MES

Mazda Engineering Standard

秘
CONFIDENTIAL
(INDEFINITELY)

Acceptable Scope of Release:
R&D Division

MES Classification:	**Automobile Parts Standard**
MES Description:	**ELECTRONIC COMPONENTS (7.6 7.7 7.8 7.9)**
MES No.:	**MES PW 67602A**

Distribution
General
Limited

Mazda Motor Corporation
3-1, Shinchi, Fuchu-cho, Aki-gun
Hiroshima, Japan

Date Established:	March 26, 2007
Date Revised:	March 1, 2011
Date Effective:	March 11, 2011

SI

1. The MES Number is stated on this cover sheet. The Number on the top right-hand side of each page of the text does not include any revision code (alphabetical suffix).

2. The effective date on this cover sheet shows the desired date of implementation. Implement these standards after coordinating any changes with related departments.

3. If there is any discrepancy between a standard and a drawing, follow the drawing.

Published by

Teruhisa Morishige
Manager
Standardization & Engineering
Information Administration Group
R&D Administration Dept.

Notices

1. Background of Establishment

This MES has been established due to separation of **MES PW 67600**.

2. Background of Revision

This MES has been revised to ensure proper quality.

3. Main Revised Points

(1) Inclusion of Ford EMC parts specification, **Ford EMCCS2009**

(2) Integration of reliability test items of **MES PW 67560E**

4. Explanation of SI Indications

Mark	Transition Phase	Description
SI	Third Phase	Only SI units are used in this standard without use of any previous unit. Example: 10 N

Contents

1. Purpose

This MES aims at assuring proper quality by standardizing specifications.

Remarks **1.** This MES, as a part of Specification Drawing, conveys the required specifications with **MES PW 67600** used in a pair.

2. In changing the suffix of this MES, the suffix of **MES PW 67600** as well shall be updated.

2. Scope

This MES describes Electromagnetic Compatibility (EMC) of electronic and electric components used for automobiles and specifies applicable tests and requirements.

Remark This MES and **MES PW 67600** apply to electronic and electric components in a pair.

3. Reporting of Evaluation Results

The quality evaluation results at development stage shall be submitted to the responsible Mazda Engineering Dept. based on the development sample size shown in **Table 1** (Evaluation Criteria). If the sample size is not specified in **Table 1**, determine the sample size by consultation with the Engineering Dept.

4. Definitions Conform to **section 4** of **MES PW 67600**.

5. Specifications Indicated on Specification Drawing Conform to **section 5** of **MES PW 67600**.

6. Evaluation Criteria Conform to **Table 1** below.

Table 1 Evaluation Criteria (1/5)

<table>
<tr><th>Evaluation Item</th><th>Evaluation Criteria
(2)</th><th>Qual-
ity
Rank</th><th>Eval.
Method</th><th>Dev.
Sample
Size (1)</th></tr>
<tr><td colspan="5">Radiated immunity</td></tr>
<tr><td>Electromagnetic field
(RI 11X)</td><td>
<table>
<tr><th></th><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr>
<tr><td>Level 1</td><td>I</td><td>I</td><td>I (*)</td></tr>
<tr><td>Level 2</td><td>I</td><td>II</td><td>II (*) (**)</td></tr>
</table>
Remarks
1. In (*), performance deterioration (e.g. strain) of audio, video and electric wave available apparatuses is permissible to some degree, however, it shall be defined on Specification Drawing and in the EMC test plan for quantification.
2. In (**), the volume level (measured with speaker terminal) of an audio unit shall not increase by 50 % or more.
</td><td>To be indicated on Specification Drawing.</td><td>7.6.1</td><td>2/2</td></tr>
</table>

Table 1 Evaluation Criteria (2/5)

<table>
<tr><th colspan="3">Evaluation Item</th><th>Evaluation Criteria ([2])</th><th>Quality Rank</th><th>Eval. Method</th><th>Dev. Sample Size ([1])</th></tr>
<tr><td colspan="7">Radiated immunity</td></tr>
<tr><td rowspan="4"></td><td colspan="2">(Specifications deleted)</td><td></td><td rowspan="4">To be indicated on Specification Drawing.</td><td>7.6.2</td><td>–</td></tr>
<tr><td rowspan="2">Coupling noise</td><td>Inductive transient noise (RI 130)</td><td><table><tr><td>Class 1</td><td>Class 2</td><td>Class 3</td></tr><tr><td>I</td><td>I</td><td>I</td></tr></table></td><td rowspan="2">7.6.3</td><td rowspan="2">2/2</td></tr>
<tr><td>Charging system noise (RI 150)</td><td><table><tr><td>Class 1</td><td>Class 2</td><td>Class 3</td></tr><tr><td>I</td><td>I</td><td>I</td></tr></table></td></tr>
<tr><td colspan="2">Magnetic field (RI 140)</td><td><table><tr><td>Class 1</td><td>Class 2</td><td>Class 3</td></tr><tr><td>I</td><td>I</td><td>I</td></tr></table></td><td>7.6.4</td><td>2/2</td></tr>
<tr><td colspan="7">Conducted immunity</td></tr>
<tr><td rowspan="3"></td><td colspan="2">Continuous noise (CI 210)</td><td><table><tr><td>Class 1</td><td>Class 2</td><td>Class 3</td></tr><tr><td>I</td><td>I</td><td>I</td></tr></table></td><td rowspan="3">To be indicated on Specification Drawing.</td><td>7.7.1</td><td>2/2</td></tr>
<tr><td colspan="2">Transient noise (CI 220)</td><td><table><tr><td></td><td>Class 1</td><td>Class 2</td><td>Class 3</td></tr><tr><td>Pulse A1/A2</td><td>II</td><td>II</td><td>II</td></tr><tr><td>Pulse C</td><td>I</td><td>I</td><td>I</td></tr><tr><td>Pulse E</td><td>II</td><td>II</td><td>II</td></tr><tr><td>Pulse F1</td><td>I</td><td>I</td><td>I</td></tr><tr><td>Pulse F2</td><td>II</td><td>II</td><td>II</td></tr><tr><td>Pulse G1/G2 (Load dump)</td><td>II</td><td>III</td><td>III</td></tr></table></td><td>7.7.2</td><td>2/2</td></tr>
<tr><td>Power voltage fluctu-ations</td><td>Power cycle (CI 230)</td><td><table><tr><td></td><td>Class 1</td><td>Class 2</td><td>Class 3</td></tr><tr><td>Waveform A</td><td>II</td><td>II</td><td>II</td></tr><tr><td>Waveform B</td><td>II (*)</td><td>II</td><td>II</td></tr><tr><td>Waveform C</td><td>II</td><td>II</td><td>II</td></tr><tr><td>Waveform D</td><td>II</td><td>II</td><td>II</td></tr></table>Remark In (*), I shall be applied to functions for engine start.</td><td>7.7.3.1</td><td>2/2</td></tr>
</table>

Table 1 Evaluation Criteria (3/5)

<table>
<tr><th colspan="2">Evaluation Item</th><th>Evaluation Criteria ([2])</th><th>Quality Rank</th><th>Eval. Method</th><th>Dev. Sample Size ([1])</th></tr>
<tr><td colspan="6">Conducted immunity</td></tr>
<tr><td>Power voltage fluctuations</td><td>Voltage drop (CI 260)</td><td><table><tr><th></th><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr><tr><td>Waveform A</td><td>II</td><td>II</td><td>II</td></tr><tr><td>Waveform B</td><td>II</td><td>II</td><td>II</td></tr><tr><td>Waveform C</td><td>I</td><td>I</td><td>I</td></tr><tr><td>Waveform D</td><td>II</td><td>II</td><td>II</td></tr><tr><td>Waveform E</td><td>II</td><td>II</td><td>II</td></tr><tr><td>Waveform F</td><td>II</td><td>II</td><td>II</td></tr><tr><td>Waveform G</td><td>I (*)</td><td>I (*)</td><td>I (*)</td></tr></table>Remark In (*), II or III may be applied according to noise waveform or effect degree.
It should be clarified in the EMC Test Plan previously.</td><td rowspan="6">To be indicated on Specification Drawing.</td><td>7.7.3.2</td><td>2/2</td></tr>
<tr><td colspan="2">(Specifications deleted)</td><td>(Alternator load dump test shall be in accordance with test pulse G1/G2 of transient noise (CI 220) test.)</td><td>7.7.4</td><td>–</td></tr>
<tr><td colspan="2">Voltage offset (CI 250)</td><td><table><tr><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr><tr><td>I</td><td>I</td><td>I</td></tr></table></td><td>7.7.5</td><td>2/2</td></tr>
<tr><td rowspan="2">DC stress (CI 270)</td><td>Reverse power connection</td><td><table><tr><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr><tr><td>III</td><td>III</td><td>III</td></tr></table></td><td rowspan="2">7.7.6</td><td rowspan="2">2/2</td></tr>
<tr><td>Overvoltage</td><td><table><tr><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr><tr><td>II (*)</td><td>II (*)</td><td>III</td></tr></table>Remark In (*), I shall be applied to functions for engine start (e.g. PATS) only when the battery is connected in series.</td></tr>
<tr><td>Electro-static dis-charge (CI 280)</td><td>Non-energization</td><td><table><tr><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr><tr><td>IV</td><td>IV</td><td>IV</td></tr></table>Remark Parameters of components and each element in components, such as resistance, electrostatic capacity and leak current, shall be within their designated tolerances.</td><td>7.7.7</td><td>2/2</td></tr>
</table>

Table 1 Evaluation Criteria (4/5)

<table>
<tr><th colspan="2">Evaluation Item</th><th>Evaluation Criteria ([2])</th><th>Quality Rank</th><th>Eval. Method</th><th>Dev. Sample Size ([1])</th></tr>
<tr><td colspan="6">Conducted immunity</td></tr>
<tr><td>Electro-static dis-charge (CI 280)</td><td>Operation</td><td>
<table>
<tr><th></th><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr>
<tr><td>Aerial discharge: ±4 kV</td><td>I</td><td>I</td><td>I</td></tr>
<tr><td>Contact discharge: ±4 kV</td><td>I</td><td>I</td><td>I</td></tr>
<tr><td>Aerial discharge: ±6 kV</td><td>I</td><td>I</td><td>I</td></tr>
<tr><td>Contact discharge: ±6 kV</td><td>II</td><td>II</td><td>II</td></tr>
<tr><td>Aerial discharge: ±8 kV</td><td>II</td><td>II</td><td>II</td></tr>
<tr><td>Contact discharge: ±8 kV</td><td>II</td><td>II</td><td>II</td></tr>
<tr><td>Aerial discharge: ±15 kV</td><td>II</td><td>II</td><td>II</td></tr>
<tr><td>Aerial discharge: ±25 kV</td><td>II</td><td>II</td><td>II</td></tr>
</table>
Remark Parameters of components and each element in components, such as resistance, electrostatic capacity and leak current, shall be within their designated tolerances.</td><td rowspan="2">To be indicated on Specification Drawing.</td><td>7.7.7</td><td>2/2</td></tr>
<tr><td colspan="2">Abnormal connection (CI 290)</td><td>
<table>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr>
<tr><td>III</td><td>III</td><td>III</td></tr>
</table>
Remark For this test item only, “Not operated” shall also satisfy the criteria. In addition, power supply short-circuit or ground short-circuit may have some breakage if it has been approved by the EMC Test Plan previously.</td><td>7.7.8</td><td>2/2</td></tr>
</table>

Table 1 Evaluation Criteria (5/5)

Evaluation Item		Evaluation Criteria ([2])	Quality Rank	Eval. Method	Dev. Sample Size ([1])
Radiated emissions					
	Electric field (RE 310)	Shall be less than or equal to the limits as shown in **Tables 25** and **26**.	To be indicated on Specification Drawing.	**7.8.1**	2/2
Conducted emissions					
	Transient (CE 410)	Transient voltage generated shall be +75 V max. and –100 V min.	To be indicated on Specification Drawing.	**7.9.1**	2/2
	RF (CE 42X)	Shall be less than or equal to the limits shown in **Tables 30**, **32**, and **Fig. 49**.		**7.9.2**	2/2

Table 1; Notes ([1]) The following is the explanation of the development sample size in **Table 1**. (The supplier and the responsible Mazda Engineering Dept. shall discuss and decide the sample size for prototypes.)

Number of samples to be tested — $\boxed{3/3}$ — Number of samples to be recorded and reported

([2]) The evaluation criteria of EMC test shall satisfy EMC Function Priority Classification (I/II/III/IV) shown in **Table 1** corresponding to the functional importance classifications (Class 1/2/3) indicated on Specification Drawing. Unless any functional importance classifications are specified on Specification Drawing, class 1 shall be selected. The functional importance classifications and EMC Function Priority Classification are defined as shown in **Table 2** and **Table 3**.

Table 2 Functional Importance Classifications

Class 1:	A function that controls or affects vehicle's essential operation, or that will bring confusion to a driver or a user who uses any other roads if the essential operation is affected. This includes a function that causes an unintended change at which a driver will be surprised and that has no possibility of its safety being corrected immediately, such as engine stall/surge, steering/brake loss and airbag deployment.
Class 2:	A function that enhances the performance of class 1, although it is not essential to the operation or control of the vehicle.
Class 3:	A function that provides a convenience.

Table 3　EMC Function Priority Classification

I: The function shall operate as designed **([1])** (or so as to satisfy specified criteria) during and after exposure to a disturbance. II: The function may not exhibit as designed **([1])** to the specified level during and after exposure to a disturbance, but shall not affect the safety of the vehicle or shall be switched to a fail safe mode.　Furthermore, it shall not have a bad influence on customer satisfaction.　The function may automatically return to a normal condition or fail safe mode after the disturbance is removed, but it shall be in accordance with a fail safe recovery strategy.　It shall not affect permanent or temporary memory.　This class can be applied only when performance does not affect other related functions that require class 1. III: The function may not exhibit as designed **([1])** during and after exposure to a disturbance, but shall not affect the safety of the vehicle and of the passenger.　A simple driver's action **([2])** may be required to return the function to its normal condition after the disturbance is removed.　It shall not affect permanent memory.　This class can be applied only when performance does not affect other related functions that require class 1. IV: Damage, change in I/O parameters (resistance, electrostatic capacity, leak current, etc.) or permanent functional degradation shall not be suffered. Common to I to IV above: No visible fuming or fire shall occur during and after exposure to a disturbance.

Table 3; Notes ([1])　The designed performance used herein does not necessarily mean that it is the same as that specified on Specification Drawing (e.g. performance, error limits).　In the EMC test, the design levels shall be higher than such a level that it is recognizable that system operation is affected (i.e., users recognize the degradation in functionality or feel uneasy about it).

([2])　"Simple driver's action" is one of the following:

(a) Changing the power supply (equivalent to the vehicle ignition key) from ON to OFF and vise versa.

(b) Changing the power switch of an electronic component like a radio power switch.

(c) Reprogramming a clock or radio presets.

(d) Replacing a main fuse in the event of reverse battery connection.
(If a fuse ensures the protection of a component, fuse replacement shall be included in the "simple driver's action".　In that case, however, an approval shall be obtained from Mazda.)
Example: Protection against reverse battery connection in an audio unit.

7. Evaluation Methods

7.1 Common evaluation conditions　Conform to the following items in addition to **section 7.1** of **MES PW 67600**.

7.1.1 Positioning of EMC test　The purpose of this MES is to ensure electromagnetic compatibility (EMC) in a vehicle inside and between the vehicle and electromagnetic environment. This MES provides EMC requirements and testing methods for developing components independent of the vehicle itself.　Deviation from the requirements designated in this MES is acceptable only when the deviation is specified on Specification Drawing of applicable components.
Components shall satisfy not only the requirements designated herein, but also requirements designated by Mazda or related vehicle EMC requirements such as international standards and UN Standards (refer to **section 10** of **MES PW 67600**) available at the installation of them on the vehicle.

7.1.2 Positioning of this standard Requirements and testing methods described in this MES are based on the international standards as far as applicable part. If the international standards are not available, company standards shall be used. Unique requirements and testing methods shall be based on experience for better duplication of vehicular electromagnetic environment. If any discrepancy exists between this MES and reference documents, requirements of this MES shall be applied on a priority basis except for regulatory requirements. This MES applies to all components relating to EMC within the range of Specification Drawing. The following steps shall be taken to ensure components EMC with Mazda.

(a) Supplementary information required to classify functional importance classifications shall be provided. (Refer to **Table 2**.)
(b) Which test is applicable shall be indicated. (Refer to **section 7.1.7**.)
(c) Evaluation criteria of components shall be indicated.
(d) The EMC Test Plan shall be prepared. (Refer to **section 7.1.3 (8)** and **Annex 1**.)
(e) The test shall be performed in a test facility designated by Mazda.
(f) The test results and data (contents to be reported are shown in **sections 7.6** and **7.7**) shall be submitted to the responsible Mazda Engineering Dept.

It is very important that the supplier shall be responsible for determining evaluation criteria of components with Mazda. (step **(c)**).

To verify that this MES is satisfied, Mazda shall reserve the right to perform inspections and tests using sample components and to witness design verification.

7.1.3 Requirements common to tests

- All testing apparatuses shall be traceable to the international standards. In the case of use of external calibration services, calibration shall be made in accordance with **ISO 17025** (or recommendations suggested by the manufacturers of testing apparatuses).
- To reduce an unintended interaction between electromagnetic environments of test sample and testing apparatus, usage of the testing apparatus and facility shall be noted in both the emission and immunity tests.
- The testing apparatuses, test setup and testing procedures shall be documented as a part of procedures for test place. Mazda shall reserve the right to check the procedures for test place.
- Generally only one component is used for a test, however, a sub system with a plurality of components (e.g. dispersed audio units) may also be tested.
- All tests require an EMC Test Plan in compliance with the requirements of **Annex 1**. For detailed information, refer to **section 7.1.3 (8)**.

(1) Load simulator

The operation of the test sample shall be performed with a load simulator constituted so as to simulate the vehicle system. The load simulator shall be a shielded medium including all external connections (e.g. sensors, loads, etc.) generally found in test samples.

The load simulator shall be an RF boundary of harness of the test sample, and shall function as an interface for a test support apparatus and a monitor during a test. For detailed information, refer to **Annex 2**.

(2) Artificial network

For some tests of this MES, use of an artificial network is required. Unless otherwise specified herein, the use and connection of the network shall be in accordance with the setup shown in **Annex 2**. The design and performance of the artificial network shall satisfy **CISPR 25** and **ISO 7637**. For the tests which do not require use of an artificial network, the power supply shall be directly connected to the ground plane, load simulator and test sample.

(3) Wire harness for test

Electrical connection between the test sample and the load simulator shall be performed with a standard harness for test. Unless otherwise specified herein, the length of the harness shall be 1700^{+300}_{0} mm. The harness shall have the same specifications as those fitted on an actual vehicle (e.g. twisted pair cable). For some tests (e.g. CE 420), a shorter power wire is needed between the test sample and the measuring system. To avoid production of plural harnesses for test, production of a wire harness for test that enables selected circuits to be removed easily and that shortens their physical lengths (e.g. inline connector) is recommended.

(4) Connection of test sample, load simulator and artificial network to ground plane

The load simulator and artificial network shall be directly connected to the ground plane used for test setup with a screw. The connection impedance shall be confirmed to be under 2.5 mΩ. The same requirements are applied to a test sample with a metal case directly connected to the ground plane (shall be specified in the EMC Test Plan). Use of a conductive tape made of metal, etc. to the connected area is prohibited unless permission from Mazda is obtained. A concrete process at a test place to demonstrate that the connection impedance remains stable during a test is needed.

(5) Test conditions

(a) Tolerances

Unless otherwise specified, the tolerances shown in **Table 4** are applied.

Table 4 Tolerances

Voltage and current	±5 %
Time, length, resistance, capacitance, inductance, impedance	±10 %
Electric field or magnetic field strength, injection current, power, energy, test parameters of amplitude of transient voltage (if adjustable)	$^{+10}_{0}$ %

(b) Environmental test conditions

Unless otherwise specified, meteorological test conditions are defined in **Table 5**.

Table 5 Environmental Test Conditions

Temperature	23 ± 5 °C
Humidity	20 to 80 % (relative humidity: RH)

(6) Test sample and operating conditions during test

(a) Program control

The test sample shall have a production level microprocessor/memory device. In addition, a vehicle condition shall be duplicable. The software shall be in a typical operating mode as much as possible. (The test sample shall not be placed in an idle or standby mode). All operating modes shall be listed in the EMC Test Plan. When a software which is remodeled to realize the operating mode is used, the outline shall be added to the EMC Test Plan and it shall be submitted to Mazda. When the test sample is equipped with a network function (e.g. J1850, CAN, LIN), normal network traffic shall be simulated by a representative of a vehicle condition. A concrete network traffic message and a detailed information on bus usage shall be added to the EMC Test Plan.

(b) Component variations

Differences in component vendors or versions, especially for the microprocessor, can have a significant effect on EMC performance. This shall be addressed by designing with those differences in mind, testing worst-case components and analyzing data accordingly.

(7) Power supply requirements

Unless otherwise specified herein, the supply voltage shall be within $13^{+0.5}_{-1.0}$ V. (When supply voltage affects a test result, the test shall be performed with the worst value between 12 and 14.5 V.) For an adjusted power supply (e.g. 5 VDC), the supply voltage shall remain within ±5 %. In some tests, a car battery may be used, however, battery voltage shall not below 12 V during the test. The battery may be charged during the test, however, only a linear type power supply shall be used for tests of RE 310, CE 420, CE 421 and CE 422. When the linear type power supply is provided outside the shield wall, a bulkhead RF filter may be used to prevent an unexpected RF signal from entering or passing through the shield room.

(8) EMC Test Plan

An EMC Test Plan shall be prepared and submitted to the responsible Mazda Engineering Dept. at least 20 days before the EMC test starts. The purpose of the Test Plan is to document contemplated procedures for verifying that each component is robust against expected electromagnetic environments where it must be operated.

Moreover, the EMC Test Plan shall be submitted to perform vehicle level tests and more correlated test setups.

The EMC Test Plan shall be prepared in accordance with the outline shown in **Annex 1**.

Mazda shall reserve the right to review and comment details of the EMC Test Plan specifications including the approval criteria of immunity test. If the latest review indicates that a test setup or evaluation criterion is insufficient, the supplier is responsible for correcting the insufficiency, tracking back to the past. If Mazda requests to correct the insufficiency, the correction and retest shall be performed with Mazda.

7.1.4 Sequence of tests ESD non-energization test (refer to **section 7.7.7.2.1**) shall be performed with a higher priority than any other tests. All the other tests may be performed in any sequence. More test samples than necessary may be used in consideration of damage by ESD, however, in a case where some measures against ESD have been taken, retests shall be performed without fail.

7.1.5 Re-approval To ensure that EMC requirements are continuously satisfied, additional EMC tests are required if there is any engineering change in a circuit or printed circuit board (PCB) (e.g. mold size reduction, PCB layout change), or change in software. To determine which additional test is required, a criterion shown in **Annex 3** shall be used. If some of engineering changes described in **Annex 3** have been planned, notification about them shall be provided to Mazda.

7.1.6 Requirements of test rooms All the tests to be reported to Mazda shall be performed in an authorized EMC test facility regardless of whether or not a test room is owned by the supplier itself or is a part of an independent test agency (the third party organization). Authorization shall be made by Mazda test audit. (For some tests, authorization may be made by Ford authorization through AEMCLRP. Contact Mazda for confirmation.). In the case of use of a test facility not described herein, a prior approval (including test audit) shall be obtained from Mazda. Mazda shall reserve the right to perform follow up correlation test including fieldwork at test audit. When rejection of follow up activity or significant differences are found, authorization may be canceled.

7.1.7 Application of requirements **Table 6** shows all EMC requirements of applicable components. The requirements may not be applied to some tests depending on systems or circuit configuration. Suppliers can limit the tests on Specification Drawing or the EMC Test Plan. Test ID may be the same as for previous version of this MES (**MES PW 67600A/B**), however, it shall be noted that requirements and verification method are not always the same. **ECE No. 10** and **ECE No. 116** have necessary requirements and verification method in addition to the ones described herein. The requirements and verification method to be added shall be described in the EMC Test Plan.

Table 6 Requirement Selection Table (1/2)

○: Applicable

Test Item	Test ID ([1])	Component Category						
		Passive component	Inductive component	Motor		Active electronic component		
		P	R	BM	EM	A	AS	AW
Radiated immunity								
Electromagnetic field	RI11X	○			○	○	○	○
Coupling noise	RI130 RI150				○	○	○	
Magnetic field	RI140				○	○	○	○
Conducted immunity								
Continuous noise	CI210				○	○		
Transient noise	CI220	○			○	○		
Power cycle	CI230				○	○		
Voltage drop	CI260				○	○	○	
Voltage offset	CI250				○	○		
DC stress	CI270	○	○	○	○	○		
Electrostatic discharge	CI280	○			○	○	○	○
Abnormal connection	CI290	○	○	○	○	○	○	

Table 6 Requirement Selection Table (2/2)

○: Applicable

Test Item	Test ID ([1])	Component Category						
		Passive component	Inductive component	Motor		Active electronic component		
		P	R	BM	EM	A	AS	AW
Emission								
Electric field	RE310	○		○	○	○	○	○
Transient	CE410		○	○	○	○		
RF	CE42X			○	○	○	○	

Passive components
P: A component constituted of only passive elements
e.g. Resistor, capacitor, coil, block or clamp diode, LED, thermister
Inductive components
R: Relay, solenoid, horn
Motor
BM: Motor
EM: Motor having an electronic control function
Active electronic components
A: A component including an active element
e.g. Analog OP amplifier circuit, SMPS (switched mode power supply), microprocessor-based controller and display
AS: A component powered by another component. Usually, this is a sensor for providing inputs into a controller.
AW: A component without connection to an external harness (e.g. RKE key)

Table 6; Note ([1]) Note that requirements and tests described herein are not always the same as for previous version **MES PW 67600A/B**.

7.2 Meteorological environment

The evaluation method of meteorological environment test shall conform to **section 7.2** of **MES PW 67601**.

7.3 Mechanical environment

The evaluation method of mechanical environment test shall conform to **section 7.3** of **MES PW 67601**.

7.4 Chemical environment

The evaluation method of chemical environment test shall conform to **section 7.4** of **MES PW 67601**.

7.5 Durability

The evaluation method of durability test shall conform to **section 7.5** of **MES PW 67601**.

7.6 Radiated immunity (RI: Radiated Immunity)

7.6.1 Electromagnetic field (RI 11X) These requirements cover a frequency range of 100 k to 3,100 MHz. The requirements are based on expected "exterior" RF source in addition to "on-vehicle" RF source (e.g. amateur radio, mobile phone, etc.)

These requirements apply to the following components categories:

Active electronic components: A, AS, AW

Electric motor: EM

Passive components: P (LED is mandatory. Other components shall be judged by operational principle.)

7.6.1.1 Common requirements The functional performance of components shall satisfy the evaluation criteria shown in **Table 1**. The dependable frequency range is wide, therefore verification is needed to perform with a combination of more than one testing methods. (However, RI 115 shall be tested singularly without a combination of other tests.) Level 1 and Level 2 requirements shall be verified according to these testing methods. If test methods except those described herein (e.g. G-TEM cell, strip line) are performed, a prior approval of Mazda by a test audit shall be obtained.

7.6.1.2 Common test procedures

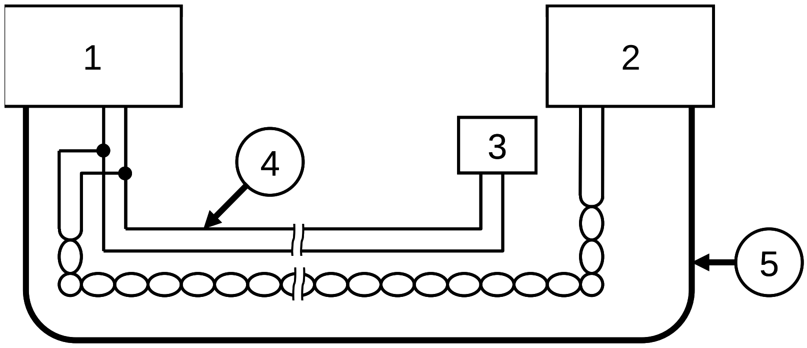
- The wire harness for test shall be routed on a dielectric support at a height of 50 mm from the ground plane (except for band 6 and band 7 of RI 110 and RI 114) over the whole length of the test sample and the load simulator.
- The test sample shall be set at a height of the center between plates for RI 110, and on a dielectric support at a height of 50 mm from the ground plane for band 4 and band 5 of RI 112 and RI 114. However, when the case of test sample is metallic and is grounded to a vehicle body electrically with a bracket, the test sample shall be grounded to the ground plane electrically in a simulated on-vehicle condition during a test. This shall be applied only in the case it is described on Specification Drawing and the case of test sample is actually grounded to a vehicle body.
  The method of grounding of the test sample shall be described in the EMC Test Plan and the test report.
  When performing a test after grounding the case of test sample for band 6 and band 7 of RI 114, a copper braided ground strap shall be used for connection of the case of test sample and the negative terminal of the power supply (vehicle battery). The length of strap shall be $1{,}700^{+300}_{\ \ 0}$ mm and the width shall not exceed 13 mm. The strap shall be connected with the wire harness for test. This method shall also be applied to the case when the power supply (negative side) of the test sample needs local ground.
- Progressive wave electric power shall be used as a reference parameter while evaluating characteristics of application level and testing a test sample actually.
- For apparatuses which use electric wave, the level of each requirement for frequency band needed for communication can be exempted, however, this band, an alternative method (e.g. lower the electromagnetic level and add an immunity test for conductivity from harness), and criterion shall be specified in the EMC Test Plan.

- RF immunity test shall be performed with a linear frequency step size which is not larger than those shown in **Table 7**.

Table 7 Test Frequency Step

Frequency Range (MHz)	Step Size (Max.) (MHz)
0.1 to 1	0.1
1 to 30	0.5
30 to 200	2
200 to 400	5
400 to 1,000	10
1,000 to 2,500	20
2,700 to 3,100	40

- The dwell time of CW and modulation (AM & Pulsed) shall be at least 2 s. Where it is estimated that the functional response time of the test sample is longer, it shall be noted that the longer dwell time is required. This information shall be described in the EMC Test Plan.
- The contents of output harmonics of the amplifier shall conform to the requirements of **ISO 11452-1**. Field modulation and leveling shall conform to the requirements shown in **Annex 4**.
- AM modulation frequency shall be 1 kHz at 80 % level.
- The same type testing apparatus shall be used during calibration and a test. An alternative method is not allowed.
- A test shall be performed with the level 2 requirements first. When any effects of immunity are observed, application level shall be lowered until the test sample functions normally. Then, the application level shall be raised until its effect occurs. The application level at this point shall be verified if it satisfies performance requirements shown in **Table 1**. When performance requirements are not satisfied, the application level shall be reported as a threshold of the effect.
- When it is assured that a test sample is not affected by a frequency lower than 1 MHz, the minimum frequency for a test may be 1 MHz. However, its ground (e.g. data of pre-test) shall be presented.
- If a wire harness for test is connected to multiple drivers of other systems at the time of installation to a vehicle, the wire harness for test shall be as shown in **Fig. 1** below.



1 Test sample
2 Load simulator
3 Connector (as close as to 2)
4 Diagnosis connection (e.g. CAN) shall not be twisted, and it shall be as long as a wire harness for test. It is bound with a harness of a circuit of other test sample, however, it shall be positioned as far as the ground plane.
5 Circuit of other test sample

Fig. 1 RI 110/RI 114/RE 310 Wire Harness for Test

7.6.1.3 0.1 to 1,000 MHz: Triplate test method (RI 110) The test sample shall be operated as required when exposed to the RF electromagnetic field described in **Table 8**.

Table 8 Triplate Requirements

Frequency [MHz]	Field Intensity [V/m rms]		Modulation
	Level 1	Level 2	
0.1 to 515	100	200	CW, AM (1 kHz 80 %), Pulsed PRR = 18 Hz, PD = 28 ms **(1)**
515 to 1,000	50	100	CW, AM (1 kHz 80 %)

Table 8; Note (1) Pulse modulation is limited to the range of 400 MHz to 470 MHz.

7.6.1.3.1 Test method and setup

- Refer to **Fig. 2** for setting.
- Refer to **Annex 5** for general test and setup conditions.
- The monitor and signal generator shall be connected through an optical fiber or a shielded cable (The shield shall be connected to the frame ground of the testing apparatus.), and it shall be as short as possible. The length of the wire harness shall be a total length of 1.7 m (+300 mm/–0 mm). To prevent RF interference at a measuring instrument, an RF filter shall be used and it shall be ensured that the RF filter has no adverse effect on EMC performance.

- A wire harness for test in an L-shaped arrangement shall be connected to the test sample and the testing apparatus. The wire harness for test shall be set at a length of at least 1.0 m in the middle between the center and bottom plate on the center line of a triplate. The test sample and wire harness for test shall be set at the central portion of the center plate parallel to the bottom ground plane (not under a pointed portion of the triplate end.). The remainder of the wire harness shall be taken out to the outside at right angles to the longitudinal axis of the triplate. The testing apparatus (including an artificial network) shall be constituted with resistance simulating other vehicle devices connected to the test sample. (Note that it may affect tests for the test sample.)
- For a test sample of a metallic case grounded to a vehicle body or chassis, the case shall be connected to the ground plane/plate through low impedance. If no ground is made on a vehicle, the test sample shall be separated from the ground plane (15 cm upward from it).
- If the power ground of the test sample is not grounded using a wire harness (e.g. grounding using a case, etc.), the ground plane/plate shall be connected in a simulated on-vehicle condition.
- As a material for setting the test sample or wire harness, a material with low dielectric constant ($\varepsilon_r \leq 1.4$ is preferable) shall be used.

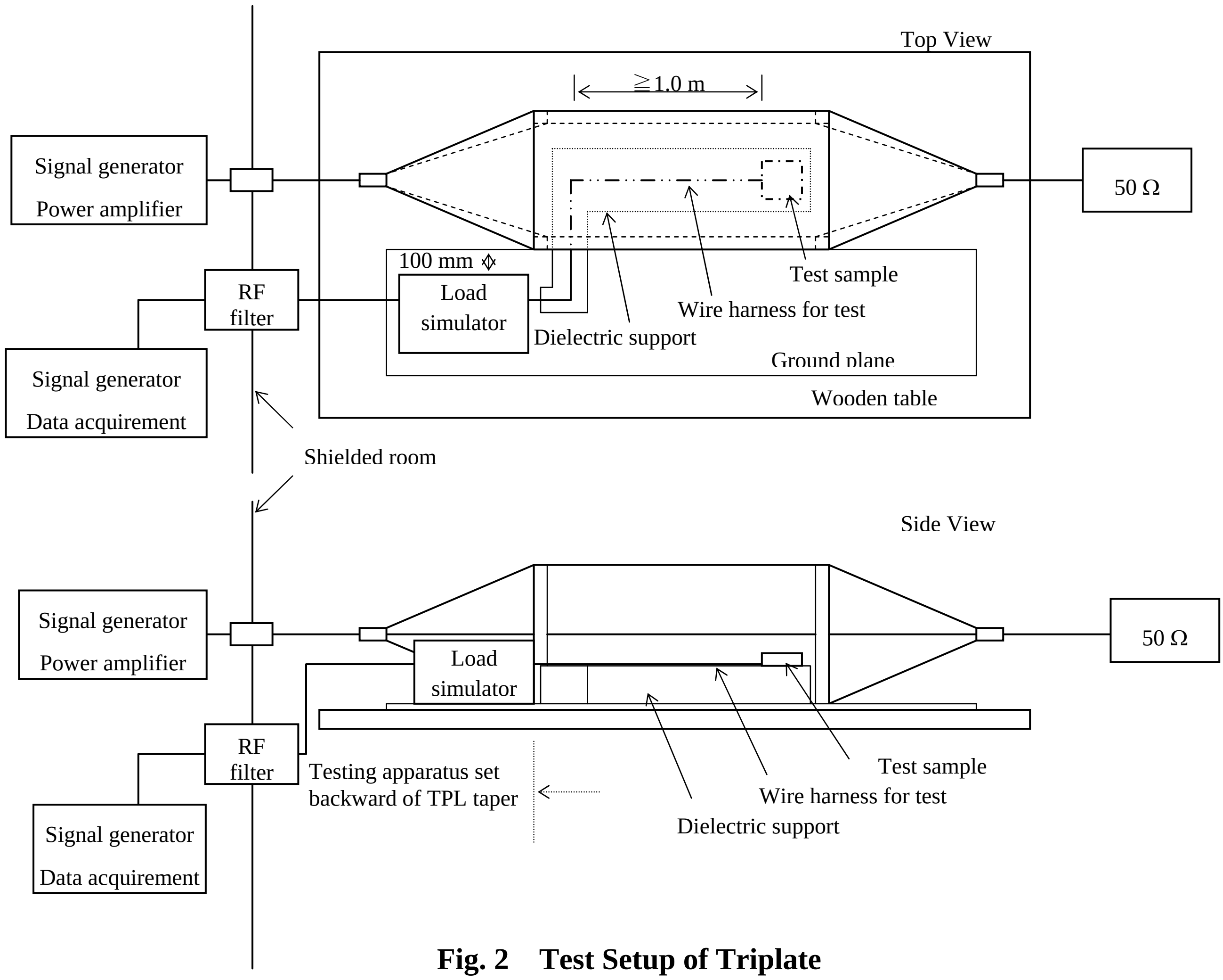


Fig. 2 Test Setup of Triplate

7.6.1.3.2 Test procedures The details of test sample operation shall be described in the EMC Test Plan and it shall be reported to Mazda prior to the test.

(a) The tests shall be performed using a substitution method.

(b) The middle point power shall be used during an actual test of the test sample as reference parameters for electric field evaluation.

(c) The step frequency shown in **Table 7** shall be used. For the modulation, CW & AM (1 kHz, 80 %) shall be used. For the range of 400 MHz to 470 MHz, PM (PRR = 18 Hz, PD = 28 ms) shall also be performed.

(d) Test samples shall be tested in at least 3 right-angled directions. When performing tests in 1 or 2 right-angled direction(s), an approval from Mazda shall be obtained prior to the test and the direction(s) for the test shall be described in the EMC Test Plan.

(e) Frequency and field intensity shall be controlled as follows:

- Conform to **ISO 11452** for adjustment of field intensity at every frequency.
- The ones capable of ensuring the safety of the tested systems shall be selected as parameters of the control method.

(f) If any effects are observed, the electric field shall be reduced until function of the test sample becomes normal. Then, the electric field shall be increased until some effect has occurred. This level shall be reported as a threshold of the effect.

7.6.1.3.3 Data report

The following elements shall be included in the test report:

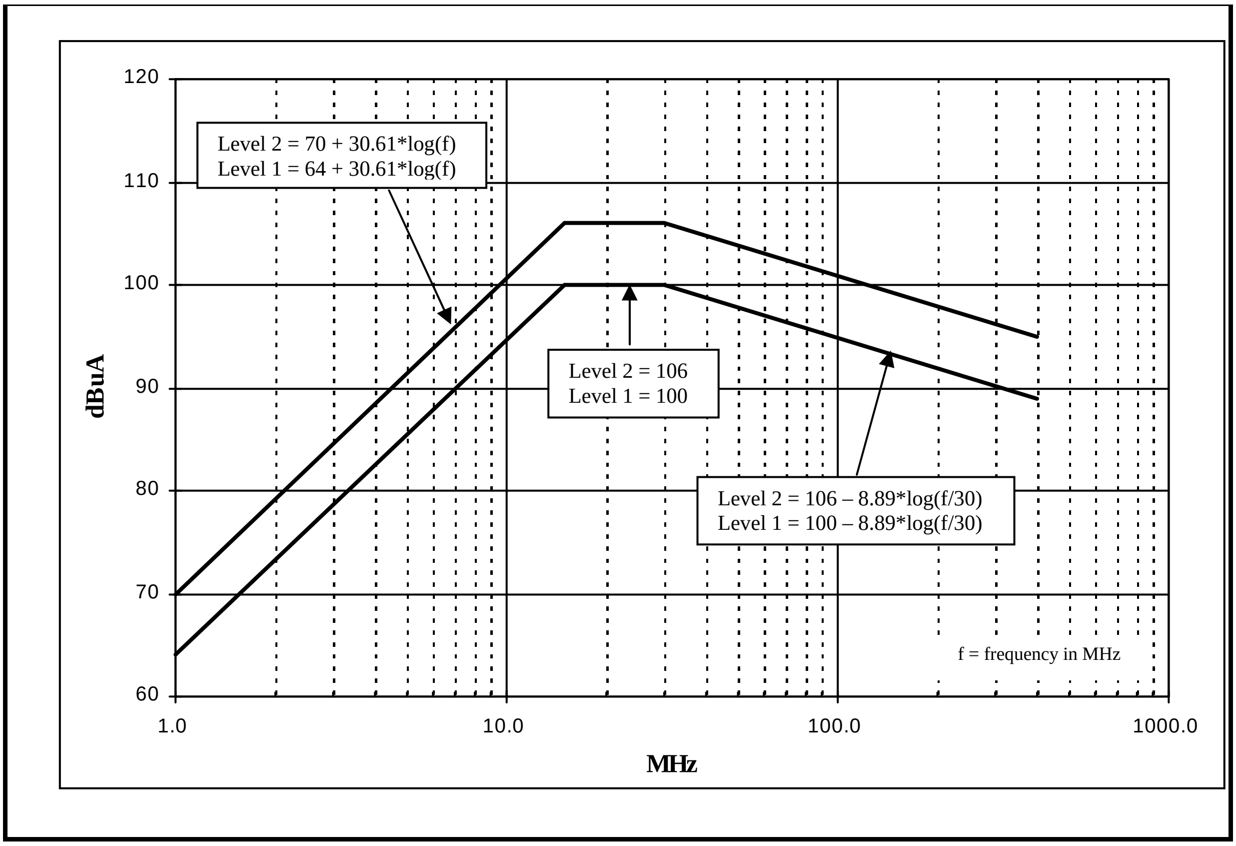
- Operation mode of test sample
- ID of test sample (e.g. serial number)
- Description of functions to be monitored
- Modulation
- Effects on every performance
- Data and plot of table that is summarized as one with only the worst case by observed effect (Individual data of each effect is also needed.)
- Plot of immunity threshold (electric field vs frequency)
- Electric field measured by electric field monitor probe (optional)
- Photograph of test setup
- Test data
- Electric/non-electric data obtained during test

7.6.1.4 1 to 400 MHz: Bulk current injection (BCI) method (RI 112) Test samples shall operate as requested when exposed to the RF current level shown in **Table 9**. The RF current is triggered by use of BCI test method.

RI 112 shall not be applied to PCB with brand-new design. If it is applied, an approval from Mazda shall be obtained. RI 112 cannot be applied in any circumstances for components category AW.

Table 9 BCI Requirements

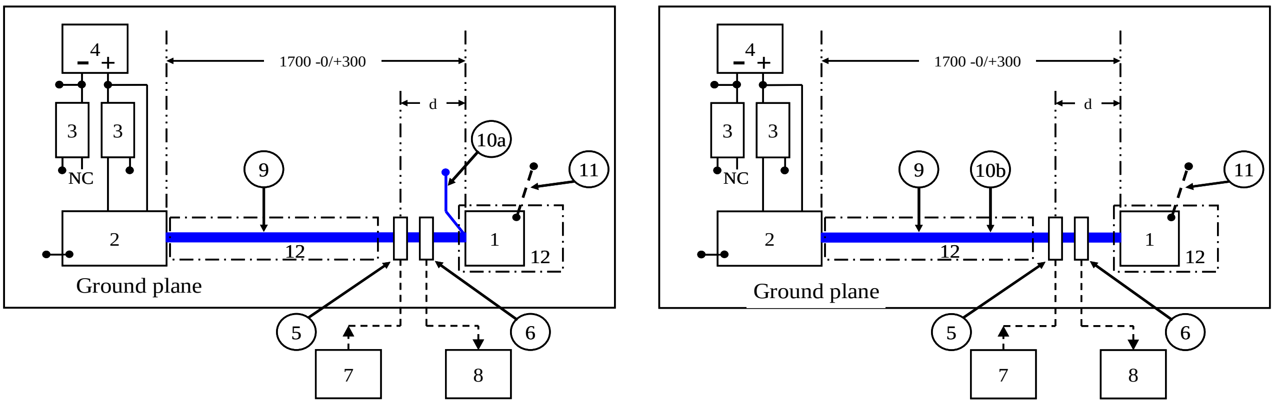
Band	Frequency Range [MHz]	Level 1 [dBμA]	Level 2 [dBμA]	Modulation
1	1 to 15	64 to 100	70 to 106	CW, AM (1 kHz 80 %)
2	15 to 30	100	106	CW, AM (1 kHz 80 %)
3	30 to 400	100 to 90	106 to 96	CW, AM (1 kHz 80 %)



7.6.1.4.1 Test method and setup Conform to **ISO 11452-4** (BCI method) except for those described herein to verify components performance.

- The test samples shall be powered with a vehicle battery. (Refer to **section 7.1.3 (7)**.) The negative terminal of the battery shall be connected to the ground plane. The battery shall be set on or under a dynamometer. The testing apparatus, battery and artificial network shall be set as shown in the standard test setup shown in **Annex 2**.
- The dynamometer shall include a ground plane in such a sufficient size as to straighten a wire harness for test. The intervals between the end of the ground plane and the wire harness for test, and between the test sample and the load simulator shall be the same as those of **ISO 114524**.
- Under the test setup condition, a distance to a conductor (shield wall, etc.) except the ground plane shall be more than 500 mm.
- When the outer case of the test sample is metallic, and it is grounded at the time of installation to a vehicle, the test sample shall be set on the ground plane and electrically connected during a test. If the case is not grounded on a vehicle, the test sample shall be set on a 50 mm-thick insulator placed on the ground plane. If these are unclear, the test shall be performed in both forms described above.
- At a frequency range of 1 MHz to 30 MHz, all negative power (ground) wires of the wire harness for test shall be terminated directly to the ground plane as shown in **Fig. 3 (a)** (DBCI). The length of wire shall be 200 ± 50 mm. The wire shall not be routed around the BCI injection probe. This requirement may not be applied when the power wire is a twist pair (shall be specified on Specification Drawing), it shall be described in the EMC Test Plan.

