable
- Broken Pilot Cable
- Short circuit between pilot core and earth core
- Intermittent breaks in Pilot-Earth loop
- Faulty, disconnected or incorrect termination module
- EC Relay not connected to pilot and earth return
- Excessive noise induced into Pilot core.

Pilot circuit designers need to be aware that when a fault is presented on the pilot system, the circuit changes and depending on the fault, may cause the earth reference potential at the load to rise to the pilot circuit voltage. Despite this anomaly, the output current will remain limited and the relay will prevent energisation of the mains supply to eliminate a dangerous fault prospect.

REQUIREMENTS FOR SAFE OPERATION

The safety requirements for electrical infrastructure are referenced in the Australian Work Health and Safety regulations as well as the relative regulations imposed by the local state and territories. In addition there are multiple Australian Standards that govern the design, application and utilisation of Earth Continuity Relays. The main standards include AS3000, AS3007, AS4871 and AS2081. The AS3000, AS3007 and AS4871 standards provide applications and utilisation requirements for EC relays, whereas AS2081 defines the design and performance requirements of the relays themselves.

It is within these references that it is recognised that an EC relay needs to be implemented such that it does not introduce a hazard itself. In understanding how an EC relay functions, it should be understood that the earth reference at the load can, under certain fault conditions, rise to the pilot voltage used. It is because of this that the pilot voltages of an EC relay are limited to within the Extra Low Voltage (ELV) rating. The recognised codes of practice have set these limits as less than or equal to 50VAC and less than or equal to 120VDC.

It is also worth noting that the Safe Work Australia code of practice for Electrical Risks in the Workplace states that any electric shock within the bounds of the ELV classification are *not a notifiable incident*. This also includes shock due to static electricity. However, to eliminate the potential for a perceived electrical contact and the site implications that this may entail, a simple control that could be put in place would be to investigate all logged EC Faults with an unknown fault location via manual continuity testing.

AMPCONTROL EC PRODUCTS

Ampcontrol offers a wide range of relays and equipment that incorporate Earth Continuity protection to satisfy the wide range applications utilising EC protection. The following detail outlines the voltages used by the various Ampcontrol EC relays.

ECM3: + 12VDC

HPB: + 30VDC

OCS: +/- 26VDC Square wave with frequency of 800Hz

RKS: +/- 26VDC Square wave with frequency of 800Hz

IPD: +/- 15VDC Square wave with frequency of 800Hz

IPM: +/- 30VDC Square wave with frequency of 800Hz

ECD: +/- 24VDC Square wave with frequency of 100Hz

PF1: +/- 24VDC Square wave with frequency of 100Hz

The above pilot voltage clarification outlines the use of only ELV Pilot signals at a frequency far greater than 50Hz. As such Ampcontrol does not believe that there is a safety risk or potential hazardous condition that can be developed from the use of these EC relays.

FIND OUT MORE

For more information on Ampcontrol EC protection relays or to find out which Ampcontrol EC relay best suits your application, please contact Ampcontrol Customer Service on +61 1300 267 373 or customerservice@ampcontrolgroup.com or visit the Ampcontrol website: www.ampcontrolgroup.com

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