LIGHTNING PROTECTION AND SHIELDING FOR GEOTECHNICAL INSTRUMENTS AND DATA ACQUISITION SYSTEMS

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INTRODUCTION

The increased use of data acquisition systems to read, store and transfer data from geotechnical instruments raises the importance of discussing lightning protection and shielding issues. The reason is that a network scheme comprising instruments connected to one or more data acquisition systems is more prone to be affected by disturbances than a series of instruments taken individually.

Lightning is of course a natural phenomena which cannot be avoided. Its effect is to generate electrical surges called transients, which can be as high as thousands of volts. Therefore, lightning strikes are the cause, and transients created by lightning strikes are what we want to be protected against.

Transient protection and shielding are two aspects that share the same goal: protection against external disturbances. For instance, surge arrestors are used to protect the instrument from being damaged due to massive surge current and high intensity electromagnetic fields. Shielding methods are used to protect the measurement signal coming from the instrument from being altered or distorted due to electrical or electromagnetic field.

THE IMPORTANCE OF GROUNDING

Transient protection and shielding are intimately joined by a common point: grounding. Grounding is the ultimate consideration that needs to be carefully implemented and studied to make sure that lightning protection and shielding are efficient. Sophisticated transient and surge protection devices combined with a poor grounding system will be useless. Let's give a simple definition of ground: this is a conducting path intentional or accidental between an electric circuit or equipment and the earth.

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Today's electronic devices are highly integrated and dielectric breakdown voltages within and between components are quite low, protection against lightning is becoming more and more important. There are three ways of minimizing the chances of lightning problems:

- Using proper type of electrical cable as per manufacturer's recommendations, good quality connections compatible with environmental conditions of installation and normal care required by the nature of geotechnical instrumentation.

- Adequate temporary protection, implying that procedures described in this article must be implemented progressively in instrument installation, as soon as it becomes possible to use them. The worst practice would be to wait until all instruments are installed to start grounding and shielding the instruments.

- Using appropriate grounding, shielding and surge protection devices, which is the scope of the present article.

Let's take the example of a field situation where a number of piezometers are to be connected to a data acquisition system.

In order to minimize the cable quantities, we can use junction boxes to which the individual piezometers are connected, and which are then linked to the data acquisition system by a multi-conductor cable.

Such a situation is illustrated in Figure 1. On this figure, individual transient protections (ITP) and grounding locations are shown.

Figure 2 illustrates a cross-section of the same layout, with more details of the different grounding points.

Grounding involves the use of grounding rods as shown on the figure. These rods are installed at each borehole collar where ITPs are located, at the junction boxes and at the data acquisition system.

Although ITPs are occasionally omitted in some instrumentation layouts, the authors believe that they are very important. ITPs should be located on the ground surface and should be as close to borehole collars as possible, since lightning surcharges travel at the ground surface and not at depth.

Grounding rods should be a minimum of 3 meters long. As can be seen on Figure 2, it is good practice to use up to three rods at important locations, such as the data acquisition system, to provide a good ground network. Obviously, the soil resistivity is a factor that must be taken into account in the above recommendations.

THE FINAL PROTECTION: SHIELDING

Figure 3 illustrates the detailed path and components of the complete grounding and shielding points.

Starting from the piezometer, we can see that it normally incorporates its own transient protection, such as a double gas tube connected to the instrument housing. Note that at this level the only ground path available is the housing.

Coming to the surface, we find the ITP which normally incorporates a minimum of two transient protection levels, such as gas tube and suppressor diode, and very often three levels.

On the figure, cable shields are represented by an oval and the location where these shields are connected to grounds is illustrated. As a general rule, the cable shield must be grounded at one end only and not at the two ends. The situation is similar to saying that there are three different cable sections between the piezometer and the data acquisition system: from the piezometer to the ITP, then to the junction box and finally to the data acquisition system. For each of these three cables, one shield end is not grounded and the other end is. In practice, from the instrument to the data acquisition system, the grounded end is on the data acquisition side.

The next component is the junction box in which it can be seen that the shields from cables between the ITPs and the junction box are connected to the ground at the junction box.

Then the multiconductor cable that runs from the junction box to the data acquisition system is also shielded to the ground at the data acquisition system end. Such multiconductor cable has preferably an individual shield for each conductor pair and an overall shield and they are all grounded to the same point. Additionally, if the cable has a metallic armor, central or overall, this armor must also be connected to the same ground as the other shields.

