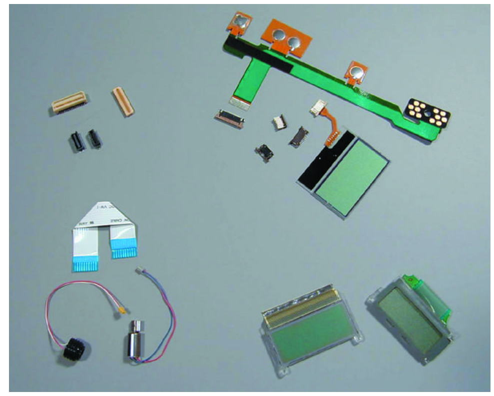
Making Wireless Wireless

While the electronic product packaging industry has changed drastically in the last 25 years, it is the past few years that have witnessed the greatest technological leaps. There are many reasons for these recent advances, but the root of them all can be summed up by the old adage: Necessity is the mother of invention.

Bill Jennings



Samples of older technology interconnects. Clockwise from upper right: board to board (BTB) connectors, flex films with zero insertion force (ZIF) connectors, heat seal connectors, ribbon cable and leaded components.

The modern marketplace has, and will continue to, force electronic packagers to push the technological envelope in their mechanical and electromechanical solutions. The sheer quantities associated with the consumer telecommunications industry have forced designers to develop complex systems capable of being robotically assembled. The increased use of electronic devices by the military and public service sectors requires designs that are extremely rugged and reliable, yet lightweight and low cost. Electronic devices used by the industrial market must meet the requirements of increasingly hostile operating environments. But most importantly, quality has become the greatest single concern and goal of the designers and producers of these products.

Quality

Quality manifests itself in many forms. Indeed, quality may truly be in the eye of the beholder. However, one undisputed sign of quality is a product that can be manufactured cost efficiently and consistently. Further, that product will function reliably in its operating environment and, in the unlikely event that it does experience a failure, will be easily disassembled and repaired. A product that meets these goals satisfies everyone's quality requirements: designer, manufacturer and end user.

In the quest to design higher quality electronic packages, one seemingly insignificant facet has received enormous attention and, consequently, made astounding progress. This component is encountered in the majority of all electronic packages, and usually more than once. It can have the greatest single impact on the ease of assembly and disassembly of the system. Likewise, it can make the difference between long-term system reliability and short-term field failure. In short, it can define the quality of the system. This facet is of course internal electrical interconnects. These devices are responsible for maintaining electrical continuity between multiple printed circuit boards (PCB), man machine interface (MMI) devices such as volume and push to talk (PTT) buttons, LCDs, speakers and microphones, just to name a few.

The present exploding electronics, and especially telecommunications, market will continue to present challenges to packaging engineers.

Interconnecting Solutions

Cellular products are one of the areas in which electrical interconnects have undergone an amazing evolution. The need to produce several million units of a given design per year necessitates cost-effective and reliable solutions for all internal electrical interconnects. Additionally, in the drive to minimize the overall volume of cellular terminals, subsequent internal interconnecting solutions have likewise been downsized. This reduction in system size also has a tightening effect on internal component tolerances. These tighter toerance requirements directly impact electrical interconnects.

In the early days, internal electrical interconnects were accommodated by individual wires or ribbon cables which were soldered to the discrete components – for example, two PCBs. Enough extra wire, called a service loop, was included to facilitate assembly (and disassembly if necessary) of the components into the mechanical assembly. This method can still be found on low-end, imported electronic products where quality measures are not as strict and labor costs are low (it's expensive to hand solder wires). This method is unheard of in today's high quality, high volume and low margin cellular industry.

Heat seal connectors are another method of electrically connecting components. Conductive printed traces are separated by dielectric similar to a flex film – each end includes an exposed area with a con-

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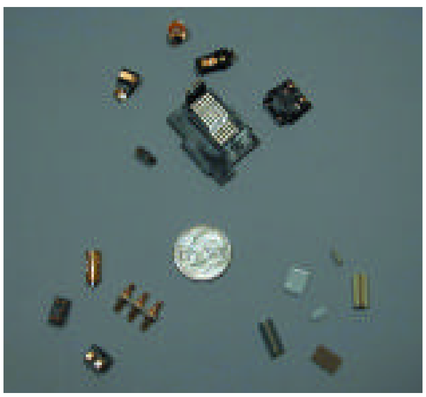
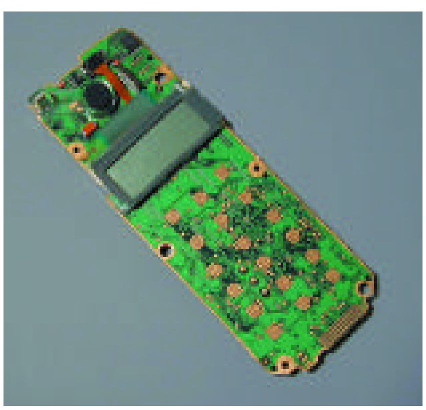
ductive temperature sensitive adhesive. Each end is then terminated to a mating trace array on a component. A typical application is connecting an LCD to a PCB. This method may be very effective provided that the components never need to be disassembled.

