Nuclear Instruments and Methods in Physics Research A 729 (2013) 147–152

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

Technical Notes

Power quality considerations for nuclear spectroscopy applications: Grounding

J.M. García-Hernández [a,b], F.J. Ramírez-Jiménez [a,b,*], L. Mondragón-Contreras [a,b], R. López-Callejas [a,b], M.A. Torres-Bribiesca [a], R. Peña-Eguiluz [a,b]

[a] Instituto Nacional de Investigaciones Nucleares, ININ, Carretera México-Toluca S/N, La Marquesa, Ocoyoacac, 52750 Estado de México, México
[b] Instituto Tecnológico de Toluca, Departamento de Estudios de Posgrado e Investigación, Av. Tecnológico S/N, ExRancho La Virgen, 52140 Metepec, México

ARTICLE INFO

Article history:
Received 12 March 2013
Received in revised form
14 June 2013
Accepted 14 June 2013
Available online 3 July 2013

Keywords:
Nuclear spectroscopy systems
Power quality
Grounding
Sensitive electronic equipment

ABSTRACT

Traditionally the electrical installations are designed for supplying power and to assure the personnel safety. In nuclear analysis laboratories, additional issues about grounding also must be considered for proper operation of high resolution nuclear spectroscopy systems. This paper shows the traditional ways of grounding nuclear spectroscopy systems and through different scenarios, it shows the effects on the more sensitive parameter of these systems: the energy resolution, it also proposes the constant monitoring of a power quality parameter as a way to preserve or to improve the resolution of the systems, avoiding the influence of excessive extrinsic noise.

1. Introduction

Power quality (PQ) plays an important role in the performance of sensitive electronic equipment. It is not a new concept but in recent years its application in diverse areas has solved many problems concerning to the erroneous operation of specific application electronic equipment [1] and also it has helped to prevent the total or partial damage of sensitive electronic equipment [2,3]. In electrical installations where the basic issues of PQ are not considered, the electrical problems and economic losses may be considerable [4].

The IEEE in its Standard [5] defines PQ as “the concept of powering and grounding sensitive equipment in a manner that is suitable to the operation of that equipment.” The International Electrotechnical Commission (IEC) defines PQ as “characteristics of the electricity at a given point on an electrical system, evaluated against a set of reference technical parameters” [6]. Ref [7] says “the power quality involves waveforms of current and voltage in an AC system, the presence of harmonic signals in bus voltages and load currents, the presence of spikes and momentary low voltages, and other issues of distortion”. From these definitions, we can infer that the PQ involves a multitude of issues that are found in any electrical power system and grounding is one of them. Moreover, grounding should be considered as one of the most critical aspects to be considered in installations with sensitive equipment such as nuclear analysis laboratories.

Because of the unscheduled shutdowns due to electrical problems in several industries, the principal reason for the application of PQ solutions could be economical. For nuclear spectroscopy systems, PQ analysis and the application of its solutions can contribute for a better performance of the systems, especially in the electrical installation of semiconductor radiation detectors, which may be very sensitive to the electrical noise because of the very small electric charge generated inside of them by the radiation interaction. For example for a ^{137}Cs radioactive source, its characteristic 661.5 keV energy peak creates a charge in an HPGe detector of [8]:

$$Q=\frac{E}{\varepsilon}e=\frac{661.5\ \text{keV}}{2.7\ \text{eV}}(1.6\times10^{-19}\text{C})=3.92\times10^{-14}\text{C} \tag{1}$$

where Q=Charge generated in the detector, E=Energy of incident photon, e=Electric Charge of an electron, and ε=Ionization energy of Ge.

Calculating in the same way for the 5.89 keV energy X-ray peak of a ^{55}Fe radioactive source, in a Si(Li) detector we obtain 2.6×10^{-16}C. These charges represent the movement of only a few hundred electrons inside the detectors, therefore the corresponding electrical signal generated can easily be disturbed by undesired signals coming from not ideal conditions of electric installations, e.g. induced noise,

* Corresponding author at: Instituto Nacional de Investigaciones Nucleares, ININ, Carretera México-Toluca S/N, La Marquesa, Ocoyoacac, 52750 Estado de México, México. Tel.: +52 5553297295; fax: +52 5553297327.
E-mail addresses: josemanuel.garcia@inin.gob.mx (J.M. García-Hernández), fjr@ieee.org (F.J. Ramírez-Jiménez).

0168-9002/$ - see front matter © 2013 Published by Elsevier B.V.
http://dx.doi.org/10.1016/j.nima.2013.06.051

harmonics, improper grounding and others types of electrical disturbances known as PQ disturbances. Actually no electrical installations exist in which PQ disturbances are nonexistent and all electronic devices are more or less susceptible to PQ disturbances [9].

2. Grounding and bonding

Grounding is the action of establishing an electrical conductive path between a circuit and some reference point. The corresponding definition used for installations where electric and electronic equipment coexist is given in [10] as "a conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth, or to some conducting body of relatively large extent that serves in place of the earth". The optional use of the earth in the last definition should be interpreted like a connection to the soil. The grounding systems that use the soil as point of reference are known as earthing systems.

