

# Chapter 2

## Regulations and Standards



*If you make 10'000 regulations you destroy all respect for the law.*

— Winston Churchill

### 2.1 Big Picture

Products which are sold on the market should have the following properties:

- **Safety.** Be safe.
- **Health.** Do not be health threatening.
- **Environment.** Do not pollute the environment (e.g., RoHS).
- **Quality.** Fulfill expectations regarding quality.
- **Reliability.** Work reliably and as intended in their defined environment (e.g., EMC, temperature, humidity, and altitude).

In order to have only products on the market which fulfill the bullet points above, governments and their legislative bodies issue laws and directives, and products must be regulatory compliant according to this legislation.

A company that is the legal manufacturer of a product must prove compliance with the regulations. This is done with *conformity assessments*. In case a product contains electronics, an EMC conformity assessment is necessary. Such an EMC conformity assessment usually comprises the proof of:

1. The conformity of the product regarding the applicable EMC standards (EMC type testing).
2. The manufacturing process control (quality).

In nearly every country, electronic devices or machines on the market must be EMC compliant, meaning they must fulfill the EMC regulations and standards for the intended use of the products. What EMC regulations and standards are applicable for which product is defined by the country where the product is sold to the end customer.

## 2.2 EMC Compliance

*EMC compliance* means that an electronic or electromechanical product is compliant with the laws, directives, and regulations of the country where it is sold to the end customer.

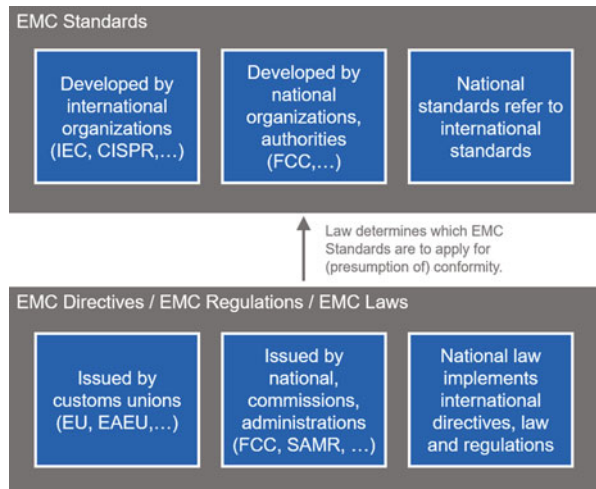
## 2.3 EMC Regulations

Every government defines its own *EMC regulations* (laws, directives) for its country. However, these national regulations often adopt multinational regulations (e.g., countries in the European Union refer to the EMC directive 2014/30/EU).

The government usually sets up or appoints an organization, commission, or committee responsible for defining the applicable EMC standards (see Fig. 2.1). Such organizations or committees define the applicable EMC standards so that products, which pass the tests defined in the applicable EMC standards, are then compliant with the EMC regulations (laws, directives).

Some authorities (administrations, organizations, commissions, committees) develop the applicable EMC standards for their countries or customs unions themselves. However, in most cases, the authorities adopt the content from the respective international EMC standards into their EMC standards or refer to the respective international EMC standards. Further information about specific countries and their responsible authorities for EMC regulations and standards can be found in Sect. 2.5.

**Fig. 2.1** EMC regulations through directives and standards



## 2.4 EMC Standards

The following chapters focus primarily on international *EMC standards* (IEC, CISPR) and not on local or country-specific standards.

### 2.4.1 What Are EMC Standards?

EMC standards define terms, rules, and test methods for EMC. Furthermore, they specify limits and minimum test levels for electric and electromagnetic emissions and immunity. Figure 2.2 shows a product and some commonly applied EMC standards for consumer electronic products.

