SURFACE VEHICLE RECOMMENDED PRACTICE

J2139	DEC2014
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Tests for Signal and Marking Devices Used on Vehicles 2032 mm or More in Overall Width

RATIONALE

Changed 4.5.2.7.7 - Photometric measurements and scan shall be performed with the light source(s) steady burning. The luminous intensity measurements (in candela) shall be recorded for each of the test points and zones specified for the function of the device under test. This is consistent with SAE J575

Changed 4.10.2.2 to reference SAE J1455 instead of SAE J1889. Tests are very similar and was already referencing J1455 for the temperatures.

Added 5.5.1.1 - For any signal and marking device, unless otherwise specified in the applicable SAE document, the minimum luminous intensity (candela) requirement between any two adjacent test points shall be no less than 60% of the lower specified minimum value of the two test points on a horizontal or vertical or diagonal line. The specified minimum value is defined by the individual test point value not the zonal value. This is consistent with SAE J575

1. SCOPE

This SAE Recommended Practice provides standardized laboratory tests, test methods, and performance requirements applicable to signal and marking devices used on vehicles 2032 mm or more in overall width.

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 J387 Terminology - Motor Vehicle Lighting

SAE J577 Vibration Test Machine and Operation Procedure

SAE J1330 Photometry Laboratory Accuracy Guidelines

SAE J1455 Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications

SAE J1889 L.E.D. Signal and Marking Lighting Devices

SAE J2357 Application Guidelines for Electronically Driven and/or Controlled Exterior Automotive Lighting Equipment

SAE J2721 Recommended Corrosion Test Methods for Commercial Vehicle Components

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

ASTM B 117 Method of Salt Spray (Fog) Testing

ASTM C 150-84 Specification for Portland Cement

ASTM E 308-85 Standard Method for Computing the Colors of Objects by Using the CIE System

2.1.3 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 20653:2006 Road vehicles - Degrees of protection (IP-Code) - Protection of electrical equipment against foreign objects, water and access

2.2 Related Documents

2.2.1 SAE Publications

SAE J575 Test Methods and Equipment for Lighting Devices for Use on Vehicles Less than 2032 mm in Overall Width

SAE J576 Plastic Material or Materials for Use in Optical Parts Such as Lenses and Reflex Reflectors of Motor Vehicle Lighting Devices

SAE J578 Color Specification

SAE J2577 Heavy Duty Lamp Electrical Connector Standard

3. DEFINITIONS

3.1 DISCHARGE SIGNAL LIGHTING (DSL) SYSTEM

A vehicular lighting system used in signal and marking applications. The DSL system is composed of a discharge light source, interconnecting wiring, and a signal or marking lighting assembly.

3.2 DISCHARGE LIGHT SOURCE

An electric light source in which light is produced by a stabilized electric discharge through an ionized gas. The light source consists of a sealed glass/tube envelope wall and ballast. The size, shape, and color will depend on the application. (For example, but not limited to: neon, or fluorescent lamps.)

3.3 LIGHT EMITTING DIODE (LED) LIGHTING DEVICE

A lighting device in which light is produced by an LED or an array of LEDs.

3.4 LIGHTING DEVICE LIGHT CENTER

The geometric center of the light source or sources used to illuminate the device function or the geometric center of the illuminated area if the light output is produced indirectly.

3.5 INCANDESCENT LIGHTING DEVICE

A lighting device in which light is produced by a filament being heated to incandescence by an electrical current.

3.6 INTEGRATED ELECTRONIC COMPONENT

Electronic component(s) integrated within the housing of the lamp assembly or physically inseparable from the lighting device used to produce the desired output.

3.7 SAMPLES

Samples submitted for test shall be representative of the device as regularly manufactured and marketed. Each sample shall be securely mounted on the test fixture in its design position and shall include all accessory equipment necessary to operate the device in its normal manner.

3.8 SEALED LIGHTING DEVICES

A lighting device that does not allow the passage of gas or water between the interior environment and the exterior environment.

3.9 TEST FIXTURE

Fixture specifically designed to support the device in its designed operating position during a laboratory test.

3.10 VIBRATION TEST FIXTURE

A fixture specifically designed to support the device in its operating position during the vibration test. The fixture shall not have a resonant frequency in the test range.

