Standardization Efforts of International Electrotechnical Commission Related to Surge Protection Components, and Receipt of METI Minister's Award

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Abstract

An International Electrotechnical Commission (IEC) international standard for surge isolation transformers (SITs) for communications use has been established based on a proposal from Japan. SITs are components featuring high insulation-breakdown voltage and impedance. They reduce lightning surges to a small voltage level so there is no effect on protected equipment, while simultaneously blocking a common mode noise loop. They provide excellent protection for the DC (direct current) SELV (safety extra-low voltage) circuit on the secondary side in information and communication technology equipment. This article introduces international standardization activities related to SITs at IEC and discusses associated technology.

Keywords: lightning protection, self-contained isolation system (SIS), surge isolation transformer

1. Introduction

There is an ongoing need to protect electronic equipment from damage caused by lightning surges, and therefore, research on technology to achieve this continues. In this section, issues that have become newly apparent are introduced.

1.1 Emergence of new issues

Lightning protection measures up to now have mainly focused on preventing permanent damage or fires caused by burning, scorching, or melting as a result of an insulation breakdown within information and communication technology (ICT) equipment and electric/electronic appliances triggered by overvoltage or overcurrent surges caused by lightning. Today, advances in lightning protection technology have reduced equipment damage due to overvoltage breakdown in hardware, but data errors have recently become evident as a new form of lightning-related damage. This is a phenomenon in which errors occur in data being processed even if the hardware itself has suffered absolutely no damage. It can give rise to problems such as corruption of original data, equipment freezing, system hang-ups, malfunctions, out-of-control operation, and system downtime. In the event of such a problem, it is usually possible to restore operation by resetting the equipment, turning power OFF/ON (rebooting), reloading the operating system, or restoring (salvaging) corrupted data. Nevertheless, such lightning-related data errors run the risk of lost opportunities, disappearance of immediately previous data deliverables, and failure to notice that data errors lay hidden within memory. While data errors that occur during data reading or transfer can usually be handled by error-correcting code, the need has arisen for more robust measures against data errors that occur at the time of a lightning strike.

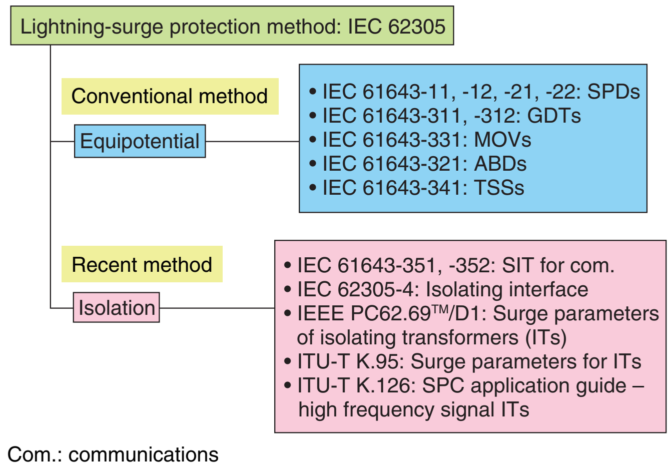


Fig. 1. Equipotential and isolation lightning-surge protection methods and their international standards.

1.2 Problem with Japan's isolated earth environment

Surge isolation transformers (SITs) have been widely used in Japan's power supply system for some time. They are known as lightning-resistance transformers, and they have rarely been used outside Japan. To give some background, while Japan focused on isolated-earth systems, the trend overseas was integrated-earth systems and lightning protection by equipotential methods such as using the earth as a reference point. For example, grounding for communications in Japan has been achieved by installing subscriber arresters for communications use in all telephone subscriber homes, but this method involves the independent grounding of subscriber arresters in isolation from the grounding of power systems, buildings, and other elements. As a result, the following problem arises with Japan's isolated earth environment: if a lightning surge flows in one such earth connection, an earth potential rise occurs due to earth resistance, resulting in a new overvoltage surge source.

The International Electrotechnical Commission (IEC) has been active in developing standards for surge protective devices (SPDs) and surge protective components (SPCs) used in equipotential methods, and the development of standards for isolation methods has been progressing at the Institute of Electrical and Electronics Engineers (IEEE) and International Telecommunication Union - Telecommunication Standardization Sector (ITU-T).