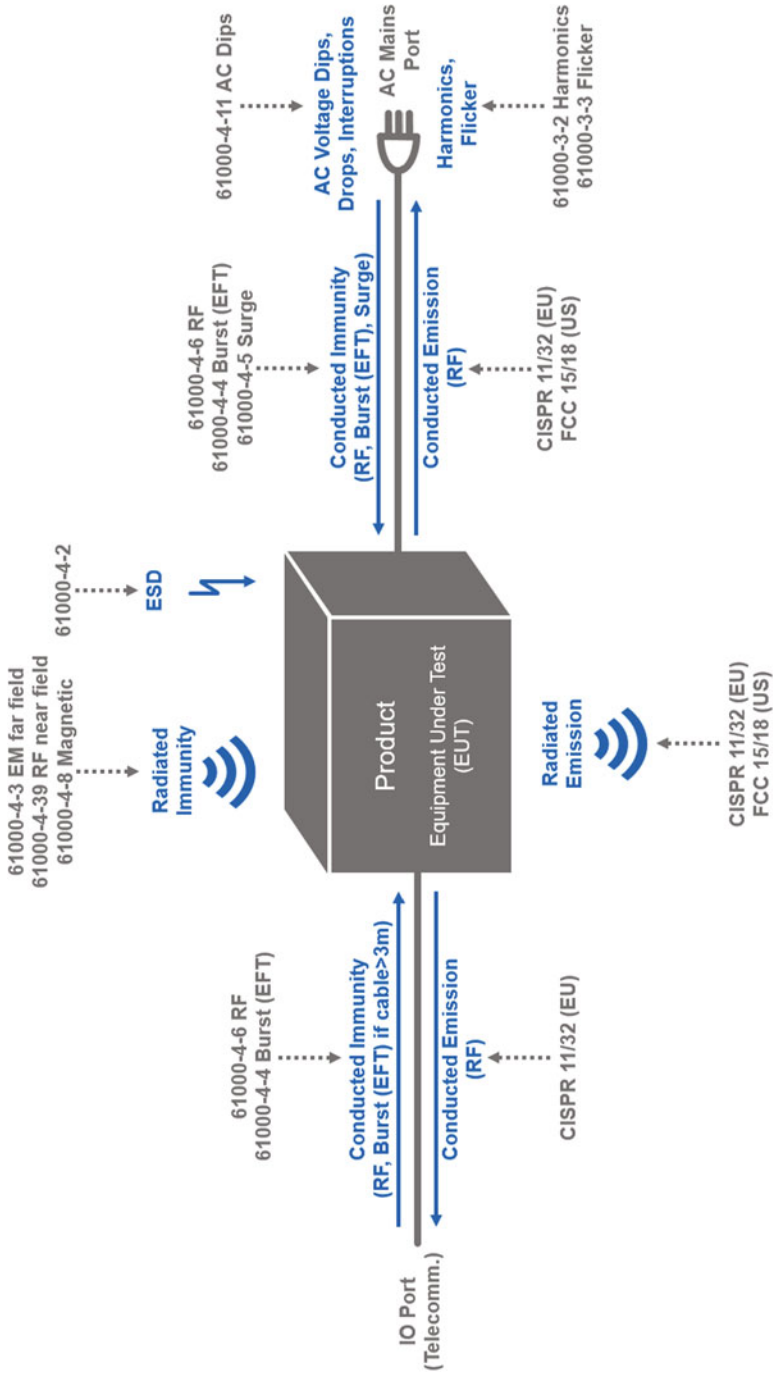
### 2.4.2 Why Do We Need EMC Standards?

EMC standards help make measurements comparable and repeatable by defining the test methods, test equipment, and test environment. Most importantly, EMC standards aim to bring harmonization to EMC testing, in the best case: global harmonization. Global harmonization of standards reduces trade barriers, and as a most important consequence for society, harmonized EMC standards help increase global prosperity and wealth.