4. TESTS

The following sections describe the individual tests which need not be performed in any particular sequence, except as noted in the test procedure. Unless otherwise specified all tests will be done at an ambient room temperature of 25 °C ± 5 °C. The completion of the tests may be expedited by performing the tests simultaneously on separately mounted samples. However, it is recommended that the design of each device be evaluated to determine if the vibration test or the warpage test affect other tests, in which case, those tests shall be performed first.

4.1 Vibration Test

This test evaluates the ability of the sample device to resist damage from vibration-induced stresses. This test is not intended to test the vibration resistance of bulb filaments, but may be used to evaluate the effects of vibration-induced stresses on shock-mounted devices.

4.1.1 Vibration Test Procedures

4.1.1.1 The DUT (Device Under Test), as mounted on the support supplied, shall be bolted to the anvil end of the table of the SAE J577 vibration test machine.

4.1.1.2 Test duration is 60 +1/–0 min.

4.2 Moisture Intrusion Tests

Choose one or more of the following tests in sections 4.2.1, 4.2.2 or 4.2.3 based on product application and with agreement between the manufacturer and customer

4.2.1 Water-Spray Moisture Test

This test procedure shall be used to test the ability of the device to resist moisture leakage into the device from a water spray and to determine the drainage capability of the device with drain holes or other exposed openings in the device.

4.2.1.1 Water-Spray Moisture Test Equipment

4.2.1.1.1 The water-spray cabinet shall be equipped with one or more nozzles which provides a solid cone of water spray of sufficient included angle to completely cover the DUT. The centerline of the nozzle shall be directed downward at an angle of 45 degrees ± 5 degrees to the vertical axis of the rotating test platform.

4.2.1.1.2 The precipitation rate of the water spray at the DUT shall be 2.5 +1.6/–0.0 mm minimum per minute as measured with a vertical cylindrical collector centered on the vertical axis of rotation. The collector shall be 100 mm high and the inside diameter shall be a minimum of 140 mm.

4.2.1.1.3 The DUT shall rotate about its vertical axis at a rate of 4.0 rpm ± 0.5 rpm.

4.2.1.2 Water-Spray Moisture Test Procedures

4.2.1.2.1 The DUT shall be mounted and tested in the design position and in accordance with the manufacturer's instructions.

4.2.1.2.2 All drain holes, slots, and other openings shall remain open during the test.

4.2.1.2.3 Devices which have a portion protected in service may have that portion of the exterior surface of the DUT protected in the same manner during the test.

4.2.1.2.4 The test duration shall be a minimum of 12 h.

4.2.1.2.5 At the end of the water-spray test period, the rotation, the electrical supply, and the water spray shall be turned off and the DUT allowed to drain for a maximum of 1 hour in the closed cabinet.

4.2.1.2.6 Upon completion of the drain period, the interior of the DUT shall be observed for moisture accumulation. If a standing pool of water has formed, or can be formed by tapping or tilting the DUT, the accumulated moisture shall be extracted and measured.

4.2.1.2.7 Alternate Method for Determining Moisture Accumulation Within the Device

The DUT before testing shall be weighed and the weight in grams recorded. Upon the completion of the drain period, the DUT shall be wiped dry of any exterior moisture and the DUT reweighed to determine the amount of water inside.

4.2.2 Water-Submersion Moisture Test

This test procedure shall be used to test devices designed to be sealed lighting devices.

4.2.2.1 Water-Submersion Moisture Test Equipment

4.2.2.1.1 A tank large enough to completely submerge the DUT to a depth of 50 mm measured from the top of the device is required.

4.2.2.1.2 The tank shall be filled with a mixture of water and wetting agent. The concentration of the mixture shall be sufficient to eliminate air bubble formation on the surface of the DUT.

4.2.2.2 Water-Submersion Moisture Test Procedures

4.2.2.2.1 The DUT shall be maintained at ambient room temperature until conditions have stabilized before testing.

4.2.2.2.2 The DUT shall be completely submerged to a depth of not less than 50 mm measured from the top of the device.

4.2.2.2.3 Test duration shall be a minimum of 1 minute.

4.2.2.2.4 The DUT shall be observed for air bubbles forming or escaping from the sealed portion of the DUT.

4.2.2.2.5 Throughout the test, the tank temperature shall be maintained at 70 °C + 5 °C/–0 °C.

4.2.3 IP rated Sealing test

4.2.3.1 The DUT shall be tested to IPX6 or greater as is specified in ISO 20653

4.3 Dust Integrity Tests

This test evaluates the ability of the device to resist dust penetration, which could significantly affect the photometric output. Choose one or more of the following tests in sections 4.3.1 or 4.3.2 based on product application and with agreement between the manufacturer and customer

4.3.1 SAE Dust Test

4.3.1.1 Dust Test Equipment

4.3.1.1.1 The interior of the test chamber shall be cubical in shape with measurements of 0.9 to 1.5 m per side. The bottom of the hopper may be cone shaped to aid in the collection of the dust.

