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Practical Application of AEC Requirements for Automotive Components (Passives & ICs)

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Introduction

- Automotive Electronics Council (AEC) has published a set of documents to address common electrical component qualification requirements
  - AEC-Q100: Failure Mechanism Based Stress Test Qualification for Integrated Circuits
  - AEC-Q101: Failure Mechanism Based Stress Test Qualification for Discrete Semiconductors
  - AEC-Q102: Failure Mechanism Based Stress Test Qualification for Discrete Optoelectronic Semiconductors in Automotive Applications (new 2017)
  - AEC-Q104: Failure Mechanism Based Stress Test Qualificaiton for Multichip Modules (MCM) in Automotive Applications (new 2017)
  - AEC-Q200: Stress Test Qualification for Passive Components

- Cover detailed qualification and re-qualification requirements
  - Includes unique test methods
  - Includes guidelines for use of generic data

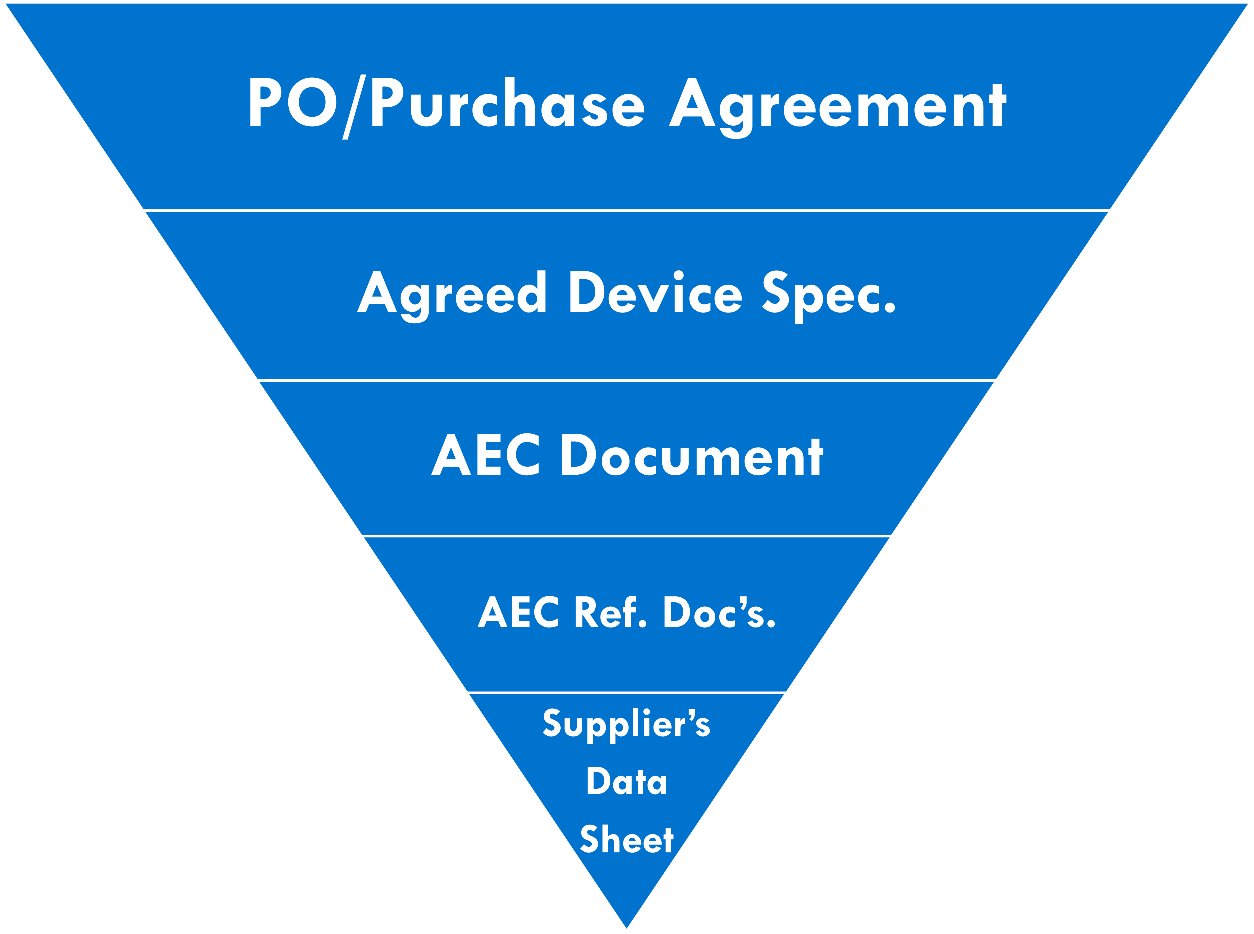
AEC Document

- What does it mean?
  - Components meeting these requirements are considered suitable for use in various levels of automotive applications (interior, exterior, under hood, etc., dependent upon the grade) without additional component level qualification testing
  - Supplier can claim component is “AEC Q100 qualified”, for example, to a particular requirement within the standard (it is NOT an all or nothing approach)
  - There are no “certifications” issued, nor a certification board run by AEC to qualify parts
    - Requires proper execution to the applicable AEC standards required by the customer and application
    - Data available for customer review to verify compliance
    - Does NOT indicate user approval

- When does it apply?
  - New component qualification
  - Changes to product and/or process (where it potentially impacts form, fit, function, quality, and/or reliability)
    - Requalification failures require root cause analysis with corrective and preventative actions for qualification
  - Customer requested

