

Submitted for recognition as an American National Standard

**(R) Electrical Interference by Conduction and Coupling—Coupling Clamp and Chattering Relay**

1. **Scope**—This SAE Standard establishes a common basis for the evaluation of devices and equipment in vehicles against transient transmission by coupling via lines other than the power supply lines. The test demonstrates the immunity of the instrument, device, or equipment to coupled fast transient disturbances, such as those caused by switching of inductive loads, relay contact bouncing, etc. Two test methods are presented - Coupling Clamp and Chattering Relay.

1.1 **Measurement Philosophy**—Years of experience with immunity testing of instruments, devices, and equipment shows the need for tests simulating fast transient coupling phenomena covering a wide range of electric and electromagnetic disturbances. The knowledge of these facts is common among EMC experts, and many companies have developed such coupling tests.

1.1.1 **COUPLING CLAMP**—The fast transient test uses bursts composed of a number of fast pulses, which are coupled into all lines other than the supply lines of electronic equipment. The short rise time, the repetition rate, and the low energy of the transients are significant for the test.

Theoretical and practical examinations of capacitive and inductive coupling test procedures for car electrical systems with respect to coupling via lines other than the supply lines have been made. Since in the actual test situation neither the original cable harness nor the possible sources of interference are available, worst case testing must be performed which is represented by capacitive coupling.

1.1.2 **CHATTERING RELAY**—In an actual vehicle, inductive transients are usually random in occurrence, amplitude, and duration. Other methods of testing using commercial test instruments that create a very repeatable event are much less effective at finding certain types of concerns since they do not create such a random sequence. This randomness is extremely critical for microprocessor type DUT's since the transients must often line up in time with a certain point in software execution to have an effect. To create such a match using commercial transient generators takes an unreasonable amount of test time. The noise created by this test is designed to provide a continuous series of random transients.

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**2. References**—General information regarding this testing including definitions, artificial loading, and safety considerations is found in SAE J1113-1. Information on test equipment for the Coupling Clamp method is in SAE J1113-11.

**2.1 Applicable Publications**—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, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1113-1—Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft)

SAE J1113-11—Immunity to Conducted Transients on Power Leads

**2.2 Related Publication**—The following publication is provided for information purposes only and is not a required part of this document.

2.2.1 ISO PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 7637-3—Road vehicles—Electrical disturbance by conduction and coupling

### 3. Test Equipment

**3.1 Grounding**—A ground plane shall be used for this test. The details of its construction are given in SAE J1113-1. The ground plane shall be connected to the protective conductor of the grounding system.

3.1.1 DUT GROUNDING—The DUT shall be placed on a ground plane as follows:

- a. Ungrounded Chassis—The chassis shall be separated from the ground plane by an insulating support having a thickness of 0.05 to 0.1 m and  $\epsilon_r \leq 1.4$ .
- b. Grounded Chassis—The chassis shall be connected to the ground plane by a short metal strap or conductive fastener at the production ground point.
- c. The remainder of the DUT shall be connected to the grounding system according to the manufacturer's installation specification; no additional grounding connections are allowed.

3.1.2 DUT LAYOUT WITH RESPECT TO THE GROUND—The DUT is arranged and connected according to its requirements over the ground plane. To minimize extraneous capacitive coupling to the DUT, it is recommended that the minimum distance between the DUT and all other conductive structures, such as walls of a shielded room (with the exception of the ground plane underneath the DUT and the coupling clamp) should be more than 0.5 m.

**3.2 Power Supply and Measurements Instrumentation**—Details of the equipment required are found in other parts as follows:

- a. Power Supply—See SAE J1113-1
- b. Oscilloscope (preferably storage)—See SAE J1113-11
- c. Voltage Probe—See SAE J1113-11

**3.3 Coupling Clamp**—The clamp provides the means of coupling the test pulses into the circuit under test without any galvanic connection to the terminals of the circuits, or any other part of the DUT.

