1

INTRODUCTION

1.1 INTRODUCTION

This book presents a vast number of areas of industry beside transportation. Transportation is one of the harshest environments for communications. Electromagnetic compatibility (EMC) is in most of the industrialized world today. As computer and other electronic components get smaller, the need for EMC analysis and testing becomes more acute. Systems are generally designed and built with components that meet or exceed requirements for emissions. However, a piece of equipment may pick up extraneous noise from emissions through a host of poor practices in grounding and wiring.

The engineer designing system components must be vigilant during the design phase to check for emissions during prototyping, production and final design phases. The closer to final product the component gets, the more expensive becomes the correction in design. As an example, a circuit board design with a poor layout can be very costly in the final stage of design. While doing consulting work, the author was asked to help a particular manufacturer get a production board into production. The board had so many defects that the FCC sent a notice the equipment could not be connected to telephone lines. The solution was not very simple. The designer did not have the correct isolation transformer and the output and input lines were not separated sufficiently to maintain the isolation. There were many other problems with the design but the point is the printed circuit (PC) board had to be redesigned and several optical isolators added to complete the design.

The case studies are the result of several analyses required to satisfy the various State Authority Requirements. More often, the testing is part of the overhaul testing of the final systems during commissioning of a transportation system. The analysis brings to light some of the EMC issues that may arise. Often the specification sheets

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for system components such as amplifiers, radios signals equipment and so on will have certain minimum Immunity Requirements that the system component must operate under with no effect in performance.

1.2 DEFINITIONS OF COMMONLY USED TERMS

Electromagnetic Compatibility (EMC) This is the ability of equipment, systems or devices to operate without deficiencies in performance in an electromagnetic environment. The system, equipment or device must also be non-polluting to the electromagnetic environment, that is it must not have emissions (both radiated and conducted) that affect other systems, equipment or devices. The electromagnetic environment is composed of both radiated and conducted emissions.

Susceptibility This is the ability of a system, equipment or device to respond to electromagnetic emissions interference. The emissions may be either radiated, conducted or both. Susceptibility is noise that affects the performance of system, equipment or device.

Immunity The ability of equipment to operate with the required performance in the presence of electromagnetic interference noise.

Electromagnetic Interference (EMI) Electromagnetic Interference (EMI) is noise due to electromagnetic energy through emissions, either radiated, conducted or both. This does not include distortion due to non-linearities in the system, equipment or device.

Radio Frequency Interference (RFI) This is radiation due to intentional and unintentional radiators. The limits are shown in the tables presented in the sections on standards.

Culprit This is the source of the emissions that result in a reduction in performance of the victim equipment, device, circuit or system. The culprit can be manmade or extraneous signals from galactic noise.

Victim This is the device, equipment, circuit or system that is affected by the culprit. It depends on the coupling from the culprit. Coupling can be due to electric fields, magnetic fields, poor grounds, lack of proper supply filtering or combinations of these.

Supervisory Control and Data Acquisition (SCADA) System This system monitors and controls complex equipment. It automates the complex system with control and monitor functions at an operation central control (OCC) room. A simplified version of the control room is shown in Figure 1.1. The project configuration is a large display the size of a wall in the OCC, that is 9 × 14 feet. The display shown in

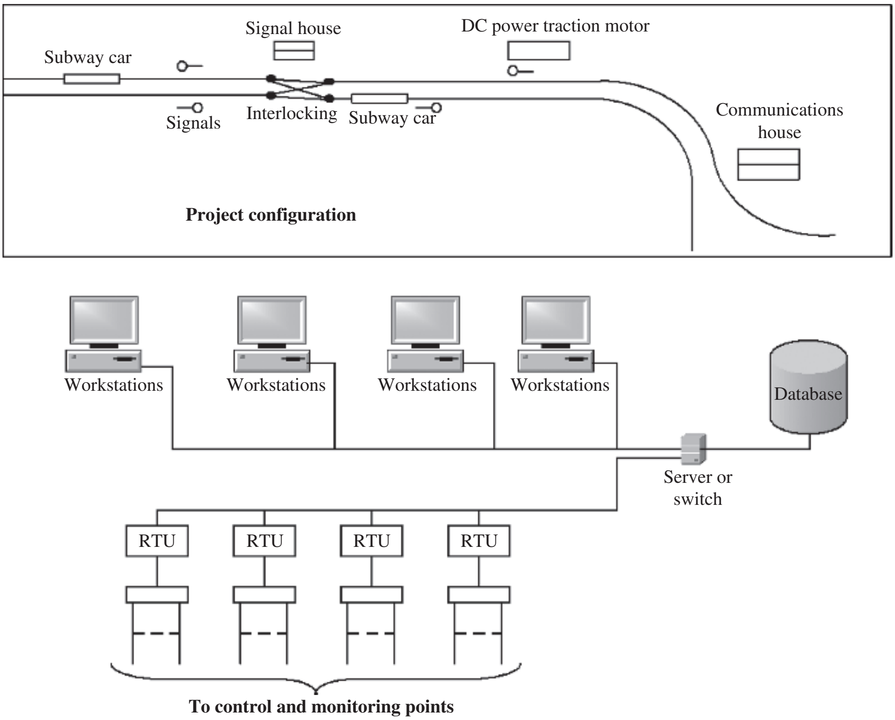

FIGURE 1.1 Operation control center simplified wall project display and workstation layout

the figure is only an example of what might be shown on the actual display. It may have as many as 15 or 20 interlockingss and signal houses and 10–12 communication houses in many miles of track, all displayed on this one board in symbolic form. It is the whole subway or bus system that is displayed. It may also have highway crossings shown with crossing gates and warning lights. The signals shown are positioned along the rails showing the direction of the traffic flow. The DC power supply houses for traction motors are shown. There may be many of these also depending on the project size. In the actual display the subway cars are shown moving in various directions and the display may indicate flow against the signals traffic. This is controlled from the OCC.

The workstations are arranged connected to a central server. Generally two servers are connected in tandem (one is a backup for the other). The primary runs the functions and the secondary shadows the primary. In the event of a failure an automatic switch over to the secondary occurs so that the service is restored; this provides a failsafe operation. Each of the workstations generally has the same software but some are dedicated to maintenance personnel, others are traffic control and one is dedicated for managerial functions. They all have logon passwords and the managerial station may have a lock to prevent tampering, with further identification functions so that only personnel with the correct credentials can use the workstation.

A large database holds information in the archives that are used later for statistical purposes and record the maintenance functions that have been performed on the equipment in the field. The network connects the workstations to the server and this is all done with fiber optics. The connections between the server and/or switch and the remote terminal units (RTUs) have a fiber optic self-healing ring with a SONET unit that connects several RTUs to a single node on the network. As can be observed, Figure 1.1 is a very simplified version of the communications between the control and monitor of devices. More details on the communications network are shown in Chapter 2 under the heading communications.

All OCCs have a backup control room, not in the same building. In the event of a catastrophe these control rooms are smaller and will not have all the functionality of the major control room. They have enough functionality to keep the subway or bus system functional if the main control room is damaged or destroyed. The backup control room will have a limited number of workstations, usually about half the number of the main control room. It will have an alternate site server/switch with the backup function of the main control room. As can be observed, signals carry the signal house data via RS 232 or RS 422 fiber optic connections to the communication house to be transported to the OCC for updating the project configuration screen. Occasionally in large systems a heartbeat is required from each RTU to determine if data is there and needs to be transported to the OCC. The heartbeat is a polling method for the RTUs. Some systems have interrupts instead of the heartbeat; this is all embedded in the software at the server/switch. The reason for designating a server/switch is some systems are small and only require servers; others are very large and require a switch and server.

Remote Terminal Unit (RTU) These units interface to objects and equipment that either monitor or control pieces of equipment such as radio systems, PA systems on platforms, visual displays on platforms, ticket collection, pumps, ventilating fans in tunnels, fire and intrusion alarm systems, power for communications and traction power supplies. This unit is also equipped with a programmable logic controller (PLC).

Programmable Logic Controller (PLC) These controllers are used for signals. They monitor and control interlockings and signage along the right of way, monitor headway between subway trains switch and control block information and other functions that are necessary for signaling.

The Communications Network The simplified workstations shown in Figure 1.1 have more than one display, usually from three to four depending on the size of the project. The reason being that dispatchers can magnify a part of the network shown on the display board for use on his/her part of the rail system. The dispatcher also has a two-way radio to be used to communicate directly with the motorman and conductor on the subway. In the event of a complete failure of the network, the dispatcher can keep in touch with the motorman and conductor via the radio system. Sometimes both radio and network are used simultaneously, depending on the traffic on the system, that is during rush hours or emergencies.

Synchronous Optical Networking (SONET) The SONET network is composed of two counter-rotating rings, as shown in Figure 1.2. The rings carry data in both directions simultaneously. This particular network has a total of 25 nodes. The head end nodes are connected to the primary OCC and backup OCC or as shown in the diagram. If a break should occur in the cable or if a node is damaged it may be removed from service and a single ring will exist that supports the other 24 nodes. Automatic switching occurs within SONET nodes that allows self-healing of the ring. If two nodes are damaged and taken out of service the ring will form two islands, that is two separate single ring nodes. Most of the newer installations have high-speed rings, for example OC-768 or the equivalent STM-256 have a transmission rate of 38.5 Gbits/s. The base rates of OC-1 and STM-1 are 51.84 and 155.52 Mbits/s respectively. All of the others are integer numbers of these base rates. All of the data from the various houses and cabinets are transported by the SONET nodes to the OCC and backup OCC. The nodes arrange all data in a digital form and arrange it in frames to perform a seamless transmission network. The bandwidth used by most authorities is much greater than necessary in most cases; they plan for large expansions that occasionally never come. Occasionally another ring is added in a gateway or a switch is used to produce a much larger ring topology.

The RTU connections are all bidirectional. They may either have fiber optic modems or be wired with copper cabling. A listing of the network functions is shown in Table 1.1.

As can be observed in Table 1.1, the communications system is not only for voice and data. It is used for command and control of the entire subway system. As a

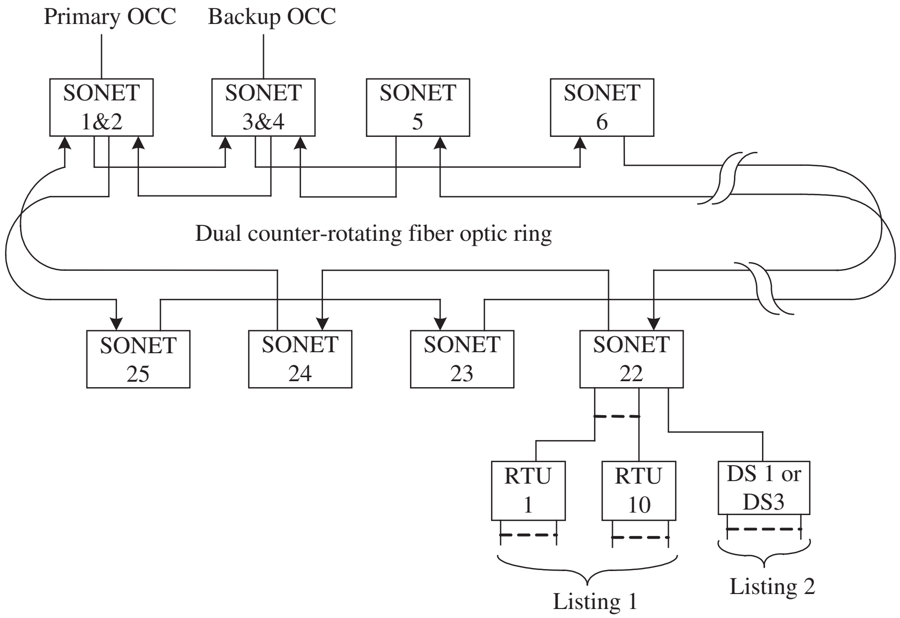

FIGURE 1.2 Network to connect all RTUs to the OCC

TABLE 1.1 Functions of Equipment in Houses, Bungalows, Cabinets and Stations Along the Right of Way

Equipment	List 1	List 2
Station platform RTUs	PLC and SCADA equipment	Telephone services
	Station communications	Emergency telephone
	Security alarms	Police Department emergency line
	Fire alarms	Fire Department direct line
	PA system control	Fare collection
	Camera monitoring	
	Parking lots camera monitoring	
	Camera control	
	Communication outage	
Communication house RTUs	AC power to the house	Telephone and extension service
	Fire alarm and suppression such as Halon gas	Fire Department direct line
	Security alarm	
	Communication outage	
	Battery monitor for Uninterrupted Power Supply (UPS)	
	UPS monitor and control	
	Emergency panel switch over	
	Smoke alarms	
	Heat alarms	
	Backup portable generator for longtime outage	
	Ventilator fan control	
Data from signal houses	Data is from vital and non-vital logic	Signal house telephone and extension
Tunnel data	Monitor and control of several vent fans in tunnels	
	Damper monitor and control in tunnels	
	Sump pump and water levels and controls in tunnels	
	Carbon monoxide level monitors in tunnels	
	Fire and smoke alarms in tunnels	

(Continued)

TABLE 1.1 (Continued)

Equipment	List 1	List 2
	Stations in tunnels of monitor and control similar to his above ground stations	
	More attention is communications houses built into tunnels i.e. extra security measures	
Data from traction power houses	Data points for control and monitoring are regulated by the DC power contractor.	Traction power house telephone and extension
Cabinets on the right of way	Signals equipment monitoring and control	Telephone service
	Audio equipment monitor and control	
	Parking lot displays control	
	SCADA equipment to monitor and control all cabinet equipment may/may not have a local RTU in the cabinet	

backup for the dispatcher, all of the subsystems have a backup by some means so that failure is always circumvented by a backup of some means. Most AC power is provided by multiple substations in the event of AC power failure. EMC is a very important aspect of the communication systems because all data is stored at the OCC and backup OCC. This is required to analyze failures using all this data to determine cause, affect and the necessary maintenance to prevent future failures. Since most of the internal wiring of a station's electronic enclosures are wired in copper, EMI emissions are always present but at a very low level if precautions are taken during the design and installation of the various pieces of equipment.