- At a frequency range of 30 MHz to 400 MHz, all wires of the wire harness for test shall be routed in the injection probe as shown in **Fig. 3 (b)**. (**CBCI**)
- When the test sample has several connectors, an injection probe shall be attached around the individual harnesses with individual connectors and a test shall be repeated (1 to 400 MHz). The circuits in each harness shall be described in the EMC Test Plan.
- When the test sample is connected to multiple drivers of other systems at the time of installation to a vehicle, an injection probe shall be attached to each line and a test shall be repeated. (1 to 400 MHz. The operation mode for evaluation may be only multiple communication.). Furthermore, for an interface signal (shall be specified in the EMC Test Plan) and a power line (CBCI shall be applied to a negative wire regardless of evaluation frequency.) that are important for immunity, an injection probe shall be attached to each line and a test shall be repeated (1 to 400 MHz). Each circuit for evaluation shall be described in the EMC Test Plan.
- The injection probe shall be isolated from the ground plane.
- To prevent an adverse effect on tests, the current monitor probe shall be set at 50 mm apart from the test sample and shall be insulated (optional).



(a) DBCI **(b) CBCI**

1 Test sample
2 Load simulator
3 Artificial network
4 Vehicle battery
5 Injection probe
6 Monitor probe (optional)
7 RF generator
8 Current monitoring instrument (optional)
9 Wire harness for test
10a Power supply ground of wire harness for test directly connected to sheet metal removed from wire harness. The length of wire shall be 200 ± 50 mm.
10b Test harness with power ground
11 Case ground of test sample
12 Dielectric support ($\varepsilon_r \leq 1.4$ is preferable)
d = Distance between test sample and injection probe

Fig. 3 BCI Harness Configuration

7.6.1.4.2 Test procedures The injection probe method (replacement method) corrected in accordance with **ISO 11452-4** shall be used.

(a) Frequency step size shown in **Table 7** and modulation designated in **Table 9** shall be used.

(b) Within the frequency range of 1 to 30 MHz, tests shall be performed at two predetermined injection probe positions (150 mm, 450 mm).

(c) Within the frequency range of 30 to 400 MHz, tests shall be performed at two predetermined injection probe positions (450 mm, 750 mm).

(d) If any effects are observed, the induction current shall be reduced until function of the test sample becomes normal. Then, the induction current shall be increased until some effect has occurred. This level shall be reported as a threshold of the effect.

(e) Each harness connected to the test sample shall be tested repeatedly.

(f) The operation mode of a test sample executed during a test shall satisfy those described in the EMC Test Plan.

(g) Use of a monitor probe is not for regulation of RF current described in **Table 9**. The measured values shall be included in the test report.

7.6.1.4.3 Data report

The following elements shall be included in the test report:

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Wire harness and connector used for test (For test sample with several connectors)
- Description of functions to be monitored
- Modulation
- Effects on every performance
- Table data and plots at two probe positions
- Table data and plots integrated into one only in the worst case for each observed effect. The probe positions of the smallest effect threshold at every frequency shall be described. Individual data of each effect are also required.
- Plots of immunity threshold (current vs frequency calculated at dBμA)
- Currents measured from the current monitor probe (optional)
- Photograph of test setup
- Test data
- Electric and non-electric data obtained during test

7.6.1.5 400 to 3,100 MHz: Anechoic chamber (Absorber-lined shielded enclosure: ALSE) method (RI 114) Reverberation method

The test sample shall operate as requested when exposed to RF electromagnetic field shown in **Table 10**.

Table 10 Requirements of 400 to 3,100 MHz

Band	Frequency Range [MHz]	Level 1 [V/m]	Level 2 [V/m]	Modulation
4 (1)	400 to 800	50	100	CW, AM (1 kHz 80 %), Pulsed PRR = 18 Hz, PD = 28 ms (2)
5	800 to 2,000	50	70	CW, Pulsed PRR = 217 Hz, PD = 0.57 ms
6	1,200 to 1,400	–	300	Pulsed PRR = 300 Hz, PD = 3 μs A test sample shall output only 50 pulses at every 1 s.
			600 (3)	
7	2,700 to 3,100	–	300	
			600 (3)	

Table 10; Notes (1) Band 4 shall not be applied to PCB with brand-new design. If it is applied, an approval from Mazda shall be obtained.

(2) Pulse modulation is limited to the range of 400 MHz to 470 MHz.

(3) The requirements of 600 V/m shall be applied only to the test sample mounted to the outside of a vehicle metallic body (e.g. front crash sensor of air bag system and radar). Contact Mazda for application of specification.

7.6.1.5.1 Test method and setup As a test method, ALSE method shall be used as much as possible. If the reverberation method is used, a prior approval of Mazda shall be obtained.

(a) When ALSE method is applied, conform to **ISO 11452-2** except for those described herein. It shall be noted that test setup shall be the same as those used in the radiated emission test. (Refer to **section 7.8.1.2**.)

(b) When reverberation method is applied, conform to **IEC 61000-4-21** except for those described herein.

7.6.1.5.1.1 ALSE method (bands 4 and 5)

- The test sample and load simulator, etc. shall be powered by a vehicle battery. (Refer to **section 7.1.3 (7)**.) The negative terminal of the battery shall be connected to the ground plane dynamometer. The battery shall be set on or under the dynamometer. The load simulator, battery and artificial network shall be laid out as shown in the standard test setup of **Annex 2**.
- For frequencies lower than 1,000 MHz, an electric field developing antenna shall be set in front of the central position of the harness. For frequencies higher than 1,000 MHz, the antenna shall be moved by 750 mm in parallel to the front edge of the ground plane toward the test sample. The center of the antenna shall be aimed directly at the test sample in place of the center of the wire harness. (Refer to **Fig. 6**.) For test calibration procedures, refer to **ISO 11452-2**.

7.6.1.5.1.2 ALSE method (bands 6 and 7)

- For setup of bands 6 and 7, the test sample, harness and testing apparatus shall be set on a table (height: 1,000 ± 50 mm) made of low-dielectric constant material ($\varepsilon_r \leq 1.4$ is preferable) removing the ground plane and artificial network as shown in **Fig. 5**.

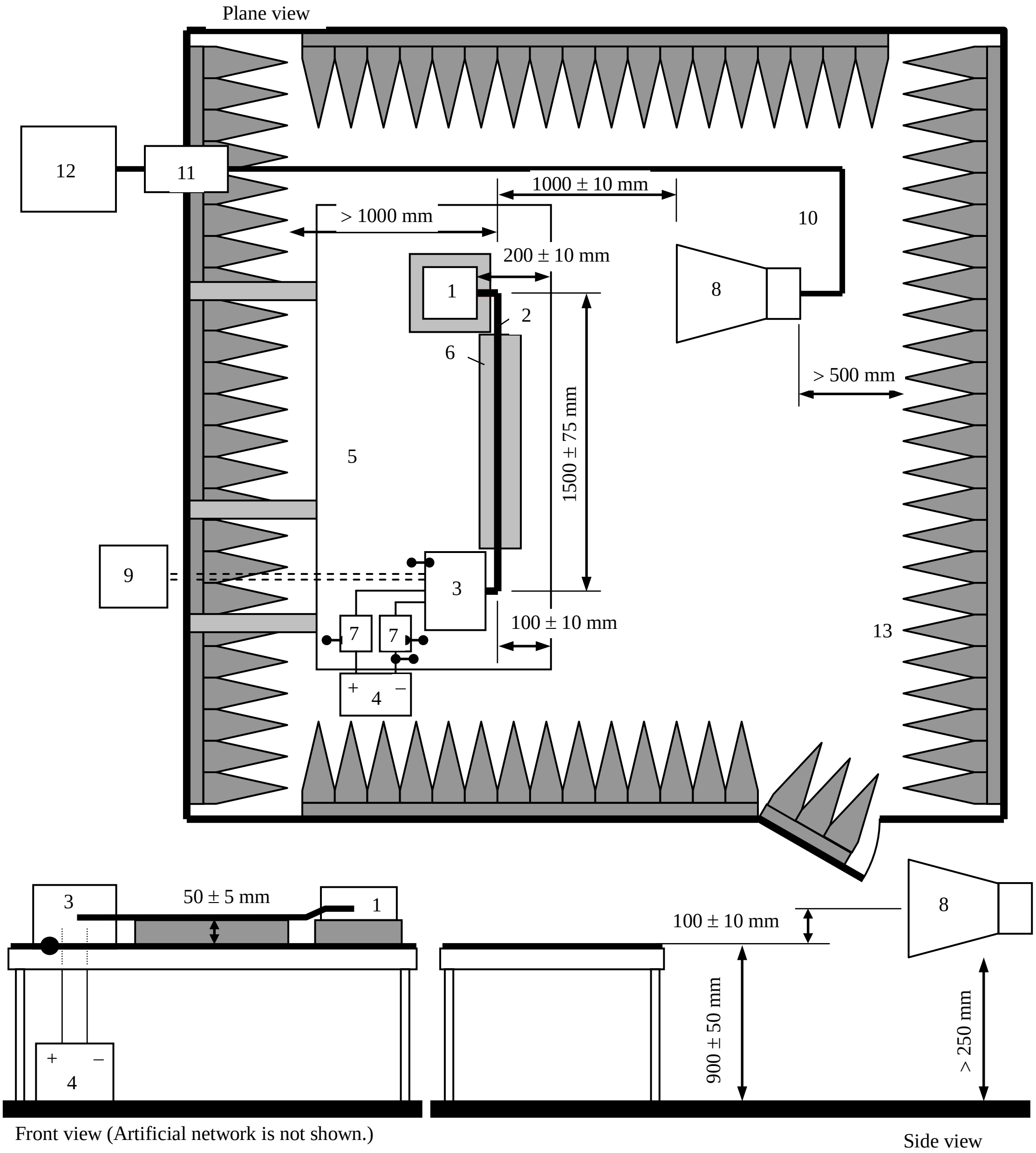
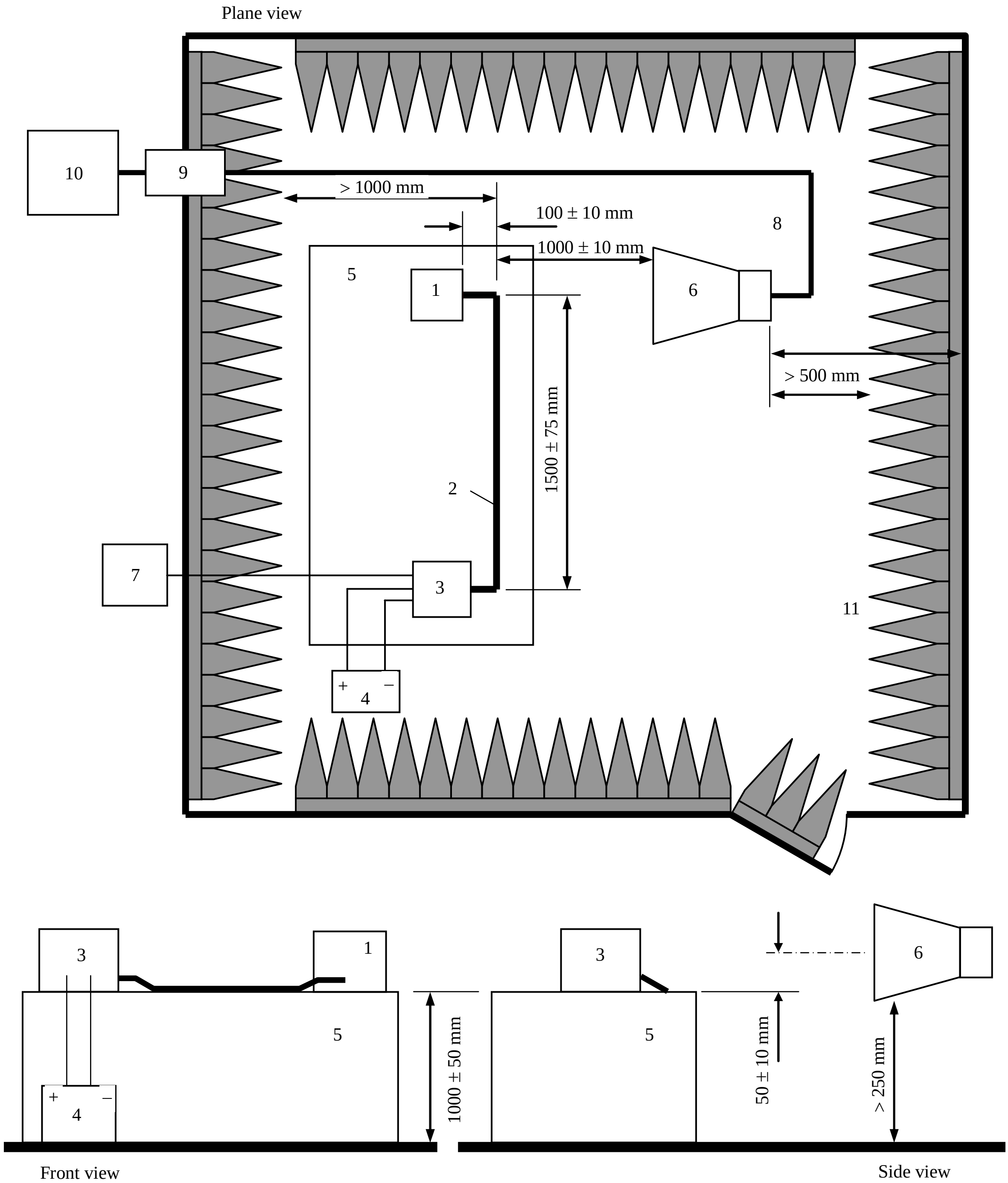


Fig. 4 is an amendment of **ISO 11452-2**.

Fig. 4; Remark Horn antenna has been moved so as to be aimed at the test sample.

1 Test sample
2 Wire harness for test
3 Load simulator
4 Vehicle battery
5 Ground plane (fixed on shield wall)
6 Dielectric support ($\varepsilon_r \leq 1.4$ is preferable)
7 Artificial network
8 Transmit antenna
9 Test support apparatus/monitor
10 High-quality double shield coaxial cable (50 Ω)
11 Bulkhead connector
12 RF generator
13 Electric wave absorber

Fig. 4 ALSE Test Setup (except for bands 6 and 7): 1,000 to 2,000 MHz



1 Test sample
2 Wire harness for test
3 Load simulator
4 Vehicle battery
(may be set on 5 below)
5 Dielectric support
($\varepsilon_r \leq 1.4$ is preferable)
6 Transmit antenna
7 Test support apparatus
8 High-quality double shield coaxial cable
9 Bulkhead connector
10 RF generator
11 Electric wave absorber

Fig. 5 ALSE Test Setup (bands 6 and 7)

7.6.1.5.1.3 Reverberation method

- Reverberation chamber shall have a capacity large enough to test the test sample within the working range of the room.
- In this test, the ground plane shall not be used.
- The tuner shall have as a large capacity as possible relative to the overall size (at least 3/4 of minimum laboratory size) and a working range.
- The electric field probe shall have a capacity to read three rectangular axes and report it.
- The RF signal generator shall have a capacity to cover the designated frequency band and modulation.
- The transmit antenna shall have a capacity to satisfy frequency applicable range requirement with straight polarized wave. The transmit antenna shall not be irradiated on any test area.
- The receiving antenna shall have a capacity to satisfy frequency applicable range requirement with straight polarized wave. The receiving antenna shall not be aimed at any test area.
- The power amplifier shall have a capacity to amplify an RF signal for development of required magnetic field strength.
- To record power level necessary for required magnetic field strength, related instruments shall be provided.
- The test sample shall be at least 250 mm apart from the laboratory wall, tuner, transmit antenna and receiving antenna.
- The overall harness length shall be $1{,}700^{+300}_{0}$ mm. The harness shall be routed on an insulator ($\varepsilon_r \leq 1.4$) in the middle of a test area with the test sample and testing apparatus.
- Any artificial network shall not be used.
- The ground from a test sample shall be connected directly with the negative terminal of the battery.
- When the outer case of the test sample is metallic, and it is grounded at the time of installation to a vehicle, a copper braided ground strap shall be used for connection of the case of test sample and the battery, or the negative terminal of the testing apparatus. The length of strap shall be $1{,}700^{+300}_{0}$ mm and the width shall not exceed 13 mm. The strap shall be run under the test harness. This method shall also be applied to the case when the ground of a test sample is single.

7.6.1.5.2 Test procedures The operation mode of test sample to be performed during a test shall satisfy those described in the EMC Test Plan. The tests shall be performed using a substitution method. For tests of bands 4 and 5, refer to **ISO 11452-2** for electric field calibration procedure. For tests of bands 6 and 7, refer to **Annex 6** of this MES for electric field calibration procedure. Electric field calibration shall be performed with field intensity of level 2 specified in **Table 10**. Evaluation of high field intensity using an electric field calibration value of low field intensity is not allowed.

7.6.1.5.2.1 ALSE method

(a) When a test is performed using pulse modulation in bands 6 and 7, CW shall not be used for leveling before pulse modulation is applied. If CW is used, a prior approval of Mazda shall be obtained.

(b) Step frequency shown in **Table 7** as well as modulation designated in **Table 10** shall be used.
(c) Tests shall be performed using horizontal and vertical antennas.
(d) For tests of a test sample in front of the antenna such as the one using test frequencies of 1,000 MHz or more, test samples shall be tested in at least 3 right-angled directions unless otherwise specified in the EMC Test Plan.
(e) If any effects are observed, the electric field shall be reduced until function of the test sample becomes normal. Then, the electric field shall be increased until some effect has occurred. This level shall be reported as a threshold of the effect.

7.6.1.5.2.2 Reverberation method

(a) Test frequencies following **Table 7** shall be used. The modulation designated in **Table 10** shall be used except for bands 6 and 7. At the bands 6 and 7, a pulse duration (PD) shall be increased until 6 μs.
(b) Any electric field probe shall not be used during a test.
(c) The test room shall be arranged.
(d) The transmit antenna shall be at the same position as the one used for calibration.
(e) The test sample shall be exposed to each electric field level and frequency at a tuner position of each mode.
(f) The input power of a laboratory for electric field level shall be determined from the following formula: (Refer to **IEC 61000-4-21**.)

$$TEST\_Input\_Power = \left[\frac{E_{test}}{\left\langle \ddot{E} \right\rangle_{24or9} \sqrt{CLF(f)}} \right]^2$$

Where,
E_{test}: Required magnetic field strength (V/m)
CLF(f): Factor of load in laboratory
$\left\langle \ddot{E} \right\rangle_{24or9}$ = Standard electric field from laboratory arrangement without a test sample. Perform linear interpolation between calibration frequency points. (CLF and standard electric field value) may be required.

(g) If any effects are observed, the electric field shall be reduced until function of the test sample becomes normal. Then, the electric field shall be increased until some effect has occurred. The level shall be reported as a threshold of the effect.

7.6.1.5.3 Data report

The following elements shall be included in the test report:
- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Description of functions to be monitored
- Modulation
- Effects on every performance
- Usage and technique of monitor
- Table and plot of minimum field intensity at each frequency where some effect occurs, including modulation and polarization (ALSE method only)
- Photograph of test setup
- Photograph showing positions of three test samples (ALSE method only)
- Number of tuner steps at each frequency (Reverberation method only)

7.6.1.6 360 to 2,700 MHz: Radio test (RI 115) The test sample shall operate as required when it is exposed to RF electromagnetic field shown in **Table 11**. RI 115 is based on a potential risk where a test sample is exposed to a portable transmitter (e.g. cellar phone). For a concrete application, a prior approval of Mazda shall be obtained and it shall be described in the EMC Test Plan.

Table 11 RI 115 Requirements

Band	Frequency Range [MHz]	Level 1 [W] ([1])	Level 2 [W] ([1])	Modulation
8	360 to 480	4.5	9.0	PM, 18 Hz, 50 %
9	800 to 1,000	7.0	14.0	PM, 217 Hz, 12.5 %
10	1,600 to 1,950	1.5	3.0	PM, 217 Hz, 12.5 %
11	1,950 to 2,200	0.75	1.5	PM, 217 Hz, 12.5 %
12	2,400 to 2,500	0.1	0.2	PM, 1,600 Hz, 50 %
13	2,500 to 2,700	0.25	0.5	PM, 217 Hz, 12.5 %

Table 11; Note ([1]) The test level is available only to the antenna designated in this MES. When other antennas are used, a prior approval of Mazda shall be obtained. Electric power for network, the value input to the antenna at least 1 m apart from various objects, is shown here.

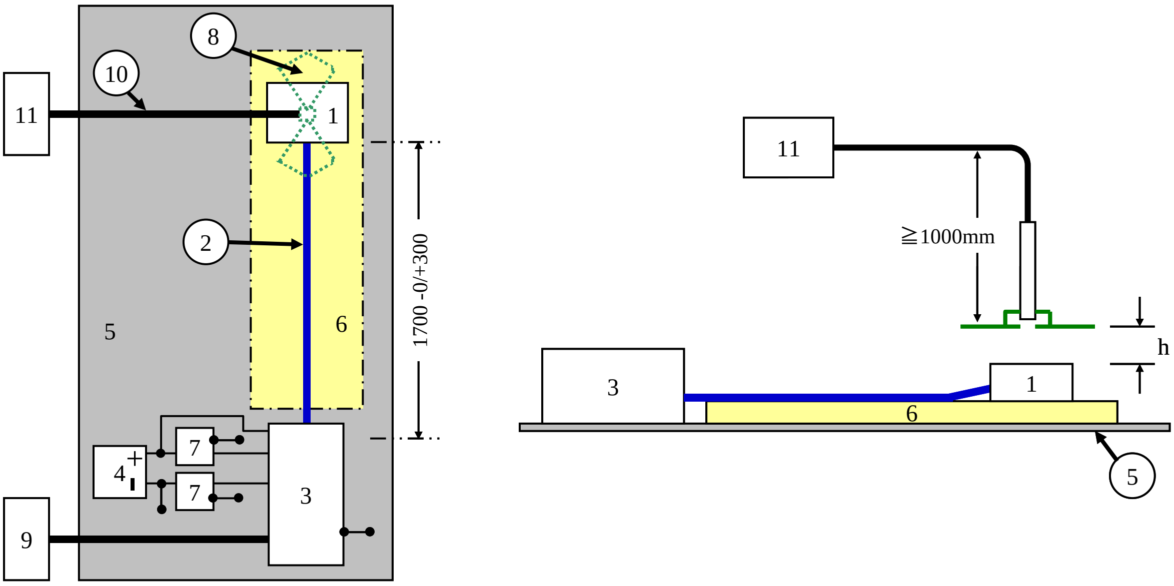
7.6.1.6.1 Test method and setup The test shall be performed with the setup shown in **Fig. 6**. For wire harness for test and artificial network, this section shall not be applied to a module without wire harness (e.g. remote entry key). All tests shall be performed in an anechoic chamber (ALSE) that conforms to **ISO 11452-2**.

- In this test procedure, use of a small broadband antenna set on a test sample or its wire harness simulates electromagnetic field occurred from a handy radio moving nearby. As the result of immunity test in the near field is greatly influenced by the kind of antenna to be used, this test shall be performed with an antenna with an element 420J, SBA9113 (produced by Schwarzbeck). When other antennas are used, a prior approval of Mazda shall be obtained.
- The interval between the antenna for test and surface of a test sample or a wire harness for test (h) shall be 5 mm or 50 mm depending on the expected closeness up to the intended storage place for a handy radio or the product type, as shown in **Table 12** below. The antenna for test shall be set with the step size shown in **Table 12** so that all surfaces of the test sample may be completely exposed to.
- The distance between the antenna and test sample surface, and positioning step shall be discussed with Mazda and shall be described in the EMC Test Plan.

Table 12 Interval and Antenna Position for RI 115

Description of Test Sample Surface or Harness	Distance between Antenna and Test Sample	Antenna Position Step
In the beginning 300 mm of surface of a test sample and its harness (measured from a test sample connector), an antenna that may be mounted between 50 to 200 mm from an intended or unintended place that a handy radio may be set.	50 mm	100 mm
A key or similar test sample that may directly contact a handy radio, and an antenna that may be mounted at a place under 50 mm from an intended storage place in the beginning 300 mm of surface of a test sample and its harness.	5 mm	30 mm

- The test sample shall be electrically powered by a vehicle battery. (Refer to **section 7.1.3 (7)** for requirements.) The negative terminal of the battery shall be connected to the ground plane. The battery can be placed on or under a dynamometer. Refer to **Annex 2** for the standard setup of a load simulator, battery and artificial network.
- The length of a wire harness for test shall be $1{,}700\ ^{+300}_{\ \ 0}$ mm and shall be routed on a dielectric support ($\varepsilon_r \leq 1.4$ is preferable) at a height of 50 mm from the ground plane over the whole length of the test sample and testing apparatus.
- The dynamometer shall include at least 100 mm larger ground plane than the setup.
- The distance between the setup and all the other inductive constructions such as a wall of shielded enclosure shall be at least 500 mm except for the ground plane.
- The antenna for test shall be set in parallel to the ground plane above the test sample. The test sample shall be placed so that its face may be aimed at the antenna during a test.



1	Test sample	8	Antenna for test (SBA9113 with 420NJ)
2	Wire harness for test	9	Test support apparatus
3	Load simulator	10	High quality double shield coaxial cable (shall be at least 1,000 mm apart from the antenna element. Refer to **Fig. 7**.)
4	Vehicle battery	11	RF generator (Refer to **Fig. 7**.)
5	Ground plane		
6	Dielectric support ($\varepsilon_r \leq 1.4$ is preferable)		
7	Artificial network		

Fig. 6 RI 115 Test Setup

7.6.1.6.2 Test procedures The same procedure as described in **ISO 11451-3** shall be used for calibration of setup prior to the test. During calibration, the radiation element of the antenna shall be set at least 500 mm apart from various absorbers and 1,000 mm apart from various objects such as the test sample, ground plane, antenna cable and a wall of test space. This setup is shown in **Fig. 7**.

Electric power level for network specified in **Table 11** is based on measured progressive wave and reflected wave electric power and shall be subjected to the following equation:

$$P_{ant,NET} = A \cdot P_{meas,FWD} - \frac{1}{A} \cdot P_{meas,REFL} \qquad A = \left[\frac{P_{ant,FWD}}{P_{meas,FWD}} \right]$$

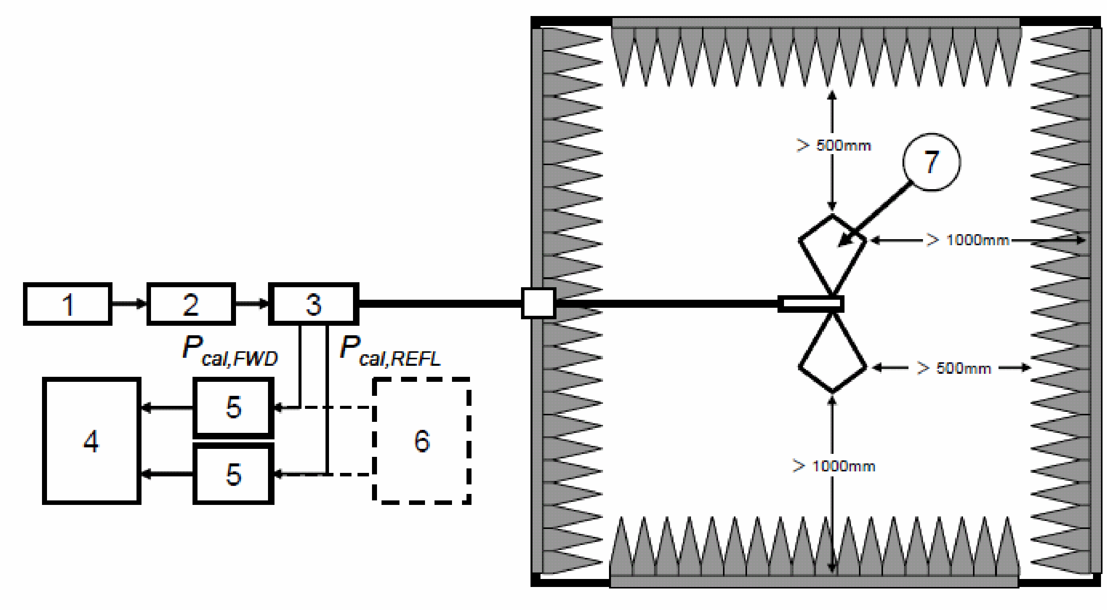
Where,

$P_{ant,NET}$: Electric power for network transmitted to the antenna specified in **Table 11**

$P_{meas,FWD}$: Progressive wave electric power measured by a directional coupler

$P_{meas,REFL}$: Reflected wave electric power measured by a directional coupler

A : Attenuation of cable ($A < 1$)



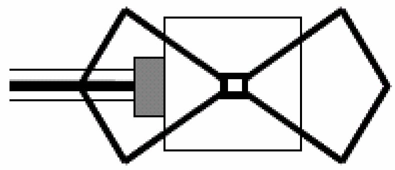
1 Signal generator
2 RF amplifier
3 Directional coupler
4 RF wattmeter
5 Peak envelope power sensor
6 Spectrum analyzer (can be used in place of power sensor)
7 Antenna for test (SBA9113 with 420NJ)

Fig. 7 RI 115 Calibration Setup

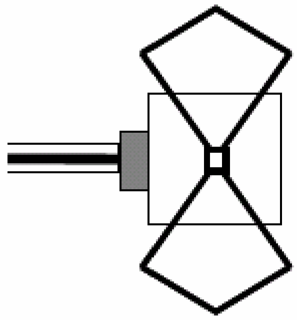
In addition to test distance from the antenna to the test sample and the antenna position step, the selection procedures for the face to be tested and the harness are shown in **sections 7.6.1.6.2.1** and **7.6.1.6.2.2**. This information shall be described in the EMC Test Plan.

7.6.1.6.2.1 Antenna positioning for coupling to test sample When the test is performed making the distance from the test sample to the antenna (h) 50 mm, the test area that a broadband antenna can be used is 100 × 100 mm. However, when the test is performed making the distance 5 mm, the space is decreased up to 30 × 30 mm. Therefore, when the test is performed making the distance 50 mm and 5 mm, the antenna shall be moved in the step of 100 mm or 30 mm. The entire faces of a test sample to be tested shall be divided into square cells of either 100 × 100 mm max. or 30 × 30 mm max. The antenna shall be set in a distance of 50 mm or 5 mm (shall be specified in the EMC Test Plan), and the center of the antenna shall be set in the center of each cell. Then, the antenna element shall be set orthogonally to the center of each cell so that the center of each cell can be exposed to the center of antenna and antenna element (4-time application in total). As electric field and magnetic field exist in a different place and they move in accordance with the test frequency, it is necessary to expose each cell to the center of the antenna and antenna element. The antenna shall be set above the center of each cell, and the test sample shall be exposed to it with the level specified in **Table 11** using the test sequence minutely described below:

(a) Place the antenna so that it is parallel to a wire harness for test and it aligns with the center of the first cell, and expose the test sample to the level specified in **Table 11**.

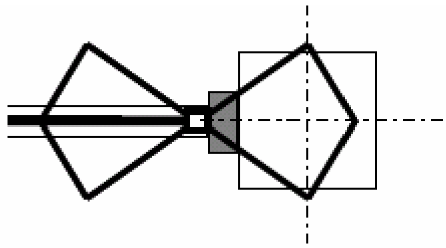


(b) Rotate the antenna at 90 ° and repeat step **(a)**.

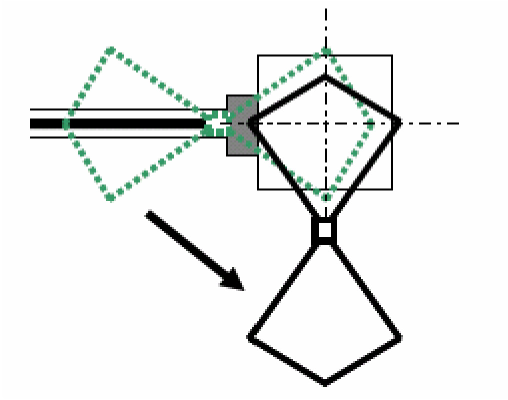


(c) Align the antenna with the center of the next cell, and repeat steps **(a)** and **(b)** until all cells are exposed to the orthogonal directions that the center of antenna and antenna element make. When the test is performed in the distance of 5 mm, steps **(d)**, **(e)** and **(f)** are not required.

(d) Return the antenna to the first cell. Align the antenna element with the center of test cell (Align the end of element with the center of test cell.), and expose the test sample to the level specified in **Table 11**.



(e) Rotate the antenna at 90 ° and repeat step **(d)**.

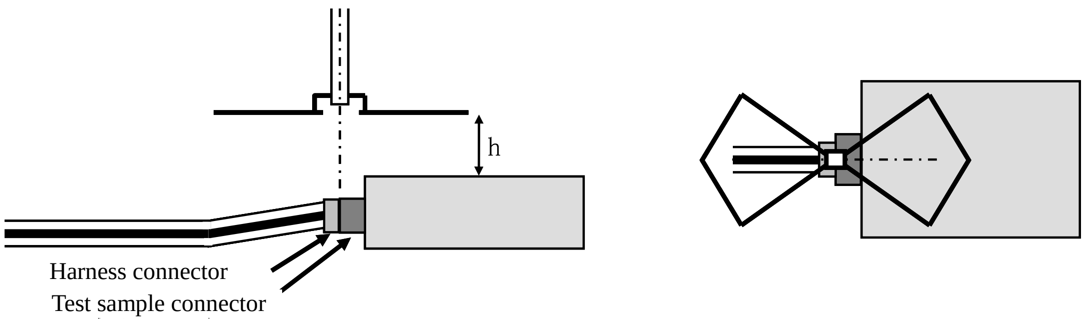


(f) Repeat steps **(d)** and **(e)** until all cells are exposed to the orthogonal directions that the center of antenna and antenna element make. When a test sample with several cells is tested, centers of some cells are sometimes exposed to the antenna element while steps **(a)** to **(c)** are performed toward nearby cells. In such a case, steps **(d)** and **(e)**, which can be duplicated, are not required. When there is uncertainty about effective exposure of cells by antenna element, steps **(d)** and **(e)** must be performed.

(g) For each face of the test sample described in the EMC Test Plan, repeat steps **(a)** to **(f)**. Rotate the test sample so that the side surface to be tested may be parallel to the ground plane. Use a low-dielectric constant material so that the face of the test sample can be supported to aim at the antenna.

7.6.1.6.2.2 Antenna positioning for coupling to harness The antenna shall be set in parallel to the harness in the center of connector for test. As shown in **Fig. 8**, the center of the antenna shall align with the outermost end of the connector of the test sample. The test sample shall be exposed to the test signal specified in **Table 11**. Next, if designated on Specification Drawing, evaluation shall also be made at a position 85 mm laterally away from the test sample. If the test sample has several connectors, or if the connector is wider than the required cell width (30 mm or 100 mm), the test shall be repeated several times.

When any effects are observed during the test, electric power shall be lowered until the test sample functions normally. Then, the electric power shall be increased until its effect occurs.
The electric power at this point shall be reported as a threshold of the effect.



(a) Side view **(b) Plane view**

Fig. 8 Antenna Positioning for RI 115 Harness Test

7.6.2 Ignition noise (Specifications deleted)

7.6.3 Coupling noise (RI 130) (RI 150)

7.6.3.1 RI 130 These requirements relate to components immunity arising from coupling between wire harnesses with unintended transient interferences. These interferences occur from switching of inductive load including solenoid or motor.

These requirements shall be applied to the following components categories:

Electronic components: A, AS

Electric motor: EM

7.6.3.1.1 Requirements The test sample shall operate without any adverse effect when exposed to coupled-transient electromagnetic interference occurred from arc discharge and bounce of switch contact. **Table 13** shows the requirements. Refer to **Annex 7** for details of transient waveforms and application mode.

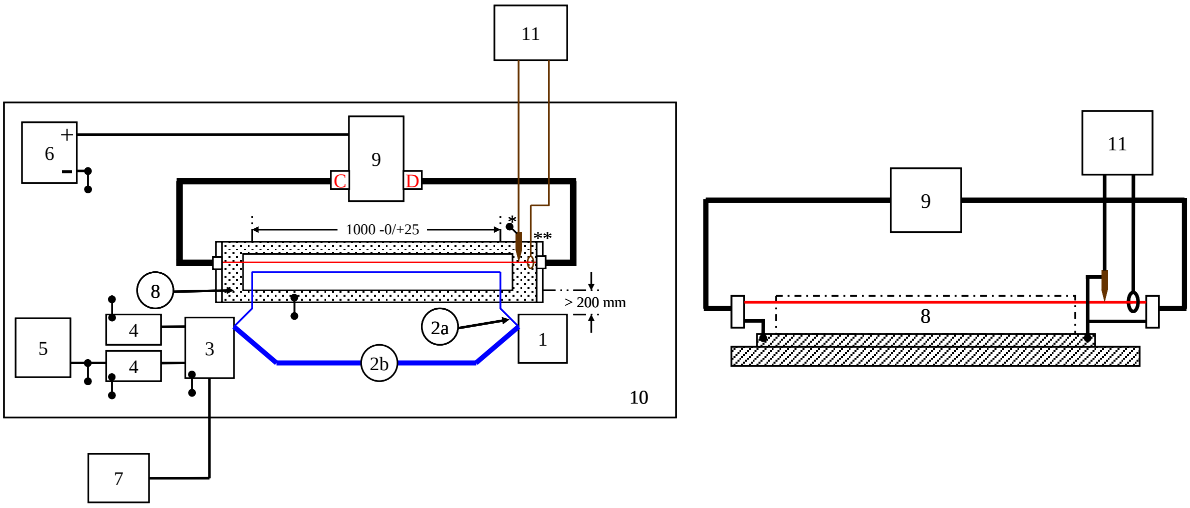
Table 13 RI 130 Requirements

Mode	Pulse
2	A2-1
	A2-2
3	A2-1
	A2-2

7.6.3.1.2 Test method and setup The test shall be performed using the test setups shown in **Fig. 9**. Individual wire harnesses to be tested shall be removed from a wire harness for test and they shall be set in the testing apparatus. Refer to **Annex 9** for information on twisted pair cable and shield wires, and basic description of testing apparatus. Refer to **Annex 7** and **Annex 8** for information on transient pulse characteristics and information on transient waveform generator respectively.

- Electric hardware in the test sample and load simulator shall be powered by a vehicle battery or linear type power supply. The negative terminal of the battery or power supply shall be connected to the ground plane dynamometer. The battery or power supply shall be set on the floor under/next to the dynamometer.
- Power supply of the test sample (positive and negative) shall be connected to the battery or power supply via artificial network. The artificial network shall conform to **CISPR 25**. The artificial network measuring port shall be terminated at 50 Ω.
- The transient waveform generator shall be powered by a vehicle battery. The metallic case of transient waveform generator shall be connected to the ground plane. Refer to **Annex 8** for details of the transient waveform generator.
- The test sample and all components in a test setup condition shall be at least 100 mm apart from the ground plane edge.
- A digital sampling oscilloscope shall be used for verification of test voltage and test current. The oscilloscope shall have a capacity shown below:
  - Have a capacity of sampling rate more than 1 giga-samples/s (single acquisition capacity).
  - The minimum memory depth of single signal channel is 8 mega sample.
- To facilitate verification of transient disturbance, a voltage and a current probes are needed. **Fig. 9** includes requirements for the probes.

- When the outer case of the test sample is metallic, and can be grounded to a vehicle body at the time of installation, the test sample shall be directly grounded to the ground plane during a test with electricity. When the case of the test sample is not grounded in a vehicle, the test sample shall be set on a dielectric support at a height of 50 mm from the ground plane.



1	Test sample	7	Monitor/test support apparatus
2a	Wire harness of test sample circuit	8	Coupling testing apparatus
2b	Wire harness for test	9	Transient waveform generator (Refer to **Annex 8** for details.) The generator shall be connected to a coupling testing apparatus with coaxial cable. The case of the generator shall be connected to the ground plane.)
3	Load simulator		
4	Artificial network	10	Ground plane
5	Vehicle battery or linear type power supply (to test sample and load simulator)	11	Digital oscilloscope (≥ 1 GS/s, ≥ 8 mega sample)
		*	1:100 High impedance probe (C < 4 pF) shall conform to **ISO 7637-2**. e.g. Agilent 10076A
6	Vehicle battery (to transient waveform generator)	**	Current probe (> 10 MHz, 30 A) e.g. Agilent N2783A

Fig. 9 RI 130 Test Setup

7.6.3.1.3 Test procedures The test shall be repeated in all operation modes of the test sample listed in the EMC Test Plan.

(a) The transient waveform generator shall be set in mode 3 and at pulse A2-1. (Refer to **Annex 8**.) Then, it shall be operated with SW0. An oscilloscope shall be used to capture at least one complete transient sequence. (Refer to **Annex 7 Fig. 12**.)

(b) Negative transient voltage interference measured at test points (refer to **Annex 9**) shall be confirmed that it is larger than 300 V. After it is confirmed, SW0 shall be turned off and operation of the transient waveform generator shall be stopped.

(c) The transient waveform generator shall be set in mode 3 and at pulse A2-2, and steps **(a)** and **(b)** shall be repeated. Peak transient interference current shall be confirmed that it is over 20 A.

(d) SW0 shall be turned off and operation of the transient waveform generator shall be stopped. Then, the generator shall be set in mode 2 and pulse A2-1.

(e) The test sample shall be operated and it shall be checked if it functions normally.

(f) Individual test sample circuit wires or paired wires (i.e., twisted pair cable) shall be set to the testing apparatus. (Refer to **Annex 9** for an appropriate circuit setup.)

(g) SW0 shall be turned on and the transient waveform generator shall be operated.

(h) The circuit wires shall be exposed for 60 s. If the response time of test sample function is expected to be longer than 60 s, longer dwell time is needed. This information shall be included in the EMC Test Plan. Performance of the test sample shall be checked that it is not affected by the transient waveform generator.

(i) The transient waveform generator shall be set in the modes shown below and step **(h)** shall be repeated.

- Mode 2, pulse A2-2
- Mode 3, pulse A2-1
- Mode 3, pulse A2-2

(j) Steps **(d)** to **(i)** shall be repeated for each test sample circuit wire.

7.6.3.1.4 Data report

The following factors shall be included in the test report:

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Description of functions to be monitored
- Effects on every performance

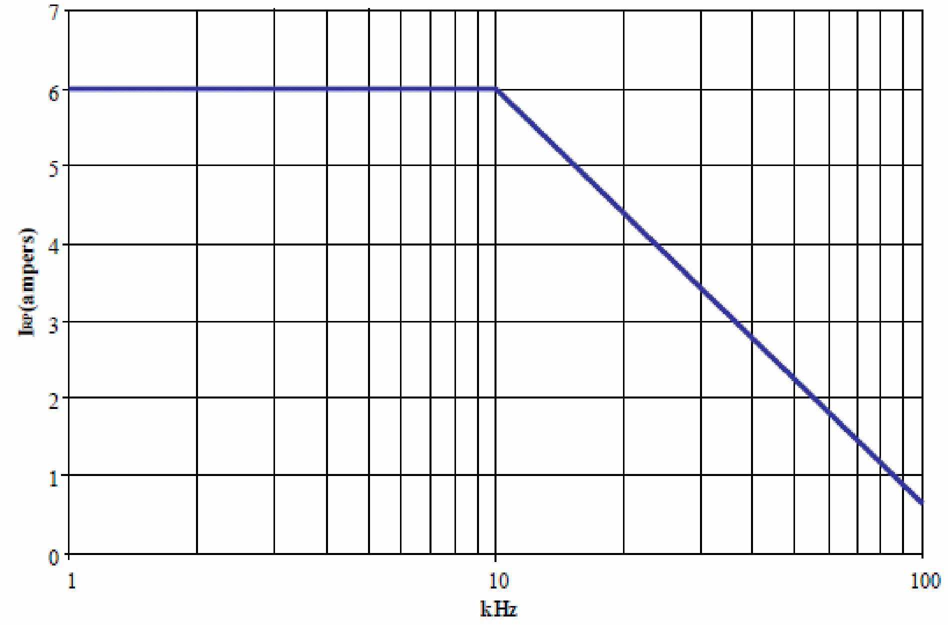
7.6.3.2 RI 150 These requirements relate to components immunity arising from coupling between wire harnesses with unintended continuous interference. These interferences occur from PWM high electric current source, charging of vehicle and ignition system.

These requirements shall be applied to the following components categories:

Electronic components: A, AS

Electric motor: EM

7.6.3.2.1 Requirements The test sample shall operate without adverse effect when exposed to sine wave electromagnetic interference shown in **Fig. 10**.

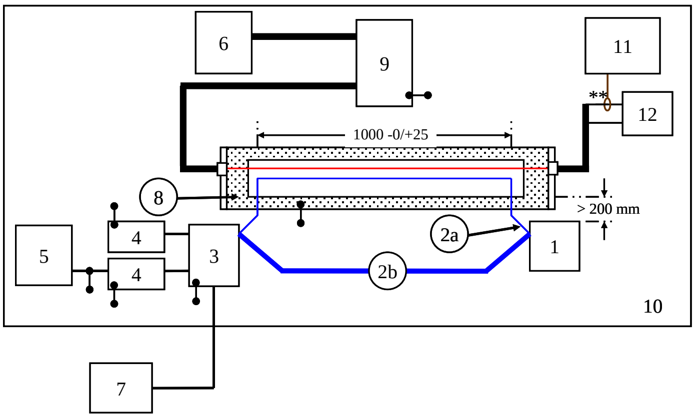


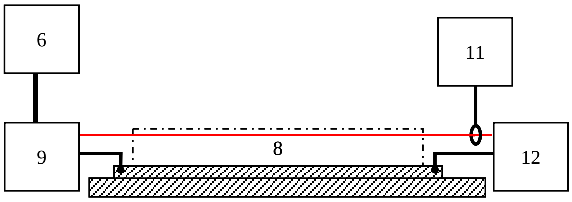
Frequency (kHz)	Level (Ip-p)
1 to 10	6
10 to 100	6-5.4log(f/10)([1])

Fig. 10; Note ([1]) f = frequency (kHz)

Fig. 10 RI 150 Requirements

7.6.3.2.2 Test method and setup The test shall be performed using the test setup shown in **Fig. 11**. Unless otherwise specified in **Fig. 11**, the setup of test sample, load simulator and wire harness for test is the same as the one used for RI 130.





1	Test sample	7	Monitor/test support apparatus
2a	Wire harness of test sample circuit	8	Coupling testing apparatus
2b	Wire harness for test	9	Amplifier (1 kHz to 100 kHz)
3	Load simulator	10	Ground plane
4	Artificial network	11	Digital oscilloscope (≥ 1 GS/s, ≥ 8 mega sample)
5	Vehicle battery or linear type power supply (to test sample and load simulator)	12	Amplifier load resistance (e.g. 4 Ω)
6	Signal generator		** Current probe (> 10 MHz, 30 A) e.g. Agilent N2783A

Fig. 11 RI 150 Test Setup

7.6.3.2.3 Test procedures The test shall be repeated in all operation modes of the test sample listed in the EMC Test Plan.

