The Nature of the Requested Opinion

The IS485-24-xxx family of temperature measurement systems employ radio waves as short range devices (SRD) with conducted RF levels under 10dBm and transmission frequencies limited to the span 425MHz – 445MHz and compliant with EN300-220. The models within this family are listed in Appendix IV. The apparatus is nominally powered from 24Vdc and in no case has voltages exceeding 72Vdc, making it exempt from **Directive 2006/95/EC**, Low Voltage Directive. The apparatus comprise components that are installed into higher level systems or into fixed sites and are exempt from other directives provided that the components are professionally installed by a responsible party so as to maintain the compliance of the fixed site.

The objective of this request for a Notified Body Opinion Request is to approve the definition of a typical installation such that end user of the apparatus is able to install systems without the need for an EMC professional and to accept test data indicating that the typical installations meet EN55011. In this case an end user is a person in the technical disciplines, able to understand and follow the installation instructions but not necessarily expert in EMC or radio devices. By following the requirements and procedures of the installation guide, the relevant sections being presented herein, a typical installation is expected to comply with EN55011 Class A radiation limits as evaluated for the site as a whole.

The Nature of the Apparatus

The apparatus consists of a pulsed radio transmitter and receiver and an assortment of passive, radio-interrogated sensors. The transmitter/receiver alternately transmits a series of up to 20 pulses of RF energy at a predetermined frequency and receives the time delayed echoes. The pulses have a 16µs Gaussian envelope and a 42µs pulse repetition rate with a modulation bandwidth of less than 400KHz. The transmitter frequency is stepped through a predetermined range to locate the nominal frequencies of a reference and a sensor resonator by detecting the delayed ring-down pulse of the resonator after it is activated by the transmitting pulse. One such frequency band may be defined between 433.266 and 434.554MHz, in which case the transmitter meets the modulation mask requirements of EN300-220 and operate within a homologated frequency range. Appendix I discusses the compliance testing already completed on the apparatus.

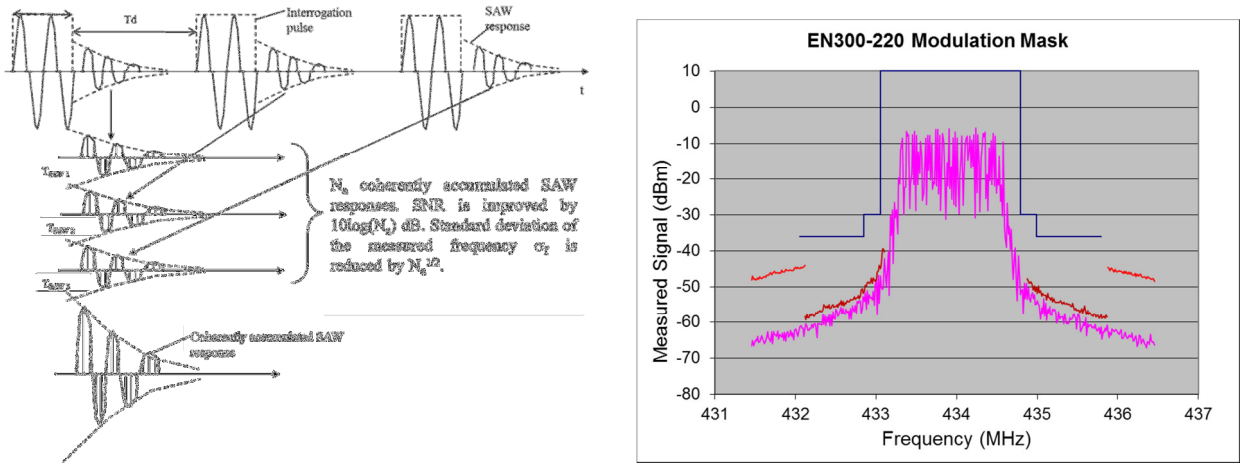


Figure 1 shows the (left) the interrogation in the time domain and (right) the measured modulation mask when interrogating under EN300-220 frequency limits. Time domain does not illustrate Gaussian shaping of pulses.

While this single homologated frequency band allows the operation of <u>one</u> passive sensor over a relevant range of temperatures, the electric grid uses <u>three phase power</u> and requires measurements at <u>more than one point per phase</u> on electric equipment. Traditional, contact measurements are not allowed due to the high voltage hazards. To this end, the IS485-24-xxx apparatus has designed 12 unique sensors and defined 12 frequency bands allowing the measurement of these sensors from -40^{0}C to 130^{0}C. While it is possible to serve the needs of the EU's electric grid with a subset of the twelve sensors, it is not possible to do so with a single sensor band.

The table below indicates the lower and upper center frequencies of transmission and the lower and upper frequencies at which the system would meet the modulation mask of EN300-220 at 100KHz IF BW, if the mask frequencies were adjusted to be centered on each band. The reader is programmed to only transmit in selected bands at installation.

