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*Instruction Manual*

Model 4999-12L/LE

(LAB 3)

Lightning Arrestor Board

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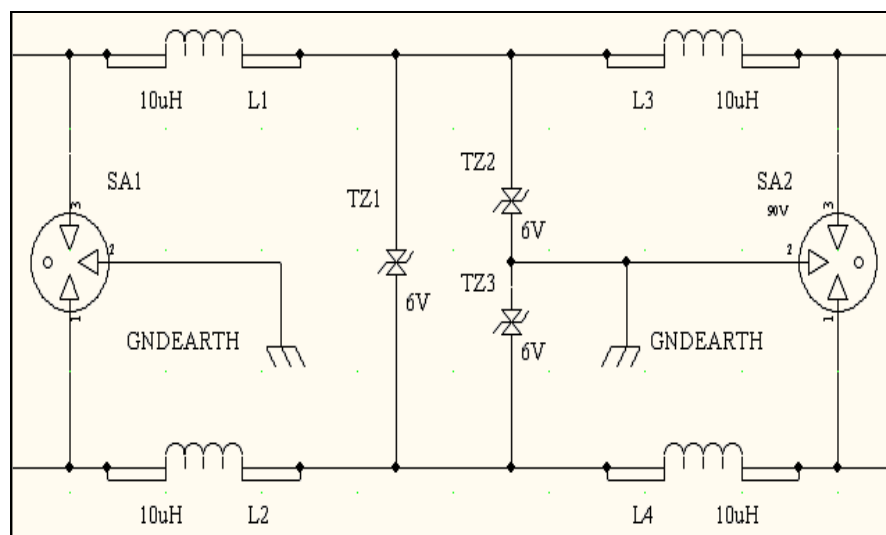
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## 1. INTRODUCTION

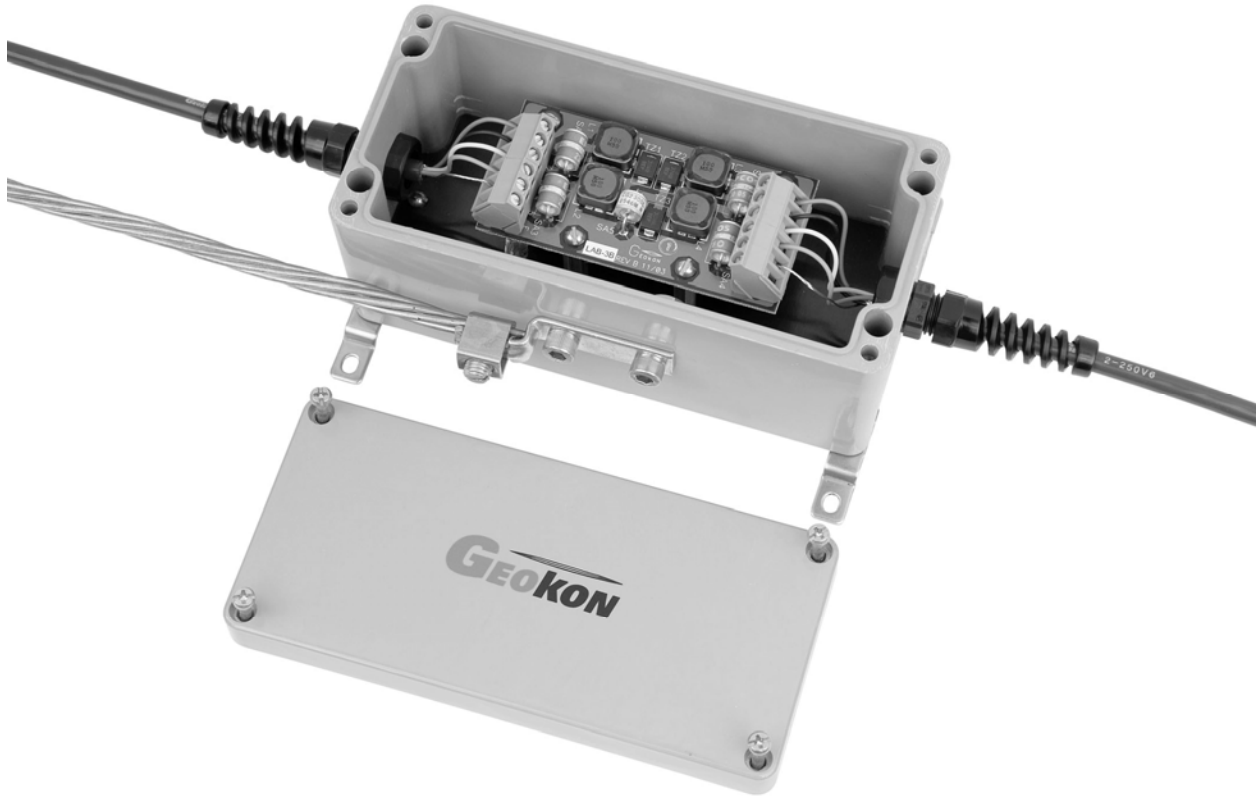
The Geokon, Inc. Model 4999-12L Surge Protection Board (LAB-3) is designed to protect Geokon vibrating wire transducers and 5V signals (-A option), 12V power and signals (-B option) and 24V power and signals (-C option) when used in conjunction with multiplexers and dataloggers, from short-duration high-voltage surges that may be induced in the transducer electrical cables by lightning strikes in the vicinity. They are designed for installation in the cable leading from the transducer to the datalogger, or in the datalogger itself. The LAB-3 is normally supplied inside a water-tight Nema 4 Enclosure (4999-12-LE).

