EN 300 386-2: 1997 or Bellcore GR-1089-CORE—What's the difference?

A comparison of Section 2 and Section 3 of GR-1089-CORE to EN 300 386-2:1997

ROBERT DELISI
Underwriters Laboratories Inc.*
Melville, NY

As we enter into a world of increasing harmonization, telecommunications companies and centers in the United States and Europe have not always seen eye to eye. In the United States, companies which desire to sell telecommunications equipment to the Regional Bell Operating Companies (RBOC) are required to meet a set of standards to ensure the networks in which they are installed do not fault in the presence of extreme electromagnetic environments. These requirements, defined in BELLCORE GR-1089-CORE, encompass not only electromagnetic environments, but also address phenomena such as lightning surge, AC power fault, electrical safety, corrosion, and bonding and grounding.

This was not always the case in Europe. Until the harmonization of the European Union (EU) in 1987, each of the fifteen member countries had its own requirements for telecommunications equipment. These requirements were based on European Telecommunications Standardization Institute (ETSI) documents, the organization responsible for publishing European Telecommunication Standards (ETS). Still, individual countries may have had their own deviations from the ETS standards, or adopted unique standards other than international standards. When the EU introduced harmonization of electromagnetic compatibility (EMC) requirements via the EMC Directive in 1996, central office equipment was not fully covered by the harmonized standards. The ETSI standards included requirements for EMC testing, but the standards were not adopted or published in the official journal. In 1998, the EU voted to accept EN 300 386-2: 1997, which is based on ETS 300 386-2, and published it in the official journal. Prior to this, equipment sold to telecommunication centers in Europe was tested to the generic immunity standard for light industrial equipment as defined in EN 50082-1.

This article focuses on the requirements of GR-1089-CORE, Section 2 and Section 3, and the equivalent requirements covered in EN 300 386-2. Other sections included in GR 1089-CORE and EN 300 386-2–*Lightning Surge, AC Power Fault, Steady-State Power Induction, Electrical Safety Corrosion, and Bonding and Grounding*–will not be covered in this article. It should be noted that both the U.S. and European telecommunications operating companies also require environmental testing for telecommunications equipment to ensure that the materials which make up the product and subcomponents and other physical characteristics of the equipment continue to operate during

*See advertisement on page 3

extreme environmental conditions. Environmental requirements are covered in BELLCORE GR-63-CORE, in the United States, and ETS 019 in Europe.

ELECTROSTATIC DISCHARGE

Electrostatic Discharge (ESD) is one of the most common electromagnetic events affecting telecommunications equipment today. ESD is caused by electrical differentials on positive and negative ions between equipment and/or people. ESD is especially harmful to equipment with digital circuitry. Not only can such induced voltages be damaging, but also the resulting electromagnetic fields generated as a result of the discharge can interfere with today's high-speed circuitry. Potential voltage buildups in excess of 15 kV, ESD can easily interrupt software operations, communications or physically damage electronic equipment. Both GR-1089-CORE and EN 300 386-2 address the issue of ESD. However, both standards define the application points and discharge potentials quite differently.

GR-1089-CORE requirements are based on humidity studies conducted throughout the United States. Humidity is the largest cause of electrostatic buildup. These studies found discharge potentials of up to 8 kV with respect to contact discharges in the United States, and up to 15 kV in discharges through the air.

GR-1089-CORE includes multiple levels of ESD requirements. The first level pertains to normal operation. The term "normal operation" is used to define locations on a product, whether on a shelf unit or an entire rack of equipment, where personnel would have access during everyday operation. These locations include, but are not limited to, the cabinet, any accessible switches, light-emitting diodes (LED), handles and covers over the product, if available.

The second level defines ESD requirements for installation and repair. "Installation and repair" are defined as points accessible to service personnel during the installation or repair process. These points include circuit packs, fuse handles or holders, shells of DB-type connectors, and other connectors located on the product. One general rule of practice is to not discharge the pins on the connectors since they are not typically accessible during normal operation conditions.

