Model 4999-12L/LE (LAB3)

Lightning Arrestor Board

Instruction Manual

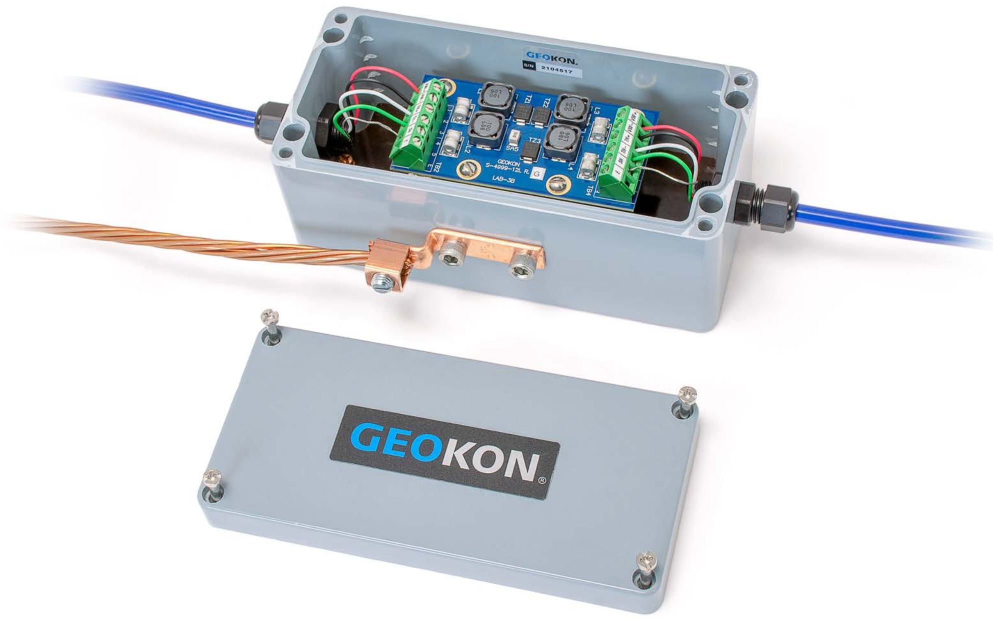

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TABLE OF CONTENTS

1. INTRODUCTION

The GEOKON Model 4999-12L Surge Protection Boards (LAB3) are designed to protect GEOKON vibrating wire sensors from short duration high voltage surges that may be induced in sensor cables by lightning strikes. The LAB3 boards can be provided in three configurations:

- Model 4999-12L-A for 5 Volt signals
- Model 4999-12L-B for 12 Volt power and signals
- Model 4999-12L-C for 24 Volt power and signals

The LAB3 board is designed for installation in the cable leading from the sensor to the data logger, or in the data logger itself. The board can be purchased separately. In most applications it is more suitable to use a Model 4999-12-LE, where the board is pre-installed inside a watertight Nema 4 Enclosure.

1.1 DISCLAIMER

Please note that nothing can protect a system from a direct lightning strike, or one so close that it overloads the capacity of the LAB3 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 LAB3 device does not guarantee that damage will not occur in the event of a lightning strike**. GEOKON is not responsible for any damage or loss suffered in the event of a lightning strike or other severe weather.

