



SURFACE VEHICLE STANDARD

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Immunity to Conducted Transients on Power Leads

RATIONALE

Document to be stabilized as no major changes are required.

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1. SCOPE

This SAE Standard defines methods and apparatus to evaluate electronic devices for immunity to potential interference from conducted transients along battery feed or switched ignition inputs. Test apparatus specifications outlined in this procedure were developed for components installed in vehicles with 12-V systems (passenger cars and light trucks, 12-V heavy-duty trucks, and vehicles with 24-V systems). Presently, it is not intended for use on other input/output (I/O) lines of the device under test (DUT).

1.1 Measurement Philosophy

Installed electrical equipment is powered from sources which contain, in addition to the desired electrical voltage, transients with peak values many times this value, caused by the release of stored energy during the operation of a relay and/or other loads connected to the source while starting and/or turning off the vehicle. These tests are designed to determine the capability of equipment to withstand such transients. The tests are performed in the laboratory (bench tests). Bench test methods give results, which also allow comparison between laboratories.

These tests may not cover all types of transients, which can occur in a vehicle. The test pulses described in Section 8 are, however, characteristic of typical pulses. To ensure proper operation of a vehicle in the electromagnetic environment, vehicle testing should be performed in addition to bench testing.

2. REFERENCES

General information regarding this document, including definitions, references, and general safety considerations, is found in SAE J1113-1.

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 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)

2.1.2 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 7637-2.3 (Release date 2004) Road vehicles—Electrical disturbance by conduction and coupling—Part 2.3: Electrical transient conduction along supply lines only

3. TEST EQUIPMENT

3.1 Test Facility

Care shall be taken to ensure that the electromagnetic environment (radiated background noise) is not so high as to interfere with the measurement instrumentation setup.

3.2 Test Instrumentation

The following list defines the equipment needed to perform the test.

3.2.1 Oscilloscope

The use of a digitizing oscilloscope is preferred. If a digitizing oscilloscope is not available, a storage oscilloscope may be used. The oscilloscope used shall meet the following requirements:

a. Digitizing Oscilloscope

Sampling Rate	2 gigasamples/s (min)
Memory Size	1000 samples (min)
Bandwidth	DC to 400 MHz (min)
Input Sensitivity.....	5 mV/div (min)
High Impedance (input impedance >1 MΩ) oscilloscope shall be used	

b. Storage Oscilloscope

Bandwidth (Single Shot)	DC to 400 MHz (min)
Input Sensitivity.....	5 mV/div (min)
Writing Speed	100 cm/μs (min)
High Impedance (input impedance >1 MΩ) oscilloscope shall be used	

3.2.2 Voltage Probe

Attenuation	Must be compatible with the scope used and with sufficient attenuation to avoid possible damage by the transients
Min. Breakdown Voltage	1.5 kV
Probe Cable Length	3 m (max)
Probe Ground Length.....	130 mm (max)
Probe capacitance C.....	< 10pf

3.2.3 DC Power Supply

(See SAE J1113-1)

If a standard power supply (with sufficient current capacity) is used to simulate the battery, it is important that the low internal impedance of the battery is also simulated.

When a battery is used, a charging source may be needed to achieve the specified reference levels.

3.2.4 Vehicle Simulator

A vehicle simulator unit shall be provided. This device must be capable of providing the inputs and loads necessary to exercise the DUT such that it operates as if it were installed in the vehicle.

3.2.5 DUT Monitoring Instrumentation

Instrumentation and/or visual observation shall be used to monitor the parameters of the DUT as stated in the Test Plan.

3.2.6 Test Pulse Generator

The test pulse generator shall be capable of producing the open circuit test pulses described in Section 8 at the maximum value of $|V_s|$. V_s shall be adjustable up to its limits.

The peak voltage V_s shall be adjusted to the test levels specified in Appendix B with tolerances of +10% and -0%. The timing (t) tolerances and internal resistance (R_i) tolerance shall be $\pm 20\%$ unless otherwise specified.

A verification procedure for the generator performance and tolerances is described in Appendix A.

Recommended values for the evaluation of immunity of devices can be chosen from Appendix B.

3.3 Test Voltages

The test voltages shall be as shown in Table 1 unless other values are agreed upon by the users of this document, in which case such values shall be documented in the test report.

