



## Encapsulation Leads to Lower Cost, More Reliable Stepper Motor

### Benefits Achieved:

- Cost reduction
- Manufacturing cycle time improvement
- Reliability
- Elimination of potting issues (cure time, VOC, strength)
- Stack-up-tolerance reduction
- Thermal rise reductions
- Component elimination: Connector housing, connectors, circuit board, end bell

The Pacific Scientific division of Danaher Corporation utilized thermoplastic encapsulation a number of years ago to enable a step change improvement in the design of precise stepper motors. The concept brought together many of the functional advantages of thermoplastics to simplify manufacturing and reduce overall costs. Many of these design approaches were later integrated into Danaher's motors for the well-known Segway Human Transporter.

The encapsulated stepper motor integrated a number of previously separate components, eliminating pieces such as eight separate connectors, a circuit board, connector housing, and end bell. The integral plastic end bell allows the motor to run 30 degrees C cooler, which translated into the use of a significantly less expensive encoder. With bearings located directly off the stator, stack-up tolerances were significantly reduced. This is advantageous given the typical 0.003" air gaps at which Danaher manufactures these motors. Terminations utilize a set of fusion welded pins. With everything robustly contained in an encapsulated package, the motor has improved reliability.

Manufacturing advantages were also achieved. Whereas the previous potted motors required two hours of cure time, thermoplastic encapsulation allows overall cycle times of 45 seconds. Aside from the significant cost improvements this provides, it also enables a much smaller manufacturing footprint. Environmental issues were significantly improved with the elimination of volatile organic compounds (VOCs).