### 2.4.3 Who Writes EMC Standards?

Standards in EMC are either developed by international, national, or regional organizations and committees on behalf of administrative bodies, or the administrative and/or regulatory bodies word the EMC standards and regulations themselves (e.g., FCC MP-5). Usually, the appointed administrative bodies (e.g., CENELEC for the EU, BSI for the UK, or ACMA for Australia) adopt the international EMC standards written by IEC/CISPR or ISO, word for word. The *International Electrotechnical Commission (IEC)* is the most important organization when it comes to EMC standards development. Within the IEC, the following committees have the lead:

- **IEC Technical Committee 77 (TC 77)**. The main scope of the TC 77 covers:
  - Immunity and related items, over the whole frequency range: Basic EMC Publications and Generic EMC Standards.
  - Emission in the low-frequency range ( $f \leq 9$  kHz, e.g., harmonics and voltage fluctuations): Basic, Generic, and Product (Family) EMC Standards.



**Fig. 2.2** Most commonly applied EMC standards for consumer electronic products with < 16 A/phase

- Emission in the high-frequency range ( $f > 9$  kHz): disturbances not covered by CISPR 10 (1992), in coordination with CISPR (e.g., mains signaling).
- **CISPR.** The main scope of CISPR is the protection of radio reception in the range 9 kHz to 400 GHz from interference caused by operation of electrical or electronic appliances and systems in the electromagnetic environment.

Here is a (not exhaustive) list of international and national organizations and committees which develop and/or define the applicable EMC standards:

- **International.**
  - IEC Committees for Basic and Generic EMC Standards:
    - . Technical Committee 77, Electromagnetic Compatibility (TC 77)
    - . International Special Committee on Radio Interference (CISPR)
  - IEC Committees for Product and Product Family EMC Standards.
  - IEC liaison partners:
    - . International Organization for Standardization (ISO)
    - . ITU Telecommunication Standardization Sector (ITU-T)
    - . International Council on Large Electric Systems (CIGRE)
    - . The Union of the Electricity Industry (Eurelectric)
    - . International Organization of Legal Metrology (OIML)
- **Australia.** Standards Australia (AS).
- **Azerbaijan, Armenia, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Uzbekistan, Ukraine.** Euro-Asian Council for Standardization, Metrology, and Certification (EASC).
- **Canada.** Canadian Standards Association (CSA).
- **China.** Standardization Administration of China (SAC, representing China in national ISO and IEC committees). SAC/TC79: National Radio Interference Standardization Technical Committee (the corresponding Chinese committee to IEC/CISPR). SAC/TC246: National Electromagnetic Compatibility Standardization Technical Committee (the corresponding Chinese committee to IEC/TC77).
- **European Union (EU).**
  - Comité Européen de Normalisation Electrotechniques (CENELEC)
  - European Telecommunications Standards Institute (ETSI)
  - International Council on Large Electric Systems (CIGRE)
  - European Committee for Standardization (CEN)
- **Germany.** The Deutsche Kommission Elektrotechnik Elektronik Informationstechnik (DKE) in DIN and VDE is the organization responsible in Germany for the development of standards, norms, and safety regulations in the fields of electrical engineering, electronics, and information technology.
- **India.** Generally: Bureau of Indian Standards (BIS). Additionally for telecommunication equipment: Telecommunication Engineering Centre (TEC).

- **Japan.**
  - Japanese Industrial Standards Committee (JISC)
  - Japanese Standards Association (JAS)
- **Korea.** Korean Standards Association (KSA).
- **New Zealand.** Standards New Zealand (NZS).
- **Russia.** Federal Agency for Technical Regulation and Metrology (GOST-R).
- **Singapore.** Info-Communications Media Development Authority (IMDA).
- **Turkey.** Turkish Standards Institution (TSE).
- **United Kingdom (UK).** British Standards Institution (BSI).
- **United States (USA).**
  - Association for the Advancement of Medical Instrumentation (AAMI)
  - American National Standards Institute (ANSI)
  - Department of Defense (DoD)
  - Federal Communications Commission (FCC)
  - Radio Technical Commission for Aeronautics (RTCA)
  - Society of Automotive Engineers (SAE)

