

An overview of conducted EMI specifications for power supplies



Timothy Hegarty
Applications Engineer
Texas Instruments

Commercial products are generally designed to minimize the amount of electromagnetic interference (EMI) produced during normal operation.

Numerous governing bodies regulate the permissible levels of conducted and radiated emissions generated by an end product in order to maintain electromagnetic compatibility (EMC). The focus of this white paper is on EMI standards for conducted emissions, particularly those relevant to automotive, communications and industrial applications.

Power converters embedded within products for these market sectors demand high switching frequencies, advances in circuit topologies and high-speed switching power devices. EMI is an increasingly significant and challenging topic for fast-switching power converters [1], [2]. Moreover, the EMI filter required to achieve regulatory compliance can represent a significant portion of the overall system footprint, volume and cost. Thus, an understanding of the EMI standards pertaining to the application is essential.

EMI standards for automotive

From a regulatory standpoint, UNECE Regulation 10 [3], titled “Uniform provisions concerning the approval of vehicles with regard to electromagnetic

compatibility,” replaced the European Union (EU) Automotive EMC Directive 2004/104/EC in November 2014. UNECE Regulation 10 requires that manufacturers gain approval for all vehicles, electronic subassemblies (ESAs), components and separate technical units.

From an automotive electronic product designer’s perspective, the essential conducted emissions tests are those specified by CISPR 25 [4], [5], the fourth edition from 2016 being relevant at the time of this writing. This international standard applies to automotive components and modules, with measurements performed using one or two 5µH/50Ω artificial networks (ANs) depending on the grounding configuration. The standard refers to the “protection of onboard receivers,” with conducted noise measured over a frequency range from 150kHz to 108MHz in specific frequency bands. These frequency ranges are dispersed across the AM broadcast, FM broadcast and mobile service bands, as shown in **Figure 1**. CISPR 25 specifies conducted emission limits for peak (PK), quasi-peak (QP), and average (AVG) signal detectors.

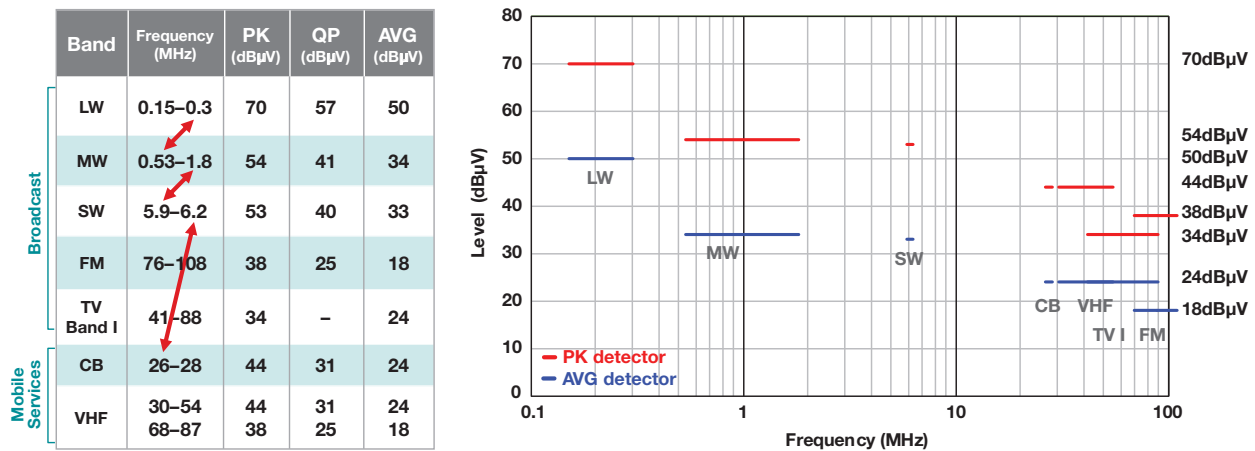


Figure 1. CISPR 25 Class 5 conducted emission limits.

Figure 1 also plots the relevant limit lines for Class 5, the most stringent requirement from CISPR 25. Even though higher noise spikes are theoretically allowed in the gaps between frequency bands, automotive manufacturers may choose to extend these frequency ranges according to their specific in-house requirements. The limits are quite challenging, particularly the 18dB μ V average (or 38dB μ V peak) limit in the VHF and FM bands spanning 68MHz to 108MHz. The filter components' parasitics degrade EMI filter attenuation at such frequencies.