(a) The test sample shall be operated and it shall be checked if it functions properly.

(b) Individual test sample circuit wire or paired wire (i.e., twisted pair cable) shall be set to the testing apparatus. (The circuit setup is the same as that of RI 130.)

(c) At each test frequency, the peak current shall be increased up to the level that corresponds to **Fig. 10**. The frequency step shown in **Fig. 14** shall be used.

- The dwell time shall be 10 s. If the response time of test sample function is expected to be longer than 10 s, longer dwell time is needed. This information shall be included in the EMC Test Plan.

Table 14 RI 150 Test Frequency Requirements

Test Frequency Range kHz	Frequency Step kHz
> 1 to 10	0.5
> 10 to 100	5

(d) The test sample function shall be monitored before, during and after application of the level shown in **Table 10** to confirm its performance is not affected.

7.6.3.2.4 Data report

The following elements shall be included in the test report:

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Descriptions of functions to be monitored
- Effects on every performance

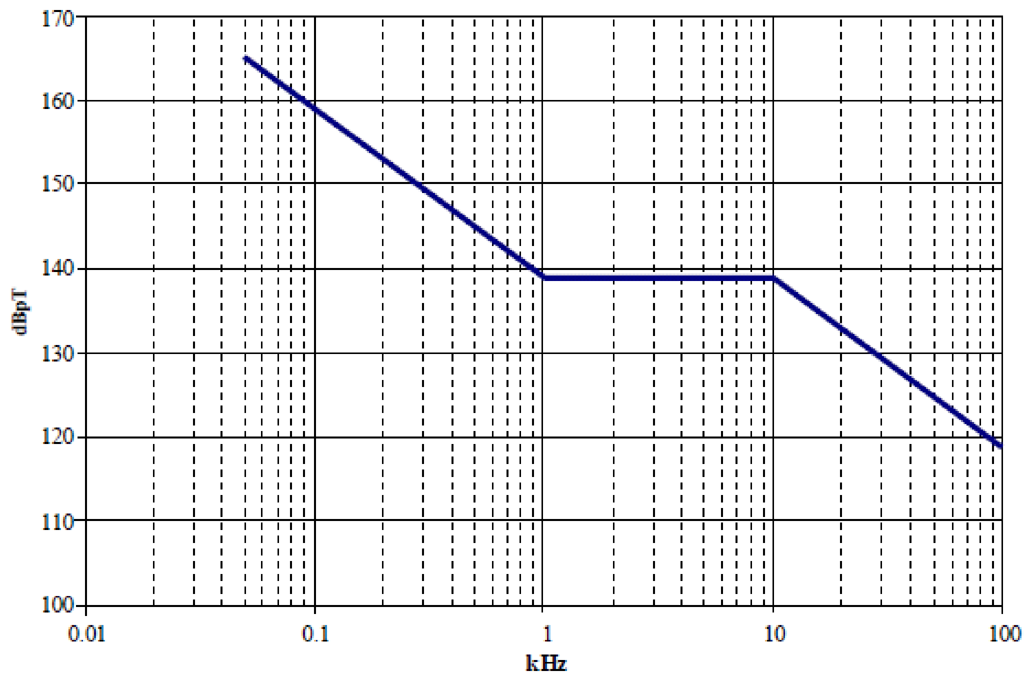
7.6.4 Magnetic field (RI 140) Magnetic field immunity requirements shall cover the frequency range of 0.05 to 100 kHz. The requirements are based on not only “on-vehicle” source (e.g. charging system, PWM source), but also expected “exterior” magnetic source (e.g. AC power line). These requirements apply to the following components categories (having a magnetic sensor, a magnetic field circuit, or a micro-current controlled circuit that is affected by magnetic field).

For actual application, contact Mazda for adjustment and decision.

Electronic components: A, AS, AW

Electric motor: EM

7.6.4.1 Requirements The components mounted with a sensor, circuit, etc. that may be affected by magnetic field shall operate without any effect of a magnetic level shown in **Fig. 12** when they are exposed to it.



Frequency (kHz)	Level (dBpT RMS)
0.05 to 1	165-20*log(f/0.05)([1])
1 to 10	139
10 to 100	139-20*log(f/10)([1])

Fig. 12; Note ([1]) f = frequency (kHz)

Fig. 12 Magnetic Field Requirements

7.6.4.2 Test method and setup

- Components performance test shall be performed using test methods described in **MIL-STD-461E RS101** except for those described herein. The test setup shall be laid out so as to facilitate a direct exposure of the test sample to a magnetic field shown in **Fig. 12** as well as an exposure of a portion of the test sample that may be affected by the magnetic field. This is performed by using an electromagnetic radiating loop antenna 120 mm in diameter or a Helmholz coil with self-resonance of over 100 kHz. **Fig. 13** and **Fig. 14** show the configuration of the test setup. The test shall be performed with frequency shown in **Table 15**. A current probe with sufficient bandwidth shall be used for either test method and only a loop current shall be monitored. (Use of a shunt resistor is not allowed.)

Table 15 Test Frequency Requirements

Frequency Range kHz	Step Size kHz
0.05 to 1	0.05
> 1 to 10	0.5
> 10 to 100	5

- The test sample shall be set on a wooden table or an insulating table for either test. A load simulator and other test support apparatuses can be set on the ground plane, however, a part of the load simulator or the ground plane shall not be as close as 200 mm from the radiating loop antenna or the Helmholz coil.
- Electric hardware such as a test sample and a load simulator shall be powered by a vehicle battery or linear type power supply. The negative terminal of the battery or power supply shall be connected to the ground plane dynamometer. The battery or the power supply shall be set on the floor under or adjacent to the dynamometer.

7.6.4.3 Test procedures The test sample operation mode during a test shall satisfy those described in the EMC Test Plan.

7.6.4.3.1 Radiation loop method

(a) Before the test of a test sample, a radiating loop antenna shall be calibrated using the procedures described in **MIL-STD-461E RS101**.

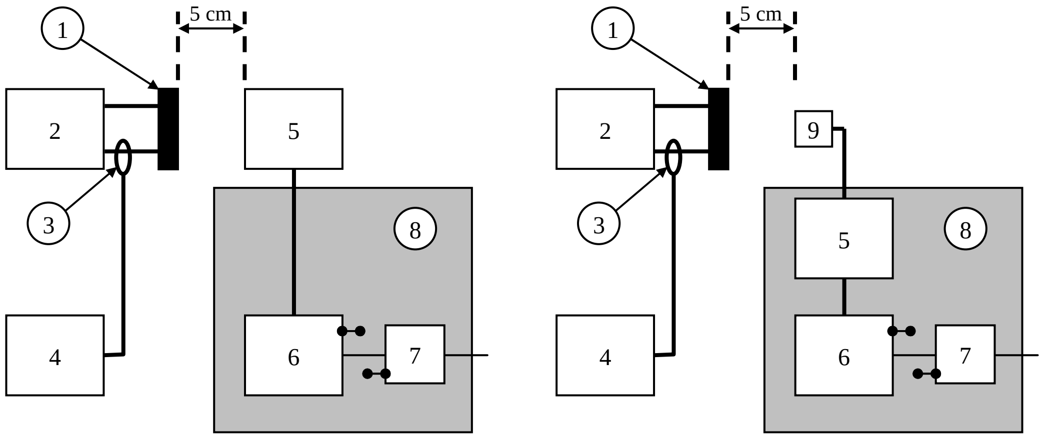
(b) Each face of the test sample shall be divided into square cells of 100 × 100 mm and position a radiating loop antenna face in the center of each of the areas. If the test sample face is under 100 × 100 mm, the radiating loop antenna shall be set in the center of the test sample face. The distance between the radiating loop antenna face and the test sample face shall be 50 mm. The loop sensor face shall be kept parallel to the test sample face and the axis of the connector.

(c) At every position, a sufficient amount of electric current shall be supplied to the loop to produce the electromagnetic level corresponding to **Fig. 12** in each test frequency step in **Table 15**.

(d) The dwell time shall be at least 2 s. If the response time of test sample function is expected to be longer than 2 s, longer dwell time is needed. This information shall be included in the EMC Test Plan.

(e) If any effects are observed, the magnetic field shall be reduced until function of the test sample becomes normal. Then, the magnetic field shall be increased until some effect has occurred. This level shall be reported as a threshold of the effect.

(f) Where a test sample is fitted with a magnetic sensor, another test shall be performed by exposing the sensor only in conjunction with confirming appropriate operation of the test sample. (Refer to **Fig. 13**.)



Test configuration of test sample only

Test configuration of test sample with magnetic sensor

1 Radiating loop antenna
2 Signal source
3 Current probe
4 Measurement receiver
5 Test sample
6 Load simulator
7 Artificial network
8 Ground plane
9 Magnetic sensor

Fig. 13 Test Setup of Magnetic Field: Radiation Loop

7.6.4.3.2 Helmholtz coil method

(a) Before the test of a test sample, a Helmholtz coil shall be set using procedures described in **MIL-STD-461E RS101**. The coil interval shall be selected based on the physical dimensions of the test sample.

- For a test sample that is smaller than the radius of one coil, the coil shall be blocked with the one coil radius. The interval between each face of the test sample and either of the coils shall be at least 50 mm.
- For a test sample larger than the radius of one coil, the coil shall be separated so that the face of the test sample may be at least 50 mm distant from either of the coils and the distance between the two coils may not exceed 1.5 times as large as the radius.

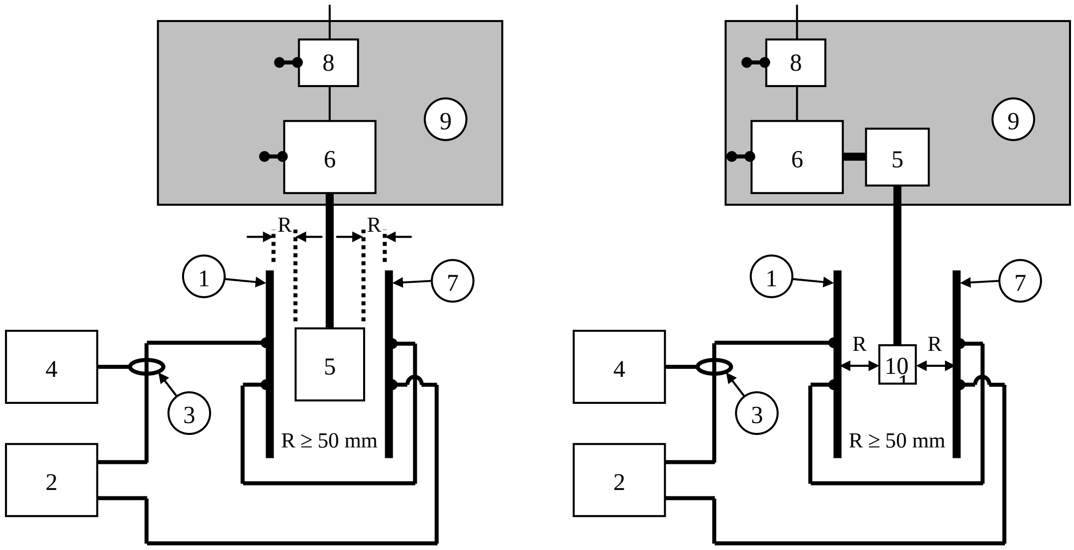
(b) At each test frequency shown in **Table 15**, a current large enough to develop a magnetic field level corresponding to **Fig. 12** shall be supplied to the Helmholtz coil.

(c) The dwell time shall be at least 2 s. If the response time of test sample function is expected to be longer than 2 s, longer dwell time is needed. This information shall be described in the EMC Test Plan.

(d) The test sample or the Helmholtz coil shall be relocated so that the two coils may be parallel to each face of the test sample and may be parallel to the axis of the connector.

(e) If any effects are observed, the magnetic field shall be reduced until function of the test sample becomes normal. This level shall be reported as a threshold of the effect.

(f) If a test sample is fitted with a magnetic sensor, another test shall be performed by exposing the sensor only in conjunction with confirming appropriate operation of the test sample. (Refer to **Fig. 14**.)



Test configuration of test sample only

Test configuration of test sample with magnetic sensor

1	Radiating loop antenna A	6	Load simulator
2	Signal source	7	Radiating loop antenna B
3	Current probe	8	Artificial network
4	Measurement receiver	9	Ground plane
5	Test sample	10	Magnetic sensor

Fig. 14 Test Setup of Magnetic Field: Helmholtz Coil

7.6.4.4 Data report

The following elements shall be included in the test report:

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Details of test setup including test position/direction and Helmholtz coil interval
- Description of functions to be monitored
- Effects on every performance
- Table and plot of minimum magnetic field at each frequency where some effect occurs, including position and direction of the antenna.
- Photograph showing position of the antenna, especially the one showing each position that does not follow specification.

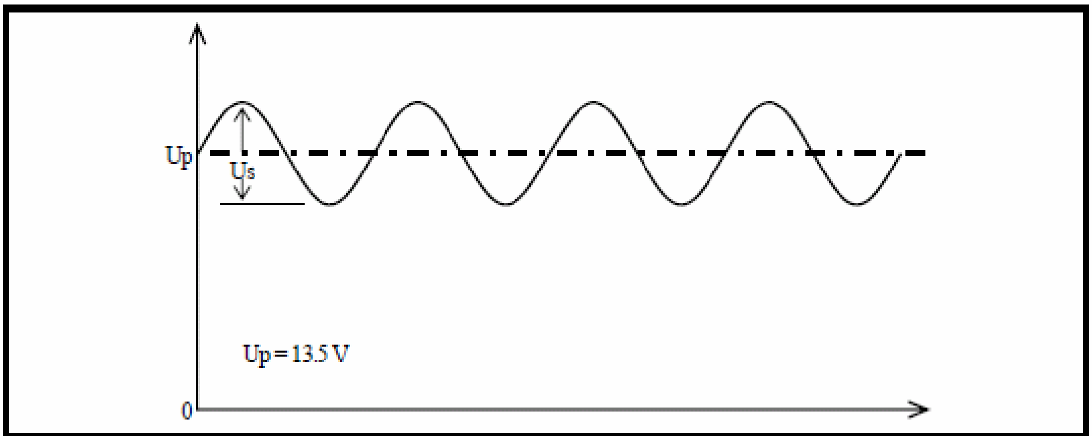
7.7 Conducted immunity (CI)

7.7.1 Continuous noise (CI 210) The test sample shall not be affected by continuous interference occurred on the low-voltage (13.5 VDC) electric distribution system of a vehicle. These requirements apply to the following components categories:

Electronic component: A

Electric motor: EM

7.7.1.1 Requirements The functional performance of the test sample shall satisfy the evaluation criteria shown in **Table 1** and **Fig. 15**.



Frequency range (kHz)	US(Vp-p)
0.05 to 1	0.2
1 to 10	0.2*f([1])
10 to 100 10 to 200 when indicated on Specification Drawing	2

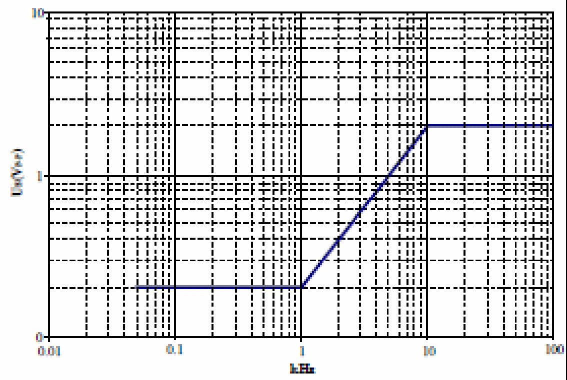
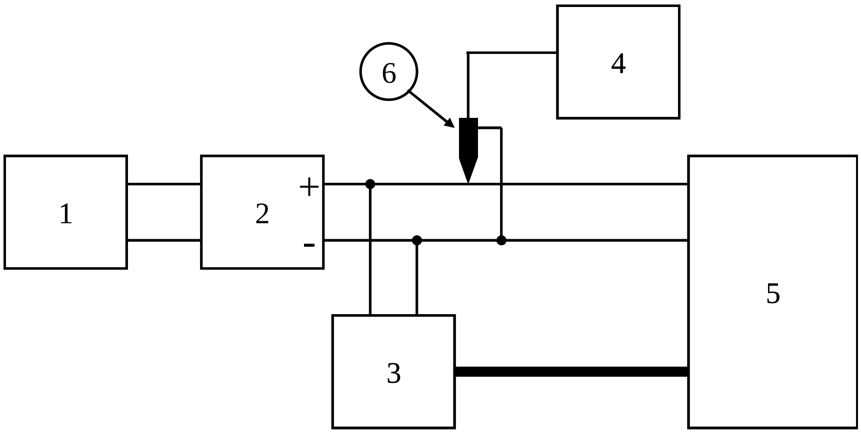


Fig. 15; Note ([1]) f = Frequency (kHz)

Fig. 15 Continuous Noise Requirements

7.7.1.2 Test method and setup The test shall be performed with the test setup shown in **Fig. 16**. The test harnesses for connecting the test sample to the load simulator and testing apparatus (modulated DC power supply) shall be 2,000 mm max. in length. All power supplies of the test sample (positive and negative) shall be connected to the testing apparatus.

- When the ground plane is used, the test sample and test harness shall be set on a 50 mm-thick insulator placed on the ground plane. The negative side of the testing apparatus and the case of the load simulator shall be grounded to the ground plane.



1 Signal generator
2 Test support apparatus (modulated DC power supply) (may be a DC audio amplifier with output impedance of under 100 mΩ.)
3 Load simulator
4 Oscilloscope
5 Test sample
6 Passive high impedance probe (< 1 MΩ, C < 10 pF)

Fig. 16 Test Setup of Continuous Noise

7.7.1.3 Test procedures

(a) In disconnected condition of the test sample, DC offset "U_p" of the signal generator and audio amplifier shall be adjusted to 13.5 V. First, AC voltage amplitude "Us" shall be set to "zero volt". (Refer to **Fig. 16**.)

(b) The test sample shall be connected, operated, and checked if it functions normally. "U_p" shall be checked if it remains 13.5 VDC. Power supply shall be adjusted to the amount needed to achieve this voltage level.

(c) In each test frequency, U_s shown in **Fig. 15** shall be increased to the test level corresponding to **Fig. 15**. The dwell time shall be at least 2 s. If the response time of test sample function is expected to be longer than 2 s, longer dwell time is needed. This information shall be included in the EMC Test Plan.

(d) Function of the test sample shall be monitored and checked if any abnormality occurs.

(e) The test frequency step shown in **Table 16** shall be used and steps **(a)** to **(d)** shall be repeated.

(f) The test shall be repeated in all operation modes of the test sample listed in the EMC Test Plan.

Table 16 Test Frequency Requirements

Frequency Range kHz	Step Size kHz
0.05 to 1	0.05
1 to 10	0.5
10 to 100	5

7.7.1.4 Data report

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Description of functions to be monitored
- Effects on every performance
- Photograph of test setup

7.7.2 Transient noise (CI 220) These requirements relate to conducted transient noise immunity of power supply and control circuit indirectly connected through a switch or a load (e.g. pull-up resistor), or connected directly to a vehicle battery.

These requirements apply to the following components categories:

Electronic component: A

Electric motor: EM

Passive component: P (Requirements may not be applied to the test depending on analysis.)

7.7.2.1 Requirements The components shall not be affected by transient voltages generated as a result of operation including internal or external inductive load switching. Application of such transient voltages or components performance requirements shall conform to **Table 17**.

Table 17 Transient Noise Requirements

Transient Pulse (1) (2) (3)	Application (2)	Transient Mode (1) (3)	Test Duration
Pulse A1	Switch type power circuit with max. current of under 5 ampere	Mode 1	120 s
	Input circuit (6)	Mode 2	20 s
Pulse A2-1	Switch type power circuit with max. current of under 5 ampere	Mode 1	120 s
Pulse A2-1 Pulse A2-2	Input circuit (6)	Mode 2 Mode 3	20 s
Pulse C-1 Pulse C-2	All power circuits and input circuits	Mode 2 Mode 3	20 s
Pulse E	Switch type power circuit with 5 ampere or more	n/a	24 pulses
	Input circuit (6)		
Pulse F1 (4)	All power circuits	n/a	5,000 pulses
Pulse F2 (4)	All power circuits	n/a	10 pulses
Pulse G1 (5) (Load dump)	All power circuits and input circuits (6)	n/a	5 pulses
Pulse G2 (Central Load Dump) (5)	All power circuits and input circuits (6)	n/a	5 pulses

Table 17; Notes (1) For description of transient pulse and mode, refer to **Annex 7**.

(2) For requirements of application of transient pulse, refer to **Annex 10**.

(3) For requirements of the generator that generates transient pulses A1, A2 and C, refer to **Annex 8**.

(4) Pulses F1 and F2 shall be applied only to components that verification of conformity to **ECE R10** and requirements of the related regulation, **ESA**, is needed.

(5) Pulse G1 or Pulse G2 is selected by necessity of protection of central load dump (CLD) for vehicles. Selected pulse shall be approved by Mazda and shall conform to the EMC Test Plan.

(6) The input circuit is a circuit that is directly or indirectly connected to a battery.

7.7.2.2 Test method and setup Conform to **ISO 7637-2** except for those described herein for the components performance test.

- Test pulses A and C shall be generated by using the test circuit shown in **Annex 8**.
- Test pulses E, F and G shall be generated by using a general transient voltage generator capable of generating standard test pulses conforming to **ISO 7637-2**.
- For the test setup to use pulse G1, a resistor having the value specified by Mazda (to be described in the EMC Test Plan) shall be connected outside a test pulse generator. Refer to **Fig. 21**.
- Test pulse G2 shall be generated by using the circuit shown in **Fig. 21**. A diode bridge shall be designed so that open circuit voltage waveform shown in **Annex 7 Fig. 10** can be generated.
- Electric hardware such as a test sample or the inside of a load simulator shall be powered by a vehicle battery. (Refer to **section 7.1.3 (7)**.) The artificial network shall not be used as a part of test setup.
- The length of each harness that connects a test sample, load simulator and transient pulse generator shall be 2,000 mm max. Individual ground circuit shall be a part of cable harness or a divided one of it as shown in **Fig. 17**. If the test sample has several power supplies (e.g. from +B, IG1 or relay) or input circuits, they shall be tested individually.
- The test sample and test harness shall be set on a 50 mm-thick insulator placed on the ground plane.
- The component (category AS) powered by an external power supply provided on any other component shall be tested as a system with a component for power supply or an equivalent power supply. The details of this setup shall be described in the EMC Test Plan.

Fig. 17 shows a general test setup of test sample with one power circuit that performs remote ground connection.

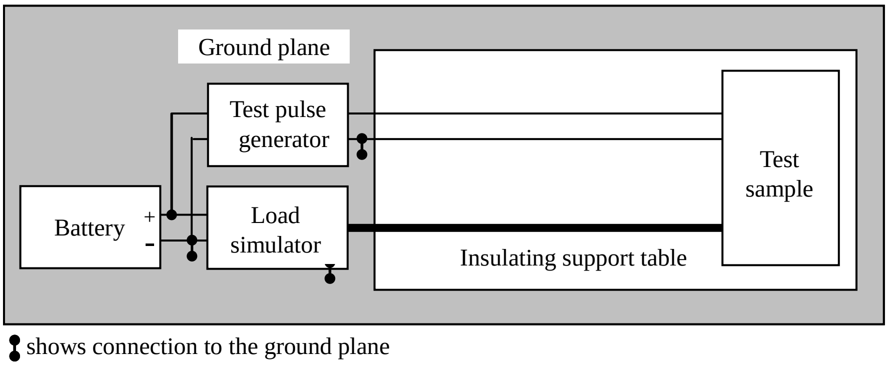


Fig. 17　Test Setup of Components with One Power Supply Circuit

Fig. 18 shows a test setup of components with two power circuits.　In this configuration, a power circuit (U_1) not to be tested is connected directly to the battery.　If the component has any other power circuit operated on the same voltage, the circuits shall be connected directly to the battery.

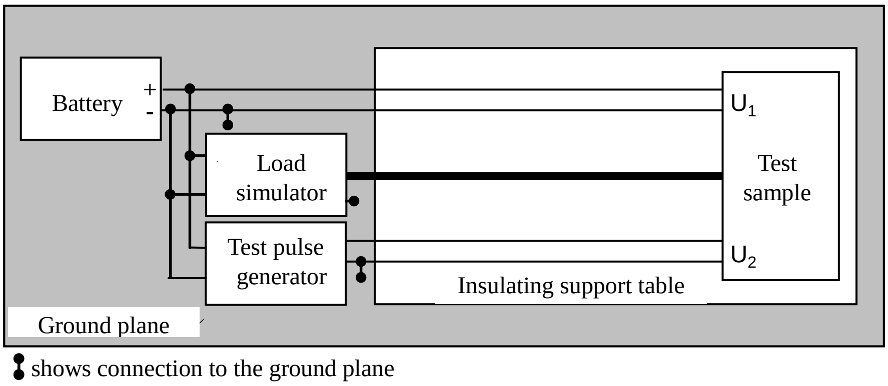


Fig. 18　Test Setup of Components with Two Power Supply Circuits

Fig. 19 shows a setup used for a test of input circuit.

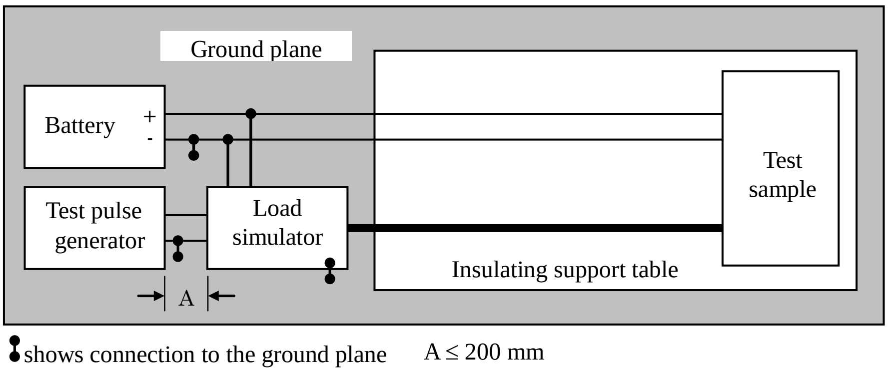


Fig. 19　Test Setup of Components with Input Circuit

Fig. 20 shows a special case of a test sample connection to a battery resulting from indirect utilization of pull-up resistor by an input circuit.

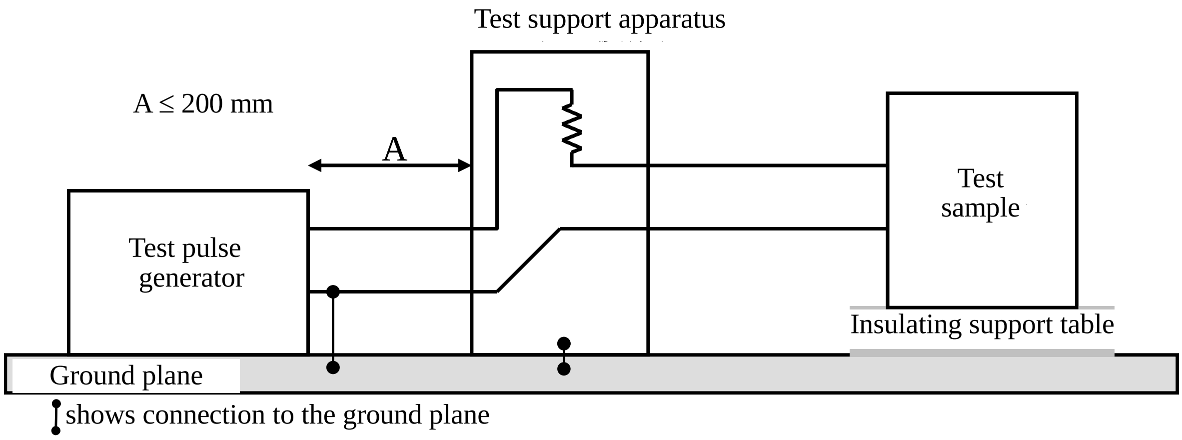


Fig. 20　Test Setup of Components with Input Circuit using Pull-up Resistor

In use of central load damp (CLD) protection, a Zener diode (Z1) shall be connected through the test pulse generator in place of R_L.　The detailed specification of the diode is indicated on Specification Drawing.　When a Zener diode is not connected and the waveform of **Annex 7 Fig. 11** is generated, a prior confirmation of Mazda shall be obtained.　If no instruction is made, CLD evaluation is not required.

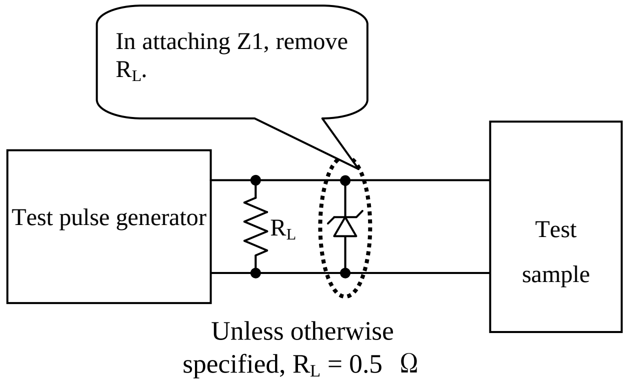


Fig. 21　Test Setup of PULSE G (Load Dump Simulator)

7.7.2.3 Test procedures　　In accordance with the requirements described in **Annex 10** and the EMC Test Plan, test pulse shall be applied to the power supply and the input circuit.

(a) Before the test

- For pulse G1, the test sample and “R” shall be disconnected (open circuit condition) and the transient waveform generator shall be adjusted to the voltage level shown in **Annex 7 Fig. 9**.　An oscilloscope and a voltage probe that satisfy requirements described in **ISO 7637-2** shall be used to facilitate pulse measurement.

- For pulse G2, the test sample shall be disconnected and "R" shall be connected. The transient waveform generator shall be adjusted to the voltage level shown in **Annex 7 Fig. 10**. An oscilloscope and a voltage probe that satisfy requirements described in **ISO 7637-2** shall be used to facilitate pulse measurement.
- For pulses A and C, the output of transient test circuit (open circuit condition) shall be checked if it produces typical waveforms described in **Annex 7**.

(b) The test sample shall be connected and it shall be checked if it functions properly.

(c) Each test pulse in **Table 17** except for pulses G1 and G2 shall be applied to one circuit each time against a test sample and an input circuit. Test pulses G1 and G2 shall be applied to all power supplies and input circuits simultaneously.

(d) Before application of pulse G1, R_L resistor shall be connected to the transient pulse generator as shown in **Fig. 21**. For pulse G2, an optional diode shall be connected in place of R_L. (In a default condition, remove the diode.) Before application of the waveform to the test sample, the waveform shall be checked if it conforms to load waveform requirements shown in **Annex 7 Fig. 9** and **Fig. 10**.

(e) Function of the test sample shall be monitored before, during and after application of each test pulse within the test period designated in **Table 17**.

7.7.2.4 Data report

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Description of functions to be monitored
- Effects on every performance
- Photograph of test setup

7.7.3 Power voltage fluctuations

7.7.3.1 Power cycle (CI 230)

These requirements apply to the following components categories:

Electronic component: A

Electric motor: EM

7.7.3.1.1 Requirements Any component shall not be affected by voltage fluctuations that occur upon vehicle engine start in a low temperature condition. This requirement shall not be applied to the condition where a warmed-up engine is restarted. **Fig. 22** shows the voltage waveforms indicating such fluctuations. Application of these waveforms depends upon connection methods to components power supplies and control circuits. **Table 18** shows applicable requirements of each waveform.

Table 18 Power Cycle Requirements

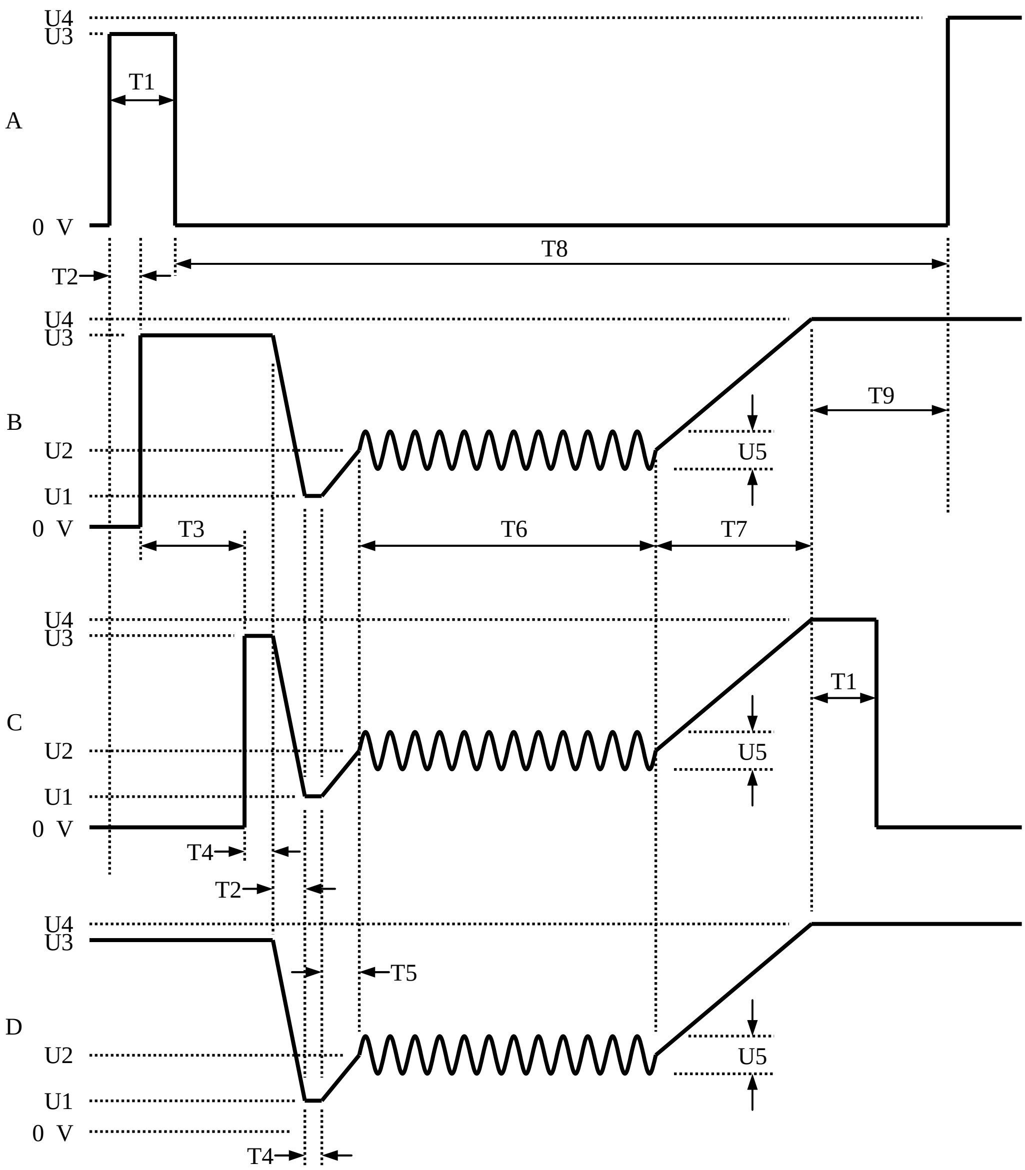
Waveform (1)	Application	Test Duration
A	Power supply and control circuit (circuit operating on RUN, not START) connected to battery using IGN2 (RUN) of ignition switch.	Once each in low temperature condition. 2 cycles in total.
B	Power supply and control circuit (circuit operating during RUN or START) connected to battery using IGN1 (RUN/START) of ignition switch. Connection to battery using relay switch is included.	
C	Power supply and control circuit (circuit operating during engine START only) connected to battery using START of ignition switch	
D	Power supply and control circuit directly connected to battery	

Table 18; **Note (1)** Waveforms shall be applied to all power supplies and control circuits at the same time.

7.7.3.1.2 Test method and setup

The test shall be performed using the test setup shown in **Fig. 23**.

- The length of each harness that connects the test sample, load simulator and transient pulse generator shall be 2,000 mm max.
- The test shall be performed at $-40^{\ 0}_{-5}$ °C or the lowest temperature designated on Specification Drawing of components. The test temperature shall be described in the EMC Test Plan.
- The test sample shall be set on a 50-mm thick insulator placed on a metal floor of a thermostatic chamber.



T1	100 ms	T8	11 s
T2	5 ms	T9	325 ms
T3	185 ms	U1	5 V
T4	15 ms	U2	9 V
T5	50 ms	U3	12.5 V
T6	10 s	U4	13.5 V
T7	500 ms	U5	2 Vp-p @4 Hz

Fig. 22 Power Cycle Waveform and Time Sequence

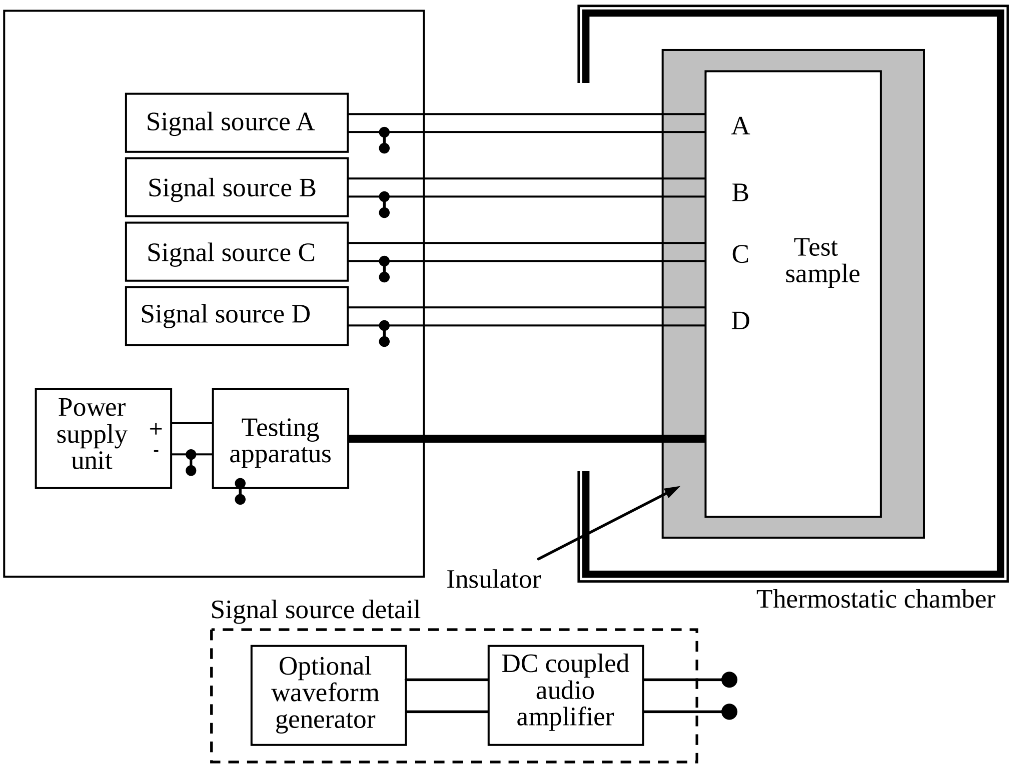


Fig. 23 Power Cycle Test Setup

7.7.3.1.3 Test procedures All waveforms shall be applied to all power supplies and control circuits at the same time according to the time sequence shown in **Fig. 22**. The waveforms shall be checked before application to the test sample.

(a) The waveforms shall be checked before application to the test sample.

(b) Unless otherwise specified in the EMC Test Plan, the test sample (inactive) shall be left untouched at the lowest operating temperature indicated on Specification Drawing or $-40^{\ 0}_{-5}$ °C for 1 h.

(c) The waveforms shown in **Fig. 22** shall be applied. The test sample functions shall be monitored before, during, and after the test. It is recommended to apply the test sequence with the test sample set inside a thermostatic chamber. (Refer to **Fig. 23**.) However, if the test sample is taken out of the thermostatic chamber after an exposure period (step **(b)**) and is tested within 10 min, tests may be performed with a test sample placed outside the thermostatic chamber. For this approach, a prior approval of Mazda is required and the exposure temperature shall be lowered further by 10 °C.

(d) The test sample shall be left untouched at the same temperature as step **(b)** for 30 min and the above step **(c)** shall be repeated. Where a test sample is tested outside the thermostatic chamber, the test sample shall be returned within 10 min.

7.7.3.1.4 Data report

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Description of functions to be monitored
- Effects on every performance
- Photograph of test setup

7.7.3.2 Voltage dropout (CI 260)

These requirements shall be applicable to the following component categories:
Electronic components: A, AS
Electric motor: EM

7.7.3.2.1 Requirements No components shall be affected by an instantaneous voltage drop which may occur under a mounting condition. Circuits affected shall include all power supplies and control circuits. These requirements shall also apply to components that are powered by another component (e.g. sensors). The requirements shall conform to **Table 19**. The purpose of this test is to verify controlled recovery of hardware and software from instantaneous power interruptions.

Table 19 Voltage Drop Requirements

Waveform	Application	Level	Test Duration
A Voltage Drop: High	All power and control circuits	See **Fig. 24a**	3 cycles separated by 20 s
B Voltage Drop: Low	All power and control circuits	See **Fig. 24 b**	3 cycles separated by 20 s
C Single Voltage Drop	All power and control circuits	See **Fig. 25**	3 cycles separated by 20 s
D Voltage Dip	All power and control circuits	See **Fig. 26**	10 cycles separated by 20 s
E Battery Recovery	Limited to power circuit with direct connection to battery	See **Fig. 27**	2 cycles separated by 20 s
F Random Bounce	All power and control circuits with max. current of under 5A	See **Fig. 28** and **Fig. 29**	60 s
G (Power supply fluctuations)	All power circuits	See **Fig. 30**	60 s

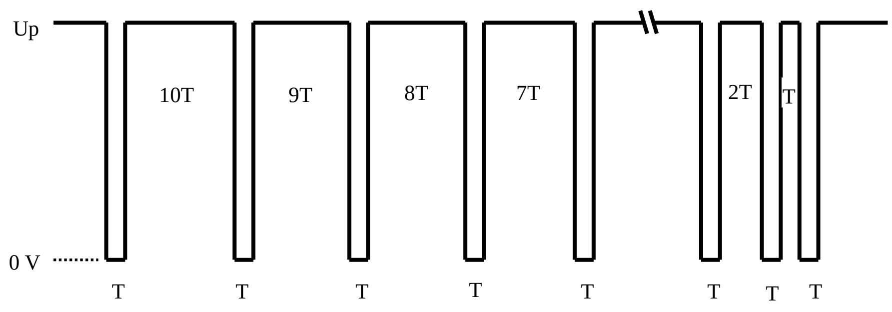
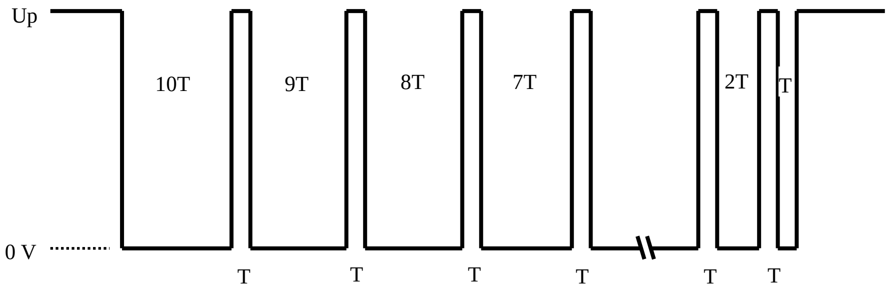


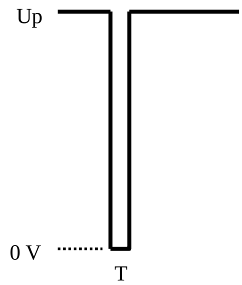
Fig. 24a Waveform A (Voltage Drop: High)



	Electric Power from Vehicle Battery				Regulated Power from another Component			
Up	13.5 V				Rated voltage (Example: 5 V, 3 V)			
T	100 µs	300 µs	500 µs	2 ms	100 µs	300 µs	500 µs	2 ms
	5 ms	10 ms	30 ms	50 ms	5 ms	10 ms	30 ms	50 ms

The waveform transition time shall be approximately 10 µs.

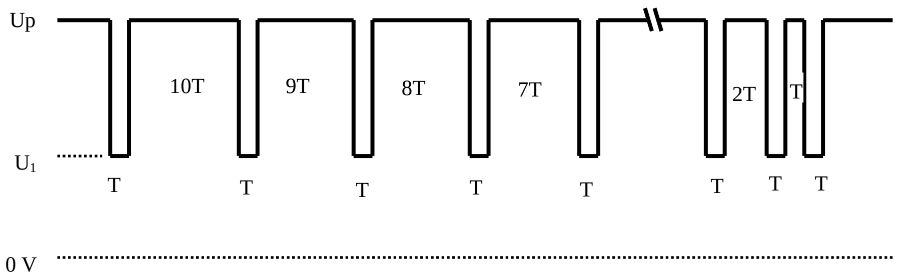
Fig. 24b Waveform B (Voltage Drop: Low)



	Electric Power from Vehicle Battery			Regulated Power from another Component		
Up	13.5 V			Rated voltage (Example: 5 V, 3 V)		
T	100 µs	300 µs	500 µs	100 µs	300 µs	500 µs

The waveform transition time shall be approximately 10 µs.