Flex films used in conjunction with low insertion force (LIF) or zero insertion force (ZIF) connectors can be very effective in providing relatively low cost and repeatable interconnect solutions. While assembly service loops may still be required, they are smaller and easier to accommodate then wires or ribbons. Further, the system can be completely disassembled by unmating the flex/connector union. However, flexes are sensitive to bending and can be problematic in terms of broken traces if not designed properly for the application.



Samples of advanced technology interconnects. Clockwise from top: formed metal and insert molded formed metal, elastomeric and pogo pin.



Populated PCB of a push to talk (PTT) radio developed in the mid nineties. Note the use of heat seal connector and flex/ZIF connector at the LCD. Additionally, there is an elastomeric connector at the upper left hand corner of the PCB, which is used to terminate a front cover mounted microphone. Thus we see new interconnect technology beginning to mingle with the old.

Surface mount, multi pin board to board (BTB) connectors are a cost-effective, volume efficient method of coupling components. A typical example is a multi band cellular terminal operating in both DAMPS and GSM and having two PCBs. It is not unusual to accommodate more than 50 circuits between two such boards. While the BTB connectors offer certain benefits, they are very unforgiving of tolerance – especially in the plane of the PCB (XY plane). As a result, careful consideration must be given to the design of the mechanical package regarding location and indexing of the PCBs. Basically, the PCBs will be located to each other by the BTB connector. Consequently, they must float in the XY plane relative to the associated mechanics. What do you do if you have multiple BTB connectors between the same two PCBs? You don't!

State-of-the-Art Interconnect Technologies

The above interconnecting solutions have various drawbacks regarding manufacturability and reliability. Some are cost prohibitive, while others do not facilitate disassembly. Certain approaches severely limit the accompanying mechanical package design, whereas some pose possible reliability issues. The following three technologies are considered state-of-the-art interconnects which are beginning to find widespread use in cellular terminals as well other electronic packaging applications.

Formed Metal Custom Connectors

Formed metal custom connectors have been around for some time; however, they are being used in greater numbers due to the high volumes and minimum space limitations imposed by modern cellular packages. Further, continuing enhancements in insert injection molding and associated secondary processing are making these connectors increasingly more viable. The use of computer aided engineering (CAE) software in the development stages of such connectors is enabling designers to minimize the size of these components without risk of premature stress or fatigue failure. Formed and heat treated beryllium copper, plated with nickel and then hard gold, provides an excellent mechanical and electrical contact. These contacts can either be insert molded or attached by a secondary process to an injection molded carrier. The entire assembly can be loaded into, or in some cases, molded directly into mechanical housings. Examples of this application include RF antenna and battery interfaces.

Ruggedized GSM push to talk/cellular hybrid radio recently developed for Ericsson, Inc. The design incorporates several state of the art internal electrical interconnecting components. The result is a highly manufacturable, reliable and rugged system.

Advanced interconnect technology components developed for the Ericsson, Inc. GSM rugged radio. Clockwise from top: Double acting pogo pins for speaker, pogo pin snap dome switches for front cover side and top rubber keys, internally/externally sealed pogo pin screws for the battery connection, elastomeric connector for the microphone, elastomeric connector for the LCD, and injection molded/formed metal contact connector and pogo pin connector for the system and remote antenna interfaces, respectively.

Elastomeric Connectors

Elastomeric connectors are a low-cost approach to maintaining continuity between components in minimum current applications. Sometimes called "zebra strips," these devices include layers of carbon particles interspersed with elastomeric material and electrically isolated by bands of elastomeric dielectric. It is imperative to follow the manufacturer's suggested dimensions for the connector, supporting structure and associated compression to assure success. With applications where several discrete circuits, and consequently a large elastomeric connector, are necessary, careful consideration of the required preloading force must be undertaken to ensure that the mechanical enclosure is capable of supporting the design. A popular application is terminating an LCD to a PCB.

Pogo Pin Connectors

Pogo pins are finding increasing favor in cellular applications. Small, reliable and extremely forgiving of X, Y and Z axis tolerance accumulation, they are the connector of choice in high-end electronic packaging. Easily incorporated into various mechanical injection molded housings and capable of carrying relatively high current, they are routinely used for speaker, microphone, battery, buzzer and vibrator applications. Further, some forward thinking designers have incorporated them into metal snap dome assemblies, resulting in highly manufacturable switch interfaces. Additionally, hybrid pogo pin connectors have been designed which are actually water-proof, providing an environmentally sealed interface to its mating counterpart.