The levels established by GR-1089-CORE are shown in Table 1. These levels are tested for both normal operation, and installation and repair locations. For normal operation locations, the system or equipment under test (EUT) shall continue to operate as intended. This test assures the RBOC that units installed in central offices will not fail or lose calls in case of an ESD event. When testing installation and repair points, the system or EUT may degrade from its intended use, but the objective is for the system or unit to continue operating as intended. If degradation in performance should occur during installation and repair point tests, the manufacturer must provide warning labels, as well as specific installation and repair instructions to alert service technicians that the system or unit could sustain damage if proper precautions are not taken.

Discharge Point	Discharge Type	Discharge Level
Normal Operation	Contact	± 8 kV
Normal Operation	Air	± 4 kV and ± 15 kV
Installation and Repair	Contact	± 8 kV
Installation and Repair	Air	± 4 kV and ± 15 kV

Table 1. GR-1089-CORE ESD requirements.

Should systems or units fail to perform during installation and repair discharges, then thresholds must be developed alerting the RBOC of any potential problems in the central office if conditions degrade to a point where ESD events can occur. This allows the RBOC to enforce the need for proper grounding and ESD protection.

In Europe, ESD requirements are quite different. First, unlike GR-1089-CORE, which requires all equipment to meet the levels shown in Table 1, EN 300 386-2 subdivides equipment into two categories. The first category encompasses equipment that is only to be installed in telecommunication centers. The second category covers equipment that is installed in locations other than telecommunication centers, such as Internet service provider equipment. The distinction between the two categories takes into account the conditions of both locations. Telecommunication centers are typically areas which are temperature- and humidity-controlled, whereas other locations may be subjected to a wide range of temperatures and humidity conditions.

The requirements for these locations are shown in Table 2. The levels illustrated are to be applied to all locations. The European standard does not distinguish normal operation from installation/repair locations. The system or EUT is expected to operate at all levels and locations as intended throughout the test. Although there is no distinction between normal operation and installation/repair, EN 300 386-2 does address resistibility to severe ESD events. These values, also shown in Table 2, are aligned with the levels required by the European standard's U.S. counterpart, GR-1089-CORE. Resistibility is defined as "withstanding the test without damage or other disturbances (such as corruption of software or misoperation of fault protection facilities) and shall

Discharge Point	Equipment Location	Discharge Type	Discharge Level
Any	Telecommunication Center	Contact	± 4 kV
Any	Telecommunication Center	Air	± 4 kV
Any	Other than Telecommunication Center	Contact	± 6 kV
Any	Other than Telecommunication Center	Air	± 8 kV
Any	Resistibility (Both Locations)	Contact	± 8 kV
Any	Resistibility (Both Locations)	Air	± 15 kV

Table 2. EN 300 386-2 ESD requirements.

operate properly within the specified limits after the transient electromagnetic phenomenon has ceased. (It is not necessary for the system or EUT to operate properly while the test condition is present.) The exposure may cause the operation of fuses or other specified devices [which have] to be reset or replaced before normal operation is restored." [EN 300 306-2: 1997]

EMISSIONS

Radio frequency (RF) noise is a result of wave propagation from block circuits within electronic circuitry. Emissions transmitted through free space are known as radiated emissions. Conducted emissions occur when products emit RF noise over mains power lines and system input/output (I/O) lines. These emissions are known to interfere with radio stations, emergency broadcast systems, and other nearby equipment.

RADIATED EMISSIONS

GR-1089-CORE addresses not only the frequency range of emissions, but also considers the probability of emissions produced when a door or multiple doors on equipment are opened. GR-1089-CORE and the Federal Communication Commission (FCC) Code of Federal Regulation 47, Part 15, both define equipment tested for radiated emissions in two classes, Class A–commercial, and Class B–residential.

