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Function Performance Status Classification for EMC Immunity Testing

RATIONALE

The document is revised to demonstrate the concept with a "single class" functional status with application of multiple categories of functions. Changes were also made to the terminology and examples to harmonize with the similar concept in SAE J1113-1, ISO 7637-1, ISO 11451-1, ISO 11452-1 and ISO 16750. Appendix B-2 was revised to align the severity levels with the latest version of the corresponding Parts of SAE J1113.

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1. SCOPE

This SAE Standard provides a general method for defining the acceptable function performance status classification for the functions of automotive electronic devices upon application of the test conditions specified as described in appropriate EMC immunity test standards (for example, SAE J1113 and SAE J551). Testing of devices could be performed either on or off vehicles. Appropriate test signal and methods, Function Performance status, and test signal severity level would have to be specified in the individual cases.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J551-1 Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)

SAE J551-11 Vehicle Electromagnetic Immunity - Off-Vehicle Source

SAE J551-12 Vehicle Electromagnetic Immunity - On-Board Transmitter Simulation

SAE J551-13 Vehicle Electromagnetic Immunity - Bulk Current Injection

SAE J551-15 Vehicle Electromagnetic Immunity - Electrostatic Discharge (ESD)

SAE J551-17 Vehicle Electromagnetic Immunity - Power Line Magnetic Fields

SAE J1113-1 Electromagnetic Compatibility Measurement Procedures and Limits for Components of Vehicles, Boats (up to 15 m), and Machines (Except Aircraft) (16.6 Hz to 18 GHz)

SAE J1113-2 Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft) - Conducted Immunity, 15 Hz to 250 kHz - All Leads

SAE J1113-3 Conducted Immunity, 250 kHz to 400 MHz, Direct Injection of Radio Frequency (RF) Power

SAE J1113-4 Immunity to Radiated Electromagnetic Fields - Bulk Current Injection (BCI) Method

SAE J1113-11 Immunity to Conducted Transients on Power Leads

SAE J1113-12 Electrical Interference by Conduction and Coupling - Capacitive and Inductive Coupling via Lines Other than Supply Lines

SAE J1113-13 Electromagnetic Compatibility Measurement Procedure for Vehicle Components - Part 13: Immunity to Electrostatic Discharge

SAE J1113-21 Electromagnetic Compatibility Measurement Procedure for Vehicle Components - Part 21: Immunity to Electromagnetic Fields, 30 MHz to 18 GHz, Absorber-Lined Chamber

SAE J1113-22 Electromagnetic Compatibility Measurement Procedure for Vehicle Components - Part 22 - Immunity to Radiated Magnetic Fields

SAE J1113-24 Immunity to Radiated Electromagnetic Fields; 10 kHz to 200 MHz - Crawford TEM Cell and 10 kHz to 5 GHz - Wideband TEM Cell

SAE J1113-26 Electromagnetic Compatibility Measurement Procedure for Vehicle Components - Immunity to AC Power Line Electric Fields

SAE J1113-27 Electromagnetic Compatibility Measurements Procedure for Vehicle Components - Part 27 - Immunity to Radiated Electromagnetic Fields - Mode Stir Reverberation Method

3. DEFINITIONS

See SAE J1113-1 or SAE J551-1.

4. MEASUREMENT PHILOSOPHY

Electrical and radio frequency interference occurs during the normal operation of many items of motor vehicle equipment and when the vehicle is subjected to electromagnetic noises from the outside environment. It is generated over a wide frequency range with various electrical characteristics and may be distributed to on-board electronic devices and systems by conduction and/or radiation.

During recent years, an increasing number of electronic devices have been introduced into vehicle designs in order to perform, control, monitor and display various functions including the engine management system. It has been necessary therefore, to consider the electrical and electromagnetic environment in which these devices are required to operate. Interference can be generated in the vehicle electrical system itself by the normal operation of various power devices such as power window, power lock, air conditioning, etc. This interference can cause a temporary malfunction or even permanent damage to the electronic equipment. Significant numbers of performance deviations, resulting from this interference, have been reported.

Narrow band and broad band signals generated from sources inside or outside the vehicle could also be coupled into the electrical/electronic system, affecting the normal performance of electronic devices. These sources of electromagnetic disturbance are, for example, vehicle's ignition system, mobile telephones, broadcast transmitters, etc. Protection from this potential interference has to be considered in a total system validation.