2. Overview of IEC committee organization

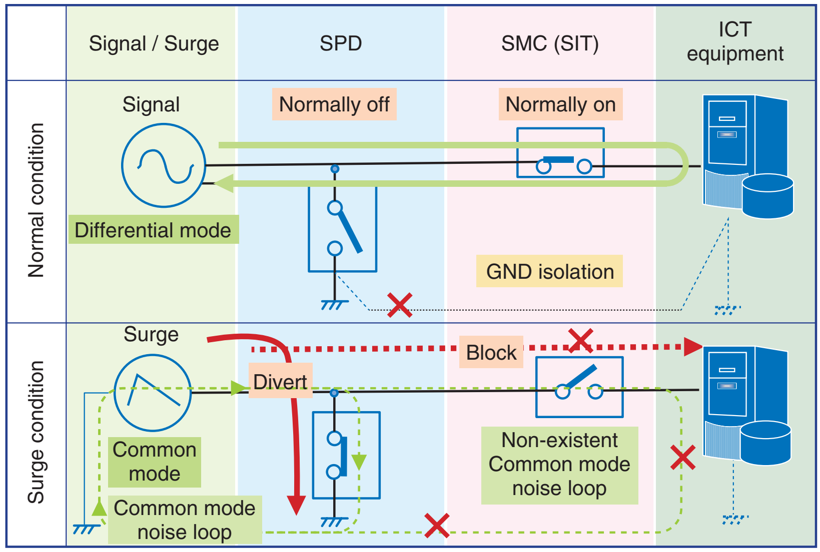
The IEC committee and Working Group addressing the standardization of technology in this area are introduced in this section.

2.1 IEC/SC 37B organization

IEC Technical Committee (TC) 37 (surge arresters)/ Subcommittee (SC) 37B (components for low-voltage surge protection) is a group working to establish IEC international standards on discrete surge-protection components that reduce lightning surges to a sufficiently small level to protect the human body, equipment, and appliances. Four international standards have been established so far: IEC 61643-311: GDTs (gas discharge tubes); IEC 61643-321: ABDs (avalanche breakdown diodes); IEC 61643-331: MOVs (metal oxide varistors); and IEC 61643-341: TSSs (thyristor surge suppressors) (**Fig. 1**). All of these standards concern components for achieving overvoltage protection through lightning equipotential methods using the voltage non-linear resistance characteristics of these SPCs. In relation to the above, Japan submitted a new work item proposal (NP) on SITs as a fifth type of SPC using an isolation method completely different from the above equipotential methods.

2.2 Overview of Working Group (WG) 3 project activities

The initial 2010 NP and CD (committee draft) was approved by international vote, but since the participation of at least four overseas experts required for



GND: ground

Fig. 2. Lightning-surge overvoltage and common mode noise protection using SIT and SPD.

establishing a project could not be obtained from the 14 participating members (P-members), Japan's proposal for a new IEC project was rejected. We attributed this to the low international awareness of SITs. We therefore conducted an information campaign over the next two years to heighten worldwide awareness, and by resubmitting the NP in 2012, we succeeded in establishing an IEC 61643-351/352 project through the participation of experts from the four countries of China, Germany, the United Kingdom, and Japan. IEC/SC 37B/WG 3 (surge isolation transformers) was then established with the author as convenor, and standardization work began.

At the same time, France and the United States opposed this project for the reason that SITs were outside the scope of SC 37B. They argued that the scope of IEC SC 37B, the parent subcommittee, is components for use as SPDs, and the definition of an SPD was "a device incorporating one or more non-linear elements having the purpose of limiting surge voltage and diverting surge current," so SITs, having no non-linear elements, were outside the scope.

A revision to the scope of SC 37B was therefore proposed by Japan at the 2013 plenary meeting and discussions, and the result of an international vote produced the following new scope: "To prepare international standards for components for low-voltage surge protection. These SPCs are used in power, telecommunication and/or signaling networks with voltages up to 1000 V a.c. and 1500 V d.c."

In other words, all components that reduce surge, or SMCs (surge mitigation components), were now to be handled by SC 37B, and on the basis of this revision, France and the United States became involved as experts. Additionally, an IEC NP in relation to SITs proposed by Japan was introduced at the ITU-T SG5 (Study Group 5: environment and circular economy) meeting in Geneva held from April 26 to May 3, 2011. As a result, even ITU-T came to recognize the need for SITs, and thus, SIT-related activities progressed with a liaison member.