The U.S. standard requires that emissions generated by products meet limitations ranging from 60 Hz and 10 GHz. Products are inspected for magnetic emissions from 60 Hz to 10 kHz (H field). Both the magnetic fields and the electric fields (E fields) are investigated in products meeting limitations ranging from 10 kHz to 30 MHz. E fields are also investigated up to 10 GHz.

Testing for the radiated emission limits included in GR-1089-CORE can be a lengthy process. To make radiated emission testing more time-efficient, the standard allows some worst-case scenario testing representing a gamut of test requirements. For example, GR-1089-CORE contains two sets of radiated emission requirements. The first set requires that the EUT meet radiated emission limitations with its cabinet door open, if applicable. While open-door limitations are quite relaxed for some bandwidths, the EUT must meet a separate set of limitations with its doors closed. From this perspective, it makes for good engineering practice to have tighter limitations with the EUT's doors closed. With this in mind, GR-1089-CORE allows one set of tests to be performed to expedite testing. This test requires the EUT to meet closed-door limitations with its doors opened. Should non-conforming results occur during closed-door limits while the EUT's doors are open, then those frequencies must be compared to open-door limits.

Europe has a different philosophy with respect to frequency ranges and limitations. EN 300 386-2 only defines radiated emissions in the range of 30 MHz to 1000 MHz. Limits are set for normal operation. According to the European standard, if service personnel can open the equipment's doors, it is reasonable to expect that the doors will not be opened indefinitely, and that nearby equipment can tolerate short durations of elevated emissions. However, EN 300 386-2 does require that equipment be tested according to product category. As discussed earlier in the subtopic "Electrostatic Discharge," EN 300 386-2 designates equipment designed for installation as "Telecommunication Center" or "Other Than Telecommunication Center." This distinction determines the limitations of the EUT. However, EN 300 386-2 defines equipment intended to be installed in telecommunication centers (central offices) to meet the Class A limitations, and that all other equipment to meet Class B limitations, as distinguished in the European standard.

Tables 3 through 5, and Figures 1 through 3, illustrate the many differences between the radiated emissions requirements of GR-1089-CORE and EN 300 386-2.

GR-1089-CORE specifies requirements ranging from 60 Hz to 30 MHz for magnetic field emissions. The limits are defined as:

$$H = E - 51.5$$

where

H = Magnetic field strength in dBmA/m

E = Electric field requirements in dBmV/m as defined in Figures 1 and 2

European emissions requirements do not address magnetic field strengths for telecommunications equipment at this time.

continued on page 65

 EN 300 386-2: 1997 or Bellcore GR-1089-CORE ... *continued from page 17*

Frequency (MHz)	Field Strength (dBµ V/m)	
	Class A	Class B
0.01 - 0.024	148.6 - 60 $\log_{10}$d	148.6 - 60 $\log_{10}$d
0.024 - 0.8	116.2 - 60 $\log_{10}$d - 20 $\log_{10}$f	116.2 - 60 $\log_{10}$d - 20 $\log_{10}$f
0.8 - 1.59	118.2 - 60 $\log_{10}$d	118.2 - 60 $\log_{10}$d
1.59 - (x*/d)	126.2 - 60 $\log_{10}$d - 40 $\log_{10}$f	126.2 - 60 $\log_{10}$d - 40 $\log_{10}$f
(x*/d) - 88	59.1 - 20 $\log_{10}$d	49.5 - 20 $\log_{10}$d
88 - 216	63.5 - 20 $\log_{10}$d	53.0 - 20 $\log_{10}$d
216 - 960	66.4 - 20 $\log_{10}$d	55.5 - 20 $\log_{10}$d
960 - 10000	69.5 - 20 $\log_{10}$d	63.5 - 20 $\log_{10}$d

Table 3. EN 300 386-2. Doors closed limits (E fields).[1]