**Disclaimer.** Please Note that nothing can protect a system from a direct lightning strike nor one so close that it swamps the capacity of the LAB-3 Board. Nor is it possible to state how far away the lightning strike must be to prevent sparking across the protective devices. Therefore use of the LAB-3 device is no guarantee that damage will not occur in the event of a strike! Geokon, Inc. is not responsible for any damage or loss suffered in that event.

### Basic Circuit:



**Figure 1: LAB-3 Schematic**



**Photo of the LAB-3 Lightning Protection**

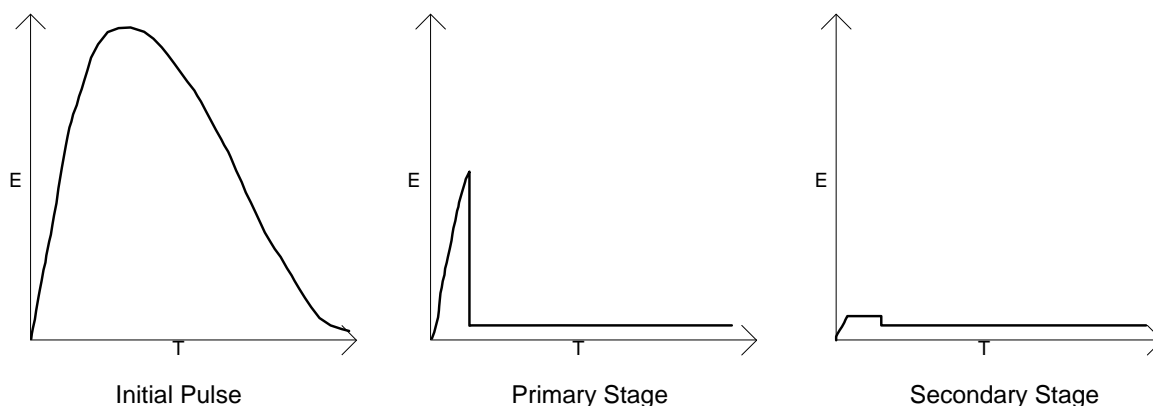
## 2. THEORY OF OPERATION

The primary protection is a tripolar gas tube protection device. This device limits the energy to the protected circuit by switching, in a few nanoseconds, from a high impedance state to a low impedance state in the presence of a sufficiently high transient voltage. It is comprised of three electrodes separated by a fixed distance in a hermetically-sealed, gas-filled chamber. The outer electrodes are connected to the two leads of the circuit to be protected, and the center electrode is connected to an earth ground. When transient voltages exceed the devices rated breakdown voltage, (dependent on electrode spacing, inert gas type, gas pressure, and rise time of the transient, in the present case a nominal 230 volts), it begins arcing or conducting, thereby diverting the potentially damaging energy away from the protected circuit and towards the earth ground.

While conducting, the voltage drop or arc voltage across the gas tube is quite low (typically less than 20 volts), hence the majority of the transient is dissipated in the earth ground, not in the gas tube itself or the protected circuit. When the transient has passed, the device returns to its former high impedance state.

The plots below illustrate energy content versus time of a lightning strike at various points in the lightning protection circuit.

The initial pulse enters the lightning board at either the SA1 or SA2 side and presents itself to the primary stage protection component (SA1 or SA2). This tripolar plasma surge arrester, (rated at 10 kA), will begin shunting the energy to ground when the nominal breakdown voltage, (230 V) is exceeded. (Typically 184-276 volts). The inductors L1 and L2 (or L3 and L4) delay the 230 volt pulse to the secondary stage protection to allow sufficient time for the breakdown voltage of the transzorb to be exceeded and therefore to actuate. The transzorb, TZ2 and TZ3, (rated at 1500 Watts), clamp the common mode voltage to a nominal 6 volts (LAB-3A), 16 volts (LAB-3B) or 30 volts (LAB-3C). The transzorb TZ1, (rated at 1500 Watts), completes the secondary stage protection by clamping the normal mode voltage to 6 volts (LAB-3A), 16 volts (LAB-3B) or 30 volts (LAB-3C).



**Figure 2: LAB-3 Lightning Transient Protection**

The shield is protected by a plasma surge arrester rated at 20kA surge absorption with a 300 volt breakdown.

### 3. INSTALLATION

#### 3.1 Protecting the Transducer

For protection of the transducer it is recommended that the LAB-3 (LAB-3A) Board be installed as close to the transducer as is practicable. For piezometers installed in boreholes, this usually means installation at the top of the borehole where the cable comes out of the ground and the LAB-3 Board is accessible.

Transducer leads are pushed through the spiral strain relief (supplied) and then through the connector on either the TB1 or TB2 end of the LAB-3 Enclosure. The leads are then connected to either the TB1 or TB2 terminal block. Connect the transducer wires as shown in the table below. The shield wire (no insulation) must be connected to the shield terminal (5). After the connections have been made, tighten the spiral strain relief onto the cable and connector and then bolt down the lid to the enclosure.

