Automotive Electronics Council
Component Technical Committee

ATTACHMENT 4

AEC - Q200 - 004 - REV A

MEASUREMENT PROCEDURES FOR RESETTABLE FUSES

Automotive Electronics Council
Component Technical Committee

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METHOD 004

PASSIVE COMPONENT MEASUREMENT METHODS FOR RESETTABLE FUSES

1.0 SCOPE

1.1 Description:

This method covers the test and measurement methods for resettable fuses based on polymeric materials with positive temperature coefficient of resistance. The purpose of this specification is to provide users of such components means to compare polymeric positive temperature coefficient (PPTC) based resettable fuses against an established standard performance requirements tested in accordance with an established test method. This method provides supplemental information required to perform tests described in Table 14 of AEC-Q200.

1.2 Terms and Definitions:

1.2.1 Absolute Maximum Resistance, A_{max}: Maximum functional resistance of devices before and after stress tests.

1.2.2. Absolute Minimum Resistance, R_{amin}: Minimum functional resistance of devices before and after stress tests.

1.2.3 Core Material (Chip): A singulated sub-component of resettable fuse material that contains conductive polymer and two electrodes that may be coated with solder.

1.2.4 Electrical Current Type: Unless otherwise specified, direct current power source shall be used.

1.2.5 Lot: Unless otherwise specified, a lot shall consist of devices manufactured to the same part drawing number, assembled at the same location using the same production techniques, materials, controls and design.

1.2.6 Maximum Hold Current, I_{hold}: The maximum current that any device of a given product designation (part number) is guaranteed to hold without tripping, at specified temperature conditions, and under specified circuit and/or source conditions.

1.2.7 Maximum Hold Current at Temperature, $I_{hold@T}$: *Maximum hold current* at the specified ambient temperature as specified in *User Specification.*

1.2.8 Maximum Operating Voltage, V_{max}: The maximum voltage a resettable fuse is designed to tolerate as specified on device User Specifications.

1.2.9 Maximum Resistance, R_{max}: The maximum resistance of a device that has not been tripped in as-shipped condition and measured at room temperature.

1.2.10 Maximum Short Circuit Current, I_{scmax}: The maximum current used to perform short circuit current durability test based on device operating parameters specified on the user specification.

1.2.7 Maximum Hold Current at Temperature, $I_{hold@T}$: *Maximum hold current* at the specified ambient temperature as specified in *User Specification.*

1.2.8 Maximum Operating Voltage, V_{max}: The maximum voltage a resettable fuse is designed to tolerate as specified on device User Specifications.

1.2.9 Maximum Resistance, R_{max}: The maximum resistance of a device that has not been tripped in as-shipped condition and measured at room temperature.

1.2.10 Maximum Short Circuit Current, I_{scmax}: The maximum current used to perform short circuit current durability test based on device operating parameters specified on the user specification.

1.2.11 Minimum Resistance, R_{min}: The lowest specified resistance of a device that has not been tripped in as-shipped condition and measured at *room temperature*.

1.2.12 Room Temperature: Unless otherwise defined, the temperature range of 25±5ºC is defined as the room temperature.

1.2.13 Passive Resistance: Resistance of a device measured with no power (excluding measurement instrument supplied power) applied to the device.

1.2.14 Steady State: A change of less than 1% in the *power dissipation* over a one minute period.

1.2.15 Still Air Environment (Non-forced Air Environment): An environment where the only air movement is from natural convection due to heating or cooling of ambient air.

1.2.16 Time-to-Trip, TtT: Time-to-trip is defined as an elapsed time from the application of a specific amount of current to a device-under-test at a specific ambient temperature specified in the user specification to the point where the device-under-test reaches the *tripped state*.

1.2.17 Trip Current, I_{trip}: The minimum current guaranteed to trip any device of a given product designation in a specified time, at specified temperature conditions, and under specified circuit and/or source conditions.

1.2.18 Tripped Power Dissipation, P_d: Power dissipation is the product of the current flowing through a device in the *tripped state* and the voltage across the device.

1.2.19 Tripped State: A device is in the tripped state when the voltage across the device-under-test rises to 80% of the open circuit source voltage, or the resistance of the device increases by a factor of 40 times or more of the maximum specified resistance at the test environment temperature.