The SCADA system is similar to the nervous system of a human body. It monitors the health of a particular subsystem such as the PA system and it makes corrections or circumvents a failure. The data is all sent to the OCC that functions similar to the brain of the system. The SCADA system has analog inputs that monitor such items as radio signal strength with a set-point that will result in an alarm if the signal strength drops below a certain level or the noise level is excessive. It also monitors temperature but is also an analog function with set-points that will send an alarm to the OCC if the temperature cannot be controlled, such as air conditioning or heating system failure.

RTUs, vital logic and non-vital logic for signals all have the latter logic embedded when programmed. They use relay contacts similar to the old-style relay logic used in older installations. This relay logic is not physical; it is all done in the software and the design engineer uses the logic as it would be employed for physical relays. The software in this equipment pre-processes the data points and a series of digital coded words are sent to the OCC indicating the health of the particular area being monitored, such as station platforms, communication cabinets along the right of way, signal house data, traction power supply and mechanical maintenance data from tunnels.

The OCC and backup OCC each has two SONET terminals. This allows them each to monitor the network in both directions. A complete failure of either of these SONET nodes will allow control by the surviving node. The RTUs implement a host of other monitor and control functions, such as grounds maintenance around the buildings and in shop areas where maintenance is being performed on subway cars. Building functions such as such as fire alarms, security systems, card swipe units, interlocking doors, cameras and camera controls are all monitored and controlled in the central control room.

Security is very strict in these OCC areas. Everyone must wear a swipe edge badge with a picture. For obvious reasons it is an ideal place for vandals or terrorists to do damage and bring down the subway system. Even some office space is highly restricted, such as where the database computers or the telephone system are kept. In some office spaces some canned messages are produced to send out both with audio and video information to PA systems and display units and stations. These of course cannot be compromised to show unauthorized messages that may even cause panic at stations; this is especially true in tunnels.

Elevators at the OCC are monitored by cameras and the data is sent back to a security workstation which is equipped with several displays, including those for stations. The operator at any time can control the camera to look at a particular event and report his findings, for example vandalism on the platform or assaults. The same holds true in tunnels where accidents may be observed and recorded and saved in the event of litigation. In this section the author has provided the reader with a good overview of how the communication system functions. This allows the reader to understand where all the EMC issues may occur.

1.3 BOOK SECTIONS AND CONTENT OVERVIEW

This book is divided into five sections. The first is introduction and standards; this includes FCC, CSA and European Union standards. Some of the testing techniques are also presented to introduce the reader to facilities that will be necessary to conduct the testing. The techniques for testing are not cast in stone. Standards are living documents that must be checked before designing systems, equipment or devices. Usually the changes are minor but these subtle differences may result in costly fixes later.

The second section is devoted to the coupling between victim and culprit circuits or equipment in general. These fundamentals are used throughout the book. It may be a refresher to some readers; however, the presentation makes the book easer to read.

The third section of the book is a discussion of Maxwell's equations and the wave equations and solutions that will be used throughout the case studies. The derivation of the solutions will not be shown in detail. References are provided to assist the reader who desires to observe how the solutions were derived. In some of the case studies a derivation will be provided, but this will be on a case by case basis.

The fourth section of the book is the largest. It involves past experiences of the author; there about 20 case studies in all. These have all been in the transportation industry. They generally deal with communications in a harsh environment. The case studies are rather diverse and can be applied in other industries as well. One such case is: shielding of a communication house due to the rebar embedded in the concrete. This same technique can be used to shield a building. Some structures that may require security can use these techniques for shielding with a little modification required for the windows and vent. The tunnel case study has applications where confined spaces have RF devices used such as cell phones and Bluetooth devices, such as the automotive industry. Radio engineers analyzing antenna farms on buildings can use some of the case studies as a guide. Subway car case studies have wideband transient analysis that can be applied to the steel industry with its overhead cranes, rolling mills, electric furnaces, shears, arc welders and other equipment where arcing may be present.

The aircraft industry engineers may use some of the information provided in this book. Present-day aluminum skin aircraft provide a good ground plane for most electronics. The newer composite aircraft may require more shielding and filtering of electronic equipment. Radiation coupling between suites of equipment can result in a degradation in performance. The transportation, rail and bus systems have similar grounding problems.

Medical facilities with electronic instrumentation engineers can use some of the case studies, such as tunnel applications. Tunnels have leaky coaxial cable to extend communications underground. The same leaky cable can be used in hospitals with microcellular phones.

The fifth section is radiation exposure safety issues for maintenance and public exposure. This will be discussed briefly and tables with exposure limits provided. A particular case is provided in the case studies. This is a case study in a tunnel.

Table 1.2 is a short list of emission sources that can lead to device, equipment and system failure or performance degradation. The first five are radiation sources due to radio transmissions; several are analyzed in the case studies. The primary part is how these sources affect the performance of various equipment and systems. Most of the devices used in transportation will have a fairly good immunity, but equipment and systems have a means of implementing either cabling or wireless communication.

The sixth and 15th sources are due to computer emissions. These are in some cases very difficult to analyze, due to a combination of radiated and conducted emissions. In a particular situation, there were two open racks (one with fiber optic communication equipment, the other with a VHF police radio). The clock for the communication equipment happened to be near the VHF radio band and, when the radio was keyed, the communication link began to drop bits. As computer device clock speeds get higher they also increase their emissions for radio and other wireless communications.

TABLE 1.2 Conduction and Radiation Emission Sources

Item	Description of source	Remarks
1	Radio transmitter broadcasts	AM and FM band radios
2	Communication narrow band radio	Two-way handheld and base station
3	Cell phones	Phones and towers
4	Wireless devices	Low level radiation, mW region
5	Radars	Weather, military and handheld
6	Receiver local oscillators from computers	High frequencies, 1–10 GHz
7	Motors	Brushes and commutation
8	Switches	Arcing
9	Fluorescent lights	Harmonics
10	Light dimmers	Track switches, phase control
11	Diathermy	Track switches, phase control
12	Dielectric heaters	Track switches, phase control
13	Welders	Arcs
14	Subway centenary and hot rail	Arcing
15	Engine ignition	Radiation from spark plug wires
16	Computer peripherals	1–10 GHz switching
17	Lightning	High rise time pulse and energy
18	Galactic noise electrostatic discharge	Space communications
19	Electromagnetic pulse (EMP; nuclear blast)	Not discussed

Sources 8–14 are due to transients. These of course are in some cases very difficult to analyze due to intermittent behavior. A transient will generally need to be analyzed with a storage device unless it is cyclic. However, the random case is usually the type that most often occurs. The case studies have some transient analysis included as part of the analysis.

1.4 REGULATIONS

Regulations are living documents, that is they are continually changing. The designer that is working on a system, equipment or device must look up the regulations to ensure compliance at the time of the design. If there are regulation changes after the design is completed, there is generally a time span before the change takes effect.

1.4.1 United States FCC Regulations

FCC Part 15 radiation regulations are represented in Tables 1.3–1.5. These are radiated emission limits for systems, equipment and devices. These limits are in terms of electric fields (E). The full range of the radiation measurement is from 9 kHz to 3 GHz.

The tables can be found or generated using CFR 47 Regulations Part 15, which has a wealth of information for EMC design. The regulations provide guidance in several areas for obtaining FCC certification.

Some of the tables in this section of the book may not appear to be very useful. However, the various emission tables will provide the EMC practitioner with a lead on where to look for possible culprit sources. For example wireless devices are now very widespread and Table 1.8 provides the frequency range for these devices. When investigating a particular problem that appears to be related to radio, FCC subparts C, D, F and H can be examined if the problem appears to be related to radio communications. Tables are not provided in these sections to prevent the book from being outdated at the time of printing. The frequency spectrum allocation is continually modified by various users.

The remarks column FM 88–108 MHz radio can cause interference for very sensitivity devices. The station power is under very strict licensing; shielding or filtering in most cases will be required.

CB radios have limits but they are sometimes violated when the culprit transmitter has higher gain (“linear amplifiers called foot warmers”) than allowed by FCC rules, or very high gain antennas. Generally the FCC will impose fines for these types of installations.

TABLE 1.3 FCC Emission Limit Regulations Measured at 3 m

Frequency (MHz)	Class B magnitude	Class A magnitude	Remarks
30–88	(28.9 μV/m) 29.5 dBμV/m	(100 μV/m) 40 dBμV/m	FM, CB band
88–216	(44.7 μV/m) 33.0 dBμV/m	(150 μV/m) 43.5 dBμV/m	FM, two way radio
216–960	(59.6 μV/m) 35.5 dBμV/m	(200 μV/m) 46.0 dBμV/m	Two way radio, CellP
>960	(298 μV/m) 49.5 dBμV/m	(500 μV/m) 54.0 dBμV/m	Wireless dev

TABLE 1.4 FCC Emission Limit Regulations 9 KHz To 30 MHz

Frequency	Electric field	Measurement distance (m)	Remarks
9–490 KHz	2400/f μV/m	300	AM L band
490–1705 KHz	2400/f μV/m	30	AM U band
1705 KHz to 30 MHz	30 μV/m	3	Multiple bands

TABLE 1.5 FCC Emission Limit Regulations Measured at 10 m

Frequency (MHz)	Class B magnitude	Class A magnitude	Remarks
30–88	(28.2 μV/m) 29 dBμV/m	(90 μV/m) 39 dBμV/m	FM, CB band
88–216	(47.3 μV/m) 33.5 dBμV/m	(150 μV/m) 43.5 dBμV/m	FM, two way radio
216–960	(59.6 μV/m) 35.5 dBμV/m	(210 μV/m) 46.5 dBμV/m	Two way radio, CellP
>960	(149.6 μV/m) 43.5 dBμV/m	(300 μV/m) 49.5 dBμV/m	Wireless dev

Two-way radios can cause interference due to their mobility. VHF and UHF radios and cell phones are always a source of noise. They are all licensed radiators and must be used prudently to prevent interference problems. As an example, a measurement was taken in a Paris subway station at rush hour. The noise produced by cell phone transmissions produced sufficient noise to disrupt train communications.

The emission limits apply to unintentional radiators the remarks column in Table 1.3 is to remind the audience that intentional radiators can be present. These must be measured, if present, and not be part of the measured emissions. Open air test systems (OATS) are discussed in Section 1.6 *EMC Testing Methods*. All radio signals can enter though grounds, power supplies, radiation (when a product has an extraneous projection acting as an antenna) and induction (where magnetic fields can couple into circuits). Coupling techniques are discussed in Chapter 2 with examples.

Two different distances are provided in the tables, for tests to making comparisons between Classes A and B. The distance of 3 m can easily be extrapolated to 10 m using Equation 1.1. The reason this is possible is the 3 m dipole used to measure 30 MHz is outside the near field limit $2*(\lambda/2)^2/\lambda$ or 2.5 m.

$$\Delta_{10} = 20*\left(1-\log 3\right) = 10.46\,\text{dB} \tag{1.1}$$

FCC part 15 is divided into subparts as follows:

1. A General information
2. B Unintentional radiators
3. C Intentional radiators
4. D Unlicensed personal communication devices
5. E Unlicensed national information infrastructure devices
6. F Ultra wideband operation
7. G Access broadband over power line wideband operation
8. H TV band devices.

Equation 1.1 is the result of the electric field reduction as a function of 1/r where r is in meters. Class B for digital or analog and digital devices are more stringent than Class A. This classification of limits is for residential environments where emissions are more likely to cause interference. Class A is for commercial, industrial or business environments where anomalies that result in interference and the culprit causing noise can be identified and eliminated. Class B limits for residential areas may not solve the problems (Tables 1.6–1.9). Interference with TV or home entertainment equipment from radiated emissions that represent culprit noise sources are the responsibility of the user of the device to solve, even if the offender meets the radiation standards (see References [4] and [5]). It is also useful to adhere to Class B limits to give the designer of equipment a better chance of passing Class A emission tests; a 10 dB margin for error is apparent. The pre-compliance testing encourages the designer to have a margin for errors.