The clamp coupling efficiency depends on the diameter and the material of the cables.

The coupling clamp, as defined in Figure 1, can be made, for example, of brass, copper or galvanized steel.

At both ends, the line shall be equipped with a coaxial connector for the connection of the test pulse generator and the terminating resistor of 50  $\Omega$ .

The recommended configuration of the coupling clamp is shown in Figure 1.

### 3.3.1 COUPLING CLAMP CHARACTERISTICS

- a. Typical coupling capacitance between cable and clamp<sup>1</sup>—about 100 pF (max. 200 pF)
- b. Applicable diameter range of harness—4 mm to 40 mm
- c. Pulse voltage insulation strength— $\geq 200$  V
- d. Impedance (without inserted lines)—50  $\Omega \pm 10\%$

3.3.2 CONNECTING WIRE BETWEEN COUPLING CLAMP AND TEST PULSE GENERATOR—A 50  $\Omega$  coaxial cable and connectors shall be used. The length shall not exceed 0.5 m.

3.3.3 TEST PULSE GENERATOR—The test pulse generator shall be capable of producing the test pulses shown in Figures 2 and 3 and shall be adjustable within the limits given in the figures.

Tolerances for the parameters are:

- a.  $\pm 10\%$  for time and resistance
- b. +10% for voltage

Coaxial connectors shall be used.

The internal resistance  $R_s$  is defined for each pulse in Figures 2 and 3.

3.3.4 TEST PULSES A AND B—These test pulses are a simulation of transients which occur as a result of the switching processes. The characteristics of these transients are influenced by distributed capacitance and inductance of the wiring harness.

The pulse shapes and parameters are given in Figures 2 and 3.

## 3.4 Chattering Relay

### 3.4.1 EQUIPMENT

- a. 12 V power supply capable of driving the DUT and the relay.
- b. Test fixture consisting of terminations for the DUT, connections to the power supply, and connections to the loads for the DUT.
- c. Wire harness fixture consisting of 1 m nonconductive mounting plate with a movable single wire 1 mm above the DUT wires as shown in Figure 4 and additional 1 m of wire which connects to the DUT and test fixture.
- d. 12 V AC normally closed relay capable of continuous chopped operation with no coil suppression. The relay specifications are shown in Figure 4. If another relay is used, it is to be included in the test report and be capable of producing 300 V spikes.
- e. Ground plane as described in SAE J1113-1 is to be placed under the items previously stated as shown in Figure 4.

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1. Capacitance value is a function of the wire used, number of circuits, etc., and the clamp construction. As long as the values are in the range given, the test is valid.

## 4. Test Setup and Procedures

### 4.1 Coupling Clamp

- 4.1.1 TEST SETUP—The test is to be set up as shown in Figure 5. The DUT should be connected to the original operating devices (loads, sensors, etc.) using a test harness or the production wiring harness, as agreed upon between the supplier and the car manufacturer. If the original operating devices are not available, they may be simulated by methods outlined in SAE J1113-1.

When using a test harness<sup>2</sup> the following is required:

- a. Power supply lines routed outside of the coupling clamp shall have a length of 1 m.
- b. The distance between device under test and coupling clamp and between peripheral device and coupling clamp shall be 400 mm  $\pm$  50 mm.
- c. The portions of the lines being tested, which are outside of the coupling clamp, shall be placed at a distance of 100 mm above the ground plane, and perpendicular (90 degrees  $\pm$  15 degrees) to the longitudinal coupling clamp axis.

When using a production harness having a length exceeding 2 m, the excess length shall be coiled into flat loops, each having a diameter of 0.3 m, and placed at a distance of 0.10 m above the ground plane. The maximum distance of 0.45 m between DUT and coupling clamp shall be maintained.

To ensure consistent test results, the hinged lid of the clamp shall be placed as flat as possible to ensure contact with the test harness.

- 4.1.2 TEST PROCEDURES—The test pulse severity levels should be mutually agreed upon between manufacturers and suppliers prior to the test.

