OAK RIDGE
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ORNL/TM-2004/246

TESTING OF THE SEMIKRON VALIDATION AIPM UNIT AT OAK RIDGE NATIONAL LABORATORY OCTOBER 2004

S. C. Nelson
C. W. Ayers
L. D. Marlino
Oak Ridge National Laboratory

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Engineering Science & Technology Division

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PURPOSE

This report documents the electrical tests performed on the Semikron high-voltage automotive integrated power module (AIPM) at Oak Ridge National Laboratory (ORNL). Testing was performed in the 100-hp dynamometer test cell at the National Transportation Research Center.

DESCRIPTION OF THE AIPM UNIT

The Semikron inverter is a validation unit developed for hybrid electric vehicle (HEV) traction drive applications. The AIPM was designed to operate with a maximum dc link voltage of 450 Vdc and a maximum continuous-rated phase current capability of 400 Arms. Its minimum and nominal dc link voltages are 200 and 325 Vdc, respectively. The inverter was constructed with 600-V, 400-A insulated gate bipolar transistors (IGBTs). It utilizes a CAN interface for communications and has integrated current sensors. The unit has over-current, over-voltage, and over-temperature protection.

As received at ORNL, the unit weighs 16.95 lbs (7.69 kg). It is rectangular in shape, but has irregular dimensions. The maximum length, including mounting flanges and hose connections, is 17.6 in. (449 mm). Excluding the mounting flanges and hose connections, the unit measures 16.1 in. (411 mm). The maximum width of is 8.2 in. (210 mm) and the minimal width is 7.2 in. (185 mm). The maximum height is about 4 in. (102 mm).

DESCRIPTION OF TESTS

Prior to shipping the AIPM unit to ORNL, Semikron performed an induction load test on the unit at their facility. The unit was supplied with 70ºC coolant during the 60-minute test. The dc link voltage was 400 Vdc with output phase currents of 332 A during the test.

The AIPM unit was visually inspected, measured, and weighed after the unit arrived at ORNL. The isolation between the input and output terminals (i.e., dc link and phase voltage terminals) was checked with a digital voltmeter prior to the testing. The minimal isolation was greater than one Mohm.

Testing of the AIPM unit was performed in the 100-hp dynamometer test cell at ORNL. Figure 1 shows a top view of the Semikron AIPM unit installed in the 100-hp dynamometer test cell. The Robicon dc power supply was used to supply dc voltage to AIPM unit. The Robicon dc power supply has a dc voltage output range of 10 to 600 V and a dc current capability of 0 to 600 A. A Solectria AC-55 induction motor was connected to the output of the AIPM unit. Figure 2 shows the Solectria motor and the 100-hp dynamometer. The Solectria motor is shown in the left side of the figure and is enclosed by a shroud for heat removal. Figure 3 shows the dynamometer control display panel located in the dynamometer control room.