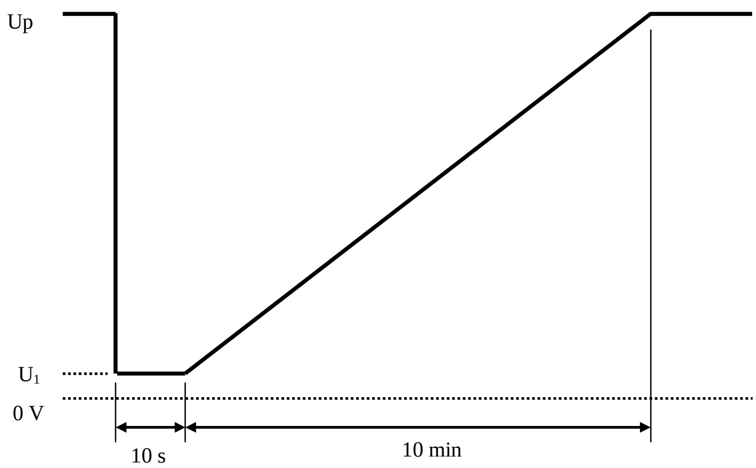
Fig. 25 Waveform C (Single Voltage Drop)



	Electric Power from Vehicle Battery				Regulated Power from another Component			
Up	13.5 V				Rated voltage (Example: 5 V, 3 V)			
U_1	5 V				80 % of rated voltage			
T	100 μs	300 μs	500 μs	2 ms	100 μs	300 μs	500 μs	2 ms
	5 ms	10 ms	30 ms	50 ms	5 ms	10 ms	30 ms	50 ms

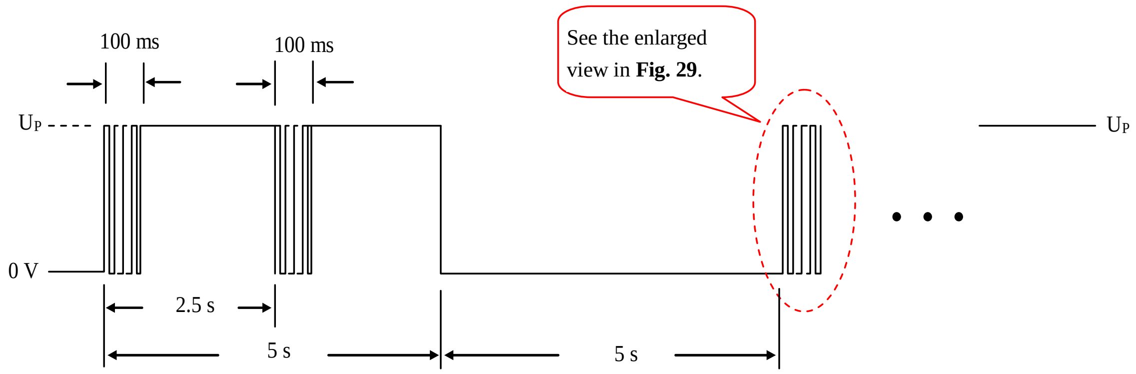
The waveform transition time shall be approximately 10 μs.

Fig. 26 Waveform D (Voltage Dip)



Up	12.5 V
U_1	5 V

Fig. 27 Waveform E (Battery Recovery)



Waveform sequence ends with Up.

Fig. 28 Waveform F (Random Bounce)

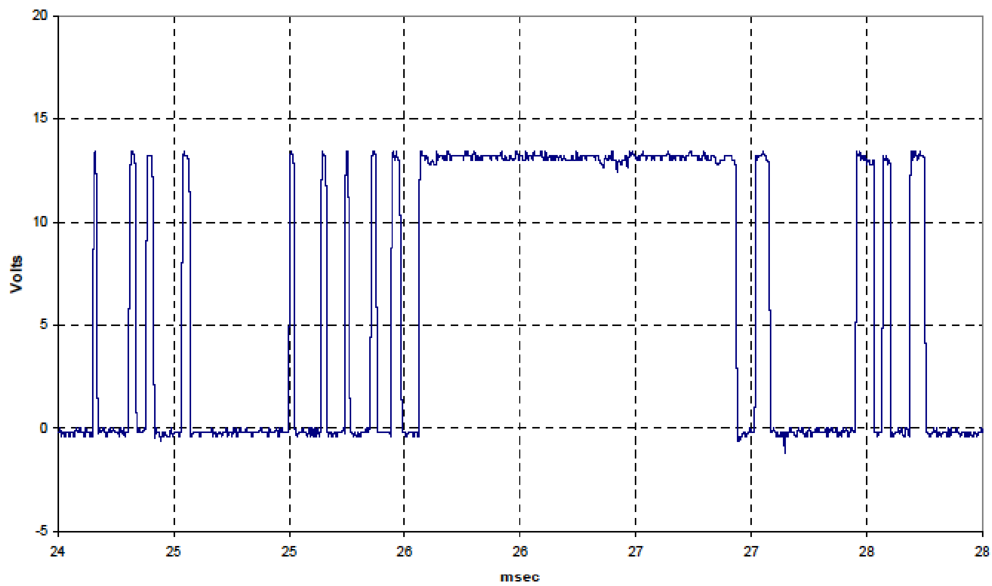


Fig. 29 Waveform F (Enlarged)

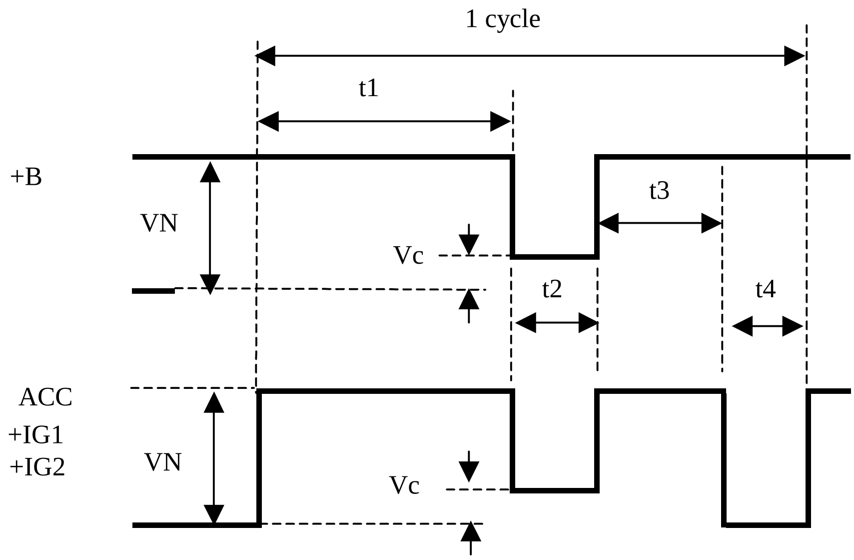


Fig. 30 Waveform G (Evaluation Parameter)

7.7.3.2.2 Test method and setup The test shall be performed in accordance with the test setups shown in **Fig. 31** to **Fig. 33**. The length of each harness that connects the test sample, load simulator and transient pulse generator shall be 2,000 mm max.

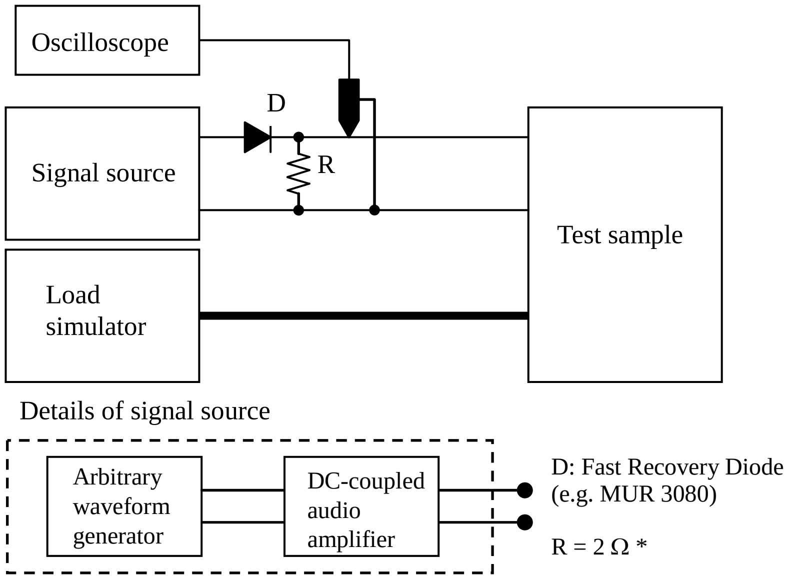


Fig. 31 Test Setup of Waveforms A, B and C

* When a test is performed for a test sample whose electricity is powered by a regulated power supply (category AS), the resistance value can be increased. This resistance value shall be agreed with Mazda mutually. The resistance value shall be described in the EMC Test Plan.

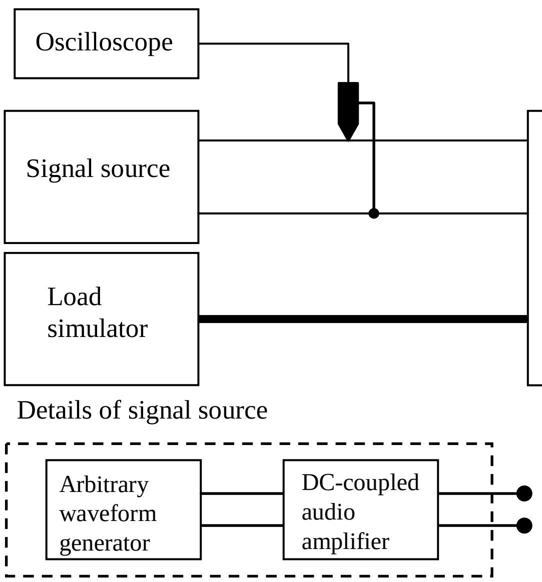
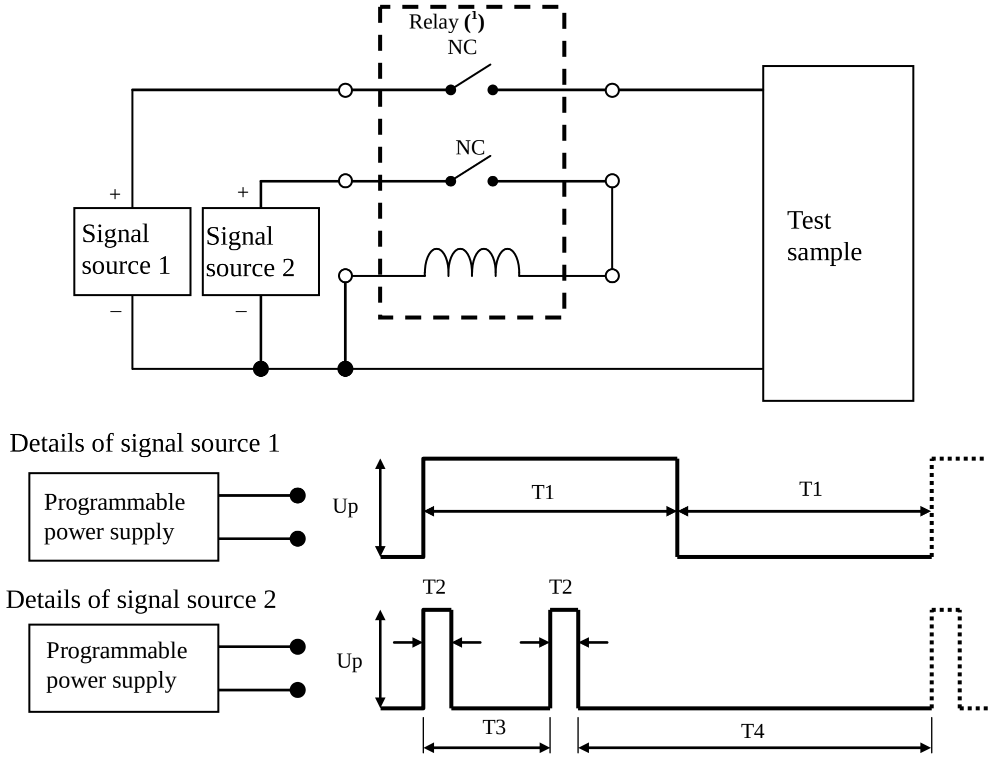


Fig. 32 Test Setup of Waveforms D, E and G



Up	13.5 V
T1	5 s
T2	100 ms
T3	2.5 s
T4	7.4 s

Fig. 33; Note (1) 12 V AC relay: Potter & Brumfield KUP-14A15-12
No substitutions permitted without permission from Mazda.
Refer to **Annex 8** for the relay specifications.

Fig. 33 Test Setup of Waveform F

7.7.3.2.3 Test procedures

(a) With the test sample disconnected (open circuit), the DC offset of the signal generator and audio amplifier shall be adjusted to 13.5 V.

(b) Before testing, test waveforms A, B, C, D, E and G shall be checked if they conform to those waveforms specified in **section 7.7.3.2.1**. As for waveform F, the test waveform voltage shall be checked if it is the same as that specified in **Fig. 29** and **Fig. 30**.
All measurements shall be performed with the test sample disconnected from the waveform generator.

(c) The test sample shall be connected and actuated. Then, it shall be checked if it functions properly.

(d) Except for waveform E, each waveform shall be applied to each power supply and control circuit separately. Waveform E shall be applied simultaneously to all power circuits with direct battery connections.

(e) Waveform G shall be evaluated as follows:

Each parameter specified in **Fig. 30** shall be changed under the following conditions of **(1)** to **(6)** shown below, and shall be evaluated. However, items of **(1)** Cranking start time (t1) and **(6)** Cranking voltage (Vc), which are not included in the operating condition of test sample, shall be excluded. Furthermore, in the specified conditions of **(2)** Cranking time (t2), conditions that operation check is not necessary undoubtedly can be exempted from evaluation with a prior approval of Mazda.

Next, conditions that have concerns of malfunctions of hardware or software shall be extracted except for operation time and reference voltage of the conditions of the following **(1)** to **(6)**, and shall be evaluated after changing cranking time and cranking voltage as described above.

(e-1) Cranking start time: t1 Starting from the operation timing defined in **(1.1)**, this test shall be performed at each timing of before, during and after the operation. The EMC Test Plan shall be presented for the detailed condition of the timing.

(e-1-1) Operation timing

- Access to inside of the test sample/external memory
- Communication to IC inside the test sample
- Communication to other units (communication reset is included)
- Initial failure diagnostic function toward a sensor/an actuator
- Interruption that occurs at rise time of power supply
- Wakeup
- Initial operation of a microcomputer
- Intrinsic operation at rise time of the applicable test sample

(e-2) Cranking time: t2

t2 = 1 to 20 ms (change at intervals of 1 ms),
20 to 100 ms (change at intervals of 10 ms)

(e-3) Elapsed time after termination of cranking: t3

Time from which malfunction of the test sample can be judged

(e-4) Power OFF: t4

As for vehicles this applicable unit is mounted, time until ACC, +IG1, +IG2 power supplies are completely OFF. (When it is not clear, take 3 s as a standard.)

(e-5) Rated voltage: VN

Typical value of voltage that assures performance

(e-6) Cranking voltage: Vc

(e-6-1) Specifications of +B and +IG1 power supplies

Taking the voltage specified in **(6.1.1)** as a reference voltage, operation at each point shall be evaluated at intervals of 0.1 V from (reference voltage − 1 V) to (reference voltage + 1 V).

In the following reference voltages, as for those that can be expressed by the voltage value of internal circuit of the test sample, +B and IG1 voltages, which are voltage values of the internal circuit, shall be calculated by the applicable test circuit conditions and they shall be the test voltages.

(e-6-1-1) Reference voltage

- CPU reset voltage value used in the test sample
- Failure detection voltage value of low voltage power supply
- Voltage value for judgment of IG OFF
- Voltage when operation of internal circuit of the test sample specified in "**(1) Cranking start time"** stops
- Voltage when actuation of other test samples, sensor and actuator specified in "**(1) Cranking start time"** stops
- Voltage value that conditions are established by intrinsic operation at rise time of the applicable test sample

(e-6-2) Specification of ACC and +IG2 power supplies

- 0 V shall be fixed.

The test shall be performed 2 cycles for each testing point defined in the above applicable conditions.

(f) Application of the waveform shall be in accordance with the requirements specified in **Table 19**. The test sample functions shall be monitored before, during, and after application of each test waveform.

(g) The test shall be repeated in all operation modes of the test sample listed in the EMC Test Plan.

Remark EMC performance class shall be checked every 1 cycle of each waveform (every 2 cycles for waveform G).

7.7.3.2.4 Data report

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Description of functions to be monitored
- Effects on every performance
- Photograph of test setup

7.7.4 (Specifications deleted)

Alternator Load Dump Test (CI 240) has been moved to **section 7.7.2**, Test Pulse G.

7.7.5 Voltage offset (CI 250)

These requirements shall be applicable to the following component categories:

Electronic component: A

Electric motor: EM

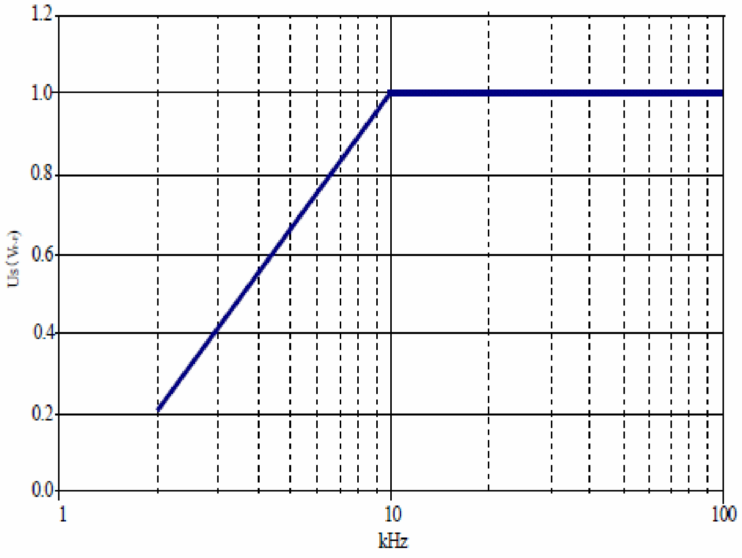
These requirements shall not be applicable to a ground line provided to another component (e.g. sensors).

7.7.5.1 Requirements The component shall not be affected by AC ground voltage offset. Continuous and transient interferences are included in the requirements.

CI 250 requirements for continuous interference are described in **Fig. 34**.

CI 250 requirements for transient interference are described from **Fig. 35** to **Fig. 37**.

Transient interference consists of sine wave pulse accompanying resonance frequency of 100 kHz. The pulse is applied using delayed sequence shown in **Fig. 37**. Delay time of 4 sequences is described in **Table 20**.



Frequency range (kHz)	Us (Vp-p)
0.1(1)	± 5V(1)
2 to 10	1.0+1.14*log(f/10)(2)
10 to 100	1.0

Fig. 34; Notes (1) Only for this frequency, 50 % of rise time and fall time shall be square-wave pulse of 10 μs, and dwell time shall be 1 min for each polarity. Only the test samples that are connected to several ground lines shall be the subject. They shall be specified in the EMC Test Plan.

(2) f = frequency (kHz)

Fig. 34 Voltage Offset Requirements

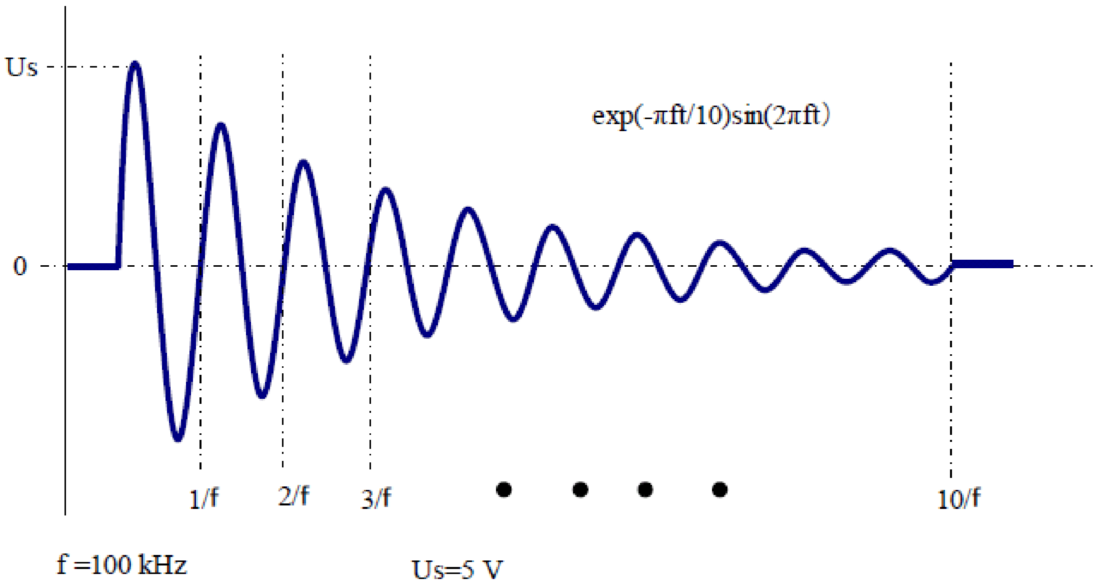


Fig. 35 Details of CI 250 Transient Pulse

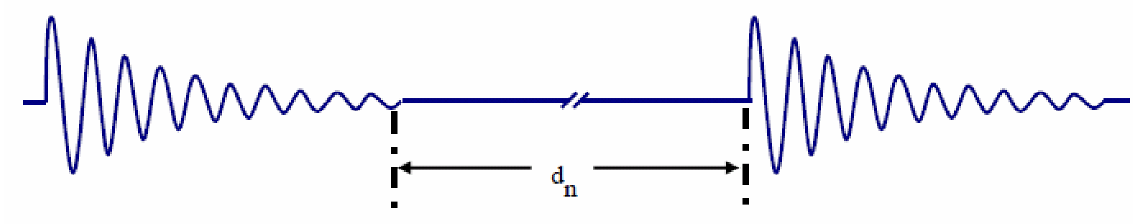


Fig. 36 Details of CI 250 Transient Pulse Delay

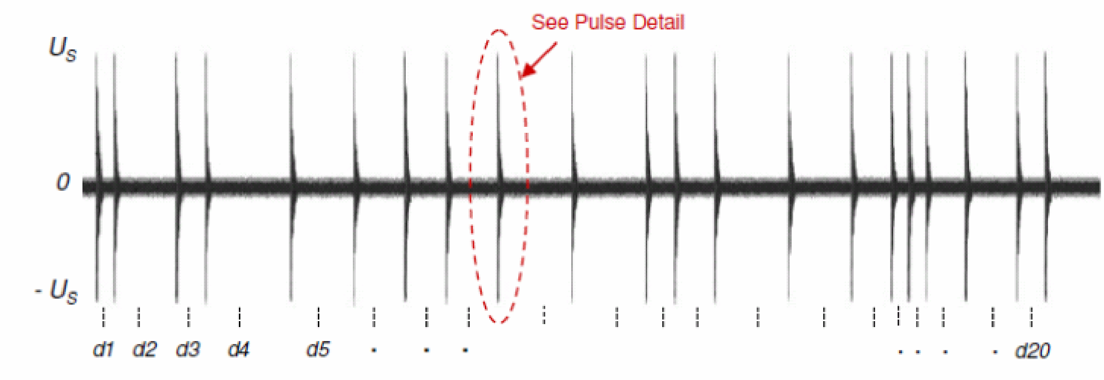


Fig. 37 CI 250 Requirements (Transient Interference Sequence)

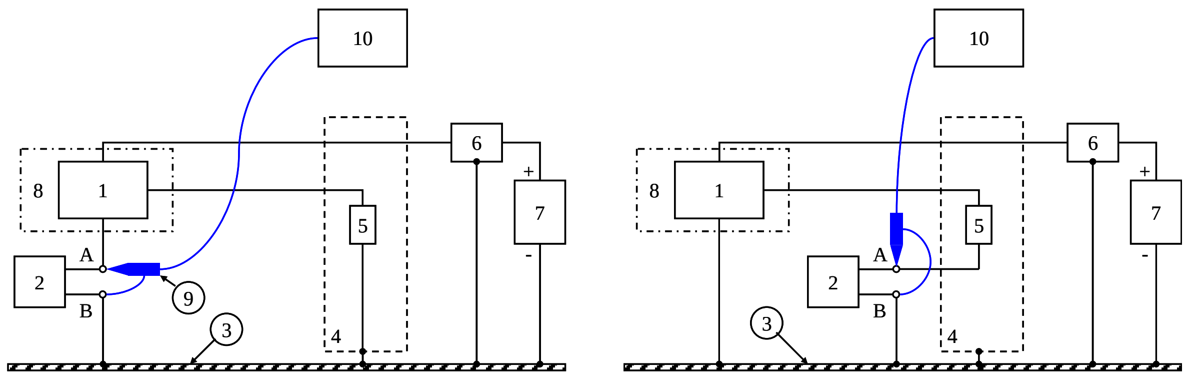
Table 20 CI 250 Delay Time Sequence 1-4

Sequence 1	*d1*	*0.1 ms*	*d6*	*0.4 ms*	*d11*	*0.2 ms*	*d16*	*0.1 ms*
	d2	*0.5 ms*	*d7*	*0.3 ms*	*d12*	*0.3 ms*	*d17*	*0.1 ms*
	d3	*0.2 ms*	*d8*	*0.4 ms*	*d13*	*0.6 ms*	*d18*	*0.3 ms*
	d4	*0.7 ms*	*d9*	*0.6 ms*	*d14*	*0.5 ms*	*d19*	*0.4 ms*
	d5	*0.5 ms*	*d10*	*0.6 ms*	*d15*	*0.3 ms*	*d20*	*0.2 ms*
Sequence 2	*d1*	*0.2 ms*	*d6*	*0.8 ms*	*d11*	*0.4 ms*	*d16*	*0.2 ms*
	d2	*1.0 ms*	*d7*	*0.6 ms*	*d12*	*0.6 ms*	*d17*	*0.2 ms*
	d3	*0.4 ms*	*d8*	*0.8 ms*	*d13*	*1.2 ms*	*d18*	*0.6 ms*
	d4	*1.4 ms*	*d9*	*1.2 ms*	*d14*	*1.0 ms*	*d19*	*0.8 ms*
	d5	*1.0 ms*	*d10*	*1.2 ms*	*d15*	*0.6 ms*	*d20*	*0.4 ms*
Sequence 3	*d1*	*0.5 ms*	*d6*	*2.0 ms*	*d11*	*1.0 ms*	*d16*	*0.5 ms*
	d2	*2.5 ms*	*d7*	*1.5 ms*	*d12*	*1.5 ms*	*d17*	*0.5 ms*
	d3	*1.0 ms*	*d8*	*2.0 ms*	*d13*	*3.0 ms*	*d18*	*1.5 ms*
	d4	*3.5 ms*	*d9*	*3.0 ms*	*d14*	*2.5 ms*	*d19*	*2.0 ms*
	d5	*2.5 ms*	*d10*	*3.0 ms*	*d15*	*1.5 ms*	*d20*	*1.0 ms*
Sequence 4	*d1*	*1 ms*	*d6*	*4 ms*	*d11*	*2 ms*	*d16*	*1 ms*
	d2	*5 ms*	*d7*	*3 ms*	*d12*	*3 ms*	*d17*	*1 ms*
	d3	*2 ms*	*d8*	*4 ms*	*d13*	*6 ms*	*d18*	*3 ms*
	d4	*7 ms*	*d9*	*6 ms*	*d14*	*5 ms*	*d19*	*4 ms*
	d5	*5 ms*	*d10*	*6 ms*	*d15*	*3 ms*	*d20*	*2 ms*

dn shows delay between continuous pulses.

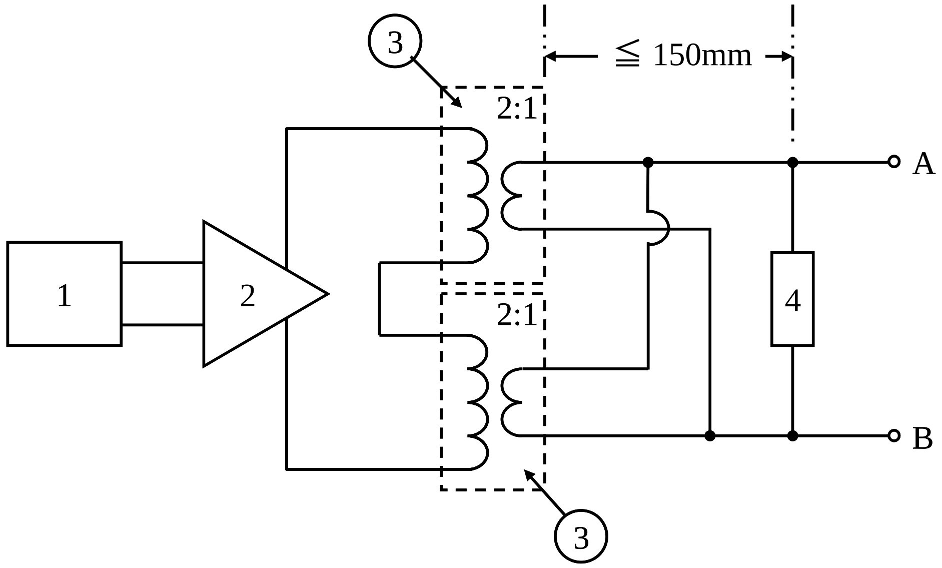
7.7.5.2 Test method and setup The test shall be performed under the standard test setup specified in **Fig. 38**. Selection of test setup is based on Mazda's verification of test sample grounding method for general vehicles. The test setup shall be described in the EMC Test Plan.

- The length of test harness that connects the test sample and load simulator shall be 2,000 mm max. in length. Individual ground circuit shall be a part of cable harness or a divided one of it as shown in the figure. If the test sample has several ground circuits, they shall be tested individually.
- The untested ground circuit shall be directly connected to the ground plane.
- Electric hardware such as the test sample and load simulator shall be powered by a vehicle battery or linear DC power supply. The power circuit to the test sample shall be connected to the power supply. The negative terminal of the power supply shall be connected to the ground plane.
- The test sample and wire harness shall be set on a 50-mm thick insulator placed on the ground plane.
- **Fig. 38** shows a signal source to generate continuous and transient interferences.
- The signal source shown in **Fig. 39** includes two insulating transformers. An insulating transformer is used to generate application level necessary for 0.5 Ω load smoothly with an amplifier. A transformer also allows the amplifier to separate from the DC component of the test sample. Alternative setup may be used if a prior approval of Mazda is obtained.



1	Test sample	6	Artificial network
2	Signal source	7	Power supply (13.5 VDC)
3	Ground plane	8	Dielectric support
4	Load simulator	9	10:1 High impedance probe (1 MΩ, C < 10 pF)
5	External load of test sample	10	Digital oscilloscope (> 100 MS/s, > 6 MB memory depth)

Fig. 38 Test Setup of Voltage Offset



1 Arbitrary waveform generator

2 Amplifier (AE Techron 7560 or equivalent is recommended)

3 Insulating transformer (Solar 6220-1A or equivalent)

4 0.5 ∧ (250 W) Unguided resistant load (Dale NH-250 or equivalent)

Fig. 39 Requirements of CI 250 Signal Source

7.7.5.3 Test procedures Unless otherwise analysis for unnecessity of individual test of each circuit is verified, the waveform shall be applied to one ground circuit each time. This analysis shall be described in the EMC Test Plan before starting of the test.

7.7.5.3.1 Procedure for continuous interference

(a) The test sample shall be connected and checked if it functions normally in the operation mode specified in the EMC Test Plan.

(b) Us shall be increased to the level corresponding to **Fig. 34** at each test frequency during operation of the test sample.

- Dwell time shall be at least 2 s. (In case of square wave pulse evaluation of 100 Hz, it shall be 1 min.) If the response time of test sample function is expected to be longer, longer dwell time is needed. This information shall be included in the EMC Test Plan.

(c) Function of the test sample shall be monitored and checked if any abnormality occurs. When any abnormality is observed, the level shall be lowered until the test sample functions normally. The measured value of Us at this threshold shall be recorded.

(d) Frequency step shown in **Table 21** shall be used and steps **(b)** and **(c)** shall be repeated.

(e) The test shall be repeated in all operation modes of the test sample listed in the EMC Test Plan.

Table 21 Test Frequency Requirements

Frequency Range [kHz]	Step Size [kHz]
2 to 10	0.5
10 to 100	5

7.7.5.3.2 Procedures for transient interference

(a) The test sample shall be connected and checked if it functions normally in the operation mode specified in the EMC Test Plan.

(b) Test sequence shown in **Fig. 37** shall be applied while the test sample is operated. Pulse amplitude (Us) shall be adjusted to the level shown in **Fig. 35**.

(c) The test sequence shall be applied repeatedly for 60 s. While the sequence is applied, function of the test sample shall be monitored and checked if any abnormality occurs. When any abnormality is observed, the level shall be lowered until the test sample functions normally. The measured value of Us at this threshold shall be recorded.

(e) The test shall be repeated in all operation modes of the test sample listed in the EMC Test Plan.

7.7.5.4 Data report

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Description of functions to be monitored
- Effects on every performance
- Photograph of test setup

7.7.6 DC stress (CI 270)

These requirements shall be applicable to the following component categories:

Electronic component: A

Motors: EM, BM

Passive component and inductive component: P, R

7.7.6.1 Requirements The component shall not be affected by excess voltage which may occur. These requirements shall apply to all power supplies or control circuits connected directly to the battery, or through the switch or another component. These requirements shall conform to **Table 22**. If the analysis clearly shows that the component satisfies the requirements in **Table 22**, these requirements may not be applied, however, a prior approval of Mazda is required.

Table 22 DC Stress Requirements

Type of Test	Requirements	
	Applied voltage [V]	Test duration
Reverse Power Connection	–14 (–0.7, +0)	60 s or longer
Excess Voltage (Failed regulator)	19 (+0.95, –0)	60 min or longer
Excess Voltage (Battery in series)	24 (**1**)	60 s or longer

Table 22; **Note (1)** Applicable to components connected directly to the battery or through the ignition switch. For components connected only to START circuit, the test duration may be 15 s.

7.7.6.2 Test method and setup Electric hardware such as the test sample and load simulator shall be powered from a linear DC power supply. In these tests, the power supply shall have a short circuit capacity of at least 100 A. A component for which reverse voltage is protected via use of a fused power circuit and a reverse biased diode in parallel shall be tested in a typical vehicle configuration. For example, if a vehicle fuse is used to protect the component, the same type (types and fuse grades) as used in the vehicle shall be used for the test. The fuse type shall be described on Specification Drawing and in the EMC Test Plan.

7.7.6.3 Test procedures

(a) Only to the power circuit (+B line), a voltage of −14 V shall be applied for 60 s. For the battery connection, it shall be applied to the rest of the switch-mode power supplies and control circuits for 60 s while maintaining the same electric potential. After completion of this test, a rated voltage of +13.5 V shall be applied, the test sample shall be turned on, and it shall be checked for proper function.

(b) Step **(a)** shall be repeated at 24 V.

(c) A voltage of 19 V shall be applied to all power supplies and control circuits. All circuits shall be tested simultaneously. The functionality shall be checked in accordance with **Table 1** and **Table 22**.

7.7.6.4 Data report

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Description of functions to be monitored
- Effects on every performance
- Photograph of test setup

7.7.7 Electrostatic discharge (CI 280) The component shall not be affected by electrostatic discharge (ESD). These requirements shall be applicable to the following component categories:

Electronic components: A, AS, AW

Electrical motor: EM

Passive component: P

7.7.7.1 Requirements

- The component shall not be affected by ESD which may occur during the normal handling and assembly (maintenance by a user is included). These requirements shall conform to **Table 23**.
- The component shall not be affected by ESD which may occur during the normal operation (at power supply). **Table 24** shows these requirements. This shall include components directly accessible in the cabin, or through an open window by a person outside the vehicle (e.g. door lock switch or combination switch). This requirement also covers components directly inaccessible.
- After ESD evaluation described in **Table 23** and **Table 24**, I/O parameter value (e.g. resistance, capacitance, leak current, etc.) of components shall be remained within a specified tolerance. This shall be done immediately after an ESD test (recommended) or after all EMC related tests are completed.

Table 23 ESD Requirements: Unpowered

Order of Discharge	Type of Discharge	Test Voltage Level	Min. Number of Discharge at each Polarity
1	Contact discharge C = 150 pF, R = 2 kΩ	±4 kV	3
2 (1)	Contact discharge C = 150 pF, R = 2 kΩ	±6 kV	3
3 (2)	Aerial discharge C = 150 pF, R = 2 kΩ	±8 kV	3

Table 23; Note (1) This table shall not be applied to maintenance by a user.

Table 24 ESD Requirements: Powered

Discharge Order	Type of Discharge	Test Voltage Level	Min. Number of Discharge at each Polarity
1	Aerial discharge C = 330 pF, R = 2 kΩ	±4 kV	3
2	Contact discharge C = 330 pF, R = 2 kΩ	±4 kV	3
3	Aerial discharge C = 330 pF, R = 2 kΩ	±6 kV	3
4	Contact discharge C = 330 pF, R = 2 kΩ	±6 kV	3
5	Aerial discharge C = 330 pF, R = 2 kΩ	±8 kV	3
6	Contact discharge C = 330 pF, R = 2 kΩ	±8 kV	3
7 (1)	Aerial discharge C = 330 pF, R = 2 kΩ	±15 kV	3
8 (2)	Aerial discharge C = 150 pF, R = 2 kΩ	±25 kV	3

Table 24; Notes (1) This requirement shall not be applied to component surfaces that are inaccessible during the normal operation.

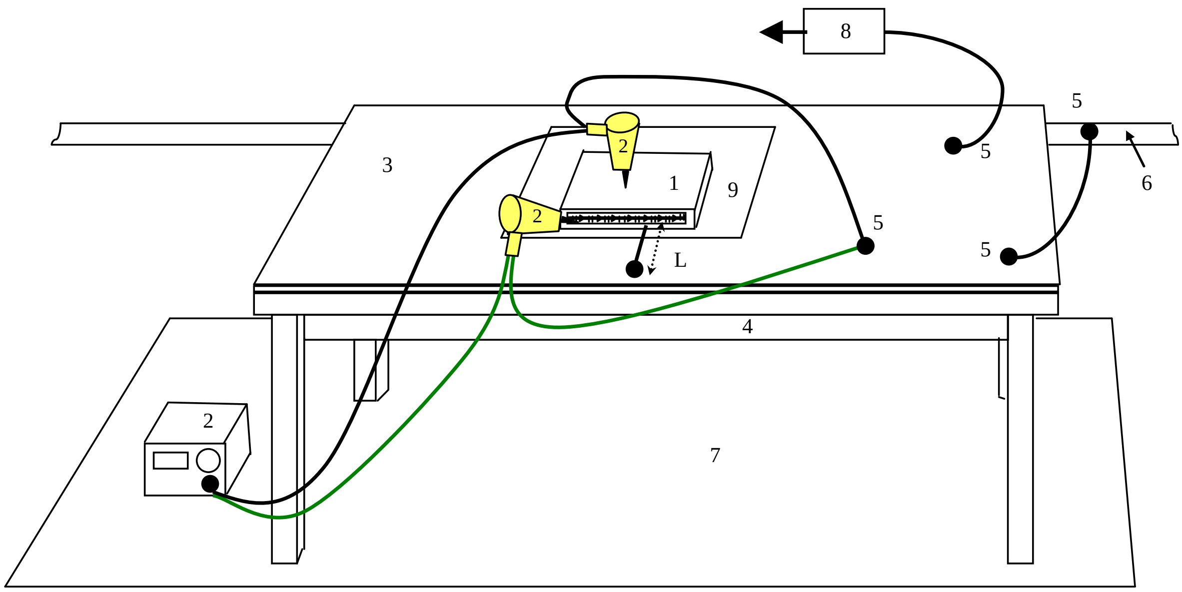
(2) This requirement shall be applied to component surfaces (e.g. SKE request switch) and cabin component surfaces (e.g. door lock switch, combination switch, etc.) that are directly accessible from outside of the vehicle without contact to any section of the vehicle.

7.7.7.2 Test method and setup The test shall be performed in accordance with **ISO 10605**, except as noted in this MES. The test facility shall be kept at 23 ± 5 °C of the ambient temperature and 20 % to 40 % of the relative humidity. ESD simulator waveform verification shall be in accordance with **ISO 10605** except for the following:

- Rise time of contact discharge ≤ 1 ns
- Rise time of aerial discharge ≤ 20 ns

The RC time constant shall be confirmed by calculation with the exponentially decaying portion of the waveform after the leading edge and/or ringing.

7.7.7.2.1 Unpowered test ESD unpowered test shall be performed before other EMC tests. (Refer to **section 7.1.4**). The standard test setup of the unpowered test shall conform to **Fig. 40**. The test sample shall be directly set on a high-resistance conductive mat under the unpowered condition. When a connector pin of the test sample is discharged, all ground terminals of the test sample shall be connected to the ground plane via a grounding strap or a wire in 200 mm in maximum length. When there are several unconnected ground terminals in the test sample, a signal ground shall be connected to the ground plane, and the remaining power ground terminals shall be evaluated for ESD like other I/O pins. As for instruments having no ground terminals (i.e., an instrument whose lowside is detected by a controller, and/or a switch with inside LED that is latched, etc.), the lowside output cord (usually connected to controller I/O) shall be attached to the ground plane.

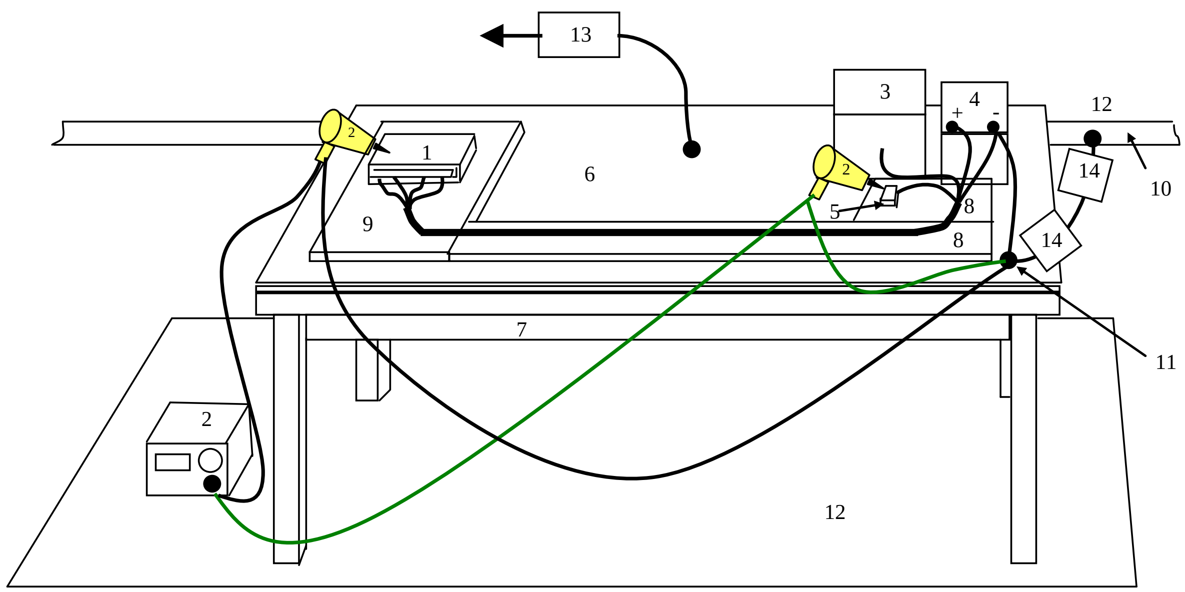


L ≦ 200 mm

1	Test sample	5	Connection to the ground plane
2	ESD simulator	6	Ground in the laboratory
3	Ground plane	7	Floor in the laboratory
4	Wooden table	8	Bleed-off resistance of approx. 1 MΩ
L:	Length of ground wire ≤ 200 mm Used only when ESD is applied to the connector pin.	9	High resistance conductive mat

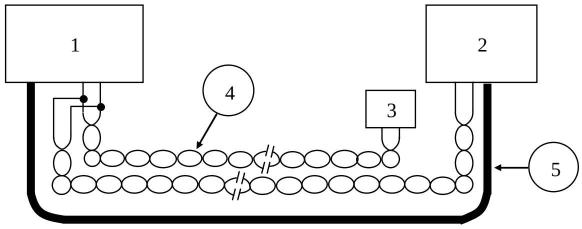
Fig. 40 Test Setup of ESD Unpowered Test

7.7.7.2.2 Operation test **Fig. 41** shows the standard setup when the test sample operates and functions. Electric hardware such as the test sample and load simulator shall be powered from the vehicle battery. (Refer to **section 7.1.3 (6)** if required.) The test sample and attached test harness shall be set on a clean dielectric support 50 mm in thickness. ($\varepsilon_r \leq 1.4$ is preferable.) The insulator shall be directly set on the ground plane. The test harnesses for connecting the test sample to the load simulator shall be $1{,}700\ ^{+300}_{\ \ 0}$ mm in length. The load simulator shall be directly connected to the ground plane.
When the outer case of the test sample is metallic, and it is grounded at the time of installation to a vehicle, the test sample shall be directly set on the ground plane. If it is unclear how test sample is installed to a vehicle, the test sample shall be tested in both configurations described above. The ground plane shall be connected to the negative terminal of the battery and the ground at the facility. The battery may be set on the floor at the facility. If the test sample has a remote input portion that can be touched by an operator (e.g. switch) or a communication bus circuit connected to the diagnosis connector, related wires shall be separated from the main harness, and typical switches and connectors shall be attached to the terminal. (Refer to **Fig. 41**.) Routing to the communication bus (e.g. CAN) shall be directly grounded and connected to the test sample. **Fig. 42** shows this requirement.
An approval of Mazda shall be obtained prior to the test for the details of these switches and connectors. When it is approved, the details of these switches shall be described in the EMC Test Plan.



1 Test sample
2 ESD simulator
3 Load simulator
4 Battery
5 Remote SW/diagnosis connector
6 Ground plane
7 Wooden table
8 Harness dielectric support
9 Test sample dielectric support (if required)
10 Ground in laboratory
11 Ground plane reference terminal
12 Ground plane connection
13 Bleed-off resistance of approx. 1 MΩ
14 Resistance of 470 kΩ

Fig. 41 Test Setup of ESD Operation Test



1 Test sample
2 Load simulator
3 Diagnosis connector (e.g. OBD II)
4 Diagnosis routing (e.g. CAN)
The routing shown shall be twisted and shall be as long as a test harness.
5 Other circuit of test sample

Fig. 42 CI 280Test Setup (Requirements of Communication Bus Connection)

7.7.7.3 Test procedures

The unpowered test shall be performed followed by the operation test (Discharge 1-7).

- Between individual discharges, the remaining electric charge shall be bled off using the bleed-off resistance (approx. 1 MΩ resistance) by touching the discharge point and the ground plane. This step is especially important for components with chromium decoration.
- In order to avoid charging by discharge of several components (such as instrument panels or large plastic components), an ionizer may be required to be used. In this case, the ionizer shall be powered off before application of each discharge, and placed away.
- After completion of the test, a parametric test shall be performed to confirm that the test sample satisfies the requirements of **Tables 1**, **23** and **24**. A parametric test shall be performed before starting the following test.

7.7.7.3.1 Unpowered test

The test sample shall be setup before staring of the test.

(a) Contact discharge of ±4 kV shall be applied to the connector pins of all test samples. (Discharge order 1) (If Specification Drawing indicates, discharge orders 2 and 3 shall not be applied.) Before start of the test, ground terminal of the test sample shall be checked that it is connected to the ground plane. If the connector body is non-metallic and connector pins are recessed, an extension contact (< 25 mm) shall be attached to facilitate the test of each pin. If the connector body is metallic and recessed pins are mounted, an extension contact shall not be attached. Application to the ground terminal shall be done under the connected condition to the ground plane. For components which a user may disassemble for maintenance (e.g. changing battery of a keyless transmitter), the ground terminal (or lowside when there is no ground) shall be grounded to the ground plane and contact discharge shall be applied under the condition in which a user can generally disassemble the components.