TABLE 1 - TEST VOLTAGES

Test Voltage	12 V System (Volts)	24 V System (Volts)
V_A	13.5 ± 0.5	27 ± 1
V_B	12 ± 0.2	24 ± 0.4

V_A is the supply voltage when the alternator is operating.

V_B is the supply voltage when the alternator is not operating.

3.4 Test Set-Up Documentation

When testing is performed, all related details of the test shall be documented per Section 7. This includes details on test set-up, wiring harnesses, equipment used, and the DUT.

4. TEST PLAN

Prior to testing, a Test Plan shall be developed by those responsible for the specific DUT. In general, the Test Plan is based on the Product Specification and is agreed upon by the customer and supplier. The Test Plan should include all the details of the tests to be performed, such as: the DUT functions to be monitored; their function performance status classifications and Test Severity Levels as defined in Section 6 and Appendix B; the definitions of DUT performance deviations; and the order, level, repetition rate, and number of applications of the waveforms. Unless otherwise specified by the Test Plan, all tests shall be conducted at room temperature ($23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$).

NOTE 1: Special consideration for time between test pulses and number of test pulses: Period t_1 , the time between test pulses given with each test pulse definition, is a default value, which applies to DUTs without timing or dynamic processes. Consideration should be given in the Test Plan for each DUT function whose susceptibility may vary according to its internal timing or processing functions. Selection of time between pulses and number of pulses should maximize the probability that a test pulse will be applied during times of highest DUT susceptibility. In no case should the time between test pulses be less than the response time of the transient generator.

NOTE 2: The load dump test pulse is only applicable to devices installed in vehicles which have a low voltage (12/24V) alternator.

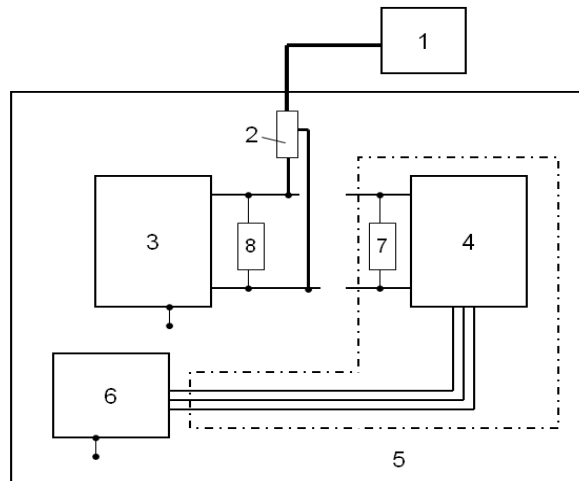
5. TEST PROCEDURE

5.1 The test setup is given in Figures 1A and 1B.

For test pulses 3a and 3b, the leads between the terminals of the test pulse generator and the device under test shall be laid out in a straight parallel line, shall have a height of $(50 \text{ mm} + 10/-0 \text{ mm})$ and shall have a length of $0.5 \text{ m} \pm 0.1 \text{ m}$.

The test pulse generator (see 3.2.6) shall be capable of producing the open circuit waveforms shown in Figures 2 through 9 with the parameters given in Tables 2 to 9.

The test pulse generator is verified according to Appendix A and then set up to provide the specific pulse polarity, amplitude, duration, and resistance with the DUT and optional resistance R_v and suppression diode bridge disconnected (see Figure 1A). (The appropriate voltage values are selected from Appendix B.)

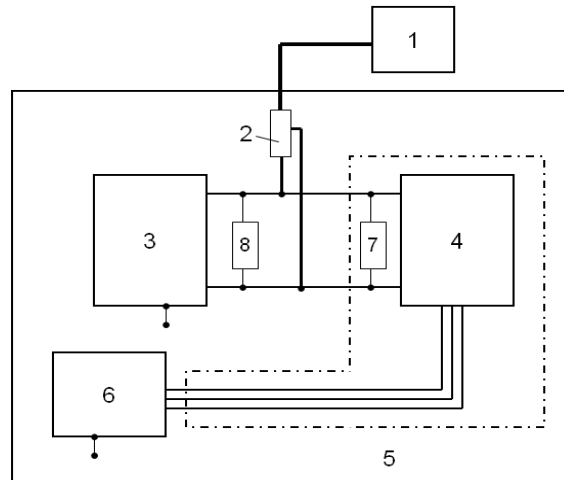


Legends:

