Conducted Emissions Testing Procedure

Revision 1.0

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Revision History

Version	Release Date	Notes
1.0	April 2025	First draft

Table of Contents

Definitions

To ensure clarity in the analysis of electromagnetic emissions, especially in the context of compliance testing for PC power supply units (PSUs), the following key terms and concepts are defined:

Electromagnetic Interference (EMI)

EMI refers to unwanted electromagnetic energy that disrupts or degrades the performance of electronic equipment. EMI can originate from internal sources within the system or external sources such as nearby devices, and it is typically categorized into radiated and conducted emissions [1].

Electromagnetic Compatibility (EMC)

EMC is the ability of an electronic device or system to function properly in its electromagnetic environment without introducing intolerable electromagnetic disturbances to other devices in the vicinity [2]. Compliance with EMC standards ensures devices do not interfere with each other.

Conducted Emissions

Conducted emissions are high-frequency electrical noise signals that travel along power or signal lines. These emissions are generated within the electronic equipment (e.g., a PSU) and propagate through the mains cables. They are typically measured in the 150 kHz to 30 MHz frequency range.

Common Mode (CM) Emissions: Noise currents that flow in the same direction on both line and neutral conductors and return via ground. Often caused by parasitic coupling between circuits and ground.
Differential Mode (DM) Emissions: Noise currents that flow in opposite directions in the line and neutral conductors. Generally produced by asymmetries in the switching circuits of the PSU.

Radiated Emissions

Radiated emissions are electromagnetic waves emitted directly into the air from a device, typically due to high-frequency switching and layout characteristics. These emissions can couple into nearby equipment via air and cause interference.

Line Impedance Stabilization Network (LISN)

A LISN is a standardized test fixture used to measure conducted emissions. It provides a consistent impedance (usually 50 Ω) for the power lines and isolates the test equipment from the power source. It also allows emissions present on the power lines to be accurately measured by an EMI receiver or spectrum analyzer.

CISPR (Comité International Spécial des Perturbations Radioélectriques)

CISPR is a technical committee within the International Electrotechnical Commission (IEC) responsible for setting standards for controlling electromagnetic interference. CISPR 32 is one of its standards applicable to multimedia equipment.

EN55032 / CISPR 32

These are harmonized EMC standards that define limits and methods of measurement for radio disturbances of multimedia equipment, including PCs and their PSUs. EN55032 [3] is the European adoption of the international CISPR 32 standard. It includes requirements for both conducted and radiated emissions.

Decibel Microvolts (dBµV)

This is the unit used to express the magnitude of conducted and radiated emissions during EMC measurements. It is a logarithmic unit of voltage referenced to 1 µV.

Switching Mode Power Supply (SMPS)

A SMPS is a type of power supply that converts electrical power using high-frequency switching techniques, typically using a power transistor or MOSFET. While efficient, the switching action generates high-frequency noise, making SMPS units, significant sources of EMI.

Spectrum Analyzer / EMI Receiver

Test instruments used to measure and analyze the frequency and amplitude of emissions. EMI receivers are specifically designed to comply with EMC test standards and often include quasi-peak and average detectors as specified by CISPR.

Quasi-Peak Detector

A type of detector used in EMI testing that gives weight to both the amplitude and repetition rate of the signal. It is defined in CISPR standards and simulates how interference is perceived by analog radio receivers.

Prologue

Electromagnetic compatibility (EMC) is a critical consideration in the design and testing of electronic equipment [4]. In the context of personal computer (PC) power supply units (PSUs), ensuring that emissions are within regulatory limits is essential to avoid interference with other electronic devices and systems [5]. PC PSUs, due to their high-frequency switching circuits and wide input voltage ranges, can be significant sources of electromagnetic interference (EMI). This white paper focuses specifically on conducted emissions originating from PC PSUs under a representative 50W load, using test procedures and compliance criteria as defined in the EN55032 and CISPR 32 Class A standards.

EN55032, harmonized with CISPR 32, governs the EMC requirements for multimedia equipment, which includes PC PSUs. These standards define both the test methodology and the allowable limits for both radiated and conducted emissions. While radiated emissions pertain to electromagnetic fields emitted into the surrounding environment, conducted emissions refer to unwanted electromagnetic noise that propagates through power lines, which can affect other equipment connected to the same electrical network [6].