1.4.2 United States Department of Transportation

Excerpts from rapid transit documents In the course of the study, excerpts will be taken when necessary to do the case study. The total regulations for Department of Transportation (DOT) will not be presented. An entire text would be required

TABLE 1.6 Measurement Range Devices for Tuned and Untuned Circuits

Highest frequency generated in device (MHz)	Upper frequency of measurement range
<1.705	30 MHZ
1.705–108	1 GHz
108–500	2 GHz
500–1000	5 GHz
>1000	Fifth harmonic of the highest frequency or 40 GHz, whichever is lower

TABLE 1.7 Maximum Electric Field Strength for Spread Spectrum Radios

Unlicensed international band device frequency range (MHz)	E field (mV/m)
902–928	500
2435–2465	500
5785–5815	500

TABLE 1.8 FCC/CISPR Conducted Limit Regulations, Class A. CISPR = Comité Internionale Special Des Perturbations, Special international Committee on Radio interference, Founded 1934

Frequency	Quasi-peak magnitude	Average magnitude	Remarks
150–500 KHz	(8.9 mV) 79 dBμV	(2 mV) 66 dBμV	AM radio bands
0.5–30 MHz	(4.47 mV) 73 dBμV	(1 mV) 60 dBμV	AM, FM, CB radio bands

TABLE 1.9 FCC/CISPR Conducted Limit Regulations, Class B

Frequency	Quasi-peak magnitude	Average magnitude	Remarks
150–500 KHz[a]	(2–0.63 mV) 66–56 dBμV	(0.63–0.2 mV) 56-46 dBμV	AM radio bands
0.5–5 MHz	(4.47 mV) 56 dBμV	(0.2 mV) 46 dBμV	AM, FM
5–30 MHz	(1.0 mV) 60 dBμV	(0.32 mV) 50 dBμV	CB radio

[a] Linear slope =35 KHz/dBμV

TABLE 1.10 DOT Radiation Emission Measurements

Frequency	BW	Field	Measurement	Remarks
14 KHz to 30 MHz 140 KHz to 30 MHz	1 KHz 10 KHz	H (field)	Loop antenna H (field) sensor	Vertical and parallel, 15 m from centerline of track
14–140 KHz		E (field)	Rod vertical E (field) sensor	Vertical, 15 m from centerline of track
30–400 MHz 400 MHz to 1 GHz	100 KHz 1 MHz	E (field)	Log-periodic horizontal polarized	Horizontal, 15 m from centerline of track

to completely describe all of the regulations and tests. Most of the equipment requiring EMC in transit systems is tested to various standards. They are not all listed in the book. Table 1.10 does not have test standards. The subway car manufacturer will have a set of test results that they must pass for DOT compliance. Since all of the scenario case studies are on equipment installed after manufacture, these devices or equipment must not create noise in communications houses, signal houses, subway or freight train radio systems or wayside wireless equipment. This installed equipment or device must have a measured immunity from radiated emissions of the subway cars. Table 1.10 indicates the type of antenna used in the measurements and the bandwidth (BW) of the instrumentation (see Figure 1.3 for the antennas). The measurements are taken at 15 m from the center of the track but measurements at 30 m is also common when possible. The 15 m measurements are used in case studies when equipment placement is hampered by a lack of access to the rails. Most of the equipment is within 15 m of the center of the right of way (track).

1.4.3 Canadian Regulations

The Canadian standards are very similar to the United States FCC standards, with cooperation between the two countries on the use of standards. The two countries accept each other's standards. The Canadians have a standard for immunity to electromagnetic radiation. The grades of immunity are as follows:

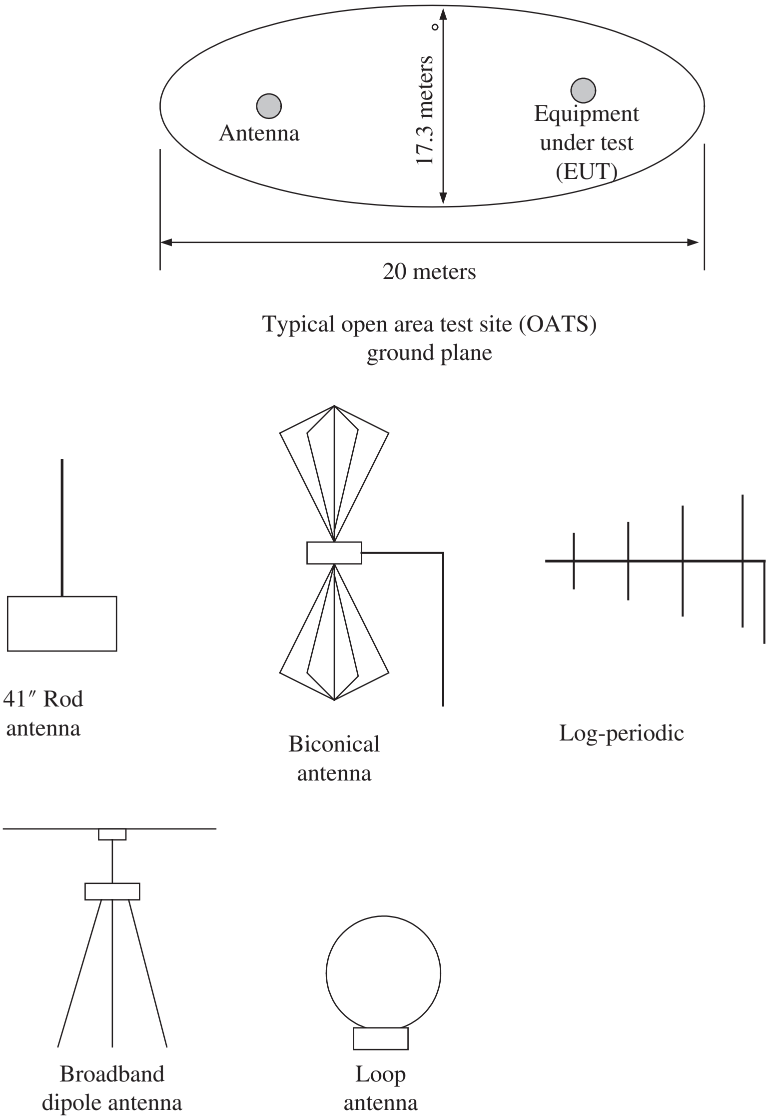

FIGURE 1.3 OATS ground plane and antennas

Canadian immunity grades

Grade 1 meets a 1 V/m test; the equipment is most likely to have performance deficiencies.

Grade 2 meets a 3 V/m test; the equipment is not likely to have an adequate performance

Grade 3 meets a 10 V/m test; the equipment is not likely to fail only under very harsh conditions.

1.5 BACKGROUND

This is a discussion of the author's background in the transportation industry. Overviews, questions at the end of each chapter and case studies are used to peak the interest of the audience. Other industries are also mentioned, where the electromagnetic compatibility (EMC) case studies may apply. DOT regulations are discussed that are in some cases more stringent than FCC regulation. For example, the DOT regulations have immunity regulations that must be met that are not required in all FCC regulations.

The emission of all system components must meet as a minimum FCC CFR 47 part 15 before they can be sold in the United States. The susceptibility of such components, devices and equipment is a de facto standard of 3 V/m for commercial and an actual standard of 10 V/m for medical. The equipment manufacturers will be asked to produce documentation confirming compliance with this standard when the study is conducted. The light rail transit (LRT) vehicle and signals emission data and susceptibility is unnecessary for CTS, PA/VMB, fire, intrusion, telephone and UPS equipment; however, an EMI/EMC analysis is required. Electromagnetic interference (EMI) from external sources for both intentional and unintentional radiators, TPSS, light rail and substations are investigated in the case studies when deemed necessary.

EMC/EMI will be coordinated with the cable and wire installation contractor to insure emission and susceptibility integrity. Wiring and coupling through ground are investigated to insure no extraneous EMI signals are coupled into the system components supplied for the case studies. Radio communications systems are some of the major case studies. Subway vehicles have several radio systems, not only for voice communications but also for monitoring the progress of vehicular travel using various sensors. The data is usually relayed to a large screen showing the route where each vehicle is bound and its progress as the vehicle travels along the right of way. The dispatcher will control the trains from the control room by observing the screens. Two-way radios serve as a backup in the event the main system fails. Wayside wireless sensors are often used for reading the bill of lading for freight train traffic. SCADA equipment is the nervous system of the subway or freight rail systems. It provides the operators in the control room with data about the health of all other systems. Some examples are radio system maintenance problems, unauthorized persons entering a communication, signal or DC power houses, fire alarm, fire suppression, public address and video monitoring camera failures, building equipment failures such as air conditioning and heating system, signals equipment and any other subsystems failures.

Induced, conducted and radiated emissions will be suppressed by various methods to provide a signal to noise ratio (SNR) consistent with good communications. In all cases, safety and reliable operation are the primary concern.

The most popular OATS sites are the 3 m emissions measurement type for obvious reasons; the sites take the least amount of space. The larger 10 m emission sites are more difficult to implement. The problems with operating in the far field are eliminated, for example measurements at 30 MHz in the near field is 20 m. Even measurements at 10 m require corrections for the near field but operating at 3 m requires even more extensive corrections. Therefore, measuring emissions about 300 MHz should not be a problem, but below this frequency the near field may begin to require corrections for machine measurements.

Radiated emissions for military equipment are taken at 1 m. These require more extensive measurements which can be found in MIL-STD-461. Most of the equipment used in transportation has had many of these measurements taken and they are not required; however, occasionally panels with components are fabricated in the shop and may need emissions testing. A case in point is a panel which was constructed with relays, controllers and audio amplifiers and was to be installed in a communication house. The panel required testing for emissions, mainly due to the wiring of the various components on the panel.

Fire and intrusion alarms are also fabricated on panels; however these are tested by the manufacturer in various configurations and require no emissions testing provided the assemblies are configured as recommended by the manufacturer. Control room panel configurations are often done using several manufacturers of the various components emission testing, as a total system is usually required and is often neglected by many of the authorities. However, when panels are constructed with shielded wire or coaxial cable and terminations are completed so that no standing waves or traveling standing waves occur, the radiation from the various areas in the panel are minimized.

Generally when testing racks of equipment for performance, poor grounding or wiring that radiates emissions is usually the culprit. During commissioning testing of subway systems some of these anomalies are found, which of course may be only require a simple shielding, changing the orientation of the particular culprit or providing simple filtering such as a line filter installed in the power line for a particular piece of equipment.

One particularly difficult instance of electromagnetic compatibility occurred when several radios were connected to a leaky radiating cable in a tunnel. The combiner network used to sum all the radios onto the leaky radiating cable worked fine in the shop when installed in a rack but, once the racks were placed in the control room in the tunnel and connected to the leaky radiating cable, intermodulation products produced many problems for the engineers installing the equipment. The racks had to be removed and the combiner network retuned in the shop. After many iterations of retuning the combiner network, the 17 channels on the leaky radiating cable finally performed satisfactorily. The cost to perform the repeated removal and retuning of the network was more than the bid for the radios and their installation. A mockup of the installation should have been done prior to installing the racks in the tunnel; this may have alleviated several problems.

1.6 EMC TESTING METHODS FOR FCC PART 15 RADIATION MEASUREMENTS

The FCC Part 15 radiated emissions open area test site (OATS) is conducted on a ground plane, as shown in Figure 1.3. The ground plane is constructed of copper mesh. The dimensions are for an elliptical minimum area but a rectangular area is generally installed at 20 m long or more and at least 18 m wide. The ground plane is sized for 10 m radiated emission measurements. For 3 m radiated emission measurements the ellipse is 6 m major axis and 5.2 m minor axis as the minimum area.

The rectangular is generally over 6 m long and at least 5.2 m wide. The ground plane is for a rotating turntable for the equipment under test (EUT).

Circular ground planes will be necessary where the antennas are moved and the EUT is on a stationary platform. The ground plane radius is 15 and 4.5 m respectively for 10 and 3 m emissions measurements. The dimensions for a square plane are 30 and 9 m square respectively for 10 and 3 m emissions. The rotating turntable allows the smallest ground plane footprint. For ground planes installed on a wooden flooring no metallic framing or fasteners can be used for construction, only glue. For concrete structures, a mesh of fiberglass for reinforcing can be used; no metallic rebar can be used. It is advisable to make a small test area of a 3 m square with concrete and reinforcing material and test its properties for construction of the main site. The testing should be done with and without the copper ground plane. Concrete is poured and should be sealed to prevent water vapor from entering it.

The ground plane area must be free on any obstructions that will result in reflections, such as trees, posts, metallic or non-metallic objects. It is best to level the area before installing the copper mesh. The weather can result in errors, if measurements are taken when the soil is damp when copper mesh is used instead of solid copper. The test site should be covered when not in use. Walls, trees, posts, building or other reflective objects at the periphery of the test area can produce errors. The periphery area should be cleared at least three times distance from the edge of the periphery of the major axis of antenna and the EUT. The antenna and focal point of the ellipse is at the antenna and EUT. For a 3 m test the cleared distance is 1.5 m to the edge of the ellipse along the major axis plus three times that distance from the edge or 6 m from the antenna and EUT. For the 10 m emission test the measurement is three times the focal distance (5 m) plus three times that from the edge of the major axis of the ellipse or 20 m from antenna and EUT.

To eliminate ground reflections while making measurements, the antenna height is moved up and down during a set of spectral measurements. Measurements for radiated emission are taken at least at 45° increments for either turntable or moving the antenna. A set of measurements are taken at various antenna heights. If deep nulls or peaks are noted during a measurement, ground reflections are occurring. The antenna height should be adjusted for each set of measurements; this will be based on the emission frequency. For heights that produce reflections, the reflected wave and the line of site wave will result in deep nulls or peaks that can result in large errors. As a first pass at measurements, the antenna should be raised from ground level to 3 m above the EUT on the turntable and reduced in increments of 1 m. The peaks and nulls are noted as the test progresses and refinements can be made in the tests to allow for reflections.