1. Oscilloscope or Equivalent
2. Voltage probe
3. Test Pulse Generator with internal power supply resistance R_i
4. Device Under Test (DUT)
5. Ground Plane
6. Vehicle simulator/Load simulator
7. Optional parallel resistance should be considered to simulate vehicle system loading for load dump testing. If used, the value of (R_v) shall be specified in the test plan. To calculate the value of R_v , $R_v = V_{\text{nominal}}/\text{minimum vehicle current draw at idle}$. If the minimum vehicle current draw is unknown or undefined at the time of test, use $R_v = 0.7 \text{ ohms}$.
8. Optional diode bridge for simulation of load dump waveform for alternator with centralized load dump suppression for pulse 5b only (see Figure 1C).

FIGURE 1A - TRANSIENT IMMUNITY TEST SET-UP - PULSE ADJUSTMENT

NOTE: The test pulse generator can be located either on or off the ground plane.



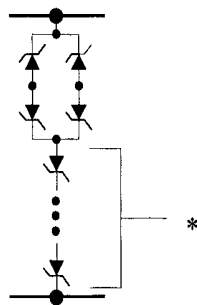
Legends:

1. Oscilloscope or Equivalent
2. Voltage probe
3. Test Pulse Generator with internal power supply resistance R_i
4. Device Under Test (DUT)
5. Ground Plane
6. Vehicle simulator/Load simulator
7. Optional parallel resistance should be considered to simulate vehicle system loading for load dump testing. If used, the value of (R_v) shall be specified in the test plan. To calculate the value of R_v , $R_v = V_{\text{nominal}}/\text{minimum vehicle current draw at idle}$. If the minimum vehicle current draw is unknown or undefined at the time of test, use $R_v = 0.7$ ohms.
8. Optional diode bridge for simulation of load dump waveform for alternator with centralized load dump suppression for pulse 5b only (see Figure 1C).

FIGURE 1B - TRANSIENT IMMUNITY TEST SET-UP - PULSE INJECTION

NOTE: The test pulse generator can be located either on or off the ground plane.

NOTE: An Oscilloscope can be connected to the test apparatus during test to obtain additional information for engineering analysis (optional).



* Add forward biased diodes as required to achieve maximum open-circuit (suppressed) voltage

FIGURE 1C - EXAMPLE OF SUPPRESSION DIODE BRIDGE FOR TEST PULSE 5B ONLY

- 5.2 Connect the DUT to the generator (see Figure 1B) and disconnect the oscilloscope.
- 5.3 Apply the transient to the DUT.
- 5.4 Monitor the DUT's performance during/after transient injection for any deviations.
- 5.5 Perform the appropriate functional tests, per the test plan, to determine deviations and record the results as outlined in Section 7.

NOTE 1: In determining the susceptibility level, care must be exercised to eliminate the effects of cumulative deterioration such as dielectric "punch through" in semi-conductor devices.

NOTE 2: When testing to a specified level, unnoticed deviations may occur which may be detected only by performing functional tests and comparing the results of tested components against those of untested components.

6. TEST SEVERITY LEVELS AND EVALUATION OF RESULTS

- 6.1 A full description and discussion of the Function Performance Status Classification including Test Severity Levels are given in SAE J1113-1. It should be reviewed prior to using the Test Severity Levels presented in Appendix B.
- 6.2 A careful examination of the DUT shall be made during and after the completion of a test to determine proper operation. Any irregularities shall be recorded in the Test Report and shall be evaluated based on the Test Plan, the specifications covering the product being tested, or by agreement between the purchaser and supplier.

7. TEST DOCUMENTATION

The following information shall be recorded, unless otherwise prescribed in the Test Plan covering the product being tested:

- 7.1 Part number and/or description of the DUT.
- 7.2 Copy of the original Test Plan.
- 7.3 Description of the test setup and equipment used.
- 7.4 Description of the harness used between the injection apparatus and the DUT.
- 7.5 Test Pulse being applied (by number).
- 7.6 Order of injection for each of the waveform amplitudes.
- 7.7 Number (repetitions) of the pulse applied.
- 7.8 Pulse period (interval between pulses).
- 7.9 Any deviation from the waveforms prescribed for testing.
- 7.10 Point of application of pulse (pin number, letter, or name).
- 7.11 Exact characteristics of any disturbance during injection of the pulse.