2.0 TEST CONDITION REQUIREMENTS

2.1 Device Mounting:

2.1.1 Mounting of Device for Electrical Test:

2.1.1.1 Leaded: Where applicable and unless otherwise specified, devices shall be mounted for electrical testing to the test apparatus via a pair of spring loaded clips. Leaded devices with formed leads shall be clipped within 5 mm from the base of the form away from the device body. Leaded devices with non-formed leads shall be clipped at 5 to 10 mm from the bottom of the body of the part.

2.1.1.2 SMD: Where applicable and unless otherwise specified, devices shall be mounted for electrical testing on printed circuit boards where the power dissipation of the mounted device is consistent with the typical power dissipation value found in User Specification. Devices shall be reflowed on to test boards using a reflow oven, or equivalent, and an appropriate reflow temperature-time profile. Devices shall be left at room temperature for a minimum of 24 hours prior to starting pre-stress tests.

2.2 Test Power Source: Unless otherwise specified, the standard open circuit test voltage shall be at the maximum operating voltage on User Specification. Unless otherwise required, the power source shall be capable of delivering the current required to perform the test. Whenever required, current delivered to the device shall be determined based on initial resistance at room temperature. This may be achieved by measuring the initial resistance at room temperature immediately preceding the test and calculating the necessary load resistance to deliver the current required by the specification.

2.3 Test conditions and Tolerances

2.3.1 Standard Stress Test Conditions: Unless otherwise specified herein, all stress tests shall be performed at the standard room condition. The standard room condition shall be defined as the temperature of 25 ± 5 °C with uncontrolled ambient air pressure and relative humidity. Whenever these conditions must be closely controlled in order to obtain reproducible results, for referee purposes, a temperature of 25 ± 3 °C, at uncontrolled ambient air pressure and relative humidity shall be used.

2.3.2 Standard Stress Test Tolerances: Unless otherwise specified, the tolerances for stress conditions shall be as follows:

Voltage:	± 2%	Weight:	± 2%
Current:	± 2%	Humidity:	± 5%
Temperature:	± 5°C	Length:	± 5%
Time:	+10% -0%		

2.3.3 Pre- and Post-Stress Test Conditions: Unless otherwise specified herein, all pre- and post-stress test evaluation measurements shall be performed at the minimum, room, and maximum rated temperatures. At the start of this test, the test chamber shall be controlled to test temperature ± 3 °C, at uncontrolled ambient air pressure and relative humidity.The temperature controller shall be capable of controlling the test chamber temperature to set temperature ± 2 °C.

3.0 TEST PROCEDURES

3.1 Physical requirement verification

Tests 9 & 10 of Table 14

3.2 Electrical Performance Verification Test Procedures

3.2.1 Passive Resistance at Temperature: Devices shall be tested in accordance with AEC-Q200-004-001.

3.2.2 Time-to-Trip at Temperature: Devices shall be tested in accordance with AEC-Q200-004-002.

3.2.3 Hold Current at Temperature: Devices shall be tested in accordance with AEC-Q200-004-003 for hold current.

3.2.4 Sequence of Testing: Unless otherwise specified, the electrical performance verification tests shall be performed in the following order and state of the device:
Passive resistance at temperature: "As is" condition following any stress tests. For devices that require soldering for mounting on a test apparatus, devices shall be in room temperature and condition storage for at least 24 hours after-soldering prior to testing.
Time-to-trip at temperature: "As is" condition after passive resistance test.
Hold current at temperature: Test shall be performed after a minimum of 1 hour from the conclusion of a trip event such as time-to-trip test. The starting of hold current test shall not exceed three hours from the conclusion of the trip event.

3.2.5 Test Environment: Electrical performance verification tests shall be performed at the minimum, room, and maximum rated temperatures. The devices shall be tested, unless otherwise specified, in a non-forced air environment. The test chamber temperature shall be monitored and controlled at a location that reasonably represents the general test chamber temperature and result in the ability to control the chamber temperature as required. Test samples shall be divided into three equal groups except when the samples are not equally divisible, the remaining one or two devices shall be included in the room temperature test group. The groups that are selected to be in a certain temperature group shall remain in the same temperature group for pre- and post-stress tests.