#### 2.4.4 *EMC Emission Standards*

*EMC emission standards* define test methods and emission limits for conducted and radiated electromagnetic emissions. Examples of EMC emission standards for residential, commercial, and industrial products are:

- IEC 61000-3-2—Test methods for harmonic currents
- IEC 61000-3-3—Test methods for flicker
- IEC 61000-6-3—Emission limits for equipment in residential environments
- IEC 61000-6-4—Emission limits for equipment in industrial environments
- IEC 61000-6-8—Emission limits for commercial and light-industrial locations
- CISPR 11—RF emission limits and methods for ISM equipment
- CISPR 14-1—RF emission limits and methods for household appliances
- CISPR 32—RF emission limits and methods for multimedia equipment
- FCC Part 15—RF radiated and conducted emissions (RF devices)
- FCC Part 18—RF radiated and conducted emissions (ISM equipment)

#### 2.4.5 *EMC Immunity Standards*

*EMC immunity standards* define test methods and immunity test levels for conducted and radiated electromagnetic disturbances. Examples of EMC immunity standards for residential, commercial, and industrial products are:

- IEC 61000-4-2—Test methods for ESD
- IEC 61000-4-3—Test methods for RF radiated, far-field
- IEC 61000-4-4—Test method for burst (EFT) immunity
- IEC 61000-4-5—Test method for surge immunity
- IEC 61000-4-6—Test methods for RF conducted
- IEC 61000-4-8—Test methods for magnetic field immunity
- IEC 61000-4-11—Test methods for AC dips
- IEC 61000-4-39—Test methods for RF radiated, near-field
- IEC 61000-6-1—Immunity test levels for residential and light-industrial
- IEC 61000-6-2—Immunity test levels for industrial environments
- CISPR 14-2—Immunity test levels for household appliances and electric tools
- CISPR 35—Immunity test levels for multimedia equipment

*Performance criteria* are used to evaluate the immunity characteristics of the equipment under test (EUT) in the course of an EMC immunity test. In other words, performance criteria describe the loss of function or degradation of performance of the EUT. The pass/fail criteria of an immunity test case are specified in the EMC test plan before testing the EUT. These criteria are typically set to A, B, C, or D. The criteria A, B, C, and D are described in detail in the respective EMC immunity standard [3]:

- **Performance criterion A.** Normal performance within limits specified by the manufacturer, requestor, or purchaser.
- **Performance criterion B.** Temporary loss of function or degradation of performance which ceases after the disturbance ceases and from which the equipment under test recovers its normal performance, without operator intervention.
- **Performance criterion C.** Temporary loss of function or degradation of performance, the correction of which requires operator intervention.
- **Performance criterion D.** Loss of function or degradation of performance which is not recoverable, owing to damage to hardware or software or loss of data.

### 2.4.6 Types of EMC Standards

The following are classes or types of EMC standards (see Fig. 2.3):

- Basic EMC Publications
- EMC Product Standards
- EMC Product Family Standards
- Generic EMC Standards

