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Overmolding of Embedded Electronics

By Steve Burk

This look at overmolding embedded electronics addresses current technological capabilities and the choices available to designers.

Figure 1.
Custom-molded PCBA.

Overmolding embedded electronics is an expanding arena within the cable assembly industry. As input/output (I/O) connections in electronic devices become more compact and reduced in physical size, embedding electronic circuitry within the cable assembly becomes a cost-effective alternative to on-board electronics. Typically referred to as smart cables or dongles, these devices can be a challenging but fulfilling design approach, compared to alternative ways of packaging (see Figure 1).

Prior to the growth of the Personal Computer Memory Card International Association (PCMCIA) industry in the early 1990s, most insert molding of electronic devices was confined to embedding simple in-line resistors and diode networks within an overmolded connector body. Early pioneers in network and modem PCMCIA products had a need to provide off-card electronics with a cable passing through the printed circuit board assembly (PCBA) and connected to the card through a high-density connector (see Figure 2).

Figure 2. PCMCIA overmolded device.

The need for a robust and portable interconnect device provided the incentive for trying new design approaches to conventional packaging. Many of these devices evolved into overmolded products. This demonstrated the possibilities of overmolded designs and paved the way for a new generation of products.

Conventional enclosures, typically two-piece polycarbonate or ABS "clamshell" designs, remain a practical approach for many devices. These products are commonplace and, depending on the requirements of the designer, the most conventional solution. Design of the plastics and the injection molding of the individual piece parts is in line with industry standards, with choices available for both mold design and molding of the discreet parts. This look at embedded electronic circuitry addresses utilization of current technology capabilities and the choices available to designers of custom products.

Overmolding PCBAs

The aesthetic appeal of overmolded designs is probably the number one attraction. Tactile feel and functional ruggedness are significant advantages. Combined with the opportunity to improve functionality and reduce cost, this makes the approach very appealing.

Figure 3. Direct attachment to PCBA.

Let's look at a PCBA, integral to an interconnect cable, that adds functionality to an electronic design. The conventional way to fabricate this product is to create a two-piece enclosure to protect and hold the PCBA. Each cable, attached to either side of the device, has a discreet board-mount connector for cable attachment. In addition, a molded-on strain relief is required for the cable exit (see Figure 3).

With an overmolded design, the cable can be soldered directly to the PCBA, thereby eliminating both the material cost for the connector and labor for termination. In addition, for almost the same labor required for molding a strain relief on the cable, the entire PCBA can be overmolded. The cost advantages come from labor and material cost reductions. This combined with significantly reduced tooling cost and more rapid product introduction helps original equipment manufacturers (OEMs) to lower the initial cost of new product introduction and reduce the time required to complete the process.

Figure 4. Direct premold, prior to overmold.

Overmolding Advantages

In general, overmolding of a PCBA device is a practical approach when the size of the PCBA is no larger than 4 X 4 X 1" and it has a cable attached.

At this point, the real advantages of an overmolded design take hold:

- Reduced cost and lead time for tooling
- Elimination of connector for cable attachment to PCBA
- Improved strain relief for cable exit
- Durability and mechanical resistance to shock and vibration

- Environmental sealing of circuitry
- Security of internal devices
- Cosmetic and functional alternatives

Overmolding Disadvantages

Figure 5. Internal clamshell and overmold.

Size constraints and manufacturing process limitations are the two primary disadvantages of overmolding. When the physical size of the PCBA exceeds practical limits, the injection molding forces necessary to complete the mold cycle begin to cause mechanical failure of an unprotected board. Also, a sizeable increase in wall thickness is required for an internal clamshell. This adds weight to the device and creates the need for larger capacity injection molding equipment that is not typically used in the cable assembly overmold industry.

Process limitations, essentially the need to have the final assembly point be at the cable assembly company, may affect outsource plans. Considerations when outsourcing these types of designs are important, and there is a substantial learning curve for consistent overmolding design and execution.

While the equipment used is similar to that used in conventional molded cable assemblies, the compliance of PCBAs is very different than terminated connectors. The need to have closed-loop programmable logic controller (PLC) equipment is almost a prerequisite, as the molding profiles require a much closer tolerance for setup than connectors. Often times, cable assembly suppliers are not equipped to process sensitive electronic components in the assembly process, and may not have the required antistatic controls in place.

Direct Overmolding

Figure 6. Internal clamshell and PCBA.

Size and PCBA layout design are instrumental to whether it is possible to overmold directly over the PCBA. The heat and pressures associated with the overmolding process can be a detriment to certain through-hole and surface-mount components. While the temperatures of the injected polymers do not typically cause reflow of the solder, the mechanical forces present in the injection process can cause damage to either the components or their electrical integrity to the PCBA.

Depending on PCBA layout and volume, there are many material choices when developing direct overmolding solutions that may affect the final choice. Thermoplastic materials and some injectable epoxy resins are the most common. In general, small compact PCBA designs with all surface-mount components are good initial candidates for direct overmolding (see Figure 4).

Inner Clamshell Design

Figure 7. Overmold PCBA solution.

Depending on the PCBA layout and component structure, developing a design with an internal clamshell can eliminate many of the perceived and real obstacles associated with direct overmolding. This configuration can protect the PCBA and provide a consistent substrate for molding (see Figures 5 and 6).

The cost of the discreet clamshell is relatively low, as it is an internal part and can often be soft-tooled. The advantages of consistent wall thickness combined with the mechanical advantages for additions, such as light-emitting diode (LED) light

pipes, create an almost infinite array of possibilities for new products.

Conclusion

Conventional wisdom would seem to indicate that inserting an electronic device into a 30 ton molding press and injecting hot thermoplastic materials at 350°F and 400 psi would not be a wise choice. As the custom cable assembly industry matures and gains more experience in insert molding smaller high-density connectors and utilizing much improved control systems available in injection molding equipment, the capabilities to overmold electronic components are an added advantage (see Figure 7). While not a candidate for all applications, and not a good choice with all suppliers, the right combination makes for an unbeatable product.

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SPEC SHEET

End Applications:
PCB cable assemblies

Related Products:
Cables, connectors, PCBs

Main Point:
As the cable assembly industry matures and gains more experience in insert molding smaller high-density connectors and utilizes improved control systems in injection molding equipment, the capabilities to overmold electronic components become an added advantage. While overmolding is not a candidate for all applications, the right combination makes for an unbeatable product.

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