electronic design

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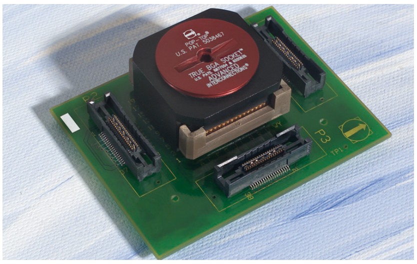
Get Yourself "Plugged In" To The Latest In Socketing Systems

With the proper sockets, you can anticipate and overcome a number of potentially troublesome and costly design issues early in the development cycle.

Electronic designers have long been familiar with using sockets as a fast and efficient method of reliably mounting (or removing in some cases) packaged electronic devices on pc boards. However, current state-of-the-art microelectronic device technology merits a fresh look at socketing.

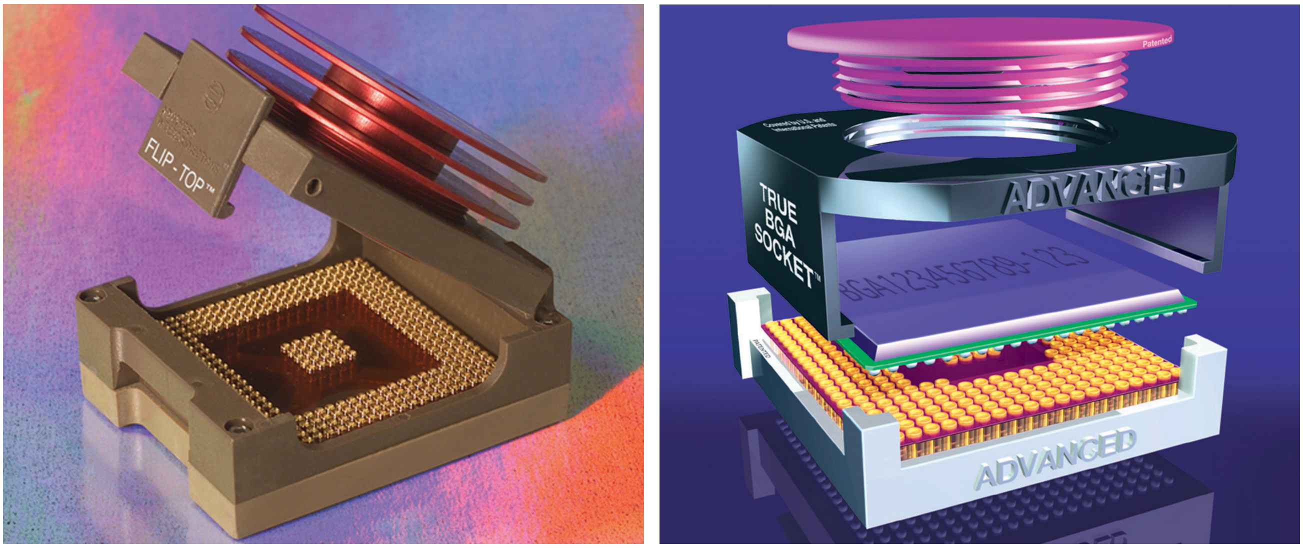
Other than speeding the production process, there are some major reasons for using sockets today. These include protecting sensitive components from physical damage and thermal shock while the motherboard is being assembled; protecting the motherboard itself when key components are installed or removed; facilitating device testing, emulation, and programming; and simplifying the replacement of failed devices on the assembly line, in the test lab, or in the field. Moreover, as the dollar value of vital electronic devices, such as microprocessors, continues to escalate with each succeeding generation, the technical and financial justifications for using sockets increase correspondingly.

Employing sockets like the one in Figure 1 gives designers novel opportunities to anticipate and overcome numerous potentially troublesome and costly design issues early in the development cycle, well before releasing a new circuit board or system to manufacturing. In many cases, resolving potential problems early means better-performing and more reliable products with fewer field failures and, consequently, fewer redesign and rework requirements.



1. Produced in a wide variety of sizes, form factors, and materials, today's socketing systems fit in a host of applications. For example, this test adapter pc board incorporates the True BGA socket from Advanced Interconnections Corp.