(b) Contact or aerial discharge shall be applied to all the shafts, buttons and switches and/or surfaces (including all components along with air gap existing between button and face plate) that have been bare as a result of product design. All discharge points shall be specified in the EMC Test Plan.

7.7.7.3.2 Operation test All tests shall be performed while the test sample is in operation at the voltage level shown in **Table 24** and the ESD constant value. The test shall be limited to one test sample operation mode. The operation mode shall be described in the EMC Test Plan. A method to decide performance of the monitors and test sample during the test shall be included in the test report. Monitoring of functions of a specific test sample shall not interfere with operation of the test sample, and shall not couple with discharge energy of the ESD simulator, which will not usually occur to a test sample. Furthermore, a measure shall be taken to exclude potential damage of monitors during a test.

(a) The test sample shall be confirmed that it operates completely.

(b) Contact or aerial discharge shall be applied to the test sample surface including air gap that exists between each button or switch, etc. and each button or face plate, etc., which are directly contacted by a passenger. All discharge points shall be specified in the EMC Test Plan. For each discharge voltage required, positive polarity discharge and negative polarity discharge shall be applied to each specified discharge point three times, respectively.

(c) When the test sample surface can be touched in a cabin or a trunk, step **(b)** shall be repeated in discharge order 7.

(d) Steps **(b)** and **(c)** shall be repeated for remote input of the test sample that an operator can touch (e.g. switch input). An alternative switch can be used, however, an approval of Mazda shall be obtained prior to the test.

(e) Orders 1 to 6 of step **(b)** shall be repeated for the test sample communication bus accessible via a diagnosis connector. Contact or aerial discharge shall be directly applied to the connector pin as shown in **Fig. 41**.

(f) Aerial discharge of ±25 kV (discharge order 8) shall be applied to the following test sample surfaces:

- Components that are mounted in a cabin and can be directly touched from outside of a vehicle (e.g. combination switch, power window switch)
- Components that can be directly touched from outside of a vehicle (e.g. keyless entry request switch)

(g) When components including wire harnesses are laid out near a seat at the time of installation to a vehicle, all wire harnesses 10 cm away from the test sample shall make discharge points, and steps **(b)**, **(c)** and **(f)** shall be repeated.
For each discharge voltage required, positive polarity discharge and negative polarity discharge shall be applied to each specified discharge point three times, respectively.

(h) After all discharges have been completed, functional performance and parameter tests shall be performed to confirm that the test sample satisfies the requirements shown in **Table 1**.

7.7.7.4 Data Report

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Any discharge events
- Effects on every performance
- Photograph of test setup
- Temperature and humidity at test

7.7.8 Abnormal connection (CI 290)

These requirements shall be applicable to the following component categories:
Electronic components: A, AS
Motors: EM, BM
Passive component and inductive component: P, R

7.7.8.1 Requirement The test sample shall not be affected by a wire harness failure that may be assumed in a vehicle.

7.7.8.2 Test method and setup Electric hardware such as the test sample and load simulator shall be powered from a linear DC power supply. In these tests, the power supply shall have a short circuit capacity of at least 100 A. A component for which reverse voltage is protected via use of a fused power circuit and a reverse biased diode in parallel shall be tested in a typical vehicle configuration. For example, if a vehicle fuse is used to protect the component, the same type (types and fuse grades) as used in the vehicle shall be used for the test. The fuse type shall be described on Specification Drawing and in the EMC Test Plan.

7.7.8.3 Test Procedures

(a) Power supply short-circuit

Power supply voltage shall be input to each terminal of the test sample for 1 h or more. If there is an engineering reason, the test duration can be shortened by describing the reason in the EMC Test Plan. If it is approved by Mazda that power supply short-circuit rarely occurs in a vehicle, it shall be described in the EMC Test Plan as out of the scope.

(b) Ground short-circuit

Each terminal of the test sample shall be connected to the ground for 1 h or more. If there is an engineering reason, the test duration can be shortened by describing the reason in the EMC Test Plan.

(c) Terminal disengagement

In all operation modes of the test sample, each terminal shall be disengaged for 1 min or more and consumption current shall be measured.

(d) Detachment of fuse

An arbitrary fuse shall be detached for 1 min or more.

7.7.8.4 Data report

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Description of functions to be monitored
- Effects on every performance
- Electric current value (only for terminal disengagement test)
- Photograph of test setup

7.8 Radiated emissions (RE: Radiated Emissions)

7.8.1 Electric field (RE 310)

The requirements specified in **Table 25** and **Table 26** shall be applicable to the following component categories:

Electronic components: A, AS, AW

Electric motors: BM (The requirements may be limited to level 1 limit B only, or may not be applied to the test depending on analysis.), EM

Passive component: P (Requirements may not be applied to the test depending on analysis.)

7.8.1.1 Requirements

- Requirements for radiated emissions cover frequency range of 0.12 to 1,583 MHz.
  The requirements relate to specific RF service band classified into level 1 and level 2.
- Level 1 requirements apply to all markets.
  - Limit A is based on peak detection.
  - Limit B is based on quasi-peak detection.
- Level 2 requirements apply to specific market.
  - Limit A is based on use of peak and average detections. Except for bands G0, EU1, G1 and G8, components are necessary only for verification of compatibility to either peak limit or average limit. (Band G0 and band G8 are based on average detection only.) Average limit can be applied to components that operate for continuous duration only. Components that operate intermittent duration shall satisfy peak limit only.
  - Limit B is based on quasi-peak detection.

Table 25 Level 1 Requirements (Worldwide Essential Requirements)

Band Number	Frequency Range [MHz]	Limit A Peak Detection [dBμV/m]	Limit B Quasi-peak Detection [dBμV/m]
M1	30 to 75	$52 - 25.13*\mathrm{Log}(f/30)$ (1)	$62 - 25.13*\mathrm{Log}(f/30)$ (1)
M2	75 to 400	$42 + 15.13*\mathrm{Log}(f/75)$ (1)	$52 + 15.13*\mathrm{Log}(f/75)$ (1)
M3	400 to 1,000	53	63

Table 25; Note (1) f = Measuring frequency (MHz)

Table 26 Level 2 Requirements (Requirements for Specific Markets)

Band Number	Region	RF Service (Available Range [MHz])	Frequency Range [MHz]	Limit A (2)		Limit B (2)
				Peak detection [dBμV/m]	Average detection (3) [dBμV/m]	Quasi-peak detection [dBμV/m]
G0	Worldwide	Low frequency	0.12 to 0.15	—	8 (4)	
EU1	EU	Low frequency	0.15 to 0.28		35	53
G1	Worldwide	Medium frequency (AM)	0.53 to 1.7	—	12	30
NA1	NA	DOT1 (45.68 to 47.34)	45 to 48 (1)	12	6	24
G2	Worldwide	4 Meter (66 to 87.2)	65 to 88 (1)	12	6	24
JA1	JPN	FM1 (76 to 90)	75 to 91 (1)	12	12	24
G3	Worldwide	FM2 (87.5 to 108)	86 to 109 (1)	12	12	24
G4	Worldwide	2 Meter (142 to 175)	140 to 176 (1)	18	12	24
EU2	EU	TV, DAB1 (174.1 to 240)	172 to 242 (1)	18	12	24
G5	Worldwide	RKE, TPMS1	310 to 320	20	14	30
EU3	EU	TETRA	380 to 424	25	19	30
G6	Worldwide	RKE, TPMA2	429 to 439	25	19	30
EU4	EU	Police	440 to 470	25	19	30
JP2	JPN	TV	470 to 710	24	24	32
EU5	EU	RKE	868 to 870	30	24	—
EU6	EU	RKE	902 to 904	30	24	—
EU7	EU	DAB L-Band	1447 to 1494	36	30	—
G8	Worldwide	GPS	1567 to 1574		50 – 20664 *log(*f*/1567) (5)	—
			1574 to 1576		10	—
			1576 to 1583		10 + 20782 *log(*f*/1576) (5)	—
NA2	NA	SDARS	2320 to 2345		25	—
G9	Worldwide	Bluetooth	2400 to 2500		25	—

Table 26; Notes (1) Variation of the available range shall be ensured to be 1 %. When oscillating frequency tolerance inside of the test sample, which is described in the EMC Test Plan, exceeds 1 %, the tolerance shall be ensured as variation.

(2) The values of limit A, peak and average are based on the use of 9/10 kHz MBW (all bands except for G0, EU1 and G1). The values of limit B and quasi-peak (EU1, G1) are based on 9 kHz MBW. The values of limit B, quasi-peak (all bands except for EU1, G1) are based on 120 kHz MBW.

(3) Average detection limit cannot be used for components that operate for intermittent duration.

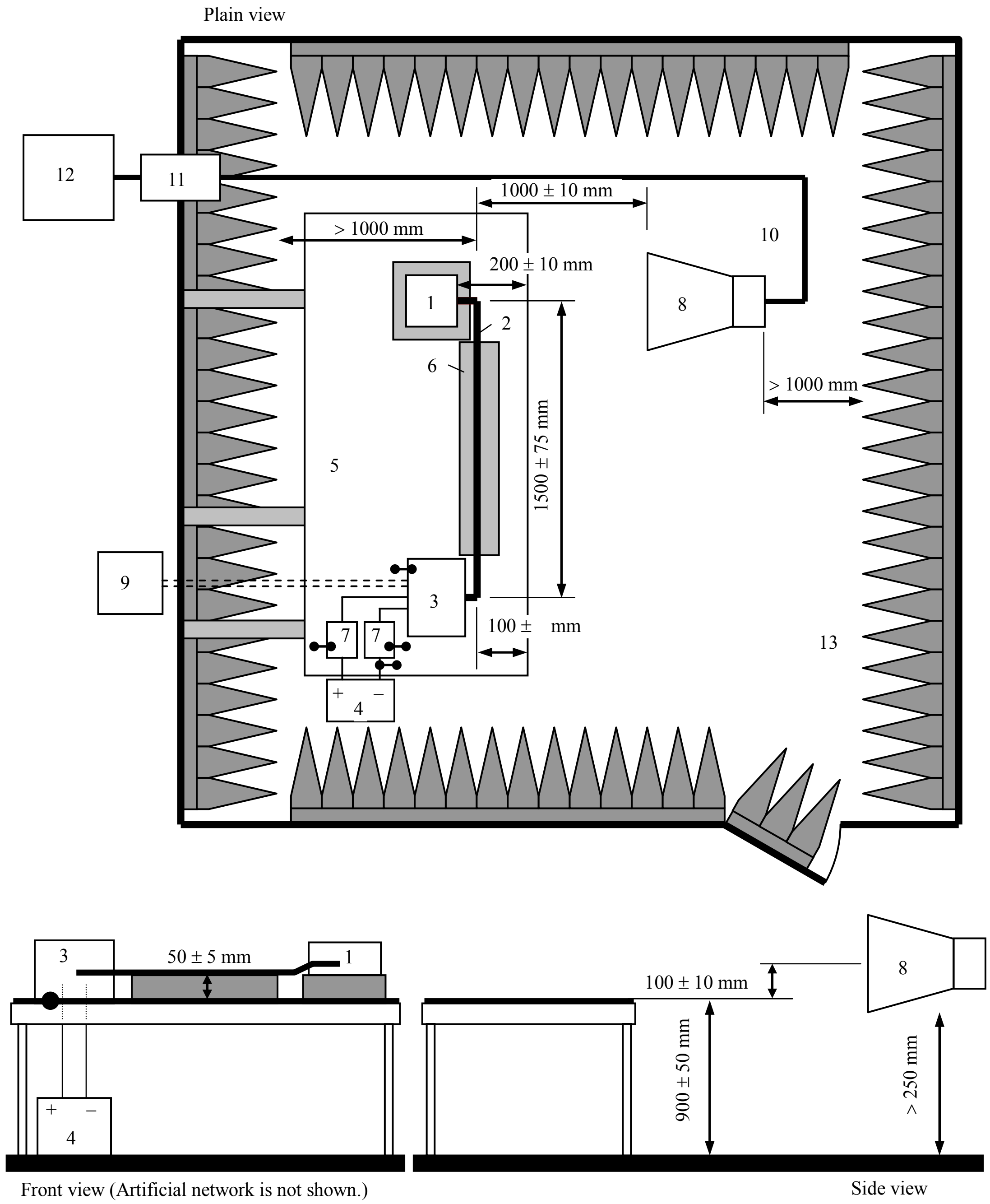
(4) Shall be applied to narrow-band noise only.
(5) f = Measuring frequency (MHz)

7.8.1.2 Test method and setup The ALSE method required for **CISPR 25** shall be used for confirmation of performance of test sample, except for the points annotated in this MES. Operations during the test shall be described in the EMC Test Plan.

- Plural receiving antennas cannot be set in the same laboratory to shorten automatic test duration.
- When a biconical or log antenna is used for the test, a coaxial cable shall be routed right behind the antenna. The cable shall keep parallel to the laboratory floor at least 1,000 mm away from reference point of the antenna. (Refer to **CISPR 25**.) The cable shall have a ferrite bead (Fair-Rite Type 43 or equivalent) at an interval of 150 mm max. A ferrite bead is not necessary for the portion of the antenna cable which is on the laboratory floor. The purpose of this improvement is to minimize the effect on the cable toward a publicized antenna correlation coefficient.
- When a preamplifier is used to satisfy the environmental conditions (refer to **section 7.8.1.3**), it shall be set where the antenna cable contacts the laboratory floor. (Refer to **Fig. 44**.) As there is a possibility of occurrence of interaction between the antenna element and a power supply wire of the preamplifier, it is not recommended to set the preamplifier where an antenna connector is placed. If measuring system environmental requirements are satisfied, the preamplifier may be set outside of the laboratory. Refer to **section 7.8.1.2.2** for additional requirements for use of a preamplifier.
- If a wire harness for test is connected to multiple drivers of other systems at the time of installation to a vehicle, the wire harness for test shown in **Fig. 1** shall be used.
- When tests of JA1 and G3, and test with over 1,000 MHz are performed, the receiving antenna shall be moved so that its center may align with the center of DUT as shown in **Fig. 43**. (JA1 and G3 will be set in two different ways for test.) The height from the ground plane dynamometer to the antenna shall not be changed.
- Electric hardware of the test sample and load simulator shall be powered by a vehicle battery. (Refer to **section 7.1.3 (6)**.) The negative terminal of the battery shall be connected to the ground plane dynamometer. The battery shall be set on/under the dynamometer. The load simulator, battery and artificial network shall be set as shown in the standard test setup of **Annex 2**.
- The overall harness length shall be $1{,}700^{+300}_{0}$ mm. The harness shall be set on a 50 mm-thick insulator placed on the ground plane.
- The test sample shall be set on a dielectric support at a height of 50 mm from the ground plane. However, when the outer case of the test sample is metallic, and it is grounded at the time of installation to a vehicle, the test sample shall be set on the ground plane and electrically connected during a test. This configuration shall be allowed only when the configuration is described on Specification Drawing and it is equivalent to vehicle application. The grounding configuration shall be described in the EMC Test Plan and test report.
- When the standard test setup cannot be applied to facilitate a test depending on a test sample, a review and an approval of Mazda shall be obtained prior to the test. The test setup shall be described in the EMC Test Plan and test report.

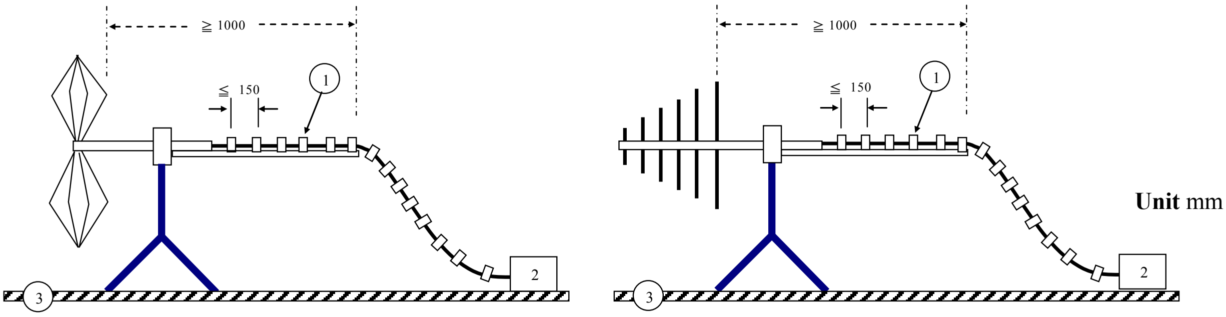
7.8.1.2.1 Test setup of engine control circuit (band EU1 and G1 only)

When a test is performed for engine control electronic device which is mounted in an engine compartment, the test setup shown in **Fig. 45** can be used. This test setup shall not be used for other module or sub system. Ignition and injector harnesses shall be removed from the main wire harness and they shall be directly set 100 mm behind the main wire harness. An RF shield shall be set on a selected wire as shown in **Fig. 45**. The RF shield shall be electrically connected to the ground plane by direct connection (e.g. fasten with screw) or using a copper tape with conductive adhesive. The use of this test setup shall be described in the EMC Test Plan and shall be approved by Mazda prior to the test. A photograph of the test setup shall be included in the test report.



1 Test sample
2 Wire harness for test
3 Load simulator
4 Vehicle battery
5 Ground plane (fixed on shield wall)
6 Insulator ($\varepsilon_r \leq 1.4$ is preferable)
7 Artificial network
8 Receiving antenna
9 Test support apparatus
10 High-quality double shield coaxial cable (RG223)
11 Bulkhead connector
12 Measuring instrument
13 Electric wave absorber

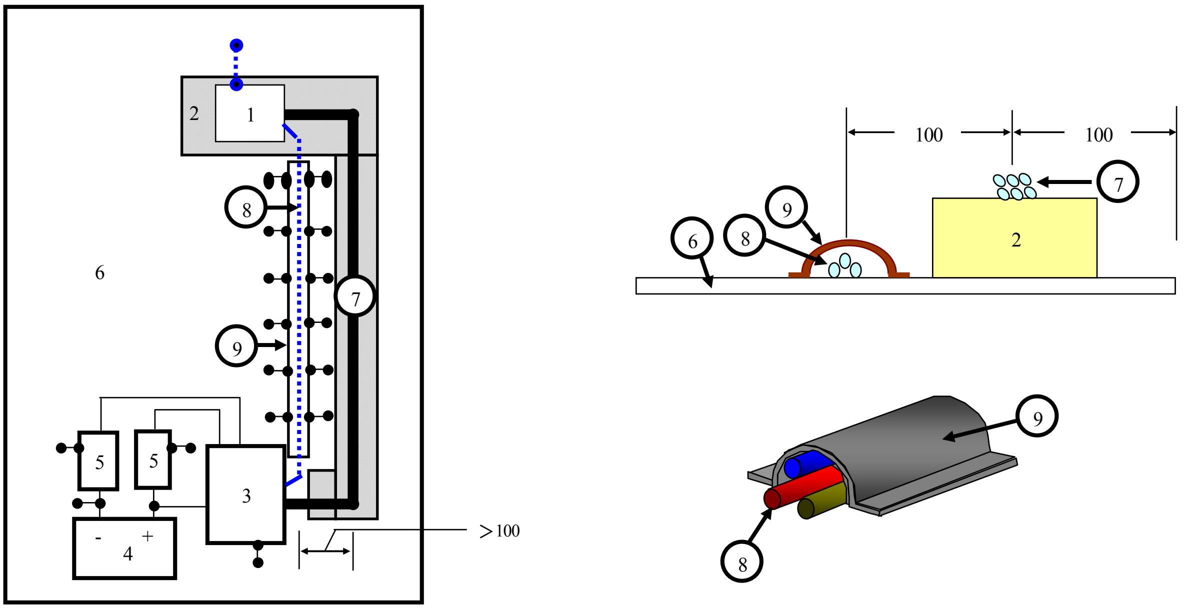
Fig. 43 Test Setup for 1,000 MHz or More



Biconical antenna
Log antenna

1 Ferrite bead cable 2 Preamplifier (if required) 3 ALSE floor

Fig. 44 Setup of RE 310 Test Antenna Cable (except for rod antenna)



1 Test sample
2 Dielectric support ($\varepsilon_r \leq 1.4$ is preferable)
3 Load simulator
4 Vehicle battery
5 Artificial network
6 Ground plane dynamometer
7 Wire harness for test
8 Wire harness separated from wire harness for test
9 RF shield of wire harness separated from wire harness for test

* Rod antenna is not shown.

Fig. 45 RE 310 Test Setup (EU1, G1) DUT with Selected Wire in Engine Compartment

7.8.1.2.2 Requirements for measuring system A measuring receiver (spectrum analyzer or step receiver) shall conform to **CISPR-16-1-1**. A measuring receiver capable of Fast Fourier Transform (FFT) can be used if a prior approval of Mazda has been obtained. (An approval is related to homologation of a laboratory.) **Tables 27**, **28** and **29** show measuring system requirements when either a sweep (i.e., spectrum analyzer) or a step EMI receiver is used.

- For all bands except for M1, M2 and M3, limit A is based on use of 9/10 kHz measuring frequency by either peak or average detection. Limit B is based on use of 120 kHz measuring frequency by quasi-peak detection.
- For bands EU1 and G1, limit A is based on use of 0.2 to 1 kHz measuring frequency by average detection. Limit B is based on use of 9 kHz measuring frequency by quasi-peak detection.
- For bands M1, M2 and M3, limit A is based on use of average detection in 120 kHz measuring frequency. Limit B is based on use quasi-peak detection in 120 kHz measuring frequency.
- When the test sample operates for intermittent duration, dwell time shown in **Tables 27**, **28** and **29** can be increased, however, a concrete logistic ground shall be described in the EMC Test Plan to verify that the increase is appropriate.

A low noise preamplifier may often be needed to satisfy measuring system environmental requirements at over 30 MHz. However, use of a preamplifier increases the possibility of overload (usually originates from out-band signal). To minimize the possibility, selection of gain of a preamplifier is recommended so that the environmental conditions specified in **section 7.8.1.3 (a)** can be satisfied. The staff in the laboratory shall prepare for a procedure to prevent overload of the preamplifier by using a step attenuator, etc.

Table 27 Requirements for Measuring Instrument Setup (Bands G0, EU1 and G1)

	Sweep Receiver		Step Receiver	
	Limit A	Limit B	Limit A	Limit B
Detection system	Average detection	Quasi-peak detection	Average detection	Quasi-peak detection
Measuring bandwidth (MBW) (kHz) (1)	0.2 ≤ MBW ≤ 1	9/10	0.2 ≤ MBW ≤ 1	9
Video bandwidth (kHz) (1)	≥ 3*MBW	n/a	—	–
Maximum sweep rate (s/kHz) (1) (2)	≥ 0.03/MBW	≥ 0.2	—	–
Maximum frequency step size (kHz) (2)	—	–	0.5*MBW	4.5
Minimum measuring time per frequency step (s) (3)	—	—	0.02	1

Table 27; Notes (1) Any frequency that falls into the specified range is acceptable.
(2) Sweep rate calculated by MBW is shown in kHz.
(3) It is allowed to increase the sweep rate and measuring time if a signal repeating rate is low. Refer to **section 7.8.1.2.2** for details.

Table 28 Requirements for Measuring Instrument Setup (All Bands except for M1, M2, M3, G0, EU1 and G1)

	Sweep Receiver		Step Receiver	
	Limit A	Limit B	Limit A	Limit B
Detection system	Peak or average detection	Quasi-peak detection	Peak or average detection	Quasi-peak detection
Measuring bandwidth (MBW) (kHz)	9/10 (1)	120	9/10 (1)	120
Video bandwidth (kHz)	≥ 3*MBW	n/a	—	—
Frequency sweep rate (s/kHz)	≥ 0.003	≥ 0.001	—	—
Maximum frequency step size (kHz)	—	—	0.5*MBW	60
Minimum measuring time per frequency step (s) (2)	—	—	0.005	1

Table 28; Notes (1) Any bandwidth that falls into the specified range is acceptable to make various type receivers available.

(2) It is allowed to increase the sweep rate and measuring time if a signal repeating rate is low. Refer to **section 7.8.1.2.2** for details.

Table 29 Requirements for Measuring Instrument Setup (M1, M2 and M3)

	Sweep Receiver		Step Receiver	
	Limit A	Limit B	Limit A	Limit B
Detection system	Peak detection	Quasi-peak detection	Peak detection	Quasi-peak detection
Measuring bandwidth (MBW) (kHz)	120	120	120	120
Video bandwidth (kHz)	≥ 500	N/A	—	—
Frequency sweep rate (s/kHz)	≥ 0.003	≥ 0.001	—	—
Maximum frequency step size (kHz)	—	—	60	60
Minimum measuring time per frequency step (s) (1)	—	—	0.005	1

Table 29; Note (1) It is allowed to increase the sweep rate and measuring time if a signal repeating rate is low. Refer to **section 7.8.1.2.2** for details.

7.8.1.3 Test procedures

(a) Before measurement of radiated emissions of the test sample, the environmental level of the test setup (with all the instruments except for the test sample switched on) shall be checked if it is at least 6 dB lower than the required values specified in **Table 25** and **Table 26**. If this requirement is not satisfied, the test shall not be performed until related test setup problems are all solved. The test setup environmental level shall be included in the test report. Except for bands G0, EU1, G1 and G8 that need use of average detection, test setup environmental measurement shall be performed at 9/10 kHz MBW of peak detection. All test setup environmental tests may be done only for vertical polarization of the measuring antenna.

When a low noise preamplifier (especially gain of 30 dB or over) is used to satisfy the requirement, the test shall be performed in consideration of the impact of overload on the measurement result.

(b) Radiated emissions of the test sample shall be measured for all the frequency bands specified in **Table 25** and **Table 26**. For a measuring frequency of 30 MHz or over, the radiated emissions shall be measured by vertical and horizontal antenna polarizations.

(c) When test sample performance is evaluated at over 30 MHz by level 1 or level 2 (except for band G8), in addition to measuring system requirements shown in **Table 29** (limit A), it can be done by using 120 kHz MBW of peak detection first. By this approach, the whole measuring time can be shortened. If resulting emission level of the test sample is lower than limit A (level 1 and level 2 (peak detection)), the test data can be submitted as a final result. When 120 kHz MBW of peak detection is used to evaluate test sample emission by level 2, limit A (peak detection), measuring system environmental requirements in step **(a)** may not be applied. If the emission level of the test sample measured in step **(c)** is higher than that of individual band requirements, an additional measurement shall be performed using measuring system requirements specified in **Table 28** and **Table 29**. **Fig. 46** and **Fig. 47** show this process.

- When conformity to level 2, limit A is evaluated, peak detection or average detection shall be measured for all frequency bands in which emission in step **(c)** exceeds the limit. Separated measurement is not required for verification of conformity to both peak detection and average detection.
- When conformity to level 2, limit B is evaluated, only individual frequency in which emission in step **(c)** exceeds the limit shall be measured.

(d) The test shall be repeated in all operation modes of the test sample listed in the EMC Test Plan.

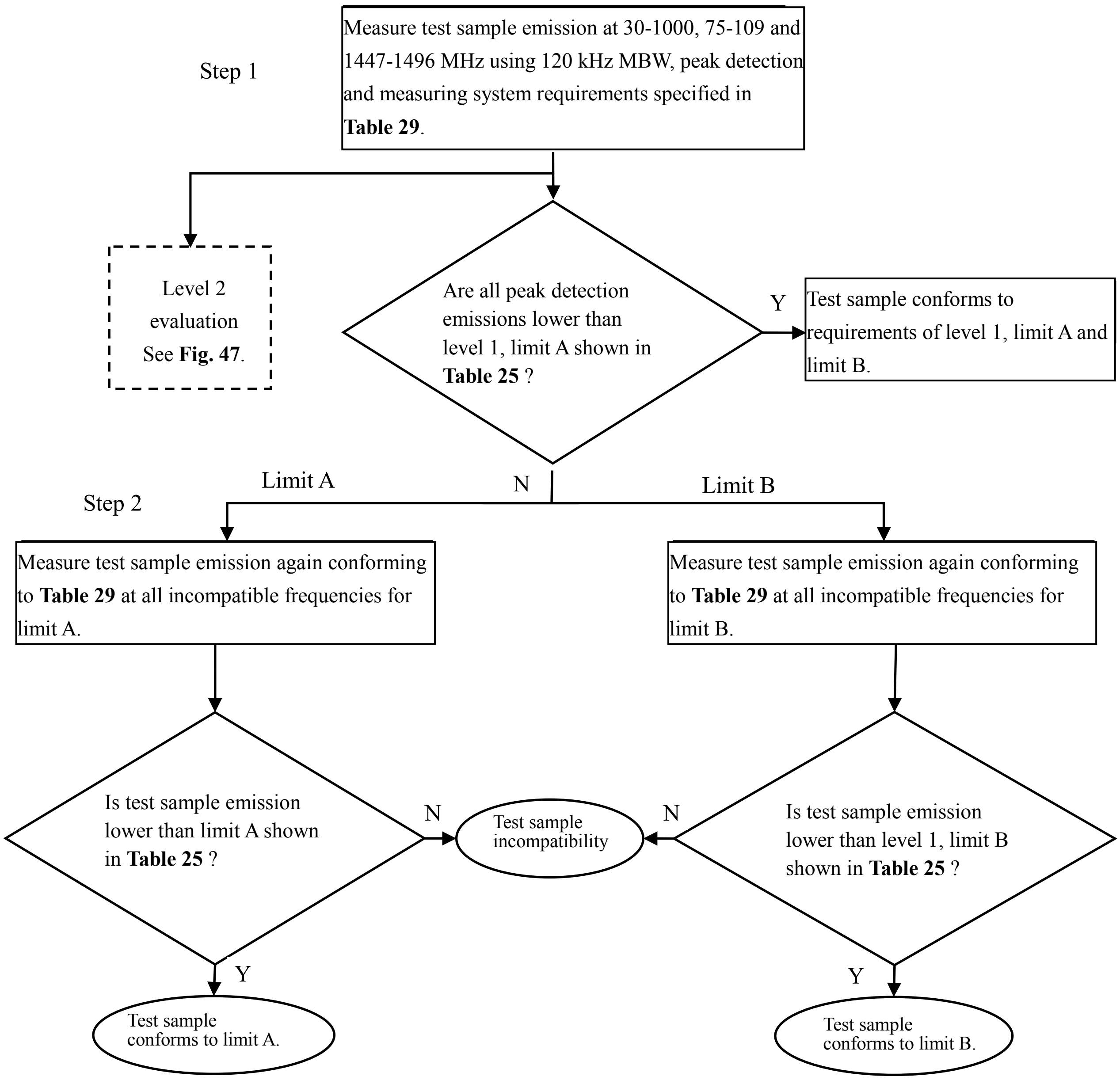


Fig. 46 Recommended Process for Test Sample Emission Evaluation by RE 310 Level 1 Requirements

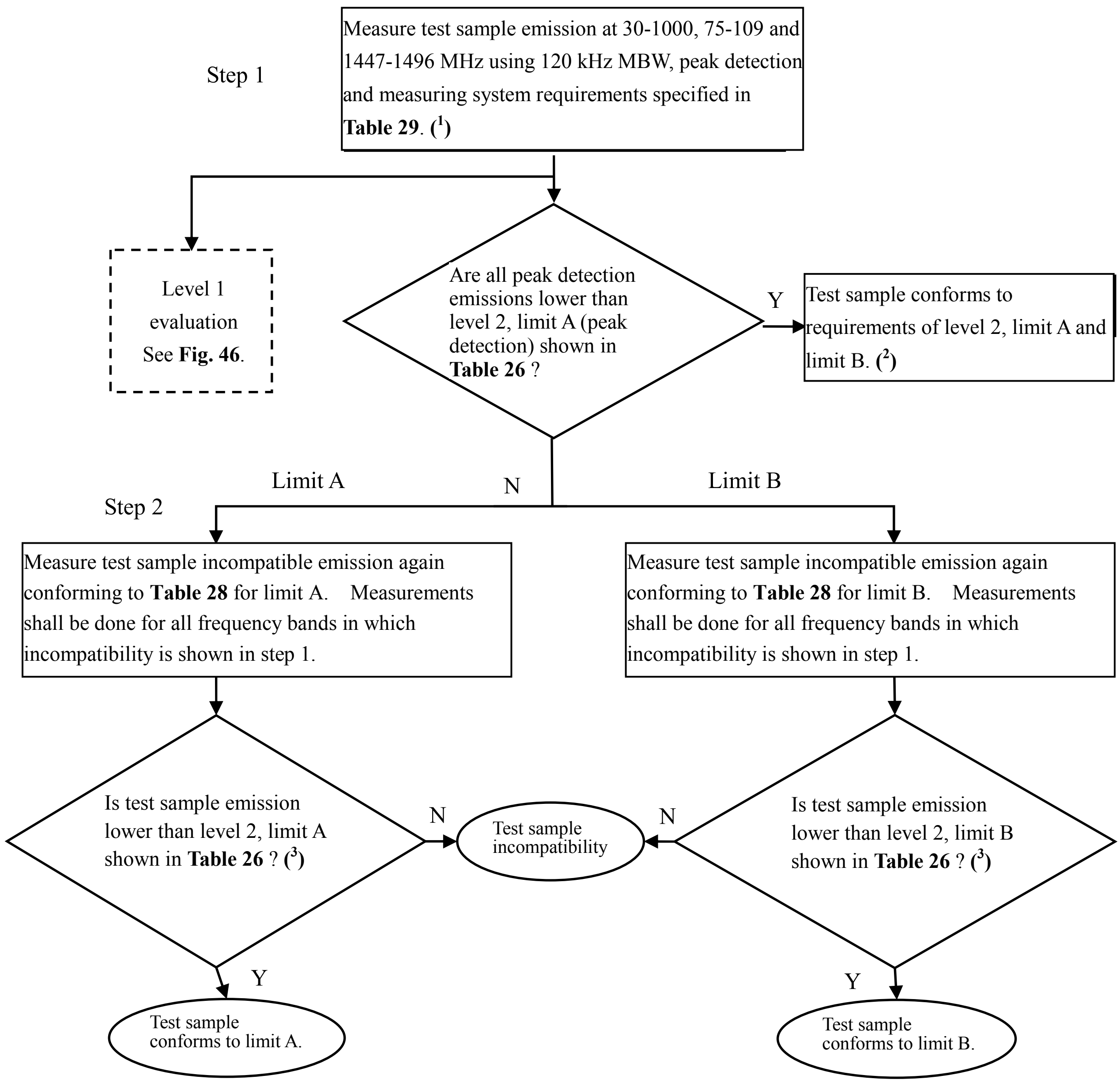


Fig. 47; Notes (1) Peak and average values can be measured simultaneously using an RF receiver capable of double detection.

(2) Environmental conditions (6 dB) shall not be applied when 120 kHz MBW, peak detection are used.

(3) Environmental conditions (6 dB) shall be applied when 9/10 kHz MBW is used.

Fig. 47 Recommended Process for Test Sample Emission Evaluation by RE 310 Level 2 Requirements (Except for bands GO, EU1, G1, G8, NA2 and G9)

7.8.1.4 Data reporting A one-page summary of the test data shall be made in terms of each operation mode of the test sample and antenna polarization. The data sheet shall contain
the following information:
- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Reference limit (limit A, limit B)
- Antenna polarization
- Measuring system bandwidth (MBW)
- Detection system (peak, quasi-peak, average)
- Emissions data plotted at each frequency band
- Tabular summary on emissions of test sample at each frequency band
  The tabular summary shall contain the band number, maximum emission levels of test sample measured at each band, and related band limit. Any nonconformity to the band requirements shall be noted clearly.

Additional information required:
- Data on ambient environment related to each band limit and polarization at the time of test setup. The data shall contain the MBW and detection system used.
- Photograph of test setup
- Any deviation from test procedures explained in the EMC Test Plan shall be noted.

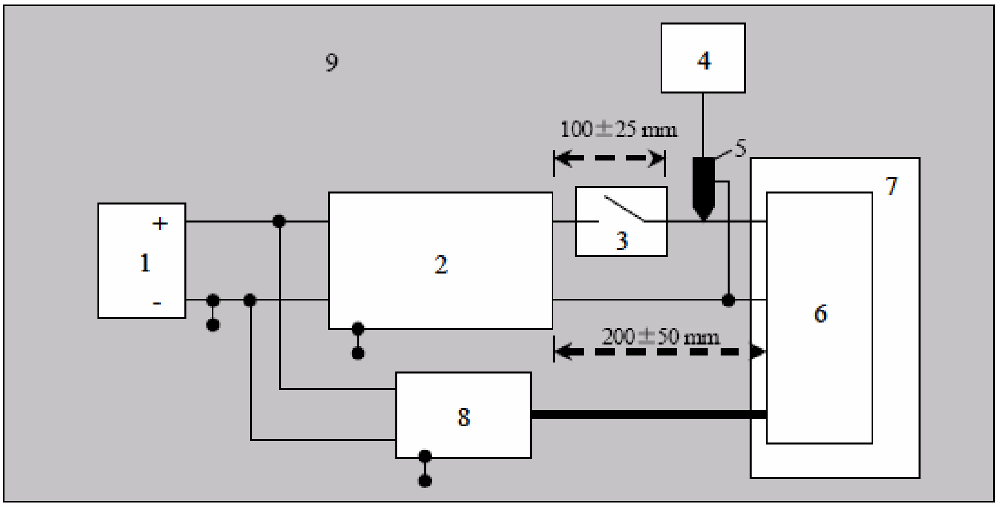
7.9 Conducted emissions (CE: Conducted Emissions)

7.9.1 Transient (CE 410)

These requirements shall be applicable to the following component categories:
Electronic component: A
Electric motors and inductive component: BM, EM, R

7.9.1.1 Requirements A component shall not produce transient voltage in excess of the value specified in **Table 1** in its power circuit.

7.9.1.2 Test method and setup The test sample shall be set up as illustrated in **Fig. 48**. The test shall be performed in accordance with **ISO 7637-2** except for the items specified in this MES.



1	Power supply	6	Test sample
2	Artificial network	7	Insulator ($\varepsilon_r \leq 1.4$ is preferable)
3	Mechanical/electro-mechanical switch	8	Load simulator
4	Digital oscilloscope	9	Ground plane
5	High impedance probe (>1 MΩ)		

Fig. 48 Setup of Transient Test

- The power circuit of the test sample shall be directly connected to artificial network via a single set of either mechanical or electro-mechanical switch. The switch shall have the following characteristics:
  - Contact rating: I ≥ 30 A or twice the capacity of rated current of test sample, (whichever is larger), continuous resistance load
  - High-purity silver contact material
  - No inhibitor for relay contact.
  - Electrically-insulated single/double position contact in coil circuit
  - Coil with transient control function

  The switch used in the test shall be described in the EMC Test Report.
- The wire connecting the test sample to the artificial network shall be 200 ± 50 mm in length. Other connection between the switch and the test sample shall not be done.
- Supply voltage to the test sample shall be +15 – 0.5/+0 V. The power supply shall have twice the capacity of 100 A current or specified lock current of the test sample. The negative terminal of the power supply shall be connected to the ground plane.
- A sampling rate of 1 Giga/s for one input is recommended for a digital sampling scope to measure voltage. The bandwidth shall be over 100 MHz. The voltage shall be measured using a probe of 1:100 (> 4 pF).
- The test sample shall be set on a dielectric support at a height of 50 mm from the ground plane. Only when the outer case of the test sample is metallic, and grounding to the vehicle is necessary for the design of the test sample, the test sample can be connected to the ground plane electrically. (This requirement shall be described on the specification of the test sample.) The grounding configuration of the specification shall be described in the EMC Test Plan and test report.

- When the test sample is an electric motor or an actuator, tests shall be performed in a “stall” condition unless an analysis verifies that stall condition may not occur. When the motor includes an internal control (e.g. PTC) that limits or shuts electric current to the test sample during stall condition, a test shall be performed with the maximum rated mechanical load to the motor/actuator.

7.9.1.3 Test procedures

(a) The external switch shall be closed (refer to **Fig. 48**) and electric power shall be supplied to the test sample. The test sample shall be checked if it functions properly.

(b) A time base shall be set to 1 ms/div.

(c) The digital oscilloscope shall be set to a single-shot mode and its trigger level shall be set at +10 V.

(d) A switch for measuring emission shall be opened and closed to confirm that the trigger works properly.

(e) Except for setting a digital sampling scope at +55 V, steps **(a)** to **(c)** shall be repeated.

(f) The oscilloscope sampling rate shall be set to a highest possible level based on the selected time base.

(g) When the test sample is component category A or EM, peak transient voltage shall be measured and recorded while the test sample is actuated in an operation mode specified in the EMC Test Plan. This step can be omitted for component categories BM and R.

(h) For all component categories having switch-type power circuit, peak transient voltage shall be measured and recorded while turning the test sample on and off ten times (Measure it ten times in on and off conditions each.) using the external switch shown in **Fig. 48**.

(i) Steps **(e)** through **(h)** above shall be repeated applying each of the following time bases:

- 100 μs/div
- 1 μs/div
- 0.5 μs/div

When these time bases cannot be used for an oscilloscope to be used, alternative time base values can be selected. A laboratory shall select closest time base available.

(j) Trigger level of the digital oscilloscope shall be reset to −60 V. Steps **(e)** to **(i)** above shall be repeated and negative peak transient voltage shall be recorded.

7.9.1.4 Data reporting The maximum positive transient voltage and the minimum negative transient voltage exceeding the trigger levels for each of the time bases shall be reported. Additionally, the following shall be described:

- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Positive and negative transient voltage (peak) exceeding the limit that occur each time
- If an oscilloscope cannot obtain a trigger during the test, information including recorded data shall be described.
- Plot of measured pulse
- Photograph of test setup
- Measured data

7.9.2 RF (CE 42X)
7.9.2.1 CE 420
These requirements shall be applicable to the following component categories:
Electronic components: A, AS
Electric motors: BM, EM
Except for the case in which a motor and/or its wire are/is set within a range of 500 mm from a vehicle radio antenna due to mounting requirements, these requirements are not applied to an electric motor/actuator that is/are operated by an operator by turning on the switch directly at an intermittent duration, however, measured data shall be reported. A review and an approval of Mazda for application of these requirements to such instruments shall be obtained prior to the test. These requirements may be loosened or out of the scope for components of positive and negative power supply routing system that are shielded with radio shield wire, etc. This requires a prior approval of Mazda based on a test or analysis review that verifies that conducted emission exceeding CE 420 level will not occur on an unshielded positive and negative power circuits due to other coupling route when mounting the components to a vehicle.

7.9.2.2.1 Requirements Conducted RF emissions of component power supplies shall not exceed the requirements shown in **Table 30**. The requirements are limited by long wave (LW), medium wave (AM) and FM broadcast services.

Table 30 Conducted RF Emissions Requirements

Band No.	Region	RF Service	Frequency Range MHz	Limit Average Detection dBμV	Limit Quasi-peak Detection
EU1	Europe	Long wave (LW)	0.15 to 0.28	77	80
G1	Worldwide	Medium wave (AM)	0.53 to 1.7	54	66
JA1	Japan	FM1	76 to 90	–	36
G3	Worldwide	FM2	87.5 to 108	–	36

7.9.2.1.2 Test method and setup
- Except for the sections noted in this MES, voltage method that is required for **CISPR 25** shall be used to component performance test. When the positive and negative power circuits of the test sample are separated, individual tests shall be performed for each circuit. A circuit for which a test has not been performed shall be directly connected to a vehicle battery. This requirement may not be applied when several circuits are used only to satisfy requirements for operating current of the test sample. (e.g. There is one power circuit, however, there are several connector pins.) Under this condition, all power circuits shall be connected to the artificial network.
- Electric hardware of the load simulator shall be powered from the vehicle battery. (Refer to **section 7.1.3 (6)**.) The negative terminal of the battery shall be connected to the ground plane.
- Power supply wire connecting the test sample to the artificial network shall be 200 ± 50 mm in length.

- The test sample shall be set on a dielectric support a height of 50 mm from the ground plane. Only when the outer case of the test sample is metallic, and grounding to the vehicle is necessary for the design of the test sample, the test sample can be connected to the ground plane electrically. (This requirement shall be described on the specification of test sample.) The grounding configuration of the specification shall be described in the EMC Test Plan and test report.
- When power supply minus line of the test sample is grounded independently in a vehicle (< 200), the line shall be directly connected to the ground plane. Under these conditions, the artificial network that is connected to the minus line of the test sample can be omitted.

7.9.2.1.2.1 Measuring system requirements A measuring receiver (spectrum analyzer or step receiver) shall conform to **CISPR 16-1-1**. A measuring receiver capable of Fast Fourier Transform (FFT) can be used if a prior approval of Mazda has been obtained. Measuring system requirements shown in **Table 27** and **Table 28** shall be followed when either a sweep (i.e., spectrum analyzer) or a step EMI receiver is used. For bands EU1 and G1, it is recommended that measuring time (step receiver) be equal to $1/f$ when f is signal repetition rate. A sweep receiver shall be adjusted in accordance with it. The measuring time shall be described in the EMC Test Plan.

7.9.2.1.3 Test procedures

(a) Before measurement of conducted emission of the test sample, the ambient level of test setup (All instruments except for the test sample shall be powered on.) shall be checked if it is at least 6 dB lower than the requirements specified in **Table 30**.
If the level is under the value specified above, the test shall not be continued until problems of the related test setup are settled.

(b) Conducted emission of the test sample shall be measured in each frequency band shown in **Table 30**.

(c) The test shall be repeated in all operation modes of the test sample listed in the EMC Test Plan.

(d) When test sample performance is evaluated, use of peak detection which has the same measuring bandwidth can be allowed as a quick pretest at all bands that improve testing efficiency. If the peak emission is lower than the limit, the test data can be submitted as a final result. If the peak emission exceeds the band requirements, an additional measurement shall be performed by quasi-peak detection at each frequency that exceeds the limit. Data on peak and quasi-peak detections shall be included in the test report.

7.9.2.1.4 Data report

- A one-page summary of the test data shall be made so that it shows a plot of measured test sample emission including applied limit plot. This format is the same as the one used for radiated emission. Any nonconformity to the band requirements shall be noted clearly. The test report shall include ambient environmental data at test setup.
- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Reference limit
- Measuring system bandwidth (MBW)
- Detection method (peak, quasi-peak, average)
- Emission data plotted at each frequency band

- Tabular summary on emissions of test sample at each frequency band
  The tabular summary shall contain the band number, maximum emission levels of the test sample measured at each band, and related band limit. Any nonconformity to the band requirements shall be noted clearly.