The test pulses defined are typical pulses which represent the characteristics of most of the transients that may occur in the vehicle.

In special cases, however, it may be necessary to apply additional test pulses that are observed in vehicles.<sup>3</sup>

The test pulse generator shall be connected to the coupling clamp terminated in a 50  $\Omega$  resistor for testing.

Verify the test pulse generator's operating characteristics to A.3.4 of Appendix A of SAE J1113-11 prior to performance of the testing.

Next the test pulse generator shall be connected to the coupling clamp which is terminated in a 50  $\Omega$  resistor for testing.

Set the pulse amplitude to the appropriate voltage value selected from Appendix A of this document using an oscilloscope. The output of the coupling clamp shall be loaded to 50  $\Omega$  including the oscilloscope and terminating resistor, if necessary. No lines are to be routed through the coupling clamp during the setting of the test level and no adjustment is needed for the wave shape.

2. Has to be specified by the users of the standard.

3. The coupling clamp is only suitable for pulses which have a rise time of 100 ns or less. The magnitude of the test pulse is reduced by 50% (to account for coupling clamp termination assuming a 50  $\Omega$  generator and the clamp coupling coefficient) from the value measured at the pulse source. It is part of the user's responsibility to define the test pulse needed for certain instruments, devices, and equipment.

The tests shall be performed according to the test plan, which shall specify:

- a. Test pulse type
- b. Test voltage level
- c. Test pulse duration
- d. Operating conditions of the DUT
- e. The use of a test harness or a production wiring harness

#### 4.2 Chattering Relay

4.2.1 TEST SETUP—Position the DUT, wire harness, test fixture, and relay as shown in Figure 4. If the relay wire is not fixtured to maintain the 1 mm spacing, a dielectric spacer of  $\epsilon_r \leq 1.4$  shall be used. The DUT shall be connected to the ground plane if it is so mounted in the vehicle. Otherwise, the DUT is to be isolated from the ground plane.

#### 4.2.2 TEST PROCEDURES

- a. Activate the relay and verify that the transients generated across the relay coil are at least 300 V at the beginning and end of the test.
- b. Move the relay wire over the entire width of the 1 m section of the wire harness fixture exposing each wire in the fixture to the noise for 5 to 10 s.
- c. Monitor the DUT for proper operation during the exposure to the noise.

NOTE— Since this is a statistical test, the magnitude of the transients do vary with time. Verifying the transient levels at the beginning and end of the test is sufficient to ensure that the intent of the test is met.

5. **Test Pulse Severity Levels and Evaluation of Results**—A full description and discussion of the Function Performance Status Classification is given in SAE J1113-1 Appendix A. Please review it prior to using the Test Severity Levels presented in Appendix A.

6. **Test Documentation**—When required in the test plan, a test report shall be submitted detailing the test performed, the test equipment used, systems tested, pulses used or deviations from the recommended relay, system interactions, and any other relevant information regarding the test such as deviations, if any, from the original test plan an explanation of why they occurred.