4.3.1.1.2 The internal chamber volume, not including a hopper-shaped bottom, shall be 2 m^3 maximum and shall be charged with 3 to 5 kg of the test dust.

4.3.1.1.3 The chamber shall have the capability of agitating the test dust by means of compressed air or blower fans in such a way that the dust is diffused throughout the chamber.

4.3.1.1.4 The test dust used shall be fine-powdered cement in accordance with ASTM C 150.

4.3.1.2 Dust Test Procedures

4.3.1.2.1 The DUT shall be mounted and tested in the design position and in accordance with the manufacturer's instructions.

4.3.1.2.2 All drain holes, slots, and other openings shall remain open during the test.

4.3.1.2.3 Devices which have a portion protected in service may have that portion of the exterior surface of the DUT protected in the same manner during the test.

4.3.1.2.4 Before the dust test, the luminous intensity at H-V shall be measured and the intensity recorded.

4.3.1.2.5 The mounted DUT shall be placed no closer than 150 mm from a wall of the dust chamber. Devices with a length exceeding 600 mm shall be horizontally centered in the test chamber.

4.3.1.2.6 The test dust shall be agitated as completely as possible by compressed air or blower(s) for 2 to 15 s at intervals of 15 min. The dust shall be allowed to settle between agitation periods.

4.3.1.2.7 The test duration shall be a minimum of 5 h.

4.3.1.3 Upon completion of the dust test, the exterior of the lamp shall be cleaned and the luminous intensity at H-V measured.

4.3.2 IP Rated Dust Test

4.3.2.1 The DUT shall be subjected to IP6X as specified in ISO 20653:

4.4 Corrosion Test

This test evaluates the ability of exterior-mounted devices to resist salt corrosion which would impair the functional characteristics of the device.

4.4.1 Corrosion Test Equipment

4.4.1.1 A salt-spray (fog) cabinet, operating at the conditions specified by ASTM B 117 shall be used.

4.4.2 Corrosion Test Procedures

4.4.2.1 The DUT shall be mounted and tested in the design position and in accordance with the manufacturer's instructions.

4.4.2.2 All drain holes, slots, and other openings shall remain open during the test.

4.4.2.3 Devices which have a portion protected in service may have that portion of the exterior surface of the DUT protected in the same manner during the test.

4.4.2.4 The test duration shall be a minimum of 240 .h

4.4.3 Additional Corrosion Testing

4.4.3.1 For products deemed to have high susceptibility to corrosion consideration should be given to using SAE J2721 Recommended Corrosion Test Methods for Commercial Vehicle Components

4.5 Photometry Test

This test measures the luminous intensities at test points throughout the light distribution pattern as specified by the applicable SAE Publication for the sample device.

4.5.1 Photometric Test Equipment

4.5.1.1 The positioner (goniometer) configuration shall be capable of positioning the sample device at the test point position specified in the applicable SAE Publication. The recommended goniometer configuration is specified as Type A as shown in Figure B1 of SAE J1330. Other systems may be used to achieve equivalent positioning, but it will be necessary at compound angles greater than 5 degrees from "H-V" to calculate the position which is equivalent to that of the recommended goniometer.

4.5.1.2 The photometer system shall consist of a sensor, amplifier, and indicator instrument. The system shall be capable of providing the luminous intensity reading (candela) of the output of the device being tested.

4.5.1.3 The sensor, unless otherwise specified, shall have a maximum effective area that will fit within a circle whose diameter is equal to 0.009 times the actual test distance from the light source of the device to the sensor. The sensor effective area is the actual area of intercepted light striking the detector surface of the photometer. For systems with lens(es) that change the diameter of the intercepter light beam before it reaches the actual detector surface, the maximum size requirements shall apply to the total area of light actually intercepted by the lens surface. The sensor shall be capable of intercepting all direct illumination from the largest illuminated dimension of the sample device at the test distance.