3. Lightning protection of ICT equipment by SITs for communications

An example of a countermeasure to lightning overvoltage surge protection and common mode noise combining an SPD (equipotential method) and SIT (isolation method) is shown in **Fig. 2** using equivalent switch circuits. Here, the SPD and SIT operate in an exclusive and complementary manner. The SPD requires grounding to achieve equipotential surge protection. In the event of a surge, it immediately turns the switch ON to form a path that diverts the surge current to earth. At this time, a large-area common mode noise loop including the earth forms, resulting in a noise source that can generate data errors, and an earth potential rise occurs due to earth

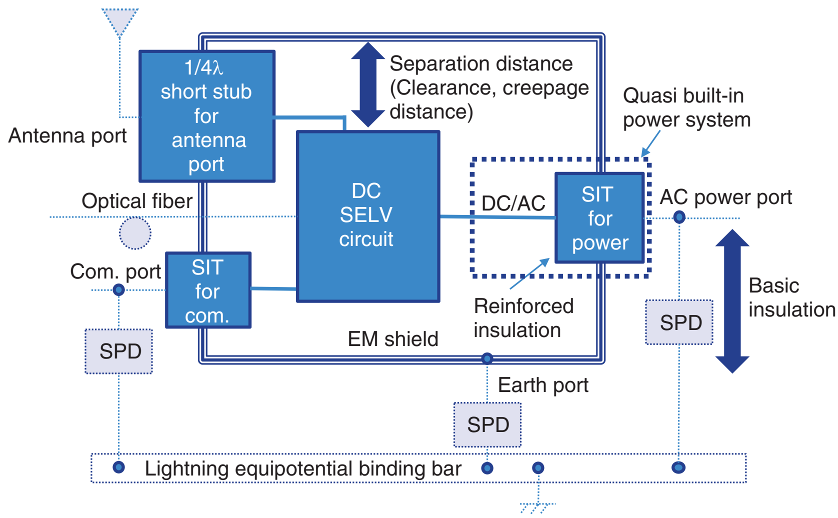


Fig. 3. Self-contained isolation system for DC SELV (direct current safety extra-low voltage) circuit in ICT and Internet of Things equipment.

resistance. These are weak points of this device.

However, the SIT turns OFF under a surge condition, thereby blocking a common mode surge current and dramatically improving noise resistance from an electromagnetic compatibility perspective. Thanks to its high insulation-breakdown voltage, a SIT can treat its primary-side and secondary-side ground (GND) potentials as different, thereby achieving GND isolation.