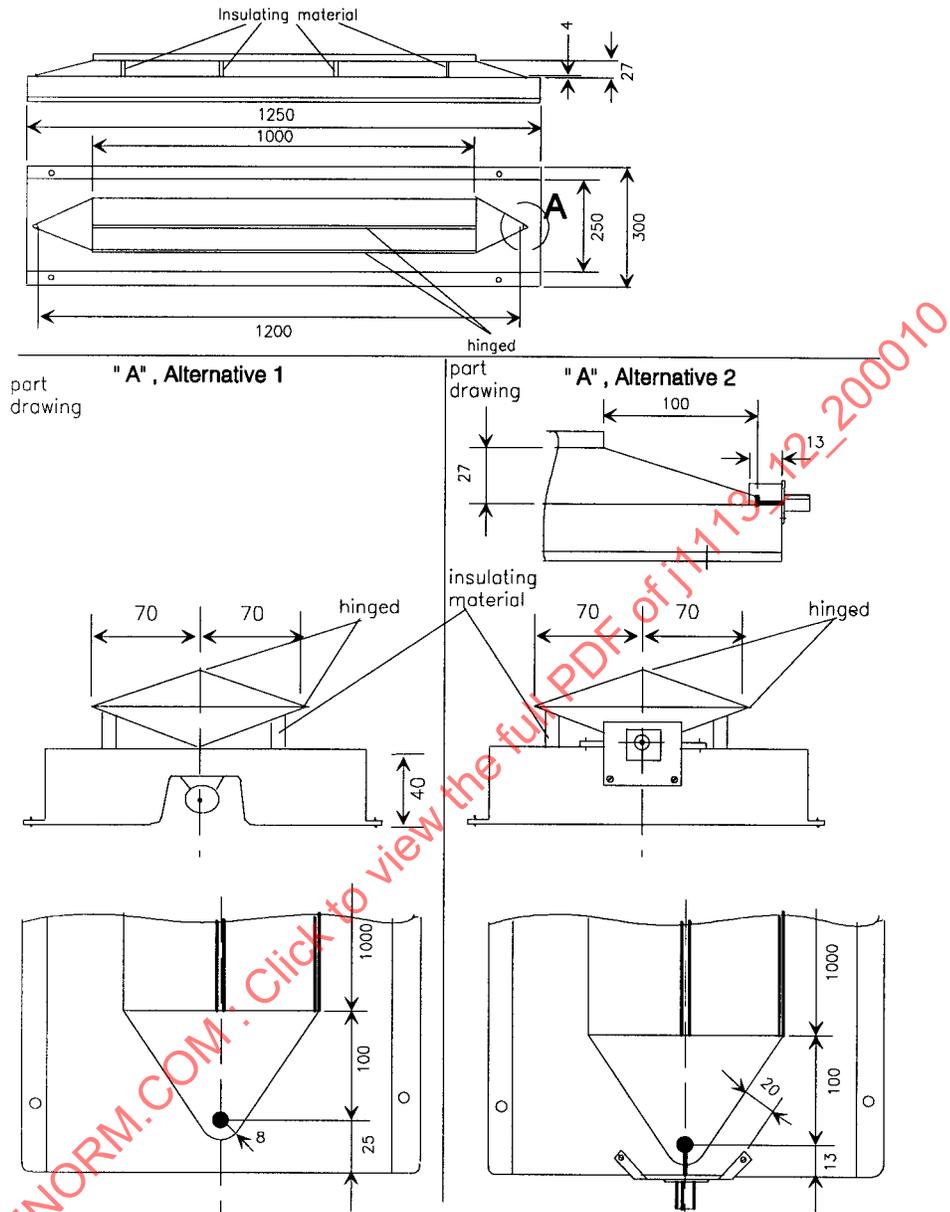
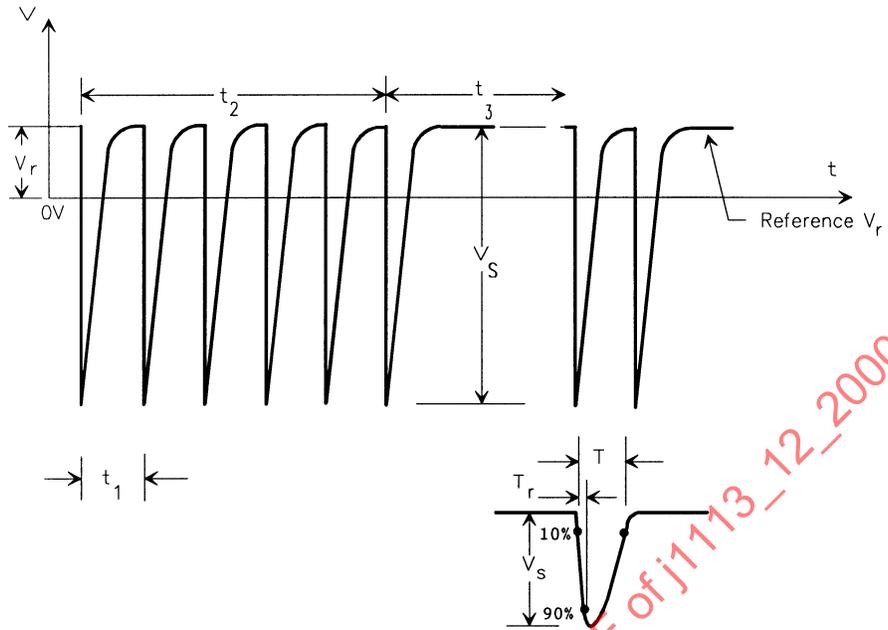


