## EMI Filter

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### 6 Supplement

1. Source Voltages in the World
1 What Is Noise?

Noises refers to unwanted variations or fluctuations in voltage, current, signals, etc. Noise comes in two types: natural noise and manmade noise. While natural noises are generated by a lightning strike or static electricity, manmade noises are generated by familiar devices such as industrial equipment, fluorescent bulbs, or communication equipment.

![Figure 1.1.1 What Is Noise?](Image 176x595 to 286x674)

2 Noise Sources

Typical devices that generate noise are switching power sources and general-purpose inverters. Such devices include switching elements such as FETs and IGBTs, and are major noise sources due to high-frequency switching of those elements.

![Figure 1.2.2 Inverter block diagram](Image 263x279 to 379x531)

3 What Is EMC?

EMC stands for electromagnetic compatibility, and refers to the ability of electrical equipment to have both EMI and EMS at once; the former indicates the ability to suppress noise radiated from the equipment itself and the latter means the ability to endure noise from other equipment.

What are EMC compliant products?
The EMC compliant products refer to those that meet standards required by EMI and EMS. They provide various types of parts that can deal with noise from the viewpoint of EMI and/or EMS. Our noise filters (hereinafter, “EMI filters”) are parts that mainly deal with conducted interference in terms of EMI.

![Figure 1.3.1 Concept of EMC](Image 710x80)
4 Propagation Paths of Noise

a. Conductive noise
   Refers to noise that propagates through a power line or PCB tracing.

b. Inductive noise
   Refers to noise that is induced due to electromagnetic or electrostatic induction caused by a power line or a signal line of a peripheral device when it is placed near a line or pattern in which noise current flows and propagates through the line.

c. Radiated noise
   Noise radiated by an antenna (or a line be having as an antenna) that propagates to other devices through the air.

5 Basics of Noise Reduction

The propagation of noise consists of a noise source, an entity that is affected by the noise, and propagation path that connects both. To reduce noise:
- Reduce the noise level of a noise source
- Make it more difficult for noise to propagate
- Make equipment less vulnerable to noise

In addition to the above, designs must consider standards, quality and cost of noise reduction methods.

6 Types of Conductive Noise

Noise is divided into two types based on its generation mode: normal mode noise and common mode noise. Normal mode noise is also called differential mode noise, and refers to noise generated between power lines. Common mode noise refers to noise generated between a power line and ground line.

![Figure 1.6.1 Noise Generation Paths](image)

7 Types of and Countermeasures for Noise

a. High-frequency noise
   Also called EMI noise or power supply noise and refers to high-frequency components such as the clock frequency of a computer and switching frequency of power sources. As an antinoise measure, an EMI filter should be installed on the input side. An appropriate filter should be selected based on requirements such as attenuation, mechanical design and cost.

![Figure 1.7.1 Example of Noise Reduction](image)
Output ripple noise from a switching power source is also a type of high-frequency noise. Ripple noise can be reduced with a DC filter designed for it.

As an antinoise measure, one could select a filter that attenuates noise because its choke coil gets saturated. As peak voltage may reach as high as a few thousand volts, generic filters may not be able to sufficiently attenuate noise because its choke coil gets saturated. As an antinoise measure, one could select a filter that uses an amorphous core for its superior pulse attenuation characteristic.

b. Pulse noise
This noise is generated when a relay or motor is driven. As peak voltage may reach as high as a few thousand volts, generic filters may not be able to sufficiently attenuate noise because its choke coil gets saturated. As an antinoise measure, one could select a filter that uses an amorphous core for its superior pulse attenuation characteristic.

c. Surge noise
This noise occurs when a natural discharge (such as lightning) affects a power line. As the generated voltage reaches as extremely high as a few kilovolts or more, EMI filters cannot suppress surge noise. As an antinoise measure, one could use a part such as a varistor to control surge voltage between power lines or between a power line and ground. EMI filters can withstand approximately 2 kV between power lines and approximately 4 kV between a power line and ground (these values are not guaranteed).