	IS01	IS02	IS03	IS04	IS05	IS06	IS07	IS08	IS09	IS10	IS11	IS12
lower mask	425.284	426.785	428.101	429.364	430.759	432.048	433.391	434.706	436.101	437.443	438.759	440.127
lower TX	425.500	427.001	428.317	429.580	430.975	432.264	433.607	434.922	436.317	437.659	438.975	440.343
upper TX	426.975	428.291	429.554	430.949	432.238	433.580	434.896	436.291	437.633	438.949	440.291	441.606
upper mask	427.211	428.527	429.790	431.185	432.474	433.816	435.132	436.527	437.869	439.185	440.527	441.842

Table 1 lists the limits of equivalent "EN300-220-like" modulation masks and the actual range of transmitted frequencies for each of the twelve sensor bands.

The modulation bands of the transmitter for the twelve bands are illustrated in the figure, below. IntelliSAW will separately pursue ***In one approach to accessing the EU market, the Notification process will be applied, requesting permission to apply the EN300-220 compliant electronics to a subset of the remaining unhomologated frequency bands, below, in specific jurisdictions.***

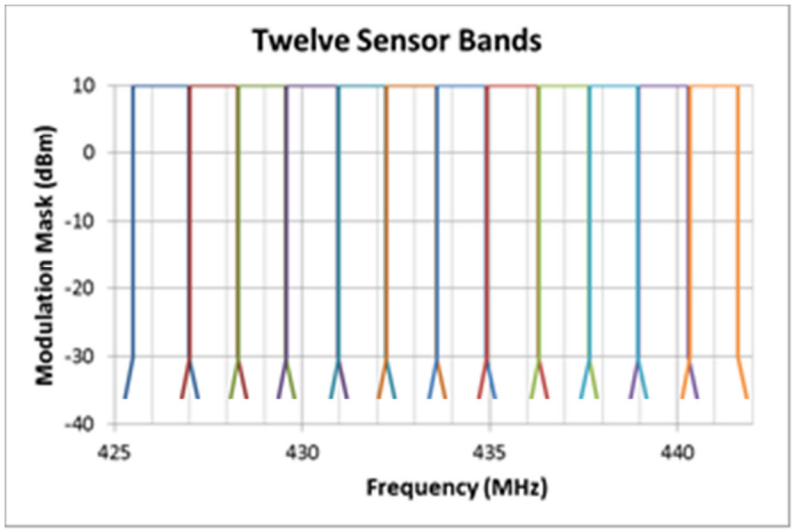


Figure 2 shows the approximate modulation masks associated with the 12 frequency bands.

A more permissive approach is available for a number of applications. These applications employ well shielded, metal enclosed switchgear and transformers following a certain set of design rules. Older, less completely shielded installations might rely on a combination of shielding and Notification, as needed.

The Nature of the Typical Installation

The IS485-24-xxx apparatus is not a consumer device and is not sold outside the industrial or public utility application space. Globally, the sales of systems are almost entirely in oil and gas refinery power plants, metals refining plants, and public utilities. As such, the typical installation sites to be covered under this Opinion have one or more of the following properties:

1. Secure location with restricted access.
2. Enclosed electric transmission and distribution equipment.
3. Industrial (high noise) environment.

The specific opinion sought relates specifically to installation of the apparatus into electrical equipment meeting these conditions. The secure location may be delineated by a safety fence reasonably intended to restrict access by the general public. If present, the fence is deemed to represent the boundary of the "fixed site" from which EN55011 Class A limits are then applied. When a fence is not present, but the equipment is located within a structure, the outer walls of the structure are taken to represent the boundary of the fixed site. When the equipment is pad mounted, the nature of the enclosure must provide all of the security, safety, and EMC shielding and the boundaries of the pad-mounted enclosure represent the boundaries of the fixed site. **The requirements under other safety directives applicable to pad mounted and indoor electrical equipment ensure the required construction for a typical piece of equipment**.

The enclosed electric T&D equipment will consist of a metal cabinet – typically of steel or aluminum construction – enclosing the high voltage (480V – 1MV) electrical transmission and distribution switches, transformers, and reactance devices. The enclosure must contain and divert explosions from unwanted arc faults, shunt fault currents as high as 50kA safely to earth, and prevent ingress of contaminants, pests, and persons into the chambers containing hazards. As such, the enclosures have the additional benefit of offering excellent EMC shielding, as seen in the discussions and photographs below.

EN55011 Class A limits dictate **40dBµV/m** or lower field strength at 10 meters from the boundary of the fixed site. Based on available RF calculators, +10dBm radiated from an isotropic antenna in an unenclosed space would result in fields of approximately 95dBµV/m at 10 meters, so a minimum of 55dB of shielding is required. Additional shielding is needed if antennas having any significant directivity are used, and 60dB of shielding is targeted. 0.5mm steel foil offers 80dB of attenuation to EMI at 400MHz. ***Even moderately-ventilated, pad-mounted equipment without the benefit of further shielding by an enclosing structure or additional physical distance enforced by a surrounding fence is still expected to typically provide the required 60dB of shielding***.