Additional information required:

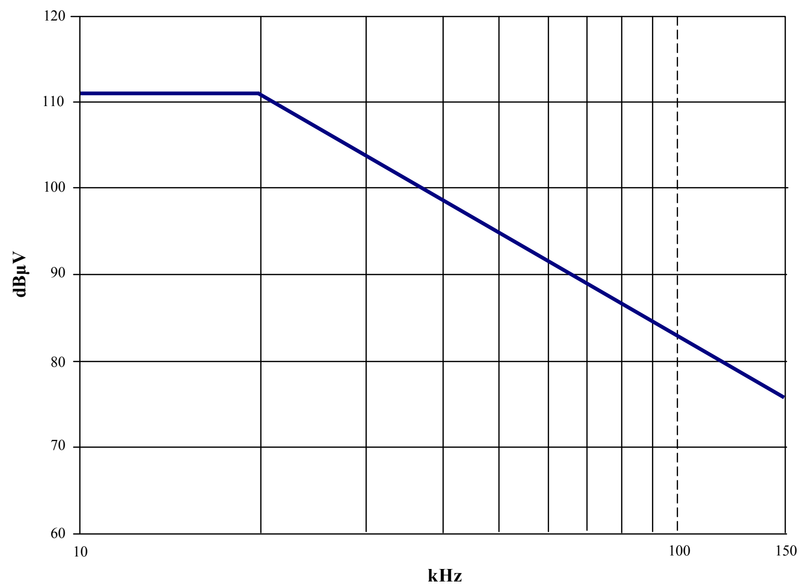
- Data on ambient environment related to each band limit and polarization at the time of test setup. The data shall contain the MBW and detection system used.
- Photograph of test setup
- Any deviation from test procedures explained in the EMC Test Plan shall be noted.

7.9.2.2 CE 421

These requirements shall be applicable to the following component categories:
Electronic components: A, AS
Electric motor: EM

7.9.2.2.1 Requirements The conducted voltage emissions of all component power circuits shall not exceed the required value specified in **Fig. 49**.

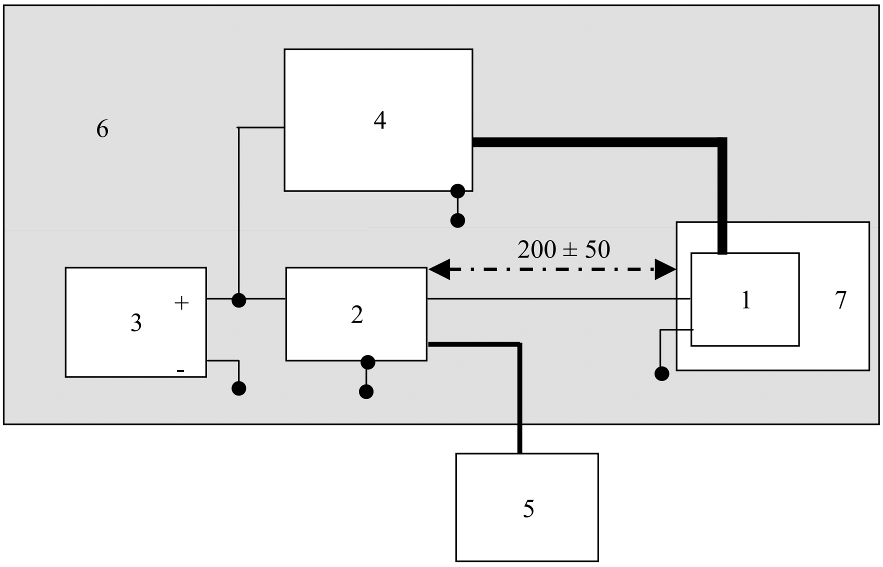
Frequency Range (kHz)	Limit (dBμV)
10-20	111
20-150	111-40Log(f/20)*



*f = Frequency (kHz)

Fig. 49 Requirements for CE 421 Conducted Emission

7.9.2.2 2 Test method and setup The test setup is the same as that used to CE 420 except for only one artificial network is used regardless of setting method of test sample in a vehicle. **Fig. 50** shows the setup. When the test sample has individual power circuits, individual tests shall be performed for each circuit. A circuit for which a test has not been performed shall be directly connected to a vehicle battery. This requirement may not be applied when several circuits are used only to satisfy requirements for operating current of the test sample. (e.g. There is one power circuit, however, there are several connector pins.) Under this condition, all power circuits shall be connected to the artificial network.



1 Test sample
2 Artificial network
3 Vehicle battery
4 Load simulator
5 Measuring receiver
6 Ground plane
7 Dielectric support ($\varepsilon_r \leq 1.4$ is preferable)

Fig. 50 CE 421 Test Setup

In CE 421, application of correction coefficient to measured data is required to clarify insertion loss of an artificial network. **Fig. 51** shows a "standard" correction coefficient of general **CISPR 25** artificial network. Correction of actual artificial network used for a test shall be used at the time of verification of test sample performance related to requirements shown in **Fig. 49** by a laboratory. Correction coefficient shall be determined by a procedure explained in **Annex 11**.

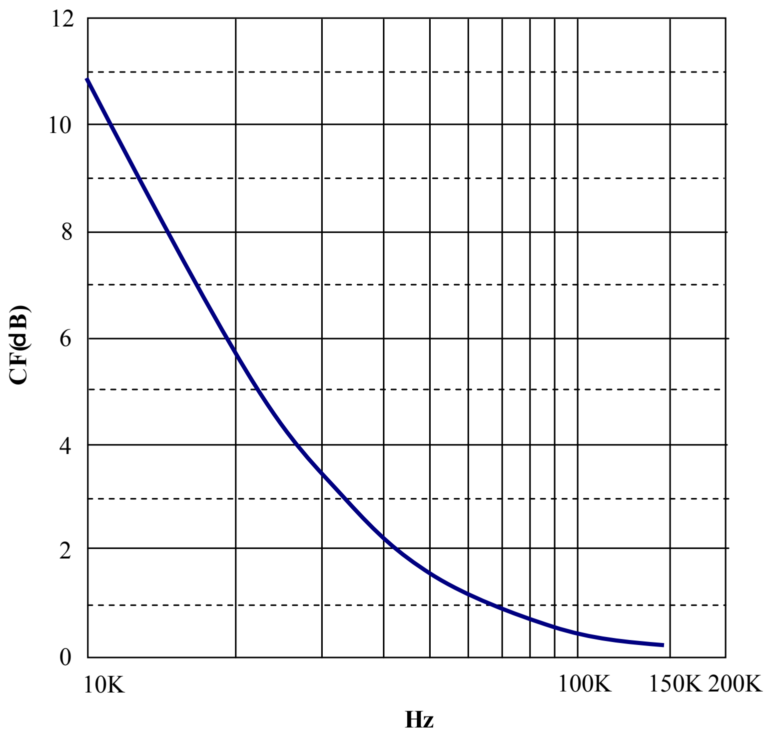


Fig. 51 Standard Correction Coefficient of CISPR 25 Artificial Network

7.9.2.2.1 Requirements for measuring system Measuring receiver (spectrum analyzer or step receiver) shall conform to **CISPR 16-1-1**. A measuring receiver capable of Fast Fourier Transform (FFT) can be used if a prior approval of Mazda has been obtained. (An approval is related to a homologation test at a laboratory.) Measuring system requirements when either a sweep (spectrum analyzer) or a step EMI receiver is used are shown in **Table 31**.

Table 31 CE 421 Measuring System Setup Requirements

	Sweep Receiver	Step Receiver
Detection system	Average detection	Average detection
Measuring bandwidth (MBW) (1) (kHz)	0.2 ≤ MBW ≤ 1	0.2 ≤ MBW ≤ 1
Video bandwidth (kHz)	≥ 3*MBW	—
Frequency sweep rate (2) (s/kHz)	≥ 0.03/MBW	—
Maximum frequency step size (kHz)	—	0.5*MBW
Measuring time per frequency step (s) (1)	—	≥ 0.02

Table 31; Notes (1) Various bandwidths that fall into the specified range are acceptable.
(2) Sweeping time is calculated by MBW given in kHz.

7.9.2.2.3 Test procedures Before verification of the limit of **Fig. 49**, correction coefficient of artificial network shall be applied to all measuring data (i.e., test setup environment, test sample conducted emission) by the following formula:

$$V_{CE}(f)=V_{RAW}(f)+CF(f)$$

Where,
$V_{CE}(f)$ = Conducted emission of a test sample at a specified measuring frequency (dBμV)
$V_{CE}(f)$ is compared to the limit shown in **Fig. 49**.
$V_{RAW}(f)$ = Conducted emission from measurement port on an artificial network at a specified measuring frequency (dBμV)
CF = Correction coefficient of an artificial network at a specific measurement frequency

(a) Before measurement of conducted emission of the test sample, the test setup environmental level (i.e., voltage is applied to all instruments except for the test sample.) shall be checked if it is at least 6 dB lower than the specified requirements in **Fig. 49**. If the level is under the value specified above, the test shall not be continued until problems of the related test setup are settled. A plot of the test setup environment shall be included in the test report.

(b) Mains-borne emission of the test sample shall be measured for the frequency range of **Fig. 49**.

(c) The test shall be repeated in all operation modes of the test sample listed in the EMC Test Plan.

7.9.2.2.4 Data report

- A one-page summary of the test data shall be made so that it shows a plot of measured test sample emission including applied limit plot.
  This format is the same as the one used for radiated emission. Any nonconformity to the band requirements shall be noted clearly.
  The test report shall include ambient environmental data at test setup.
- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Reference limit
- Measuring system bandwidth (MBW)
- Detection method (peak, quasi-peak, average)
- Emission data plotted at each frequency band
- Tabular summary on emissions of test sample at each frequency band
  The tabular summary shall contain the band number, maximum emission levels of the test sample measured at each band, and related band limit. Any nonconformity to the band requirements shall be noted clearly.

Additional information required:

- Data on ambient environment related to each band limit and polarization at the time of test setup. The data shall contain the MBW and detection system used.
- Photograph of test setup
- Any deviation from test procedures explained in the EMC Test Plan shall be noted.

7.9.2.3 CE 422
These requirements shall be applicable to the following component categories:
Electronic components: A, AS
Electric motor: EM

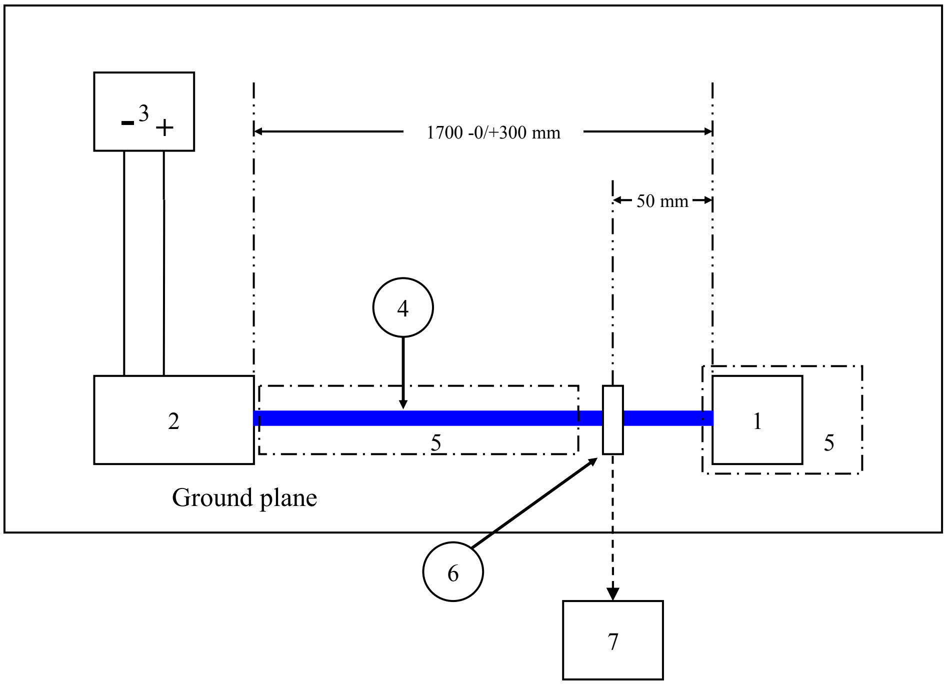
7.9.2.3.1 Requirements RF current that flows power supply and all input/output circuits shall not exceed the requirements shown in **Table 32**. The limit to be used shall be discussed with Mazda and shall be described in the EMC Test Plan.

Table 32 Requirements for AM Band High Frequency Current (Peak Detection, Frequency Range: 0.53 to 1.8 MHz)

Harness Connected Place ([1])	Type of Antenna for AM				
	Front pole	A pillar	Front center roof	Rear center roof	Glass
Instrument panel	14 dBμA	14 dBμA	14 dBμA	23.5 dBμA	23.5 dBμA
Cabin	23.5 dBμA	23.5 dBμA	23.5 dBμA	23.5 dBμA	23.5 dBμA
Engine compartment	29 dBμA	39 dBμA	39 dBμA	39 dBμA	39 dBμA

Table 32; Note ([1]) If the test sample is in the engine compartment and a harness that is connected to the test sample is in the cabin, the cabin standard shall be applied.

7.9.2.3.2 Test method and setup Refer to **Fig. 52** for test setup based on **CISPR 25**. A vehicle battery shall be used and AN (artificial power supply network) shall not be connected.



1	Test sample	5	Insulator ($\varepsilon_r \leq 1.4$ is preferable)
2	Load simulator	6	Current probe (Individual wire harness shall be measured)
3	Vehicle battery		
4	Wire harness for test	7	Measurement receiver

Fig. 52 Radio Noise Test Setup

7.9.2.3.2.1 Requirements for measuring system A measuring receiver (spectrum analyzer or step receiver) shall conform to **CISPR 16-1-1**. **Table 28** shows measuring system requirements when either a sweep (spectrum analyzer) or a step EMI receiver is used.

7.9.2.3.3 Test procedures

(a) Narrow-band high frequency current of all terminals shall be measured under the following conditions:

- Diameter and load of a wire harness for test shall be in a simulated on-vehicle condition.
- Measurement shall be made under the condition where the maximum electric current flows to the load and test sample. As for the test sample that performs PWM control, measurement shall be made under the condition where the maximum frequency and the maximum electric current (DUTY 100 % is not available.) flow to the load and test sample.
- When a switch is connected to the test sample, the input/output terminals shall be measured under both ON/OFF conditions of the switch.
- The measurement point shall be 50 mm away from the test sample. When the measurement point is changed, a prior confirmation of Mazda shall be obtained and it shall be described in the EMC Test Plan.
- In the case where requirements of **Table 32** can be loosened due to an engineering reason (e.g. Requirements of simultaneous measurement of several terminals shall be satisfied, etc.), a prior approval of Mazda shall be obtained.

(b) When another control unit is required to actuate the system, an artificial control unit may be an alternative. An approval of Mazda shall be obtained for the use and connection method of the artificial control unit.

7.9.2.3.4 Data report

- A one-page summary of the test data shall be made so that it shows a plot of measured test sample emission including applied limit plot.
  This format is the same as the one used for radiated emission. Any nonconformity to the band requirements shall be noted clearly.
  The test report shall include ambient environmental data at test setup.
- Operation mode of test sample
- Test sample ID (e.g. serial number)
- Reference limit
- Measuring system bandwidth (MBW)
- Emission data plotted at each frequency band

Additional information required:

- Data on ambient environment at the time of test setup. The data shall contain the MBW and detection system used.
- Photograph of test setup
- Any deviation from test procedures explained in the EMC Test Plan shall be noted.

8. Revision of Standard

The MES revision shall be made in accordance with **section 8** of **MES PW 67600**.

9. Indication Methods on Specification Drawing

The indication methods on Specification Drawing shall conform to **section 9** of **MES PW 67600**.

10. Applicable Regulations and Standards

The applicable regulations and standards shall conform to **section 10** of **MES PW 67600**.

Annex 1 EMC Test Plan

The EMC test plan shall be prepared in accordance with the outline shown in **Annex 1 Fig. 1**. **Annex 1 Fig. 2** shows an image of the title page. The title page shall be used for all EMC Test Plans. The format to be used for practical purposes is provided by Mazda.

Title page (Refer to **Annex 1 Fig. 2**.)
1.0 Introduction
- 1.1 Product description
- 1.2 Theory of operation
- 1.3 Physical construction
- 1.4 EMC specification
- 1.5 Test facility
- 1.6 Component part number(s)
- 1.7 Component manufacturer(s)
- 1.8 Component usage

2.0 EMC requirements analysis
- 2.1 Critical interface signals
- 2.2 Potential sources of emissions
- 2.3 Typical test sample

3.0 Test design and requirements
- 3.1 Component operating modes/functional importance classifications
- 3.2 Test requirements
- 3.3 Input requirements
- 3.4 Output requirements
- 3.5 Load box/test support requirements

4.0 Test setup

Annex 1 Fig. 1 Example of Outline of EMC Test Plan

<table>
<tr><td colspan="2">Product Name:</td></tr>
<tr><td>Supplier Name:</td><td rowspan="2">Recognized EMC Test Facility:
Lab Manager Name</td></tr>
<tr><td>Product Design Engineer:</td></tr>
<tr><td>Product Manager:</td><td rowspan="2">Vehicles & Model Year Using this Product:
(May be listed on separate page)</td></tr>
<tr><td>Product Part No.:
(May be listed on separate page)</td></tr>
<tr><td>Product Manufacturing Locations:</td><td>Applied EMC Specification:</td></tr>
</table>

We certify that the information contained in this test plan is factual including description of the product operation, accuracy of functional classifications, acceptance criteria, etc. We shall contact you in advance when changing this test plan prior to a design verification test after its submission. We shall submit a document with a technical reason when we perform a test again in accordance with a test plan that has been changed and revised after completion of EMC test to obtain your approval. We understand that we cannot obtain your approval for EMC test data applied to the product if we change or revise this test plan without an approval mentioned above. We also understand that EMC performance requirements validated via this test plan are relevant only to the specific vehicles that the product is to be fitted to, and that use of the product on other vehicle platform may require additional EMC performance requirements such as an additional verification test of the product. We certify that the product samples submitted for the EMC test are of a production representative design. We agree to submit a summary report to you no later than five (5) business days following completion of the EMC test. We also agree to forward a copy of the detailed EMC test report to Mazda within thirty (30) business days following completion of the EMC test.

Product Design Engineer:

____

Signature and Date

Product Manager (Approval):

____

Signature and Date

Mazda Engineering Dept. (Receipt):

____

Signature and Date

Annex 1 Fig. 2 Title Page of EMC Test Plan (Image) (Example)

Annex 2 Requirements of Load Simulator

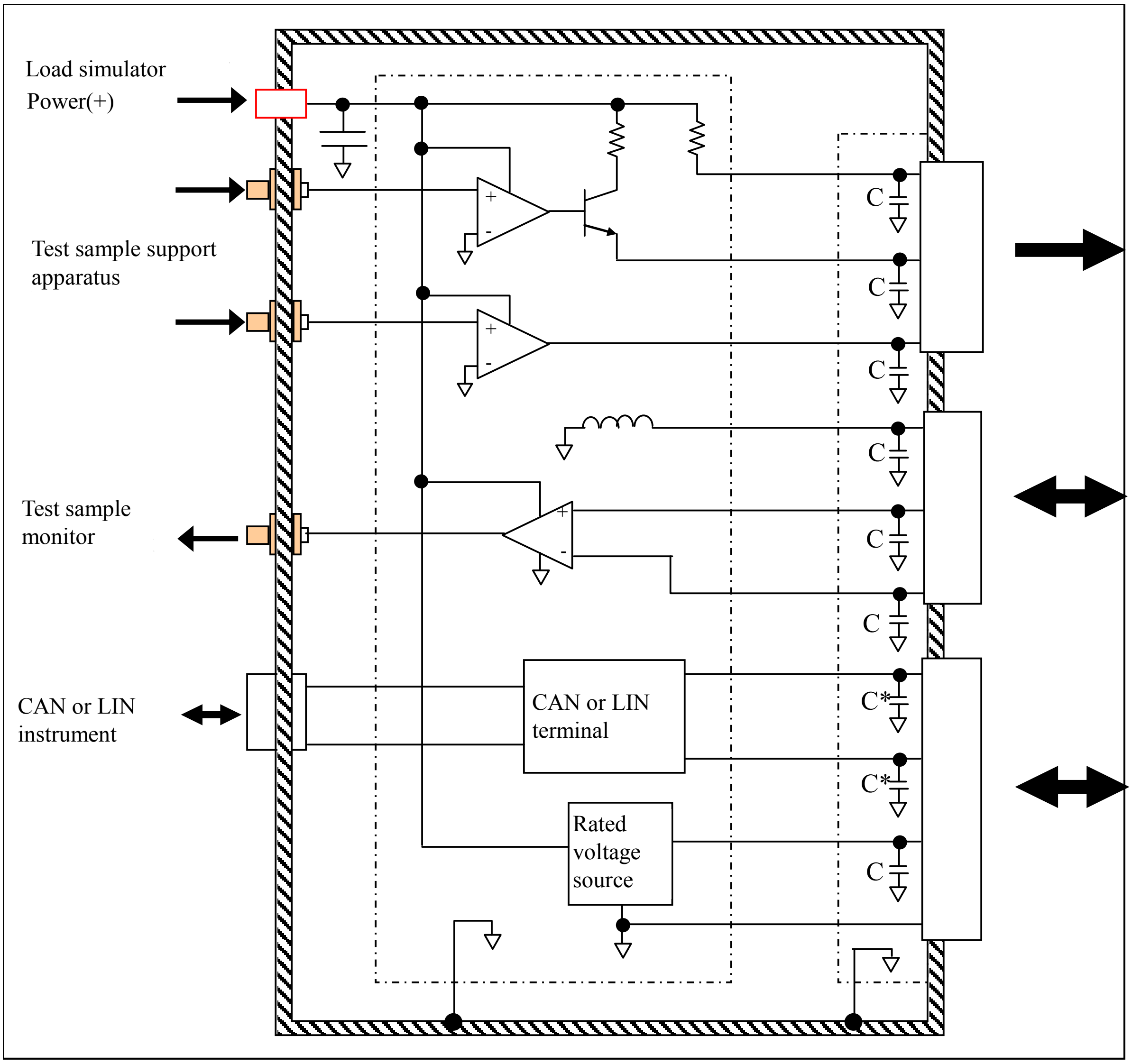
A load simulator is a shielded box-type instrument including all external electric interfaces (sensor, load, etc.) usually connected to a test sample. A load simulator has functions in assistance required during a test, interface to a monitor and RF boundary to a test sample. **Annex 2 Fig. 1** shows a general load simulator. The circuits in the figure show what can be included in the load simulator. An actual circuit is specific to the function of a test sample, however, the requirements shown below shall be followed when the load simulator is designed.

- For all interface circuits in the load simulator except for CAN, a 10 nF condenser shall be included between each interface circuit and chassis of a load simulator as long as actual electrical load is not used. An approval of Mazda shall be obtained prior to a test to omit the10 nF condenser. The value of 10 nF of the condenser shows an interface condenser to almost all modules. When the load simulator includes CAN interface (incl. MS or HS CAN), the capacitance shall be 470 pF. The condenser shall be placed as close to the load simulator/test sample harness interface connector as possible. **Annex 2 Fig. 1** shows the position of the condenser. It is recommended that a surface mounting condenser be used on individual PCB that are directly attached to the interface connector. This minimizes inductance of a lead wire between the interface circuit and the chassis of the load simulator. Use of a filter connector is possible, however, a prior approval of Mazda is required.
- When CAN communication is included in the test sample, the circuit shown in **Annex 2 Fig. 2** shall be set in the load simulator. Configuration A shall be used to an instrument with internal CAN bus termination. Configuration B shall be used to an instrument without termination. When LIN communication is included, the circuit shown in **Annex 2 Fig. 3** shall be set in the load simulator.
- Components to be produced shall be used as a load, wherever possible. This is especially important for an inductive circuit and pulse width modulation (PWM) circuit. When an actual load cannot be obtained, an artificial load can be used, however, impedance expected in a productive vehicle (resistance, capacitance and inductance) shall be shown correctly. Pure resistance load shall not be used unless an approval of Mazda is obtained.
- When the test sample is powered by other electric module (e.g. sensor), the power supply of the module shall be correctly simulated by the inside of the load simulator. Other active element can be included inside the load simulator, however, an appropriate step shall be taken to prevent a potential effect of RF energy occurred from the element actuation.
- Generally, all inputs and outputs shall be based on a power ground at one position in the load simulator, and be connected to a metallic chassis of the load simulator. Only exception is that there is a necessity of occurrence of voltage offset between a ground plane and a load included in the load simulator for CI 250. Refer to **section 7.7.5** for additional details.

Annex 2 Fig. 4 shows a load simulator for a general test setup.

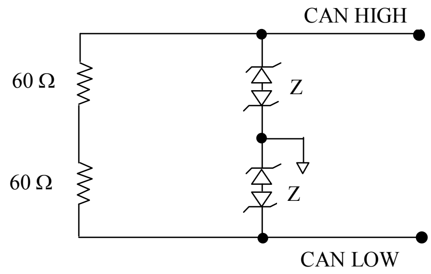
- Chassis of the load simulator shall be electrically connected to the ground plane of test setup with a direct connection (screw) and/or a ground strap. An alternative connection method (e.g. copper tape with conductive adhesive) is not allowed.

- Test sample input that needs an external signal source can be facilitated through the load simulator. Optical fiber is recommended for these connections, however, a coaxial cable can be used to connect a remote support equipment to the load simulator. When coaxial connection is used, however, ferrite beads shall be attached on cables of all cable connections at an interval of 150 mm max. A review and an approval of Mazda shall be obtained for use of ferrite beads except for the type shown in **Annex 2 Fig. 4** as a process of test audit.
- An optical fiber medium shall be used to connect output of the test sample to a remotely-set monitor. Frequency bandwidth of the optical fiber medium shall be selected in accordance with operating bandwidth of the monitored test sample signal, however, shall be limited to prevent potential influence on the monitor by coupling of unintended RF energy. Use of non-optical interface to the monitor can be allowed only when a prior approval of Mazda is obtained. Details of the signal monitor and supporting interface shall be described in the EMC Test Plan.
- All optical fiber media shall be verified in advance that they will not be influenced by the RF application level described in **section 7.6.1** in this MES.
- Ferrite beads shall be attached to the cable of a wire that connects a battery to the artificial network and the load simulator at an interval of at least 150 mm.

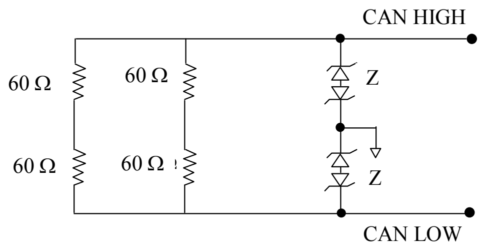


C = 10 to 100 nF
Unless there is a provision in the EMC specification of the product, this value shall be mandatory to application to all load simulators. Any nonconformity to this value shall require Mazda's approval, and it shall be described in the EMC Test Plan.
C* = 470 pF (CAN and LIN interfaces only) shall not be attached to the testing apparatus. When it is attached, it shall be described in the EMC Test Plan.

Annex 2 Fig. 1 Load Simulator (General Design)

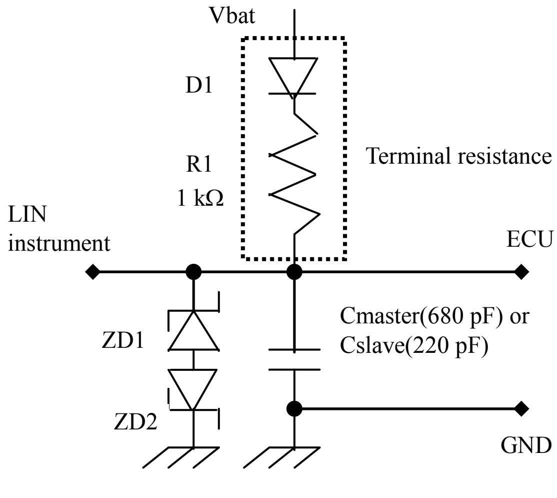


Configuration A
Instrument with build-in CAN terminal

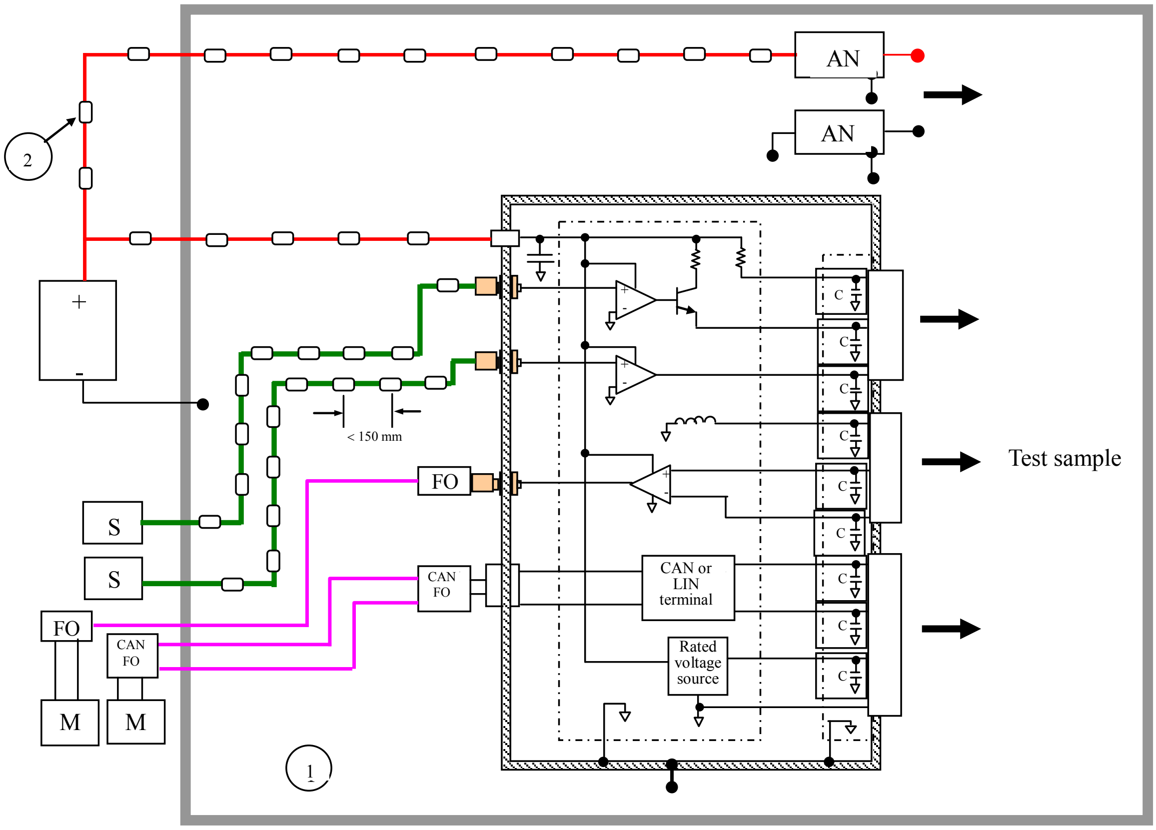


Configuration B
Instrument without build-in CAN terminal

Annex 2 Fig. 2 Requirements of Load Simulator CAN Interface Circuit Design



Annex 2 Fig. 3 Requirements of Load Simulator LIN Interface Circuit Design



1	Ground plane	M	Monitor
2	Ferrite bead (Fair-Rite type 43 or equivalent		Reference ground for chassis signal of load simulator
	Reference ground for signal		Electrical connection to ground plane
MO	Optical fiber medium	S	Support apparatus

Annex 2 Fig. 4　Load Simulator Test Setup

Annex 3 EMC Retest Procedures

An engineering change to the original MP parts often affects the EMC characteristics. Some EMC retests are required to ensure that such an engineering change does not adversely affect the EMC characteristics. The information provided here shows the procedures for determining what EMC retests need to be implemented, when a certain part engineering change is studied.

The information provided in **Annex 3 Tables 1** to **5** shall be used to determine EMC retests required for studying the effectiveness of an engineering change. The responsible Mazda Engineering Gr. shall be contacted before the retests. The original EMC Test Plan for the parts shall be used to facilitate the retests. A prior approval of Mazda shall be obtained if the test procedures deviate from the ones specified above.

Annex 3 Table 1 Changes in Electrical Connection on Circuit Board

Changed Portion	Degree of Change	Required Test	Section
Outer connecter I/O	Layout change ≥ 0.152 mm Pattern width ≥ 0.152 mm	Electric field Electromagnetic field Electrostatic discharge	**7.8.1** **7.6.1** **7.7.7**
Multiple line (e.g. SCP, CAN)	Layout change ≥ 0.152 mm Length ≥ 0.152 mm	Electric field	**7.8.1**
Reset line	Layout change ≥ 0.152 mm Length ≥ 0.152 mm	Electromagnetic field Coupling noise	**7.6.1** **7.6.3**
Low electric power analogue portion	Layout change ≥ 0.152 mm Length ≥ 0.152 mm	Electromagnetic field Coupling noise	**7.6.1** **7.6.3**
Ground pattern	All	Electric field Electromagnetic field Coupling noise Electrostatic discharge	**7.8.1** **7.6.1** **7.6.3** **7.7.7**
General	Layout change ≥ 0.152 mm Thickness, Pattern width ≥ 0.152 mm	Electric field	**7.8.1**
Power supply line, High current portion	Layout change ≥ 0.152 mm Pattern width ≥ 0.152 mm	Electric field Electromagnetic field	**7.8.1** **7.6.1**

Annex 3 Table 2 Changes in Software

Characteristics	Change	Required Test	Section
PLL	Frequency	Electric field Electromagnetic field	**7.8.1** **7.6.1**
O/P Slew Rate	Increase/decrease	Electric field RF	**7.8.1** **7.9.2**
Watchdog, Reset, Interrupt	All	Electromagnetic field Voltage drop	**7.6.1** **7.7.3.2**
General	All	Electric field	**7.8.1**

Annex 3 Table 3 Part Changes on Substrate

Part	Change	Required Test	Section
I/O condenser	Change in value (10 times)	Electric field Electromagnetic field Electrostatic discharge	**7.8.1** **7.6.1** **7.7.7**
Regulator condenser (I/P)	Change in value (10 times)	Electric field Electromagnetic field Continuous noise Transient noise Power cycle	**7.8.1** **7.6.1** **7.7.1** **7.7.2** **7.7.3.1**
IC decoupling condenser	Change in value (10 times)	Electric field	**7.8.1**
Slew Rate condenser	Change in value (10 times)	Electric field Electromagnetic field	**7.8.1** **7.6.1**
OP amplifier input condenser	Change in value (> 10 %)	Electromagnetic field	**7.6.1**
I/O series resistance	Change in value (> 10 %)	Electric field Electromagnetic field Electrostatic discharge	**7.8.1** **7.6.1** **7.7.7**
Slew Rate resistance	Change in value (> 5 %)	Electric field Electromagnetic field	**7.8.1** **7.6.1**
B line zener/MOV (Metal oxide varistor)	Voltage rate	Transient noise DC stress	**7.7.2** **7.7.6**
Microprocessor	From OPT to ROM	Electric field Electromagnetic field	**7.8.1** **7.6.1**
Oscillator	Frequency	Electric field Voltage drop	**7.8.1** **7.7.3.2**
PWM control	Slew Rate/current	Electric field RF	**7.8.1** **7.9.2**
IC, Condenser, Coil	Change in manufacturer	Shall be reviewed by Mazda to determine additional tests.	–

Annex 3 Table 4 Changes in Packaging or Mechanical Setting

Characteristics	Change	Required Test	Section
Package material	Conductivity	Electric field Electromagnetic field Electrostatic discharge	**7.8.1** **7.6.1** **7.7.7**
Grounding	Impedance, Layout	Electric field Electromagnetic field Electrostatic discharge	**7.8.1** **7.6.1** **7.7.7**
Heat sink	Size, Layout, Grounding	Electric field (Grounding only) Electrostatic discharge	**7.8.1** **7.7.7**
Opening	Size, Layout	Electrostatic discharge	**7.7.7**

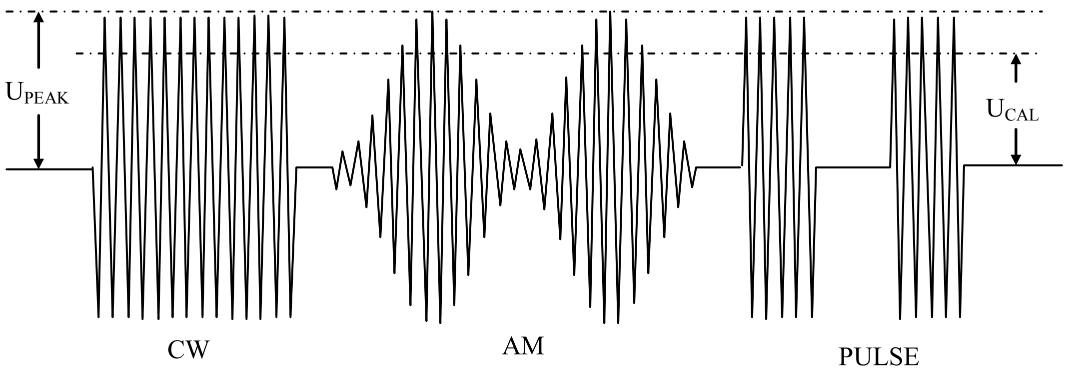
Annex 3 Table 5 Changes in Load

Characteristics	Change	Required Test	Section
Solenoid, Motor, Relay	Impedance	Transient	**7.9.1**
Active sensor	Sensor impedance	Electromagnetic field Voltage offset	**7.6.1** **7.7.5**

Annex 4 Requirements of RI 11X Modulation and Leveling

4-1 Peak maintenance

Peak shall be maintained during radiated immunity test for application of AM and peak modulation in accordance with **ISO 11452-1**. (Refer to **section 7.6.1**.)
Annex 4 Fig. 1 shows peak maintenance. Peak maintenance shall be verified by actual measurement as a calibration process.



U_{CAL} = Application level shown in **Tables 8**, **9**, **10** and **11** (RMS)
U_{PEAK} = Peak application level

Annex 4 Fig. 1 RF Immunity Peak Maintenance

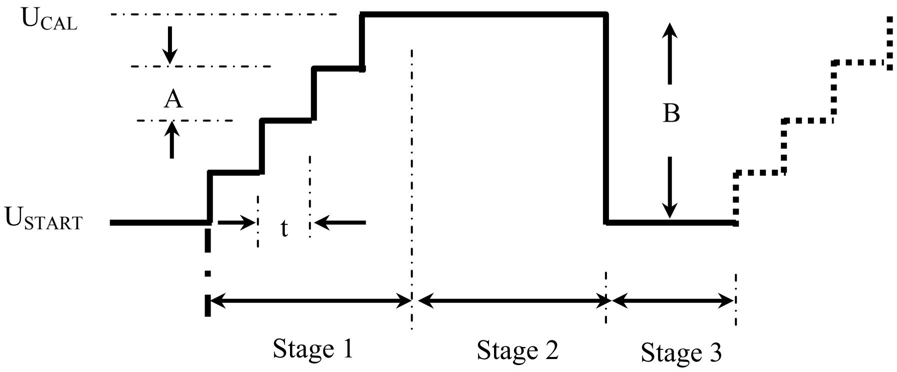
4-2 Application leveling procedures

At least 3 different stages shown in **Annex 4 Fig. 2** appear at each test frequency during tests of RI 110, RI 112, RI 114 and RI 115. Stage 1 consists of leveling process to achieve application level required at each test frequency. Stage 1 is generated by setting application level of output of the signal generator at least 10 dB lower than the required application level (i.e., U_{CAL}). The value of the signal generator is lead based on calibration of the application level. The leveling process is indispensable as the required application level shall not exceed as much as 1.0 dB. Two factors may be influential.

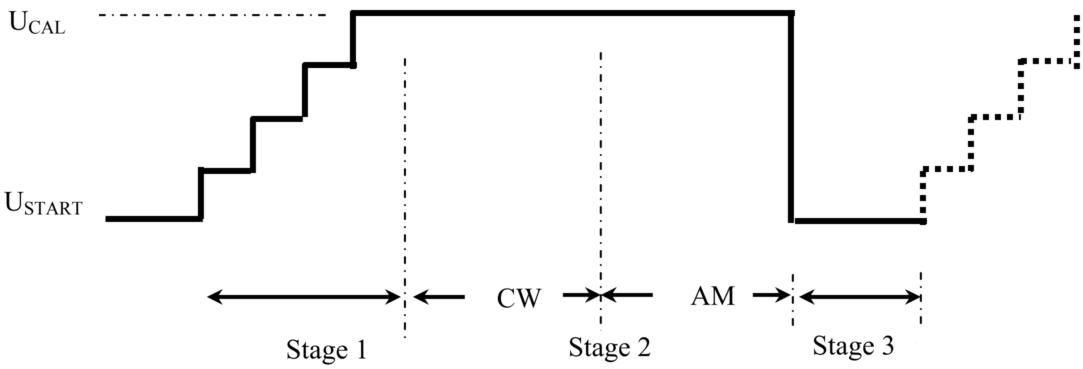
1 Selection of application increased amount “A” (Refer to **Annex 4 Fig. 2**.)
Use of a certain small increased amount of application during the leveling process can be selected, however, making the leveling time minimum so that the aimed application level may not exceed over 1 dB shall be considered. Additionally, selected application increased amount can be changed in accordance with difference between measured application level and aimed application level. Total leveling time shall not exceed 6 s.

2 Overshoot of RF signal source during step change at RF amplifier output
Overshoot shall not exceed the aimed application level by 1 dB. Overshoot shall be minimized by using many hardware and software parameters. Step change of electromechanical attenuation that can be critical source of overshoot shall be avoided. This is not a request, however, use of a signal generator with attenuator is recommended.

Stage 2 shall be achieved when the required application level has been achieved.
The application level shall be constant for 2 s, which is the minimum dwell time, unless longer testing time is specified in the EMC Test Plan. CW, AM, or pulse modulation can be used during this time. Individual tests can be performed for each modulation type, or modulation type can be performed in stages at each frequency (recommended).
Annex 4 Fig. 3 shows the latter method. When this method is used, a measure shall be taken to distinguish abnormality of test samples that occurs from a specific modulation type.
When the dwell time is finished, the required application level shall be decreased by at least 10 dB (Stage 3). At this time, the next test frequency is selected and the above process is repeated. Duration of Stage 3 is affected only by the time taken for starting leveling procedures transferring to the next frequency (Stage 1) by initial setting. This is determined by hardware or testing software.



Annex 4 Fig. 2 General Leveling and Dwelling Process for RF Immunity



Annex 4 Fig. 3 Example of Dwelling for Combination of RF Immunity CW and AM

Stage 1: Leveling stage USTART: At least 10 dB lower than initial application level: UTARGET

Stage 2: Dwelling stage UTARGET: Aimed application level
(Initial setting is 2 s.)　A: Application increased amount (constant or variable)

Stage 3: Application shall be removed.　B: Next dwelling level: UTARGET of the next test frequency shall be changed to the next frequency.　At least 10 dB lower than UTARGET.
(Depend on hardware and software)

t: Time required for measurement of RF power
(Depend on hardware and software)

4-3 Procedures of test sample function threshold

Effect (abnormality) threshold level of the test sample function shall be determined by the following procedures:

1. Application level shall be lowered until the effect on test sample function disappears.
2. The application level shall be increased at a step less than 1 dB until the effect on function reappears.
3. The application level obtained in Step 2 shall be taken as a threshold.

Annex 5 Triplate

Overview of triplate

(a) The sides of the triplate mentioned in this MES are open, not closed. This configuration helps to prevent resonance caused by the closed triplate configuration and obtain a more uniform electric field even under a high frequency condition.

The triplate method has the following advantages, compared to the strip-line method:

- A larger volumetric capacity makes it possible to set a larger test sample in the cell.
- It is possible to monitor input/output power of the triplate.
- A symmetrical configuration provides the same electric field to the upper and lower sections. This makes it possible to put a test sample in the lower section and monitor the electric field in the upper section.

A disadvantage of the triplate method is that a larger volumetric capacity requires larger power supply to produce field intensity.

The field intensity "Ev(f)" shall be determined by the following formula:

$$Ev(f)\ (V/m) = (P_{MID}(f) \times Z(f))^{1/2} / h$$

$$P_{MID}(f)\ (W) = (P_{NET} + P_{OUT}) / 2$$

Where,

$P_{MID}(f)$: Intermediate point power

h: Distance between ground plate and center plate (m)

If it is confirmed that $P_{MID}(f)$ equals P_{NET}, P_{NET} is allowed to be used. Z(f) will be described hereinafter.

(b) In reality, the electric field generated is uniform only up to a certain frequency. Using a long straight wire harness in the test sample, however, integrates the electric field in accordance with the wire harness under a high frequency condition.

