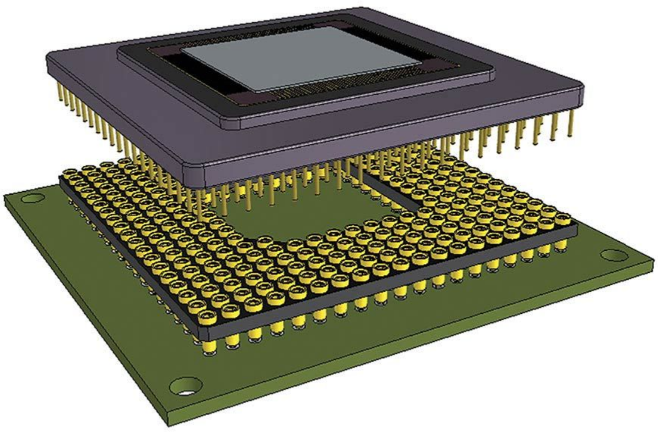
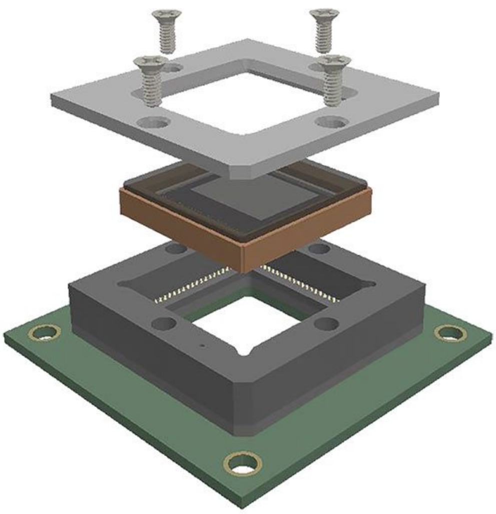
Image Sensor Sockets: A Key Factor in Camera Design

The proliferation of valuable high-resolution, high-speed, and 3D image sensors makes the use of sockets an increasingly important factor in camera development.

Camera makers — and, therefore, image sensor makers — today are under greater pressure than ever to offer new models that provide higher resolution and higher speed, respectively. With higher resolution comes sharper images. With higher speed, comes the ability to capture moving images with greater clarity than ever before.



The relatively high value of larger image sensors in PGA (pin grid array) or µPGA packages, as well as the ability to surface-mount these thru-hole packages, makes the use of sockets a compelling value proposition. Courtesy of Andon Electronics Corp.



The high value of larger image sensors in LGA (land grid array) or BGA (ball grid array) packages, as well as the ability to thru-hole mount these surface-mount packages, also makes the use of sockets a compelling value proposition. Courtesy of Andon Electronics Corp.

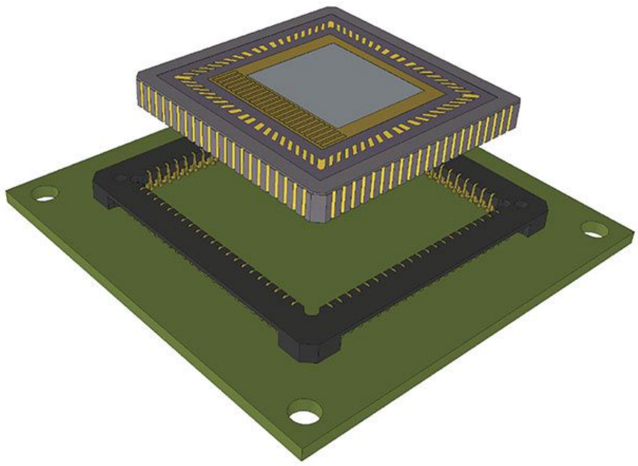
Meanwhile, the demand for 3D imaging — especially for medical imaging, industrial quality control, and time-of-flight applications — is growing rapidly, with compound annual growth rates projected to exceed 20% over the next 5 to 7 years, according to numerous market research sources. 3D imaging provides depth of field and enables the ability to rotate images in space — attributes that are highly valued for a wide variety of applications.