3.3 Environmental, Electrical, and Mechanical Stress Test Procedures

3.3.1 Operational Life: Parts shall be tested per MIL-STD-202 Method 108 with the following details:
Distance of temperature measurement from specimen: 10.16 cm minimum
Still-air Requirement: None - Circulation oven permitted provided that there is no direct impingement of air flow on devices under test.
Test Temperatures: At 85C (125C for 125 C parts)
Operating Conditions: Apply $I_{hold@T}$ in constant current mode with power on for 15 seconds and off for 15 seconds. Devices-under-test may be connected in series for simplification of the power delivery system.

3.3.2 Terminal Strength (Leaded only): Parts shall be tested per MIL-STD-202 Method 211 with the following details:

Test Condition A:

Applied Force: 2.27 Kg

Method of Holding the device: Device-under-test (DUT) shall be held using a strip of fiberglass loaded Teflon sheet which is bent around DUT in between the pant legs in a "U" shape. Two free ends of the strip shall be held in the jaw or vice. The load shall be applied to one lead at a time in the manner prescribed in MIL-STD-202 Method 211. The width of the strip shall be slightly less than the distance between the pant legs. The strip shall be secured to DUT by means of adhesive tape such as fiber-glass tape to prevent slippage.

Test Condition C:

Applied Force: 227 g

Post-stress visual examination: Prior to post-stress electrical tests examine the bend area for cracks or breakage of wire lead. with a microscope with magnification of no greater than 10.

3.3.3 Short Circuit Fault Current Durability:

Apply the maximum short circuit current (I_{SCMAX}) specified in the user specification through the device under test for 5 to 10 seconds. Then remove the current for a minimum of 2 minutes. Repeat for the number of cycles specified in the user specification, where $V_{POWER\ SUPPLY} = I_{SCMAX} \times R_{TEST\ SYSTEM.}$ $V_{POWER\ SUPPLY,}$ however, shall not exceed rated voltage for the device, and to set I_{SCMAX}, a shorting buss bar shall be used across the DUT mounting clips.

The device shall be functional after the test as verified per post-stress tests that include visual inspection, resistance, time-to-trip verification, and hold current verification.

3.3.4 Fault Current Durability:

Apply a minimum of 6 times the rated hold current (I_{HOLD}) specified in the user specification through the device under test for 5 to 7 minutes and then remove for a minimum of 10 minutes. Repeat for the number of cycles specified in the user specification.

The device shall be functional after the test as verified per post-stress tests that include visual inspection, resistance, time-to-trip verification, and hold current verification.

3.3.5 End-of-life Mode Verification:

Use the devices that were subjected to the fault durability test. Apply enough current, long enough to trip the device (current shall be a minimum of 6 times I_{HOLD} specified in the user specification). Hold in the tripped condition for 5 to 10 seconds and then turn power off for a minimum of minute. Repeat for the number of cycles specified in the user specification.

After stressing, examine for burnt devices and measure resistance. The device shall exhibit PTC of resistance behavior or shall have a resistance value that is high enough to limit the current to the hold current (I_{HOLD}) specified for the device at the rated voltage specified in the user specification.

3.3.6 Jump Start Endurance:

Apply 26 volts across R_L in series with the device under test. Monitor the voltage across R_L with an oscilloscope or equivalent. Apply voltage for 1minute ± 3 seconds then turn off for a minimum of 2 minutes. Apply and remove voltage 3 times. $R_L \leq V_{max\ of\ device} / I_{hold}$. Resistance due to wire and other electrical connections and the source impedance of the power supply shall be included in the calculation of R_L

The device shall be functional after the test as verified per post-stress tests that include visual inspection, resistance, time-to-trip verification, and hold current verification.

3.3.7 Load Dump Endurance: Devices shall be tested in accordance with ISO7635-1 using Test Pulse number 5.

Apply ISO 7635-1 load dump voltage V_S across R_L and the device under test . Monitor the voltage across R_L with an oscilloscope or equivalent. The pulses shall be applied every 90 ± 30 seconds for a total of 10 pulses. $R_L \leq V_{max\ of\ device} / I_{hold}$. Resistance due to wire and other electrical connections and the source impedance of the power supply shall be included in the calculation of R_L

The device shall be functional after the test as verified per post-stress tests that include visual inspection, resistance, time-to-trip verification, and hold current verification.

