Draft Electromagnetic Compatibility Requirements

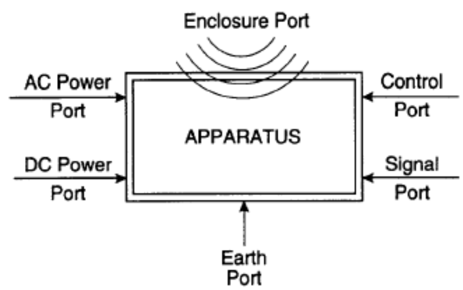
March 6, 2007

This paper presents, for discussion, a draft outline of electromagnetic compatibility requirements for VVSG07, and an incomplete draft set of developed requirements.

Volume III: PRODUCT STANDARD

5.3.3 Electromagnetic Compatibility (EMC) Immunity

The International Electrotechnical Commission (IEC) Technical Committee 77 on Electromagnetic Compatibility has defined the concept of "ports" as the interface of an electronic device ("apparatus") with its electrical and electromagnetic environment, as illustrated below. In the sketch, the arrows point toward the apparatus but in a complete assessment of the compatibility, one should also consider the other direction, that is, what disturbances ("emissions") can the apparatus inject into its environment.



Five of these ports involve conducted disturbances carried by metallic conductors, and the sixth, the "enclosure" allows radiated disturbances to impinge on the apparatus. In this context, the term "enclosure" should not be understood as limited to a physical entity (metallic, non metallic, totally enclosed or with openings) but rather be understood as simply the route whereby electromagnetic radiations couple with the circuitry and components of the apparatus.

In previous standards covering voting systems, possible interactions and immunity concerns have been described but perhaps not in explicit terms relating them to the concept of ports. In this updated version of the Guidelines, the recitation of compatibility requirements is structured by considering the ports one at a time, plus some consideration of a possible interaction between ports:

1. **Power port** – also described as "power supply" – via ordinary receptacles of the polling place
2. **Earth port** – implied in the NEC stipulations for dealing with the power supply of the polling place
3. **Signal port** – connection to the landline telephone of the polling place to the central tabulator
4. **Control port** – inter-system connections such as voting station to precinct tabulator
5. **Enclosure port** – considerations on immunity to radiated disturbances and electrostatic discharge
6. **Interaction** between signal port and power port during surge events

5.3.3.1- Steady-State Conditions

Adequate operation of an eventual surge-protective device and, more important, safety considerations demand that the power supply receptacles be of the three-prong type (Line, Neutral, and Equipment Grounding Conductor). The use of a "cheater" adapter for older type receptacles with only two-blade capacity and no dependable grounding conductor should be prohibited. Details on the safety considerations are addressed in Section …. "Safety."

The requirement of using a dedicated landline telephone service should also be satisfied for a polling place to be approved by the local Board of Elections.

Steady state conditions of a polling place are generally out of the control of the authority conducting the elections. However, for a polling place to ensure reliable voting, it is necessary to ensure that the power supply and telephone service to be used are suitable for the purpose. Compliance with the National Electrical Code is generally required by the authorities having jurisdiction, grandfather situations notwithstanding.

5.3.3.1-A AC Power Supply – Energy Service Provider

To obtain maximum flexibility of application, the voting system shall be powered by a 120 Vrms, single phase power supply, as available in polling places, derived from typical energy service providers.

DISCUSSION

It is assumed that the AC power necessary to operate the voting system will be derived from the existing power distribution system of the facility housing the polling place. This single-phase power may be a leg of a 120/240 V single phase system, or a leg of a 120/208 V three-phase system, at a frequency of 60 Hz, according to the limits defined in ANSI C84.1, and premises wiring compliant with the National Electrical Code NFPA 70, in particular its grounding requirements.

5.3.3.1-B Telecommunications Services Provider

To avoid interference with the voting integrity (accidental or intentional), the telephone connection shall use a dedicated line (no extensions on the same telephone number) and be compatible with the requirements of the telephone service provider.

DISCUSSION

Communications (upon closing of the poll) between the polling place and the central tabulator of the state subdivision is expected to be provided exclusively by the landline network of the telephone service provider connected to the facility housing the polling place.