Frequency (MHz)	Field Strength (dBµ V/m)
0.01 - 0.024	148.6 - 60 $\log_{10}$d
0.024 - 0.8	116.2 - 60 $\log_{10}$d - 20 $\log_{10}$f
0.8 - 1.59	118.2 - 60 $\log_{10}$d
1.59 - 3.11	126.2 - 60 $\log_{10}$d - 40 $\log_{10}$f
3.11 - 47.7/d	106.5 - 60 $\log_{10}$d
47.7/d - 47.7	39.4 - 20 $\log_{10}$d + 40 $\log_{10}$f
47.7 - 10000	106.5 - 20 $\log_{10}$d

Table 4. Bellcore GR-1089-Core.[1] Doors closed limits (E fields).

Frequency (MHz)	Class A Field Strength (dBµ V/m)	Class B Field Strength (dBµ V/m)
30 - 230	40	30
230 - 1000	47	37

Table 5. EN 300 386-2 limits for radiated emissions.[5]

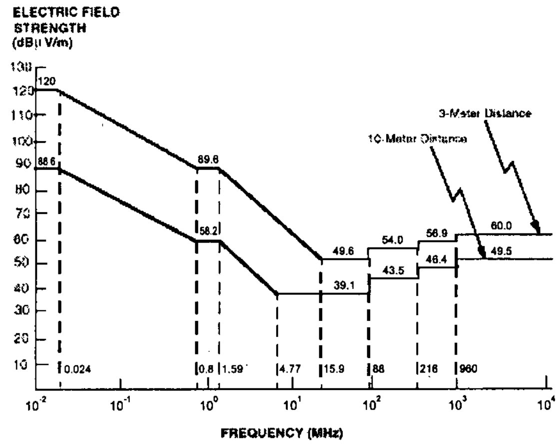


Figure 1. EN 300 386-2. Graphical representation of doors closed limits (E fields).[1]

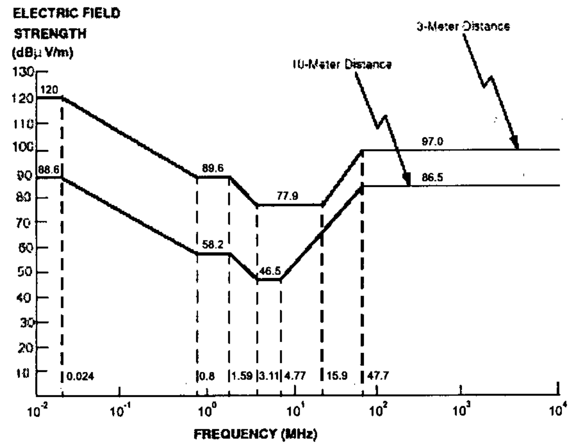


Figure 2. Bellcore GR-1089-Core. Graphical representation of doors closed limits (E fields).[1]

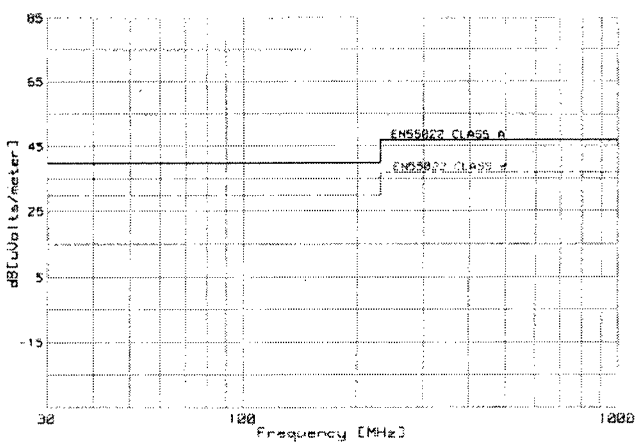


Figure 3. Graphical representation of EN 300 386-2 limits for radiated emissions.[5]