If surges are a concern, surge countermeasures should be selected and installed to handle the EMI filter’s capabilities.
1 Rated Voltage

The rated voltage is the maximum line voltage (nominal value) allowable to be used.
As the rated voltages for some parts used within an EMI filter are high in reality, however, voltages higher than the rated voltage of the EMI filter may be used without causing any trouble.
In fact, the rated voltages of filter components are often higher, in which case the filter can handle actual voltages that exceed its ratings.
In the case of some EMI filters, the maximum operation voltages are defined by specifications for them, separately from rated voltages.
Note that using EMI filters at voltages lower than their rated voltages do not pose any problems. For example, an EMI filter with a rated voltage of AC 250 V can be used for power lines of AC 100 V.
As for line frequency, EMI filters for AC power supply lines have been basically designed to be used with the commercial frequency (50 Hz/60 Hz). Higher frequencies such as 400 Hz can cause problems such as excessive capacitor heating.
Note that EMI filters for AC power lines can also be used for DC power supply lines.

2 Rated Current

The rated current is the maximum load current (nominal value) that can be continuously carried. If the ambient temperature is high, however, the load current needs to be derated.
Figure 2.2.1 shows an example of a derating characteristic.

![Derating Curve](image)

Figure 2.2.1 Derating Curve

This example indicates that when the maximum ambient temperature reaches 75, the EMI filter should be used with a load factor of approximately 60% (approximately 60% of the rated current) or lower.
Current higher than the rated current would be allowed to flow in EMI filters for a short period of time only. Inrush current (Up to 40 A or 10 times the rated current, single shots with a length of a few milliseconds) from devices such as a general switching power source does not cause any problems, but relatively long and/or repetitive peak current draws can result in the average current exceeding the filter's rating.

3 Test Voltage (Withstand Voltage)

The test voltage is a voltage value that is applied at the time of withstand voltage test. The withstand voltage test is to verify that the part does not break when applying a high voltage in a short period of time between a terminal (line) and the mounting plate (ground) of an EMI filter.
In the case of EMI filters for AC power lines, the test voltage is generally AC 2000 V or AC 2500 V.
In withstand voltage tests, the high voltage applied between a line and ground, results in abnormally high leakage current flow. When carrying out a withstand voltage test in an acceptance inspection, please set the cutoff current of withstand voltage test equipment to an appropriate value (the cutoff current defined in the specifications for the EMI filter).
For some EMI filters that have ground capacitors with extremely large capacity, DC voltages may be used for test voltages because the leakage current becomes too high when AC voltages are applied.

4 Insulation Resistance (Isolation Resistance)

Insulation resistance is a resistance value when applying a specified DC voltage (normally 500 V) between isolated conductors such as a terminal (line) and the mounting plate (ground), and regarded as one indicator of degree of insulation.
The insulation resistance is found by measuring the very small current that flows in an insulating material such as a resin case and capacitor when DC voltage is applied.

5 Leakage Current

The leakage current is an electric current that flows from the ground terminal of an EMI filter when the filter is connected to an AC power line.
Generally, as one sets the capacitance of a ground capacitor to a higher value, the reduction effect on common mode noise will be heightened and at the same time, the leakage current will increase.
Care must be taken, because large leakage current could cause a circuit breaker to trip or electric shock to occur when the EMI filter is not properly grounded.
Current (I) that flows from each power line to ground is represented with the following expression; it forms the basis of leakage current calculation.

\[ I = 2 \pi f C E \]

\( f \): Power frequency

\( C \): Capacitance between line and ground

\( E \): Power supply voltage between line and ground
6 DC Resistance

DC resistance is a resistance value between the input and output of an EMI filter (the sum of resistance values for both directions). It is mostly accounted for with the coil resistances but also includes connections between the coils and terminals. The voltage drop caused by an EMI filter is represented with the following expression:

**Voltage drop = DC resistance x Load current**

Note that specifications for some products define resistance values.

7 Temperature/Humidity

a. Operating temperature
   
   This is the range of ambient temperatures for which the product's usage is guaranteed. If an ambient temperature is high, the load current needs to be derated.

b. Operating humidity
   
   This is the range of ambient humidities for which the product's usage is guaranteed. It assumes no condensation.

c. Storage temperature and humidity
   
   The specified ranges of ambient temperatures and humidities that EMI filters in an unenergized state can be stored without deteriorating performance. No condensation is assumed for the storage humidity.