Test Parameters:

V_s: The test pulse voltage shall be the rated device load dump voltage as defined in User Specification.
R_i: In accordance with the table below.
U_A: 13.5 ± 0.5 V
t_d: In accordance with the table below.
t_r: 5-10 ms

Vs (V)	Ri (Ω)	td (ms)
26.5	0.50	40
46.5	1.67	160
66.5	2.83	280
86.5	4.00	400

AEC-Q200-004-001

Resistance Measurement Method

1.0 SCOPE

1.1 **Purpose**: This AEC-Q200-004-001 covers methods used to measure resistance of PolySwitch devices while the devices are in the off state.

2.0 EQUIPMENT

2.1 **2-Wire Resistance Measurement Instrument**: A digital ohmmeter or multimeter measuring to at least 1% accuracy is required. The instrument shall be capable of making zero adjustment with the test clips shorted together to compensate for the lead resistance. An example of instruments capable of making 2 wire resistance measurements is Hewlett-Packard digital multimeter HP34401A, or equivalent.

2.2 **4-Wire Resistance Measurement Instrument**: A digital ohmmeter or multimeter measuring to at least 1% accuracy is required. The instrument shall be capable of applying the test current at the point of resistance measurement for accurately compensating for the test lead resistance. Examples of instruments capable of making 4 wire resistance measurements are Hewlett-Packard digital multimeter HP34401A, Valhalla Scientific 4150ATC Digital Ohmmeter, or equivalent.

3.0 PROCEDURE

Caution: The resistance of a resettable fuse is sensitive to temperature by nature. Instruments used to measure the resistance of PolySwitch devices must minimize heating of the test specimen. It is recommended that the device be handled using a pair of tweezers, or equivalent, to minimize influencing the resistance measurement due to the elevated temperature of fingers or hands. The devices shall be placed in the position in which the measurement is to take place and allow sufficient time for the device to reach the measurement temperature.

3.1 **Test Circuit, 2-Wire**: The measuring instrument may be connected to the test device with any suitable clip leads. This method shall be used to measure device resistance values of 20 ohms or higher.

3.2 **Test Circuit, 4-Wire**: The measuring instrument is generally connected to the test device with special Kelvin clip leads. If standard clip leads are used, the voltage leads must be the closer to the body of the device, and the current leads further from the body of the device. This method of resistance measurement shall be used to measure device resistance values of less than 20 ohms.

3.3 **Device Mounting and Resistance Measurement Location**: Resistance of devices shall be measured at the connection point to the fixture as defined in Paragraph 2.1.1 of AEC-Q200-004..

3.4 **Resistance Measurements for Devices Mounted with Heat**: Initial resistance of the devices that require heat for mounting onto test fixtures (e.g. soldering of SMD components) shall be the value measured at least 24 hours from the time of the heating operation.

AEC-Q200-004-002

Time-to-Trip Measurement Method

1.0 SCOPE

1.1 **Purpose**: The purpose of this test is to verify that a test specimen will trip within a specified length of time at a specified current.

2.0 EQUIPMENT

2.1 **Power Supply**: A power source capable of supplying the trip current specified in the user specification, at the voltage specified in the user specification. The source voltage must be controlled to ± 2%. The source current is controlled by the load resistor.

2.2 **Load Resistor**: A load resistor to adjust the current through the test specimen to ± 2% of the trip current specified in the user specification, when the power source is set for the maximum operating voltage specified in the user specification.

2.3 **Parametric Measurement Instruments**: A system for measuring either the voltage across the test specimen, or the current through it (or both), as a function of time. The time resolution of the system needs to be 100 milliseconds or better, unless otherwise specified in the user specification. The voltage or current needs to be determined to be an accuracy of ± 2%. Digital equipment is suggested, for ease in storing and transferring information. Suitable systems include digital oscilloscopes, A/D converters, and computer-controlled multimeters.

3.0 PROCEDURES

3.1 **Device Mounting**: Test samples shall be mounted in accordance with Paragraph 2.1.1 of AEC-Q200-004.. The devices shall be tested individually or multiple devices in parallel. When multiple devices are connected in parallel, the current through each device shall be controlled and monitored separately. In addition, time-to-trip measurement shall be measured individually

3.2 **Resistance**: Resistance of test samples shall be measured prior to the time-to-trip test and one hour after the conclusion of the test in accordance with AEC-Q200-004-001.