CONDUCTED EMISSIONS

While radiated emissions measure the amount of RF energy emitted by a device through free space, conducted emissions measure RF energy conducted over AC and DC mains, as well as I/O lines. In today's world of rapidly expanding technology and increasing clock speeds, it is more likely that problems occurring over I/O lines are found in the hundreds of megahertz. But some components are still working on low-frequency (e.g., kilohertz and megahertz) clock speeds, as well as switching power supplies that typically operate in the kilohertz range. Therefore, the propagation of electromagnetic noise is measured on mains power lines and I/O lines. I/O lines can encompass telecommunications ports (both digital and analog), computer peripheral lines (RS232, Centronics Parallel, etc.), Ethernet, and others.

Two techniques are used to measure AC mains power conducted emissions. The first method uses a

Frequency (MHz)	Maximum Radio-Frequency Line Voltage			
	Class A		Class B	
	(μV)	(dBμV)	(μV)	(dBμV)
0.45 - 1.705	1000	60.0	250	47.9
1.705 - 30	3000	69.5	250	47.9

Table 6. Conducted voltage limitations for AC mains.[1]

Frequency (MHz)	Maximum Line Current (dBμ A)
0.01 - 0.27	79
0.27 - 0.8	$67.6 - 20 \log_{10} f$
0.8 - 30	69.5

Table 7. Conducted current emissions for mains and I/O lines.[1]

50 mH/50 ohm Line Impedance Stabilization Network (LISN) to measure the conducted voltage. The LISN measures the RF energy conducted back on to the AC mains. The second method uses a current probe to measure RF energy conducted in terms of current. For I/O lines, the current probe method measures the

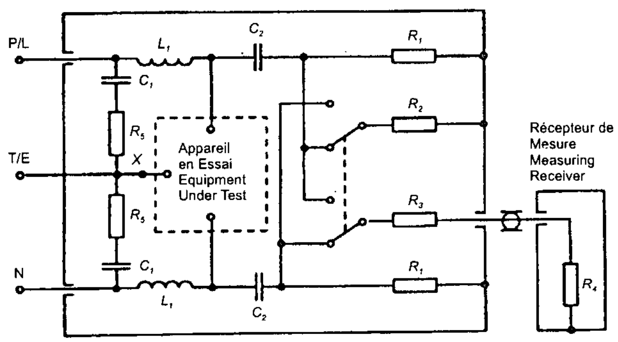


Figure 4. Line impedance stabilization network (LISN) schematic.[2]

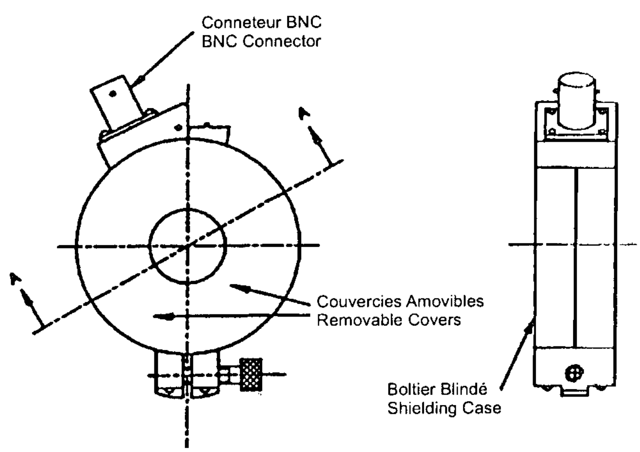


Figure 5. Current emissions clamp.[2]

Center Frequency (f) of 8-kHz Bands (kHz)	Maximum Voltage in All 8-kHz Bands (dBV)	Terminating Impedance	
		Metallic (Ohms)	Longitudinal (Ohms)
8 - 12	$-(6.4 + 12.6 \log_{10} f)$	300	500
12 - 90	$-(23 - 40 \log_{10} f)$	135	90
90 - 270	- 55	135	90
270 - 6000	- 15	135	90