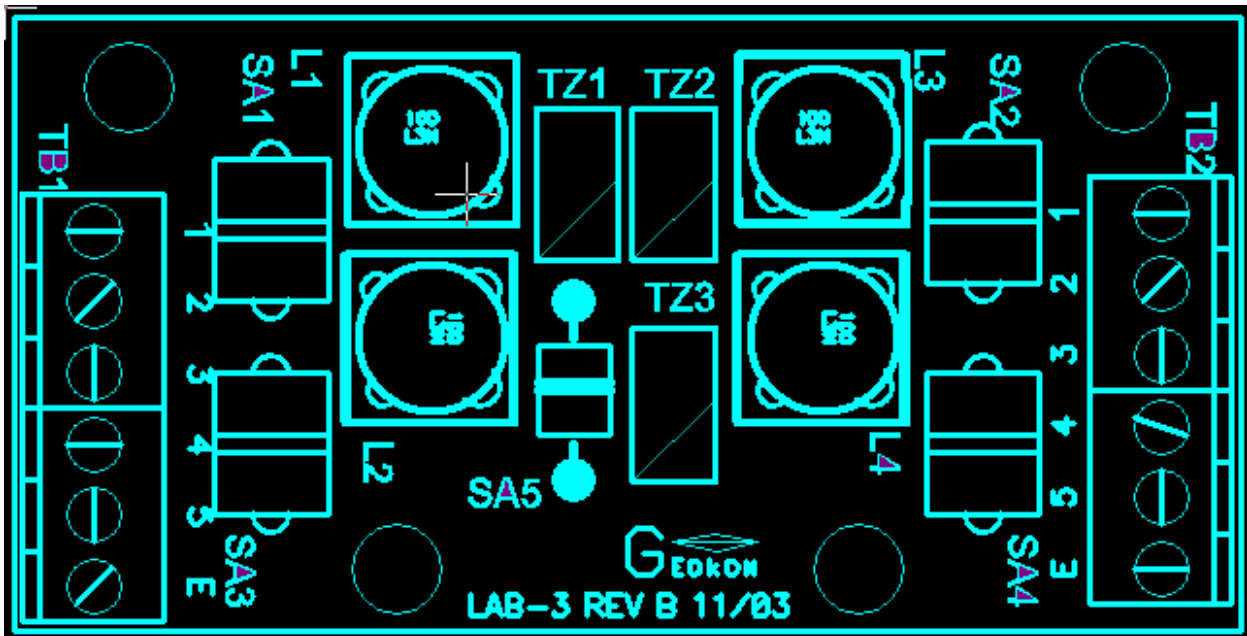


Figure 3: LAB-3 Circuit Board

| TB1/TB2 POSITION | SIGNAL | WIRE COLOR |
|------------------|--------|------------|
| 1                | VW+    | RED        |
| 2                | VW-    | BLACK      |
| 3                | TH+    | WHITE      |
| 4                | TH-    | GREEN      |
| 5                | SHIELD | SHIELD     |
| E                | EARTH  | -          |

Table 1: LAB-3 Circuit Board Wiring

In order for the LAB-3 board to be effective it is essential that it be located as close as practically possible to the protected device and **that a proper earth ground be established. (See section 3.4)**. The preferred way to achieve solid earth ground is to solder a length of ¼" tinned copper wire braid from the EARTH solder pad (located on the back side of the LAB-3 circuit board adjacent to TB-1) to a ground lug on the side of the LAB-3 enclosure. **All model 4999-12-LE (in NEMA 4 Enclosure) LAB-3 devices manufactured at Geokon have the external Earth Ground lug connected to the circuit board in this fashion.**

Alternatively (but not recommended), earth ground connection may be made via the (2) E terminals on TB1 and TB2 or via the circuit board mounting holes. When the board is mounted to a grounded metal enclosure, electrical continuity is made from the mounting holes to the board via the stand-offs. It may be necessary to scrape off some of the paint to get a low resistance value. An earth ground can then be made through the bolts holding the enclosure. Connection to earth ground can then be completed by running a wire (at least 14 AWG) from the ground lug on the side of the enclosure to a known, or constructed earth ground (either a ground stake or local electrical system ground. See section 3.4 for more details).

### 3.2 Protecting the Datalogger

In the event that the LAB 3 Board is used to protect a multiplexer or a datalogger, locate the LAB-3 board as close to the multiplexer or datalogger as possible.

### 3.3 Protecting Ancillary Equipment

The LAB-3 board is a 2-circuit protection device, with TB1/TB2 pins 1 & 2 provided for the first circuit to be protected, and TB1/TB2 pins 3 & 4 provided for the second circuit to be protected. The LAB-3 is also provided in 3 configurations:

- 5V signals (-A option)
- 12V power and signals (-B option)
- 24V power and signals (-C option)

Typical signals and systems that can be protected include CMOS and TTL logic (5V), Power supplies (12V and 24V) and 4-20mA current loops (24V).