As can be seen on the figure, multi-stage transient protection is incorporated in the data acquisition system to protect its entries from transients that would come along the connection cables.

Finally, a few last recommendations:

- It is also essential to use a good quality cable to connect instruments to the data acquisition system. Good quality refers to mechanical and electrical characteristics of the cable, such as waterproof overall jacket, armoring and individual or overall shielding of electrical conductors.

- Radio links should also be adequately protected using standard RF (radio frequency) surge protections.

- Whenever AC power is used for the data acquisition system or for any instrument or accessory, AC arrestors should be used.

- Solar power equipment should also be grounded.

- If a phone line is used, it also requires adequate protection.

CONCLUSION

Lightning protection cannot be treated as a general recipe. The authors recognize that each site and each instrumentation scheme require adaptation to the general rules presented in this article. It is believed that the various procedures detailed in this article correspond to sound engineering practice. It should, however, be recognized that no lightning protection can guarantee 100% effectiveness due to unknown and large scale effects of lightning in close vicinity of an instrumentation site. This observation explains, incidentally, the strong interest in novel fiber-optic sensors which hold the promise of being completely immune to lightning and other interferences. Such sensors have been recently introduced to the market and will certainly be adapted and find applications in the field of geotechnical instrumentation in the foreseeable future.

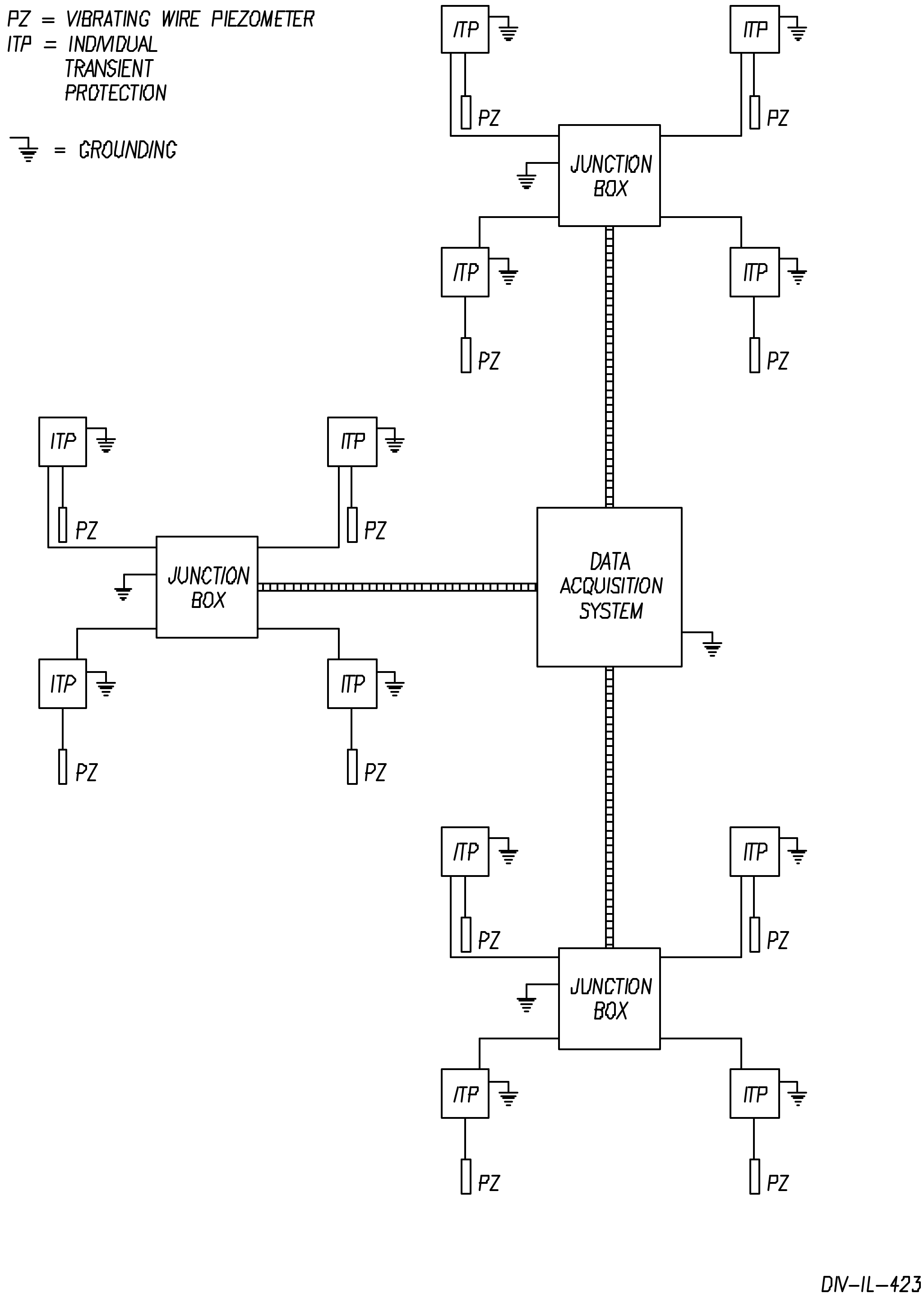

Figure 1: Example of plan view of a series of piezometers connected to a field data acquisition system