4.5.1.4 The color response of the photometer sensor shall be corrected to that of the 1931 CIE Standard observer (2 degree) Photopic Response Curve (ASTM E 308).

4.5.2 Photometric Test Procedure

4.5.2.1 The DUT shall be mounted and tested in the design position(s) or as mounted on the vehicle in accordance with the manufacturer's instruction.

4.5.2.2 Unless otherwise specified, accurate, rated bulbs shall be used. They shall be selected for accuracy as specified in SAE J387 and shall be operated at their design mean spherical candlepower.

4.5.2.3 Where special bulbs are used, they shall be aged in accordance with SAE J387 and operated at their design mean spherical candlepower.

4.5.2.4 If the design value of the mean spherical candlepower is not available or the light source is an integral part of the device, operate the light source (bulb filament) at its specified design voltage.

4.5.2.5 If the design mean spherical candlepower of the bulb is intentionally modified from specifications for a device through internal or external circuitry, operate the bulb with the voltage-modification circuitry attached and with the specified design voltage applied to the input of the modification circuitry.

4.5.2.6 The test distance for measuring the luminous intensity shall be made at equal to, or greater than, the minimum test distance between the center of the light source (or the face of a reflex reflector) and the photometer sensor as specified in the SAE Publication applicable to the function of the sample device.

4.5.2.7 The locations of test points are specified in the applicable SAE Publication. The following nomenclature shall apply:

4.5.2.7.1 The letters "V" and "H" designate the vertical and horizontal planes intersecting both the center of the device light source (or center of a reflex reflector) and the goniometer axis.

4.5.2.7.2 A device using a bulb that has a major and a minor light source shall be oriented with respect to its major light source.

4.5.2.7.3 "H-V" designates the zero test point angle at the intersection of the "H" and "V" planes. Unless otherwise specified, this intersection shall be parallel to the longitudinal axis of the vehicle in the case of front and rear function devices and shall be horizontal and perpendicular to the longitudinal axis of the vehicle in the case of side function devices. The letters "U," "D," "L," and "R" (up, down, left, and right, respectively) designates the angular position in degree from the H-V planes to the goniometer as viewed from a lamp or to the source of illumination as viewed from a reflex reflector.

4.5.2.7.4 The horizontal angle of the test point ("L" left and "R" right) is the angle between the vertical plane and the projection of the light ray from the device onto the horizontal plane.

4.5.2.7.5 The vertical angle of the test point ("U" up and "D" down) is the true angle between the horizontal plane and the light ray from the device.

4.5.2.7.6 The direction of an angular test point can be visualized when an observer stands behind the device and looks in the direction of the emanating light beam towards the photometer sensor when the device is properly aimed with respect to H-V.

4.5.2.7.7 Photometric measurements and scan shall be made with the light source(s) steady burning. The luminous intensity measurements, in candela, shall be recorded for each of the test points and zones specified for that function of the device being tested.

4.5.3 Testing Procedures for LED based lighting

4.5.3.1 When testing LED based lighting devices SAE J1889 L.E.D. Signal and Marking Lighting Devices section 5.1.5 shall be used.

4.6 Warpage Test for Devices with Plastic Components

This test evaluates the ability of the plastic components of the sample device to resist warpage due to ambient heat and heat from the light source.

4.6.1 Warpage Test Equipment

4.6.1.1 A circulating air oven.

4.6.2 Warpage Test Procedure

4.6.2.1 The DUT shall be mounted and tested in the design position in accordance with the manufacturer's instructions.

4.6.2.2 Test shall be conducted at room temperature, 23 °C + 2 °C with still air.

4.6.2.3 Unless otherwise specified, the light source(s) shall be operated at design voltage specified by the device manufacturer and cycled as specified in Table 1.

Table 1 - Cycle times (minutes)

Device Type	Steady Burn	5 On - 5 Off	Steady Flash
Clearance	x		
Identification	x		
Side Marker	x		
Tail	x		
Stop		x	
Front & Rear Turn Signal			x
Side Turn Signal			x
High-Mounted Stop		x	
Back Up		x	
License Plate	x		
Non Headlamp DRL	x		

4.6.2.4 Test duration is 1 h.

4.6.2.5 The flash rate shall be between 80 and 100 flashes per minute with a 50% ± 2% on time.

4.6.2.6 Devices with multiple functions shall be tested with all functions simultaneously operating as specified, except for the backup function, which shall be tested separately. Stop and turn signal lamp combinations shall be tested as a stop lamp function only.