1.2 BASIC CIRCUIT

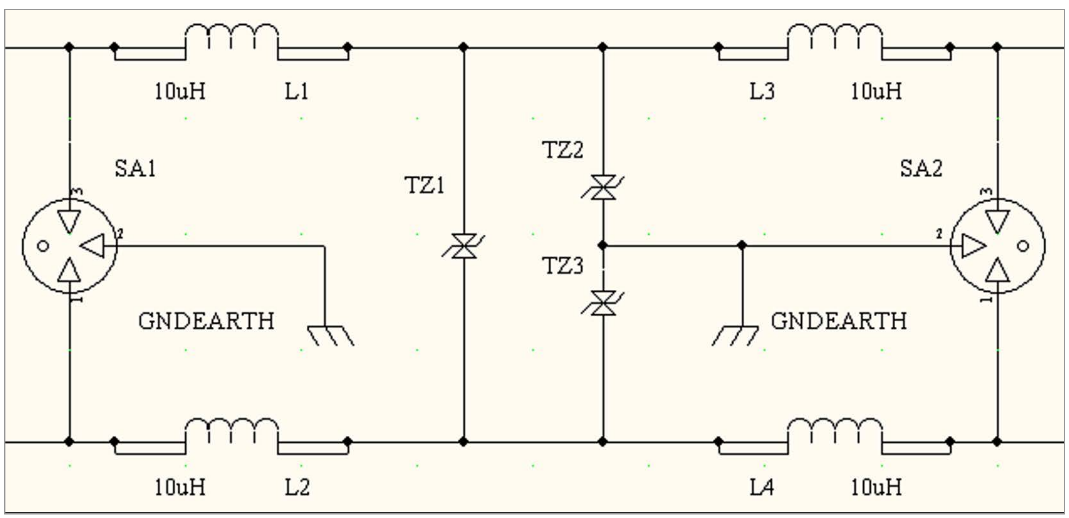

FIGURE 1: *LAB3 Schematic*

1.3 THEORY OF OPERATION

The primary protection is provided by a tripolar gas tube protection device. This device limits the energy sent to the protected circuit by switching from a high to a low impedance state in the space of a few nanoseconds when in the presence of a sufficiently high transient voltage. It is comprised of three electrodes separated by a fixed distance inside 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 transients exceed the device's rated breakdown voltage, it begins arcing or conducting, thereby diverting the potentially damaging energy away from the protected circuit and towards the earth ground. Break down voltage is dependent on electrode spacing, inert gas type, gas pressure, and rise time of the transient voltage. In the present case, it is a nominal 230 Volts.

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 shown in Figure 2 illustrate energy content versus time of a lightning strike at various points in the lightning protection circuit.

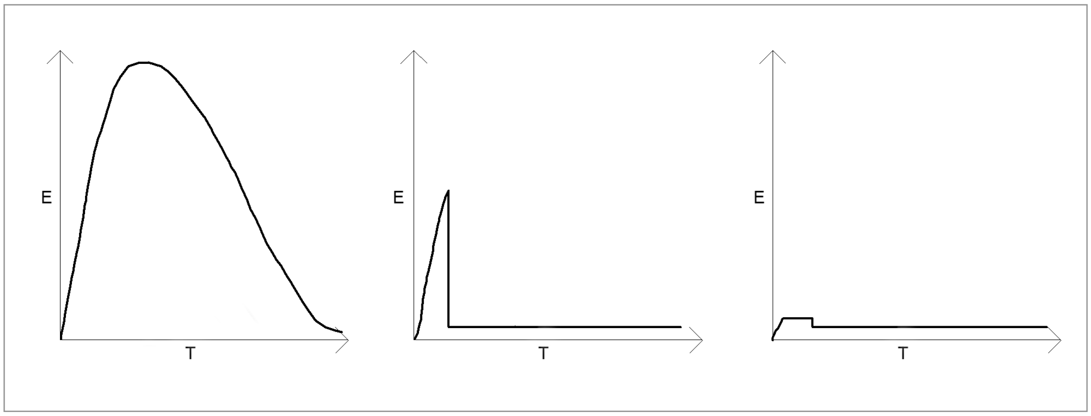

FIGURE 2: *LAB3 Lightning Transient Protection*

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). The tripolar plasma surge arrestor (rated at 5 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 transzorbs to be exceeded and therefore to actuate. The transzorbs, TZ2 and TZ3,(rated at 1500 Watts), clamp the common mode voltage to a nominal 7.5 Volts (4999-12L-A), 16 Volts (4999-12L-B), or 30 Volts (4999-12L-C). The transzorb TZ1, (rated at 1500 Watts), completes the secondary stage protection by clamping the normal mode voltage to 7.5 Volts (4999-12L-A), 16 Volts (4999-12L-B), or 30 Volts (4999-12L-C).