5.3.3.2 Conducted Disturbances Immunity

As described in the introductory paragraphs of this EMC section, several ports of the voting system are gateways to possible electromagnetic disturbances, both inbound and outbound. This subsection dealing with conducted disturbances immunity addresses concerns about the Power Port and the communications ports (a combination of the in-house communications and communications to remote tabulating facilities.

Limitations of outbound conducted disturbances ("emissions" in EMC language) that might inject objectionable interference into the facility power distribution system or the telephone service connection are addressed in subsection 5.3.4.

5.3.3.2-A Power Port Disturbances

All electronic systems shall withstand conducted electrical disturbances that affect the power ports of the system.

DISCUSSION

The power distribution system of the polling place can be expected to be affected by several types of disturbances, ranging from very brief surges (microseconds) to longer durations (milliseconds) and ultimately the possibility of a long-term outage. These are addressed in the following sub-paragraphs A1, A2, A3, and A4.

There are several scenarios of accidental conditions that can produce voltages far in excess of the deviations implied by ANSI C84.1 or the ITI Curve, such as loss of a neutral conductor, commingling of distribution systems with low-voltage conductors (knocked down poles, falling tree limbs). Such an event will produce in the building massive failures of equipment other than voting systems, and be obvious to the officials conducting the polling. Fortunately, their occurrence is quite rare albeit not impossible. Hardware failure of the voting system can be expected; so that such a extreme stress should not be included in the EMC requirements nor the regimen of Certification Testing – provided that the failure mode would not result in a safety hazard. Listing of the voting equipment by a Nationally Recognized Testing Laboratory (NRTL) with explicit reference to the corresponding safety standard should address this concern. This type of accidental conditions is mentioned here only for the sake of completeness.

5.3.3.2-A.1 Combination Wave

All electronic systems shall be able to withstand, without disruption of normal operation or loss of data, a "Combination Wave" surge of 1.2/50 μs for open-circuit voltage and 8/20 μs for short-circuit current

DISCUSSION

The so-called "Combination Wave" has been accepted by industry as representative of surges that might occur in low-voltage AC power systems and be imposed on connected loads. Therefore the voting system immunity against such disturbance must be demonstrated:

Source: IEEE Std C62.41.2™-2002

Test References: Volume V. 5.1.1.2-A.1

5.3.3.2-A.2 Ring Wave

All electronic systems shall be able to withstand, without disruption of normal operation or loss of data, a "Ring Wave" surge with a 0.5 μs rise time and a decaying oscillation at 100 kHz.

DISCUSSION

This test waveform, proposed by IEEE since 1980 as a "Standard Waveform," and more recently adopted by the IEC represents common disturbances on AC power lines but it was not included in previous versions of the VVSG. It originates during disturbances of power flow within the building, an occurrence more frequent than lightning surges. Therefore the voting system immunity against such disturbance must be demonstrated.

Source: IEEE Std C62.41.2™-2002

Test References: Volume V. 5.1.1.2-A.2

5.3.3.2-A.3 Electrical Fast Transient Burst

All electronic systems shall be able to withstand, without disruption of normal operation or loss of data, a burst of repetitive fast transients with a waveform of 5/50 ns, each burst lasting 15 ms.

DISCUSSION

While the fast transients involved in this immunity requirement do not propagate very far and are not expected to travel from the energy supply provider, they can be induced within a facility if cable runs are exposed to switching disturbances in other loads. Therefore, the voting system immunity against such disturbances must be demonstrated.

Source: IEEE Std C62.41.2™-2002

Test References: Volume V. 5.1.1.2-A.3

5.3.3.2-A.4 Sags and Swells

All electronic systems shall be able to withstand, without disruption of normal operation or loss of data, a temporary overvoltage, with the time/amplitude characteristics shown in the corresponding ITI graph of Volume V.