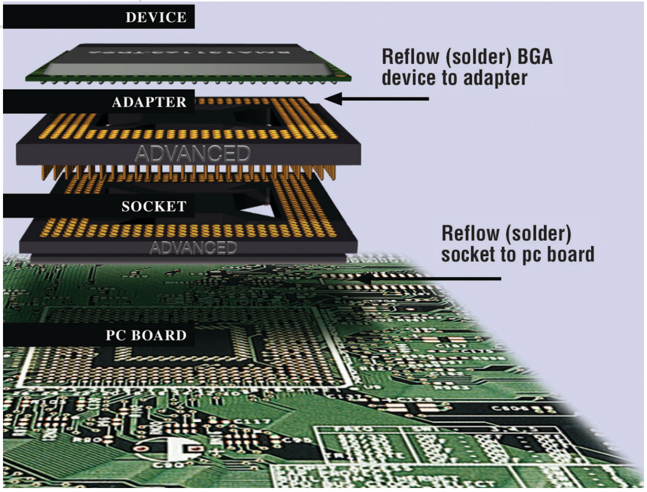
SOCKETS BOOST PRODUCTION EFFICIENCY • As electronic devices—especially high-reliability types—move from design through prototyping into production, there are critical points at which testing, emulation, and programming activities must occur to validate performance and quality and permit the device to function operationally. Sockets provide a fast and dependable means of temporarily mounting packaged devices onto test fixtures while minimizing or eliminating thermal or mechanical stresses (i.e., soldering, desol-



2. Two types of solderless socketing systems used to mount BGA devices to a circuit board are the Flip-Top (left) and the True BGA (right). They're used extensively in testing and emulation applications.

dering, package deformation, excessive handling, potential droppage, etc.) that could damage the devices *(Fig. 2)*. This benefit then carries over to subsequent assembly steps on the production line and ultimately to any field test/repair/upgrade activities that might be required during the service life of the device and its motherboard.

Using sockets can also have a positive impact on new-product-development timetables. Typically, electronic design and production activities involve various processes that must occur in parallel to maintain tight production schedules and maximize the efficient use of available resources. Often it's impractical to synchronize these processes so that they all reach "critical mass" at the same time. Thus, a ready-for-production motherboard design for a state-of-the-art computer system may be completed months before a new microprocessor chip, destined for the same computer, successfully exits the design-validation process. Under such circumstances, advance production of socketed motherboards will enable packaged chips to be inserted at a later date as soon as they become available.



3. This "exploded" view illustrates the various components of a soldered socketing system used to mount BGA devices to a circuit board.

Designing boards with sockets also affords other manufacturability benefits. For instance, many production lines use solder reflow to attach sockets to boards *(see "Build A Custom Board-To-Board Connector System Using Sockets," below)*. Sockets typically have a smaller mass than the device package to be mounted. This often significant reduction in mass helps simplify the process of profiling the reflow oven for optimal heat distribution, facilitates socket attachment, and reduces time in the oven. These factors yield payoffs in reduced energy costs and faster processing times.

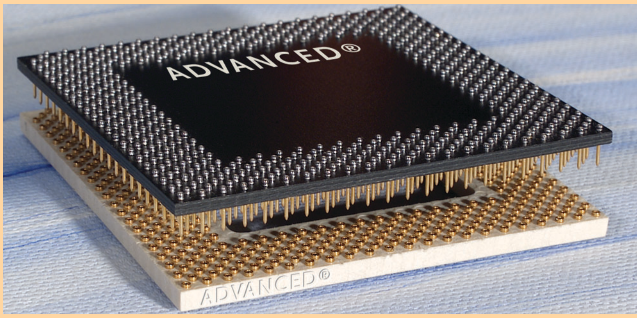
Another critical solder-related factor during initial board design is the anticipated strength of solder bonds retaining the sockets on the motherboard and the resulting influence on reliability for the service life of the board. Socket pins are frequently butt-soldered to pads on the motherboard. However, variations in the board's relative flatness (coplanarity) and the package to be mounted may cause the solder joints to vary in bond strength, as well as in resistance to shock and temperature cycling. One way to alleviate this problem is by specifying sockets that incorporate low-temperature eutectic solder-ball terminals, which yield stronger solder joints than typical pin-to-pad connections.

DESIGN CRITERIA FOR BOARDS WITH SOCKETS • In an ideal world, the socket

BUILD A CUSTOM BOARD-TO-BOARD CONNECTOR SYSTEM USING SOCKETS

A major automotive-electronics test-equipment manufacturer needed to overcome several design challenges involving stackable, socketed pc test boards employed by users to field-configure the manufacturer's rear-end and engine test systems. Initially, the manufacturer specified relatively complex and costly conventional FR-4 multilayer test boards with plated through-holes and high pin counts. Assembly was time consuming, board rejects were too high, and bad boards had to be scrapped. Especially troublesome was an intermittent electrical "open" problem. This was due to solder from the preforms used on an adapter in the upper through-hole board running too far down the extended-length male pins that plug into a socket on a lower pc board.

To solve these problems, we developed a custom surface-mount, interstitial pin-grid-array (PGA) socket-adapter system *(see the figure)*. This system employs a two-piece PGA connector consisting of a molded liquid crystal polymer (LCP) socket incorporating three-finger low-force, gold-plated beryllium copper contacts; and an FR-4 adapter with screw-machined, gold-plated brass pins. Both the socket and adapter use eutectic solder-ball terminals to provide secure joints.