3.3 **Non-Forced Air Ambient**: The time-to-trip of PolySwitch devices may be influenced substantially by air flow. As such, there shall be no air circulation around the test specimen during the test, including air flow due to body motion. Naturally convective airflow due to heating and cooling of the test specimen shall be allowed.

3.4 **Test Temperature**: The devices shall be tested at the temperature specified in this specification or User Specification. The test specimens shall be allowed to equilibrate at the specified temperature

for a minimum of 5 minutes.

3.5 **Test Current**: The time-to-trip evaluation test current level shall be as specified in User Specification. In cases where the test current is not specified, 5 times the $I_{hold@T}$ shall be used.

3.6. **Test Sequence**: The time-to-trip test shall be performed after a resistance measurement. The device shall not experience any trip event(s) after manufacturing, soldering, or stress testing, whichever is the most recent event, prior to the time-to-trip test.

AEC-Q200-004-003

Hold Current Measurement Method

1.0 SCOPE

1.1 **Purpose**: The purpose of this test is to verify that a test specimen will pass a specified current without tripping.

2.0 EQUIPMENT

2.1 **Power Supply**: A power source capable of supplying the trip current specified in the user specification, at the voltage specified in the user specification. The source voltage must be controlled to ± 2%. The source current is controlled by the load resistor.

2.2 **Load Resistor**: A load resistor to adjust the current through the test specimen to ± 1% of the trip current specified in the user specification, when the power source is set for the maximum operating voltage specified in the user specification.

2.3 **Parametric Measurement Instruments**: A system for measuring either the voltage across the test specimen, or the current through it (or both), as a function of time. The voltage or current needs to be determined to an accuracy of ± 1%. Digital equipment is suggested, for ease in storing and transferring information. Suitable systems include digital oscilloscopes, A/D converters, and computer-controlled multimeters.

2.4 **Elapsed Time Measurement Device**: Commonly used time measuring instrument capable of timing the hold current test duration, e.g. stop watch.

3.0 PROCEDURES

3.1 **Device Mounting**: Test samples shall be mounted in accordance with Paragraph 2.1.1 of AEC-Q200-004. The devices may be tested individually or in groups. If tested in a group, the devices shall be connected in series.

3.2 **Resistance**: Resistance of test samples shall be measured prior to the hold current test and one hour after the conclusion of the test in accordance with AEC-Q200-004-001.

3.3 **Non-Forced Air Ambient**: The hold current capability of PolySwitch devices may be influenced substantially by airflow. As such, there shall be no air circulation around the test specimen during the test, including airflow due to body motion. Naturally convective airflow due to heating and cooling of the test specimen shall be allowed.

3.4 **Test Temperature**: The devices shall be tested at the temperature specified in this specification or User Specification. The test specimens shall be allowed to equilibrate at the specified temperature for a minimum of 5 minutes.

3.5 **Test Current**: The hold current level shall be as specified in User Specification as $I_{hold@T}$.

3.6 **Test Sequence**: The hold current evaluation test shall be performed at least one hour, but not more than three hours, after the most recent trip event. In most cases, this trip event will be a time-to-trip evaluation test.

3.7 **Test duration**: The hold current as defined in accordance with User Specification shall be applied to the test specimen for 15 minutes or more.

3.8 **Pass/Fail Criteria**: The samples that pass the hold current evaluation test shall be capable of conducting specified $I_{hold@T}$ for a minimum of 15 minutes.

AEC-Q200-004-004

Trip Current Measurement Method

1.0 SCOPE

1.1 **Purpose**: The purpose of this test is to verify that a test specimen will trip at a specified current.

2.0 EQUIPMENT

2.1 **Power Supply**: A power source capable of supplying the trip current specified in the user specification, at the voltage specified in the user specification. The source voltage must be controlled to ± 2%.

2.2 **Load Resistor**: A load resistor to adjust the current through the test specimen to ± 2% of the trip current specified in the user specification, when the power source is set for the maximum operating voltage specified in the user specification.