8 Circuitry

The following represents examples of EMI filter circuit structures.

a. Single-phase 1-stage filter

![Figure 2.8.1 Circuit Structure Example of a Single-phase 1-stage EMI Filter](image1)

This figure shows a standard circuit structure for single-phase EMI filters. L and CYs reduce the common mode noise; CXs and leakage inductance from L reduce the normal mode noise. R indicates a discharge resistance for capacitors.

b. Single-phase 2-stage EMI filter

![Figure 2.8.2 Circuit Structure Example of a Single-phase 2-stage EMI Filter](image2)

The above figure represents a circuit structure example of placing choke coils in two stages to improve the attenuation characteristic. The following graph shows an example comparison of attenuation characteristics for a 1-stage and 2-stage EMI filter.

![Figure 2.8.3 Example of Comparing Attenuation Characteristics between 1-stage and 2-stage EMI Filters](image3)
9  Safety Standards

a. General description of safety standards
The international standards consist of IEC standards which concern the electrical fields, and ISO standards which concern the non-electrical fields.

IEC
(International Electrotechnical Commission)
Standardization organization for standards related to the electrical fields; its headquarters is located in Switzerland. It releases technical standards for electricity based on the latest sciences and technologies, and each country develops its own specific safety standards based on the corresponding IEC standards.

CISPR
(Comité International Spécial des Perturbations Radioélectriques =International Special Committee on Radio Interference)
One of IEC’s special committees; it was established with the aim to integrate standards such as allowable values and measurement methods for interfering waves causing radio communication failures, and includes a standardization committee for EMC (Electro Magnetic Compatibility).

European Standard / EN Standard
(Europäische Norm=European Standard)
The EN Standard was created based on the IEC and CISPR standards, and consists of items almost similar to those in both standards. A unique number is assigned to each standard. (Example: IEC939 EN60939)

[An example of Certification Authorities in Europe based on EN Standard]

<table>
<thead>
<tr>
<th>VDE</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUV</td>
<td>Germany</td>
</tr>
<tr>
<td>DEMKO</td>
<td>Denmark</td>
</tr>
<tr>
<td>SEMKO</td>
<td>Sweden</td>
</tr>
</tbody>
</table>

EN Standard: EN
Europe standard sign

Sequence number
Standard classification number

<table>
<thead>
<tr>
<th>Standard classification number</th>
<th>Reference standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN50000 series</td>
<td>General European standards</td>
</tr>
<tr>
<td>EN55000 series</td>
<td>CISPR standards</td>
</tr>
<tr>
<td>EN60000 series</td>
<td>IEC standards</td>
</tr>
</tbody>
</table>

b. Safety standards for EMI filters
Different products may conform to different safety standards and bear different approval marks (for use in different countries). Check the approved safety standards when considering purchasing them.

<table>
<thead>
<tr>
<th>IEC939</th>
<th>International standard</th>
<th>IEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN60939</td>
<td>EU</td>
<td>EN</td>
</tr>
<tr>
<td>UL1283</td>
<td>USA</td>
<td>UL</td>
</tr>
<tr>
<td>C22.2 No.8</td>
<td>Canada</td>
<td>CSA</td>
</tr>
</tbody>
</table>

c. CCC approval from China
EMI filters do not fall within the scope of CCC. (as of November 2011)
**Attenuation Characteristic (Static Characteristic)**

Attenuation characteristic provides a rough indication of noise reduction effect. The graph is derived from plotting an attenuation characteristic when connecting an EMI filter to a specified measurement circuit with frequency on the horizontal axis and with attenuation on the vertical axis.

The measurement methods are shown in Figure 2.10.1 and Figure 2.10.2. The attenuation is given as the ratio of U01 to U02, where U01 is output when EMI filters are not in the measured circuit and U02 is when an EMI filter is in the circuit, and normally expressed with the logarithm of that ratio in [dB].

\[
\text{Attenuation} = 20\log_{10} \left(\frac{U_{01}}{U_{02}}\right) \text{[dB]}
\]

U01: Generated voltage when an EMI filter is not inserted [V]
U02: Generated voltage when an EMI filter is inserted [V]

- An attenuation of 20 [dB] means that the noise level reduces to 1/10 of the one without an EMI filter.
- Similarly, 40 [dB] and 60 [dB] mean a 1/100 and 1/1000 reduction of the noise level, respectively.