The shield is protected by a plasma surge arrestor rated at 2 kA surge absorption with a 150-Volt breakdown.

2. INSTALLATION

2.1 PLACEMENT

To protect a sensor it is recommended that the LAB3 board be installed as close to the sensor as is practical, while still allowing access to the board. For piezometers installed in boreholes, this usually means installation at the top of the borehole where the cable comes out of the ground. In the event that the LAB3 board is used to protect a multiplexer or a data logger, locate the LAB3 board as close to the multiplexer or data logger as possible.

2.2 ESTABLISHING AN EARTH GROUND

In order for the LAB3 board to be effective, **it is essential that a proper earth ground be established**. An inadequate grounding system may reduce the overall effectiveness of the surge protection. The lightning needs to encounter high impedance through the sensor and low impedance to earth ground. For best results, the resistance to ground should be 20 ohms or less. However, local ground conditions may preclude this. In order to achieve the lowest resistance possible, there are four variables to consider:

- The use of a sufficient number of ground rods
- Placement in the right soils
- Sufficient depth
- Soil conductivity enhancement

2.2.1 GROUND RODS

When choosing ground rods use only higher quality types available in electrical supply houses (i.e., the ones with thick copper plating). If these are not available, a 1/2” diameter copper pipe will suffice. The length of the rods should be at least two meters. Ground rods with copper wire and ground lug are available from GEOKON (Model 8032-20).

The soil into which the ground rods are driven may not be soft enough to allow deep penetration in which case multiple rods may be necessary. Multiple rods can be connected in parallel when spaced at least six feet apart.

It is best to connect the ground wire to the ground rod using silver solder. If clamps are used, they may corrode over time and therefore require frequent inspection to ensure that they remain in good condition. No loops should be permitted in the ground wires.

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 about a pound 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. Ground rods should be driven at least 0.5 to 1 m below the frost line.

2.2.2 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 m apart. Refer to Figure 3 and the procedure below.

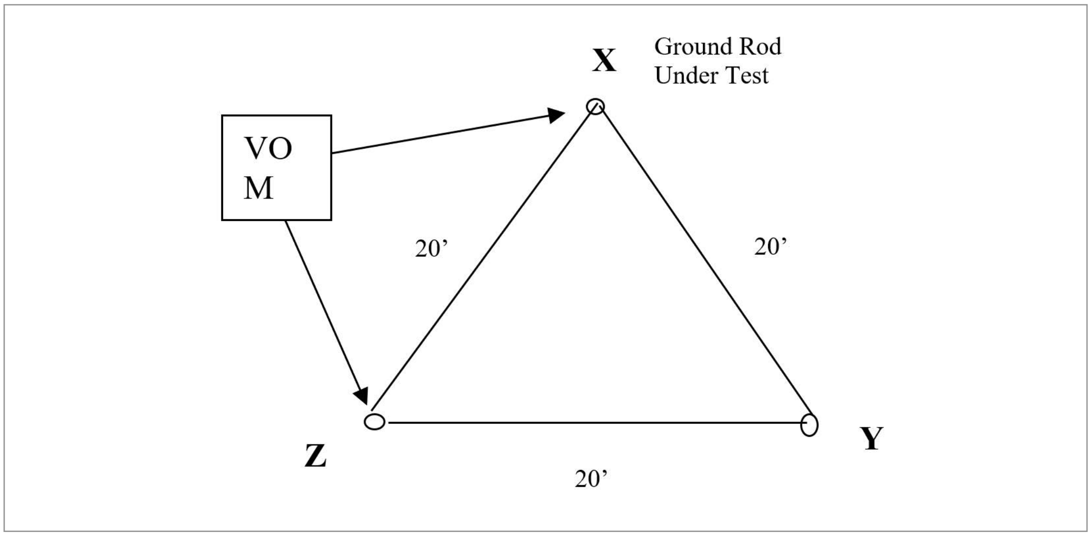

FIGURE 3: *Suggested Setup for Measuring the Soil Resistance of a Ground Rod*

First measure and record the resistance between rods X and Y. Reverse the meter leads and record the reading. Calculate the average of the two readings and label it as (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: Ground Rod Resistance = (XY) + (XZ) – (YZ)