1.6.1 Measurement Errors

The analyzer and attenuator (if required) can be setup poorly; this can contribute errors of 1–2 dB depending on the skill of the operator. Reflection errors can be as high as ± 10 dB that will be either a null or peak above the RMS value of the emission.

The cable to EUT and attenuator or spectrum analyzer can give a mismatch of –2 dB. The far field at 30 MHz is approximately 2.5 m for a 0.5 wavelength antenna. A 3 m measurement distance can result in a small error if the near field does not have a sharp transition to the far field. If the correct antenna is installed that is made for EMC testing, this should not be a problem. Most of the antennas have a matching network built in; these usually have a 2–3 dB loss and generally the manufacturer will provide an insertion loss value. When measurements must be taken for vertical and horizontal polarization there is approximately 20 dB difference between them. For turntable use, the cable between the spectrum analyzer or attenuation and the antenna needs to be extra long to allow for coiling of the cable as the EUT is rotated. The coil cannot be tight or this will introduce a large loss in the cable. The cable should be calibrated before the test to provide a correction table that can be stored and used during the tests. The calibration should be plotted with sufficient accuracy to allow the operator to interpolate losses from the curve or curves. Generally a skilled operator can produce a reading within ± 1 dB.

1.6.2 Antenna Selection

The antennas implemented for radiation testing are shown in Figure 1.3. When setting up an OATS facility, the facilitator should always check for newer antennas that may be an improvement over those depicted in Figure 1.3. For frequencies below 30 MHz a rod antenna will be used to measure frequencies down to 9 kHz. This antenna will require a counterpoise which is generally available from the supplier. There are some that have automatic switching of the matching networks and conversion of dBμV to dBμV/m (antenna factor). The antenna must be calibrated at least yearly, due to component aging. These antennas have a preamplifier and switching built into the unit. The biconical antenna is used for bands between 30 and 216 MHz and the conversion of dBμV to dBμV/m (antenna factor) must be stated or automatically corrected for distance. The antenna requires calibration at least on a yearly basis. The log periodic broadband antenna is designed for frequency measurements between 30 MHz and 15 GHz; it can be used for the entire band of frequencies above 30 MHz. This antenna has high directivity and a narrow beam-width. However, it does not require changing antennas and that can be a source of errors. The di-pole broadband antenna in Figure 1.3 from 20 to 200 MHz has many of the attributes of the others; it is shown as an alternative to the biconical and it will be somewhat lower in cost. The final antenna shown is for measuring magnetic fields at frequencies below 30 MHz. The construction, that is loop diameter and turns, is determined by the frequency, sensitivity and accuracy to be measured.

To set up an actual site, check the FCC title CFR 47 regulations. As stated previously, these change and the book representation has excerpts that typify an OATS facility (Figure 1.4). The dimensions are accurate for the construction of a 3 m emission test at the time the book is written. The copper is shown as very thick; this is not the case. The minimum thickness depends or the mechanical strength and the skin affects the depth of the emissions. Since the lowest radiation frequency is 30 MHz, the copper thickness is calculated using Equations 2.18 and 2.19

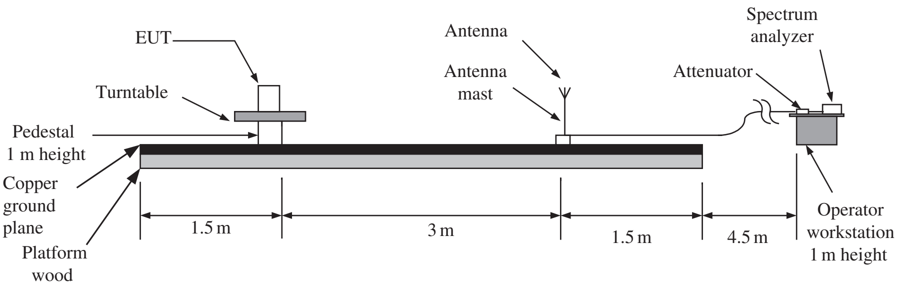

FIGURE 1.4 Typical 3 m emission test facility. (The components are not to scale)

in Chapter 2; $1/\alpha \approx 21.5$ μm skin depth. This is 63% of the thickness of the copper mat, it must be three times the thickness or 64.5 μm; however for mechanical strength 1/8 inch or more is a better choice. The pedestal is where connections to the EUT turntable drive mechanism are installed. The antenna mast can be an electronic telescoping or manual type to change the antenna height during testing. An attenuator (optional) and spectrum analyzer is required with sufficient bandwidth and sensitivity to complete measurements. The selection should be determined based on oscillators, clocks or expected transients of the EUT. As an example, a fiber optic component such as an audio modem will have a bit stream of about 1.5 Mbits/s.

OATS measurements and testing is an expensive undertaking. For a test facility to be certified by the FCC is rather costly (US $ 30 000–40 000. Manufacturing of equipment or devices depending on size, production runs and skilled personnel will determine whether the outlay of the cost is beneficial or not. Private FCC certified laboratories are the best alternative to designing and getting FCC certification. Underwriters Laboratory (UL) has a large facility that can test large or small devices or equipment, even aircraft. There are many others that may be better suited for small-scale tests. To do a low-cost solution, pre-compliance testing can be done and later, when the tests provide a level of confidence the equipment or device will pass the emission test, it can be done at a FCC certified laboratory. Pre-compliance for microwave ovens, radios and other physically small-size equipment can be bench tested. Once compliance is achieved, the manufacturing methods are established and only a spot check of equipment or device may be required.

1.6.3 Pre-compliance Radiation Measurement and Testing

Most equipment will fail EMC FCC radiation testing unless some tests are done prior to the final FCC certification tests. Pre-compliance testing will assist in achieving the final FCC certification where perhaps only minor adjustments to the equipment or device are needed to pass. The EMC radiation emission tests must be at least 5 or 10 dB better than the standards in the tables in Section 1.4 to provide a margin for measurement errors alluded to in OATS testing. When a piece of equipment or device has passed, a sample should be kept if possible to use as a sort of an in-house standard to be used when testing random units. It can be used to set up the test facility for pre-compliance testing at a later date. This may not be possible if the device or equipment is quite expensive, such as test equipment. Keeping accurate records of the test setup and equipment that passed including all environment factors such as temperature, humidity and all equipment in the test area. References [4] and [5] have an excellent treatment of pre-compliance issues.

1.6.4 Conducted Emission

The test conducted in Figure 1.5a is for single phase input power to the EUT. The line impedance stabilization network (LISN) is necessary on the power input and ground return. The return allows the harmonics and noise from switched power supplies to be measured. For an isolated and very clean 120 V AC input the LISN may not be necessary. For any of the LISN not used for a measurement, it must have a 50 Ω termination. The instruments connected to measurement port must have a 50 Ω output impedance to prevent mismatch reflections. When dealing with power lines, it is necessary to place an attenuator between the measurement device and the LISN instrument port. Transients on power lines in particular transportation applications can be destructive to the instrument. The harsh environment from arcing of catenaries and the third hot rail can also be very destructive to other circuits. The tests are conducted on a ground plane with LISN bonded to it. The power lines are connected to the EUT with feed-through capacitors connected to a ground connection through copper plate at a 90° angle to the ground plane, as shown in Figure 1.6. The AC mains should have line filters or isolations transformers and not inject noise into the measurements. LISN can be constructed or purchased; however, if constructed poorly they can be a hindrance to measurement accuracy. The LISN circuit design is provided in Figure 1.7.

Figure 1.5b is the block diagram for a three phase conducted emission test. A LISN is installed on the neutral due to several types of switching DC power supplies that may be connected to the 120 V AC mains and filtering or isolation transformers does not take out all the noise. The switching DC power supplies can be at various frequencies and mixing may occur, thus providing a host of harmonics. Unlicensed radiators such as 902–928 MHz equipment may be operating on one phase and a 857 MHz radio bay station may be operating on another leg of the power mains with a potential for 5–31 MHz for mixing if the grounds have poor connections due to corrosion. Therefore the operator must be vigilant when making measurements not inject these frequencies into the results. Any LISN not connected to a measurement device must have a termination. This diagram depicts a four channel spectrum analyzer. If it is not available each phase may be tested separately.

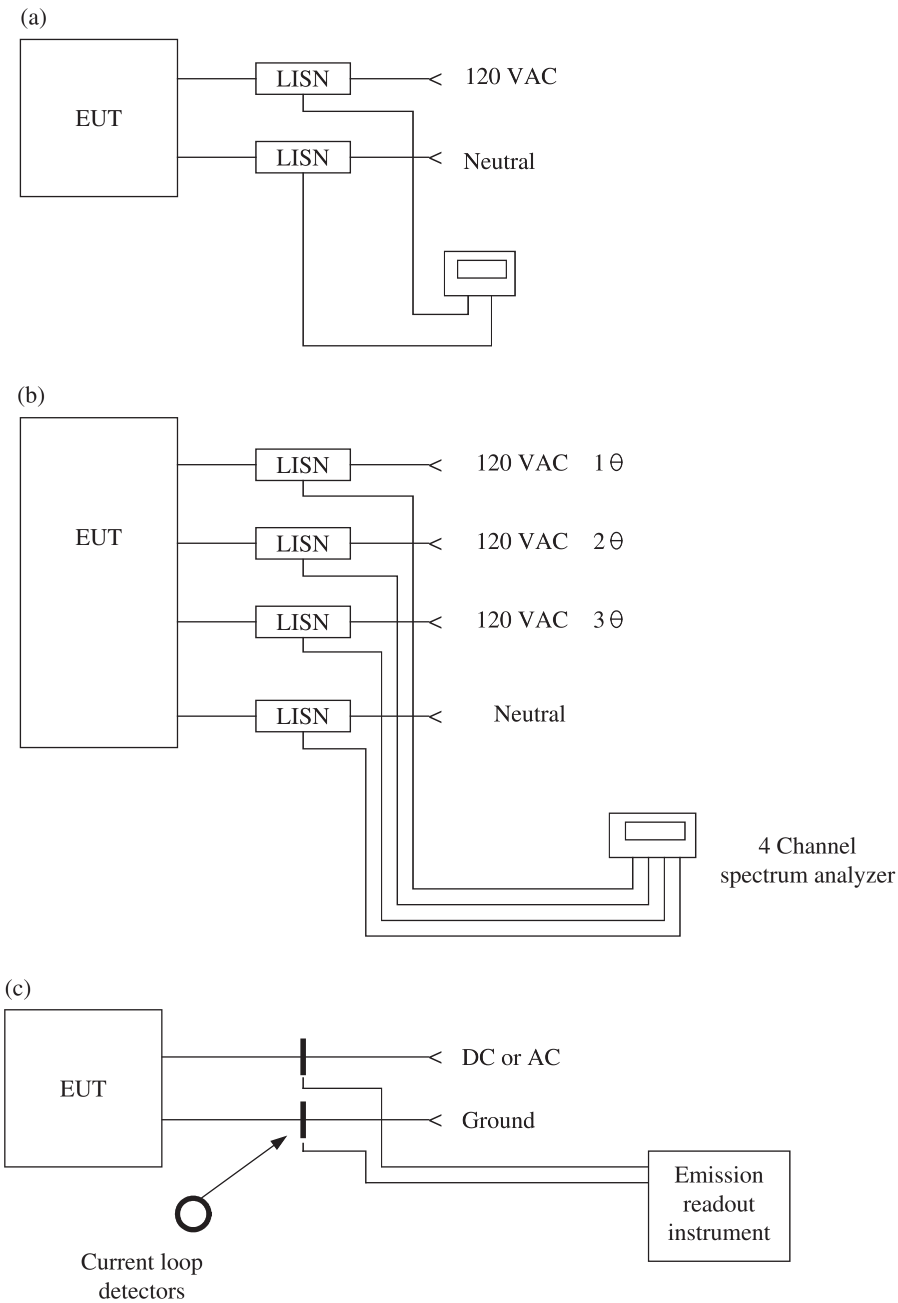

FIGURE 1.5 Typical test apparatus for conducting emission tests. (a) Single phase. (b) Three phases. (c) DC or AC emission current measurement