DISCUSSION

Most standards stipulating equipment immunity against sags and swells now refer to a graphic disseminated as “the ITI (CBEMA) Curve” which shows limits of these two disturbances as a function of their duration. While the ITI curve is generally accepted by information technology manufacturers and industrial process manufacturers, in the case of voting systems immunity against short duration overvoltages (surges) will be demonstrated by the three preceding requirements. This leaves only the long duration, more modest overvoltage levels as defined by ANSI C.84.1

Because the general specifications of VVSG stipulate a two-hour back up, generally implemented by a floating battery pack, sag immunity is inherently ensured. However, the floating battery, unless buffered by a switch-mode power supply with inherent cut-off in case of a large swell, might not ensure inherent immunity against swells (short duration system overvoltages). Therefore, that immunity must be demonstrated:

Source: ITI (CBEMA) Curve – Published by Information Technology Industry Council

Test reference: Volume V. 5.1.1.2-A.4

5.3.3.2-B Communications (telephone) Port Disturbances

All electronic systems shall withstand conducted electrical disturbances that affect the telephone ports of the system.

DISCUSSION

The dedicated telephone cabling circuits of the polling place can be expected to be affected by several types of disturbances, including conducted emissions from other connected equipment, lightning, power fault and power cross. In the context of the VVSG compatibility, not only must the voting system equipment be immune to these disturbances, but also the public switched telephone network must be protected against harm originating from customer premises equipment. Protection of the network is discussed in the section addressing emission limits. Immunity to disturbances impinging on the voting system is addressed in the following subparagraphs B1, B2, B3 and B4.

5.3.3.2-B.1 Emissions from other connected equipment

All elements of an electronic voting system shall be able to withstand the conducted emissions generated by other elements of the voting system

DISCUSSION

This requirement is an issue of inherent compatibility among the diverse elements of a voting system, not compatibility with the polling place environment or subscriber equipment other than those making up the voting system. It is understood and implemented that security requirements dictate that the voting system outgoing communications be provided by a dedicated landline telephone service excluding other subscriber terminal equipment otherwise used by entities occupying the facility when telephone communications with central tabulators is established.

Such potentially disturbing emissions include ………. at the maximum levels implied by the emission limits enumerated under section 5.3.4 “Emission Limits.”

5.3.3.2-B.2 Lightning-induced disturbances

All electronic systems shall be able to withstand the stresses induced into the network by lightning events.

DISCUSSION *[TBD]*

5.3.3.2-B3 Power faults-induced disturbances

All electronic systems shall be able to withstand the stresses induced into the network by power faults occurring in adjacent power distribution systems.

DISCUSSION *[TBD]*

5.3.3.2-B4 Power cross-induced disturbances

All electronic systems shall be able to withstand the stresses appearing at the telephone port as a result from an accidental contact between the telephone network cables and nearby power distribution cables.

DISCUSSION*[TBD]*

5.3.3.2 - C – Interaction between Power Port and Telephone Port

All electronic systems connected to both a power supply and a landline telephone system shall withstand the potential difference caused by the flow of surge current in the facility grounding network.

DISCUSSION

A voting system that is powered via its Power Port to the power distribution system of the facility and to the telephone service provider via its Telephone Port can experience a potentially damaging stress between the two ports during the expected operation of the telephone Network Interface Device in the event of a surge occurring in the telephone system.

Source: IEEE Std C62.41.1™-2002
IEEE Std 1100™2005

Test References: Volume V. 5.1.1.2-C

5.3.3.3 Radiated Disturbances Immunity

Radiated disturbances impacting the enclosure port of the voting system include electric and magnetic fields originating from adjacent or distant sources, as well as a particular radiation associated with electrostatic discharge, as addressed in this subsection.
Emissions limits requirements of radiated disturbances are addressed in section 5.3.4.2.

5.3.3.3-A, B, C (Electric fields , magnetic fields, high frequency and low frequency…)
[TBD by EEEL Division 818]

Requirements
DISCUSSION

5.3.3.3- N Electrostatic Discharge Immunity

All electronic systems shall withstand, without disruption of normal operation or loss of data, electrostatic discharges associated with human contact and contact with mobile equipment (service carts, wheelchairs, etc.).

DISCUSSION

Electrostatic discharge events can originate from direct contact between an "intruder" (person or object) charged at a potential different from that of the units of the voting system, or from an approaching person about to touch the equipment – an "air discharge." The resulting discharge current can induce disturbances in the circuits of the equipment. Depending upon the type of enclosure (conductive or insulating) simulation of the event can require different modes of discharge with different waveshapes and levels, as will be discussed in more detail in Volume V, Test Standards.