Requirements Fit

- The Requirements Hierarchy
  - Qualification to AEC document only if the specification documents above it do not waive or detract from its requirements
- Test Methods and Standards referenced
  - Automotive (AEC, SAE)
  - Military
  - Industrial (JEDEC, UL, IPC, JESD)
- Additional Requirements
  - Supersedes requirements in the referenced test methods/standards



Execution

- Use generic data where possible (accelerate and streamline qualification process)
  - Same major product, process, and materials elements across devices
  - If similarities only, make sure worst cases of differences are covered (with technical justification)
  - Use Qualification Test Plan templates (download from AEC at http://www.aecouncil.com)
- Supplier Data Sheets
  - Tie the appropriate data sheet tolerances and tests to the applicable test methods outlined in AEC
  - For instance, specification requirements for passives (i.e., capacitance, dissipation factor, insulation resistance, etc.) are not dictated by AEC, but are required to perform as intended after subjected to AEC test method (i.e., THB)
  - Pre-bake and post-bake: Some manufacturer's data sheets stipulate these procedures before measurement; even though it may not reflect real-world use (i.e., capacitors can "recover" from capacitance drift if post-baked following testing)
- Stoppages in Test/Interruptions
  - Can be inevitable with lightning strikes/brown-outs in power grid (if not running a backup power generator)
  - Passives undergoing THB:
    - Capacitors can generally recover some once removed from THB environment after several days/weeks; limit downtime during interim testing and disruptions, or use sealed bags to extend moisture retention by several days
    - Inductors can have mixed results; while damage accumulated on inductors from THB exposure remains if pulled from test, minimize time outside of test conditions

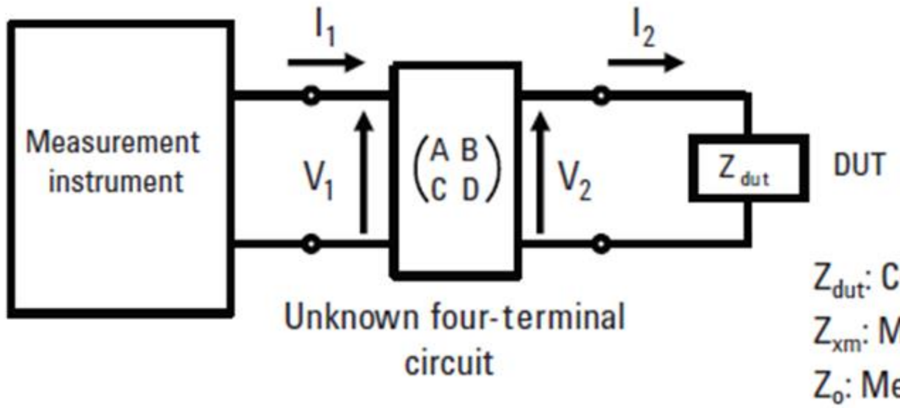
Equipment/Setup

- RF Material Analyzer Equipment
  - Give sufficient warm-up time after turning on equipment before using (30 minutes or more)
  - Use open, short, and load standards connected to the desired reference plane (calibration reference plane) for conducting calibration of equipment (resuming after power turned off or interrupted); use test head and calibration kit designed for analyzer
  - Error in accuracy measurement can double if calibration performed beyond controlled lab temp. (23+/-5C for example)
  - Use open/short or open/short/load compensation methods when DUT is connected to a terminal that is extended from the calibration reference plane
  - Minimize chances of electrical interference by minimizing:
    - Electrical length to extension terminals
    - Nearby RF devices, particularly for low impedance devices (low capacitance/inductance)

- For Passive measurements (capacitors/inductors)
  - Use break-out boards with resistors to minimize in-rush current (typically <50 mA)
  - Avoid use of test coupons with very sensitive devices (particularly low impedance devices); better to isolate and measure device directly if possible
  - If test coupon board is used, ensure trace lengths are equal in length and symmetric to each device on test coupon being tested

Error Compensation

- Apply Open/Short/Load method of compensation
  - Apply when difference between measurement of standard and measurement of known good device differ significantly (1% to 5% can be significant)
  - Must use complex algebra (all parameters are complex numbers with real and imaginary components)
  - Compensation method is not "bullet-proof"; to reduce additional error being introduced
    - OPEN impedance must be >100 times measured impedance of DUT
    - SHORT impedance should be <1/100 of the measured impedance of DUT

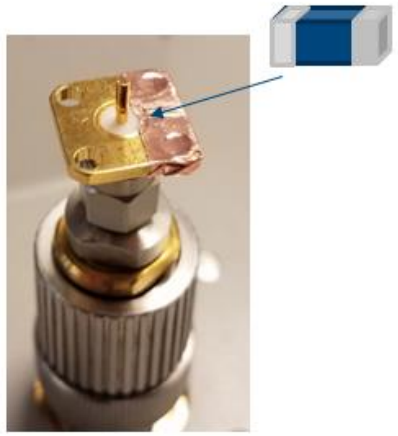


Z_{dut}: Corrected DUT impedance
Z_{xm}: Measured DUT impedance
Z_o: Measured open impedance
Z_s: Measured short impedance
Z_{sm}: Measured impedance of the load device
Z_{std}: True value of the load device

Open/short/load compensation formula

$$Z_{dut} = \frac{(Z_s - Z_{xm})(Z_{sm} - Z_o)}{(Z_{xm} - Z_o)(Z_s - Z_{sm})} Z_{std}$$

Source: per Agilent Impedance Measurement Handbook, 4th ed., pg. 4-6)



Individual component placed on port for measurement