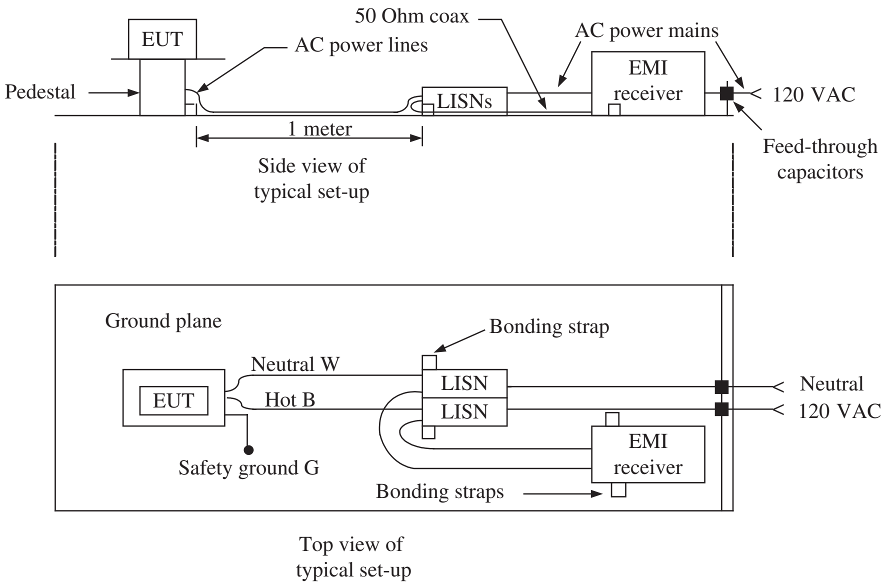

FIGURE 1.6 Typical test set-up for conducting voltage emission measurements

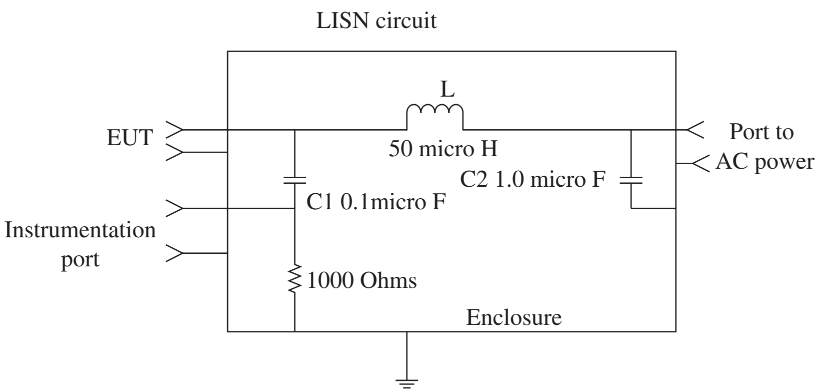

FIGURE 1.7 LISN designed for conducting emission measurements

Conducted emission current is measured using the set-up shown in Figure 1.5c. There is a large variety of loop detectors available. It is best to use an online search for these types of detectors. The technology is changing rapidly and particular detectors that are available today may be either replaced or obsolete by the time of printing. The instrument for measurement should have an attenuator between the LISN instrumentation port and the measurement device. It should have a storage readout to allow for transients and other anomalies. Keying radios, AM/FM radio and transportation have other issues such as steel rails with signals with 10 KHz carriers, catenary and third rail arcing and inrush currents of traction motors. Occasionally the 13.5 kV power lines from substations are routed above ground to the DC power station for the subway. As can be expected the rail right of way authority may lease space for other utilities.

A typical measurement installation is shown in Figure 1.6. This is a description of how a single phase AC voltage measurement is made. The 120 V AC power mains will have an isolation transformer upstream from the LISNs and a copper plate fitted with feed-through capacitors in the 90° upright; this can be part of the copper ground plane bent to a 90° angle. The ground plane can be solid copper or copper mesh. The LISNs are both bonded to the ground plane. The hot side black wire and white neutral can be measured separately. Terminate the instrument port not being used for the measurements. The safety ground or green wire from the EUT is affixed to the grounded plane. In some cases, only two wires are present for double insulated devices. An EMI receiver is the best instrument to use; it saves time and is generally made to measure quasi-peak and average dBVμ measurements directly. Other instrumentation may require calculations. Not shown in Figure 1.5 is the plug to convert a three-wire output to two wires; it is located in the pedestal.

1.7 CANADIAN REGULATIONS

1.7.1 Canadian Immunity Grades

Grade 1 meets a 1 V/m test, the equipment is most likely to have performance deficiencies.

Grade 2 meets a 3 V/m test, the equipment is not likely to have an adequate performance

Grade 3 meets a 10/m test, the equipment is not likely to fail only under very harsh conditions.

1.8 EUROPEAN UNION REGULATIONS

The European Union electromagnetic compatibility (EMC) list of standards is provided in Table 1.11. These cover a host of products and systems. The reader interested in a particular standard will need to use the information provided below. The rationale for providing only the listings is that the standards are continually changing and being updated; and one who is working on a particular project that needs a standard should look up the latest version. The European Union is composed of a number of countries as compared to the United States that is one homogeneous country. Each of the partners of the European Union contributes to the generation of standards.

These standards cover a variety of products and systems. Several in particular are necessary for the designer or analyst dealing with transportation issues and these are provided in Table 1.11. The summary below only covers some of the most important standards. However there are others that are relevant, for example standards dealing with communication house and signal house construction. This summary does not cover all aspects of a particular standard; it provides a lead for the audience of where to pursue more details about the standard.

1. The EN 50121-5:2006/AC:2008 covers railway equipment including subways emissions and power supplies.
2. Electromagnetic compatibility – Road traffic signal systems – Product standard EN 50293:2000 for an example at grade crossings.
3. EN 50130-4:1995 Alarm systems, part 4: Electromagnetic compatibility – Product family standard. Immunity requirements for components of fire, intruder and social alarm systems and communication houses and signals bungalows.
4. EN 50529-2:2010 EMC network standard, part 2: Wire-line telecommunications networks using coaxial cables is necessary for communications.
5. EN 60947 Low-voltage switchgear and control-gear for SCADA systems.
6. EN 61000-3-2:2006 Electromagnetic compatibility (EMC), part 3-2: Limits for harmonic current emissions (equipment input current ≤ 16 A per phase). IEC 61000-3-2:2005.
7. EN 61000-6-2:2005 Electromagnetic compatibility (EMC), part 6-2: Generic standards – Immunity for industrial environments that lack a standard. IEC 61000-6-2:2005.
8. EN 61131-2:2007 Programmable controllers, part 2: Equipment requirements and tests. IEC 61131-2:2007.
9. EN 61547:2009 Equipment for general lighting purposes. EMC immunity requirements. IEC 61547:2009 + IS1:2013.
10. EN 300 386 V1.4.1 Electromagnetic compatibility and radio spectrum matters (ERM); Telecommunication network equipment; Electromagnetic Compatibility (EMC) requirements.
11. EN 300 386 V1.6.1 Electromagnetic compatibility and radio spectrum matters (ERM); Telecommunication network equipment; Electromagnetic compatibility (EMC) requirements.

For information about the content and availability of European standards, please contact the European standardization organizations (ESOs; e.g. CEN, Brussels, http://www.cen.eu; Cenelec, Brussels, http://www.cenelec.eu; ETSI, Sophia Antipolis, http://www.etsi.eu).

TABLE 1.11 List of European EMC Standards

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
CEN	EN 617:2001+A1:2010 Continuous handling equipment and systems – Safety and EMC requirements for the equipment for the storage of bulk materials in silos, bunkers, bins and hoppers	EN 617:2001[c]	Date expired (30/06/2011)
CEN	EN 618:2002+A1:2010 Continuous handling equipment and systems – Safety and EMC requirements for equipment for mechanical handling of bulk materials except fixed belt conveyors	EN 618:2002[c]	Date expired (30/06/2011)
CEN	EN 619:2002+A1:2010 Continuous handling equipment and systems – Safety and EMC requirements for equipment for mechanical handling of unit loads	EN 619:2002[c]	Date expired (30/04/2011)
CEN	EN 620:2002+A1:2010 Continuous handling equipment and systems – Safety and EMC requirements for fixed belt conveyors for bulk materials	EN 620:2002[c]	Date expired (30/06/2011)
CEN	EN 1155:1997 Building hardware – Electrically powered hold-open devices for swing doors – Requirements and test methods		
CEN	EN 12015:2004 Electromagnetic compatibility – Product family standard for lifts, escalators and moving walks – Emission	EN 12015:1998[c]	Date expired (30/06/2006)

CEN	EN 12016:2013 **(new)** Electromagnetic compatibility – Product family standard for lifts, escalators and moving walks – Immunity	EN 12016:2004 + A1:2008[c]	28/02/2014
CEN	EN 12895:2000 Industrial trucks – Electromagnetic compatibility		
N	EN 13241-1:2003+A1:2011 Industrial, commercial and garage doors and gates – Product standard – Part 1: Products without fire resistance or smoke control characteristics	EN 13241-1:2003[c]	Date expired (31/10/2011)
CEN	EN 13309:2010 Construction machinery – Electromagnetic compatibility of machines with internal power supply	EN 13309:2000[c]	Date expired (31/01/2011)
CEN	EN 14010:2003+A1:2009 Safety of machinery – Equipment for power driven parking of motor vehicles – Safety and EMC requirements for design, manufacturing, erection and commissioning stages	EN 14010:2003[c]	Date expired (31/01/2010)
CEN	EN ISO 14982:2009 Agricultural and forestry machinery – Electromagnetic compatibility – Test methods and acceptance criteria (ISO 14982:1998)	EN ISO 14982:1998[c]	Date expired (28/12/2009)
CEN	EN 16361:2013 (new) Power operated pedestrian doors – Product standard, performance characteristics – Pedestrian door sets, other than swing type, initially designed for installation with power operation without resistance to fire and smoke leakage characteristics		

(Continued)

TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 50065-1:2001 Signaling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Part 1: General requirements, frequency bands and electromagnetic disturbances	EN 50065-1:1991 + A1:1992 + A2:1995 + A3:1996[c]	Date expired (01/04/2003)
	EN 50065-1:2001/A1:2010	[d]	Date expired (01/10/2012)
Cenelec	EN 50065-1:2011 Signaling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Part 1: General requirements, frequency bands and electromagnetic disturbances	EN 50065-1:2001 and its amendment[c]	
lec	EN 50065-2-1:2003 Signaling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Part 2-1: Immunity requirements for mains communications equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in residential, commercial and light industrial environments	Relevant generic standard(s)[e]	Date expired (01/10/2004)
	EN 50065-2-1:2003/A1:2005	[d]	Date expired (01/07/2008)
	EN 50065-2-1:2003/AC:2003		
Cenelec	EN 50065-2-2:2003 Signaling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Part 2-2: Immunity requirements for mains communications equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in industrial environments	Relevant generic standard(s)[e]	Date expired (01/10/2004)

	EN 50065-2-2:2003/A1:2005	[d]	Date expired (01/07/2008)
	EN 50065-2-2:2003/A1:2005/AC:2006		
	EN 50065-2-2:2003/AC:2003		
Cenelec	EN 50065-2-3:2003 Signaling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Part 2-3: Immunity requirements for mains communications equipment and systems operating in the range of frequencies 3 kHz to 95 kHz and intended for use by electricity suppliers and distributors	Relevant generic standard(s)[c]	Date expired (01/08/2004)
	EN 50065-2-3:2003/A1:2005	[d]	Date expired (01/07/2008)
	EN 50065-2-3:2003/AC:2003		
Cenelec	EN 50083-2:2012 Cable networks for television signals, sound signals and interactive services – Part 2: Electromagnetic compatibility for equipment	EN 50083-2:2006[c]	Date expired (21/06/2013)
Cenelec	EN 50121-1:2006 Railway applications – Electromagnetic compatibility – Part 1: General	Relevant generic standard(s)[c]	Date expired (01/07/2009)
	EN 50121-1:2006/AC:2008		
Cenelec	EN 50121-2:2006 Railway applications – Electromagnetic compatibility – Part 2: Emission of the whole railway system to the outside world	Relevant generic standard(s)[c]	Date expired (01/07/2009)
	EN 50121-2:2006/AC:2008		
Cenelec	EN 50121-3-1:2006 Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock – Train and complete vehicle	Relevant generic standard(s)[e]	Date expired (01/07/2009)

(Continued)

TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
	EN 50121-3-1:2006/AC:2008		
Cenelec	EN 50121-3-2:2006 Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus	Relevant generic standard(s)[e]	Date expired (01/07/2009)
	EN 50121-3-2:2006/AC:2008		
Cenelec	EN 50121-4:2006 Railway applications – Electromagnetic compatibility – Part 4: Emission and immunity of the signaling and telecommunications apparatus	Relevant generic standard(s)[e]	Date expired (01/07/2009)
	EN 50121-4:2006/AC:2008		
Cenelec	EN 50121-5:2006 Railway applications – Electromagnetic compatibility – Part 5: Emission and immunity of fixed power supply installations and apparatus	Relevant generic standard(s)[e]	Date expired (01/07/2009)
	EN 50121-5:2006/AC:2008		
Cenelec	EN 50130-4:1995 Alarm systems – Part 4: Electromagnetic compatibility – Product family standard: Immunity requirements for components of fire, intruder and social alarm systems	Relevant generic standard(s)[e]	Date expired (01/01/2001)
	EN 50130-4:1995/A1:1998	[d]	Date expired (01/01/2001)
	EN 50130-4:1995/A2:2003	[d]	Date expired (01/09/2007)
	EN 50130-4:1995/A2:2003/AC:2003		

Cenelec	EN 50130-4:2011 Alarm systems – Part 4: Electromagnetic compatibility – Product family standard: Immunity requirements for components of fire, intruder, hold up, CCTV, access control and social alarm systems	EN 50130-4:1995 and its amendments[c]	13/06/2014
Cenelec	EN 50148:1995 Electronic taximeters BT(IT/NOT)12	Relevant generic standard(s)[e]	Date expired (15/12/1995)
Cenelec	EN 50270:2006 Electromagnetic compatibility – Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen	EN 50270:1999[e]	Date expired (01/06/2009)
Cenelec	EN 50293:2000 Electromagnetic compatibility – Road traffic signal systems – Product standard	Relevant generic standard(s)[e]	Date expired (01/04/2003)
Cenelec	EN 50293:2012 (new) Road traffic signal systems – Electromagnetic compatibility	EN 50293:2000[c]	11/05/2015
Cenelec	EN 50295:1999 Low-voltage switchgear and control gear – Controller and device interface systems – Actuator Sensor interface (AS-i)	Relevant generic standard(s)[e]	Date expired (01/12/1999)
Cenelec	EN 50370-1:2005 Electromagnetic compatibility (EMC) – Product family standard for machine tools – Part 1: Emission	Relevant generic standard(s)[e]	Date expired (01/02/2008)
Cenelec	EN 50370-2:2003 Electromagnetic compatibility (EMC) – Product family standard for machine tools – Part 2: Immunity	Relevant generic standard(s)[e]	Date expired (01/11/2005)
Cenelec	EN 50412-2-1:2005 Power line communication apparatus and systems used in low-voltage installations in the frequency range 1,6 MHz to 30 MHz – Part 2-1: Residential, commercial and industrial environment - Immunity requirements	Relevant generic standard(s)[e]	Date expired (01/04/2008)