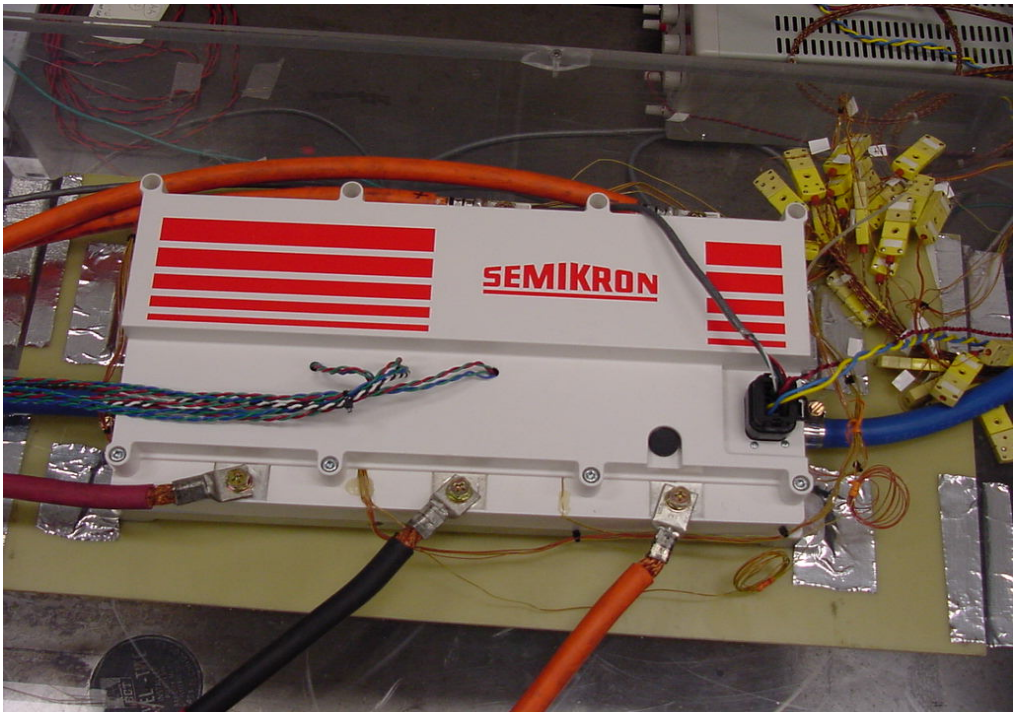

Fig. 1. Top view of Semikron AIPM unit.

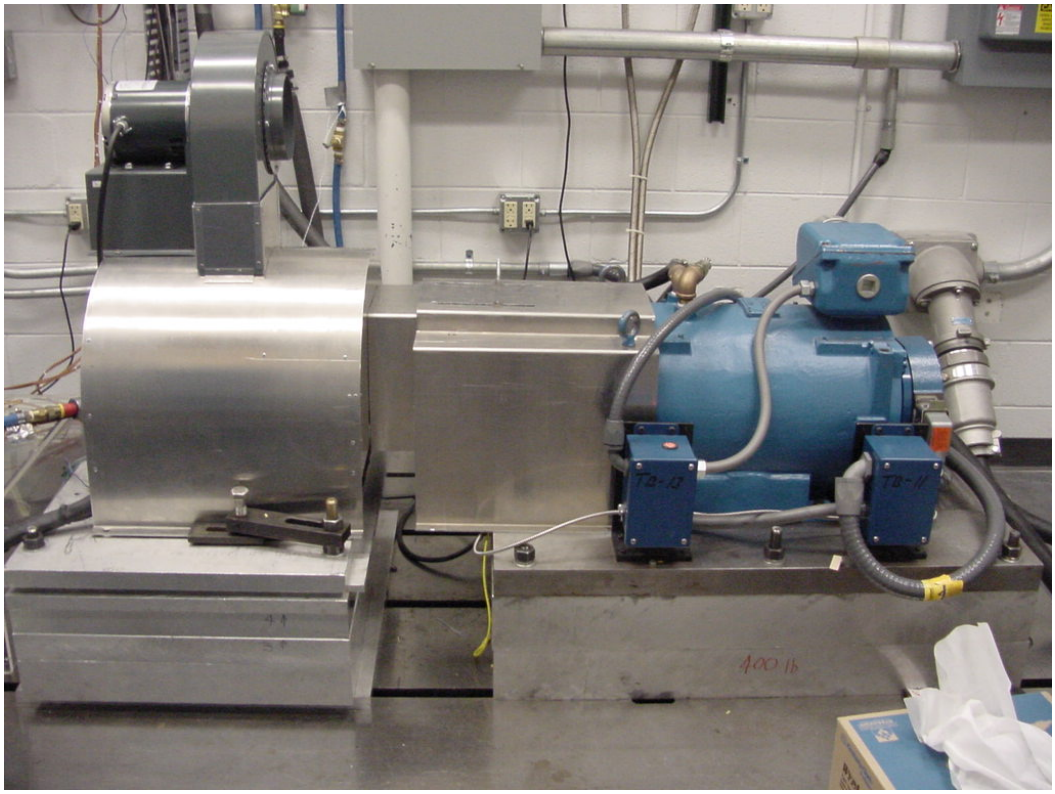

Fig. 2. Solectria motor and 100-hp dynamometer.