Table 8. Conducted analog voice band leads limitations for metallic voltages.[1]

Center Frequency (f) of 8-kHz Bands (kHz)	Maximum Voltage in All 8-kHz Bands (dBV)	Terminating Impedance	
		Metallic (Ohms)	Longitudinal (Ohms)
8 - 12	$-(18.4 + 20 \log_{10} f)$	300	500
12 - 42	$-(3 - 40 \log_{10} f)$	135	90
42 - 270	- 62	135	90
270 - 6000	- 30	135	90

Table 9. Conducted analog voice band leads limitations for longitudinal voltages.[1]

amount of emissions emitting from cabling connected to the EUT. This is a non-intrusive means of measuring EMI from I/O lines, as well as emissions generated from DC mains. Both measure the common mode voltage from the product. This means all emissions are measured with respect to earth ground. (See Figure 4 illustrating the schematic for a LISN, and Table 5 for a schematic of a current probe. Refer to Table 6 for conducted voltage limitations for AC mains, and to Table 7 for conducted current emissions for mains and I/O lines.)

Frequency (MHz)	Limits dB (μV)	
	Quasi-peak	Average
0.15 - 0.50	79	66
0.50 - 30	73	60

Table 10. Telecommunication centers (EN 300 386-2).[5]

Frequency (MHz)	Limits dB (μV)	
	Quasi-peak	Average
0.15 - 0.50	66 - 56	56 - 46
0.50 - 5	56	46
5 - 30	60	50

Table 11. Other than telecommunication centers (EN 300 386-2).[5]

GR-1089-CORE uses both methods described here and requires all mains, including AC and DC, as well as all I/O lines, to meet requirements as defined in the standard.

Another requirement defined in GR-1089-CORE is *Conducted Emissions from Analog Voiceband Leads*. These requirements are similar to those included in FCC Part 68, and are only applied to Plain Old Telephone Service (POTS). Analog voiceband leads include both metallic and longitudinal requirements, which measure the amount of signal power transmitted over the POTS lines to ensure that the network is not harmed by excessive signal power. Tables 8 and 9 illustrate the conducted analog voiceband leads limitations for metallic and longitudinal voltages.

EN 300 386-2 covers conducted emissions from AC and DC mains, but does not yet address I/O lines. AC mains are tested at ranges from 150 kHz to 30 MHz. DC mains are tested at ranges of 20 kHz to 30 MHz. Typically, the LISN 50 mH/50 ohm is used to measure conducted emissions from devices. In such cases, within the range of 20 kHz to 30 MHz, the LISN also includes a series of 5-ohm resistors (50 mH/ 50 ohm + 5 ohms). This allows the necessary line impedance matching at these frequencies. Tables 10 and 11 highlight the limitations of AC mains conducted emissions for telecommunication centers, and equipment intended for installation in locations other than telecommunication centers. For DC ports, the limits highlighted in Table 10 are applied, with the exception of the 20 Hz to 150 kHzm ranges in which limits are expressed in quasi-peak measurements with a value of 79 dBmV throughout this range.

IMMUNITY

Immunity is defined by a product's ability to resist and operate in an electromagnetic environment. When a product is designed, it is not only designed for limited emissions, but also to reject or keep out electromagnetic fields generated from nearby equipment.

Radiated Immunity

GR-1089-CORE requires that products demonstrate immunity to RF fields ranging from 10 kHz to 10 GHz. The standard specifies that equipment meet two sets of requirements including the aforementioned RF field ranges, and conditional requirements, such as when a local exchange carrier identifies application environments exceeding the nominal tested values. As with radiated emissions testing, there are also objectives in testing for radiated immunity.