(Continued)

TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
	EN 50412-2-1:2005/AC:2009		
Cenelec	EN 50428:2005 Switches for household and similar fixed electrical installations – Collateral standard – Switches and related accessories for use in home and building electronic systems (HBES)	Relevant generic standard(s)[e]	Date expired (01/01/2008)
	EN 50428:2005/A1:2007	[d]	Date expired (01/10/2010)
	EN 50428:2005/A2:2009	[d]	Date expired (01/06/2012)
Cenelec	EN 50470-1:2006 Electricity metering equipment (AC.) – Part 1: General requirements, tests and test conditions - Metering equipment (class indexes A, B and C)	Relevant generic standard(s)[e]	Date expired (01/05/2009)
Cenelec	EN 50490:2008 Electrical installations for lighting and beaconing of aerodromes – Technical requirements for aeronautical ground lighting control and monitoring systems – Units for selective switching and monitoring of individual lamps	Relevant generic standard(s)[e]	Date expired (01/04/2011)
Cenelec	EN 50491-5-1:2010 General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) – Part 5-1: EMC requirements, conditions and test set-up	EN 50090-2-2: 1996 + A2:2007[c]	Date expired (01/04/2013)
Cenelec	EN 50491-5-2:2010 General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) – Part 5-2: EMC requirements for HBES/BACS used in residential, commercial and light industry environment	EN 50090-2-2: 1996 + A2:2007[c]	Date expired (01/04/2013)

Cenelec	EN 50491-5-3:2010 General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) – Part 5-3: EMC requirements for HBES/BACS used in industry environment	EN 50090-2-2: 1996 + A2:2007[c]	Date expired (01/04/2013)
Cenelec	EN 50498:2010 Electromagnetic compatibility (EMC) – Product family standard for aftermarket electronic equipment in vehicles	Relevant generic standard(s)[c]	Date expired (01/07/2013)
Cenelec	EN 50512:2009 Electrical installations for lighting and beaconing of aerodromes – Advanced Visual Docking Guidance Systems (A-VDGS)	Relevant generic standard(s)[c]	
Cenelec	EN 50529-1:2010 EMC Network Standard – Part 1: Wire-line telecommunications networks using telephone wires		
Cenelec	EN 50529-2:2010 EMC Network Standard – Part 2: Wire-line telecommunications networks using coaxial cables		
Cenelec	EN 50550:2011 Power frequency overvoltage protective device for household and similar applications (POP)		
	EN 50550:2011/AC:2012		
Cenelec	EN 50557:2011 (new) Requirements for automatic reclosing devices (ARDs) for circuit breakers-RCBOs-RCCBs for household and similar uses		

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 50561-1:2013 (new) Power line communication apparatus used in low-voltage installations – Radio disturbance characteristics – Limits and methods of measurement – Part 1: Apparatus for in-home use	EN 55022:2010 + EN 55032:2012[c]	
Cenelec	EN 55011:2009 Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement CISPR 11:2009 (Modified)	EN 55011:2007 + A2:2007[c]	Date expired (01/09/2012)
	EN 55011:2009/A1:2010 CISPR 11:2009/A1:2010	[d]	Date expired (01/07/2013)
Cenelec	EN 55012:2007 Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers CISPR 12:2007	EN 55012:2002 + A1:2005[c]	Date expired (01/09/2010)
	EN 55012:2007/A1:2009 CISPR 12:2007/A1:2009	[d]	Date expired (01/07/2012)
EN 55012 is applicable for giving presumption of conformity under directive 2004/108/EC for those vehicles, boats and internal combustion engine-driven devices that are not within the scope of directives 95/54/EC, 97/24/EC, 2000/2/EC or 2004/104/EC.			
Cenelec	EN 55013:2001 Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement CISPR 13:2001 (Modified)	EN 55013:1990 + A12:1994 + A13:1996 + A14:1999[c]	Date expired (01/09/2004)
	EN 55013:2001/A1:2003 CISPR 13:2001/A1:2003	[d]	Date expired (01/04/2006)
	EN 55013:2001/A2:2006 CISPR 13:2001/A2:2006	[d]	Date expired (01/03/2009)

Cenelec	EN 55013:2013 (**new**) Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement CISPR 13:2009 (Modified)	EN 55013:2001 and its amendments[c]	22/04/2016
Cenelec	EN 55014-1:2006 Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission CISPR 14-1:2005	EN 55014-1:2000 + A1:2001 + A2:2002[c]	Date expired (01/09/2009)
	EN 55014-1:2006/A1:2009 CISPR 14-1:2005/A1:2008	[d]	Date expired (01/05/2012)
	EN 55014-1:2006/A2:2011 CISPR 14-1:2005/A2:2011	[d]	16/08/2014
Cenelec	EN 55014-2:1997 Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 2: Immunity – Product family standard CISPR 14-2:1997	EN 55104:1995[c]	Date expired (01/01/2001)
	EN 55014-2:1997/A1:2001 CISPR 14-2:1997/A1:2001	[d]	Date expired (01/12/2004)
	EN 55014-2:1997/A2:2008 CISPR 14-2:1997/A2:2008	[d]	Date expired (01/09/2011)
	EN 55014-2:1997/AC:1997		
Cenelec	EN 55015:2006 Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment CISPR 15:2005	EN 55015:2000 + A1:2001 + A2:2002[c]	Date expired (01/09/2009)
	EN 55015:2006/A1:2007 CISPR 15:2005/A1:2006	[d]	Date expired (01/05/2010)
	EN 55015:2006/A2:2009 CISPR 15:2005/A2:2008	[d]	Date expired (01/03/2012)
Cenelec	EN 55015:2013 (new) Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment CISPR 15:2013 + IS1:2013 + IS2:2013	EN 55015:2006 and its amendments[c]	12/06/2016

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 55020:2007 Sound and television broadcast receivers and associated equipment – Immunity characteristics – Limits and methods of measurement CISPR 20:2006	EN 55020:2002 + A1:2003 + A2:2005[c]	Date expired (01/12/2009)
	EN 55020:2007/A11:2011	[d]	Date expired (01/01/2013)
Cenelec	EN 55022:2010 Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement CISPR 22:2008 (Modified)	EN 55022:2006 + A1:2007	Date expired (01/12/2013)
	EN 55022:2010/AC:2011		
Cenelec	EN 55024:2010 Information technology equipment – Immunity characteristics – Limits and methods of measurement CISPR 24:2010	EN 55024:1998 + A1:2001 + A2:2003	Date expired (01/12/2013)
Cenelec	EN 55032:2012 (new) Electromagnetic compatibility of multimedia equipment – Emission requirements CISPR 32:2012	EN 55013:2013 + EN 55022:2010 + EN 55103-1:2009 and its amendment[c]	05/03/2017
	EN 55032:2012/AC:2013 (new)		
Cenelec	EN 55103-1:2009 Electromagnetic compatibility – Product family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use – Part 1: Emissions	EN 55103-1:1996[c]	Date expired (01/07/2012)
	EN 55103-1:2009/A1:2012 (new)	[d]	05/11/2015

Cenelec	EN 55103-2:2009 Electromagnetic compatibility – Product family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use – Part 2: Immunity	EN 55103-2:1996[c]	Date expired (01/07/2012)
Cenelec	EN 60034-1:2010 Rotating electrical machines – Part 1: Rating and performance IEC 60034-1:2010 (Modified)	Relevant generic standard(s)[c]	Date expired (01/10/2013)
	EN 60034-1:2010/AC:2010		
Cenelec	EN 60204-31:1998 Safety of machinery – Electrical equipment of machines – Part 31: Particular safety and EMC requirements for sewing machines, units and systems IEC 60204-31:1996 (Modified)	Relevant generic standard(s)[e]	Date expired (01/06/2002)
	EN 60204-31:1998/AC:2000		
Cenelec	EN 60204-31:2013 (new) Safety of machinery – Electrical equipment of machines – Part 31: Particular safety and EMC requirements for sewing machines, units and systems IEC 60204-31:2013	EN 60204-31:1998[c]	28/05/2016
Cenelec	EN 60255-26:2013 (new) Measuring relays and protection equipment – Part 26: Electromagnetic compatibility requirements IEC 60255-26:2013		
	EN 60255-26:2013/AC:2013 (new)		
Cenelec	EN 60439-1:1999 Low-voltage switchgear and control gear assemblies – Part 1: Type-tested and partially type-tested assemblies IEC 60439-1:1999	EN 60439-1:1994 + A11:1996[c]	Date expired (01/08/2002)

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 60669-2-1:2004 Switches for household and similar fixed electrical installations – Part 2-1: Particular requirements – Electronic switches IEC 60669-2-1:2002 (Modified) + IS1:2011 + IS2:2012	EN 60669-2-1:2000 + A2:2001[c]	Date expired (01/07/2009)
	EN 60669-2-1:2004/A1:2009 IEC 60669-2-1:2002/A1:2008 (Modified)	[d]	Date expired (01/04/2012)
	EN 60669-2-1:2004/A12:2010	[d]	Date expired (01/06/2013)
	EN 60669-2-1:2004/AC:2007		
Cenelec	EN 60730-1:1995 Automatic electrical controls for household and similar use – Part 1: General requirements IEC 60730-1:1993 (Modified)		
	EN 60730-1:1995/A11:1996	[d]	Date expired (01/01/1998)
	EN 60730-1:1995/A17:2000	[d]	Date expired (01/10/2002)
	EN 60730-1:1995/AC:2007		
Cenelec	EN 60730-1:2000 Automatic electrical controls for household and similar use – Part 1: General requirements IEC 60730-1:1999 (Modified)	EN 60730-1:1995 and its amendments[c]	
	EN 60730-1:2000/A1:2004 IEC 60730-1:1999/A1:2003 (Modified)	[d]	
	EN 60730-1:2000/A16:2007	[d]	Date expired (01/06/2010)
	EN 60730-1:2000/A2:2008 IEC 60730-1:1999/A2:2007 (Modified)	[d]	Date expired (01/06/2011)
	EN 60730-1:2000/AC:2007		
	EN 60730-1:2000/A16:2007/AC:2010		

Cenelec	EN 60730-1:2011 Automatic electrical controls for household and similar use – Part 1: General requirements IEC 60730-1:2010 (Modified)	EN 60730-1:2000 and its amendments[c]	Date expired (01/10/2013)
Cenelec	EN 60730-2-5:2002 Automatic electrical controls for household and similar use – Part 2-5: Particular requirements for automatic electrical burner control systems IEC 60730-2-5:2000 (Modified)		
	EN 60730-2-5:2002/A1:2004 IEC 60730-2-5:2000/A1:2004 (Modified)	[d]	Date expired (01/12/2008)
	EN 60730-2-5:2002/A11:2005	[d]	Date expired (01/12/2008)
	EN 60730-2-5:2002/A2:2010 IEC 60730-2-5:2000/A2:2008 (Modified)	[d]	Date expired (01/03/2013)
Cenelec	EN 60730-2-6:2008 Automatic electrical controls for household and similar use – Part 2-6: Particular requirements for automatic electrical pressure sensing controls including mechanical requirements IEC 60730-2-6:2007 (Modified)	EN 60730-2-6:1995 + A1:1997	Date expired (01/07/2011)
Cenelec	EN 60730-2-7:2010 Automatic electrical controls for household and similar use – Part 2-7: Particular requirements for timers and time switches IEC 60730-2-7:2008 (Modified)	EN 60730-2-7:1991 + A1:1997[c]	Date expired (01/10/2013)
	EN 60730-2-7:2010/AC:2011		
Cenelec	EN 60730-2-8:2002 Automatic electrical controls for household and similar use – Part 2-8: Particular requirements for electrically operated water valves, including mechanical requirements IEC 60730-2-8:2000 (Modified)	EN 60730-2-8:1995 + A1:1997 + A2:1997[c]	Date expired (01/12/2008)
	EN 60730-2-8:2002/A1:2003 IEC 60730-2-8:2000/A1:2002 (Modified)	[d]	Date expired (01/12/2008)

