

Direct water-cooling of resistors on electronic circuit boards

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ABSTRACT

Electronic components mounted on printed circuit boards dissipate large amounts of heat that must be removed. This is often done by placing the board on a metal cold plate through which water is circulated. However, the cold plate adds weight and occupies a large volume, and the circuit board creates a large thermal resistance between the plate and the heat source. This study was done to directly water-cool a resistor on a circuit board without using a cold plate.

A wire arc spray system was used to directly deposit metal on a circuit board under the location of a heat-dissipating resistor. By spraying through a mask, surface features in the form of channels and pin fins were made on the board to enhance the heat transfer area. Experiments were done to measure the temperature of the resistor while cooling water was passed over the surface features in a channel that was 0.75 mm high. The water inlet and outlet temperatures were measured while the heat flux was varied from 5 to 75 W/cm² and the water flow rate varied from 0.1 L/min to 0.5 L/min. In some tests an aperture was cut in the circuit board to directly deposit metal on the resistor, further reducing the resistance. Pin fins, 0.75 mm in height, were the most effective in distributing water over the cooled area, reducing the resistor temperatures by up to 50°C. Adding pin fins reduced the thermal resistance between the resistor and the water from 3.46°C/W to 1.49°C/W. Providing an aperture in the circuit board decreased the resistance further to 1.06 °C/W.