The socket and adapter are reflow-soldered to the circuit board's surface-mount pads using solder balls. This alleviates the need for wave soldering, solves the electrical "open" problem previously caused by solder running down the through-hole pins, and permits boards to be reworked if necessary without scrapping them.

Using surface-mount PGA connectors to facilitate board-to-board connections lets the test-system manufacturer produce test boards with fewer layers, eliminate plated through-holes, simplify assembly, and reduce manufacturing costs. In addition, product reliability was enhanced and good-board yield increased by as much as 20% compared to the original production method.

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would be “transparent” in dimensional, electrical, mechanical, and thermal terms. In other words, the perception would be the same as if the packaged device were being mounted directly to the board. In the real world, however, the socket needs to be viewed in the same light as any other electronic component, with discrete dimensional, electrical, thermal, mechanical, and cost properties.

Understanding Dimensional Issues: Packaged electronic devices vary widely in configuration, size, and modes of attachment, as do the sockets associated with each package type. For illustrative purposes, Figure 3 details the various components of a soldered socketing system for mounting BGA devices to a circuit board *(for a closer look at BGA-packaged chip testing, see “Build A Socketed Chip Test-Fixture Board,” right)*.

When designing a new board configured from the outset to accommodate socket-mounted devices, the engineer must consider—jointly—a number of factors. These factors include the package and socket dimensions (i.e., combined footprint and height), the clearances required around and above the socket-mounted package for proper airflow and heatsinking, and general accessibility to allow for problem-free mounting or removal of the device.

But if the objective is to rework an existing motherboard design to retrofit sockets so as to facilitate the mounting of packaged devices, then other considerations bear attention. For instance, suppose the devices were previously soldered directly to pads on the motherboard. The footprint and height of the package, as formerly mounted, might be significantly less than the footprint and height of the same package when mounted in a socket.

This disparity will reduce the clearances around and above the socketed device to the point where it may be technically impractical to accomplish the retrofit unless the motherboard is completely redesigned. The redesign must ensure an adequate “keep away” zone around the device to permit proper airflow, heatsinking, and unobstructed mounting of the motherboard to a chassis.

Under such circumstances, the use of low-profile sockets with footprints identical to that of the packaged device may help minimize or eliminate any board-redesign requirements. In fact, even in the case of a new board design (where the installation of sockets is planned from the outset), low-profile sockets can save valuable board “real estate.”

Understanding Electrical Issues: When planning to mount an electronic device with a socket, it’s important that the socket interfere as little as possible with device signals. In the case of a low-speed device, the socket’s electrical properties may make minimal impact on signal processing, so using a socket may prove simple. If the device operates at very high speed, the socket might alter the signal path, impeding signals and adversely affecting the device’s functionality. This situation may call for the incorporation of additional electronic components into the motherboard design to preserve signal integrity. For board designers, this is key as it’s generally easier and more cost-effective to resolve component specification and placement issues early in the design cycle.

Understanding Mechanical Issues: Mechanically, sockets and socket-adapter systems must exert adequate force to retain the packaged device securely and ensure proper electrical contact with the motherboard. On the other hand, the physical force needed to mate the adapter to the socket (or to remove it) must be low enough to prevent distortion or damage to the device or the motherboard. Hence, it’s beneficial for designers to know the precise retentive qualities of a socketing system before specifying it. This will ensure that when the device is inserted, it won’t loosen when subjected to vibration or fit so snugly that attempts to remove it will possibly cause damage.

Equally important is the material and mode of construction of the socket contacts. For example, a screw-machined beryllium-copper contact with heavy gold plating will typically deliver more predictable and consistent mechanical and electrical performance than a stamped contact of the same material with thinner gold plating. Plated thickness is particularly important when dealing with test fixtures. Repeated insertion and extraction of adapters into a socket will eventually wear away the gold plating, changing the contact resistance and potentially skewing test results. So if the plating thickness is inadequate, the number of permissible insertion/extraction cycles may be reduced, which will necessitate replacing the socket itself more frequently.

BUILD A SOCKETED CHIP TEST-FIXTURE BOARD

Many new electronic devices, such as microprocessors, require testing at every step, from design to production. Conventional test-fixture designs often require that chip packages be soldered to adapters, which then plug into test sockets on the test fixture board. However, by adding a soldering step to the test process, this approach extends the overall test cycle time, slows throughput, requires tested chip packages to be “reballed,” and introduces the risk of thermal damage to the chips.

A test-equipment manufacturer needed help in accelerating BGA-packaged chip testing without having to solder the BGA package to the adapter. We produced a custom multilayer FR-4 test fixture board that incorporates a combination of three cable-to-board connectors to interface with the test system, along with an adaptation of an existing BGA socketing system into which the packages-under-test insert.

