



STANDARDS CORNER

Developing IEEE 1613

Standards for communications networks in substations

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The widespread use of multifunctional intelligent electronic devices (IEDs) with advanced communications capabilities has resulted in a new trend in substation automation systems—the implementation of high-speed peer-to-peer communications-based control schemes. The IEDs exchange messages over the substation local area network (LAN). The communication messages replace the hard-wired interface between control devices in conventional substations in order to perform critical control functions as well as other user-specific distributed control or recording applications.

It is obvious that the successful application of communications-based control schemes is possible only if the communications equipment used for the substation LAN or for interface with the utility wide area network (WAN) meets the same (and in some cases perhaps even higher) withstand, environmental, and performance requirements than the existing control devices being integrated into a distributed control system. This is due to the fact that the failure of a single element of the substation LAN, such as a switch or hub, will result in a loss of communications between the different IEDs and in the failure of any distributed control scheme that relies on the exchange of communications messages.

A number of industry experts had observed that an unambiguous standard for network devices when installed in the harsh environmental conditions in these substations did not exist. As a result, a task force (C2TF1) of the PES Substations Committee was formed and began work in January 2002. At that meeting, the task force decided to build on the relevant standards developed by the Power System Relaying Committee (PSRC). The focus of the task force was to define the communications channels during the transient tests and develop new criteria for acceptance.

During many years of effort, the PSRC developed four standards for protective relays and relay systems installed in the harsh substation environment.

- C37.90 defines service conditions, voltage ratings, temperature operating ranges, humidity, and the required dielectric and impulse withstand capability.
- In substations, when high-voltage switches are opened or large inductors are deenergized, large oscillatory or fast rising transients are generated. C37.90.1 defines the required capability
 - to withstand these known
 - transients—without damage or false operation.
- With the advent of solid-state relays, there were a number of false relay operations caused by the operation of handheld transceivers in close proximity to these relays. As a result, C37.90.2 was developed to define the required immunity to such devices.
- Recent substation control rooms have been built with nonconductive flooring where high-voltage static charges can build up on the human body and be discharged when a person touches a grounded metallic surface. C37.90.3 defines the required immunity of relays and relay systems to these transients.

The Work of the Task Force

The members of task force C2TF1 knew of these four standards when they began work on what is now IEEE 1613 and decided to adapt them to substation applications that do not involve protective relaying. They also chose to make the standard apply at the device, not system, level. In the existing standards there is a requirement of no false operations of the relay system during transients. This requirement had to be modified for communications networking devices. Thus, IEEE 1613 defines the communications required during device tests. There are several other differences. The following is quoted from the Introduction Clause of IEEE 1613:

"This document has been compiled from the relevant clauses of IEEE Standards C37.90, C37.90.1, C37.90.2, and C37.90.3. In addition, it establishes more stringent requirements than exist in these IEEE or relevant IEC standards in the following areas:

- Clause 4 requires the operation of the device with no fans or forced ventilation. It also requires startup after soaking at the temperature extremes (not required in IEEE Std C37.90-1989 or in IEC 60255-6).
- Clauses 7, 8, & 9 define the communications required during tests, and two Performance Classes. Class 1 allows communications errors or interruption during the defined transient but requires automatic recovery. Class 2 requires communication without errors or interruption. (Neither are presently defined in IEEE or IEC).
- Clause 8 requires testing at an RF field strength level of 35 volts/meter, as defined in IEEE Std C37.90.2-1995 and reflecting North American experience. This is more severe than IEC 60255-22-3 that requires only 10 volts/meter maximum. The test method is the one defined by IEC 60255-22-3.
- Clause 9 requires testing at voltage levels corresponding to a relative humidity less than 35%, identical to IEEE Std C37.90.3-2001. (Not required by IEC 61000-4-2)."

The oscillatory SWC and fast transient SWC test waveforms in IEEE 1613 Clause 7 are identical to IEEE Std C37.90.1-2002. These are severe tests. The oscillatory test waveform has a rise time of 75 ns to a crest of 2.5 kV with an oscillatory burst at 1 MHz lasting 4–6 s, then with 6 to 10 bursts per period of system frequency lasting 2 seconds. The fast transient SWC test waveform has a rise time of 5 ns to a crest of 4 kV, decaying to 50% in 50 ns. The pulse is repeated at 400 s intervals for 15 ms. This pulse stream is repeated at 300 ms intervals for 1 minute. Both oscillatory and fast transient tests require these transients to be coupled common mode to communications circuits with a capacitive coupling clamp. Experimental tests have shown that, even with shielded communications cables, these transients will disrupt communications. For power supply and control circuits, the transients are applied in both common and transverse mode.