Equipment tested to GR-1089-CORE requires that equipment operate without interruption throughout the test when tested to a 2 V/m field. This field is modulated with 1 kHz 80-percent amplitude modulation from 10 kHz to 1 GHz. From 1 GHz to 10 GHz, the field is 50-percent pulse modulated. These tests are performed with cabinet doors both opened and closed. The conditional requirement specifies that testing be performed at 8.5 V/m with the same modulation scenarios. The objective is for equipment to operate as intended throughout the test with the cabinet doors left open, if applicable. If this cannot be achieved, thresholds are developed with and without the doors opened.

Radiated immunity is tested in a uniform field environment in accordance with IEC 1000-4-3. Anechoic chambers used for radiated immunity testing must be pre-calibrated to achieve a 75-percent confidence rate that the room is delivering a desirable field between 0 dB and + 6 dB (See Figure 6 for details of field uniformity.)

Like its U.S. counterpart, EN 300 386-2 also requires that equipment

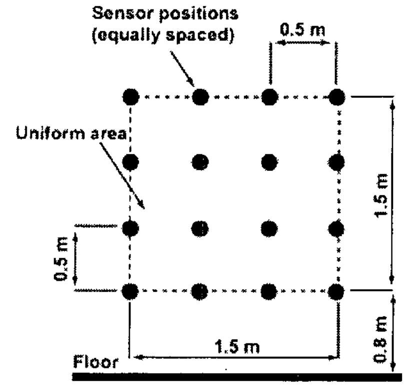


Figure 6. Field uniformity.[3]

be subjected to radiated immunity testing to meet the same uniform field requirements defined in the standard. The major difference between the U.S. and European standards, is that EN 300 386-2 only requires testing between 80 MHz and 1 GHz, with the field strength of 3 V/m employing the same 1 kHz, 80-percent amplitude modulation within this particular range. There are no objectives or conditional requirements, and, in accordance with radiated immunity requirements of EN 300 386-2, products are tested with doors in their normal operating position (e.g., closed).

Conducted Immunity

As conducted emissions are distributed over mains lines and I/O lines, conducted immunity tests determine how power supplies, electronic circuitry and cabling connected to the device resist common mode electromagnetic energy.

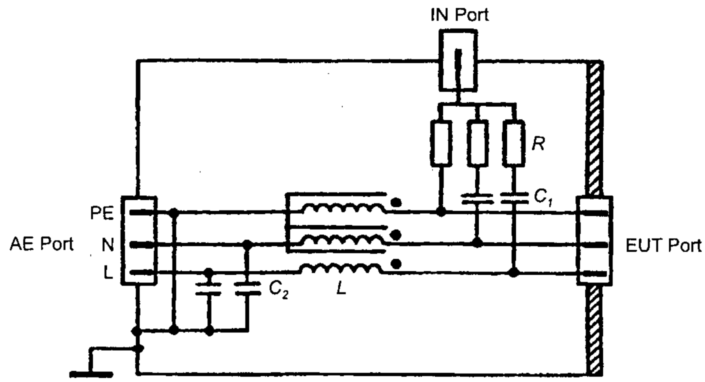
GR-1089-CORE specifies that products demonstrate immunity to this phenomenon in ranges of 10 kHz to 30 MHz. Equipment must operate as intended throughout the entire frequency range. There are no objectives or conditional requirements covered by this portion of the standard. Conducted immunity requirements in GR-1089-CORE are highlighted in Table 12.

All conducted immunity tests are

performed with a current clamp that injects RF energy onto the mains and I/O lines. As with radiated immunity, levels induced on the lines are modulated by 1 kHz, 80-percent amplitude modulation. The test methodology defined in the standard is equivalent to the bulk current injection method and calibration specified in IEC 1000-4-6.

In Europe, conducted immunity test methods are relatively the same with the exception of the frequency range, mains injection method, and the levels injected on to both the mains and I/O lines.