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 60730-2-9:2010 Automatic electrical controls for household and similar use – Part 2-9: Particular requirements for temperature sensing controls IEC 60730-2-9:2008 (Modified)	EN 60730-2-9:2002 + A1:2003 + A2:2005	Date expired (01/11/2013)
Cenelec	EN 60730-2-14:1997 Automatic electrical controls for household and similar use – Part 2-14: Particular requirements for electric actuators IEC 60730-2-14:1995 (Modified)	EN 60730-1:1995 and its amendments[e]	Date expired (01/06/2004)
	EN 60730-2-14:1997/A1:2001 IEC 60730-2-14:1995/A1:2001	[d]	Date expired (01/07/2008)
Cenelec	EN 60730-2-15:2010 Automatic electrical controls for household and similar use – Part 2-15: Particular requirements for automatic electrical air flow, water flow and water level sensing controls IEC 60730-2-15:2008 (Modified)	EN 60730-2-18:1999[c]	Date expired (01/03/2013)
Cenelec	EN 60870-2-1:1996 Tele-control equipment and systems – Part 2: Operating conditions – Section 1: Power supply and electromagnetic compatibility IEC 60870-2-1:1995	Relevant generic standard(s)[e]	Date expired (01/09/1996)
Cenelec	EN 60945:2002 Maritime navigation and radio communication equipment and systems – General requirements – Methods of testing and required test results IEC 60945:2002	EN 60945:1997[c]	Date expired (01/10/2005)

Cenelec	EN 60947-1:2007 Low-voltage switchgear and control gear – Part 1: General rules IEC 60947-1:2007	EN 60947-1:2004[c]	Date expired (01/07/2010)
	EN 60947-1:2007/A1:2011 IEC 60947-1:2007/A1:2010	[d]	Date expired (01/01/2014)
Cenelec	EN 60947-2:2006 Low-voltage switchgear and control gear – Part 2: Circuit-breakers IEC 60947-2:2006	EN 60947-2:2003[c]	Date expired (01/07/2009)
	EN 60947-2:2006/A1:2009 IEC 60947-2:2006/A1:2009	[d]	Date expired (01/07/2012)
	EN 60947-2:2006/A2:2013 IEC 60947-2:2006/A2:2013 (new)	[d]	07/03/2016
Cenelec	EN 60947-3:2009 Low-voltage switchgear and control gear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units IEC 60947-3:2008	EN 60947-3:1999 + A1:2001[c]	Date expired (01/05/2012)
	EN 60947-3:2009/A1:2012 IEC 60947-3:2008/A1:2012	[d]	21/03/2015
Cenelec	EN 60947-4-1:2010 Low-voltage switchgear and control gear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters IEC 60947-4-1:2009	EN 60947-4-1:2001 + A1:2002 + A2:2005[c]	Date expired (01/04/2013)
	EN 60947-4-1:2010/A1:2012 IEC 60947-4-1:2009/A1:2012 (new)	[d]	24/08/2015
Cenelec	EN 60947-4-2:2000 Low-voltage switchgear and control gear – Part 4-2: Contactors and motor-starters – AC semiconductor motor controllers and starters IEC 60947-4-2:1999	EN 60947-4-2:1996 + A2:1998[c]	Date expired (01/12/2002)
	EN 60947-4-2:2000/A1:2002 IEC 60947-4-2:1999/A1:2001	[d]	Date expired (01/03/2005)
	EN 60947-4-2:2000/A2:2006 IEC 60947-4-2:1999/A2:2006	[d]	Date expired (01/12/2009)

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 60947-4-2:2012 (new) Low-voltage switchgear and control gear – Part 4-2: Contactors and motor-starters – AC semiconductor motor controllers and starters IEC 60947-4-2:2011	EN 60947-4-2:2000 and its amendments[c]	22/06/2014
Cenelec	EN 60947-4-3:2000 Low-voltage switchgear and control gear – Part 4-3: Contactors and motor-starters – AC semiconductor controllers and contactors for non-motor loads IEC 60947-4-3:1999	Relevant generic standard(s)[e]	Date expired (01/12/2002)
	EN 60947-4-3:2000/A1:2006 IEC 60947-4-3:1999/A1:2006	[d]	Date expired (01/11/2009)
	EN 60947-4-3:2000/A2:2011 IEC 60947-4-3:1999/A2:2011	[d]	18/04/2014
Cenelec	EN 60947-5-1:2004 Low-voltage switchgear and control gear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices IEC 60947-5-1:2003	EN 60947-5-1:1997 + A12:1999[c]	Date expired (01/05/2007)
	EN 60947-5-1:2004/A1:2009 IEC 60947-5-1:2003/A1:2009	[d]	Date expired (01/05/2012)
	EN 60947-5-1:2004/AC:2005		
Cenelec	EN 60947-5-2:2007 Low-voltage switchgear and control gear – Part 5-2: Control circuit devices and switching elements – Proximity switches IEC 60947-5-2:2007	EN 60947-5-2:1998 + A2:2004[c]	Date expired (01/11/2010)
	EN 60947-5-2:2007/A1:2012 IEC 60947-5-2:2007/A1:2012 (new)	[d]	01/11/2015

Cenelec	EN 60947-5-3:1999 Low-voltage switchgear and control gear – Part 5-3: Control circuit devices and switching elements – Requirements for proximity devices with defined behavior under fault conditions (PDF) IEC 60947-5-3:1999	Relevant generic standard(s)[c]	Date expired (01/05/2002)
	EN 60947-5-3:1999/A1:2005 IEC 60947-5-3:1999/A1:2005	[d]	Date expired (01/03/2008)
Cenelec	EN 60947-5-6:2000 Low-voltage switchgear and control gear – Part 5-6: Control circuit devices and switching elements – DC interface for proximity sensors and switching amplifiers (NAMUR) IEC 60947-5-6:1999	EN 50227:1997[c]	Date expired (01/01/2003)
Cenelec	EN 60947-5-7:2003 Low-voltage switchgear and control gear – Part 5-7: Control circuit devices and switching elements – Requirements for proximity devices with analogue output IEC 60947-5-7:2003	Relevant generic standard(s)[c]	Date expired (01/09/2006)
Cenelec	EN 60947-5-9:2007 Low-voltage switchgear and control gear – Part 5-9: Control circuit devices and switching elements – Flow rate switches IEC 60947-5-9:2006		
Cenelec	EN 60947-6-1:2005 Low-voltage switchgear and control gear – Part 6-1: Multiple function equipment – Transfer switching equipment IEC 60947-6-1:2005	EN 60947-6-1:1991 + A2:1997[c]	Date expired (01/10/2008)
Cenelec	EN 60947-6-2:2003 Low-voltage switchgear and control gear – Part 6-2: Multiple function equipment – Control and protective switching devices (or equipment) (CPS) IEC 60947-6-2:2002	EN 60947-6-2:1993 + A1:1997[c]	Date expired (01/09/2005)
	EN 60947-6-2:2003/A1:2007 IEC 60947-6-2:2002/A1:2007	[d]	Date expired (01/03/2010)

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 60947-8:2003 Low-voltage switchgear and control gear – Part 8: Control units for built-in thermal protection (PTC) for rotating electrical machines IEC 60947-8:2003	Relevant generic standard(s)[e]	Date expired (01/07/2006)
	EN 60947-8:2003/A1:2006 IEC 60947-8:2003/A1:2006	[d]	Date expired (01/10/2009)
	EN 60947-8:2003/A2:2012 IEC 60947-8:2003/A2:2011 (new)	[d]	22/06/2014
Cenelec	EN 60974-10:2007 Arc welding equipment – Part 10: Electromagnetic compatibility (EMC) requirements IEC 60974-10:2007	EN 60974-10:2003[c]	Date expired (01/12/2010)
Cenelec	EN 61000-3-2:2006 Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase) IEC 61000-3-2:2005	EN 61000-3-2:2000 + A2:2005[c]	Date expired (01/02/2009)
	EN 61000-3-2:2006/A1:2009 IEC 61000-3-2:2005/A1:2008	[d]	Date expired (01/07/2012)
	EN 61000-3-2:2006/A2:2009 IEC 61000-3-2:2005/A2:2009	[d]	Date expired (01/07/2012)
Cenelec	EN 61000-3-3:2008 Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection IEC 61000-3-3:2008	EN 61000-3-3:1995 + A1:2001 + A2:2005	Date expired (01/09/2011)
Cenelec	EN 61000-3-3:2013 (new) Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection IEC 61000-3-3:2013	EN 61000-3-3:2008[c]	18/06/2016

Cenelec	EN 61000-3-11:2000 Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection IEC 61000-3-11:2000	Relevant generic standard(s)[e]	Date expired (01/11/2003)
Cenelec	EN 61000-3-12:2005 Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase IEC 61000-3-12:2004	Relevant generic standard(s)[e]	Date expired (01/02/2008)
Cenelec	EN 61000-3-12:2011 Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase IEC 61000-3-12:2011 + IS1:2012	EN 61000-3-12:2005[c]	16/06/2014
Cenelec	EN 61000-6-1:2007 Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments IEC 61000-6-1:2005	EN 61000-6-1:2001[c]	Date expired (01/12/2009)
Cenelec	EN 61000-6-2:2005 Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments IEC 61000-6-2:2005	EN 61000-6-2:2001[c]	Date expired (01/06/2008)
	EN 61000-6-2:2005/AC:2005		

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 61000-6-3:2007 Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments IEC 61000-6-3:2006	EN 61000-6-3:2001 + A11:2004[c]	Date expired (01/12/2009)
	EN 61000-6-3:2007/A1:2011 IEC 61000-6-3:2006/A1:2010	[d]	Date expired (12/01/2014)
	EN 61000-6-3:2007/A1:2011/AC:2012 (new)		
Cenelec	EN 61000-6-4:2007 Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments IEC 61000-6-4:2006	EN 61000-6-4:2001[c]	Date expired (01/12/2009)
	EN 61000-6-4:2007/A1:2011 IEC 61000-6-4:2006/A1:2010	[d]	Date expired (12/01/2014)
Cenelec	EN 61008-1:2004 Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's) – Part 1: General rules IEC 61008-1:1996 (Modified) + A1:2002 (Modified)	EN 61008-1:1994 + A2:1995 + A14:1998[c]	Date expired (01/04/2009)
	EN 61008-1:2004/A12:2009	[d]	Date expired (01/12/2011)
Cenelec	EN 61008-1:2012 (new) Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules IEC 61008-1:2010 (Modified)	EN 61008-1:2004 and its amendment[c]	18/06/2017
Cenelec	EN 61009-1:2004 Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) – Part 1: General rules IEC 61009-1:1996 (Modified) + A1:2002 (Modified)	EN 61009-1:1994 + A1:1995 + A14:1998[c]	Date expired (01/04/2009)

	EN 61009-1:2004/A13:2009	[d]	Date expired (01/12/2011)
	EN 61009-1:2004/A12:2009	[d]	Date expired (01/12/2011)
	EN 61009-1:2004/AC:2006		
Cenelec	EN 61009-1:2012 (new) Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) – Part 1: General rules IEC 61009-1:2010 (Modified)	EN 61009-1:2004 and its amendments[c]	18/06/2017
Cenelec	EN 61131-2:2007 Programmable controllers – Part 2: Equipment requirements and tests IEC 61131-2:2007	EN 61131-2:2003[c]	Date expired (01/08/2010)
Cenelec	EN 61204-3:2000 Low voltage power supplies, DC output – Part 3: Electromagnetic compatibility (EMC) IEC 61204-3:2000	Relevant generic standard(s)[e]	Date expired (01/11/2003)
Cenelec	EN 61326-1:2006 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements IEC 61326-1:2005	EN 61326:1997 + A1:1998 + A2:2001 + A3:2003	Date expired (01/02/2009)
Cenelec	EN 61326-1:2013 (new) Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements IEC 61326-1:2012	EN 61326-1:2006[c]	14/08/2015
Cenelec	EN 61326-2-1:2006 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-1: Particular requirements – Test configurations, operational conditions and performance criteria for sensitive test and measurement equipment for EMC unprotected applications IEC 61326-2-1:2005	EN 61326:1997 + A1:1998 + A2:2001 + A3:2003	Date expired (01/02/2009)

(Continued)

TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 61326-2-1:2013 (new) Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-1: Particular requirements – Test configurations, operational conditions and performance criteria for sensitive test and measurement equipment for EMC unprotected applications IEC 61326-2-1:2012	EN 61326-2-1:2006[c]	06/11/2015
Cenelec	EN 61326-2-2:2006 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-2: Particular requirements – Test configurations, operational conditions and performance criteria for portable test, measuring and monitoring equipment used in low-voltage distribution systems IEC 61326-2-2:2005	EN 61326:1997 + A1:1998 + A2:2001 + A3:2003	Date expired (01/02/2009)
Cenelec	EN 61326-2-2:2013 (new) Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-2: Particular requirements – Test configurations, operational conditions and performance criteria for portable test, measuring and monitoring equipment used in low-voltage distribution systems IEC 61326-2-2:2012	EN 61326-2-2:2006[c]	06/11/2015
Cenelec	EN 61326-2-3:2006 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-3: Particular requirements – Test configuration, operational conditions and performance criteria for transducers with integrated or remote signal conditioning IEC 61326-2-3:2006	EN 61326:1997 + A1:1998 + A2:2001 + A3:2003	Date expired (01/08/2009)

Cenelec	EN 61326-2-3:2013 (new) Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-3: Particular requirements – Test configuration, operational conditions and performance criteria for transducers with integrated or remote signal conditioning IEC 61326-2-3:2012	EN 61326-2-3:2006[c]	14/08/2015
Cenelec	EN 61326-2-4:2006 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-4: Particular requirements – Test configurations, operational conditions and performance criteria for insulation monitoring devices according to IEC 61557-8 and for equipment for insulation fault location according to IEC 61557-9 IEC 61326-2-4:2006	EN 61326:1997 + A1:1998 + A2:2001 + A3:2003	Date expired (01/11/2009)
Cenelec	EN 61326-2-4:2013 (new) Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-4: Particular requirements – Test configurations, operational conditions and performance criteria for insulation monitoring devices according to IEC 61557-8 and for equipment for insulation fault location according to IEC 61557-9 IEC 61326-2-4:2012	EN 61326-2-4:2006[c]	14/08/2015
Cenelec	EN 61326-2-5:2006 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-5: Particular requirements – Test configurations, operational conditions and performance criteria for field devices with interfaces according to IEC 61784-1, CP 3/2 IEC 61326-2-5:2006	EN 61326:1997 + A1:1998 + A2:2001 + A3:2003	Date expired (01/09/2009)