The high noise of public utility environments and industrial facilities cannot be overstated. The transmission and distribution equipment suffers unwanted partial discharges and corona discharges that frequently result in EMI levels exceeding EN55011 Class A limits. Even if the apparatus were to be installed with slightly less than perfect shielding, emissions slightly above the 40dBµV/m limits might not be distinguishable from baseline levels in a steel mill, aluminum refinery, or transmission and distribution substation. While the target of the typical installation is to operate well below the Class A limits, even the occasional installation with leakage levels less than 50dBµV/m might not be measurable compared to background industrial noise.

1. **Pad mounted distribution transformers with weather-proof, metal-enclosed cable boxes.**

Pad mounted distribution transformers typically receive 3.3 to 13.6kV power by buried cable and then provide 480V power to a region. The transformer itself is located in one section of the enclosure and two additional chambers provide access to cable terminations for the medium voltage primary and low voltage secondary systems. Antennas and sensors are located within these cable compartments and the sealed doors prevent unwanted radiated RF emissions. The enclosures are bonded to earth in such a way to provide safety to unauthorized persons even during a line fault. The weatherproof construction of the doors and lack of ventilation louvers on the cable compartment doors results in excellent shielding.

Figure 3. 6.8 kV pad mount transformer with wireless sensors installed.

2. **Pad mounted medium voltage switchgear with weather-proof, metal-enclosed construction.**

Like the transformer above, the pad mounted switchgear have weather-proof construction with no ingress avenues. In some cases, IR-transparent windows are employed; however even these apertures in the metal construction offer limited RF leakage because they view a metal object enclosing the gas or vacuum insulated switch, which is located between the sensor/antenna positions and the IR window.

Figure 4. A small bank of medium voltage switchboxes shows both weather-tight and RF-tight enclosures. Such systems have very low spurious emissions.

3. **Indoor medium voltage distribution transformers enclosed in metal cabinets located within a secure structure.**

Since the cabinet construction must meet the same weather-proofing and ingress protection of the switchgear, indoor distribution transformers in metal cabinets also are expected to offer a similar level of EMC shielding.

Figure 5. Indoor distribution transformers are often housed in NEMA or similar rated cabinets that fit seamlessly with the incomer and feeder switches of the distribution substation.

4. **Indoor medium voltage switchgear enclosed in metal cabinets located within a secure structure.**

Indoor switches may not be weather-proof against driving rain or snow; however they still employ sealed steel constructions. An arc fault in an 11kV switch can explode with the force of 10kg of TNT. The construction must contain this blast and direct it through vent flaps into designated exhaust ducts. RF leakage from such well-constructed enclosures is anticipated to approach the ideal attenuation of the steel sheet (perhaps 60dB). Note that the cables in this class of equipment exit through the floor (bottom left) and travel via shielded high voltage cable to the distribution grid or from the transmission grid.

Figure 6 shows that indoor medium voltage switchgear, such as these Siemens 8BT1-24 operated by a utility in Finland, employ multiple layers of steel construction between the positions where antennas and sensors would be located and the interior of the structure housing the switches.

5. **Indoor low voltage distribution panels enclosed in metal cabinets.**

Despite the lower voltages of the final stage of power distribution, these switchpanels still require suitably constructed enclosures and are seen to offer excellent shielding.

Figure 7 shows a low voltage distribution panel in a typical metal cabinet.

Evidence of Sufficient Shielding

As a preliminary experiment towards approval in Korea, an IS485-24-xxx system was located in a PVC enclosure and operated. Despite the much lower shielding of PVC compared to steel cabinets, and despite the viewing window, the emissions were lower than expected.
The system was not expected to pass the Korean limits of 35µV/m in this enclosure; however the resulting fields from even a PVC enclosure nearly met the EN55011 Class A limits of 40dBµV/m, failing by about a 12dB margin.

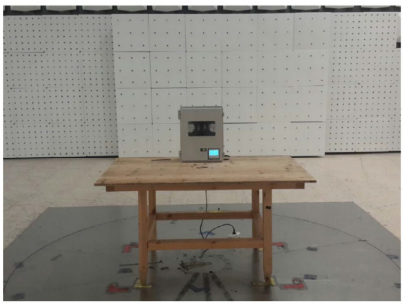
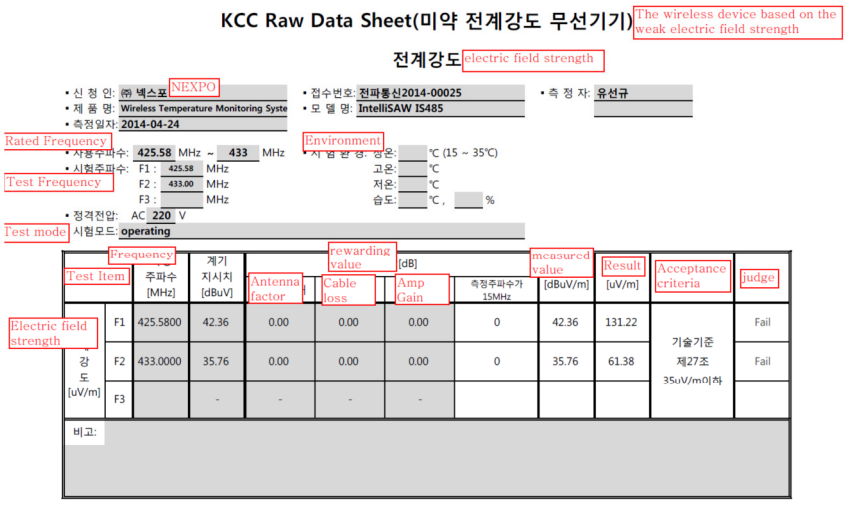