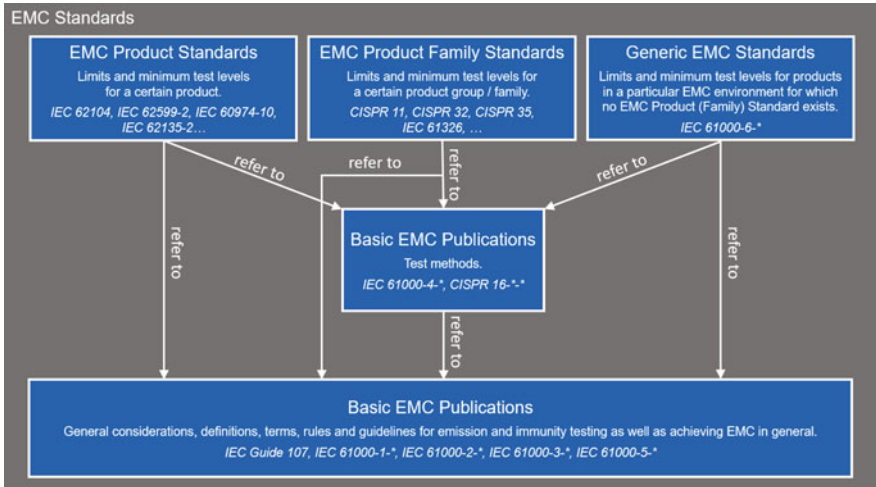


Fig. 2.3 Types of EMC standards and their dependencies

#### 2.4.6.1 Basic EMC Publications

*Basic EMC Publications* specify terms and conditions for EMC testing, define the rules necessary for achieving electromagnetic compatibility, specify test methods (testing techniques, test setup, test equipment, and environment), and so on. Basic EMC Publications are the EMC standards to which other EMC standards (EMC Product Standards, Generic EMC Standards, etc.) refer.

The IEC Basic EMC Publications are structured into the following categories [1]:

- **General.** Guidance on how to draft an EMC publication, definition of the EMC terminology and vocabulary, general considerations. Examples are IEC Guide 107, IEC 60050-161, IEC TR 61000-1-1, IEC 61000-1-xx, etc.
- **Environment.** Classification and description of different electromagnetic environments and compatibility levels. Examples are IEC TS 61000-2-5, IEC TR 61000-2-3, IEC 61000-2-xx, etc.
- **Emission.** Definition of test setups, testing techniques, test equipment, test environment, and other considerations regarding EMC emission testing and measurement. Examples are IEC 61000-3-2, IEC 61000-3-3, IEC 61000-3-xx, CISPR 16, etc. CISPR 16 is itself a series of publications specifying equipment and methods for measuring disturbances and immunity impacting them at frequencies above 9 kHz.
- **Immunity.** Definition of test setups, testing techniques, test equipment, test environment, and other considerations regarding EMC immunity testing. Examples are IEC 61000-4-1, IEC 61000-4-2, IEC 61000-4-3, IEC 61000-4-xx, etc.



- **Installation/Mitigation.** Installation and mitigation guidelines regarding earthing and cabling, mitigation of external electromagnetic influences, HEMP protection concepts, and so on. Examples are IEC TR 61000-5-1, IEC TR 61000-5-2, IEC 61000-5-xx, etc.

#### 2.4.6.2 EMC Product Standards

*EMC Product Standards* apply to particular products. EMC Product Standards refer to the relevant Basic EMC Publications (for that particular product) and specify the limits of emission and immunity (the minimum test levels).

Examples of EMC Product Standards are IEC 62104 (DAB receivers), IEC 61851-21 (electric road vehicles charging system), IEC 62599-2 (alarm and electronic security systems), etc.

#### 2.4.6.3 EMC Product Family Standards

*EMC Product Family Standards* apply to a group of products with common general characteristics and may operate in the same environment and have neighboring fields of application. EMC Product Family Standards refer to the relevant Basic EMC Publications (for that particular product) and specify the limits of emission and immunity (the minimum test levels).

Examples of EMC Product Family Standards are IEC 61967 (integrated circuits), IEC 61326 (electrical equipment for measurement, control, and laboratory use), and IEC 60947 (switchgear and controlgear).

#### 2.4.6.4 Generic EMC Standards

The *Generic EMC Standards* are for products operating in a particular EMC environment (residential/industrial), where a specific EMC Product (Family) Standard does not exist. They are general and somewhat simplified EMC Product Standards while referring to Basic EMC Publications for detailed measurement and test methods. Generic EMC Standards specify a limited number of emission and immunity tests and minimum test levels.