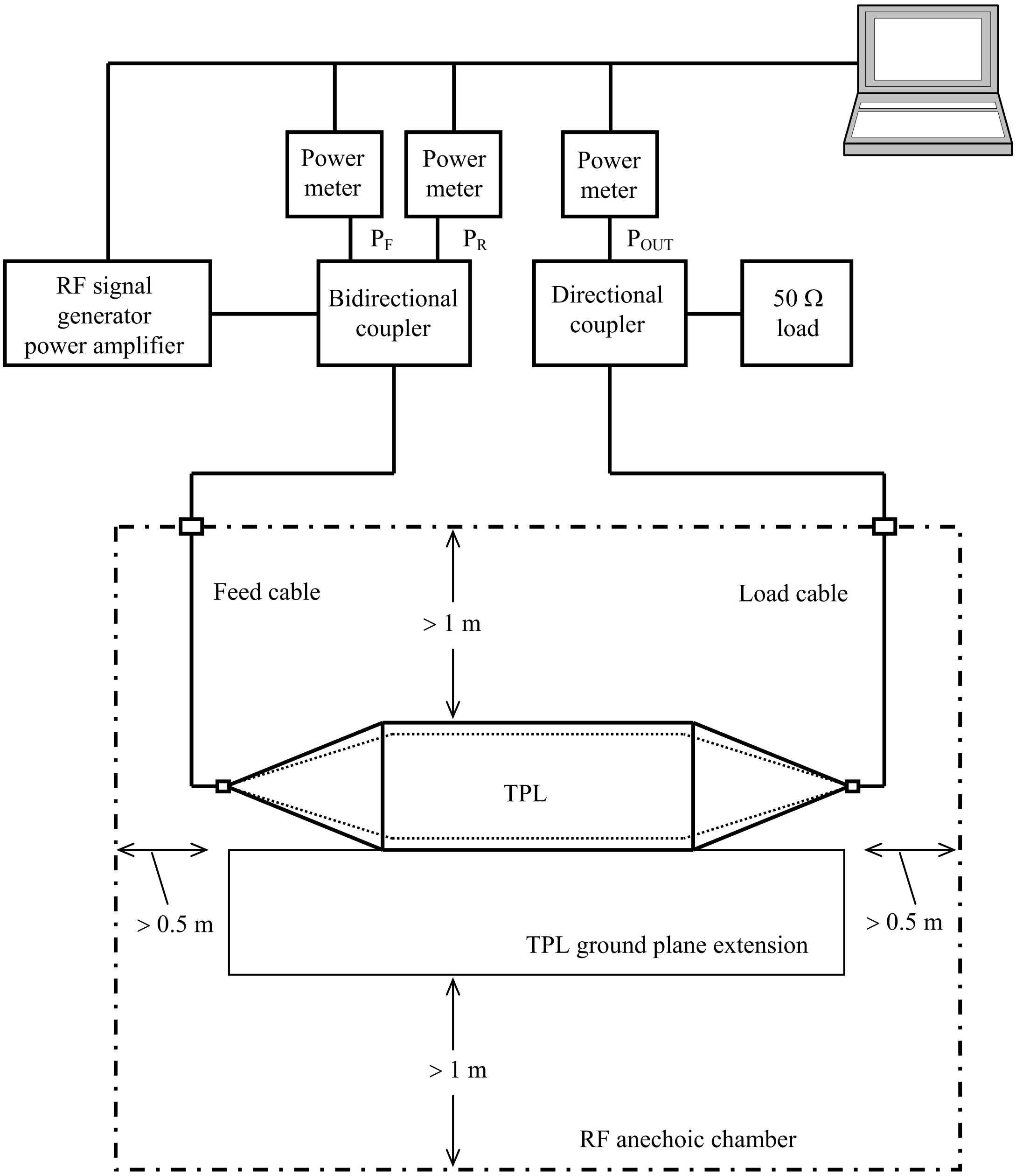
Since the test sample is located in the triplate, it may possibly be exposed to a resonance point of the electric field under a high frequency condition. (The electric field changes in accordance with the plate's length direction under a high frequency condition.) It shall be ensured that the test sample is not in a condition to be evaluated when there is a chance of such an exposure. (e.g. The test sample shall be moved, or the field intensity shall be measured at the position of the test sample.)

(c) It shall be ensured that the triplate will not cause any environmental deprivation during the test. For reasons of safety of the human body (due to generation of an intense electric field), the test shall be performed in a shielded room. Since the triplate emits radio waves under a high frequency condition, it shall be ensured that a wave absorber is installed on the wall of the shielded room to minimize the reflection.

(d) The field intensity of the triplate shall be the average of Root Mean Square values (RMS). (The average of field intensity values obtained at five points in the center line of the testing space measured with an isotropic field probe (center section when its width and length are each divided into three equal parts) shall be taken.)

The field intensity values shall be measured with nothing placed in the triplate. When a metallic substance is placed in the triplate, the field intensity value changes. Some degree of field intensity variation is acceptable as long as the metallic substance is not large. Therefore, the size of the test sample shall be 1/3 or less of the plate height.

Setup
The triplate shall be set in an RF anechoic chamber as shown in **Annex 5 Fig. 1**.
The ground plane of the triplate shall be grounded on the shielded wall or floor using a bonding strap, or using an earth wire of the coaxial cable if the coaxial cable is 2 m or less in length.



Annex 5 Fig. 1　Setup Diagram

Electric field calibration (Z(f))

The calibrated electric field value provided below shall be used during the test.

$Ev(f)$ (V/m) = $(P_{MID}(f) \times Z(f))^{1/2} / h$

$P_{MID}(f)$ (W) = $(P_{NET} + P_{OUT}) / 2$

Where,

h: Distance between ground plate and center plate (m)

$P_{NET} = P_F - P_R$: Net RF power input into triplate

P_F: Traveling wave power that flows in triplate input portion

P_R: Reflected wave power that flows in triplate input portion

P_{OUT}: Power that flows toward end point of triplate output portion (termination)

Z(f) is defined as follows:

(a) The triplate shall be empty and small RF field probes shall be set at five positions as illustrated in **Annex 5 Fig. 2**. The height of the probes shall be 15 cm above the ground plane as in the case of the test sample and harness.

(b) In addition to five electric field values, P_F, P_R and P_{OUT} shall be determined.

(c) The average electric field value shall be determined by the following formula:

$$E_{AVG} = \frac{1}{5}\sum_{N=1}^{5} E_N$$

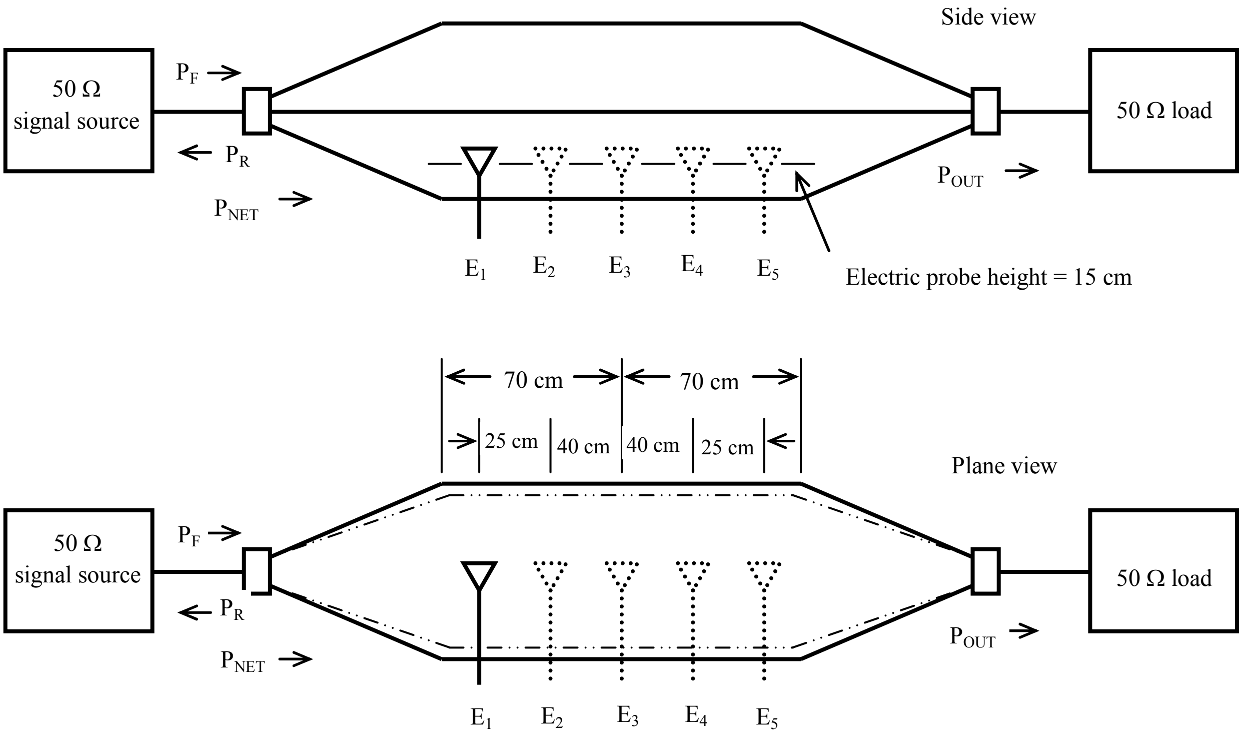
E_N represents the electric field value at each probe position.

(d) $P_{MID}(f)$ shall be determined.

(e) Z(f) shall be determined by the following formula:

$Z(f) = h^2 \times E_{AVG}{}^2(f) / P_{MID}(f)$

(f) Z(f) shall be determined at each frequency.



Annex 5 Fig. 2 Electric Field Measuring Points

Triplate configuration

Annex 5 Fig. 3 illustrates the triplate configuration.

Approximately 70 Ω in calculation.

$Z (\Omega) = (30 \times \pi) / [c + (k + w) / b]$

Where,

Z (Ω): electric field calibration of triplate

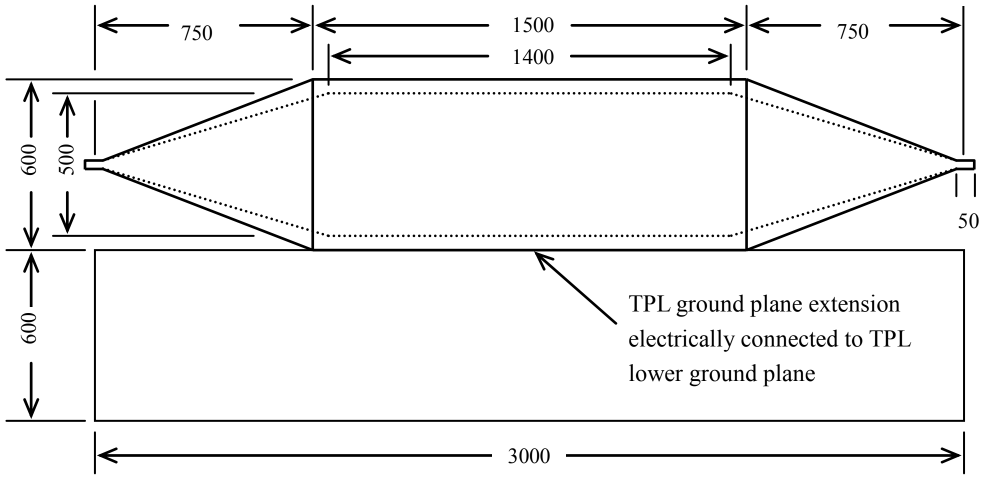
b (cm): Height of triplate (Distance between outer plates)

w (cm): Width of center plate of triplate

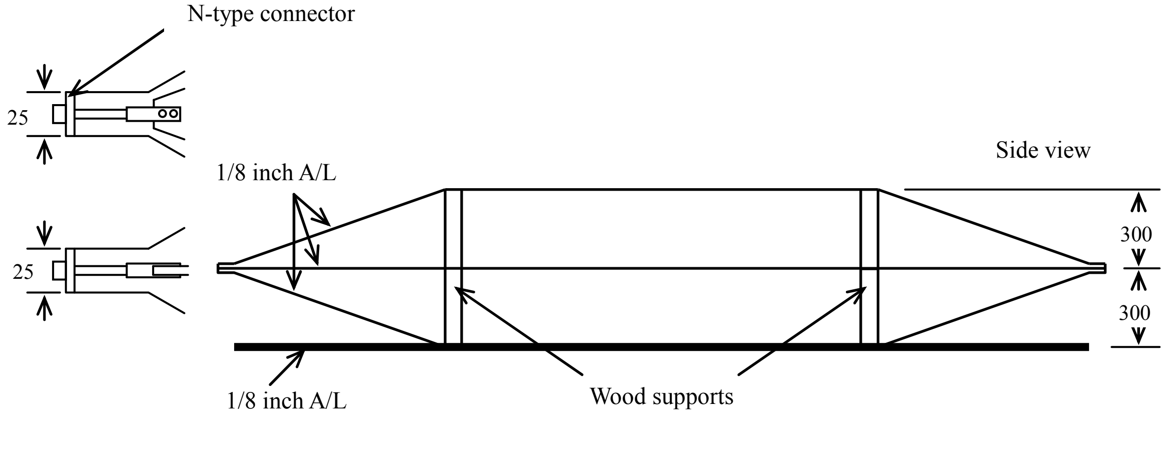
$k = 1 / (1 - t / b)$

t: Thickness of partition

$c = 1 / \pi \times [(2 \times k) \times \text{In} (k + 1) - (k - 1) \times \text{In} (k^2 - 1)]$



(Unless otherwise specified, **Unit** mm)



Annex 5 Fig. 3 Triplate Configuration

Annex 6 ALSE Method Electric Field Calibration for 1,000 MHz or Over

Electric field calibration shall be performed smoothly by using the procedures outlined in this Annex, as it is necessary to produce high field intensity correctly for band 6 and band 7. These procedures are alternatives to those specified in **ISO 11452-2**. Either a field probe or a receiving antenna can be used for this calibration. Electric field calibration specified in **ISO 11452-2** shall be used for band 4 and band 5. The procedures outlined in this Annex shall not be used for electric field calibration of band 4 and band 5.

6-1 Field probe method

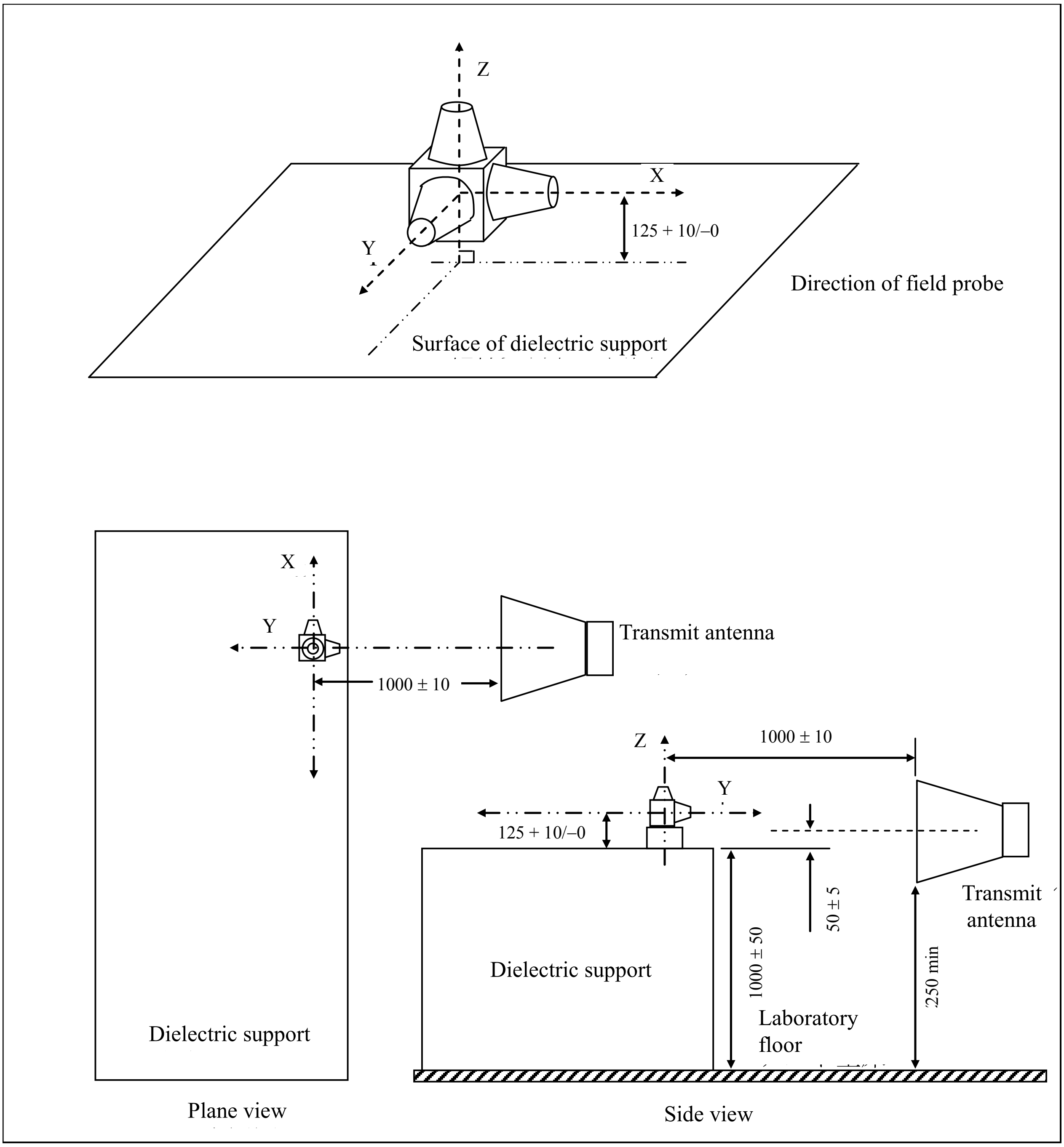
Details on the axial direction of a field probe against surfaces of a dielectric support and a transmit antenna are described. **Annex 6 Fig. 1** and **Fig. 2** show positioning of two types of general probe. A special deliberation is required for some probes to ensure they are set in an accurate direction. In **Annex 6 Fig. 2**, the probe is set at a correct position by tilting the probe handle above the dielectric support (usually at 30 °), and by rotating it making the axis perpendicular to the dielectric support the center (usually at 135 °). The actual positioning shall be determined by the probe specification. The center of phase of any probe (the origin of axis of the probe) shall be 125 mm above the surface of a dielectric support used to an actual test.

Calibration of vertical or horizontal polarized waves shall not be related to a vector resultant force (e.g. Etotal) but be related to a specific axis.

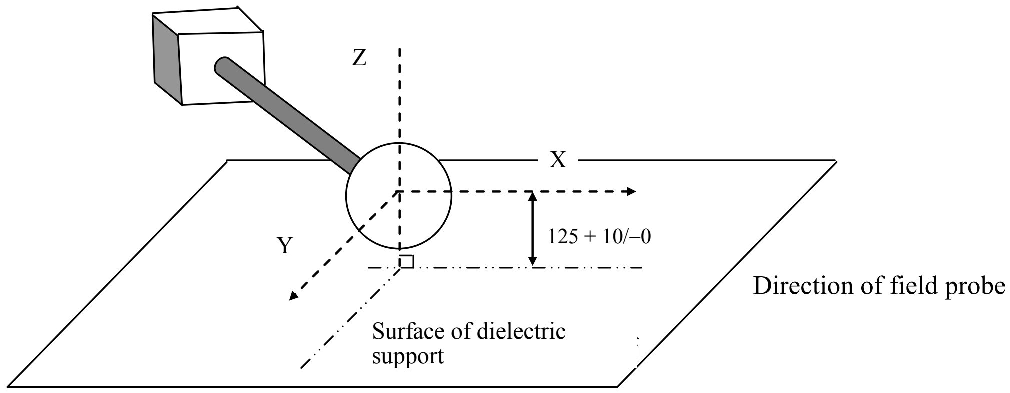
E.g. For a vertical polarized wave, field calibration shall be related to the field probe sensor that is vertically oriented (i.e., Z axis sensor). For a horizontal wave, electric field calibration shall be related to the field probe sensor that is horizontally oriented (i.e., X axis sensor). To use this method, a field probe that can read individual electric field axis is required. A field probe that outputs only the total of measured electric field vectors shall not be used.

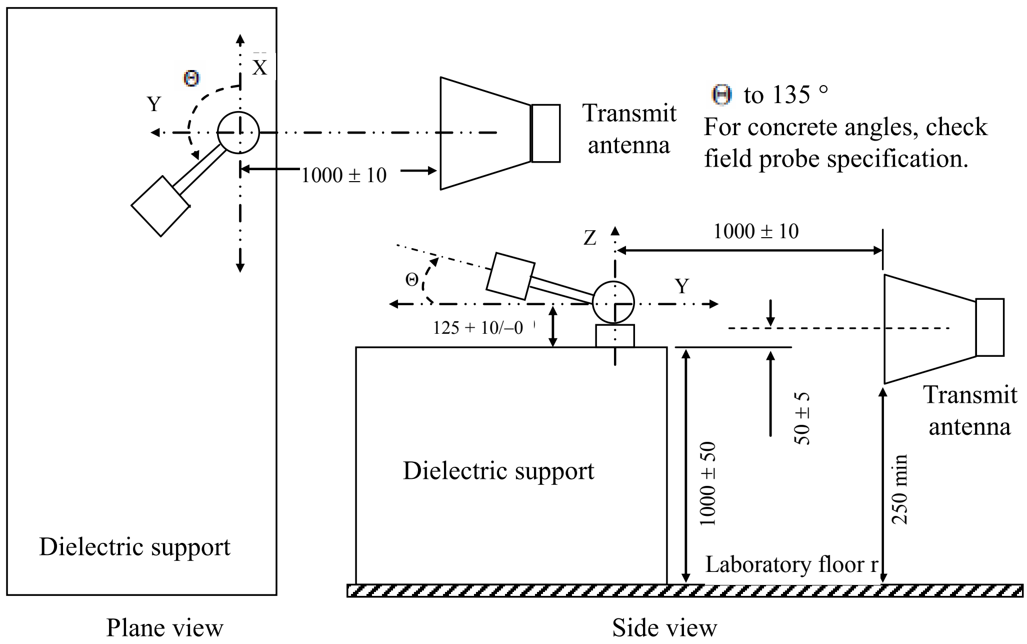
Additional requirements

- The center of phase of a field probe shall be set 125 mm above the surface of the dielectric support that is used during actual tests.
- Peak progressive wave electric power shall be the reference parameter of electric field calibration. This progressive wave shall be measured by using either a peak envelope power (PEP) sensor (recommended) or a spectrum analyzer. When a spectrum analyzer is used, it shall be adjusted to individual frequency using zero span setting of measurement bandwidth of over 3 MHz.
- Pulse modulation characteristics shall be the same as shown in **Annex 4 Fig. 1**.
- Electric field calibration shall be done using CW with the field intensity required in **Table 10**. Evaluation of high field intensity using electric field calibration value at low field intensity is not allowed.
- The electric field probe to be used shall have the capacity to measure electric field shown in **Table 10** (e.g. 300/600 V/m).
- The field probe shall be calibrated for the following frequencies strictly:
    - 1.3 GHz
    - 2.9 GHz



Annex 6 Fig. 1 Setup of Field Probe (Type A)





Annex 6 Fig. 2 Setting of Field Probe (Type B)

6-2 Pulse field probe method

Only when Mazda's prior approval is obtained, a field probe capable of direct measurement of pulse field intensity directly can be used. The probe shall satisfy requirements for field probe (**section 6-1**) except for unnecessity of field intensity measurement for CW.

6-3 Antenna method

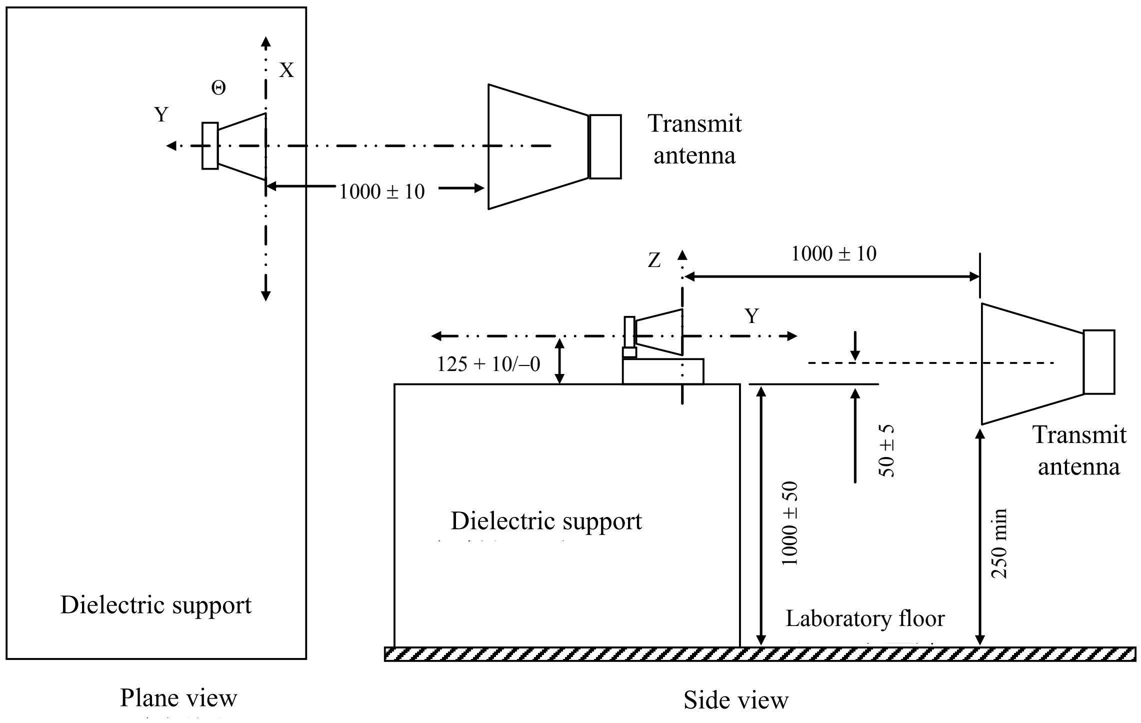
Annex 6 Fig. 3 shows setup when a receiving antenna is used for electric field calibration. This method is used when CW or a pulse amplifier is used. Any of the following shall be used as a receiving antenna in this method:

- ETS Lindgren DRG 3115
- Antenna Research: DRG 118/A
- Rohde & Schwarz: HF906

When another antenna is used, an approval of Mazda shall be obtained.

Additional requirements are as follows:

- The center of phase of an antenna shall be set 125 mm above the surface of the dielectric support that is used during actual tests.
- Peak progressive wave electric power shall be the reference parameter of electric field calibration. This progressive wave shall be measured by using either a peak envelope power (PEP) sensor (recommended) or a spectrum analyzer. When a spectrum analyzer is used, it shall be adjusted to individual frequency using zero span setting of measurement bandwidth of over 3 MHz.
- Pulse modulation characteristics shall be the same as shown in **Annex 4 Fig. 1**. RMS maximum progressive wave electric power (Ppulse) shall be the same as CW calibration power (P_{CW}_cal) (i.e., Ppulse = P_{CW}_cal).
- Electric field calibration shall be done with the field intensity required in **Table 10**. Evaluation of high field intensity using electric field calibration value at low field intensity is not allowed.



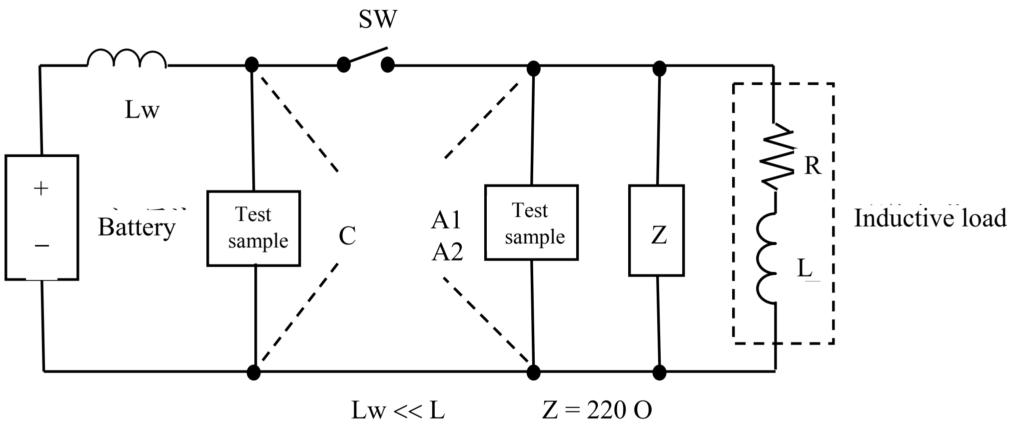
Annex 6 Fig. 3   Setting of Antenna Method

Annex 7 CI 220 Transient Waveform Explanation

CI 220 transient immunity test consists of standard pulse described in **ISO 7637-2** and nonstandard pulse which includes the one generated by electromechanical switching of inductive load. These nonstandard transient pulses are not described in **ISO 7637-2**, however, they are included in a vehicle to generate common transient waveforms.
Nonstandard transient waveforms produced by this method are strongly affected by many factors including resistance or capacitive load commonly having the same circuit as inductive load (not limited to these factors). Continuous transient phenomena produced like this often lack repeatability compared to standard ISO test pulse, however, it was found by experience that this random movement can generate abnormality that had often been missed when only standard ISO repetitive pulse had been used.
In this Annex, information on CI 220 transient pulse characteristics described in this MES is provided. This information shall be considered during compartment initial design as well.

7-1 Test pulses A1, A2, C, E

Annex 7 Fig. 1 shows a simplified vehicle circuit consisted of an ignition switch used to operate or stop inductive load (e.g. power door lock). Lw shows series connection inductance between a battery and an ignition switch. Load inductance "L" is much larger than series connection inductance (usually 1 μH/m).



Annex 7 Fig. 1 Simplified Circuit of Transient Immunity

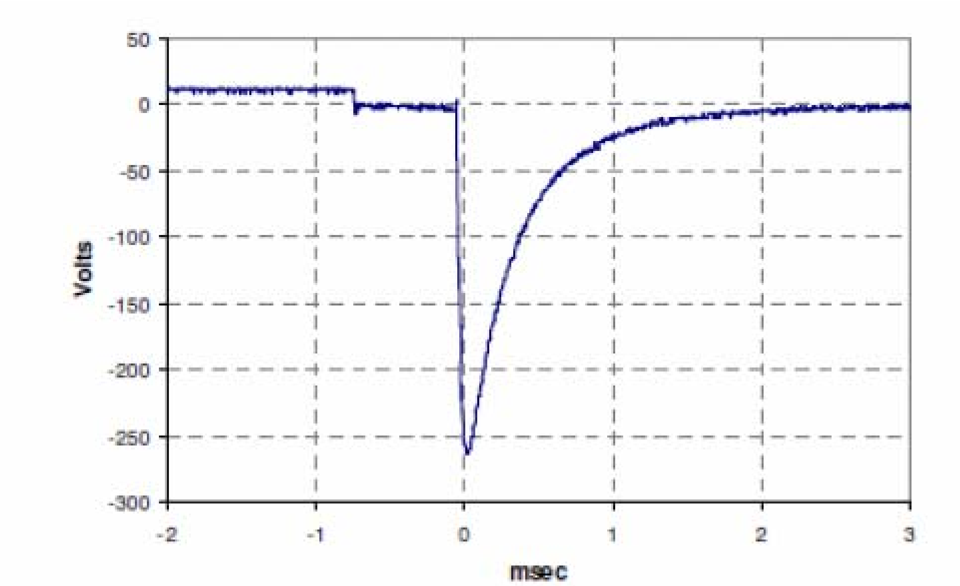
Test pulse A1 shows transient voltage generated during switching of high electric current (1 to 5 A) inductive load commonly having the same circuit as the test sample. "Z" shows impedance of other electrical load commonly having the same circuit as the test sample and its inductive load. The value "Z" (set at 220 Ω) simulates the circuit to which the minimum load is applied. **Annex 7 Fig. 2** shows pulse A1. Peak pulse voltage level changes between −250 V and −300 V.

Test pulse A2 shows transient voltage generated during switching of low electric current (< 1 A) inductive load commonly having the same circuit as the test sample.
The characteristics of pulse A2 can be changed remarkably due to impedance of other load commonly having the same circuit as the test sample. To consider this dependency, two individual conditions exist for A2 as follows:

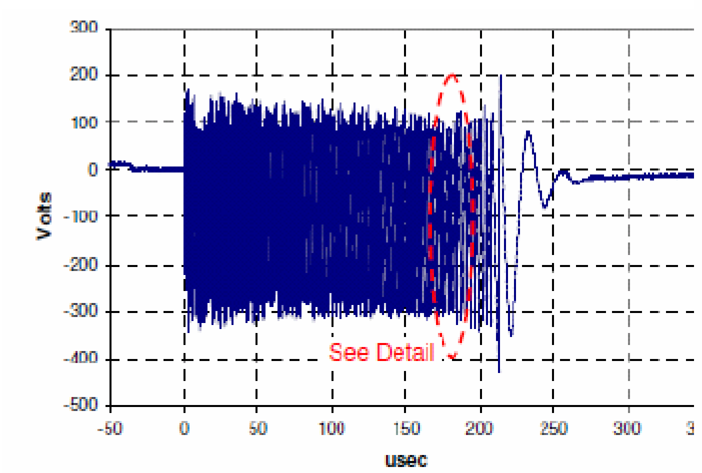
Pulse A2-1 occurs when a circuit consists of only a test sample and a switch inductive load.

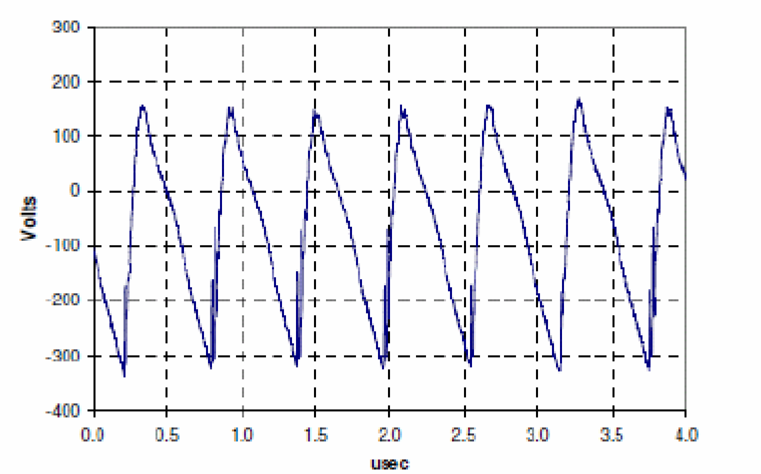
Pulse A2-2 occurs when a circuit contains a test sample and other electrical load commonly having the same circuit as a switch inductive load. Most of other electrical loads are capacitive (e.g. wiper motor filter condenser).

Annex 7 Fig. 3 and **Fig. 4** shows typical waveforms of pulse A2-1 and pulse A2-2. When the effect of an external circuit is not considered, transient (pulse A2-1) is mainly the result of contact arc discharge. The characteristic of this transient resides in high frequency repetitive pulse having peak positive voltage level between +100 V and +300 V and peak negative voltage level between −280 V and −500 V. Individual pulse duration changes (refer to **Annex 7 Fig. 3b**) between 100 ns and 1 μs. The characteristic shown in **Annex 7 Fig. 3** was measured when the contact point is open, however, similar transient may occur when the switch contact point bounces back under the contact point closed condition. The transient of A2-1 is also called “showering arc transient” in general. When the external circuit is mainly capacitive, the resulting transient (pulse A2-2) is remarkably different from pulse A2-1. When the switch contact point is open, damped sine transient (f_{res} to 2 kHz) occurs. When the switch contact point bounces back under the contact point closed condition, damped sine transient with higher frequency (f_{res} to 180 kHz) occurs. During this phase, corresponding electric current as large as approximately 30 Ap-p (refer to **Annex 7 Fig. 4c**) exists. When pulse A2-2 is measured with an oscilloscope, it is recommended that transient current be used for a trigger.



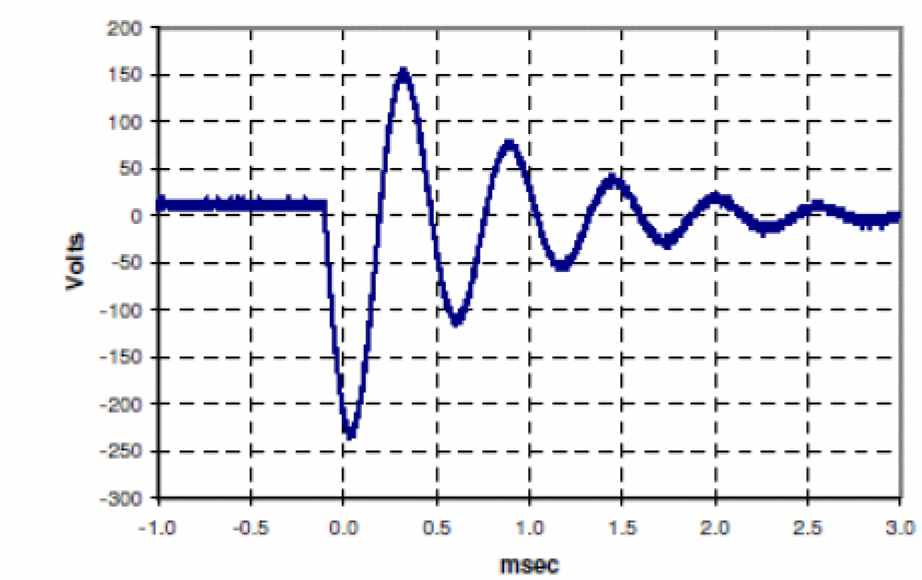
Annex 7 Fig. 2 CI 220 Pulse A1 Composite Waveform



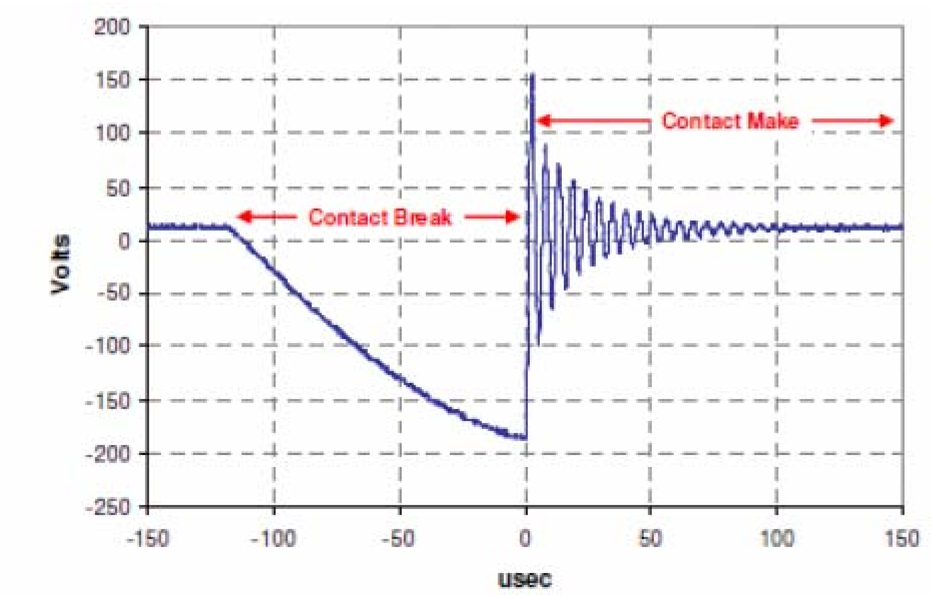


a) At the time of opening contact point and bounce **b) Details of the left figure**

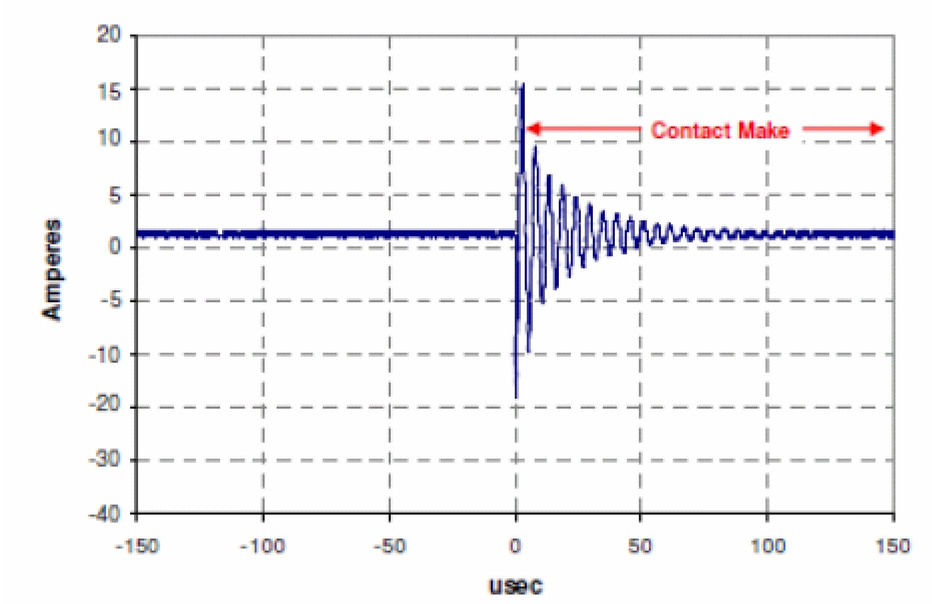
Annex 7 Fig. 3 CI 220 Pulse A2-1 Pulse Characteristics



a) At the time of opening contact point



b) Bouncing back of contact point (voltage)



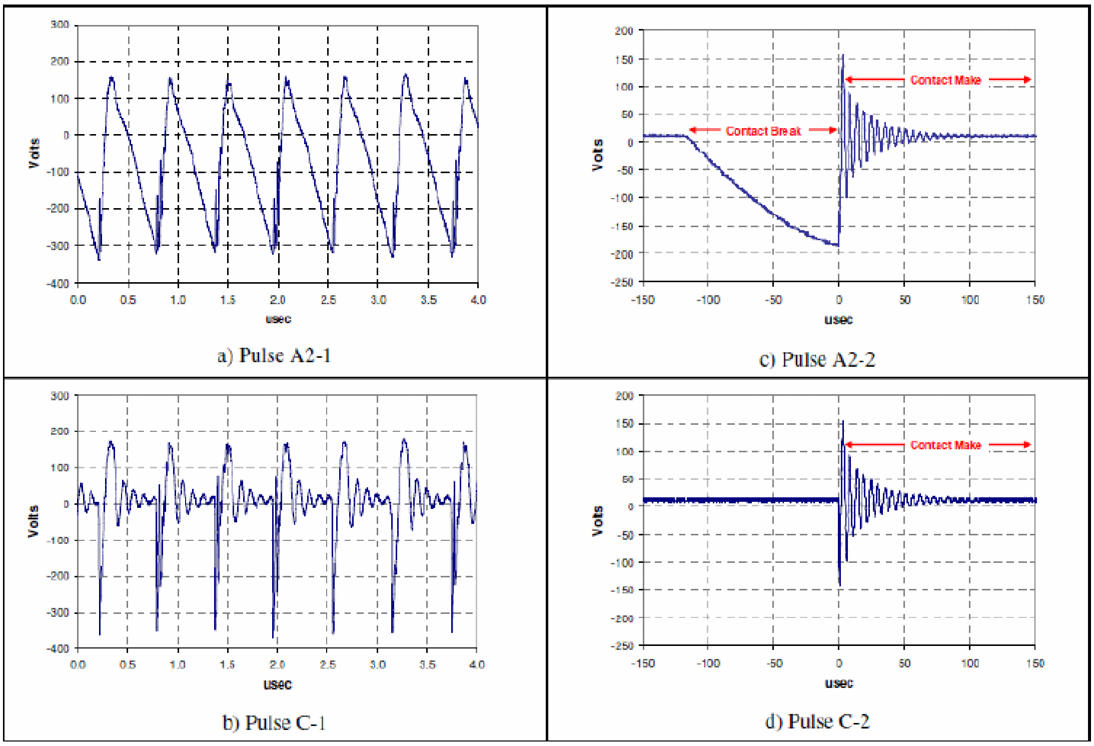
c) Bouncing back of contact point (current)

Annex 7 Fig. 4 CI 220 Pulse A2-2 Pulse Characteristics

Test pulse C shows transient voltage generated by switch contact arc discharge and contact point bounce during inductive load switching. Transient characteristic resides in a function of current occurred during direct connection inductance and arc discharge (with switch contact point open), or contact point bounce. Pulse C is directly related to pulse A2. To consider this dependency, two different conditions exist corresponding to each of pulses A2-1 and A2-2 (pulses C-1 and C-2).

Annex 7 Fig. 5b) shows characteristic of pulse C-1. Characteristic of this transient resides in damped sine wave pulse with high frequency (f_{res} to 10 MHz) whose peak positive and negative voltage levels are approximately ±150 V. Duration of sine wave transient pulse changes between 100 ns and 1 µs.

Annex 7 Fig. 5d) shows characteristic of pulse C-2. Characteristic of this transient resides in damped sine wave pulse with low frequency (f_{res} to 180 kHz) whose peak positive and negative voltage levels are approximately ±150 V. Duration of sine wave transient pulse is approximately 50 ns.

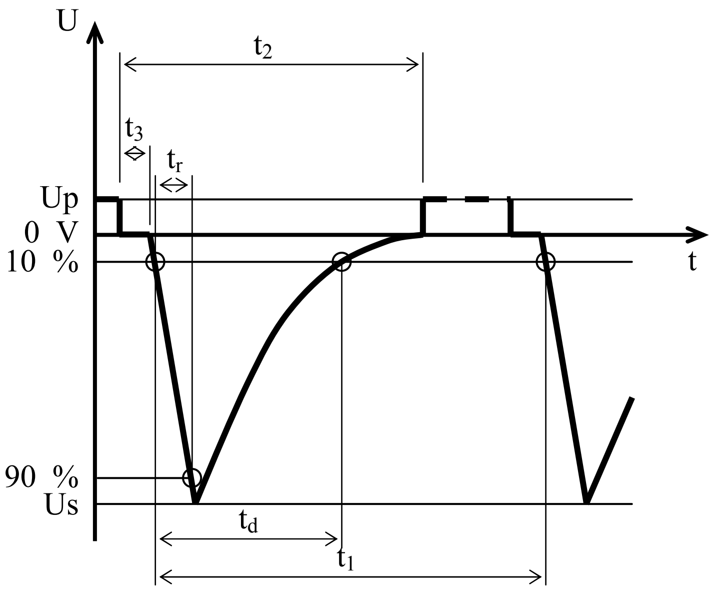


Annex 7 Fig. 5 CI 220 Pulse C Characteristics

Pulse E shows transient voltage generated during switching of high electric current (> 5 A) inductive load commonly having the same circuit as the test sample.
The test pulse is the same as test pulse 1 described in **ISO 7637-2**. Pulse E is similar to A1 except for the fact that high electric current load (> 5 A) occurs when the pulse has the same circuit as the inductive load. The pulse also occurs on a circuit having a high capacity load (> 2 μF). **Annex 7 Fig. 6** shows characteristic of pulse E.

7-2 Test pulses F1 and F2

Pulse F1 simulates cutoff of electric current that flows through inductance that is directly switched with the test sample. The test pulse is the same as test pulse 2a described in **ISO 7637-2**. Application of this test pulse is limited to components that requires to satisfy **ESA** requirements of power circuit and **ECE R10**.
Pulse F2 simulates cutoff of electric current that flows a brush motor whose low side is switched. The test pulse is the same as test pulse 2b described in **ISO 7637-2**.
Application of this test pulse is limited to components that requires to satisfy **ESA** requirements of power circuit and **ECE R10**.