**Attenuation Characteristics**

<table>
<thead>
<tr>
<th>Frequency [MHz]</th>
<th>0.01</th>
<th>0.1</th>
<th>1</th>
<th>10</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attenuation [dB]</td>
<td>0.00</td>
<td>0.6</td>
<td>3</td>
<td>30</td>
<td>70</td>
</tr>
</tbody>
</table>

**Pulse Attenuation Characteristic**

Figure 2.11.2 represents how much the EMI filter can attenuate pulse common mode noises, which may cause malfunctions of electronic equipment, connected to a power line. Figure 2.11.1 illustrates the measurement method.

When terminating the input and output of the EMI filter with 50Ω, and applying a specified pulse waveform on the input, pulse voltages appearing on the output are measured and plotted with the horizontal axis representing input pulse voltage and with the vertical axis representing output pulse voltage.
Selection of EMI Filters

Attenuation Characteristic (Static Characteristic)

Figure 2.10.1

Selection of EMI Filters

Attenuation Characteristic (Static Characteristic)

Figure 2.10.2

Selection of EMI Filters

Attenuation Characteristic (Static Characteristic)

Figure 2.10.3

Selection of EMI Filters

Pulse Attenuation Characteristic

Figure 2.11.1

Selection of EMI Filters

Table 2.12.1

Selection of EMI Filters

12 Ground Capacitor Codes

Many EMI filters can support various capacities of ground capacitors by specifying an appropriate code. The selectable ground capacitor codes depend on the types of EMI filters; the following table lists an example of ground capacitor codes and attenuation characteristics.

Table 2.12.1 Example of Ground Capacitor Codes (EAP series)

<table>
<thead>
<tr>
<th>Code</th>
<th>Leak Current (input 125/250V 60Hz)</th>
<th>Line to ground capacitor (nominal value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>5 µA / 10 µA max</td>
<td>Not Provided</td>
</tr>
<tr>
<td>101</td>
<td>12.5 µA / 25 µA max</td>
<td>100pF</td>
</tr>
<tr>
<td>221</td>
<td>25 µA / 50 µA max</td>
<td>220pF</td>
</tr>
<tr>
<td>331</td>
<td>37.5 µA / 75 µA max</td>
<td>330pF</td>
</tr>
<tr>
<td>471</td>
<td>50 µA / 100 µA max</td>
<td>470pF</td>
</tr>
<tr>
<td>681</td>
<td>75.5 µA / 150 µA max</td>
<td>680pF</td>
</tr>
<tr>
<td>102</td>
<td>0.13 mA / 0.25 mA max</td>
<td>1000pF</td>
</tr>
<tr>
<td>222</td>
<td>0.25 mA / 0.5 mA max</td>
<td>2200pF</td>
</tr>
<tr>
<td>332</td>
<td>0.38 mA / 0.75 mA max</td>
<td>3300pF</td>
</tr>
<tr>
<td>472</td>
<td>0.5 mA / 1.0 mA max</td>
<td>4700pF</td>
</tr>
</tbody>
</table>

Figure 2.13.1 Examples of DIN Rail Installation Type EMI Filters

Note that as this type of EMI filter may not produce proper noise attenuation with grounding through a DIN rail, one must connect the ground to the protective earth terminal (PE) of the EMI filter. For EMI filters that have two protective earth terminals, it can connect the ground to either one only.
b. Terminal block type: T
These types of EMI filters use a terminal block as their interface (if the standard product uses a connector).

Figure 2.13.2 Comparison between Standard Product and T-option Product


c. High permeability choke coil type (ultra low-frequency and ultra high attenuation): H
These types of EMI filters use the choke coil core with a high permeability core. These types improve the common mode attenuation characteristic for low frequencies compared to their standard products.

Figure 2.13.3 Example of Comparing Common Mode Attenuation Characteristics between Standard Product and H-option Product

*d. Hexagon socket head cap bolt type: S*
These types of EMI filters have a hexagon socket head cap (Allen) bolt in their terminal block instead of the standard bolt (cross recessed Philips hexagon head bolt). Customers can select the desired type of bolt for tools they are using.

Figure 2.13.4 Comparison between Standard Product and S-option Product

*e. With switch of line to ground capacitor type: G*
These types of Ultra high attenuation type for EU, with switch of line to ground capacitor.