Figure 8IS485-24-xxx installed in a PVC enclosure and operating in an anechoic chamber.

In very few circumstances would it be likely that the enclosure radiation from an earth-bonded steel enclosure would not have at least 12 dB more shielding than the PVC enclosure that was tested. In these cases, which would include heavily perforated metal enclosures restricted to indoor applications, IntelliSAW further relies on the fixed, indoor, location of the switchgear. In this case, the distance from the leakage point of the switchgear that exceeds EN55011 to the structure boundaries and propagation losses through the structure can reasonably be expected to provide the remaining attenuation of undesired signals. Even the PVC enclosure, above, located adjacent to a steel-reinforced cement wall typical of most industrial structures would be likely to meet EN55011 as measured at the standard distance from the outer boundary of the structure.

The degree of shielding required depends, in part, on the antenna used. EN300-220 evaluations of the system used a 9cm monopole with a gain of +1dBi. Alternate planar antennas might be desirable, especially for use with broadband detection of UHF emissions from partial discharge faults in the system. Such antennas might have as much as +6dBi gain, requiring 60dB of shielding.


KCC Raw Data Sheet(미약 전계강도 무선기기) The wireless device based on the weak electric field strength

전계강도 electric field strength

• 신 청 인: ㈜ 넥스포 NEXPO
• 제 품 명: Wireless Temperature Monitoring Syste
• 측정일자: 2014-04-24
• 접수번호: 전파통신2014-00025
• 모 델 명: IntelliSAW IS485
• 측 정 자: 유선규

Rated Frequency
• 사용주파수: 425.58 MHz ~ 433 MHz
Test Frequency
• 시험주파수: F1 : 425.58 MHz
F2 : 433.00 MHz
F3 : MHz
• 정격전압: AC 220 V
Test mode 시험모드: operating

Environment
• 시험 환 경: 정온: ℃ (15 ~ 35℃)
고온: ℃
저온: ℃
습도: ℃, %

Test Item		Frequency 주파수 [MHz]	계기 지시치 [dBuV]	rewarding value [dB] Antenna factor	Cable loss	Amp Gain	측정주파수가 15MHz	measured value [dBuV/m]	Result [uV/m]	Acceptance criteria	judge
Electric field strength 강도 [uV/m]	F1	425.5800	42.36	0.00	0.00	0.00	0	42.36	131.22	기술기준 제27조 35uV/m이하	Fail
	F2	433.0000	35.76	0.00	0.00	0.00	0	35.76	61.38		Fail
	F3		-	-	-	-					

비고:

Figure 9 shows the diagnostic report on the measurements. While the emissions at 425.58MHz are four times the allowed limits, only 12dB more shielding would have been required to meet the strict limits of a "weak field" device.

Specific Request for Opinion Regarding Operation in a Shielded Environment

The Notified Body is asked to provide an Opinion, based on the evidence of typical systems testing, that installation of the IS485-24-xxx apparatus in systems typified by 1 – 5, above should be allowed following the specifications of Appendix III without the need for confirmatory EMC testing and that such installations are not expected to result in interference with protected users of the frequency spectrum.

- The apparatus meets, by testing or by exemption, the standards required for CE (**Directive 99/5/EC (R&TTE), Directive 2004/108/EC, Directive 93/68/EEC, and Directive 2006/95/EC**) when operation is restricted to a reduced range of frequencies and other than the frequencies employed is allowed for use without shielding.
- Shielding of 60dB or more would reduce the cabinet radiation of the apparatus to below EN55011 Class A limits even with internally generated 10dBm EIRP power levels delivered to a +6dBi antenna within the enclosure.
- Operation of the apparatus within a metal enclosure (shielded environment) consistent with properly designed and rated power equipment will typically attain the required shielding.
- In those circumstances where the metal enclosure has limited vectors of insufficient shielding due to less rugged construction, it is most likely to be operated within a structure situated in a secure facility, offering a second level of shielding and an extended physical propagation path from the leakage point to the effective boundary of the fixed site.