The BGA package to be tested is simply placed on top of the modified socket, covered with a support plate, and secured by a sliding clamp and coin screw. Optimal electrical continuity is ensured by spring-loaded beryllium copper contacts loaded in pogo pin terminals, the heads of which compress against the balls of the BGA package to create a gas-tight seal.

The redesigned test-fixture board employs surface-mount technologies. Vias are used to make required trace-to-trace connections between the various board layers, and the cable-to-board connectors are surface-mounted. All soldering of the test board can be accomplished in one step. The simplified mode of board construction ensures that the boards can be produced quickly for the test-equipment manufacturer at a reduced cost.

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Understanding Thermal Issues: To maintain optimal mechanical integrity and electrical performance throughout all temperature cycles, the designer should match the socket's temperature performance characteristics (i.e., thermal resistance, temperature stability, coefficient of expansion, melting point, etc.) to those of the package to be mounted. This will alleviate potential problems that may adversely affect heat dissipation, mean time before failure (MTBF), frequency of field repair, and consistency of lab simulations with actual field experiences *(for a birds-eye look at how socketing averted thermal problems with power converters, see "Mounting Power Converters On Printed-Circuit Boards With Sockets," below)*.

If, for example, the maximum operating temperature of a device package exceeds the maximum service temperature of the plastic used in the socket and adapter, either of the latter might deform or melt. Moreover, if the package has a different thermal coefficient of expansion than the socket and adapter, localized deformation problems, such as warpage, may result in the board or the package.

Understanding Cost Issues: Any time additional components are required in an electronic system, cost tradeoffs must occur. For example, if a motherboard or packaged device carries a low price tag, it's intuitive to treat them as disposable items. In such cases, specifying sockets would drive up production (and selling) costs unnecessarily without improving the product. However, sockets will more than justify the added cost of incorporating them into the design if the board or device carries a high value or if the development/test/emulation/assembly process must be accelerated. This is true too if the device must be field-programmed before mounting to the motherboard or the board and device is to undergo field-testing, repairs, and upgrades. ED **ED Online 7840**

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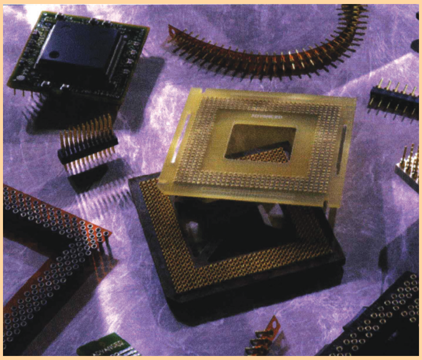
MOUNTING POWER CONVERTERS ON PRINTED-CIRCUIT BOARDS WITH SOCKETS

High-value pc boards, used in mainframe computers, automatic test equipment, industrial control systems, and telecommunications systems, frequently incorporate single or multiple ac-dc or dc-dc converters, power supplies, and battery packs. During assembly, conventional approaches to mounting the converters involve soldering them to the pc board using wave or reflow techniques. However, power converters can be relatively bulky with considerable thermal mass, causing them to act like large heatsinks.

Therefore, board makers must compensate by extending thermal exposure times to complete the soldering operation. This lengthens production cycles, boosts energy usage, and drives up board-assembly costs. Moreover, if boards with conventional soldered-on converters fail in the field, repair is often time-consuming and costly.

On the other hand, if designers specify sockets for mounting these large devices, they can simplify assembly, shorten production time, cut energy costs, and facilitate field rework and repair operations. For example, Advanced Interconnections has employed a peel-away socket carrier to alleviate the above converter mounting problems *(see the figure)*. This approach also works well for mounting other large and/or heat-sensitive components such as battery packs.



Each socket carrier consists of a flexible yet stable, transparent polyimide carrier film that incorporates an array of low-profile (0.15-in. [0.38-mm] installed) socket terminals. These terminals match the footprint and pin pattern of the converter to be mounted. Screw-machined terminals with beryllium copper contacts can handle the heavy amperage requirements of the power-conversion devices.

The socket carrier aligns precisely to the board's mating surface every time. It also ensures that all sockets are vertical to the plane of the board before soldering to allow for proper insertion of the converter's contact pins. Because it has only a fraction of the thermal mass of the power converter, the socket carrier can be soldered more quickly and economically by wave or oven reflow. Another advantage is that the socket carrier lets multiple sockets be installed faster and more easily than individual loose sockets, which must be positioned and soldered individually.

Once the terminals are installed on the circuit board, the converter mounts quickly and securely without soldering by pressing its contact pins into the terminals. If a converter ever needs field replacement, the failed unit can simply be withdrawn from the socket and a replacement plugged in. This minimizes system downtime, safeguards the circuit board from damage during repair, and reduces the need to stock costly spare boards. **ED Online 7839**