Modeling of flashover current on a solar array

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1. Background & Purpose

In recent years, charging and discharging accidents on the solar cell array of spacecraft are increasing due to the increase in size and power consumption of satellites. Therefore, it is necessary to conduct a ground test which realistically reproduces the discharge phenomenon occurring on such solar cell arrays.

In our previous studies, we found that the discharge plasma propagates concentrically and the plasma resistance of the discharge plasma varies with propagation.

In this research, we aim to simulate the flashover discharge phenomenon by electrically modeling discharge plasma characteristics from experimental results.

2. Flashover Discharge Test

Simulated coupons were created by arranging ring-shaped copper electrodes concentrically and applying an insulating tape on the surface. It was used to measure flashover discharge phenomenon due to discharge plasma propagating concentrically. The surface of the coupon was charged in a vacuum chamber, and discharge was generated only at the center of the coupon. Then, the flashover discharge current waveform and the surface potential before and after discharging were acquired.

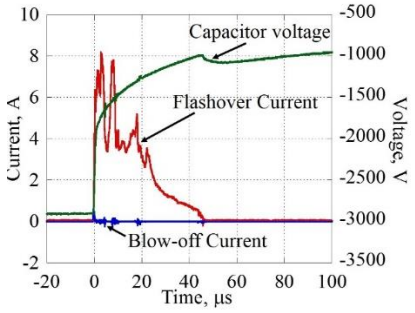

Figure 1. Typical flashover discharge current

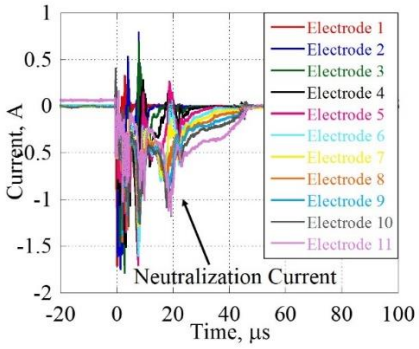

Figure 2. Neutralization current flowing to each electrode

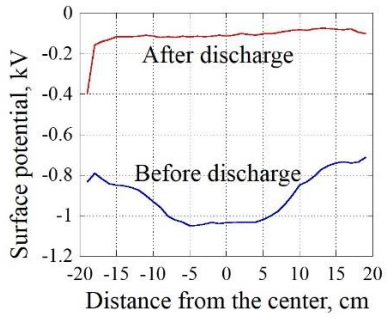

Figure 3. Surface potential before and after discharge

3. Flashover Discharge Analysis

From the measured neutralization current waveform and surface potential, the plasma resistance propagated immediately after discharge was calculated. As shown in Fig. 3, the plasma resistance to the neutralization current sharply decreased as the current increased.

Therefore, the parameters of plasma resistance used for simulation were obtained.

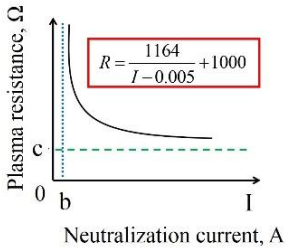

Figure 4. Discharge plasma resistance characteristics

4. Flashover Discharge Simulation

It is possible to approximate the charge amount, peak value, and duration of flashover discharge current to experimental values, using discharge plasma resistance characteristics and inductance characteristics obtained from experimental values. The neutralization ratio of the differential voltage is also the same as the experimental value, as the differential voltage increased, the neutralization ratio increased.

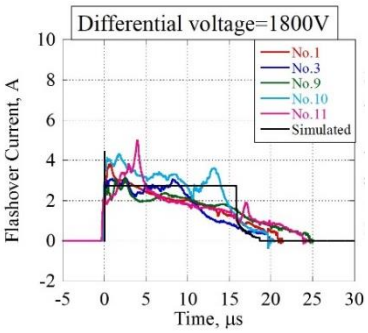

Figure 5. Simulation result of flashover current

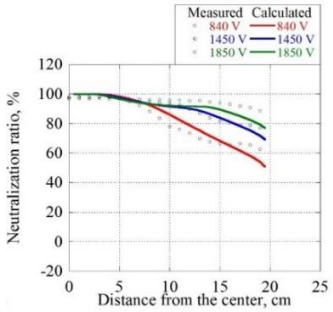

Figure 6. Simulation result of neutralization ratio

5. Conclusion

From the flashover discharge test using the ring coupon, the electrical characteristics of the discharge plasma were obtained in a simple way.

In the simulation results using discharge plasma characteristics and inductance characteristics, it was possible to approximate the charge amount, peak value, and duration of flashover discharge current to experimental values. The neutralization ratio of the differential voltage also showed the same characteristics as the experimental value.

6. Future Tasks

In order to simulate flashover discharge on large solar arrays in the future, it is necessary to evaluate the model by flashover discharge test using larger coupons and perform simulation using the model obtained in this research.