FIGURE 1—COUPLING CLAMP



For 12V Systems

$V = 0$  to  $-60$  V  
 $R_{S1} = 50 \Omega$

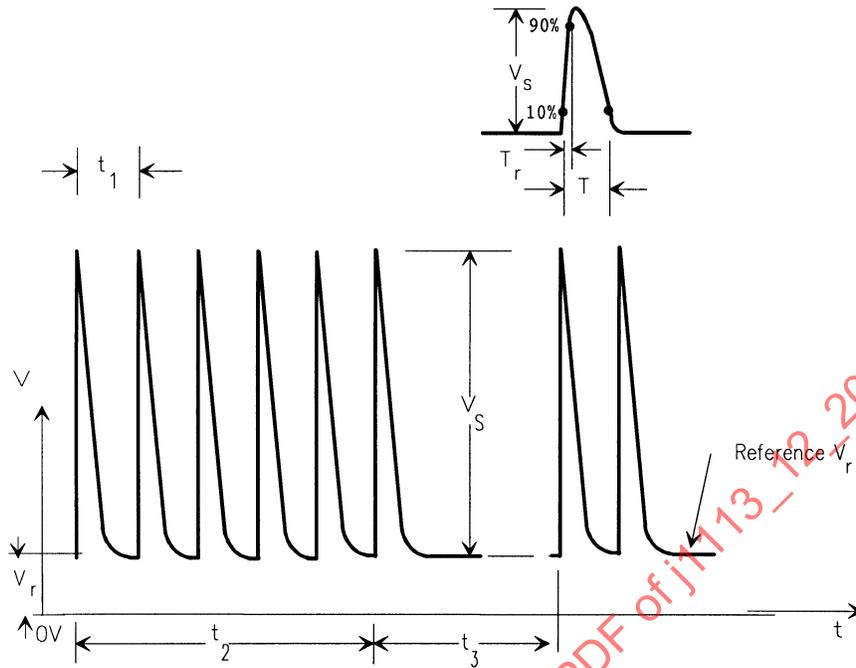
For 24V Systems

$V = 0$  to  $-80$  V  
 $R_{S1} = 50 \Omega$

$T = 0.1 \mu s + 100 / -0\%$   
 $T_r = 5 \text{ ns} \pm 50\%$   
 $t_1 = 100 \mu s$   
 $t_2 = 10 \text{ ms}$   
 $t_3 \geq 90 \text{ ms}$

FIGURE 2—TEST PULSE A

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For 12V Systems

$V_s = 0 \text{ to } +40 \text{ V}$   
 $R_1 = 50 \ \Omega$

For 24V Systems

$V_s = 0 \text{ to } +80 \text{ V}$   
 $R_1 = 50 \ \Omega$

$T = 0.1 \ \mu\text{s} + 100 / -0\%$   
 $T_r = 5 \ \text{ns} \pm 50\%$   
 $t_1 = 100 \ \mu\text{s}$   
 $t_2 = 10 \ \text{ms}$   
 $t_3 \geq 90 \ \text{ms}$