Source: ANSI Std C63.16-1993
IEC 61000-4-2 2001

Test References: Volume V. 5.1.1.2-N

5.3.4 Electromagnetic Compatibility (EMC) Emission Limits

5.3.4.1 Conducted Emissions

All electronic systems installed in a polling place shall comply with emission limits affecting the power supply connection to the energy service provider and the telephone public network connection.

5.3.4.1-A Power Port connection to the facility power supply

All electronic systems installed in a polling place shall comply with emission limits affecting the power supply connection to the energy service provider

DISCUSSION

The normal operation of an electronic system can produce disturbances that will travel upstream an affect the power supply system of the polling place, creating a potential deviation from the expected electromagnetic compatibility of the system. The issue is whether these actual disturbances (after possible mitigation means incorporated in the equipment) reach a significant level to exceed stipulated limits, which include the following categories:

- Harmonic emissions associated with the load current drawn by the voting equipment
- High-frequency conducted emissions (distinct from the harmonic spectrum) into the power cord by coupling from high-frequency switching or data transmission inherent to the system operation.

Source: IEEE Std 519
Part 15 of FCC/CFR Rules

Test References: Volume V. 5.3.4.1-A

5.3.4.1-B Telephone port connection to the public network

All electronic systems installed in a polling place shall comply with emission limits stipulated by the telephone service provider.

DISCUSSION

Regulatory testing requirements for protecting the network (public switched telephone network) from harms via customer premises equipment are contained in the source documents and compliance to these documents is considered MANDATORY

Source: TIA/EIA-968-A
47 CFR Part 68

Test References: Volume V. 5.3.4.1-B

5.3.4.1-C Grounding port
All electronic systems installed in a polling place shall comply with limits of leakage currents established by any listed Ground Fault Current Interrupter (GFCI) that might be installed in the branch circuit supplying the voting system.

DISCUSSION
Excessive leakage current is objectionable for two reasons:

- High levels of leakage current would cause the GFCI to trip and therefore disable the operation of the system.
- Should the power cord lose the connection to the equipment grounding conductor of the receptacle, a personnel hazard would occur. (Note the prohibition of “cheater” adapters in the discussion of general requirements for the polling place).

Source UL 943 “*Ground Fault Circuit Interrupters*”
NEC® *Article 210.8*

Test References: Volume V. 5.3.4.1-C

5.3.4.2 Radiated Emissions

5.3.4.2-A Low Frequency Emissions *[TBD by EEEL Division 818]*
Requirements
DISCUSSION

5.3.4.2-B High Frequency Emissions *[TBD by EEEL Division 818]*
Requirements
DISCUSSION

5.3.5 Regulatory requirements
In addition to the requirements associated with EMC discussed in the preceding sections, there are requirements promulgated by diverse entities that have to be satisfied when installing a voting system in a polling place – a facility with public access, notwithstanding the fact that these guidelines are labeled “Voluntary.” These requirements include personnel safety considerations (addressed elsewhere in these Guidelines), hardware failure modes,

5.3.5.1 Dielectric strength All electronic systems shall be able to withstand the dielectric test stresses associated with connection to the network, characterized by limits of the admissible leakage current.

DISCUSSION
Dielectric strength regulatory requirements involve the insulation and leakage current limits between elements of the voting system hardware, including the following:
- Network and device or accessible circuitry which might in turn connect to the user
- Network and hazardous power system
- Power equipment