Fig. 3. Dynamometer controller display panel.

Testing of the unit at ORNL was initiated on October 4, 2004. The inverter was operated in the speed mode under no-load conditions. The dc link voltage to the inverter was 325 V with a dc link current limit of 100 A. The inverter was supplied with coolant at about 25 ºC at a flow rate of about 11 L/m. A target speed of 800 rpm was requested via the CAN bus controller with a resulting speed of 88 rpm being reached. The target speed was lowered to 100 rpm, and the actual speed obtained was 50 rpm. It was determined that the inverter did not exhibit sufficient stability in the speed mode. Figure 4 shows the AIPM unit in the background with the current sensors in the foreground. Figure 5 shows the AIPM CAN bus display. Figure 6 shows a view of the 100-hp dynamometer cell from the control room.

Testing of the inverter was continued with the mode of operation being changed to the torque mode. The dynamometer was used to drive the Solectria motor to the target speed (i.e., 500 rpm) with the inverter being operated in the torque mode to load the motor. The dc link voltage to the inverter was 325 V with a dc link current limit of 100 A. The unit was supplied with coolant at about 25ºC at a flow rate of 11 L/m. The CAN bus controller was set to torque mode with an ac current setting of 30 A and a torque of 5 Nm was obtained. The dc link and ac current limits were 90 and 100 A, respectively. The current setting in the CAN bus controller was increased to 50 A with a resulting torque of 5 Nm. The current setting was increased to 70 A with a resulting torque of 5.1 Nm. An over-current fault occurred with the AIPM unit simultaneously with a sound that appeared to originate in the dynamometer test cell. The inverter was checked after the fault event for damage and showed no apparent damage based on external measurements. The fault condition did not allow further testing. The unit was returned to Semikron to be repaired.