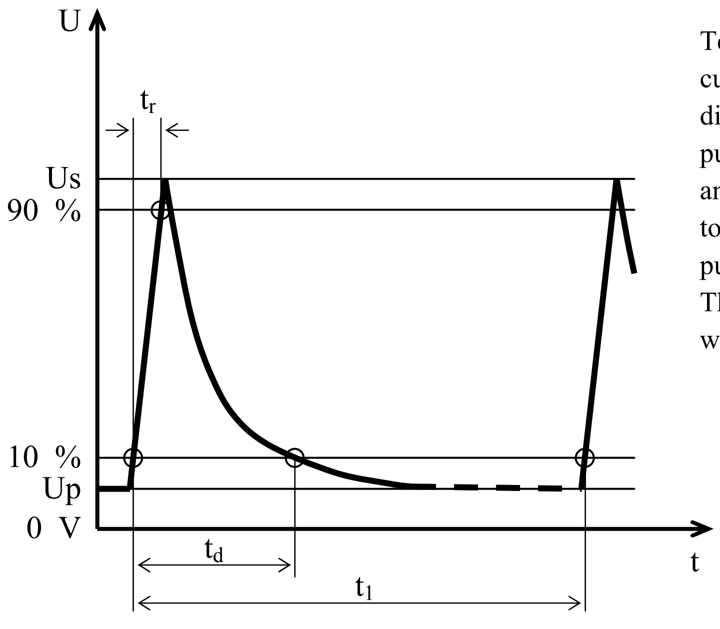


Test pulse E simulates switching-off of supply voltage to inductive load that is switched with test sample in parallel. This test pulse shall be applied only to switch type power circuit and control circuit. This is equal to test pulse 1 described in **ISO 7637-2**.
The waveform voltage shall start and finish with U_p.

Test Pulse E Parameter

U_p	13.5 V
U_s	−100 V [12 V system]
	−200 V [24 V system]
t_r	1 µs
t_d	2 ms
t_1	5 s
t_2	200 ms
t_3	≤ 100 µs
R_i	10 Ω

Annex 7 Fig. 6 Waveform of Test Pulse E

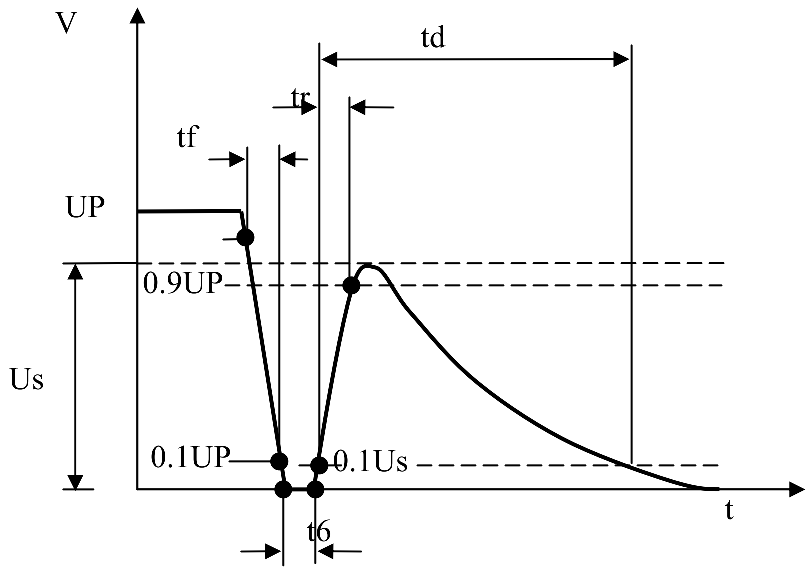


Test pulse F1 simulates cutoff of electric current that flows through inductance that is directly switched with test sample. This pulse shall be applied only to power supply and control circuit that are directly connected to battery. This is almost equal to test pulse 2a described in **ISO 7637-2**.
The waveform voltage shall start and finish with U_p.

Test Pulse F1 Parameter

U_p	13.5 V
U_s	37 V
t_r	1 µs
t_d	50 µs
t_1	200 to 500 ms
R_i	2 Ω

Annex 7 Fig. 7 Waveform of Test Pulse F1



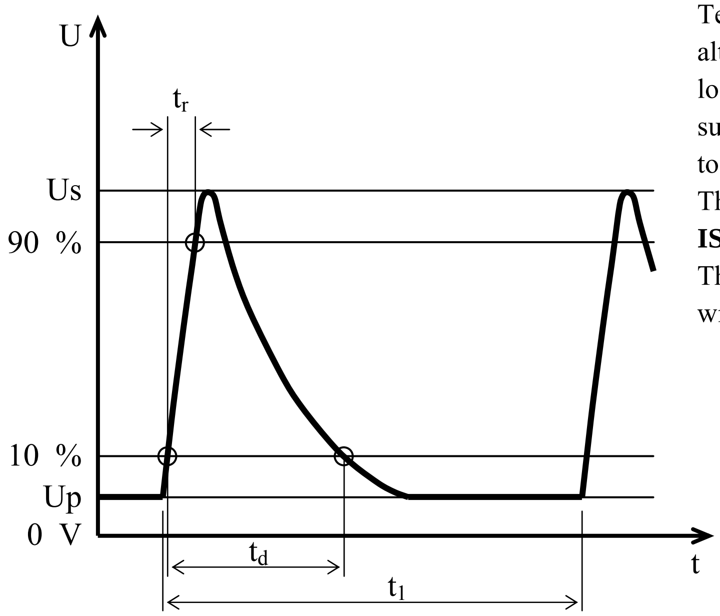
Test Pulse F2 Parameter

U_p	13.5 V
U_s	10 V
t_r	1 ± 0.5 ms
t_f	1 ± 0.5 ms
t_6	1 ± 0.5 ms
t_d	0.2 to 2 s
R_i	< 0.5 Ω

Annex 7 Fig. 8   Waveform of Test Pulse F2

7-3 Test pulses G1 and G2

Pulse G1 shows transient occurred from sudden separation of a battery from an alternator. The test pulse is the same as test pulse 5a described in **ISO 7637-2**.   **Annex 7 Fig. 9** shows characteristic of pulse G1.



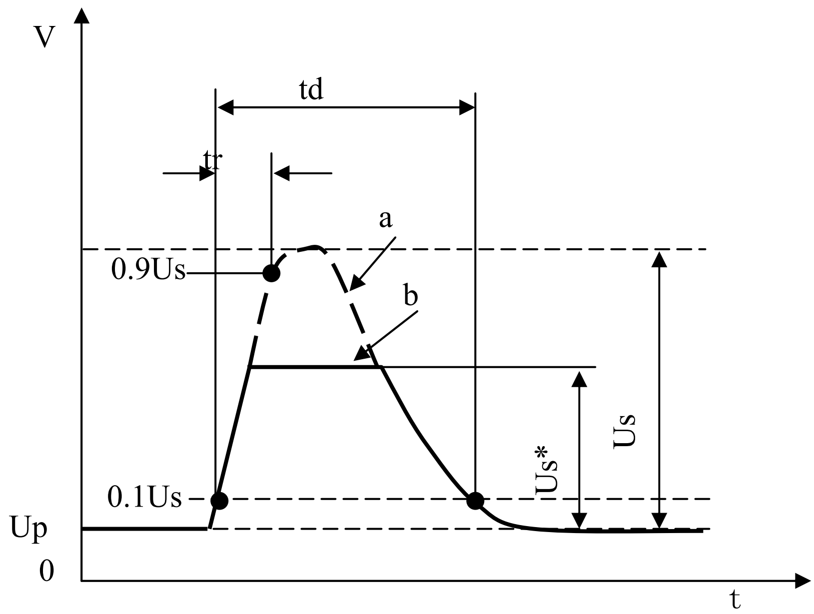
Test pulse G simulates transient occurred from alternator due to sudden cutting of electrical load. This pulse shall be applied to all power supplies and control circuits that are connected to battery with switch type or directly.
This is equal to test pulse 5 described in **ISO 7637-2**.
The waveform voltage shall start and finish with U_p.

Test Pulse G Parameter

U_p	13.5 V
U_s	73.5 V
t_r	10 ms
t_d	300 ms ± 20 %
t_1	30 s
R_i	0.5 Ω

Annex 7 Fig. 9 CI 220 Pulse G1 Characteristic

Pulse G2 shows voltage clamp transient occurred from sudden separation from an alternator with central load dump (CLD) protection from a battery. **Annex 7 Fig. 10** shows waveform of pulse G2. Parameters of each type are the same as those of **Annex 7 Fig. 9**.



a: Test waveform at calibration (without zener diode)
b: Test waveform (with zener diode)
Unless otherwise specified on Specification Drawing, Up + Us* = 35 V.

Annex 7 Fig. 10 CI 220 Pulse G2 Waveform

7-4 Transient application mode

Transient pulses A1, A2 and C are applied to the test sample smoothly by using three different operation modes.

Mode 1 shows the situation when a test pulse is applied at a constant repetition rate as shown in **Annex 7 Table 1**. Mode 1 is applied to pulses A1 and A2 only when they are applied to the switching power circuit of the test sample.

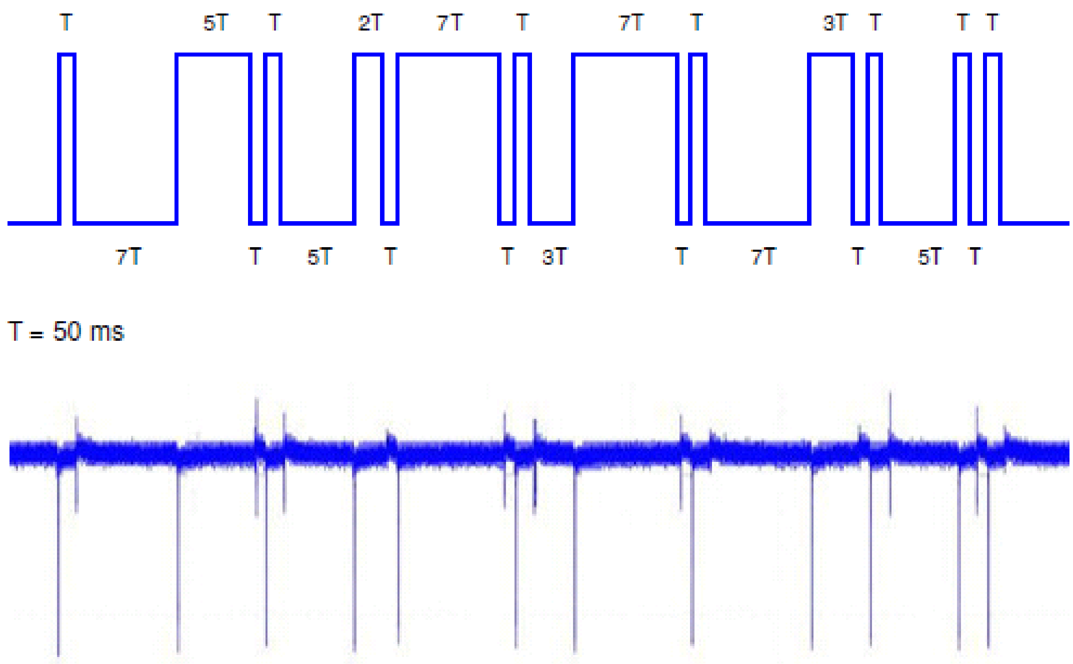
Annex 7 Table 1 CI 220 Mode 1 Character Transient Pulse

	Pulse Repetition Rate (PRR)	Duration
A1	0.2 Hz, 10 % Duty Cycle	120 s
A2-1		

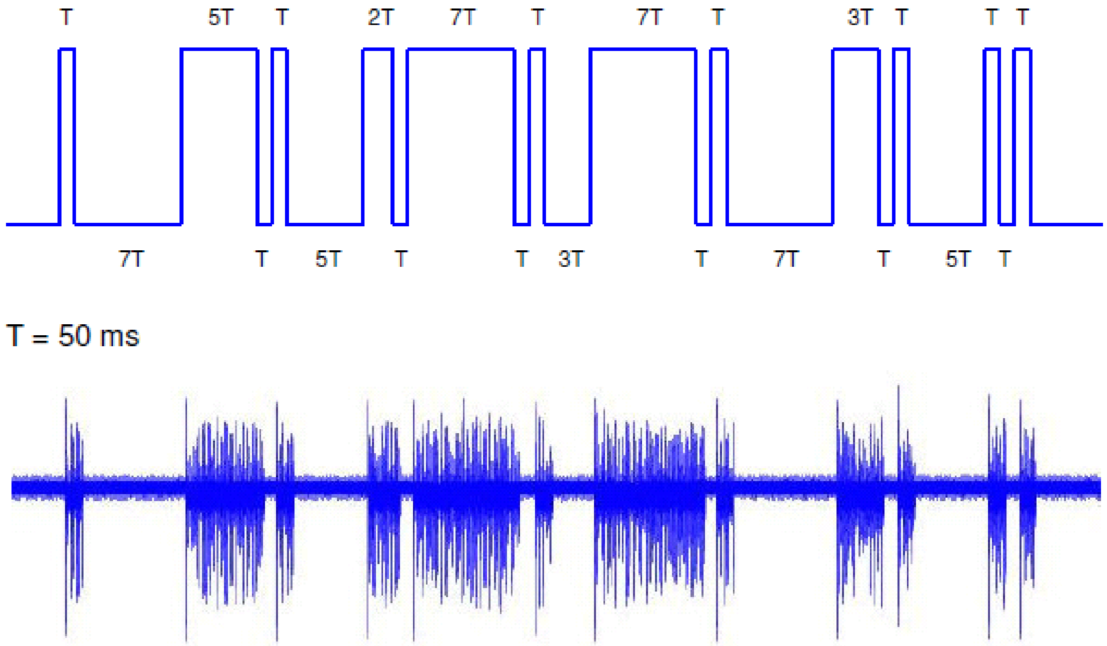
Mode 2 shows the situation when a test pulse is applied using the simulated random timing sequence shown in **Annex 7 Fig. 11**. Mode 2 is applied only with test pulse A1 when it is applied to test sample input. Time "T" is 50 ms.

Mode 3 shows the situation when a test pulse is applied using simulated random burst shown in **Annex 7 Fig. 12**. Timing sequence is the same as that of Mode 2. Mode 3 is used only with pulses A2-1, A2-2, C-1 and C-2. Burst time "T" is 50 ms.

Modes 2 and 3 are also used when a test is performed in accordance with RI 130. (Refer to **section 13**.) Modes 1, 2 and 3 are generated in a circuit of transient waveform generator specified in **Annex 8**.



Annex 7 Fig. 11 CI 220 Mode 2 Characteristic

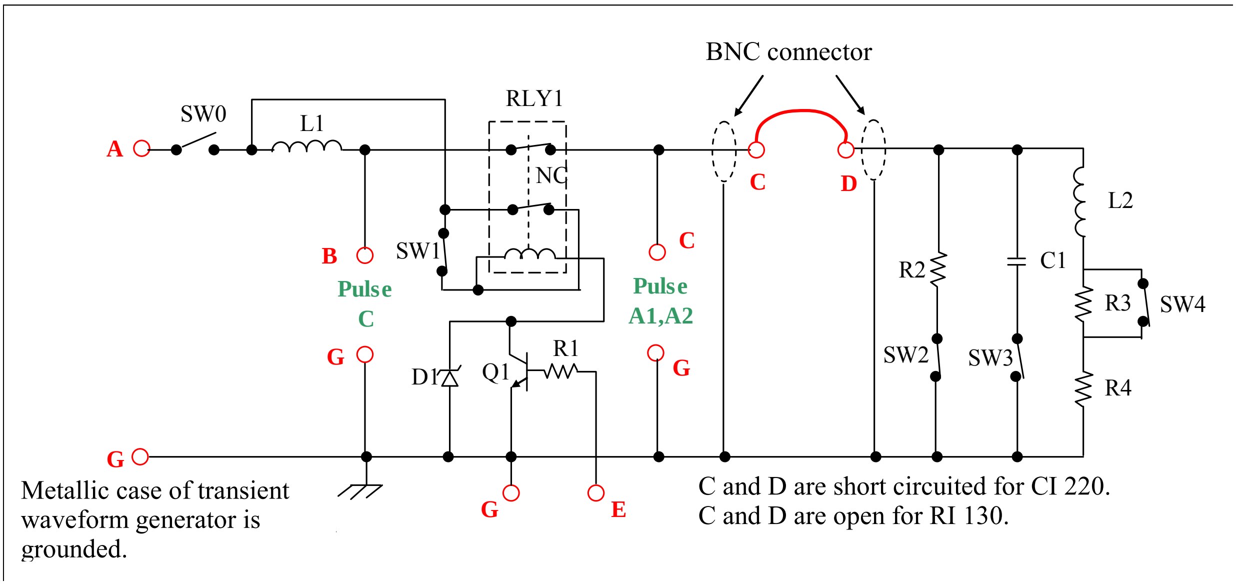


Annex 7 Fig. 12 CI 220 Mode 3 Characteristic

Annex 8   Transient Test Circuit

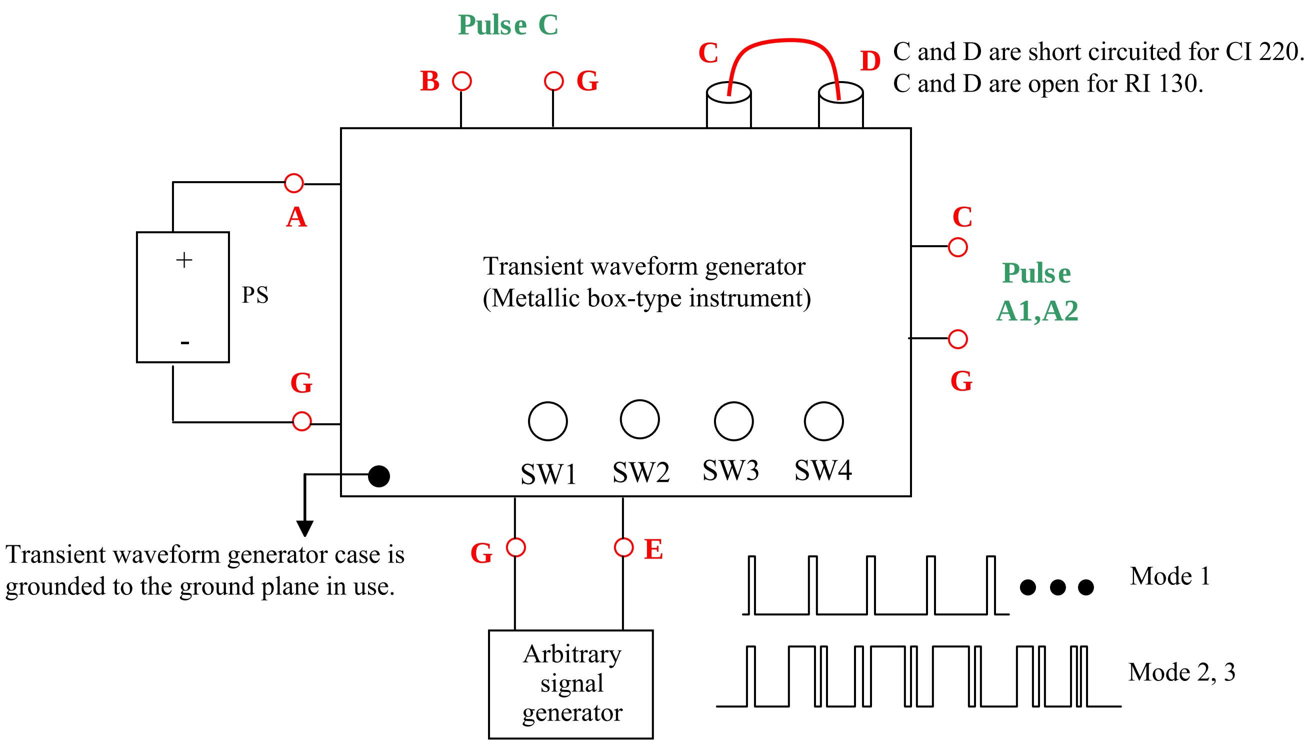
Test generator specified in this Annex generates transient used in the following tests:
- RI 130
- CI 220 pulses A1, A2 and C

Annex 8 Fig. 1 shows the circuit of a transient waveform generator that generates CI 220 transient pulses A1, A2 and C in modes 1, 2 and 3. The test pulse and operation mode can be selected by simple setting of the switches. **Annex 8 Table 1** summarizes configuration of these switches and related test pulses/operation modes.



R1: 51 Ω, 25 W
L2: 100 mH inductor
(Osborn Transformer Part Number 32416)*
R2: 220 Ω ± 5 %, 2 W
D1: Zener diode, 39 V, 5 W (IN5366A)
R3: 33 Ω ± 5 %, 10 W
Q1: NPN transistor (TIP41)
R4: 6 Ω ± 5 %, 50 W
SW0 to SW4: Single stage switch (10 contact rating)
C1: 100 nF ceramic condenser or polyester condenser (low ESR)
RLY1: 12 V AC relay** normally closed (NC) contact shall be used
(Potter & Brumfield KUP-14A15-12)*
L1: 5 μH Inductor (Osborn Transformer Part Number 8745)*
* Important component: Alternatives are not allowed unless an approval of Mazda is obtained.
** Refer to **Annex 8 Table 2** for specification of the relay.

Annex 8 Fig. 1   RI 130 and CI 220 Transient Waveform Generator Circuit



Annex 8 Fig. 2 Transient Waveform Generator (External Connection)

Annex 8 Table 1 Switch Setting of CI 220 Transient Waveform Generator

Pulse	Mode	SW1	SW2	SW3	SW4
A1	1, 2	Closed	Closed	Closed	Closed
A2-1	1	Closed	Open	Open	Open
A2-1, C-1	2	Closed	Open	Open	Open
A2-2, C-2	2	Closed	Open	Closed	Open
A2-1, C-1	3	Open	Open	Open	Open
A2-2, C-2	3	Open	Open	Closed	Open

*Refer to **Annex 7** for explanation of mode operation conditions.

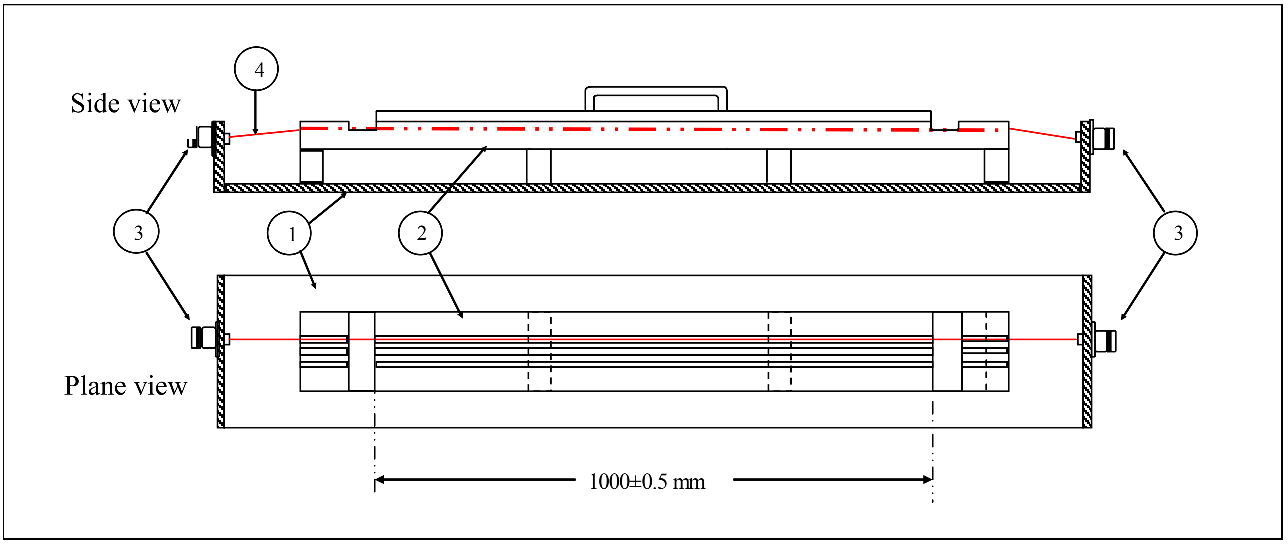
Potter & Brumfield (P&B) relay is used for some tests in this MES. **Annex 8 Table 2** shows the specifications of this relay. Empirically, almost all 12AC relays which follow this specification can be used for this test. Voltage shall be measured before using of an alternative relay and it shall be compared to the waveform described in **Annex 6**.
A review and an approval of Mazda shall be obtained for these measurement results prior to the use of an alternative relay.
When these relays are used for this MES, it is recommended that the relay be exchanged after the use for 100 h.

Annex 8 Table 2 P&B Relay Specifications

Contact Arrangement:	3 Form C, 3PDT, 3 C/O
Contact Current Rating (Amps.):	10
Coil Magnetic System:	Monostable
Coil Selection Criteria:	Nominal Voltage
Actuating System:	AC
Input Voltage (VAC):	12
Coil Suppression Diode:	Without
Coil Resistance (Ω)	18
Coil Power, Nominal (VA):	2.70
Mounting Options:	Plain Case
Termination Type:	.187 x .020 Quick Connect Terminals
Enclosure:	Enclosed
Contact Material:	Silver Cadmium Oxide
Approved Standards:	UL Recognized, CSA Certified

Annex 9 RI 130, RI 150 Testing Apparatus and Application

Annex 9 Fig. 1 shows testing apparatus to be used for RI 130 and RI 150. This apparatus consists of a wire support apparatus mounted on an aluminum board. The wire support apparatus consists of Delrin 570 NC000.

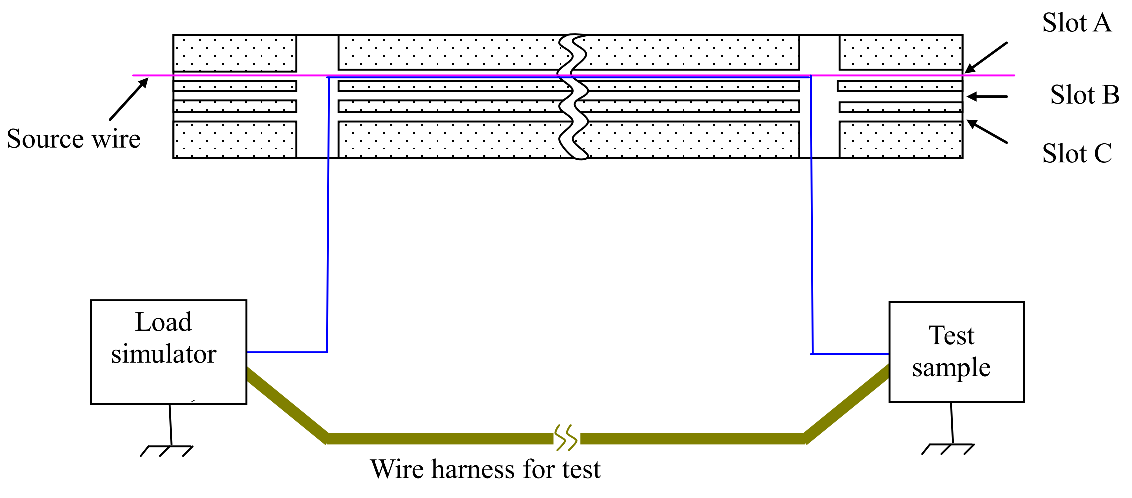


Plane view without lid

1	Aluminum board	2	Type N connector
2	Wire support (Delrin 570 NC000)	4	14 AWG copper wire

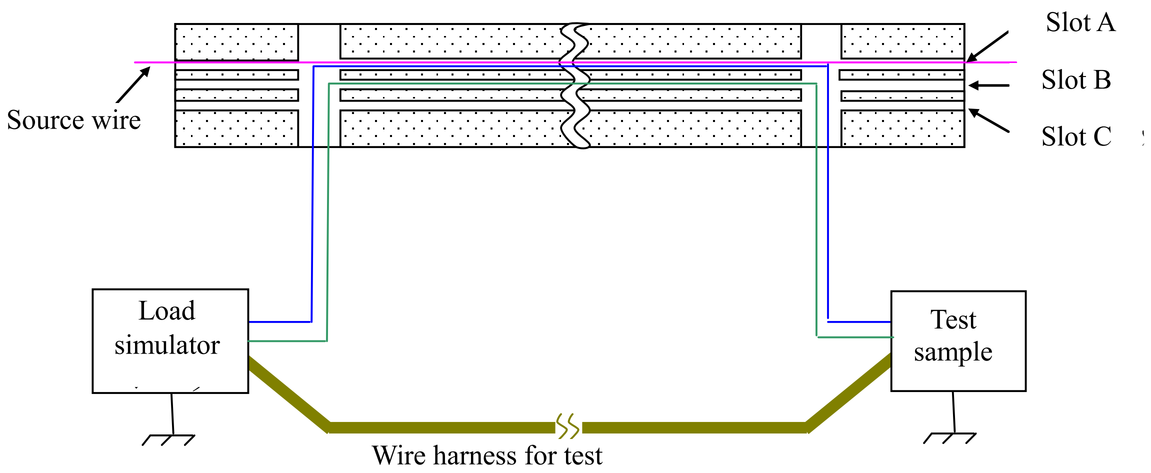
Annex 9 Fig. 1 RI 130/150 Testing Apparatus (Plane View)

This apparatus includes a copper wire ("source wire") connected to a signal source which generates interference of RI 130/RI 150. A test of the test sample is performed by setting individual wires on the slot right above the source wire (slot A) as shown in **Annex 9 Fig. 2**.



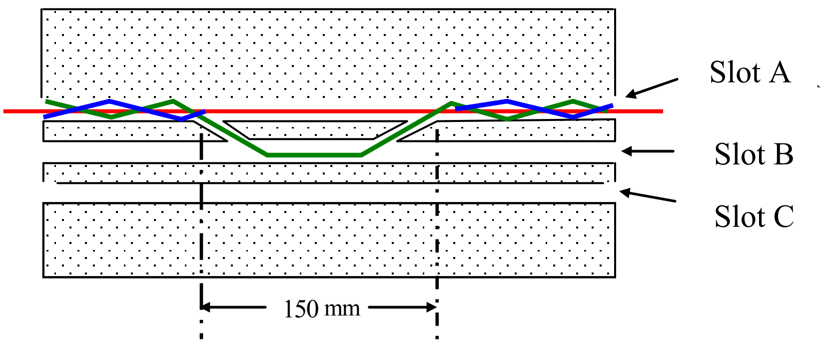
Annex 9 Fig. 2 RI 130/150 Test Setup (Position of Default Test Sample Wire)

When the test sample includes a circuit load having exclusive signal return that goes back to the test sample (signal return that is not shared with other circuit loads), each of the mating wire shall be placed in the separated slot (slot A and slot B) set in the testing apparatus as shown in **Annex 9 Fig. 3**. Exclusive signal return shall always be set in slot B unless otherwise specified in the EMC Test Plan.



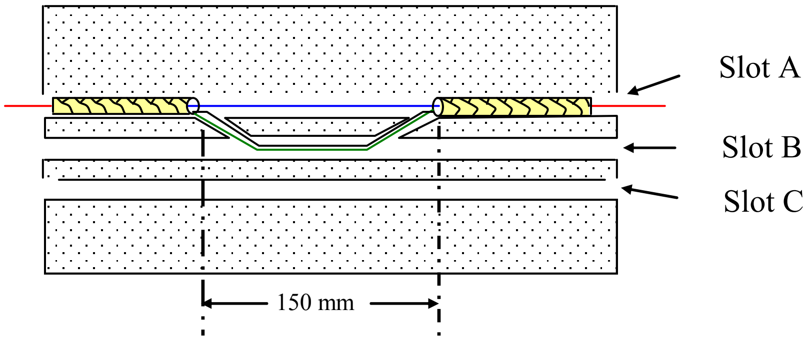
Annex 9 Fig. 3　RI 130/150 Test Setup (Test Sample with Exclusive Return Wire)

When the test sample has twisted pair cables, each twisted pair cable shall be set in slot A as shown in **Annex 9 Fig. 4**. However, lay of the cable shall be untwisted by 150 mm. This is facilitated by using the central portion of the testing apparatus. Use of the connector or the in-line connector of the apparatus is simulated by including this untwisted and unshielded portion.



Annex 9 Fig. 4　RI 130/150 Test Setup (Positioning of Twisted Pair Cable)

When the test sample includes a shield wire (except for RF antenna cable), each of the mating shielded wire shall be set in slot A as shown in **Annex 9 Fig. 5**. However, the circuit shield shall be taken by 150 mm. This is facilitated by using the central portion of the testing apparatus. The setup is similar to the one that is used for a twisted pair cable.



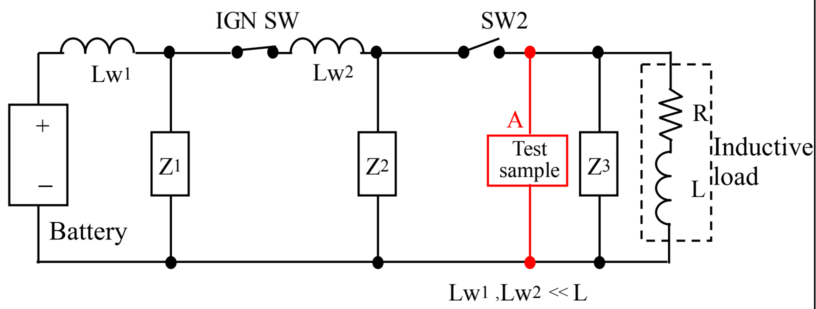
Annex 9 Fig. 5 RI 130/150 Test Setup (Positioning of Shielded Twisted Pair Cable)

Annex 10 Transient Waveform

Application of test pulses A, C, E and G greatly depend on connection method of test sample to power supply. This Annex provides basic information on application of each transient test pulse. The figure shows the typical configuration including an external electronic load "Z" that is connected at various points on the ignition switch, remote switch (SW2), inductive load, test sample and the electric power distribution system. To apply transient pulse appropriately, how actual component (test sample) is used shall be analyzed. Actual configuration of the apparatus is often a combination of illustrated general configurations. Pulses F1 and F2 shall be applied only to the power circuit of components that verification of conformity to ESA requirements described in **ECE No. 10** is needed.

Configuration 1

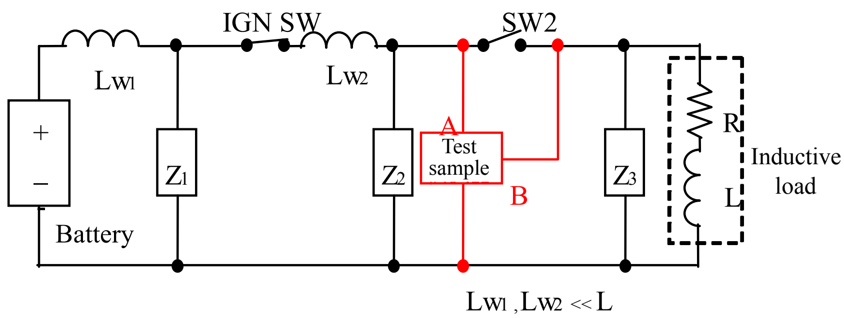
The power circuit "A" of a test sample shares the same circuit as an inductive load (e.g. window lift motor). The test sample and inductive load can be switched via. SW2. When IGN SW is kept closed and SW2 is kept open, transient pulses A1, A2 and E exist in "A". When IGN SW and SW2 are closed, pulses C and G (load dump) exist in "A".



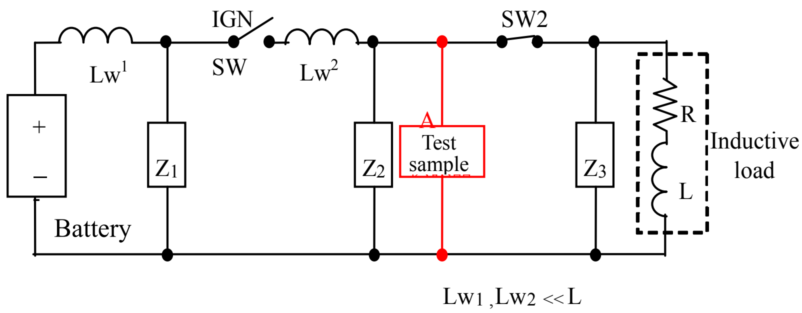
Pulse application
Transient pulses A1, A2-1, A2-2, C1, C2, E, G1 and G2 shall be applied to power circuit "A" of the test sample.

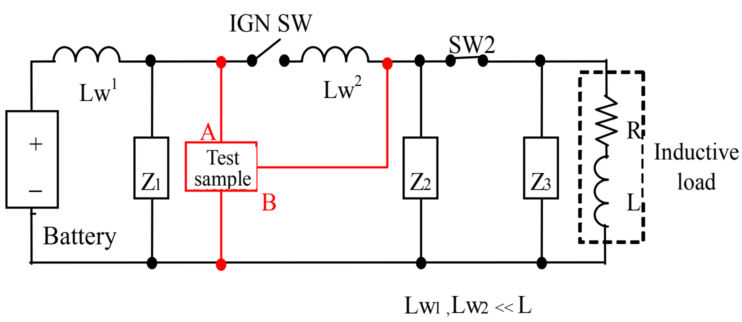
Configuration 2

The power circuit "A" of the test sample keeps the power supply "ON" even if SW of inductive load is OFF by SW2. The test sample has input circuit "B" that is connected to the circuit including inductive load. When SW2 is open, transient pulses A1, A2 and E exist in "B". When IGN SW is kept closed and SW2 is open or bounces back, pulse C exists in "A". When IGN SW and SW2 are closed, pulses C and G (load dump) exist in "A".



Pulse application
Transient pulses C1, C2, G1 and G2 shall be applied to power circuit "A" of the test sample.
Transient pulses A1, A2-1, A2-2 and E shall be applied to input "B" of the test sample.

Configuration 3 When SW is closed, the power circuit "A" of the test sample shares the same circuit as an inductive load. The test sample and inductive load can be switched via. IGN SW or relay. When SW2 is kept closed and IGN SW is open, transient pulses A1, A2 and E exist in "A". When IGN SW is kept closed and SW2 is open or bounces back, transient pulses C exists in "A". When IGN SW is closed, pulses C and G (load dump) exist in "A".	
	Pulse application Transient pulses A1, A2-1, A2-2, C1, C2, E, G1 and G2 shall be applied to power circuit "A" of the test sample.

Configuration 4 The power circuit "A" of the test sample is directly connected to the battery. The test sample has the second power circuit "B" that is connected to a circuit that is switched by input or IG. When SW2 is closed and IGN SW is open or bounces back, transient pulse C exists in "A". When SW2 is closed and IGN SW is open, transient pulses A1, A2 and E exist in "B". When IGN SW is closed and SW2 is open or bounces back, pulse C exists in "B". When IGN SW is closed, pulses C and G (load dump) exist in "A" and "B".	
	Pulse application Transient pulses A1, A2-1, A2-2, C1, C2 and E shall be applied to "A" and "B" separately. Transient pulses C1, C2, G1 and G2 shall be applied to "A" and "B" simultaneously.

Annex 11 Decision Method of CE 421 Correction Coefficient

Voltage measurement similar to requirements of CE 420 is needed for CE 421, however, it shall be done at a frequency band lower than that specified in **CISPR 25**. Application of correction coefficient (CF) is needed to make this measurement. This correction coefficient can be a factor of insertion loss between a test sample and a measurement port of an artificial network, however, it is not the same as the insertion loss (e.g. S21) which is usually announced from a manufacturer of the artificial network.

Annex 11 Fig. 1 shows CE 421 test setup by which standard **CISPR 25** artificial network is used. In 100 kHz, impedance seen in test sample connection of the artificial network is approximately 3 Ω. The loss occurred from impedance mismatch at the test sample connection port is approximately 20 dB. The same loss is seen at the measurement port and it is the insertion loss announced from the manufacturer of the artificial network (e.g. S21). Impedance of the artificial network becomes proportionally lower at a frequency under 100 kHz (Impedance converges on DC resistance of 5 μH inductor), resulting in increment of mismatch loss. However, the loss at the measurement port becomes larger than the one seen in the test sample connection due to the loss which is increased through series capacitance at a low frequency. Correction coefficient (CF) shows this loss at frequencies from 10 kHz to 150 kHz.

Correction coefficient can be determined by the following steps:

Step 1 (Refer to **Annex 11 Fig. 2**.):

- **a)** Power supply connection ports A and B shall be short circuited by using a copper braided strap 25 mm in width.
- **b)** 50 Ω terminating resistance shall be connected through ports C and B.
- **c)** Ports P and B shall be connected to the output of a 50 Ω signal generator and the input of 50 Ω measurement receiver. A coaxial cable shall be used for this connection. The length of the cable shall be 1,000 mm and less.
- **d)** The frequency step of **Table 31** shall be used and the signal level through frequency bands from 10 kHz to 150 kHz (Pout (dBm)) shall be measured.

Step 2 (Refer to **Annex 11 Fig. 3**.):

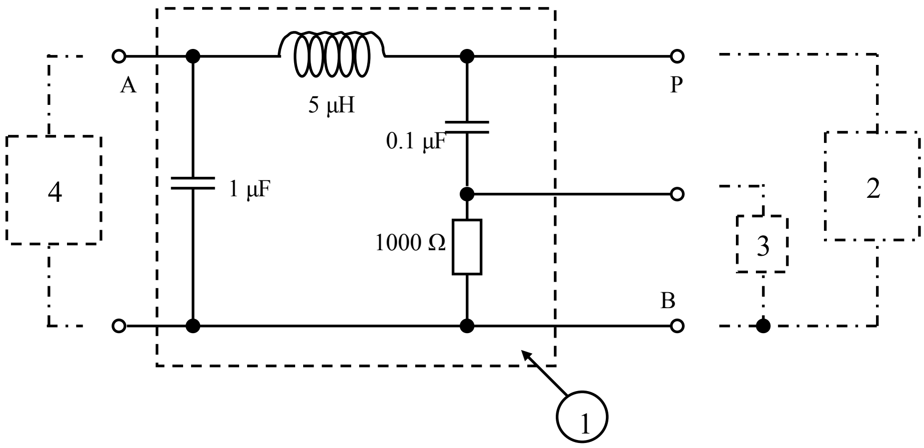
- **a)** 50 Ω termination shall be disconnected from ports C and B, and it shall be connected to ports P and B.
- **b)** The measurement receiver shall be disconnected from ports P and B, and it shall be connected to ports C and B.
- **c)** The signal level (Pin (dBm)) shall be measured through frequency bands from 10 kHz to 150 kHz, which is the same as the ones used for measurement of Pout in step 1.

Step 3:

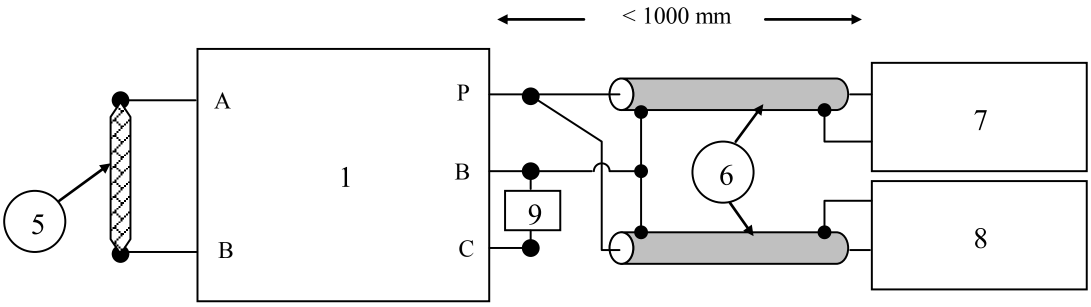
The measurement data obtained from steps 1 and 2 shall be used and correction coefficient (CF) for each frequency shall be determined. (Refer to **Table 9-1**.)

CF (dB) = Pout (dBm) − Pin (dBm)

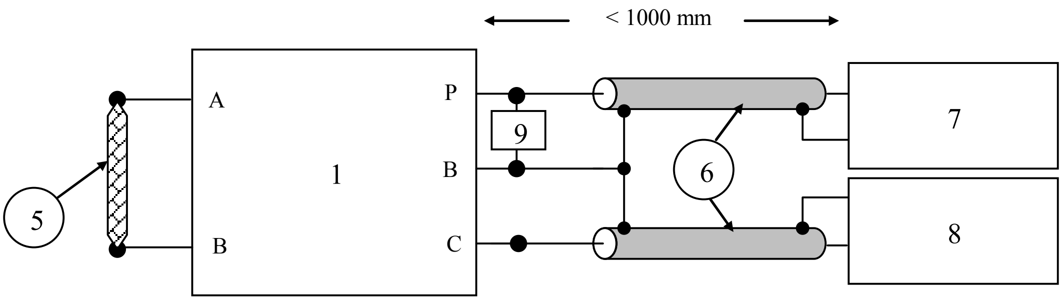
Only (CF) value shall be applied when test of CE 421 is performed. At that time, comprehensive insertion loss of the artificial network announced by the manufacturer shall not be used.



Annex 11 Fig. 1 CE 421 Test Setup with Standard CISPR 25 Artificial Network



Annex 11 Fig. 2 CE 421 Test Setup for Pout Measurement



Annex 11 Fig. 3 CE 421 Test Setup for Pin Measurement

1 Artificial network (conform to **CISPR 25**.)
2 Test sample
3 Measurement receiver
4 Power supply
5 Braided ground strap (> 25 mm in width)
6 50 Ω coaxial cable (RG 58 or equivalent)
7 50 Ω signal generator
8 50 Ω measurement receiver
9 50 Ω termination

*Questions concerning Japanese Industrial Standards (JIS) may be addressed at any of the following:

AUSTRALIA (SAA)
Standards Australia
PO Box 5420
Sydney NSW 2001

AUSTRIA (ON)
Osterreichisches Normungsinstitut
Heinestrasse 38
1020 Vienna

CANADA (SCC)
Standards Council of Canada
270 Albert Street, Suite 200
Ottawa ON, K1P 6N7

FRANCE (AFNOR)
Association française de normalisation
11, avenue Francis de Pressensé
FR-93571 Saint-Denis La Plaine Cedex

GERMANY (DIN)
DIN Deutsches Institut für Normung
Burggrafenstrasse 6
DE-10787 Berlin

ITALY (UNI)
Ente Nazionale Italiano di Unificazione
Via Battistotti Sassi 11/b
1-20133 Milano

KOREA, Rep. of (KSA)
Korean Standards Association
13-31, Yoido-dong, Youngdungpo-gu
Seoul 150-010

NEW ZEALAND (SANZ)
Standards Association of New Zealand
155 The Terrace
Private Bag 2439
Wellington

SWITZERLAND (SNV)
Swiss Association for Standardization
Bürglistr. 29
8400 Winterthur

UNITED KINGDOM (BSI)
British Standards Institution
389 Chiswick High Road
GB-London W4 4AL

USA (ANSI)
American National Standards Institute
25 West 43rd Street , Fourth Floor
US-New York N.Y. 10036

*Questions concerning Japanese Automobile Standards (JASO) may be addressed at the following:

Society of Automotive Engineers of Japan, Inc.
10-2, Goban-cho, Chiyoda-ku
Tokyo 102-0076
Japan