Protecting valuable image sensors

Traditionally, image sensors were soldered directly to the printed circuit board (PCB) behind the lens of the camera. The solder was composed of an alloy consisting of 63% tin and 37% lead. The melting temperature of this tin-lead alloy was 183 ºC.

With the European Union's 2006 implementation of the Restriction of Hazardous Substances (RoHS) Directive, which restricted the use of lead and other hazardous substances in the manufacture of various types of electronic equipment, the allowable amount of lead in solder changed to virtually none. Tin-lead was replaced with tin-silver-copper. The melting temperature of this new mixture increased from 183 to 217 ºC. Soldering protocols were adjusted accordingly.

Consequently, camera makers observed a rising incidence of solder-related damage to the color array, as well as solder joint cracking and the associated intermittency attributable to differences in the coefficient of linear thermal expansion of the device and the PCB material. The more valuable the device, the more impactful, and — therefore — the more intolerable, the yield losses are.

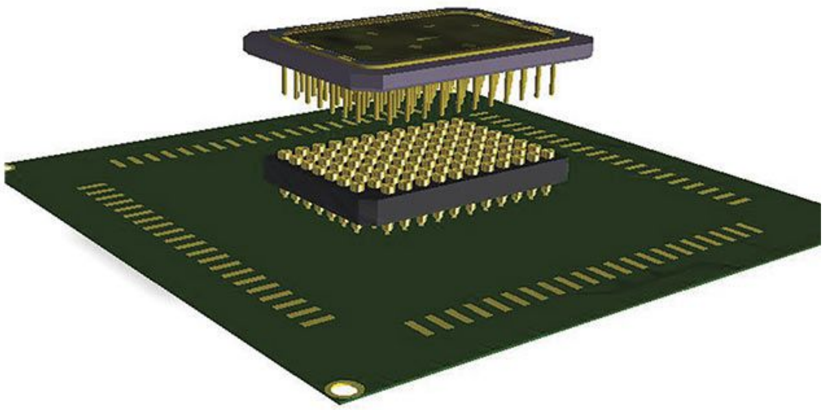


An LCC (leadless chip carrier) socket that captures the package by its metalized castellations can hold the device in true position even under high shock and vibration — despite the low insertion force. Courtesy of Andon Electronics Corp.

High resolution, high speed, and 3D imaging are features that increase the value — and the cost — of related image sensors. Not surprisingly, protecting these valuable image sensors against damage during the production of the electronics within the camera is of increasing concern in camera hardware design, especially for the more sophisticated cameras used in industrial (e.g., machine vision), aerospace, defense and homeland security, scientific, and medical/life science applications. In contrast, avoiding yield losses for the relatively low-cost image sensors used in cameras for consumer (e.g., smartphones), automotive, and home and office applications has not been a significant concern.

Solution: image sensor sockets

Production sockets have been used for decades in a variety of electronic products. Depending on the cost of the socket compared to the cost of the device, socketing has been widely regarded as a cost-effective way to circumvent the device damage and solder joint cracking associated with soldering the device directly to the PCB. Instead, the socket — not the device — is soldered directly to the PCB. Then the device is inserted into the socket. Sockets have, in some applications, had the additional advantage of facilitating field replacement of the device. They enable the user to simply remove the device from the socket and plug in a new one — without having to remove the entire PCB, desolder the device (and risk damaging the device in the process), and then solder a new device to the PCB.



Rapid advancement of hyperspectral sensors is driving the use of sockets for easy replacement of earlier sensor models. Courtesy of Andon Electronics Corp.

Sockets have been a popular option for decades for integrated circuits with rectangular dual in-line packages (DIPs) on 0.100-in. (2.54 mm) pitch. With the emergence of personal computers, sockets have likewise been used regularly for the associated microprocessors (e.g., Intel i486, Motorola 68030, and Advanced Micro Devices Am386) housed in square pin grid array (PGA) packages with the same 0.100-in. pitch. Meanwhile, round sockets have been regularly used for transistors packaged in transistor cans with a standard array of transistor outline packages (e.g., TO-3, TO-5, and TO-39), as well as in oil logging applications.