The required immunity to radio frequency field strength levels of 35 v/m, as defined in IEEE 1613 Clause 8, is identical to IEEE Std C37.90.2-1995. However, the RF test method is as defined in IEC 60255-22-3, in anticipation of a similar revision in IEEE 37.90.2 now underway.

IEEE 1613 Clause 9 defines the required immunity to electrostatic discharges. The electrostatic charge that may build up on a human body is inversely affected by relative humidity. With lower humidity, higher charges may occur. The relevant IEC standard only requires testing for electrostatic charges that may occur in environments of 35% relative humidity and above. When PSRC developed IEEE Std C37.90.3-2002, the working group concluded that many substations have substantially lower relative humidity and so require a test level corresponding to 10% relative humidity. IEEE 1613 Clause 9 requires the same test level.

As noted, the relevant PSRC standards require that no false operations occur as a result of these transients. These standards do allow communications to be disrupted during the transient tests provided recovery is automatic without human intervention. In IEEE 1613, Performance Class 1 is essentially identical to these PSRC requirements. The Substations Committee Task Force concluded that an additional optional performance class was warranted, requiring that the devices ride through these transients without interruption of communications. As a result, an optional Performance Class 2 was added.

This is no trivial addition. To meet the requirements of Performance Class 2, it is expected that fiber-optic media will be necessary for the communications cables. In addition, the internal power supplies of communications networking devices that meet Performance Class 2 will need to be very well shielded. If not, the transients that might appear on the power supply input could affect communications. It should be noted that Performance Class 2 is not mandatory but is an option that may be specified.

There are two categories of profiles of required communications during the transient tests. One is for equipment with specified ranges of frame size (e.g., an Ethernet switch) and includes the three profiles shown in Table 1.

For equipment without specified ranges of frame size (e.g., serial media converters), the three profiles in Table 2 apply.

The equipment shall be considered to have passed the tests if—during, or as a result of, the tests—all of the conditions below are met for the performance class of the device.

- a. No hardware damage occurs.
- b. No loss or corruption of stored memory or data, including active or stored settings, occurs.
- c. Device resets do not occur, and manual resetting is not required.
- d. No changes in the states of the electrical, mechanical, or communication status outputs occur. This includes alarms, status outputs, or targets.
- e. No erroneous, permanent change of state of the visual, audio, or message outputs results. Momentary changes of these outputs during the tests are permitted.
- f. No error outside normal tolerances of the data communication signals (SCADA analogs) occurs.

These criteria are the same as in the standards developed by PSRC. New criteria were developed to reflect the unique

requirements of substation communications systems. For Performance Class 1, there is one additional condition to be met:

- Established communications as defined in the appropriate Communication Profiles may be disrupted or sustain errors during the period the tests are applied. If disrupted, the communications recovers within the manufacturer's specified time period.

For Performance Class 2, the additional condition is:

- Established communications as defined in the appropriate Communications Profiles shall NOT be disrupted or experience errors during the period the tests are applied.

Summary

A task force (C2TF1) of the PES Substations Committee prepared this new standard. Representatives of electric utilities, consultants, and manufacturers formed a 22-member task force. C2TF1 worked primarily via e-mail, but did have some face-to-face meetings. Draft 6 of the 46-page document was balloted via e-mail to a 102-person balloting body, with an 88% response and 95% affirmative vote. A second ballot, adding the words "and Testing" to the title and text resulted in a 92% response of which 95% was affirmative. Eleven months after the first meeting of the task force, the balloting was completed. The IEEE-SA Board, at its March 2003 meeting, approved IEEE 1613. The document is available online at <http://shop.ieee.org/store/>, where it must be identified by its number: 1613.

A number of manufacturers of communications networking devices report that they have development projects underway or completed to produce devices that meet this new standard.

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Summary: The widespread use of multifunctional intelligent electronic devices (IEDs) with advanced communications capabilities has resulted in a new trend in substation automation systems, i.e. the implementation of high-speed peer-to-peer communications-based control schemes. The IEDs exchange messages over the substation local area network (LAN). A number of industry experts had observed that an unambiguous standard for network devices when installed in harsh environmental conditions in these substations did not exist. As a result, a task force (C2TF1) of the PES Substations Committee was formed. The task force C2TF1 adapts the four standards developed by Power System Relaying Committee (PSRC) for substation applications that do not involve protective relaying, which is now IEEE 1613 standard. They also chose to make the standard apply at the device, not system level. This paper presents the standard (IEEE 1613) developed by task force C2TF1 for communications networks in substation.