Source: TIA/EIA 968-A

Test Reference: Volume V 5.3.5.1

5.3.5.2 FCC Radiated emission limits
[TBD by EEEL Division 818]

Volume V: TESTING STANDARD

5.1.1 Electromagnetic Compatibility (EMC) Immunity

Because it is likely that voting system vendors will decline requests for providing detailed description of their circuitry and provisions for inherent immunity, testing of voting systems for EMC will be conducted in the so-called "black box testing," that is, "*Testing that ignores the internal mechanism of a system or component and focuses solely on the outputs generated in response to selected inputs and execution conditions*" (IEEE Std 100). Consequently, it will be necessary to subject voting systems to a regimen of tests including most, if not all disturbances that might be expected to impinge on the system under test. These tests are briefly described in the following paragraphs; complete details of the test procedures and specific pass/fail criteria will be found in the Certification guidelines, for instance, acceptability of very limited loss of data (one ballot being cast when a rare disturbance should occur) is part of the process of a pre-test agreement between a prospective vendor (which has knowledge of the expected behavior of the equipment when subjected to disturbances) and the Nationally Recognized Testing Laboratory commissioned to perform the tests.

5.1.1.1 Steady State Conditions

Test laboratories that will perform certification tests can be expected to have readily available a 120 V power supply from an energy service provider and access to a landline telephone service provider that will enable them to simulate the environment of a typical polling place and therefore perform the required tests.

5.1.1.2 Conducted Disturbances Immunity

Immunity to conducted disturbances shall be demonstrated by appropriate industry-recognized tests and criteria, for the ports involved in the operation of the voting system.

5.1.1.2-A Power Port Disturbances

Testing shall be conducted in accordance with the power port stress testing specified in IEEE Std C62.41.2™-2002 and IEEE Std C62.45™-2002.

DISCUSSION

Both the IEEE and the IEC have developed test protocols for immunity of equipment power ports. In the case of a voting system intended for application in the United States, test equipment tailored to perform tests according to these two IEEE standards is readily available in tests laboratories, thus facilitating the process of compliance testing.

5.1.1.2-A-1 Combination Wave

Testing shall be conducted in accordance with the power port stress of "Category B" to be applied by a Combination Waveform generator, in the powered mode, between line and neutral as well as between line and equipment grounding conductor.

DISCUSSION

To satisfy the above requirement, the voting system equipment shall be capable of withstanding a 1.2/50 – 8/20 Combination Wave of 6 kV open-circuit voltage, 3 kA short-circuit current, with the following application points.

- Three surges, positive polarity at the positive peak of the line voltage.

- Three surges, negative polarity at the negative peak of the line voltage, line to neutral
- Three surges, positive polarity at the positive peak of the line voltage, line to equipment grounding conductor
- Three surges, negative polarity at the negative peak of the line voltage, line to equipment grounding conductor

The requirement of three successive pulses is based on the need to monitor any possible change in the equipment response caused by the application of the surges. Details of the test procedure, test equipment and test sequences will be provided in the Certification Procedures volume of these Guidelines, based on some benchmark tests and observation of the voltage and current waveforms during the test to detect possible "walking wounded" after occurrence of a severe but not lethal surge.

Pass/fail criteria
The equipment is required to withstand the applied surges without exhibiting any of the symptoms described in the definition of "Failure":
(a) loss of one or more functions,
(b) degradation of performance such that the device is unable to perform its intended function for longer than 10 seconds,
(c) automatic reset, restart or reboot of the voting system, operating system or application software,
(d) a requirement for an unanticipated human intervention before the test can continue,
(e) error messages and/or audit log entries indicating that a failure has occurred.

In addition to these symptoms of malfunction, of course any hardware failure shall not produce a safety hazard (charring, risk of fire, exposure of live parts) as addressed in the …. Section "Safety"

Reference standard
IEEE Std C62.41.2™-2002, *IEEE Recommended Practice on Characterization of Surges in Low-Voltage AC Power Circuits. See Table 3.*

5.1.1.2-A-2 Ring Wave
Testing shall be conducted in accordance with the power port stress of "Category B" to be applied by a "Ring Wave" generator, in the powered mode, between line and neutral as well as between line and equipment grounding conductor and neutral to equipment grounding conductor, at the levels shown below.