EMI standards for IT and multimedia equipment

For many years, power-supply products marketed for communications and information technology (IT) end equipment within the EU have complied with the well-known European Standard EN 55022, derived principally from the CISPR 22 [6] product standard, with the Conformité Européenne (CE) Declaration of Conformity (DoC) [7] for external power supplies referencing EN 55022 to demonstrate compliance to the essential requirements of the EU's EMC Directive 2014/30/EU [8].

As an aside, European standardization organizations (ESOs) define and develop EU

harmonized standards. EN550xx standards come from European Committee for Electrotechnical Standardization (CENELEC), the other ESOs being the European Committee for Standardization (CEN) and European Telecommunications Standards Institute (ETSI). The EMC directive also requires publication of the references to these standards in the "Official Journal of the EU" (OJEU) in order for them to be harmonized and thus provide for a presumption of conformity.

Recently, however, CISPR 22/EN 55022 was subsumed into CISPR 32/EN 55032 [9]. This new emissions standard covers multimedia equipment and becomes effective as a harmonized standard [10] in compliance with the EMC directive. More pointedly, any product previously tested under EN 55022 that ships into the EU after March 2, 2017 must now meet the requirements of EN 55032. Equipment intended primarily for use in a residential environment must meet Class B limits, with all other equipment complying with Class A [11].

Figure 2 shows the EN 55022/32 Class A and Class B limits for conducted emissions with quasi-peak and average signal detectors over the applicable frequency range of 150kHz to 30MHz. Both quasi-peak and average limits must be satisfied.

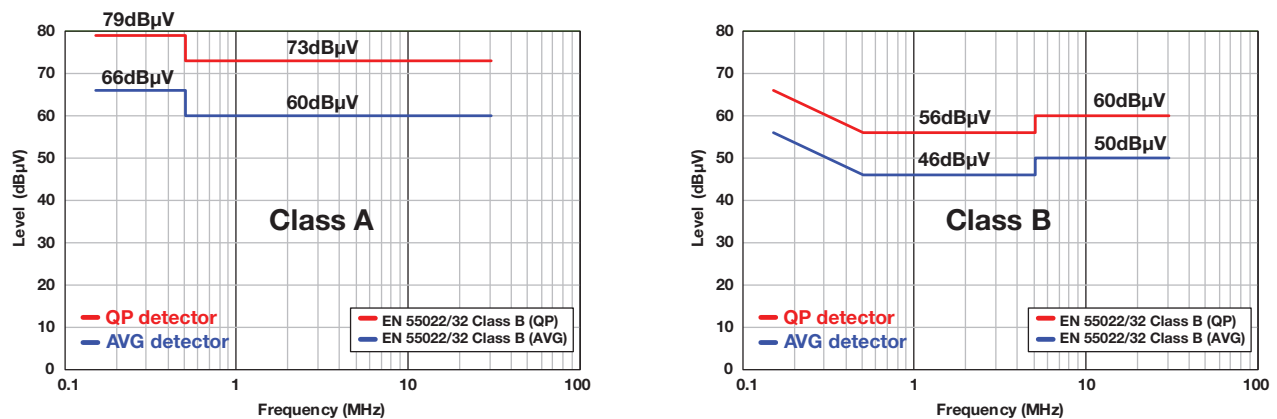


Figure 2. CISPR/EN 55022/32 Class A and Class B conducted emission limits.

Meanwhile, products designed for North American markets have complied with equivalent limits established by FCC Part 15 Subpart B for unintentional radiators [12]. Section 15.107 establishes conducted emissions limits equivalent to those in CISPR 22 and likewise measured with a 50 μ H/50 Ω V-type line impedance stabilization network (LISN). A DoC requires testing performed at an accredited test laboratory.

EMI standards for industrial equipment

CISPR 11 is the international product standard for EMI disturbances from industrial, scientific and medical (ISM) radio-frequency (RF) equipment [13]. Originally published in 1975, the sixth edition was released in 2015. CISPR 11 applies to a wide variety of equipment, including wireless power transfer (WPT) charging equipment, Wi-Fi® systems, induction cooking hobs and arc welders.

Equipment in Groups 1 and 2 are delineated with scope for general-purpose and RF-specific applications, respectively. Each group is further subdivided in two classes: Class A equipment is for use in all establishments other than domestic and may be measured on a test site or in situ; Class B covers domestic and is measured only on a test site

[14]. While CISPR 11 Class B uses the default limits as used for CISPR 22/32, limits for Class A depend on the equipment group and power level. Figure 3 provides CISPR 11 Class A limits using quasi-peak and average signal detectors.