Examples of Generic EMC Standards are IEC 61000-6-1 (immunity standard for residential, commercial, and light-industrial environments), IEC 61000-6-2 (immunity standard for industrial environments), IEC 61000-6-3 (emission standard for equipment in residential environments), IEC 61000-6-4 (emission standard for industrial environments), and IEC 61000-6-8 (emission standard for professional equipment in commercial and light-industrial locations).

### 2.4.7 EMC Standards in Different Industries

Some industries require their own industry-specific EMC standards. Sometimes they are also called EMC Product (Family) Standards. Table 2.1 lists some popular international and industry-specific EMC standards, e.g., automotive, aviation, lightning, or medical.

**Table 2.1** EMC product (Family) standards and industry-specific EMC standard

EMC Product (Family) Standards			
	Emission	Immunity	Remark
<b>Automotive: Vehicles, boats</b> and internal combustion engines	CISPR 12 CISPR 25 CISPR 36	-	CISPR 36: Electric and hybrid electric road vehicles.
<b>Automotive: Road vehicles</b> - Vehicle test methods	-	ISO 11451 ISO 10605	Vehicles.
<b>Automotive: Road vehicles</b> - Component test methods	-	ISO 11452 ISO 7637 ISO 10605	Components.
<b>Avionics:</b> Airborne equipment, aircraft, helicopters	RTCA DO-160 EUROCAE ED-14		RTCA DO-160 and EUROCAE ED-14 are identically worded.
<b>Electricity metering equipment (AC)</b>	-	IEC 62052-11	
<b>Household: Household appliances</b> , electric tools and similar apparatus	CISPR 14-1	CISPR 14-2	
<b>Information technology equipment: ITE</b> , notebooks, telephones	CISPR 32	CISPR 35	CISPR 32 replaced CISPR 22 in 2017. CISPR 35 replaces CISPR 24 in 2022.
<b>Lightning: Electrical lighting</b> and similar equipment	CISPR 15	IEC 61547	
<b>Medical equipment:</b> Medical electrical equipment - General requirements for basic safety and essential performance - Collateral Standard: Electromagnetic disturbances - Requirements and tests	IEC 60601-1-2		
<b>Laboratory equipment:</b> Electrical equipment for measurement, control and laboratory use - EMC requirements	IEC 61326-1	IEC 61326-1	
<b>Medical IVD equipment:</b> Electrical equipment for measurement, control and laboratory use - EMC requirements	IEC 61326-2-6		
<b>Medical safety equipment:</b> Electrical equipment for measurement, control and laboratory use - Immunity requirements for safety-related systems and equipment	-	IEC 61326-3-1	
<b>Power unititles:</b> Communication networks and systems for power utility automation	IEC 61850-3		
<b>Relays: Measuring relays</b> and protection equipment	IEC 60255-26	IEC 60255-26	
<b>Residual current operated circuit-breakers</b> with integral overcurrentprotection for household and similar uses	IEC 61009-1		
<b>Ships</b> with a metallic hull: Electrical and electronic installations in ships - Electromagnetic compatibility (EMC)	IEC 60533	IEC 60533	

### 2.4.8 Which EMC Standards to Apply?

As mentioned above in Sect. 2.3, the applicable EMC standards are defined by the responsible governmental administrations, organizations, commissions, or committees. Therefore, the process of finding the applicable standards often differs from country to country. As an example, Fig. 2.4 shows a flow chart based on the EMCD Guide published by the European Commission [4].

Other useful tips:

- Contact the national authorities—where the product will be sold—for legal advice.
- Check which EMC standards your competitors apply.
- Ask your EMC test laboratory for advice on which EMC standards to apply.

## 2.5 Compliance Marks

Which compliance marks to go for? To decide if and which *compliance marks* you need for your product depends on which countries or customs unions (e.g., EU) you want to sell your product to.

Let's take a step back to the big picture of conformity marks: mandatory marks vs. nonmandatory marks.