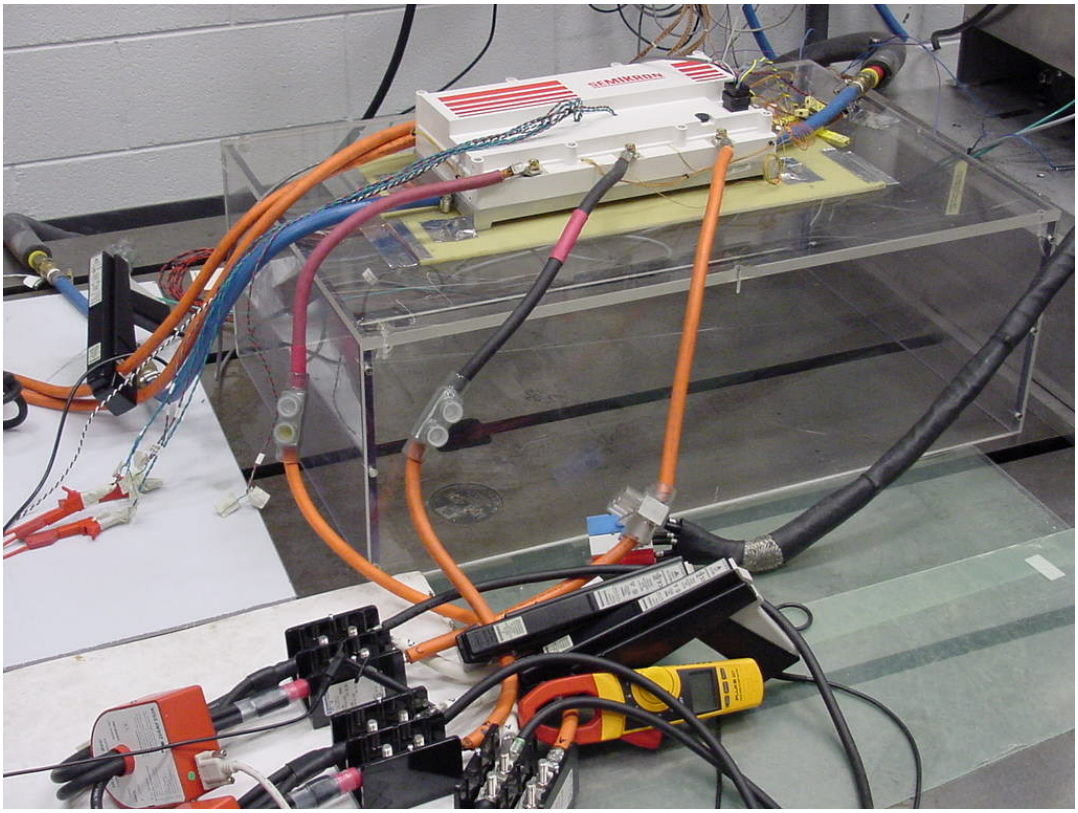

Fig. 4. AIPM unit and current sensor probes.

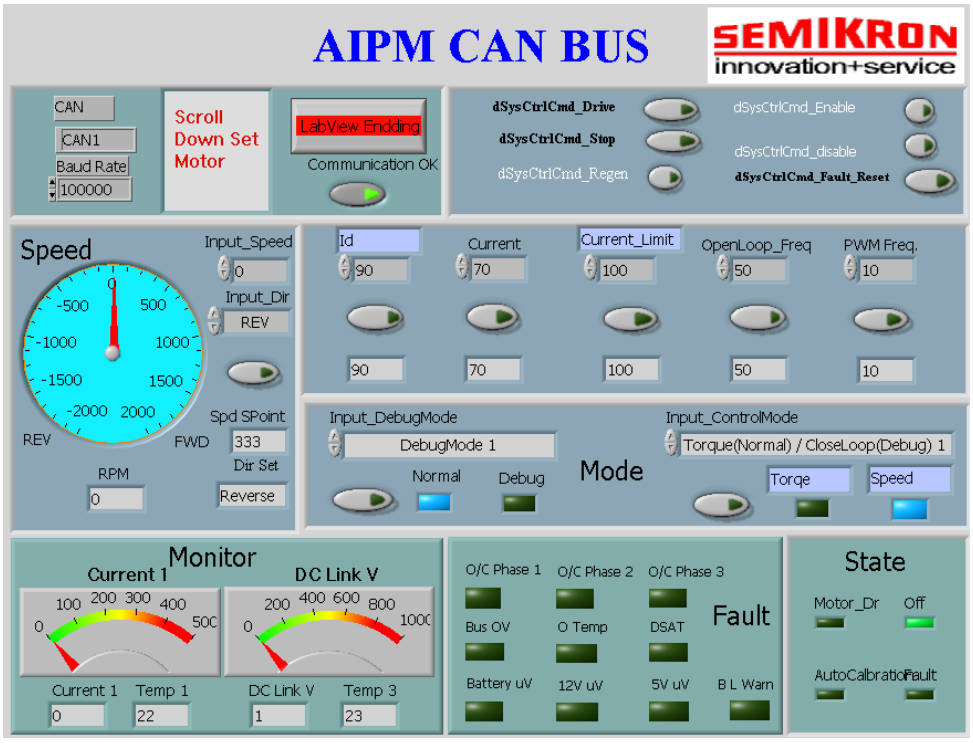

Fig. 5. AIPM CAN bus display.