EN 300 386-2 defines a frequency range of 150 kHz to 30 MHz. For mains power lines, a coupling/decoupling network is used to capacitively inject RF voltages on to the power lines. (See Figure 7). The same common-mode injection techniques included in GR-1089-CORE are used for testing I/O lines. Again, both the mains and I/O lines are tested using methodology specified in IEC 1000-4-6. Levels for this range and for both injection methodologies are 3 V, applying the same 1 kHz 80-percent amplitude modulation.



Note: CDN-M3, C_1 (typ) = 10 nF, C_2 (typ) = 47 nF, R = 300 Ω, $L \geq 280$ µH at 150 kHz.
CDN-M2, C_1 (typ) = 10 nF, C_2 (typ) = 47 nF, R = 200 Ω, $L \geq 280$ µH at 150 kHz.
CDN-M1, C_1 (typ) = 22 nF, C_2 (typ) = 47 nF, R = 100 Ω, $L \geq 280$ µH at 150 kHz.

Figure 7. Coupling/decoupling network.[4]

CONCLUSION

Although there are many differences in the ranges of tests performed to GR-1089-CORE and EN 300-38-2, it must be noted that both the Regional Bell Operating Companies in the United States and telecommunication centers in Europe take great care in verifying the equipment purchased and placed in service for public and emergency communications. These requirements place restrictions on products to ensure that if unexpected electromagnetic phenomena were to occur, the equipment carrying telephony service can be maintained. This is especially true for the emergency communications systems such as E911. It is imperative that the equipment supporting these services operates without interference, as well as under extreme environmental conditions.

Frequency (MHz)	Test Level (Volts)
10 kHz - 270 kHz	1.4
270 kHz - 800 kHz	1.4 - 0.472 (decrease with the log of frequency)
800 kHz - 30 MHz	0.472

Table 12. Conducted Immunity GR-1089-CORE 1.[1]

ROBERT DELISI is an engineering group leader at one of Underwriters Laboratories Inc.'s six full-service EMC facilities in the United States. Joining UL in 1989, Mr. DeLisi has since advanced from engineering assistant to Engineering Group Leader. Currently, he is involved in EMC testing operations, as well as such varied activities as SAR testing of wireless devices, testing to FCC Part 68, and evaluations of connecting hardware in accordance with TIA-568-A. He also coordinates the implementation of new equipment and software, staff training, and maintains laboratory operations and regulatory accreditations.

Mr. DeLisi was instrumental in the construction of UL's new EMC facility in Melville, NY, which includes a 10-meter semi-anechoic chamber, one of four maintained by UL for commercial EMC testing in North America. He has served on various task groups for TIA/EIA (Telecommunications Industry Association/Electronic Industry Association) TR41.8.1 and is a member of the ANSI C63.4 Subcommittee 8 Group. Mr. DeLisi holds a bachelor's degree in Electrical Engineering Technology from the State University of New York in Farmingdale, NY.

REFERENCES

1. Generic Requirements GR-1089-CORE Issue 2, December 1997 with Revision 1, February 1999, "Electromagnetic Compatibility and Electrical Safety – Generic Criteria for Network Telecommunications Equipment."
2. CISPR 16-1 First edition: 1993-08, "Specifications for Radio Disturbance and Immunity Measuring Apparatus and Methods. Part 1: Radio Disturbance and Immunity Measuring Apparatus."
3. BS EN 61000-4-3: 1997, "Electromagnetic Compatibility (EMC). Part 3: Testing and Measurement Techniques. Section 4: Radiated, Radio-frequency Electromagnetic Field Immunity Test."
4. BS EN 61000-4-6: 1996 Incorporating Amendment No. 1, "Electromagnetic Compatibility (EMC). Part 4: Testing and Measurement Techniques. Section 6. Immunity to Conducted Disturbances, Induced by Radio-frequency Fields."
5. ETS EN 300 386-2, V1.1.3(1997-12), "Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Telecommunication Network Equipment ElectroMagnetic Compatibility (EMC) Requirements. Part 2: Product Family Standard" □