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# A Modeling Study of Aluminum Electrolytic Capacitors Considering Lifetime Degradation

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At the 2022 JSAE Annual Congress (Spring), an impedance-based electrical model for aluminum electrolytic capacitors that incorporates temperature characteristics was examined. This led to the introduction of a "Detailed Model" (Detail-Model) that more accurately represents electrical characteristics at low temperatures. Furthermore, it was demonstrated that capacitor element temperature, loss, and lifetime consumption rates can be calculated by integrating the thermal model of the capacitor with a multi-domain model.

When applying aluminum electrolytic capacitors to high-reliability applications, such as automotive equipment, lifetime estimation is essential to ensure compliance with reliability requirements. However, the electrical performance of these capacitors near their end-of-life (EOL) is generally not reviewed, primarily because deducing EOL electrical characteristics across a wide temperature range remains challenging. Consequently, this study explores a multi-domain model in which electrical characteristics vary in accordance with lifetime consumption.

The Society of Automotive Engineers of Japan (JSAE) has accepted a contribution-type research project to verify the correlation between detailed model-based simulations and the accuracy of the mounting board. For this project, a device utilizing an air valve actuator and a DC motor was selected as the test subject. Specifically, the bus capacitor following the booster circuit of the air valve drive was chosen for the multi-domain model (incorporating lifetime degradation effects). To prepare capacitor samples at various lifetime stages, endurance tests were conducted at 125 °C with a 50 V bias voltage. Currently, the endurance testing has reached 2,000 hours (the rated lifetime). Upon completion of the endurance tests and the test bench board, the degraded capacitors will be evaluated, and system simulation results using this multi-domain model will be compared with experimental data.

We explain the concept of the multi-domain model incorporating lifetime degradation, the methodology for linking electrical performance with lifetime consumption stages, and the current progress of the modeling.

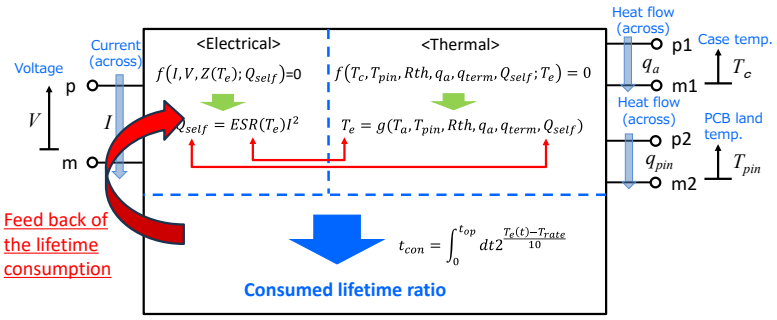


Fig.1 The multi-domain model incorporating the lifetime degradation effects