2.3 **Parametric Measurement Instruments**: A system for measuring either the voltage across the test specimen, or the current through it (or both). The voltage or current needs to be determined to an accuracy of ± 2%. Digital equipment is suggested, for ease in storing and transferring information. Suitable systems include digital oscilloscopes, A/D converters, and computer-controlled multimeters.

2.4 **Elapsed Time Measurement Device**: Simple time measuring instrument capable of timing the trip current test duration.

3.0 PROCEDURES

3.1 **Device Mounting**: Test samples shall be mounted in accordance with Paragraph 2.1.1 of AEC-Q200-004 The devices shall be tested individually or connected to the power supply in parallel.

3.2 **Resistance**: Resistance of test samples shall be measured prior to the trip current test and one hour after the conclusion of the test in accordance with AEC-Q200-004-001.

3.3 **Non-Forced Air Ambient**: The trip current capability of PolySwitch devices may be influenced substantially by airflow. As such, there shall be no air circulation around the test specimen during the test, including airflow due to body motion. Naturally convective airflow due to heating and cooling of the test specimen shall be allowed.

3.4 **Test Temperature**: The devices shall be tested at the temperature specified in this specification or User Specification. The test specimens shall be allowed to equilibrate at the specified temperature for minimum of 5 minutes.

3.5 **Test Current**: The trip current level shall be as specified in User Specification as $I_{trip@T}$.

3.6 **Test Sequence**: The trip current evaluation test shall be performed on devices that have not been tripped. If a heating process, such as soldering, is necessary to perform tests on a test fixture, the device shall be conditioned at the standard room condition for at least 24 hours prior to the testing of the trip current.

3.7 **Test duration**: The trip current as defined in accordance with User Specification shall be applied to the test specimen for 15 minutes or until the device trips, whichever occurs first.

3.8 **Pass/Fail Criteria**: The samples that pass the trip current evaluation test shall trip at the specified $I_{trip@T}$ in 15 minutes or less.

AEC-Q200-004-005

Power Dissipation Measurement Method

1.0 SCOPE

1.1 **Description**: The purpose of this test is to determine the amount of power dissipated by a device in a standard environment after it has stabilized in the tripped state.

2.0 EQUIPMENT

2.1 **Power Supply**: A power source capable of supplying the trip current specified in the user specification, at the voltage specified in the user specification. The source may be either ac or dc, unless the type is specified in the user specification. The source voltage must be controlled to ± 2%. The source current is controlled by the load resistor.

2.2 **Load Resistor**: A load resistor to adjust the current through the test specimen to ± 2% of the trip current specified in the user specification, when the power source is set for the maximum operating voltage specified in the user specification.

2.3 **Parametric Measurement Instruments**: A system for measuring either the voltage across the test specimen and the current through the device-under-test. The voltage or current needs to be determined to an accuracy of ± 2%. Digital equipment is suggested, for ease in storing and transferring information. Suitable systems include digital oscilloscopes, A/D converters, and computer-controlled multimeters, or equivalent.

3.0 PROCEDURE

3.1 **Device Mounting**: Test samples shall be mounted in accordance with Paragraph 2.1.1 of AEC-Q200-004. The devices may be connected to the power source in parallel.

3.2 **Resistance**: Resistance of test samples shall be measured prior to the power dissipation test and one hour after the conclusion of the test in accordance with AEC-Q200-004-001.

3.3 **Non-Forced Air Ambient**: The power dissipation of PolySwitch devices may be influenced substantially by airflow. As such, there shall be no air circulation around the test specimen during the test, including airflow due to body motion. Naturally convective airflow due to heating and cooling of the test specimen shall be allowed.

3.4 **Test Temperature**: The devices shall be tested at the temperature specified in this specification or User Specification. The test specimens shall be allowed to equilibrate at the specified temperature for minimum of 5 minutes.

3.5 **Test Current**: The minimum power dissipation test current level shall be the trip current as specified in User Specification as $I_{trip@T}$.

3.6 **Test Sequence**: The power dissipation measurement shall be performed on devices that are in the tripped state. Once the test sample reaches the tripped state, measure the voltage across the device and the current through the device. The power dissipation may be calculated from the voltage and current measurements

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Revision History

Rev #	Date of change	Brief summary listing affected paragraphs
-	March 15, 2000	Initial Release.
A	June 1, 2010	Notice Statement (Page 2) Added. Format Updated.