Figure 2.13.5 Example of Comparing Common Mode Attenuation Characteristics between Standard Product and Ultra high attenuation type for EU Product

*f. Improve differential mode attenuation type: U*
These types of change the rated voltage 250V.

Figure 2.13.6 With switch of line to ground capacitor type (Customers use when Test Voltage)

*g. Ultra high attenuation type for EU: L*
These types of Ultra high attenuation type for EU.

Figure 2.13.7 Example of Comparing Differential Mode Attenuation Characteristics between Standard Product and L-option Product

<table>
<thead>
<tr>
<th>Standard Product</th>
<th>Option:G</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTA-50-683</td>
<td>FTA-50-335</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Product</th>
<th>Option:U</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTA-50-683</td>
<td>FTA-50-683-U</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Product</th>
<th>Option:L</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTB-150-663</td>
<td>FTB-150-355-L</td>
</tr>
</tbody>
</table>

Option code is possible combination.
Please contact us for more information.
1 Ground Wiring

When wiring an EMI filter with a ground wire, use a wire as thick and short as possible. A long ground wire will deteriorate attenuation of high frequencies due to inductance in the wire.

If customers connect the metal chassis of their EMI filter, they can obtain an effect similar to a short ground wire.

2 Input and Output Wiring

Separate input wires from output wires. If one binds input and output wires of EMI filters, or lays them close to each other, the filters may lose their proper attenuation effect because the high-frequency noise component may bypass them.

Twisting input (and/or output) wires in pairs can reduce noise.
1 Input and Output Impedance and Filter Circuit

The input/output impedances of a noise source and a load will have various optimal filter circuits. General EMI filters take a configuration of a low pass filter that combines L and C. If the expected attenuation effect cannot be obtained, impedances of noise source and load may be the reasons.

Table 4.1.1 Combinations of I/O Impedances and Optimal Filters

<table>
<thead>
<tr>
<th>Input impedance (Zi)</th>
<th>Output impedance (Zo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Figure 4.1.1 Input/output Impedances of an EMI Filter Circuit

2 EMI Filter Installation and Orientation

Generally, an EMI filter is placed in a way that the LINE terminal is connected to the input side, but it can also be used in a reverse configuration. However, it may end up producing a different attenuation effect.

If the internal circuit consists of a symmetric EMI filter (one of the NBC series or TBC series), the direction in which the filter is connected will not cause any difference in noise attenuation. But in the case of asymmetric ones, it may cause difference in the attenuation.

Figure 4.2.1 Direction in which an EMI Filter Is Attached and Connected

Figure 4.2.2 Example of Effect of Filter Orientation on Noise

Figure 4.2.3 TAC Series Circuit Diagram (Circuit Is Asymmetric)

Figure 4.2.4 TBC Series Circuit Diagram (Circuit Is Symmetric)
3 Combining Multiple EMI Filters

If one EMI filter cannot provide sufficient attenuation, the attenuation effect can be improved by connecting two filters in series. However, one must pay attention to the fact that it will result in combining the leakage current and voltage drop of two EMI filters.

When connecting two EMI filters, the direction in which they are connected may also cause difference in the attenuation characteristic. Figure 4.3.3 shows the results of comparing the attenuation characteristics (static characteristics) due to different directions in which two EMI filters are connected.

Figure 4.3.4 shows the actual sample noise characteristics caused by the connection directions.

Unlike the static characteristic data, connection 4 does not improve the attenuation in this case. This phenomenon occurred because the input and output impedances of the EMI filters were different from the conditions of static characteristics.

When trying to optimize the way EMI filters are connected, one must evaluate by checking actual noise levels.

4 External Ferrite Core

If one EMI filter cannot provide sufficient attenuation, the effect can be improved by inserting an external core.

Whether a core is inserted on the LINE side or on the LOAD side of an EMI filter may cause difference in the attenuation characteristic.

Just inserting on the LINE side a core whose performance is equal to or less than that of the internal choke coil does not contribute to reducing noise.