Until about five years ago, adoption of image sensor sockets among camera makers was relatively modest. In general, field replacement of the image sensor in a camera is not nearly as compelling a proposition as field replacement of a microprocessor in a personal computer. As long as camera manufacturers (and, when applicable, their electronics manufacturing services providers) could solder the image sensor without damaging it or getting an intermittent connection, they typically were not compelled to add the cost of a socket to the bill of material.

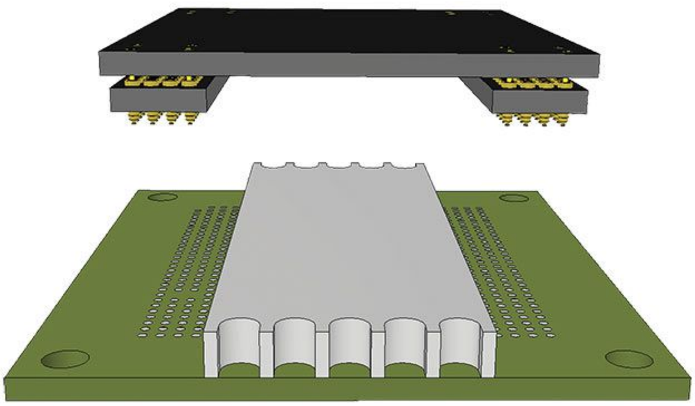
However, key developments in the last half decade have triggered a surge in demand for image sensor sockets. Foremost among them has been a growing understanding of the connection between RoHS-influenced solder temperature elevation and the associated device damage and solder joint cracking. To some degree, this growing understanding was inevitable as more time passed since the implementation of the RoHS Directive. To a greater degree, perhaps, this understanding was catalyzed by the missionary work performed by Andon Electronics, the inventor of image sensor sockets. Other key developments include the proliferation of increasingly valuable image sensors, yielding a more compelling return-on-investment case; as well as the growth of surface-mount technology — driving the surface-mounting of image sensors in thru-hole packages in order to save space and avoid performing two separate soldering processes for surface-mount and thru-hole devices.

Another key driver is the significant increase in image sensor lead times, prompting many manufacturers to solder the sockets to the PCB before the image sensors arrive — for faster turnaround. Also, users of hyperspectral cameras are benefiting from the ability to upgrade and replace the image sensor with ease. And, in the case of high-speed image sensors, combining the benefits of a socket and a heat sink into a single solution is an effective way to avoid the power and space required for a thermoelectric cooler.

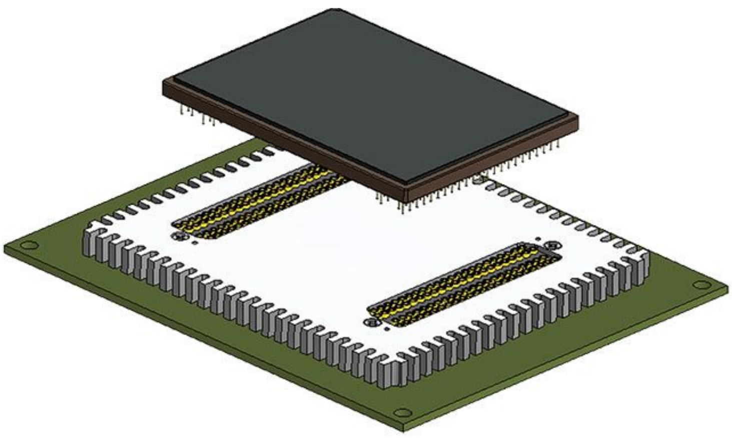
Sensor-socket compatibility is key

Those developing new cameras would be wise to engage the socket supplier as early as possible in the camera design and development process. Socketability may very well influence one's choice of image sensor package. Holding interactive discussions simultaneously with both the image sensor maker and the socket maker is prudent. If the plan is to use a preexisting image sensor model, one should access a cross-reference to the compatible socket. If the plan is to use a newly developed image sensor, one should provide the socket maker with a device package outline drawing; the socket maker should then reverse engineer it to create a socket drawing and a 3D model showing the image sensor in the socket.