### 3.4 Establishing an Earth Ground.

A poor grounding system will render the whole system useless. The lightning needs to see a high impedance through the transducer and a low impedance to earth ground. The resistance to ground must be **20 ohms or less**. So the main objective is to get as low a resistance as possible. In order to achieve this there are four variables to consider: the use of a sufficient number of ground rods, placement in the right soils, sufficient depth and soil conductivity enhancement.

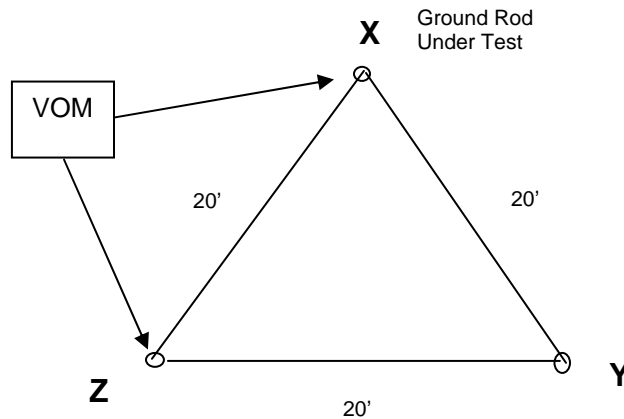
### 3.4.1 Ground Rods

When choosing a ground rod use only the better quality types available in electrical supply houses – the ones with thick copper plating. If these are not available a ½ inch diameter copper pipe will suffice. The length should be at least 2 meters. More than one rod can be connected in parallel. Rods connected in parallel should be spaced at least 6 ft apart. Connection of the ground wire to the ground rod is best done with silver solder. If clamps are used they may corrode requiring frequent inspection to see that they remain in good condition. No loops should be permitted in the ground wires.

The soil in which the ground rod is driven may not be soft enough to allow deep penetration in which case multiple rods may be necessary. As an alternative to rods, buried mats of wire mesh have been used. Soil conductivity can be enhanced by charging the soil around the ground rod with a pound or so of rock salt or magnesium sulfate. Sandy soils have the highest resistance and may require these special enhancement measures. Be aware that frozen ground has a much higher resistance, (up to eight times higher), than unfrozen ground so that ground rods should be driven at least half to one meter below the frost line.

### 3.4.2 Measuring the Resistance of the Grounding System

In order to measure the ground resistance the following method is suggested. If a VOM is used it is necessary to take into account the AC component from ground currents and the DC component from electrolytic action. This mandates the use of two additional ground rods spaced 6 meters apart. Refer to the figure below for the following.



**Figure 4: Suggested setup for measuring the soil resistance of a ground rod**

First measure and record the resistance between rods X and Y. Reverse the meter leads and again record the reading. Calculate the average of the two readings and call it (XY). Repeat this procedure between rods X and Z and between rods Y and Z then calculate the resistance to ground of rod X, the ground rod under test, from the formula.

$$\text{Ground Rod Resistance} = (XY) + (XZ) - (YZ)$$

#### 4. COMPONENT SPECIFICATIONS

##### 4999-12-A

TRANSIENT VOLTAGE SUPPRESSOR: Diodes Inc.  
SMCJ6.0CA-13  
6.0V 1500W  
Bi-directional

##### 4999-12-B

TRANSIENT VOLTAGE SUPPRESSOR: Diodes Inc.  
SMCJ16CA-13  
16V 1500W  
Bi-directional

##### 4999-12-C

TRANSIENT VOLTAGE SUPPRESSOR: Diodes Inc.  
SMCJ30CA-13  
30V 1500W  
Bi-directional

##### 4999-12-A,B,C

TRIPOLAR PLASMA SURGE ARRESTOR: Citel BTR-230  
230V Breakdown Voltage  
10kA current capability

BIPOLAR PLASMA SURGE ARRESTOR: CP CLARE CG2-300L  
300V Breakdown Voltage  
20kA current capability

10uH INDUCTOR: Sumida CDRH125-100MC  
10uH 4A