When inserting it on the LOAD side, it will produce a large attenuation effect because the circuit takes a configuration of a T-type EMI filter circuit.
1 CE Marking

For machines and electric products to be sold in the EU area, manufacturers are required to bear a CE mark to prove they are in compliance with safety requirements, quality control, and ecocide prevention. To be allowed to do so, they must meet appropriate EC directives. The following describes the EC directives that are applied to general machinery products:

a. Machinery directive
This directive covers products that are an assembly of parts and have a driving section (with the central focus on industrial equipment).

b. EMC directive
This directive is intended to apply to electric parts which can be sources of radio disturbance or are affected by electromagnetic interference. It requires that two items, emission (EMI) and immunity (EMS), be met.

c. Low voltage directive
This directive is intended to apply to products that operate with a rated voltage in the range of 50 to 1000 V AC or 75 to 1500 V DC.

As there are no appropriate EC directives (including the ones described above) which apply to EMI filters, EMI filter products cannot bear a CE mark.

However, EMI filters can obtain an ENEC mark, which has a similar effect on bypassing application procedures of its signatories.

2 Conducted Emission EN61000-6-4

The voltages of interfering waves propagated through a power cable from equipment to the outside are measured with LISN in an open site or anechoic chamber.

- Refer to the description in “Terminology related to EMC Test” in this document.

3 Radiated Emission EN61000-6-4

When operating equipment, the strength of electromagnetic waves is measured in a range of specified frequencies at a location 3 or 10 m away from the equipment.

4 Power Supply Harmonic Current EN61000-3-2

One analyzes the frequencies of input currents and checks the value of the harmonic current for each order.

5 Electrostatic Discharge EN61000-4-2

This test simulates effects of electrostatic discharge (malfunctions or destruction of semiconductor elements) and includes contact discharge and aerial discharge in its scope.
5 EMC Test

6 Radio frequency electromagnetic field EN61000-4-3
This test checks immunities of equipment to effects of electromagnetic waves.

7 Fast Transient/Burst EN61000-4-4
This test checks immunities to burst waves by from injecting via cable pulses that resemble the results of a discharge.

8 Surge EN61000-4-5
This test checks immunities to surges by applying a specified surge waveform.

9 Conducted Radio-frequency Interference EN61000-4-6
This test checks immunities to conducted disturbances when electromagnetic waves pass into equipment through a cable.

10 Power Frequency Magnetic Field EN61000-4-8
This test checks immunities to magnetic fields generated by power frequency currents flowing through an input line or a power wiring.

11 Voltage Dip/Momentary Power Interruption EN61000-4-11
These tests check if equipment functions normally after momentary voltage drop, or power failure that decreases voltage to 0.

Figure 5.11.1 Example of a Waveform of Voltage Dips

12 Unit of Noise
Noise is represented with 1 [µV] as its reference in [dB]. It is assumed that 1 [µV] equals 0 [dBµV]. For example, 1 [V] is represented as follows:

\[
20 \log_{10} \frac{1}{1 \times 10^{-6}} = 120 \text{ [dBµV]}
\]

10 [V] ⇒ 140 [dBµV]
100 [V] ⇒ 160 [dBµV]
1000 [V] ⇒ 180 [dBµV]

13 Detection Method

a. Peak detection (PK)
It detects the heights of peaks of an output waveform.

b. Quasi-peak detection (QP)
It detects quasi-peaks through a circuit that has time constants at the time of charge and discharge. Quasi-peak detection value equals an intermediate value between peak and average ones. This detection has high measurement results when noise has a long duration or occurs frequently.

c. Average detection (AV)
It detects an average of values of an output waveform.

Figure 5.13.1 Relations between Detection Methods and Measurement Levels
### Conducted and Radiated Emission Limits (Excerpt)

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Conducted emission limit</th>
<th>Radiated emission limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1 - 50.5MHz</td>
<td>30 - 230MHz</td>
</tr>
<tr>
<td>QP</td>
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<td>0.15 - 0.5MHz</td>
<td>230MHz - 1GHz</td>
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<td>0.5 - 5MHz</td>
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<td>76 - 90</td>
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<td>50 - 60</td>
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<td></td>
<td>5 - 30MHz</td>
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<td>160 - 200</td>
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<td></td>
<td>60 - 76</td>
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<tr>
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<td>0.15 - 0.5MHz</td>
<td>230MHz - 1GHz</td>
</tr>
<tr>
<td></td>
<td>56 - 66</td>
<td>37 - 47</td>
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<td>76 - 90</td>
<td>300 - 500</td>
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**Note:** Refer to the description in “Terminology related to EMC Test” in this document.