The socket selected can have an influence on the camera design in a number of ways. Adding a socket to a device adds to the location of the device in the z-axis, which affects focal length. The socket height can influence one or more of the outside dimensions of the camera. Furthermore, if a thru-hole socket is used, the imager board must have plated thru holes, and if a surface-mount socket is used, the top surface of the imager board must have solder pads.



Using a rigid 'carrier' provides fast, accurate loading of individual pins or separate socket sections while bypassing a heat sink or other components already mounted on the printed circuit board.



This patented Heat Sink Socket™ avoids solder-related device damage while providing a power- and space-saving way to dissipate heat and noise — solving two problems at once.

A land grid array (LGA) package can be socketed in one of two ways: 1) Solder the LGA package to the top of an adapter, solder a thru-hole or surface-mount PGA socket to the imager board, and then insert the terminals at the bottom of the adapter into the contacts of the PGA socket below; or 2) Solder a thru-hole or surface-mount LGA socket to the imager board, drop the LGA package into the guide layer of this multilayer LGA socket, put a cover over the socket, and secure the cover with screws. If the LGA (versus a PGA) socket approach is selected, the length, width, and height of the socket is greater than that of the device, which in turn affects the device height (hence, the focal length), the amount of available room for the placement of other devices on the imager board, and the outside dimensions of the camera.

The selection of the package — for example, PGA, µPGA, LGA/BGA (ball grid array), or LCC (leadless chip carrier) — influences the overall socket design, which in turn influences the insertion and withdrawal force required by the image sensor on the socket. Sockets for PGA packages require the highest insertion force, followed by sockets for LGA/BGA packages, followed by sockets for LCC packages. In the case of LCC packages, whether a socket is used can influence the PCB footprint. The location at which the LCC socket makes contact with the PCB may differ from the location at which the device, alone, would contact the PCB.

Important Criteria for Selecting a Socket Source

When selecting an image sensor socket source, consider the following:

• How many years of experience does the source have in designing and producing image sensor sockets, in particular with pitches as tight as 0.032 in. (0.8 mm) for land grid array (LGA) and leadless chip carrier (LCC) sockets, and 0.039 in. (1 mm) for pin grid array (PGA) sockets?

• Does the source have socket cross- references to all the major image sensor brands used in industrial, aerospace, defense, scientific, and medical/life science applications — for example, Gpixel, Sony, ams (formerly CMOSIS), ON Semiconductor, Teledyne e2v, Canon, BAE Systems (formerly Fairchild Imaging), and Luxima Technology?

• Does the source have the endorsement of, and a close working relationship with, the leading image sensor makers?

• Does the source have sockets available for PGA, µPGA, LGA/BGA (ball grid array), LCC, and dual in-line packages?

• Does the source offer both thru-hole and surface-mount terminal options?

• Does the source offer a terminal option that is specially designed for high-shock and high-vibration applications?

• Does the source offer a solution that delivers individual socket pins, or separate sockets, on a firm carrier — for fast, accurate loading in low-profile environments, or environments in which a socket insulator would interfere with a heat sink or other devices already on the printed circuit board?

• Does the source offer sockets that provide heat and noise dissipation, without the power or space required by thermoelectric coolers?

• Does the source offer a low insertion force socket for high-pin-count µPGA packages with 0.050-in. (1.27-mm) pitch?

• Does the source use high-speed methods, tools, and machines for loading plated contacts into plated terminals?

• Does the source use high-speed methods, tools, and machines for loading plated terminal assemblies into socket insulators?

• Does the source have long-established relationships with image sensor socket raw material suppliers?

• Is the manufacturing facility ISO9001:2015 certified?

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