4.7 Humidity-Temperature Test

This test is for lighting devices including, but not limited to, LEDs and Discharge Signal Lighting Systems (DSLs) with Integrated electronic components. It is a combination test designed to verify operation throughout extremes of temperature and under conditions of high humidity.

4.7.1 Humidity-Temperature Test Equipment

Must be capable of performing the testing described in the temperature profile shown in Figure 1. Note that the 90% Relative Humidity requirement is applied only during the 38 °C part of the profile.

4.7.2 Humidity-Temperature Test Procedure

4.7.2.1 The DUT shall be mounted and tested in the design position(s) or in accordance with the manufacturer's instructions.

4.7.2.2 All drain holes, slots, and openings shall remain open during the test.

4.7.2.3 Devices which have a portion protected in service may have that portion of the DUT protected in the same manner during the test.

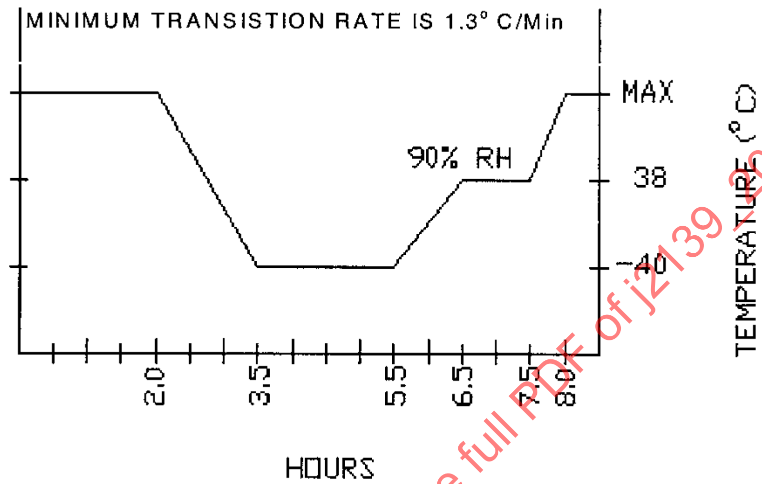

Figure 1 - Combined humidity - temperature profile

4.7.2.4 The DUT need not be energized during the test cycle illustrated in Figure 1. The maximum test temperature selected shall be appropriate to that expected for the location and use of the device and may not be less than 76 °C. Note that SAE J1455 offers environmental temperature extreme summary tables that may aid in selecting an appropriate maximum temperature. The maximum temperature should be documented in the test report. A minimum of one 8-h cycle is to be completed. The number of cycles should also be documented in the report.

4.8 Voltage Regulation Tolerance Testing

This test is for lighting devices containing integrated electronic components used to modify the vehicle voltages needed to energize LEDs, Discharge Signal Lighting Systems (DSLs), Discharge Light Sources or Incandescent Lighting Devices.

4.8.1 Voltage Regulation Tolerance Test Equipment

This equipment must be capable of providing the DC voltages as referenced in 4.8.2.2 for 12 V systems and 4.8.2.3 for 24 V systems. The DC power supply should meet the following specifications:

4.8.1.1 Line Regulation

±0.1%.

4.8.1.2 Ripple and Noise

0.4% maximum.

4.8.1.3 Stability

±0.1%.

4.8.2 Voltage Regulation Test Procedure

4.8.2.1 The DUT shall be mounted and tested in the design position(s) in accordance with the manufacturer's instructions.

4.8.2.2 The DUT shall be subjected to the test conditions for 12 V systems shown in Table 2:

Table 2 - Voltage conditions

Condition	D.C. Voltage	Application Time
Minimum Normal Operating Vehicle Voltage	7.0 V	2 min
Jumper Starts	24.0V	2 min
Reverse Polarity	-12.0 V	2 min

4.8.2.3 The DUT shall be subjected to the following test conditions for 24.0 V systems as shown in Table 3:

Table 3 - Voltage conditions

Condition	D.C. Voltage	Application Time
Minimum Normal Operating Vehicle Voltage	18.0 V	2 min
Jumper Starts	48.0 V	2 min
Reverse Polarity	-24.0 V	2 min

4.9 Vehicle Transient Voltage Tests

These tests are to insure that transient (short duration) voltage changes do not cause failure in lighting devices containing integrated electronic circuits which are necessary for proper operation of the device.