1. **Mandatory conformity marks and labels.** Mandatory marks and labels are legally binding and have to be attached to the product. Examples of mandatory marks and labels are:

- **Australia and New Zealand.** RCM mark (Regulatory Compliance Mark).
- **Brazil.** ANATEL label (Agência Nacional de Telecomunicações).
- **Canada.** ISED label (Innovation, Science, and Economic Development).
- **China.** CCC mark (China Compulsory Certificate).
- **EEU (Russia).** EAC mark (Eurasian Conformity).
- **EU.** CE mark (Conformité Européenne).
- **Japan.** PSE mark (Product Safety Electrical Appliance and Material).
- **Republic of Korea (South Korea).** KC mark (Korean Certification).
- **Singapore.** IMDA label (Infocomm Media Development Authority).
- **Switzerland.** CH mark (Swiss Conformity Mark).
- **Taiwan.** BSMI mark (Bureau of Standards, Metrology, and Inspection).
- **UK.** UKCA (United Kingdom Conformity Assessed).
- **USA.** FCC mark (Federal Communications Commission).

2. **Nonmandatory conformity marks and labels.** Nonmandatory marks are not legally binding and are therefore optional. Examples of nonmandatory marks are:

- **Canada.** CSA (Canadian Standards Association).

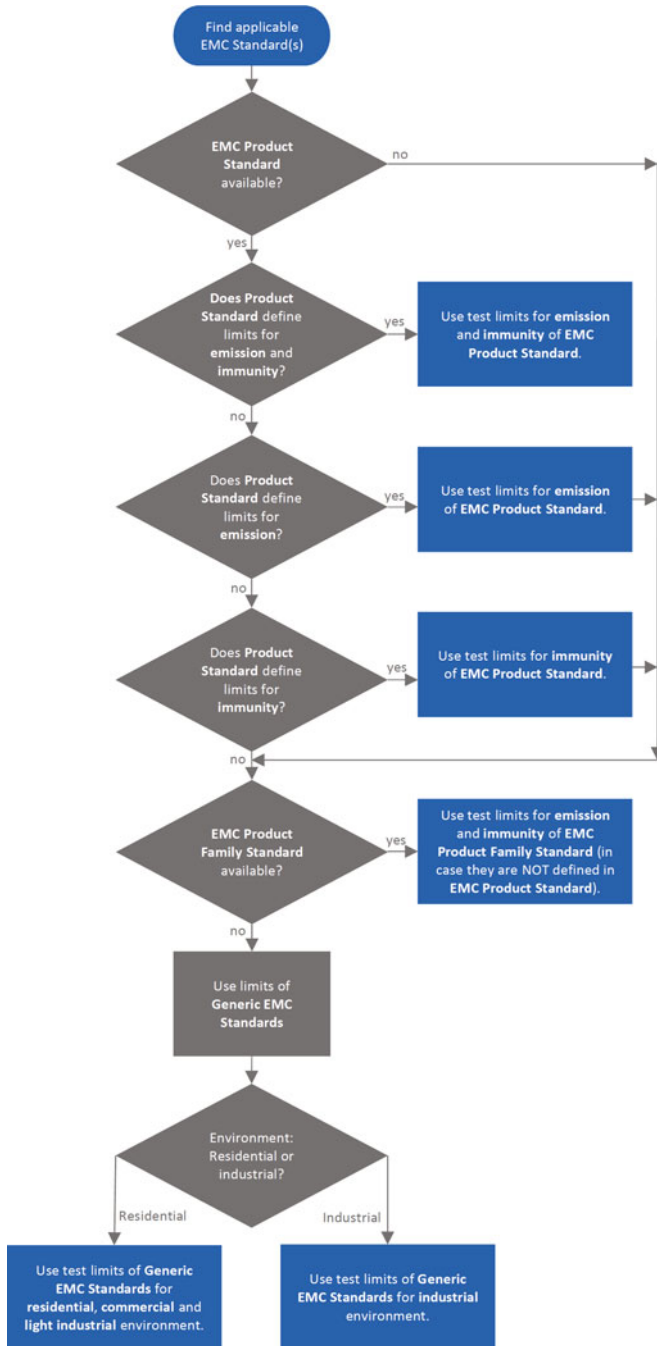


Fig. 2.4 Flow chart based on the EMCD Guide published by the European Commission [4]

- **Germany.** GS (Geprüfte Sicherheit).
- **Japan.** VCCI (Voluntary Control Council for Interference).
- **USA.** UL (Underwriters Laboratory).