ATX power supplies are widely used in consumer and industrial electronics, and as such, they must comply with electromagnetic interference (EMI) standards to ensure they do not cause harmful interference to other nearby devices. For Class B compliance under EN55032, which targets residential environments, the conducted emissions generated by the ATX power supply must fall within strict limits across the 150 kHz to 30 MHz frequency range. These emissions are measured using a Line Impedance Stabilization Network (LISN) and evaluated through various detector modes—specifically average, peak, and quasi-peak detection.

Types of Electromagnetic Emissions

Electromagnetic emissions from electronic devices are generally classified into two major categories [7]:

1. Radiated Emissions

Radiated emissions are electromagnetic waves emitted directly from the equipment into free space. In PC PSUs, sources of radiated emissions typically include:

- Switching components and transformers (due to rapid voltage and current changes).
- Printed circuit board (PCB) traces acting as unintended antennas.
- Cables connected to the PSU (e.g., AC power cord, DC outputs).

Radiated emissions are more challenging to control in complex systems and are tested in specialized environments like semi-anechoic chambers.

2. Conducted Emissions

Conducted emissions are high-frequency noise signals that travel along the power supply lines, typically in the range of 150 kHz to 30 MHz. These emissions originate from the PSU's switching activity and can affect the operation of other devices sharing the same mains supply [8]. They are subdivided into:

- Differential Mode (DM) Emissions: Noise currents that flow in opposite directions in the line and neutral conductors. They are typically generated by imbalances or nonlinearities in the power conversion circuitry.
- Common Mode (CM) Emissions: Noise currents that flow in the same direction through both the line and neutral conductors and return via the ground. CM emissions often result from parasitic capacitances between high-frequency nodes and ground, including PCB parasitic paths and transformer inter-winding capacitance.

Both types of conducted emissions can cause interference with other electronic equipment, making mitigation crucial [9].

Importance of Conducted Emissions Testing

For PC PSUs, which are mass-market components, maintaining low conducted emissions is vital to ensure compatibility in environments with numerous interconnected devices. Some of the most important reasons are:

- Regulatory Compliance: Regulatory bodies require equipment to meet specific conducted emissions limits to minimize interference risks.
- System Reliability: Excessive EMI can cause malfunction or degradation in nearby systems, especially in sensitive environments such as medical or industrial settings.
- Market Access: Products must pass EMC testing to be legally sold in many markets (e.g., EU, North America, Asia).
- Brand Reputation: Failures in EMC compliance can lead to product recalls or customer dissatisfaction.

Testing Standards

EN55032 is the European adaptation of CISPR 32, an international standard issued by the International Special Committee on Radio Interference (CISPR). It specifies limits and methods of measurement of radio disturbance characteristics of multimedia equipment with a rated AC mains supply voltage not exceeding 600 V.

- Class A Equipment: Intended for use in all establishments except domestic dwellings. Class A has more relaxed limits compared to Class B.
- Class B Equipment: Intended for use in residential environments, including domestic dwellings. Class B has stricter emission limits compared to Class A to ensure minimal interference with sensitive home devices such as radios, televisions, and communication equipment.

- Frequency Range for Conducted Emissions: 150 kHz to 30 MHz.
- Measurement Setup: Conducted emissions are measured using a Line Impedance Stabilization Network (LISN), which standardizes the impedance of the power line and allows accurate measurements of conducted noise.
- Test Configuration: The equipment under test (EUT) is powered via the LISN, and the noise voltage on the mains lines is measured using a spectrum analyzer or EMI receiver.

The applicable conducted emissions limits (in dBμV) depend on frequency and are lower for Class B equipment, which is intended for residential environments. Class B equipment is subject to more stringent conducted emissions limits (measured in dBμV), especially at lower frequencies, to ensure compatibility with residential RF environments. Compliance with these tighter limits is essential for devices intended for consumer markets.

According to the Intel ATX Design Guide [10], a PSU "shall comply with FCC Part 15, EN55023 and CISPR 22, 5th ed., meeting Class B for both conducted and radiated emissions with a 4 dB margin". Since these standards have been updated, Cybenetics uses the newer ones, EN 55032 and CISPR 32, as previously discussed.

Detector Types

In conducted EMI testing, particularly for compliance with standards like EN55032, multiple detector types are used to assess the electromagnetic emissions of a device under test. The most commonly used detectors are Average (AVG), Peak (PK), and Quasi-Peak (QP). Each serves a specific purpose and applies a different measurement approach to evaluate how the emissions from a device might affect other electronics in the environment [11].