4.9.1 Vehicle Transient Voltage Test Equipment

4.9.1.1 The vehicle Transient Voltage Test Equipment shall be capable of meeting the requirements cited in Tables 4 and 5 for the following requirements: Load Dump, Inductive Load Switching, and Mutual for 12 and/or 24 V applications.

NOTE: Source resistance (ohms) may be changed where applicable in following tables.

Table 4 - Typical 12 V vehicle transient voltage characteristics

Lines	Type	Source (ohms)	Rise (μs)	Open Circuit Equation	Repetition	Energy
Power	Load Dump	0.4	100	$14+86e^{(-t/0.4)}$	5 Pulses at 10 s intervals	(1)(2)
I/O –(3)	Inductive Switching	20	1	$14+/- 600e^{(-t/0.001)}$	10 Pulses at 1 s intervals	(3)(2)
I/O All	Mutual	50	1	$14+/- 300\ e^{(-t/0.000015)}$	10 Pulses at 1 s intervals.	(2)

1. The alternator is capable of outputting much more energy than can be absorbed by commonly used electronic clamping devices. Therefore, when clamping devices are used in electronic modules, caution must be used in the design of the vehicle electrical system to insure the energy limitations of each clamping device are observed (see Appendix B in SAE J1455 AUG94).
2. The transient waveforms described previously in mathematical form may actually be implemented by diode OR-ing or "combining" a DC and transient voltage.
3. This transient applies to those I/O lines which may be connected to unclamped inductive loads. In addition, the energy available will be 0.5LI^2 where I is the current through the inductor in amps and L is the inductance in henries.

Table 5 - Typical 24 V vehicle transient voltage characteristics

Lines	Type	Source (ohms)	Rise (μs)	Open Circuit Equation	Repetition	Energy
Power	Load Dump	0.8	100	$28+122e^{(-t/0.4)}$	5 Pulses at 10 s intervals	(1)(2)
I/O –(3)	Inductive Switching	20	1	$28+/- 600e^{(-t/0.001)}$	10 Pulses at 1 s intervals	(3)(2)
I/O All	Mutual	50	1	$28+/- 300\ e^{(-t/0.000015)}$	10 Pulses at 1 s intervals.	(2)

1. The alternator is capable of outputting much more energy than can be absorbed by commonly used electronic clamping devices. Therefore, when clamping devices are used in electronic modules, caution must be used in the design of the vehicle electrical system to insure the energy limitations of each clamping device are observed (see Appendix B in SAE J1455 AUG94).
2. The transient waveforms described previously in mathematical form may actually be implemented by diode OR-ing or “combining” a DC and transient voltage.
3. This transient applies to those I/O lines which may be connected to unclamped inductive loads. In addition, the energy available will be 0.5LI^2 where I is the current through the inductor in amps and L is the inductance in henries.

4.9.1.2 Vehicle Transient Voltage Test Circuit

The circuit in Figure 2 is an example of the basic setup for Transient Voltage Testing, which can also be modified to perform Load Dump, Inductive and Mutual Switching. Values for the circuit components can be determined by using the equations in Tables 4 and 5. Note that all 3 types of test circuits mentioned are designed to have simulated resistance, not just the alternator resistance alone. The reason for this is that actual alternator source resistance by itself is approximately 0.25 Ω – and the realistic load resistance on the rest of the truck system varies. It includes harness system component resistance and other device resistance - connected in parallel on common lines. These devices will all dissipate a part of the total energy. Therefore, surge current should be limited when testing a single device by using series resistance as noted on test circuit.

NOTE: For Inductive Switching and Mutual Testing, the 3 ohms series resistor type and value has to be changed to Non-Inductive, 20 and 50 Ω respectively.

The first equation in Table 4 shows the Load Dump calculation represented by the exponential function for the discharging of a capacitor. This equation may be simplified as follows:

$$Vc = Vi\ e^{(-t/T)} \qquad \text{(Eq. 1)}$$

where:

Vc = Capacitor Voltage at any particular time
Vi = Initial Voltage
e = 2.7183 (base of natural logarithms)
T = RC time constant
t = Particular time which Vc is desired

In Table 4, the load dump equation shows 14 V as the DC output voltage used for nominal 12 V systems; 86 V is the peak voltage for the short duration described by the equation 0.4 = T or RC. To design a circuit with the proper time duration, it is necessary to select a capacitor value for C. Figure 3 shows an example using a 22 000 µF capacitor. We can calculate a resistor value R using the formula T = RC.