Access to one or more customer locations within about 2 hours driving time of Curtis Straus will be sought. Once the sites are secured, one or more IS485 systems will be installed in advance of access for testing. Testing will address a typical pad mounted installation and a typical indoor installation in order to cover both extremes. The pad mounted equipment relies upon the weather-proof enclosure for all of the shielding requirements while the indoor equipment may have less shielding and rely upon the structure and extended distances.

Because the apparatus has already been evaluated with regards to all requirements for EN300-220 and because the use of additional frequencies from the circuit will not result in transmission

of meaningful signals below 420MHz and above 450MHz, the only aspect potentially requiring testing are the radiated emissions of the system in this frequency range. Testing shall consist of measuring emissions over the range 420 – 450MHz at a distance from the site perimeter in accordance with EN55011.

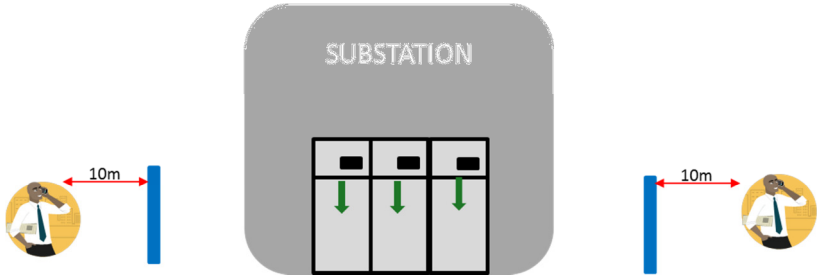


Figure 10 illustrates the most typical case, where IntelliSAW components are inserted into metal enclosed switchgear and transformers. Leakage fields from the metal cabinets must propagate through the substation walls and to the perimeter fence, at which point they are considered to be emissions of the fixed site.

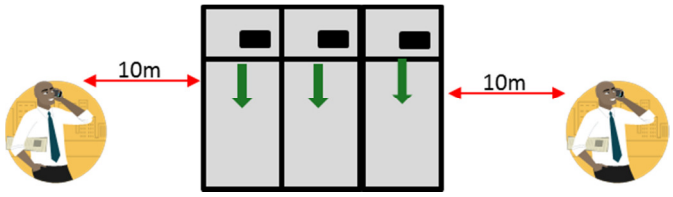


Figure 11 illustrates another typical case, where IntelliSAW components are inserted into metal enclosed, pad-mounted switchgear and transformers. The construction of outdoor equipment is required to be weather-proof and offers much better shielding than the indoor rated equipment, allowing it to provide the entire shielding requirement.

The test may be modified to be mutually consistent with FCC unintentional radiator (see Appendix V discussion of 15.109) and EU requirements, if possible, in which case test data will be collected in a mutually acceptable manner and then adjusted for use by both the Notified Body and the TCB. Measurements at frequencies below and above this range are unnecessary because the apparatus has passed testing in other frequencies at Curtis Strauss without shielding and there is not potential for signals outside the transmitter modulation bandwidth to be relevant to the requirements. Data will be taken with all systems having transmitters off and with all systems operating normally. If necessary, measurements of individual system operation might also be taken.

Based on the results of the test data and observation of the typical environment in which systems are installed, an opinion allowing the installations will then be requested based on the test data.

Installations that are Excluded from this Opinion

There exist a large number of pole mounted and unshielded distribution transformers that serve to transform 3.3kV to 13.6kV distribution mains into the 120V, 240V, and 480V residential and industrial feeds to individual buildings. These systems are typically too poorly shielded to meet the requirements set out, above. These systems are far too prevalent to allow the further exemptions requested for critical infrastructure below. It is estimated that there are 150k such distribution transformers in the Netherlands alone. These and similar unshielded or poorly shielded applications are expressly not contemplated in the requested Opinion.

APPENDIX I: Existing Certifications

The following reports from Bureau Veritas (Curtis Straus LLC) relate to the construction of the IS485 and its operation. On the merits of these test reports, the IS485-24-ISU and IS485-24-ISH have been certified to comply with

- **Directive 99/5/EC (R&TTE)**, through operation enforced by software settings.
- **Directive 2004/108/EC**, Electromagnetic Compatibility Directive
- **Directive 93/68/EEC**, CE Marking Directive
- **Directive 2006/95/EC**, Low Voltage Directive, by exemption.

EM0538-1 September 27, 2012

Summary

On June 5 and 26, 2012 we tested the IS485, IS485-24-ISU, and IS11A for compliance with the following requirements:

EMC Immunity:

- IEC 61000-4-2 Electrostatic Discharge (test to failure)
  Contact +/- 8kV
  Air Discharge +/- 15kV
- IEC 61000-4-3 Radiated RF Interference (10V/m)
- IEC 61000-4-4 Electrical Fast Transients
  Signal Ports +/- 2kV
  Power Ports +/- 4kV
  Earth Ground Ports +/- 4kV
- IEC 61000-4-8 Magnetic Field
  Enclosure Ports 100A/m continuous
- IEC 61000-4-29 Voltage Dips and Interrupts - DC Power Ports
  30% for 0.1s, 60% for 0.1s, 10% for 0.05s, 70% for 0.1s, 40% for 0.1s, 90% for 0.5s
- IEC 61000-4-17 Ripple on DC Power Supply
  DC Power Ports 10% of nominal voltage

We found that the product met the above requirements with modification. Colin Lanzl from IntelliSAW Inc. was present during the testing. The test sample was received in good condition. The sample was received on June 5, 2012.