The Peak (PK) detector captures the highest amplitude of the signal within a given frequency band. It responds instantly to transients, making it a very sensitive and fast measurement method. The objective of the Peak measurement is to quickly identify the worst-case emission levels during a scan. It is often used as a first step to determine whether further, more detailed measurements (like Quasi-Peak) are necessary. Because Peak measurements are more permissive, devices often pass this test even if some emissions are close to the limit.

The Average (AVG) detector, on the other hand, smooths out short-term fluctuations by computing the average power level of emissions over a specific time window. This provides a better representation of how persistent the emissions are, particularly in terms of their potential to interfere with other electronic equipment in a typical use case. The Average detector is less responsive to brief spikes and focuses more on continuous or sustained interference.

The Quasi-Peak (QP) detector is perhaps the most challenging measurement in conducted EMI testing [12]. It is designed to weigh emissions based not only on amplitude but also on repetition rate. That means signals which occur more frequently are penalized more heavily than occasional bursts. The idea behind this is psychological and practical: frequent, low-level interference is more likely to be noticed and cause disruption than a rare high-level spike. QP detection uses a slower charging and discharging response curve, which mimics the response of traditional radio receivers to interference.

When comparing which test is harder to pass, the Quasi-Peak measurement is generally the most difficult. This is because it is more selective and penalizes both high amplitude and high repetition rate. A device that passes the Peak test might still fail the Quasi-Peak test if it emits many repetitive bursts of noise, even if those bursts aren’t very strong individually. As a result, Quasi-Peak testing is often used as the final determination of compliance in borderline cases.

Test Equipment

In a typical conducted emissions test setup for Class B equipment, the following components are connected in a specific configuration to ensure accurate and repeatable measurements:

DC Loader: FAST AUTO FA-828 ATE [13]: Used to simulate various load conditions on the power supply during EMI testing. It helps evaluate the performance and emissions of the Device Under Test (DUT) under dynamic current demands.

Figure 1: FA-828 ATE

Spectrum Analyzer: Rohde & Schwarz FPC 1500 [14]: A versatile spectrum analyzer used to measure the frequency and amplitude of conducted emissions. It provides high-resolution spectral data essential for EMI diagnostics and compliance verification.

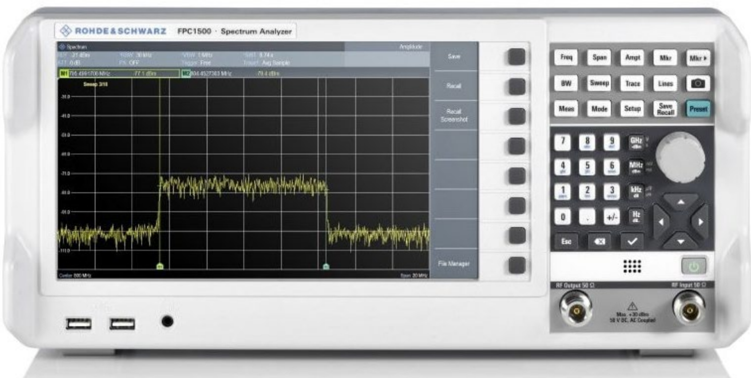


Figure 2: Rohde & Schwarz FPC 1500

Line Impedance Stabilization Network (LISN): TekBox TBLC08 [15]: The LISN is connected directly between the AC mains power source and the DUT. It performs two key functions: it isolates the test setup from external power line noise and provides a standardized impedance for accurate emission measurements. The LISN also routes conducted noise from the EUT to the measurement instrument.