More country-specific EMC regulations and requirements can be found in the Appendix in Chap. J.

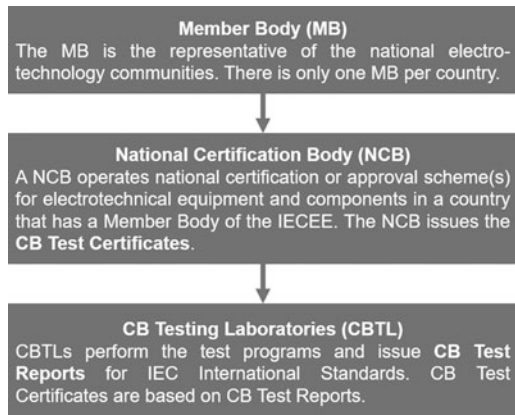
## 2.6 Global Market Access

Section 2.5 and Appendix J show that the situation regarding EMC regulations and standards can be confusing. However, there is a great way to get access to the global market with a single EMC test report: test your product according to the International Electrotechnical Commission for Electrical Equipment (IECEE) Certified Body (CB) Scheme. The IECEE CB Scheme is a system for mutual recognition of safety and EMC test certificates of conformity for over 50 countries. It is also a tool for accessing global markets directly when national authorities and regulators, retailers, buyers, and vendors accept CB test certificates and the associate test reports. The same concept of the IECEE CB Scheme does also apply for safety regulations and standards. Figure 2.5 shows the organizational hierarchy of the Member Body (there is one MB per country), the National Certification Body (NCB issues the CB test certificate), and the Certified Body Test Laboratories (CBTLs do perform the actual EMC testing).

This is how the EMC testing for global market access works:

1. **EMC testing.** Find a Certified Body EMC Test Lab (CBTL) and test your product according to the CB Scheme at this CBTL and obtain a CB EMC Test Report for your product. CBTLs are listed on the IECEE website [2].

**Fig. 2.5** Involved institutions for EMC testing for global market access



2. **CB test certificate.** Request a CB EMC Test Certificate at a National Certification Body (NCB) for your product. NCBs are listed on the IECEE website [2].
3. **Request market access.** To obtain a national EMC certification for a participating CB Scheme country without additional retesting of your product, you have to submit your CB EMC Test Certificate and CB EMC Test Report to the Notified Certified Body (NCB) of that country where you would like to get market access to. Countries that accept the CB Scheme are listed on the IECEE website [2].

## 2.7 Summary

**EMC compliance.** EMC compliance means that a product is compliant to the laws, directives, and regulations of the country where it is sold to the end customer.

**EMC standards.** Each country or customs union defines the applicable EMC standards itself.

**Global market access.** Testing a product according to the CB Scheme helps to get global market access (for over 50 countries) with minimum test effort.

## References

1. International Electrotechnical Commission (IEC). *Basic EMC Publications*. Feb. 12, 2021. URL: <https://www.iec.ch/basic-emc-publications>.
2. International Electrotechnical Commission for Electrical Equipment (IECEE). *About IECEE - CB Scheme*. Feb. 12, 2021. URL: <https://www.iecee.org/about/cb-scheme/>.
3. *Electromagnetic compatibility (EMC) – Part 4–5: Testing and measurement techniques – Surge immunity test*. International Electrotechnical Commission (IEC). 2014.
4. *Guide for the EMCD (Directive 2014/30/EU)*. European Commission (EC). Dec. 19, 2018.

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