FIGURE 3—TEST PULSE B

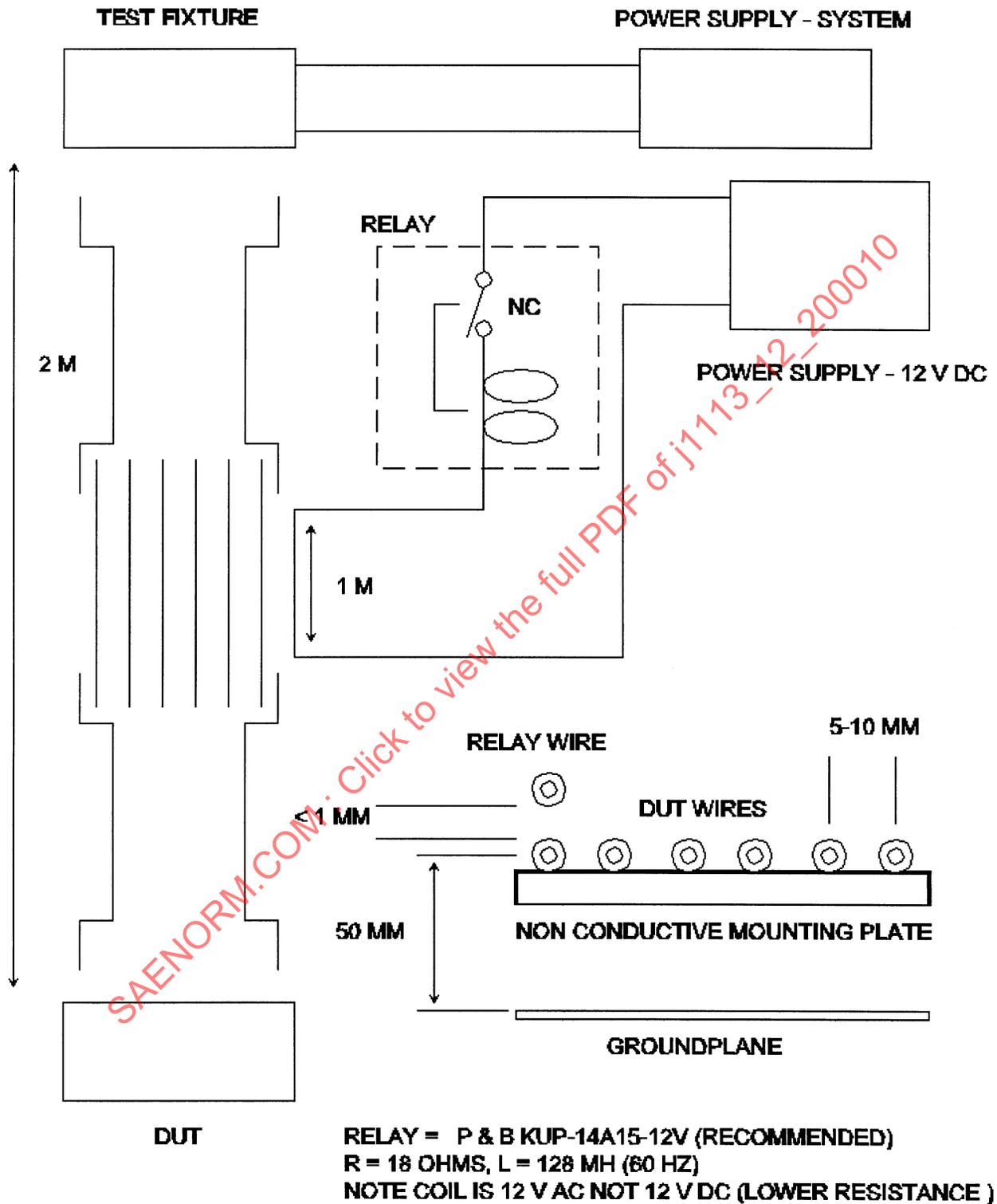


FIGURE 4—TEST SETUP WITH CHATTERING RELAY