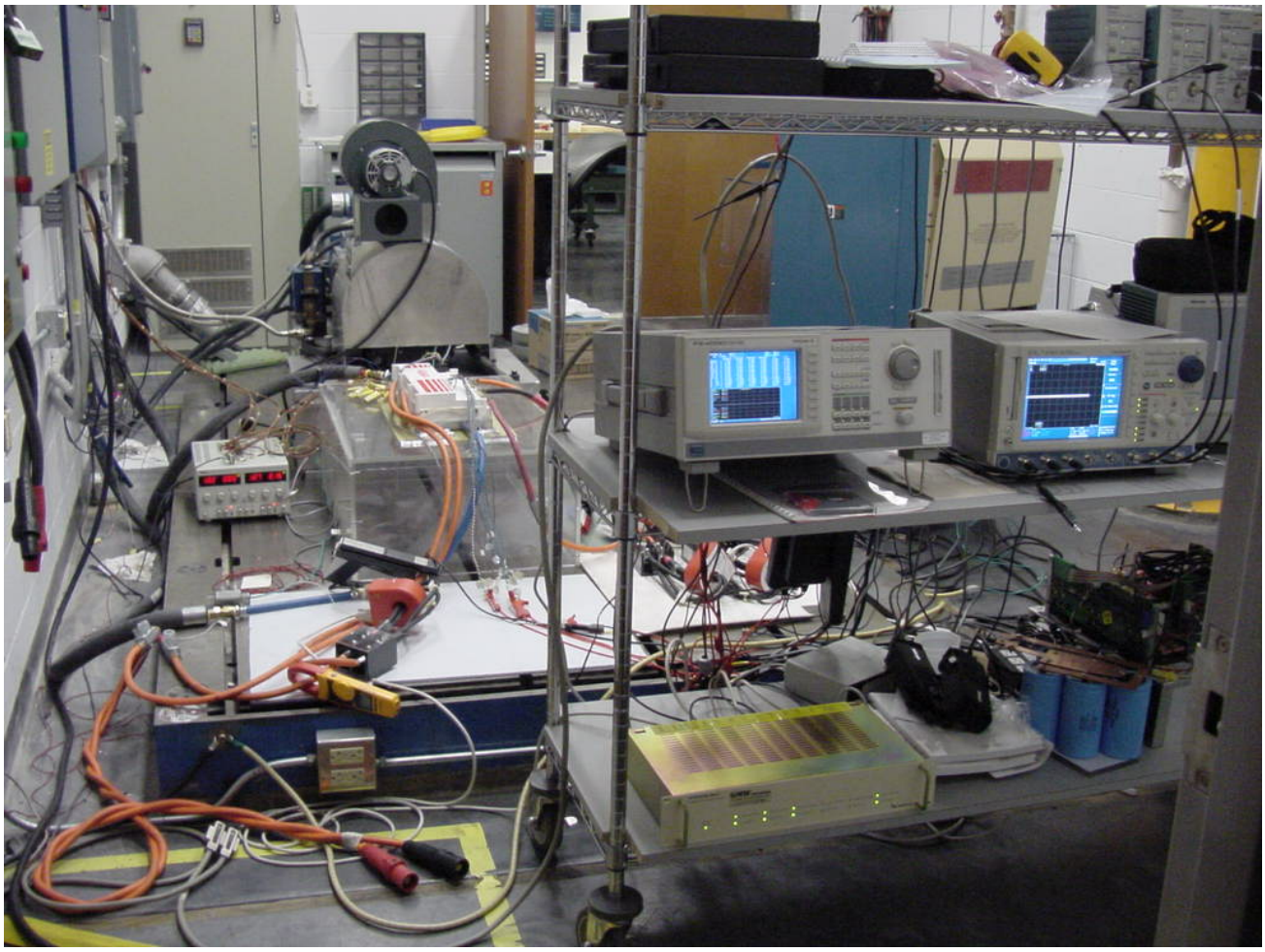

Fig. 6. View of dynamometer test cell from the control room.

CONCLUSION

The Semikron AIPM inverter operated for a short period of time before exhibiting fault conditions and subsequent failure. The inverter produced only limited torque when operated in the torque mode. Instability of the control system was observed during the testing as has been observed with previous Semikron inverters. The unit did not demonstrate ability to operate in the speed mode. A better control algorithm needs to be developed for the unit if any useful test data is to be obtained with dynamometer testing.

DISTRIBUTION

Internal

1. D. J. Adams
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7–8. Laboratory Records

External

9. S. A. Rogers, U.S. Department of Energy, EE-2G/Forrestal Building, 1000 Independence Avenue, S.W., Washington, D.C. 20585.
10. E. J. Wall, U.S. Department of Energy, EE-2G/Forrestal Building, 1000 Independence Avenue, S.W., Washington, D.C. 20585.