Cellular Application

Nowhere is the use of cutting edge interconnecting technology more pronounced than in a recent product development effort headed by Stone Mountain, Ltd. — a Virginia based electronic product design and development company – for a ruggedized hybrid push to talk radio/cellular terminal. The product was developed for Ericsson Indelec, located in Bilbao, Spain, for the GSM European market. The system was designed to meet rigorous European military environmental requirements – including submersion, drop, shock, salt fog and humidity. While geared to an elite niche market, yearly quantities still required a reliable, cost-effective and highly manufacturable design. Stone Mountain was responsible for the overall mechanical conceptual design as well as the majority of the detail design and development. In this task, Stone Mountain exclusively used Unigraphics CAD and CAE software to develop more than 60 solid models and assemblies of the various components. A great deal of effort was devoted to the design and development of the numerous electrical interconnects, which needed to survive the rugged system operating environment and accommodate the strict "Z" axis assembly criteria imposed by the customer.

A custom elastomeric connector was developed to electrically connect the microphone to the PCB. The elastomeric is installed in a custom designed, removable injection molded housing which attaches to the PCB. Proper preloading and deflection of the connector is maintained by the close proximity of two unit assembly screws. Additionally, an elastomeric connector was developed to terminate the LCD to the PCB. This connector is housed in an integrally molded cavity in the LCD lightguide.

A formed metal connector attached to a custom designed injection molded carrier terminates the antenna to the PCB. Designed to maintain a 50-ohm impedance, the connector performs the dual role of acting as a switch for a remote antenna interface. The connector is robotically placed and soldered to the PCB. The spring material is beryllium copper overplated with nickel and hard gold.

Stone Mountain designed and developed three custom pogo pin connectors. An internally and externally sealed pogo pin/screw hybrid is used to electrically connect the external battery. The screw/pogo pin fastens the PCB to the die

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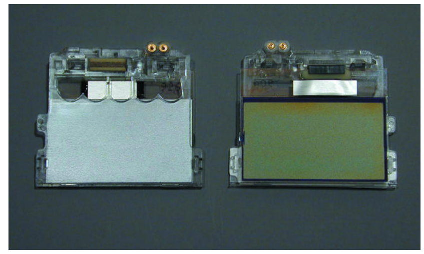

GSM radio LCD/lightguide assembly. The LCD elastomeric connector is visible in the left view. An integrally molded recess in the lightguide captivates the connector. The two double acting speaker pogo pin interconnects are likewise snap fit into the upper portion of the lightguide.

PCB and rear cover subassembly of GSM radio. Note LCD lightguide with integrally molded speaker pogo pin and LCD elastomeric connector captivation geometry (upper left and upper center, respectively, of lightguide). Directly above the lightguide are the two sealed screw/pogo pin battery interconnects. At the lower left corner of the PCB is the microphone elastomeric connector and molded housing.

Inside view of ruggedized GSM radio front cover. Note four custom designed snap dome pogo pin switches, used to interface to integrally molded rubber keys. The design facilitates Z-axis assembly while providing an extremely rugged and watertight enclosure.

Ruggedized GSM radio battery, rear cover assembly and PCB. The injection molded/formed metal system antenna connector is in the upper right corner of the PCB. The pogo pin remote antenna connector is in the upper right corner of the rear cover assembly. Also visible are the two sealed pogo pins for the battery contacts (directly below the remote antenna connector). The mating battery contacts are shown on the adjacent battery.

The use of computer aided engineering (CAE) software in the development stages of such connectors is enabling designers to minimize the size of these components without risk of premature stress or fatigue failure.

cast metal frame by threading into dielectric bushings. These pogo pin connectors maintain a watertight seal to two (2) meters of submergence. A double acting pogo pin was developed to terminate the speaker (fastened inside the front cover) to the PCB. These pogo pins snap into integrally molded cavities in the LCD lightguide. Perhaps the most innovative use of a pogo pin is found in the custom snap dome switches, used to maintain an electrical interface between the alert, push to talk (PTT) and volume adjust buttons. These buttons are actually integrally formed into the front cover during a two shot revolving platen rubber overmolding process. Each switch includes two pogo pin assemblies and a snap dome that is loaded into an injection molded carrier. This carrier includes two rib geometries that slide into mating channels integrally molded into the front cover. The pogo pins interface with gold pads on the PCB. The result is a watertight button arrangement that includes excellent tactile feel. And best of all, pure “Z” axis assembly.

The present exploding electronics, and especially telecommunications, market will continue to present challenges to packaging engineers. Ever increasing demands imposed by operating environments, miniaturization, produceability, reliability and, most of all, quality will require new advances in all aspects of electronic packaging. One area that continues to demand and reap the benefit of innovation is that of internal electrical interconnects. The increasing use of various CAD and CAE software during the design process is facilitating the technology advances that must occur to keep pace with this dynamic environment.

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