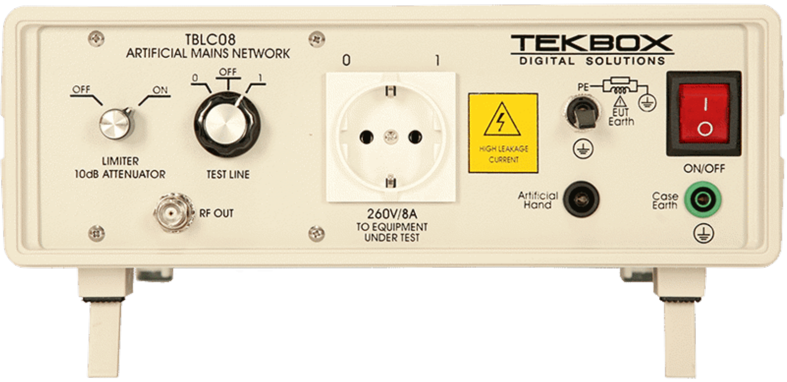
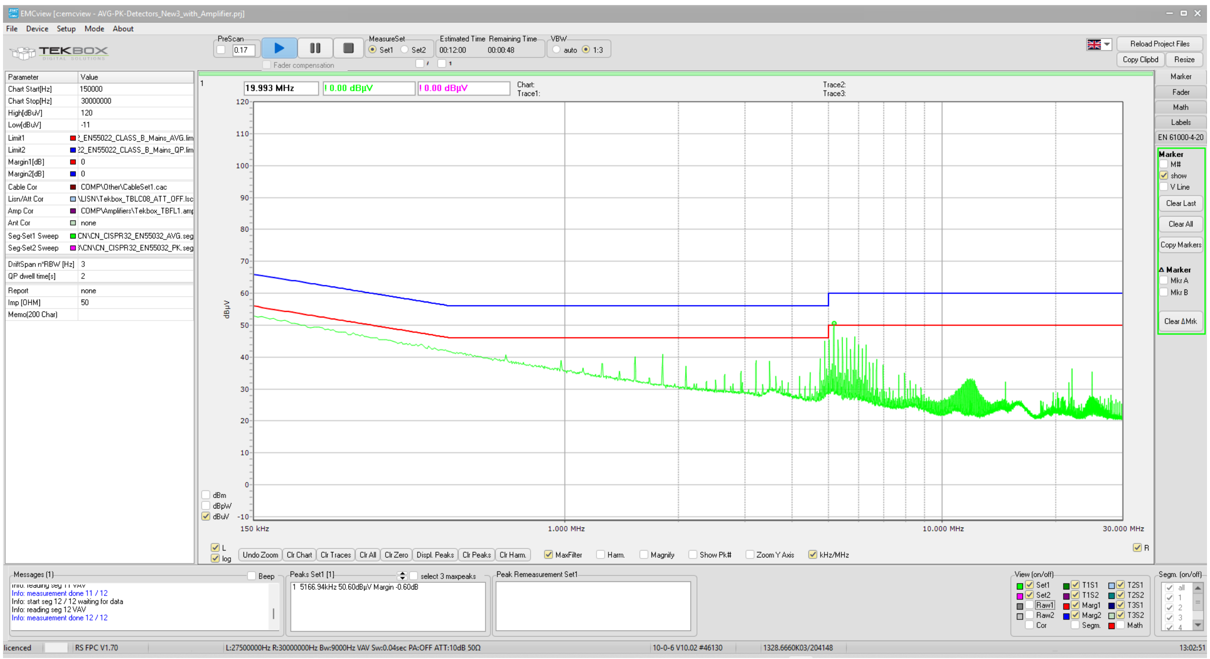


Figure 3: TEKBOX TBLC08

Testing Software

EMC View [16] is a user-friendly software tool designed for visualizing, analyzing, and logging EMI and EMC test data. Often used in conjunction with spectrum analyzers and EMI receivers, it allows users to view real-time conducted and radiated emissions, compare results against regulatory limits (such as EN55032 Class B), and generate test reports. Its intuitive interface makes it ideal for both pre-compliance testing and full compliance evaluations.



Testing Methodology

The EMI testing process begins with careful preparation of the equipment and setup, as the instruments involved are sensitive and can be damaged by incorrect handling. The operator must first ensure that all devices are powered off, and the LISN Test Line knob is in the off position. This precaution is essential to prevent unintentional signal flow that might damage the measurement instruments. Once verified, the ATX power cable is connected from the DUT to the DC electronic load (FA-828 ATE), which will later be used to apply a consistent and controlled load on the PSU during the test. Simultaneously, an AC power cable is connected from the LISN to the PSU, taking special care to match the line and neutral orientation correctly to avoid electrical faults.

After all connections are confirmed, the operator proceeds to power on the equipment in a specific sequence. First, the DC Loader is switched on, followed by the LISN, and then the Spectrum Analyzer (Rohde & Schwarz FPC 1500). The latter should be allowed to warm up for at least 30 minutes to ensure stable performance. Once the warm-up period is complete, the DUT is powered on. The operator then applies a 50-watt DC load to the PSU using the loader, initiating a 10-minute warm-up period for the PSU under load, which helps simulate realistic operating conditions.