EXAMPLE

T = RC
0.4s = R(22000µF)
R=18Ω

The oscilloscope screen in Figure 4 displays the voltage that the DUT will see during a load dump pulse on a 12 V (14.0-V) system. These scope measurements are made at the DUT connection point without the DUT attached.

NOTE: It takes approximately 5 time constants (5T) to charge or discharge a capacitor.

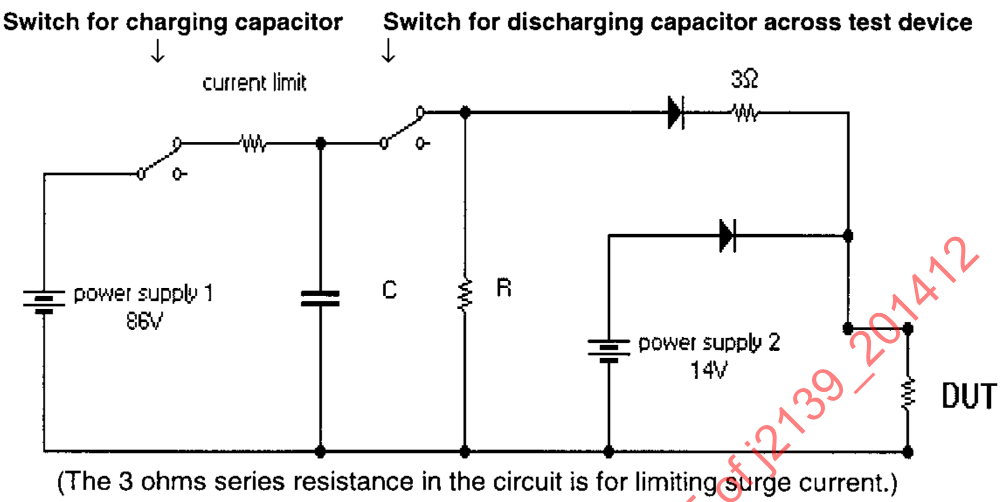

Figure 2 - Load dump testing circuit

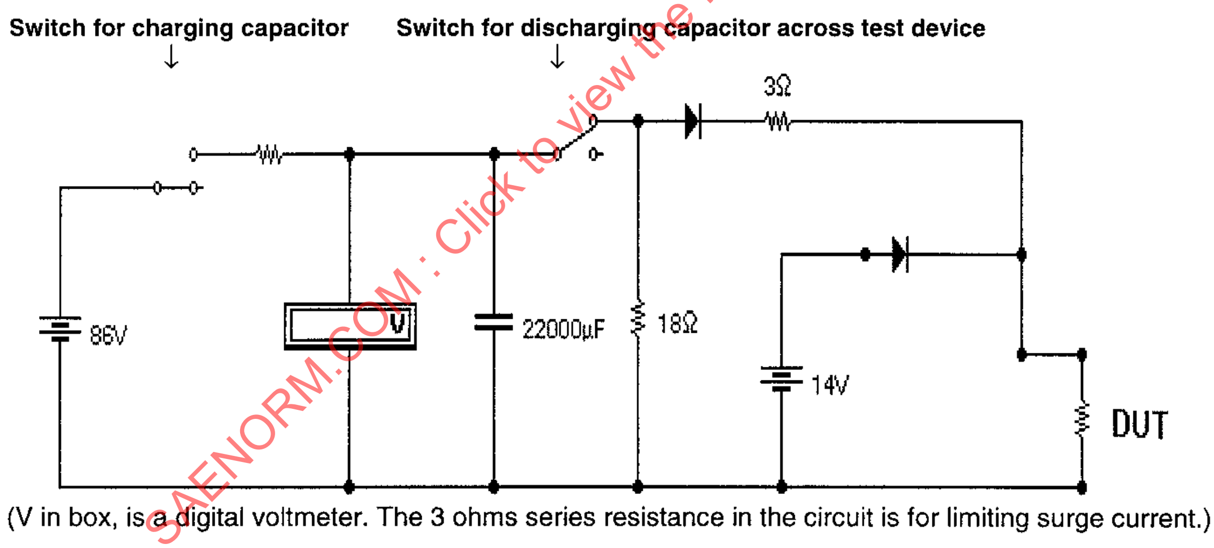

Figure 3 - Example of a load dump testing circuit