DISCUSSION
Two different levels are recommended:
A) 6 kV open-circuit voltage per Table 2 of IEEE Std C62.41.1™-2002, applied as follows:

- Three surges, positive polarity at the positive peak of the line voltage, line to neutral
- Three surges, negative polarity at the negative peak of the line voltage, line to neutral
- Three surges, positive polarity at the positive peak of the line voltage, line to equipment grounding conductor
- Three surges, negative polarity at the negative peak of the line voltage, line to equipment grounding conductor

B) 3 kV open circuit voltage, per Table 5 of IEEE Std C62.41.1™-2002, applied as follows:

- Three surges, positive polarity at the positive peak of the line voltage, neutral to equipment grounding conductor
- Three surges, negative polarity at the negative peak of the line voltage, neutral to equipment grounding conductor

Pass/fail criteria
The equipment is required to withstand the applied surges without exhibiting any of the symptoms described in the definition of "Failure":

(a) loss of one or more functions,
(b) degradation of performance such that the device is unable to perform its intended function for longer than 10 seconds,
(c) automatic reset, restart or reboot of the voting system, operating system or application software,
(d) a requirement for an unanticipated human intervention before the test can continue,
(e) error messages and/or audit log entries indicating that a failure has occurred.

Details of the test procedure, test equipment and test sequences will be provided in the Certification Procedures volume of these Guidelines, based on some benchmark tests and observation of the voltage and current waveforms during the test

In addition to these symptoms of malfunction, of course any hardware failure shall not produce a safety hazard (charring, risk of fire, exposure of live parts) as addressed in …. Section "Safety"

Reference standard
IEEE Std C62.41.2™-2002, *IEEE Recommended Practice on Characterization of Surges in Low-Voltage AC Power Circuits. See Table 2 and Table 5.*

5.1.1.2-A-3 Electrical Fast Transient Burst
Testing shall be conducted in accordance with the recommendations of IEEE Std C62.41.2™-2002 and IEEE Std C62.45™-2002.

DISCUSSION*[TBD]*

Reference Standards
IEEE Std C62.41.2™-2002, *IEEE Recommended Practice on Characterization of Surges in Low-Voltage AC Power Circuits. See Table 6.*

5.1.1.2-A.4 - Sags and Swells *[TBD]*
Specification
DISCUSSION

5.1.1.2-B – Communications (telephone) Port Disturbances *[TBD]*

5.1.1.2-C – Interaction between Power Port and Telephone Port *[TBD]*
Specification
DISCUSSION

5.1.1.3 - Radiated Disturbances Immunity
[-A, -B, etc. TBD by EEEL Division 818]
Specification
DISCUSSION

5.1.1.3- N - Electrostatic Discharge Immunity
Testing shall be conducted in accordance with the recommendations of ANSI Std C63.16, applying an air discharge or a contact discharge according to the nature of the enclosure of the voting system device EUT.

DISCUSSION
Electrostatic discharges occurring as an intruder, simulated by a portable ESD simulator approaches the EUT involve an air discharge that can upset the logic operations of the circuits, depending on their status. In the case of a conducting enclosure, the resulting discharge current flowing in the enclosure can couple

with the circuits and also upset the logic operations. Therefore, it is necessary to apply a sufficient number of discharges to significantly increase the probability that the circuits will be exposed to the interference at the time of the most critical transition of the logic. This condition can be satisfied by using a simulator with repetitive discharge capability while a test operator operated to voting terminal, mimicking the actions of a voter.

Reference Standard

ANSI C63.16-1993 *American National Standard Guide for Electrostratic Discharge Test – Methodology and Criteria for Electronic Equipment.*

5.1.2 Electromagnetic Compatibility (EMC) Emissions limits

Because it is likely that voting system vendors will decline requests for providing detailed description of their circuitry and possible emissions of disturbances, testing of voting systems for EMC will be conducted in the so-called "black box testing," that is, "*Testing that ignores the internal mechanism of a system or component and focuses solely on the outputs generated in response to selected inputs and execution conditions*" (IEEE Std 100). Consequently, it will be necessary to subject voting systems to a regimen of tests including most, if not all disturbances that might be expected to be emitted from the system under test, unless compliance with mandatory limits such as FCC regulations is explicitly stated for the system under test. These tests are described in the following paragraphs.

5.1.2.1 Conducted Emissions Limits *[TBD]*

5.1.2.1-A Power Port *[TBD]*

Specification

DISCUSSION

5.1.2.1-B Communications (telephone) Port *[TBD]*