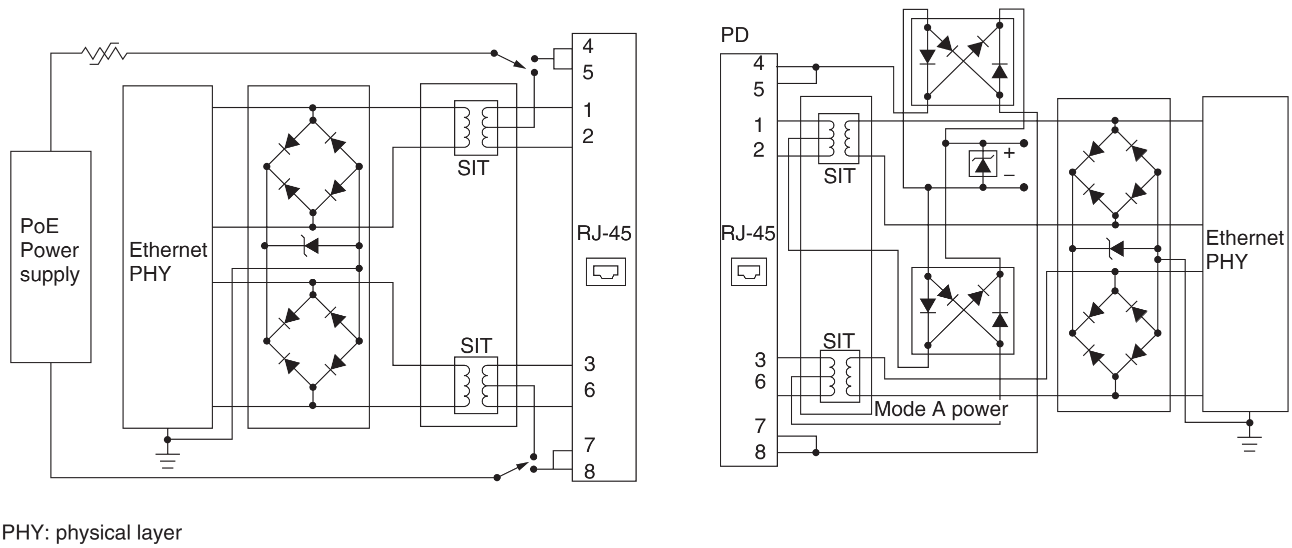
An example of the application of a SIT to ICT equipment is shown in **Fig. 3** and to Ethernet communications in combination with a direct current (DC) power feed is shown in **Fig. 4**. The ICT equipment on the secondary side usually features a DC safety extra-low voltage (SELV; not exceeding a peak value of 42.4 V or DC 60 V) circuit that requires no grounding when used in combination with insulation, enabling it to be set at a floating potential. In conventional SPD multistage protection, the let-through current that flows due to SPD coordination becomes a powerful common mode noise source that has been the cause of data errors in ICT equipment. The combined SPD and SIT block common mode noise by virtue of the SIT and drastically reduce surge voltage migration to 1/100–1/1000 of the SPD peak voltage. It is therefore an excellent countermeasure to both lightning overvoltage surges and data errors.

4. METI Minister's Award

The author received the 2018 Ministry of Economy, Trade and Industry (METI) Minister's Award in Industrial Standardization in recognition of the following activities: submitting Japan's proposal for IEC/TC 37/SC 37B/WG 3 and serving as convenor (WG 3 international chairman); contributing to the formulation of IEC 61643-351 (SIT performance requirements and test methods) and IEC 61643-352 (SIT selection and application principles); and in anticipation of artificial intelligence (AI), Internet of Things (IoT), and big data connections that are expected to expand on a global scale, formulating international standards for lightning protection measures in SELV ICT equipment connected to the Internet, thereby making Japan a forerunner in this endeavor and enhancing the country's international industrial competitiveness.

5. Future plans

In recent years, studies have been accelerating on Industry 4.0 (transformation of the manufacturing industry through IoT and AI technologies) and the international standardization of ISO (International Organization for Standardization) 8000 (data quality) with an eye to achieving the Society 5.0 vision [1].



(a) PSE (power sourcing equipment) side

(b) PD (power device) side

Fig. 4. SIT application example for PoE (Power over Ethernet) communication.

From here on, as the use of big data expands and IoT and AI spread throughout society, we can expect data quality to become all the more important in industrial, service, and medical-care fields and in databases released by government and public institutions. In addition to simultaneously supporting lightning overvoltage surge protection and data quality, the SIT is a leading component embodying the idea of a self-contained isolation system [2], similar to that of airplanes, having a proven record in withstanding direct lightning strikes and lightning electromagnetic waves. With this in mind, we plan to proceed with the IEC international standardization of SITs for power supply systems.

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He received a B.E. from Iwate University in 1981 and a Ph.D. from Tohoku University in 1995. In 1981, he joined Musashino Electrical Communications Laboratories of the Nippon Telegraph and Telephone Public Corporation (now NTT), in Musahino-shi, Tokyo. He was a visiting professor at the University Technology Malaysia (UTM) in 1996 and returned to the NTT laboratories in 1997. He is currently affiliated with the research and development (R&D) division of NTT Facilities, where he has been engaged in R&D of lightning protection technologies and their standardization as chairman of IEC SC37A and SC37B Japanese National Committee. He received the METI Minister's Award in 2018, and IEC 1906 Awards in 2013 and 2018. He is a Professional Engineer Jp, IntPE(Jp), and APEC Engineer (Electrical). Dr. Sato is a senior member of IEEE and the Institute of Electronics, Information and Communication Engineers (IEICE), and a member of the Institute of Electrical Installation Engineers of Japan (IEIE) and the Institute of Electrical Engineers of Japan (IEEJ).