The FPSC approach is based on the following principles:

1. Functional performance status classification is applicable to each individual function. Hence, a vehicle will have many functions and a DUT will likely include several functions (e.g., an electronic unit can manage front wiping, courtesy lighting and low beam lighting)

2. A function can be a simple On-Off operation or be complex as data communication on a data bus.

It has to be emphasized that components or systems shall only be tested under the conditions, as described in SAE EMC test standards that represent the simulated automotive electromagnetic environments to which the devices would actually be subjected. This will help to ensure a technically and economically optimized design for potentially susceptible components and systems.

It should also be noted that this document is not intended to be a product specification and cannot function as one. It should be used in conjunction with a specific test procedure in applicable EMC immunity testing standards such as SAE J1113 and SAE J551 series of documents. Therefore, no specific values for the test signal severity level are included in this document since they should be determined by the vehicle manufacturers and component suppliers. Nevertheless, using the concepts described in this document and by careful application and agreement between manufacturer and supplier, this document can be used to describe the functional status requirements for a specific device. This can then, in fact, be a statement of how a particular device can be expected to perform under the influence of the specified test signals.

This method is based on the following considerations:

1. A DUT/vehicle can include one or several functions (e.g., an electronic unit can manage front wiping, courtesy lighting and low beam lighting)

2. A function can have one or several operating modes (e.g., low beam ON, low beam OFF, courtesy lighting ON, courtesy lighting OFF).

3. An operating mode can have several Performance Status (I, II, III, IV) (e.g., in low beam ON operating mode , the Status II can be associated to low beam OFF during disturbance application with automatic recovery of low beam after disturbance suppression)

The function performance status classification is applicable to each function.

Examples for the application of how the concept of function performance status classification could be applied to the conducted and radiated immunity testing are included in this document (See Appendix A and B).

5. ESSENTIAL ELEMENTS OF FUNCTION PERFORMANCE STATUS CLASSIFICATION (FPSC)

Three elements are required to describe a function performance status classification. They can be generically applied to all immunity testing for electromagnetic disturbances (both conducted and radiated). These elements are listed below. The application of these essential elements is illustrated in Appendix A and B.

5.1 Test Signal and Test Method

This element defines the test signals applied to the device under test and the test method used. They are usually referred to in specific test procedures. The test procedures used and methods of application are to be described in specific standards.

5.2 Function Performance Status

This element defines the expected performance objectives for the function of the device under test subjected to the test conditions. The four Function Performance status (s) of the function (expected behavior of the function observed during test) are listed below:

NOTE 1: This element is individually applicable to every single individual function of a DUT and describes the operational status of the defined function during and after a test.

NOTE 2: The minimum function performance status shall be given in each test. An additional test requirement may be agreed between supplier and vehicle manufacturer.

5.2.1 Status I

The function performs as designed during and after the test.

5.2.2 Status II

The function does not perform as designed during the test but returns automatically to normal operation after the test.

5.2.3 Status III

The function does not perform as designed during the test and does not return to normal operation without a simple driver/passenger intervention such as turning off/on the DUT or cycling the ignition switch after the disturbance is removed.

5.2.4 Status IV

The function does not perform as designed during and after the test and cannot be returned to proper operation without more extensive intervention such as disconnecting and reconnecting the battery or power feed. The function shall not have sustained any permanent damage as a result of the testing.

5.3 Test Signal Severity Level

This element defines the specification of test signal severity level (test severity level) of essential signal parameters. The test signal severity level is the stress level applied to the device under test for any given test method. The test signal severity levels should be determined by the vehicle manufacturer and supplier depending on the required operational characteristics of the function.

The severity levels could be separated into number of categories. The number of categories as well as the severity levels associated with each of the categories are to be determined by the vehicle manufacturer (examples for how the test signal severity level could be applied are included in the Appendices A and B).

6. NOTES

6.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE ELECTROMAGNETIC COMPATIBILITY (EMC) STANDARDS COMMITTEE

APPENDIX A - ILLUSTRATION OF FUNCTION PERFORMANCE STATUS CLASSIFICATION

A.1 APPLICATION OF FUNCTION PERFORMANCE STATUS AND TEST SIGNAL SEVERITY LEVEL

This illustration demonstrates the relationship between the test signal severity levels (Severity Levels) and their corresponding Function performance status (Status). In other words, based on the table listed below:

The function must exhibit: **Status I** performance up the severity level L_{1i}, **Status II** (status I allowed) performance up to severity level L_{2i}, etc.