In addition, “generic standards” are provided by the International Electrotechnical Commission (IEC) as well as their EN counterparts developed by the CENELEC. More specifically, IEC 61000-6-3 [15] applies to products targeted for residential/commercial/light-industrial applications [15], while IEC 61000-6-4 covers heavy-industrial environments [16].

Certain industrial end equipment may have dedicated system-level standards that direct EMC tests by referencing CISPR 11. For instance, IEC 61131-2 provides emission requirements for programmable controllers and their associated peripherals [17]. This applies to, for example, programmable logic controller (PLC) and programmable automation controller (PAC) component devices widely used in factory automation and process control applications. Other system-level standards include IEC 61800-3 and IEC 61326-1, which dictates EMC requirements for adjustable-speed motor drive systems [18] and laboratory equipment, respectively.

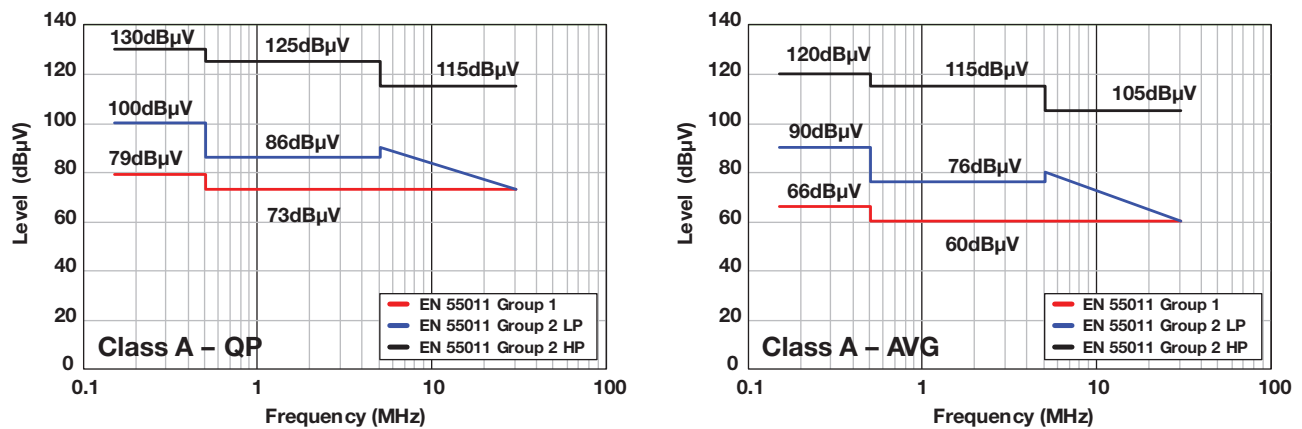


Figure 3. CISPR/EN 55011 Class A conducted emission limits.

EMI measurements

Virtually all CISPR-based test standards specify limits for conducted emissions measured up to 30MHz, except for CISPR 25, where the applicable upper frequency extends to 108MHz.

The three most commonly referenced harmonized standards for the purposes of the EMC Directive – EN 55011, EN 55014-1 and EN 55032 (based on CISPR 11, CISPR 14-1 and CISPR 32, respectively) – have measuring methods that are largely similar. EN 55015, based on CISPR 15 for lighting equipment, has a similar test, but the measurement range extends down to 9kHz for some apparatus.

Table 1 presents a synopsis of CISPR, EN and FCC standards for the relevant product sector.

Product sector	CISPR standard	EN standard	FCC standard
Automotive	CISPR 25	EN 55025	–
Multimedia	CISPR 32	EN 55032	Part 15
ISM	CISPR 11	EN 55011	Part 18
Household appliances, electric tools and similar apparatus	CISPR 14-1	EN 55014-1	–
Lighting equipment	CISPR 15	EN 55015	Part 15/18

Table 1. Summary of main product standards for conducted emissions.

Summary

EMI is often a highly vexing issue in a product's design and qualification cycle, and one that many system designers have great difficulty with. All products must generally meet some type of EMI performance metric, whether established in the product's design specifications or to comply with regulatory requirements. This discussion delved into EMI from the point of view of relevant standards, with an emphasis on conducted EMI phenomena specifically apropos the EMC requirements for automotive, communications and industrial end equipment.

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