EN0434-1 August 8, 2013

Summary

On April 16 and 19, 2013 we tested the IS485 for compliance with the following requirements:

EMC Immunity:

- EN 61000-4-5:2006 Surge immunity test, Level 4: ±4kV

We found that the product met the above requirements with modification (see *Modifications Required for Compliance* section on page 5). Colin Lanzl from IntelliSAW Inc. was present during the testing. The test sample was received in good condition. The sample was received on February 25, 2013.

EN0434-2, May 14, 2014

Summary

On May 10, August 29, September 13, October 28, November 6, and 7, 2013 we tested the IS485 for compliance with the following requirements:

EMC Radiated Emissions:

- ICES-003 Issue 5 Class A Digital Apparatus emissions requirements (Canada)
- EN 55011:2009/A2:2006 Sound and television broadcast receivers and associated equipment - radio disturbance characteristics (EU)

EMC Immunity per IntelliSAW custom test plan:

- IEC 61000-4-3:2006, Level 3 RFI
  Enclosure: 1.4-2.7GHz, 10V/m, 1KHz, 80% AM

- IEC 61000-4-6: 2009, Level 3 Conducted RFI
  Power and Signal Ports 0.15-80MHz, 10Vrms, 1KHz, 80% AM

We found that the product met the above requirements with modification (see *Modifications Required for Compliance* section on page 6). Colin Lanzl from IntelliSAW was present during the testing. The test sample was received in good condition. The sample was received on May 3, 2013.

EN0434-5 May 7, 2014 ETSI EN300-220-1 and -2

Summary

On November 6-8, 2013 we tested the IS485 with the following requirements:

Electromagnetic compatibility and Radio spectrum Matters (ERM):

- ETSI EN 300 220-1 V2.4.1 Short Range Devices (SRD); Radio equipment to be used in the 25MHz to 1000MHz frequency range with power levels ranging up to 500mW; Part 1: Technical characteristics and test methods

- ETSI EN 300 220-2 V2.4.1 Short Range Devices (SRD); Radio equipment to be used in the 25MHz to 1000MHz frequency range with power levels ranging up to 500mW; Part 2: Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive

We found that the product met the above requirements. Jeff Andle from IntelliSAW, Inc. was present during the testing. The test sample was received in good condition.

EN0434-6 May 7, 2014 ETSI EN301-489-3

Summary

On May 3, 10, August 29, September 13, October 28, November 6, 2013 we tested the IS485 with the following requirements:

Electromagnetic compatibility and Radio spectrum Matters (ERM):

- ETSI EN 301 489-3 V1.4.1 EMC standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9kHz and 40GHz for the following tests only:
  - EN61000-4-4 – Radiated RF Immunity
  - EN61000-4-6:2009 – Conducted RF Immunity

We found that the product met the above requirements with modifications (see *Modifications Required for Compliance* section on page 5). Jeff Andle from IntelliSAW, Inc. was present during the testing. The test sample was received in good condition.

EO0322-1

Summary

On February 14, 21, 22, and 28, 2014 we tested the IS485 for diagnostic purposes with the following requirements:

EMC Conducted Emissions:

- ICES-003 Issue 5 Class A Digital Apparatus emissions requirements (Canada)
- EN 55011:2009/A2:2006 Sound and television broadcast receivers and associated equipment - radio disturbance characteristics (EU)

EMC Immunity per IntelliSAW custom test plan:

- IEC 61000-4-5:2006, Level 4 Surge
  Signal Ports ±4kV L-PE
  Power Ports ±2kV L-PE

- IEC 61000-4-6: 2009, Level 3 Conducted RFI
  Signal and Power Ports 0.15-80MHz, 10Vrms, 1KHz, 80% AM

We found that the product met the above requirements with modification (see *Modifications Required for Compliance* section on page 6). Maly Chap from IntelliSAW was present during the testing. The test sample was received in good condition. The sample was received on February 14, 2014.

Please see the Product Documentation section in this report for the IntelliSAW test plan.

APPENDIX II: Typical Enclosures

See, for example, section9_0307.pdf on www.Schneider-electric.us for a discussion of enclosures. Similar standards in the EU apply to the equipment under discussion.

NEMA enclosure types

One common characteristic of all of the equipment types covered in this section is that they are all enclosed for safety. The enclosures for enclosed equipment generally follow the guidelines set forth in NEMA 250-2003 [1], and, although this standard is intended for equipment less than 1000 V, this is true of medium voltage power equipment also.

The most common NEMA enclosure types are described as follows [1]:

Type 1: Enclosures constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts and to provide a degree of protection of the equipment inside the ingress of solid foreign objects.