2.3 CONNECTING TO EARTH GROUND

2.3.1 LAB3 BOARD (4999-12L MODELS) CONNECTION

In order for the LAB3 board to be effective, **it is essential that a proper earth ground be established.**

The preferred way to achieve solid earth ground is to solder a length of 1/4” tinned copper wire braid from the EARTH solder pad (located on the back side of the board, adjacent to TB2) to a ground lug on the side of the enclosure the LAB3 will be mounted in.

Alternatively (but not recommended), earth ground connection may be made via the two E terminals on TB2 and TB4 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 standoffs. 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.

In either case, connection to the earth ground must be completed by running a wire (at least 14 AWG) from the enclosure to a known or constructed earth ground (either a ground stake or local electrical system ground).

2.3.2 ENCLOSURE (4999-12LE MODELS) CONNECTION

1. Open the enclosure by loosening the four corner screws and removing the lid. **Make sure that no dirt, water, or other contaminants are allowed to enter the enclosure.**
2. Locate and remove the bag containing the mounting feet. If desired, install the mounting feet onto the enclosure by following instructions included with the feet.
3. Loosen the nuts on the cable fittings and remove the white plastic dowels.
4. Insert the cables through the cable fittings.
5. Wire the conductors of the cables into the terminal strips per Table 1 in Section 2.4.
6. Tighten the cable fitting nuts. **This must be done to ensure that water does not enter the enclosure.**

7. Reinstall the lid onto the enclosure, making sure to tighten the screws evenly on all four sides so that no gap occurs between the lid and the enclosure.
8. Connect the enclosure to an established earth ground 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).

2.4 WIRING

Loosen the screws on the backside of the terminal strips. Wire the conductors of the cables into the terminal strips per Table 1. Tighten the corresponding screw on the terminal strip after inserting each conductor. Gently pull on the conductors to ensure they are adequately secured in the terminal strip.

Note: The shield wire (no insulation), must be connected to the shield terminal (Position 5).

Terminal Strip Position	Signal	Wire Color
1	VW+	RED
2	VW-	BLACK
3	TH+	WHITE
4	TH-	GREEN
5	SHIELD	SHIELD
E	EARTH	N/C

TABLE 1: *LAB3 Circuit Board Wiring*

2.5 PROTECTING ANCILLARY EQUIPMENT

The LAB3 board is a two-circuit protection device. TB1/TB3 pins one and two are provided for the first circuit to be protected. TB1/TB3 pin three and TB2/TB4 pin four are provided for the second circuit to be protected. The LAB3 can be provided in three configurations. Typical signals and systems that can be protected include: Five Volt signals such as CMOS and TTL logic by the 4999-12L-A; 12 Volt power supplies and signals by the 4999-12L-B; and 24 Volt power supplies, signals, and 4-20mA current loops by the 4999-12L-C.

APPENDIX A. SPECIFICATIONS

A.1 MODEL 4999-12L SPECIFICATIONS

Model	4999-12L-A	4999-12L-B	4999-12L-C
Transient Voltage Suppressor	Fairchild SMCJ7.5CA 7.5 V 1500 W Bi-directional	Fairchild SMCJ16CA 16 V 1500 W Bi-directional	Fairchild SMCJ30CA 30 V 1500 W Bi-directional
Tripolar Plasma Surge Arrestor	Bourns 2054-23-SM-RPLF 230 V Breakdown Voltage 5 kA current capability		
Bipolar Plasma Surge Arrestor	Bourns 2051-15-SM-RPLF 150 V Breakdown Voltage 2 kA current capability		
10 uH Inductor	Sumida CDRH125-100MC 10 uH 4A		

TABLE 2: *Model 4999-12L (LAB3) Lighting Arrestor Board Specifications*

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