With the system stable, the EMC View software is launched on a connected PC. The software is used to control the spectrum analyzer and display real-time measurement data. Within EMC View, the operator connects to the analyzer by navigating to the device menu and selecting the appropriate connection. Once connected, the relevant test file is loaded. This file contains preconfigured measurement settings and regulatory limits required for EN55032 Class B compliance.

To begin the conducted emissions testing, the LISN Test Line knob is turned from the off position to “0,” which activates the signal path for measurement. The average measurement is conducted first by selecting “Set 1” and starting the test. Results are displayed on a graph, where a red line represents the compliance limit for average emissions. Following this, the peak measurement is performed by selecting “Set 2” and clicking start. The blue line in this graph indicates the peak emissions limit. If the PSU passes the peak test, the testing process can conclude at this point. However, if it fails, the operator must proceed to perform the quasi-peak measurement by loading the appropriate test file and repeating the process.

Throughout the testing process, the EMC View software provides visual indicators of compliance, and any failures are clearly flagged below the graph. The user has the option to toggle the display of measurement limit lines for clarity and can also edit test report attributes via the device menu. Upon completion, the results are saved by exporting the charts and traces to a designated folder, and printed or saved as image files for documentation purposes.

The shutdown process must be performed carefully to protect the equipment. The LISN Test Line knob is returned to the off position first. Then, the DC Load is stopped, followed by powering down the DUT. Once these components are off, the remaining devices—LISN, Spectrum Analyzer, and DC Loader—can be turned off in any order. This structured procedure ensures accurate EMI measurement while maintaining the safety and longevity of the test equipment.

Results and Interpretation

A compliant ATX PSU must exhibit emissions levels below the defined limits across all relevant frequency bands. These limits are frequency-dependent and typically decrease as the frequency increases. The results are displayed graphically in EMC View software, where the emission values (measured in dBµV) are plotted against the frequency spectrum. Horizontal lines on the graph represent the regulatory limits: the red line for average limits and the blue line for peak limits. If the emission trace remains entirely under these lines, the device is considered compliant for that test mode.

A 4 dBµV margin is typically applied during the evaluation phase as per the Intel Design Guide, to provide a buffer zone between the measured emission levels and the regulatory limit. This margin accounts for potential measurement uncertainties, environmental variations, and repeatability differences that may occur during formal compliance testing in certified labs. For example, if a particular emission is measured at 44 dBµV, and the limit at that frequency is 48 dBµV, the result is interpreted as "passing with a 4 dBµV margin." This buffer provides confidence that even with slight variations in test conditions, the product is still likely to comply under more rigorous certification environments.

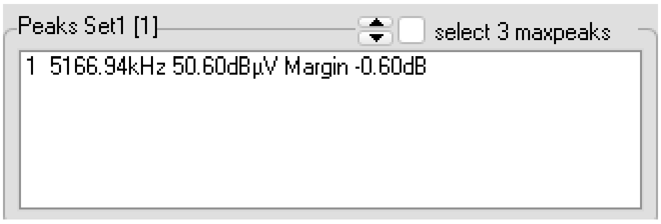


Figure 4: Example of pass with the 4dBmV margin

If any emission peak exceeds the limit with the 4 dBµV margin, it gets flagged for further analysis. While the device may still technically pass the test, it is often advisable to optimize the design or improve shielding to reduce emissions, especially if the product is nearing production.

Peak measurements are quick and catch the highest emission levels, Average measurements assess continuous noise levels, and Quasi-Peak measurements provide a realistic middle ground by evaluating both the strength and frequency of emissions. Quasi-Peak is typically run after a DUT fails to pass. It is the most demanding, as it aligns more closely with how interference affects real-world radio and electronic systems, and is often the deciding factor in pass/fail compliance outcomes.

Table 1 presents the official limits for conducted emissions [17]:

EN55032 / CISPR 32	Limit dB(µV)	
Frequency Range (MHz)	**Quasi-peak**	**Average**

0.15 - 0.50	66 to 56	56 to 46
0.50 - 5	56	46
5 - 30	60	50

Table 1: Conducted Emissions Limits

Epilogue

Conducted emissions represent a significant aspect of electromagnetic compatibility testing, particularly in switch-mode power supplies like those used in PCs. By adhering to standards such as EN55032 and CISPR 32, designers and manufacturers can ensure that their products do not cause excessive interference in typical usage environments.

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