(As of November 2011)
**Terminology related to EMC Test**

- **EUT**
  Stands for Equipment Under Test, and refers to equipment that will be tested or provided for a test.

- **Immunity test**
  Refers to a test to evaluate the durability of EUT against electromagnetic interference.

- **Emission test**
  Refers to a test to evaluate whether the strength of electromagnetic interference emitted from EUT exceeds a given limit.

- **Open site**
  Refers to an experimental facility installed outdoors to be used for activities such as EMC measurement.

- **Anechoic chamber**
  Refers to a facility to be used to create an electromagnetically isolated environment; the interior surfaces of the chamber absorb radio frequency waves.

- **CISPR**
  One of IEC’s special committees; it was established to integrate standards such as those for allowable values and measurement methods for interfering waves causing radio communication failures and includes a standardization committee for EMC (Electro Magnetic Compatibility).

- **Group 1 and Group 2 in EN55011**
  Group 1: Equipment for laboratories, healthcare, and sciences  
  (Example: frequency counters, spectrum analyzers, switching power source, and measuring apparatus)  
  Group 2: Industrial induction heating equipment, induction heating equipment, industrial microwave heating equipment, household microwave ovens, medical equipment, spark erosion equipment, and spot welders.

- **ISM equipment**
  Stands for Industrial, Scientific and Medical radio-frequency equipment and refers to radio-frequency equipment for industry, science, and health care.

- **LISN**
  Stands for Line Impedance Stabilization Network. It refers to equipment that sends noise components to a measurement device while monitoring impedances, looking at the power source from EUT. It is also called AMN (Artificial Mains Network).
# Source Voltages in the World

<table>
<thead>
<tr>
<th>Country</th>
<th>Single phase 2 wire</th>
<th>Three phase 4 wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>People’s Republic of China</td>
<td>220V</td>
<td>380V, 380V</td>
</tr>
<tr>
<td>Taiwan</td>
<td>110V, 220V</td>
<td>380V</td>
</tr>
<tr>
<td>India</td>
<td>230V, 240V</td>
<td>400V, 415V</td>
</tr>
<tr>
<td>Indonesia</td>
<td>220V</td>
<td>380V</td>
</tr>
<tr>
<td>Japan</td>
<td>100V, 200V</td>
<td>3 wire 200V</td>
</tr>
<tr>
<td>Korea</td>
<td>110V, 220V</td>
<td>200V, 380V</td>
</tr>
<tr>
<td>Philippines</td>
<td>220V, 230V, 240V</td>
<td>3 wire 480V</td>
</tr>
<tr>
<td>Singapore</td>
<td>230V, 240V</td>
<td>400V</td>
</tr>
<tr>
<td>Thailand</td>
<td>220V</td>
<td>380V</td>
</tr>
<tr>
<td>Malaysia</td>
<td>240V</td>
<td>415V</td>
</tr>
<tr>
<td>Egypt</td>
<td>220V</td>
<td>380V</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>127V, 220V</td>
<td>380V</td>
</tr>
<tr>
<td>Australia</td>
<td>240V</td>
<td>415V</td>
</tr>
<tr>
<td>New Zealand</td>
<td>230V, 240V</td>
<td>400V, 415V</td>
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<td>Austria</td>
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<td>Germany</td>
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<td>400V</td>
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<tr>
<td>UK</td>
<td>240V</td>
<td>415V</td>
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<tr>
<td>Netherlands</td>
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<tr>
<td>Italy</td>
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<td>Spain</td>
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<tr>
<td>Switzerland</td>
<td>230V</td>
<td>400V</td>
</tr>
<tr>
<td>Russia (former republics of the Soviet Union)</td>
<td>127V, 220V</td>
<td>380V</td>
</tr>
<tr>
<td>USA</td>
<td>120V, 265V, 277V</td>
<td>208V, 460V, 480V</td>
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<tr>
<td>Single phase 3 wire 115/230V, 120/240V, 240/480V</td>
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<td></td>
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<tr>
<td>Brazil</td>
<td>127V</td>
<td>400V, 220V</td>
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