In the test severity levels, the numerical index (1, 2, 3, 4) denotes the function performance status (I, II, III, IV) and the index i denotes the category (1, 2, 3).

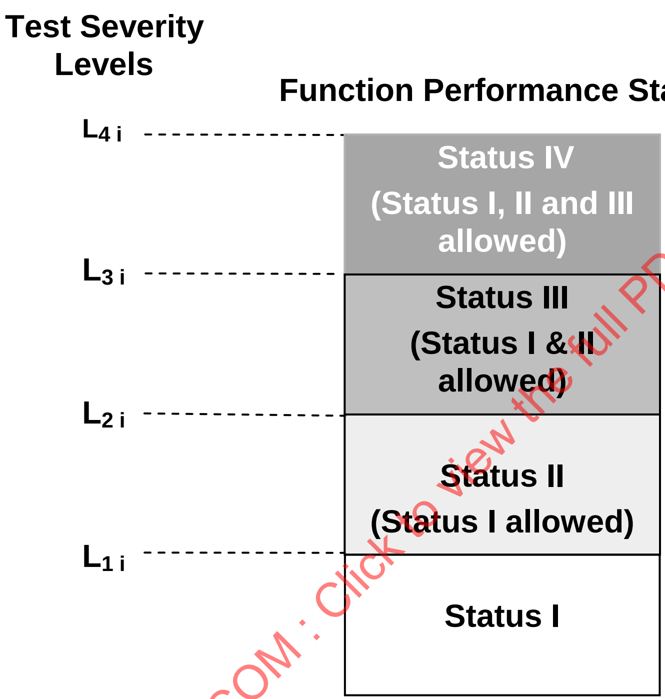

FIGURE A1 - ILLUSTRATION OF FUNCTION PERFORMANCE STATUS CLASSIFICATION

APPENDIX B - APPLICATION OF FUNCTION PERFORMANCE STATUS CLASSIFICATION

B.1 APPLICATION OF FUNCTION PERFORMANCE STATUS CLASSIFICATION WITH MULTIPLE CATEGORIES

In certain applications, the function performance status classification is required to be expressed in multiple categories (such as critical nature of the function as related to the operation of the vehicle or frequency bands of the test signals etc.).

This example illustrates the concept of how the function can be expressed for 3 different Categories (Table B1).

NOTE: In the test severity levels, the numerical index (1, 2, 3, 4) denotes the function performance status (I, II, III, IV) and the index i denotes the category (1, 2 & 3). For example, L_{42} is the severity level for function classified as Status IV & Category 2.

TABLE B1 - ILLUSTRATION OF FSPC WITH 3 CATEGORY OF FUNCTIONS

Severity Levels	Category 1	Category 2	Category 3
L_4	**Status IV (Status I, II, III allowed)**	**Status IV (Status I, II, III allowed)**	**Status IV (Status I, II, III allowed)**
L_3	**Status III (Status I, II allowed)**	**Status III (Status I, II allowed)**	**Status III (Status I, II allowed)**
L_2	**Status II (Status I allowed)**	**Status II (Status I allowed)**	**Status II (Status I allowed)**
L_1	**Status I**	**Status I**	**Status I**

Status	Category 1	Category 2	Category 3
IV	**L_{41}**	**L_{42}**	**L_{43}**
III	**L_{31}**	**L_{32}**	**L_{33}**
II	**L_{21}**	**L_{22}**	**L_{23}**
I	**L_{11}**	**L_{12}**	**L_{13}**

B.2 APPLICATION OF FPSC FOR EMC IMMUNITY TESTING

It also demonstrates, as an example of how the severity levels can be specified for application to the testing of immunity to two different test methodologies. It is important to point out the severity levels given in this example are for the purpose of demonstration only and they are not recommended values. The actual requirements must be based on the product specifications agreed to by the suppliers and the vehicle manufacturers.

B.2.1 EXAMPLE OF APPLICATION OF FPSC TO IMMUNITY TO CONDUCTED TRANSIENTS WITH VARIOUS PULSES FOR A SINGLE CATEGORY

This example illustrates how the function of the device (single category) is expected to perform when exposed to the injected transient voltage Vs for a 12 volt system. (See Table B2)