Bonding is defined as "the electrical interconnecting of conductive parts, designed to maintain a common electrical potential" [10]. Bonding can be understood as the process of establishing a required degree of electrical continuity between conductive surfaces of members to be joined. The members involved may be subassemblies or components such as an electronic assembly, or the chassis or enclosure of an electrical machine. Sometimes, bonding may be confused with grounding, however it is important to understand that the two terms are complementary, but not synonymous [11]; a proper grounding performance depends of a high quality bonding.

3. Grounding for safety and electronic equipment

An earthing system can be required by several subsystems in a single facility, e.g. safety, antistatic, shielding, lightning, electric and electronic equipments among others. Since every subsystem must define the objective of its earthing system and this objective may be accomplished by different means, each subsystem can have its own earthing system. However, separate earthing systems in a facility are not recommended by the electrical safety codes [12,13], if there are more than one earthing system, all of them must be joined in a single point. This type of interconnected grounding system is known as equipotential grounding system and is implemented in modern facilities to avoid unsafe electrical conditions to electrical and electronic equipment. Nevertheless, its fundamental function is the safety of the people involved in the electrical environment, providing a low impedance return path for the flow of current when unintentionally the hot wire touches the ground wire or the grounded chassis of the equipment. To obtain this type of protection, two actions should be implemented: (a) the chassis or enclosure of the electric and electronic equipments must be connected to the equipotential grounding system, and (b) the neutral line ought to be connected to the earth in the service entrance [10] (see Fig. 1).

On the other hand, usually the chassis and the signal ground of the power supply inside of electronic equipments are connected together. Because the chassis should be joined to the equipotential system, the electronic equipment is prone to problems related with the noise injected by fault currents, interference from other systems, lightning and other problems in the earthing system, causing improper operation of the equipment [10].

Because the earthing systems should be used by the electronic equipment for safety of the personnel (safety ground), while its connection may cause problems of noise and others, it is necessary to use the better grounding practices where sensitive electronic equipment is allocated to prevent its undesirable operation. In nuclear instrumentation, the proper grounding represents one of the most important ways to provide protection against interfering signals, i.e. extrinsic noise; and it usually requires no additional devices, just additional skills [14,15].

4. Grounding for nuclear spectroscopy systems

The response of nuclear spectroscopy systems depends on some of the three following conditions: (a) any drift on the operating characteristics of the detector or associated electronics during the measurements, (b) sources of random noise within the detector and instrumentation system (intrinsic and extrinsic noise), and (c) statistical noise arising from the discrete nature of the measured signal itself [8,16]. The extrinsic noise referred in (b) can be heightened when the nuclear instruments are connected into an earthing system where improper or null considerations for its installation were implemented. To understand this situation of risk, we can consider the internal grounding connections in the most common electronic modules used in nuclear spectroscopy systems which follow the NIM standard to define its mechanical and electrical specifications [17].

The NIM standard defines a rack known as BIN that includes twelve bussed connectors for mating with other connectors on NIM modules to provide power to each module. For internal grounding connections the NIM standard defines two types of grounds on the BIN connector: the pin 34 is defined as a normal

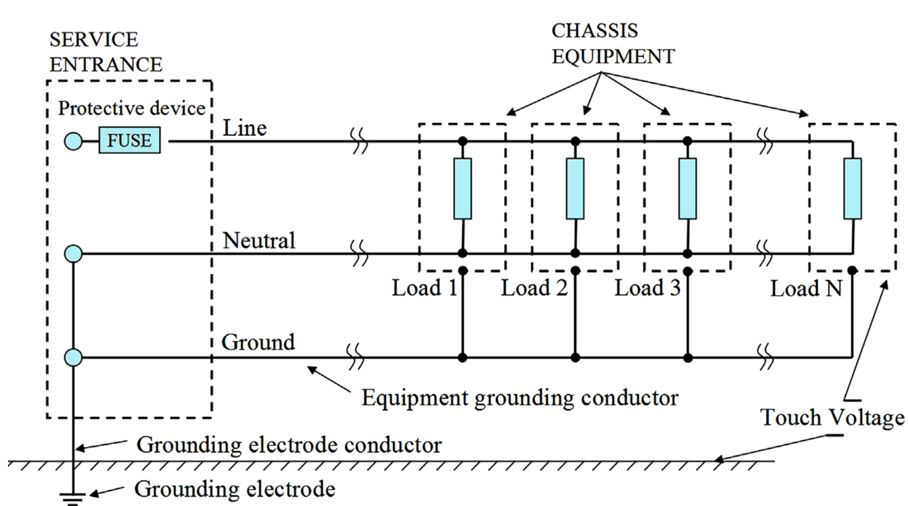

Fig. 1. Typical connections between the neutral and the safety ground according to electrical safety codes.