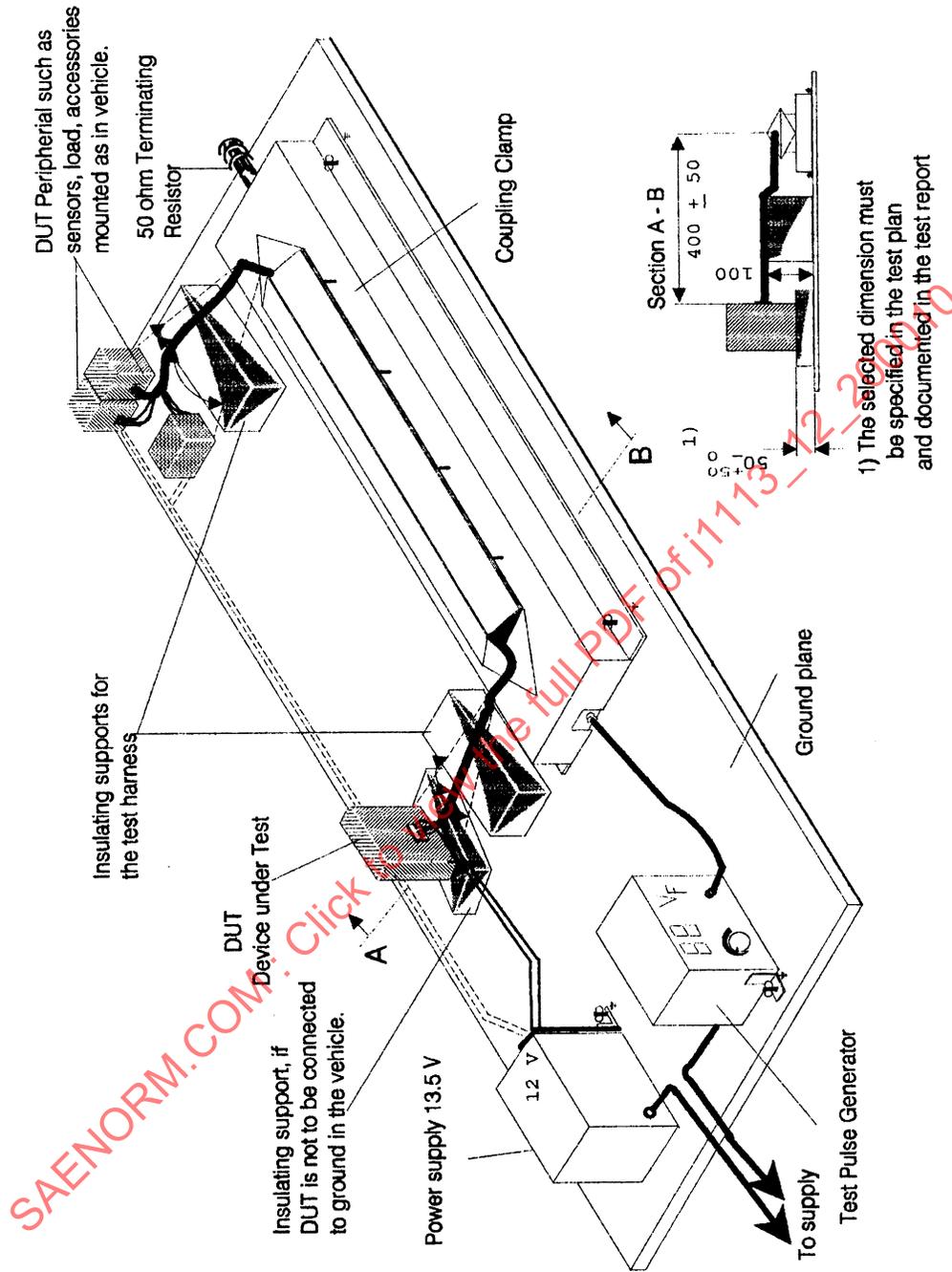


FIGURE 5—TEST SETUP WITH COUPLING CLAMP