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 61326-2-5:2013 (new) Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-5: Particular requirements – Test configurations, operational conditions and performance criteria for devices with field bus interfaces according to IEC 61784-1 IEC 61326-2-5:2012	EN 61326-2-5:2006[c]	06/11/2015
Cenelec	EN 61439-1:2009 Low-voltage switchgear and control gear assemblies – Part 1: General rules IEC 61439-1:2009 (Modified)	EN 60439-1:1999[c]	01/11/2014
	EN 61439-1:2009/AC:2013 (new)		
EN 61439-1:2009 does not give presumption of conformity without another part of the standard.			
Cenelec	EN 61439-1:2011 Low-voltage switchgear and control gear assemblies – Part 1: General rules IEC 61439-1:2011	EN 61439-1:2009[c]	23/09/2014
Cenelec	EN 61439-2:2009 Low-voltage switchgear and control gear assemblies – Part 2: Power switchgear and control gear assemblies IEC 61439-2:2009		
Cenelec	EN 61439-2:2011 Low-voltage switchgear and control gear assemblies – Part 2: Power switchgear and control gear assemblies IEC 61439-2:2011	EN 61439-2:2009[c]	23/09/2014
Cenelec	EN 61439-3:2012 Low-voltage switchgear and control gear assemblies – Part 3: Distribution boards intended to be operated by ordinary persons (DBO) IEC 61439-3:2012		

Cenelec	EN 61439-4:2013 **(new)** Low-voltage switchgear and control gear assemblies – Part 4: Particular requirements for assemblies for construction sites (ACS) IEC 61439-4:2012		
Cenelec	EN 61439-5:2011 Low-voltage switchgear and control gear assemblies – Part 5: Assemblies for power distribution in public networks IEC 61439-5:2010		
Cenelec	EN 61439-6:2012 **(new)** Low-voltage switchgear and control gear assemblies – Part 6: Busbar trunking systems (busways) IEC 61439-6:2012		
Cenelec	EN 61543:1995 Residual current-operated protective devices (RCDs) for household and similar use – Electromagnetic compatibility IEC 61543:1995	Relevant generic standard(s)[e]	Date expired (04/07/1998)
	EN 61543:1995/A11:2003	[d]	Date expired (01/03/2007)
	EN 61543:1995/A12:2005	[d]	Date expired (01/03/2008)
	EN 61543:1995/A2:2006 IEC 61543:1995/A2:2005	[d]	Date expired (01/12/2008)
	EN 61543:1995/AC:1997		
	EN 61543:1995/A11:2003/AC:2004		
Cenelec	EN 61547:2009 Equipment for general lighting purposes – EMC immunity requirements IEC 61547:2009 + IS1:2013	EN 61547:1995 + A1:2000	Date expired (01/07/2012)
Cenelec	EN 61557-12:2008 Electrical safety in low voltage distribution systems up to 1000 V AC and 1500 V DC. – Equipment for testing, measuring or monitoring of protective measures – Part 12: Performance measuring and monitoring devices (PMD) IEC 61557-12:2007		

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 61800-3:2004 Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods IEC 61800-3:2004	EN 61800-3:1996 + A11:2000[c]	Date expired (01/10/2007)
	EN 61800-3:2004/A1:2012 IEC 61800-3:2004/A1:2011	[d]	19/12/2014
Cenelec	EN 61812-1:1996 Specified time relays for industrial use – Part 1: Requirements and tests IEC 61812-1:1996		
	EN 61812-1:1996/A11:1999	[d]	Date expired (01/01/2002)
	EN 61812-1:1996/AC:1999		
Cenelec	EN 61812-1:2011 Time relays for industrial and residential use – Part 1: Requirements and tests IEC 61812-1:2011	EN 61812-1:1996 and its amendment[c]	29/06/2014
Cenelec	EN 62020:1998 Electrical accessories – Residual current monitors for household and similar uses (RCMs) IEC 62020:1998		
	EN 62020:1998/A1:2005 IEC 62020:1998/A1:2003 (Modified)	[d]	Date expired (01/03/2008)
Cenelec	EN 62026-1:2007 Low-voltage switchgear and control gear – Controller-device interfaces (CDIs) – Part 1: General rules IEC 62026-1:2007	Relevant generic standard(s)[c]	Date expired (01/09/2010)
EN 62026-1:2007 does not give presumption of conformity without another part of the standard.			
Cenelec	EN 62026-2:2013 **(new)** Low-voltage switchgear and control gear – Controller-device interfaces (CDIs) – Part 2: Actuator sensor interface (AS-i) IEC 62026-2:2008 (Modified)	EN 50295:1999[c]	03/12/2015

Cenelec	EN 62026-3:2009 Low-voltage switchgear and control gear – Controller-device interfaces (CDIs) – Part 3: Device Net IEC 62026-3:2008	Relevant generic standard(s)[c]	
Cenelec	EN 62026-7:2013 **(new)** Low-voltage switchgear and control gear – Controller-device interfaces (CDIs) – Part 7: CompoNet IEC 62026-7:2010 (Modified)		
Cenelec	EN 62040-2:2006 Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements IEC 62040-2:2005	EN 50091-2:1995[c]	Date expired (01/10/2008)
	EN 62040-2:2006/AC:2006		
Cenelec	EN 62052-11:2003 Electricity metering equipment (AC) – General requirements, tests and test conditions – Part 11: Metering equipment IEC 62052-11:2003	Relevant generic standard(s)[e]	Date expired (01/03/2006)
EN 62052-11:2003 does not give presumption of conformity without a part of the EN 62053 series.			
Cenelec	EN 62052-21:2004 Electricity metering equipment (AC.) – General requirements, tests and test conditions – Part 21: Tariff and load control equipment IEC 62052-21:2004	EN 61037:1992 + A1:1996 + A2:1998 + EN 61038:1992 + A1:1996 + A2:1998[c]	Date expired (01/07/2007)
EN 62052-21:2004 does not give presumption of conformity without a part of the EN 62054 series.			
Cenelec	EN 62053-11:2003 Electricity metering equipment (AC.) – Particular requirements – Part 11: Electromechanical meters for active energy (classes 0,5, 1 and 2) IEC 62053-11:2003	EN 60521:1995[c]	Date expired (01/03/2006)

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
Cenelec	EN 62053-21:2003 Electricity metering equipment (AC.) – Particular requirements – Part 21: Static meters for active energy (classes 1 and 2) IEC 62053-21:2003	EN 61036:1996 + A1:2000[c]	Date expired (01/03/2006)
Cenelec	EN 62053-22:2003 Electricity metering equipment (AC.) – Particular requirements – Part 22: Static meters for active energy (classes 0,2 S and 0,5 S) IEC 62053-22:2003	EN 60687:1992[c]	Date expired (01/03/2006)
Cenelec	EN 62053-23:2003 Electricity metering equipment AC.) – Particular requirements – Part 23: Static meters for reactive energy (classes 2 and 3) IEC 62053-23:2003	EN 61268:1996[c]	Date expired (01/03/2006)
Cenelec	EN 62054-11:2004 Electricity metering (AC.) – Tariff and load control – Part 11: Particular requirements for electronic ripple control receivers IEC 62054-11:2004	EN 61037:1992 + A1:1996 + A2:1998[c]	Date expired (01/07/2007)
Cenelec	EN 62054-21:2004 Electricity metering (AC.) – Tariff and load control – Part 21: Particular requirements for time switches IEC 62054-21:2004	EN 61038:1992 + A1:1996 + A2:1998[c]	Date expired (01/07/2007)
Cenelec	EN 62135-2:2008 Resistance welding equipment – Part 2: Electromagnetic compatibility (EMC) requirements IEC 62135-2:2007	EN 50240:2004[c]	Date expired (01/02/2011)
Cenelec	EN 62310-2:2007 Static transfer systems (STS) – Part 2: Electromagnetic compatibility (EMC) requirements IEC 62310-2:2006 (Modified)	Relevant generic standard(s)[c]	Date expired (01/09/2009)

Cenelec	EN 62423:2009 Type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses (Type B RCCBs and Type B RCBOs) IEC 62423:2007 (Modified)		
Cenelec	EN 62423:2012 **(new)** Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses IEC 62423:2009 (modified)	EN 62423:2009[c]	19/06/2017
Cenelec	EN 62606:2013 **(new)** General requirements for arc fault detection devices IEC 62606:2013 (modified)		
ETSI	EN 300 386 V1.4.1 Electromagnetic compatibility and radio spectrum matters (ERM); Telecommunication network equipment; Electromagnetic compatibility (EMC) requirements	EN 300 386 V1.3.3[c]	Date expired (31/07/2011)
ETSI	EN 300 386 V1.5.1 Electromagnetic compatibility and radio spectrum matters (ERM); Telecommunication network equipment; Electromagnetic compatibility (EMC) requirements	EN 300 386 V1.4.1[c]	Date expired (31/01/2014)
ETSI	EN 300 386 V1.6.1 Electromagnetic compatibility and radio spectrum matters (ERM); Telecommunication network equipment; Electromagnetic compatibility (EMC) requirements	EN 300 386 V1.5.1[c]	30/11/2015
ETSI	EN 301 489-1 V1.9.2 Electromagnetic compatibility and radio spectrum matters (ERM); Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements	EN 301 489-1 V1.8.1[c]	Date expired (30/06/2013)

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TABLE 1.11 (Continued)

ESO[a]	Reference and title of the harmonized standard (and reference document)	Reference of superseded standard	Date of cessation of presumption of conformity of superseded standard[b]
ETSI	EN 301 489-34 V1.1.1 Electromagnetic compatibility and radio spectrum matters (ERM); Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 34: Specific conditions for external power supply (EPS) for mobile phones		
ETSI	EN 301 489-34 V1.3.1 Electromagnetic compatibility and radio spectrum matters (ERM); Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 34: Specific conditions for external power supply (EPS) for mobile phones	EN 301 489-34 V1.1.1[c]	28/02/2014
ETSI	EN 301 489-34 V1.4.1 **(new)** Electromagnetic compatibility and radio spectrum matters (ERM); Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 34: Specific conditions for external power supply (EPS) for mobile phones	EN 301 489-34 V1.3.1[c]	28/02/2015

[a] ESO: European standardization organization: CEN, http://www.cen.eu; CENELEC, http://www.cenelec.eu; ETSI, http://www.etsi.eu.

[b] Generally the date of cessation of presumption of conformity will be the date of withdrawal ("dow"), set by the European standardization organization, but attention of users of these standards is drawn to the fact that in certain exceptional cases this can be otherwise.

[c] The new (or amended) standard has the same scope as the superseded standard. On the date stated, the superseded standard ceases to give presumption of conformity with the essential or other requirements of the relevant Union legislation.

[d] In the case of amendments, the referenced standard is EN CCCCC:YYYY, with its previous amendments, if any, and the new, quoted amendment. The superseded standard therefore consists of EN CCCCC:YYYY and its previous amendments, if any, but without the new quoted amendment. On the date stated, the superseded standard ceases to give presumption of conformity with the essential or other requirements of the relevant Union legislation.

[e] The new standard has a narrower scope than the superseded standard. On the date stated the (partially) superseded standard ceases to give a presumption of conformity with the essential or other requirements of the relevant European Union legislation for those products or services that fall within the scope of the new standard. Presumption of conformity with the essential or other requirements of the relevant European Union legislation for products or services that still fall within the scope of the (partially) superseded standard, but that do not fall within the scope of the new standard, is unaffected.

1.9 REVIEW PROBLEMS

Problem 1.1
Immunity to radiated emissions has a de facto standard and medical standard of ____ and ____ V/m respectively.

Problem 1.2
Immunity allow a system or equipment to function with no reduction in performance in the presence of EMI noise:

a) True
b) False.

Problem 1.3
FCC emission is limited to ______ at 3 m at 35.5 MHz.

Problem 1.4
The European Union has no limits on immunity to EMI noise:

a) True
b) False.

Problem 1.5
Construction of the communication house or signal bungalow may require the use of generic standards if the railway standards do not comply with the mission requirements:

a) True
b) False.

Problem 1.6
If you are checking emissions from the signaling system which European standard would you use?

Problem 1.7
To check whether an FM station is affecting your emission, using an OATS measurement at 3 m for signal system components, what is the maximum emission _______ V/m or ______dBμV/m?

1.10 ANSWERS TO REVIEW PROBLEMS

Problem 1.1
3 and 10 V/m respectively.

Problem 1.2
The ability of equipment or devices to function as required in the presence of EMI noise without a degradation in performance.

Problem 1.3
40 dBμ/m.

Problem 1.4
False.

Problem 1.5
True.

Problem 1.6
EN 50121-4:2006.

Problem 1.7
FCC emission limit regulations measured at 3 m, class B 44.7 μV/m or 33.0 dBμV/m.