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RIPPLE CURRENT TESTING

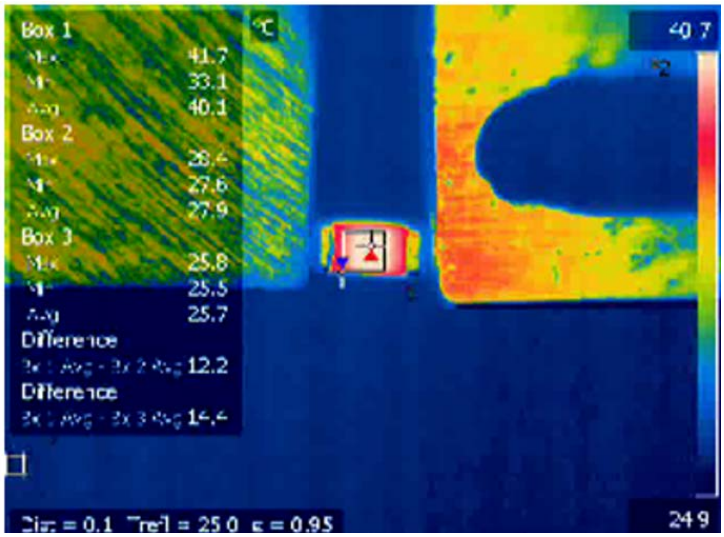
WHAT IS RIPPLE CURRENT?

As the world shifts towards miniaturized, high-efficiency electronics, signal integrity and power delivery become more of a concern. Because of this, ripple current testing is becoming more relevant as it allows for a better understanding of the limitations of individual capacitive components. Excessive ripple current can lead to increased ESR, reduced performance, or failures in RF applications where low ESR is critical.

In an ideal scenario, capacitors would block DC current while allowing AC current to pass through. However, in many RF circuits, there is a combination of a steady DC bias with the AC ripple. This passing AC current will begin to generate heat within the part. Ripple current testing will evaluate how much of this AC ripple that a capacitor can handle while avoiding the excessive temperature rise. This test involves applying an AC signal to a capacitor in high amplitude and narrow bandwidth pulses. Evaluating this response over time will inform on both the circuit design and type of capacitor to use in these low loss applications

FACTORS THAT AFFECT TEMPERATURE RISE

- Heat Generation
  - Driven by ripple current and ESR
- Heat Dissipation
  - Surface area of the device
  - Air convection around the component
  - Thermal conduction through internal electrodes, ceramic material, and PCB/termination contact
- Board Mounting
  - Trace width and amount of copper can produce high heat
  - Large planes can conduct heat and prevent thermal buildup
- Mounting Method
  - Can influence ripple current performance



$$P_{generated} = I_{Ripple}^{2} ESR$$

RIPPLE CURRENT TESTING

CAPABILITIES

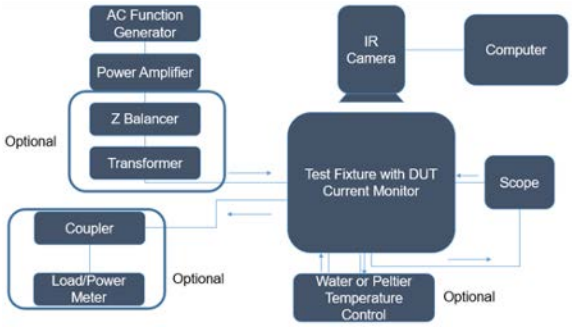
- Wideband Signal Generation
  - Keysight Function Generator: 10kHz to 1GHz
- High-Power Amplification
  - Up to 2,000W at low frequencies
  - 250W at high frequencies
- Thermal Management
  - Water-cooled platform ensures stable temperature conditions

Optional Features:

- Heated Test Fixture
  - Up to 200°C sample temperature
- Impedance Matching
  - Transformers and inductors for maximum power delivery
- Load Testing
  - Dummy load with a power meter in series

CAPACITOR TYPES (DUTS)

- NP0: Low ESR, resilient against temperature shifts
- X7R: High K = high capacitance
- Tantalum: High stability across wider DC voltage, long life



Want more information?
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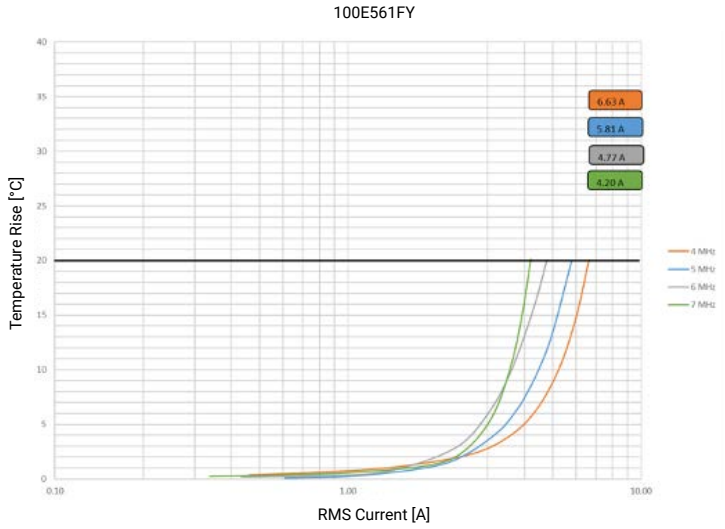
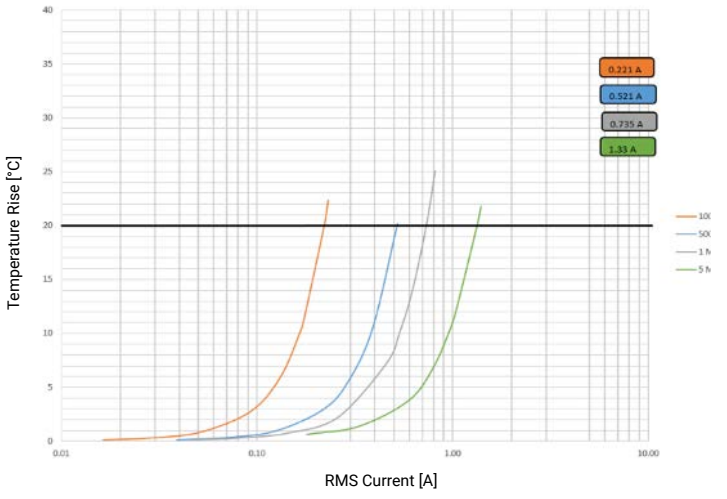
TEST PROCEDURE

- **Z and ESR Characterization**
  Perform an impedance analyzer sweep to measure impedance and equivalent series resistance.
- **Data Collection**
  Apply voltage to the DUT. Record the current and temperature responses during operation.
- **Data Analysis/Post-Processing**
  Plot impedance, ESR and temperature data vs. frequency. Validate impedance performance against expected values.

RESULTS:



Thermal performance of ultra-low ESR, RF MLCC (100 series) under ripple current load.



Thermal performance of a high voltage, X7R MLCC under ripple current load.

Note: Different capacitor part numbers were used to illustrate a range of typical responses

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