Type 3R: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt and windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow); and that will be undamaged by the external formation of ice on the enclosure.

Type 4: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt and windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose directed water); and that will be undamaged by the external formation of ice on the enclosure.

Type 4X: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose directed water); that provides an additional level of protection against corrosion; and that will be undamaged by the external formation of ice on the enclosure.

Enclosure type 1 and its international equivalents is the minimum standard for indoor metal enclosed electrical equipment consistent with the Low Voltage Directive or with medium voltage electrical apparatus safety. This class of equipment may have cutouts and louvers for instrumentation and/or ventilation that could result in slightly less than 60dB of shielding. However, the indoor operation and secure locations of typical installations will typically provide in excess of 60dB of shielding inclusive of the switch-room structure.

The remaining classes of enclosure suitable for outdoor application necessarily have weather-proof and dust-proof seals and should typically offer in excess of 60dB of shielding.

APPENDIX III: Typical Installation Guidelines

EMC immunity & safety

The IS485 requires two earthing wires with length less than 25cm. One wire ensures proper earthing of the antenna shields to divert any induced 50Hz currents to earth and connects from the PE earthing stud of the case. The other wire connects from PE of the Eurostyle screw terminal header and provides the earth return of the protective circuitry. The two PE connections earth isolated systems. The case stud earths the case, antenna cables, and internal RF and digital circuitry, while the screw terminal earths the RS485, I2C, and power protection circuits.

Immunity to conducted RFI and fast transients was tested without earth connection; however the earth connections are important to reliable operation. Surge immunity is critically dependent on the screw terminal earth connection.

EMI minimization from spurious emissions

EN55011 Class A operation was tested without earth connection; however proper earthing of the case and coaxial cables will reduce the potential for unwanted cabinet radiation. Conducted EMI will be reduced by properly earthing the screw terminal PE and by solidly mounting the IS485-24-xxx onto a grounded DIN rail.

IntelliSAW provides coaxial cables and antenna mounts. The IntelliSAW-provided cables use low-loss, double-shielded cable. End users and systems integrators that source their own cables should consult with the factory concerning materials and quality control requirements for cables. The IntelliSAW-sourced antenna mounts provide electrical match that is suitable for either a 5cm total height monopole with nominally -1dBi efficiency and gain or a 9cm total height monopole with nominally +1dBi. Prototype antennas with +6dBi nominal are also used in certain applications requiring simultaneous active monitoring of temperature and passive (receive-only) monitoring of partial discharge faults. The system integrator is required to discuss any alternate antennas with the factory before substituting them under this Opinion.

Antenna, cable, and sensor location and safety

Antennas are located on the interior of the earthed metal walls of the equipment. The antenna must maintain a bonded path of its body to earth either through multiple earthed magnets with 15N pull strength or through bolt mounting to the cabinet. The cables must be run either within the existing cable chases of the system or along the earthed metal walls, physically secured.

The safety of the system is ensured by maintaining a physical separation between the antenna/cable and any energized conductors that is sufficient to pass the basic insulation level (BIL) requirement of the equipment as stated by the manufacturer. Absent a specification, the following tables are to be used and follow IEC60071 and IEC 60298.

Similarly, sensors must be mounted to the energized points to be measured in such a way that they do not reduce the spacing between conductors of different potential below the requirements. For the purposes of evaluating distances for rated voltages above 6.6kV, the plastic body of the antenna, antenna base, antenna cables, and antenna are assumed to be “conductors”. The plastic of the sensor is rated at 18kV and can provide the over-voltage withstand requirements of a 6.6kV rated equipment and also contribute to the approximately 18 to 50kV BIL requirements of equipment rated for voltages from <1kV to about 6.6kV.

Rated voltage kV rms.	Rated lightning impulse withstand voltage 1.2/50 µs 50 Hz kV peak		Rated power-frequency withstand voltage 1 minute kV rms.	Normal operating voltage kV rms.
	list 1	list 2		
7.2	40	60	20	3.3 to 6.6
12	60	75	28	10 to 11
17.5	75	95	38	13.8 to 15
24	95	125	50	20 to 22
36	145	170	70	25.8 to 36

Insulation levels apply to metal-enclosed switchgear at altitudes of less than 1 000 metres, 20°C, 11 g/m³ humidity and a pressure of 1 013 mbar. Above this, derating should be considered.
Each insulation level corresponds to a distance in air which guarantees equipment withstand without a test certificate.