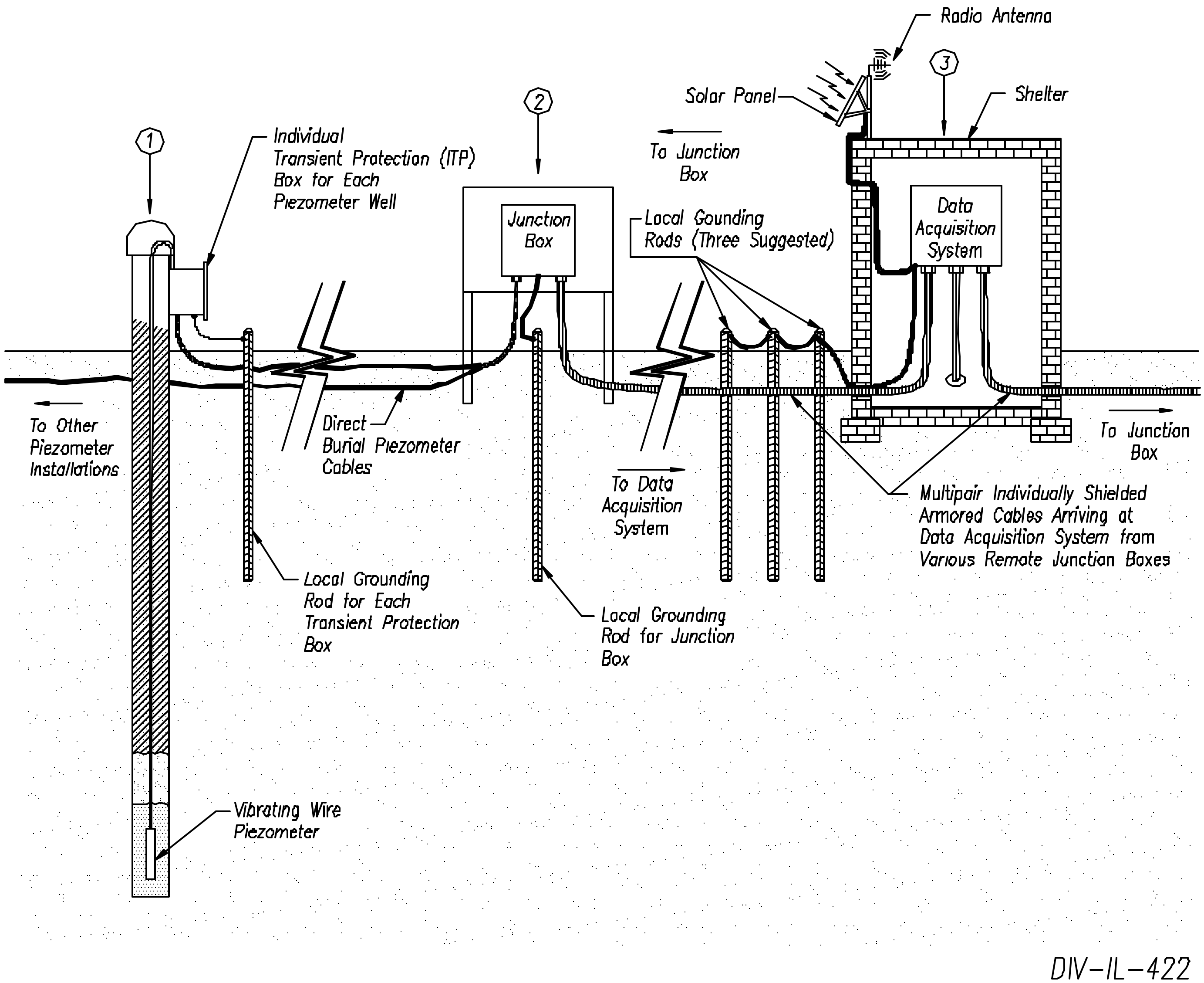

Figure 2: Sectional view of the same installation as in Figure 1

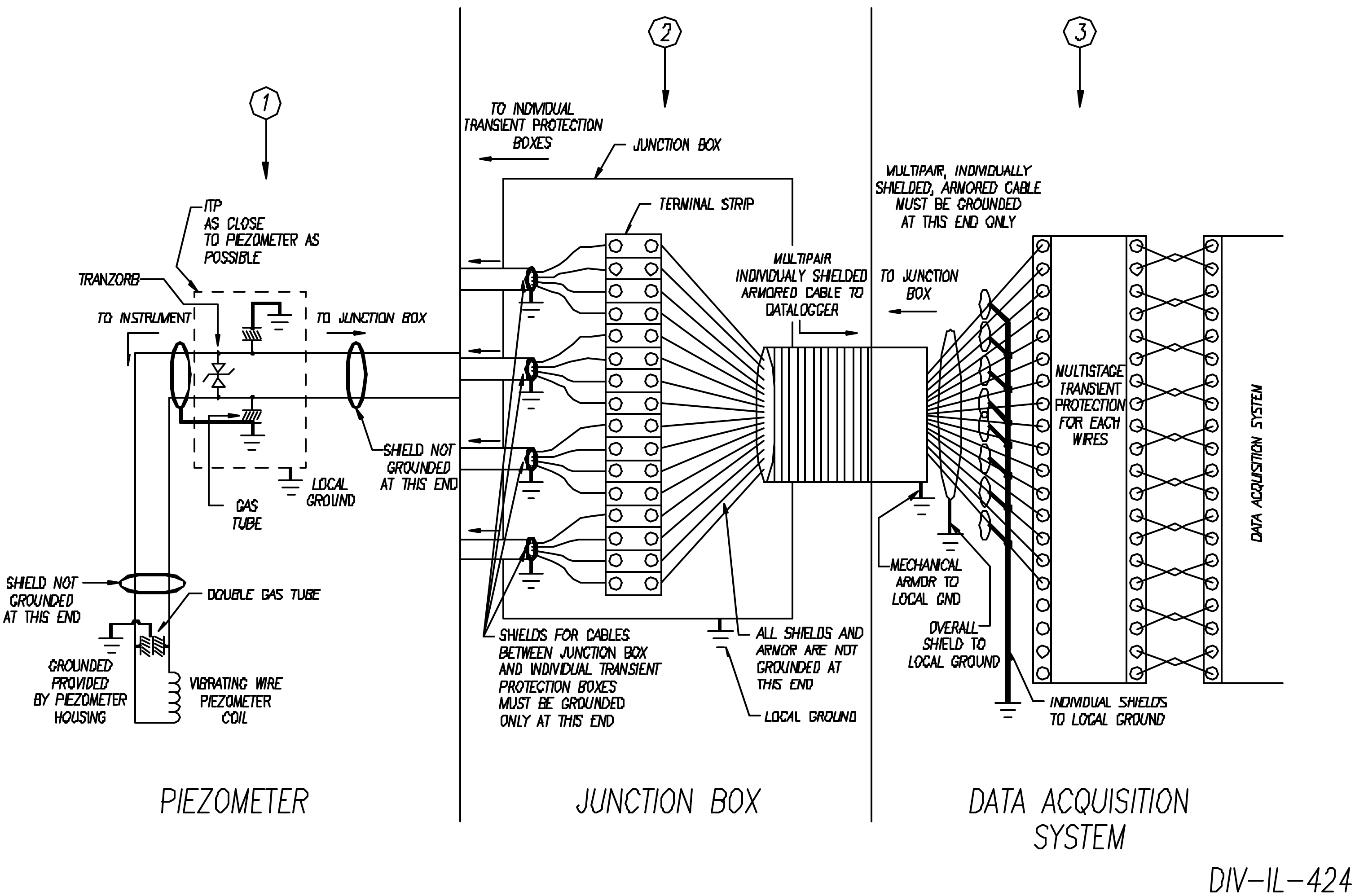

Figure 3: Example of detailed path and components of the complete grounding and shielding points, at locations 1,2 and 3, shown in Figure 2