Rated voltage kV rms.	Rated impulse withstand voltage 1.2/50 µs kV peak	Distance/earth in air cm
7.2	60	10
12	75	12
17.5	95	16
24	125	22
36	170	32

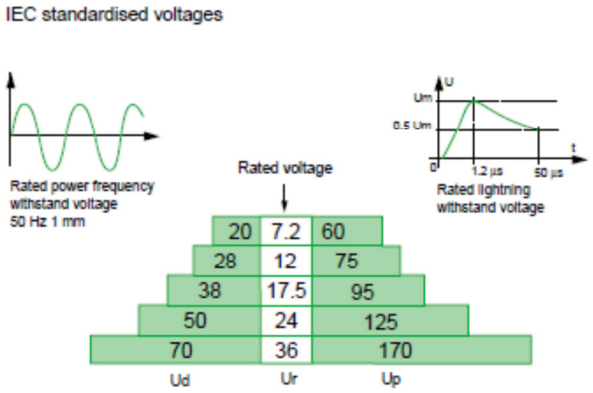


Table 2 lists typical lightning impulse (BIL) ratings and withstand voltages for various equipment ratings (top left). It also provides the default BIL and the minimum distance between an energized conductor and earth, including the closest point of the antenna or cable (bottom left). The figure (right) illustrates the relationship between over-voltage withstand (Ud), rating (Ur), and lightning BIL (Up).

EMI minimization from spurious emissions

The antennas are the source of all radiated fields of any consequence. Antennas should be located on and adjacent to solid metal or perforated metal with perforations smaller than 5mm diameter. Location of an antenna with line of sight to a viewing window (e.g. an IR thermography window) or other large aperture can result in a directed emission with insufficient shielding. If no location is identified other than one adjacent to such an aperture, additional shielding may be added. Rather than relying solely on this Opinion, such an installation should be discussed with the factory for an engineering opinion.

When line of sight radiation from the antenna to an aperture of the metal enclosure does not exist, then the system is considered to be a typical installation within a shielded enclosure. Measurements within the enclosures but behind ancillary components such as the circuit breaker, current transformers, etc., show typical field strengths more than 30dB below the radiated near field levels in the line of sight of the antenna. Apertures that are less than 10cm in at least one direction and not in the line of sight of the antenna are expected to offer sufficient shielding for indoor operation in a secure and dedicated switch-room.

APPENDIX IV: Equipment covered by this Opinion

Interrogation units (transmitters)

IS485-24-ISU Temperature monitoring interrogator.
IS485-24-ISH Temperature monitoring interrogator with I2C humidity sensor support.
IS485-24-ISP Temperature monitoring interrogator with partial discharge monitoring support.[1]

Sensors

IS01 – IS12	Passive wireless sensors in shielded environments. Some or all of the sensors to be allowed in critical infrastructure applications.
IH10	Humidity and ambient temperature sensor operated over wired I2C.[2]

Antennas

IA-MM-5	5cm high magnetic mount monopole antenna with -1dBi typical gain.
IA-BM-5	5cm high bolt mount monopole antenna with -1dBi typical gain.
IA-MM-9	9cm high magnetic mount monopole antenna with +1dBi typical gain.
IA-BM-9	9cm high bolt mount monopole antenna with +1dBi typical gain.

[1] Pending release and CE recertification of added electronics.
[2] Pending release and component CE certification. This is a non-radio device using wired, digital electronics.

APPENDIX V: Relevant FCC Rules Allowing the Device Analogous to this Opinion

15.103 Exempted Devices

The following devices are subject only to the general conditions of operation in § § 15.5 and 15.29 and are **exempt from the specific technical standards and other requirements contained in this part**. **The operator of the exempted device shall be required to stop operating the device upon a finding by the Commission or its representative that the device is *causing* harmful interference. Operation shall not resume until the condition causing the harmful interference has been corrected. Although *not mandatory*, it is strongly recommended that the manufacturer of an exempted device endeavor to have the device meet the specific technical standards in this part.**

(b) A digital device **used exclusively as an electronic control or power system utilized by a public utility or in an industrial plant**. The term public utility includes equipment only to the extent that it is in a dedicated building or large room owned or leased by the utility and does not extend to equipment installed in a subscriber's facility.

(c) A digital device used exclusively as industrial, commercial, or medical test equipment.

This clause specifically allows operation outside 15.231.e or other rules in our intended location and mode of operation and allows operation without a license. Since our components, when properly located and integrated into a system comprising the control box of an electric power controls system, are not intended to transmit radio waves, the system into which we integrate is a digital device and we are a component thereof.

§ 15.15 General technical requirements.

(a) An intentional or unintentional radiator shall be constructed in accordance with good engineering design and manufacturing practice. Emanations from the device shall be suppressed as much as practicable, **but in no case shall the emanations exceed the levels specified in these rules**.

§ 15.109 Radiated emission limits.

(b) The field strength of radiated emissions from a Class A digital device, as determined at a distance of 10 meters, shall not exceed the following:

Frequency of emission (MHz)	**Field strength (microvolts/meter)**
216-960	**210 (46.4 dBµV/m)**

(3) Other intentional and unintentional radiators are to be measured for compliance using the following procedure excluding sections 4.1.5.2, 5.7, 9 and 14: **ANSI C63.4-2003**: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see § 15.38). This incorporation by reference was approved by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51.

15.107 conducted limits are tested in the lab and cannot be evaluated adequately in the final installation.