IC Socket – Selection Criteria

Many products are designed with today's high-performance Integrated Circuits (IC). Without IC sockets, the design, testing, and/or production phases of a new product development process will be chaotic. In response to these demanding needs, sockets featuring a wide variety of contacting methods, form factors, and mounting techniques were developed. High-performance applications require the smallest possible socket form factor to place related components in close proximity to the device pads. As devices with finer pitch, larger I/O counts, and increased gate densities are utilized, the requirements for sockets continue to increase accordingly. These place extreme demand on shortened contact lengths and to integrate controlled impedance geometries into the contact.

Testing can be classified into two categories – IC (Integrated Circuit) level and System level. IC level testing involves evaluating the life and performance of IC devices such as Microprocessors, Microcontrollers, ASICs, and Chipsets. System level testing involves evaluating the functional application of those devices under different environments. Both kinds of testing need different sets of criteria for validating the final product. The function of a socket is to provide a connection mechanism from the IC to the circuit board with as little electrical load as possible. This allows the IC to function as it is soldered into the PCB (printed circuit board) but can be replaced by another IC to upgrade or test multiple IC's.

Figure 1: Clamshell BGA Socket using stamped spring pin contact.

The IC socket (Figure 1) plays a major role in determining whether the device met design intent or not. Because of this criterion, the IC socket has to be carefully selected. The number one factor is bandwidth specified in terms of frequency. Because the IC has to perform certain functions at specific speed, the signal loss has to be minimal. Since additional socket interface is introduced in the signal loop, either the socket has to have sufficient bandwidth to pass signal without insertion/return losses or the socket specifics has to be de-embedded in the functional verification. Since it is very complex to de-embed specific parameter, safer solution is to find a socket with higher bandwidth.

Socket bandwidth is correlated from scattering parameter which is an insertion loss curve over a frequency range. An insertion loss measurement using vector network analyzer for the frequency range interested typically provides at what frequency -1dB is crossed. For example, a micro pin-socket interface's bandwidth is 20GHz. Insertion loss of -1dB @ 20GHz is interpreted as 90% of signal pass through the interconnect medium and only 10% of signal is lost through the interconnect transition at 20GHz frequency. This is very critical for the test engineer as the device functionality is being verified at the specific frequency.

Next to bandwidth, DC series resistance plays an important role. Socket technology that can provide low and consistent contact resistance is preferable to avoid false failures. When the signal path is highly resistive, certain functional test may fail. Force, Compliance and Resistance are interrelated to each other. Because the devices have wide co-planarity, the contact technology chosen has to accommodate the flatness variations of devices through the "compliance" variable. Force is directly proportional to compliance and inversely proportional to resistance. Based on the device flatness, certain compliance of contact is needed. This results in needed force and resistance factor. On the contrary, a low resistance requirement can drive the needed force and available compliance.

The next factor is current carrying capability. An image sensor may require a low current such as 100mA to 200mA per ball whereas a power management device may require 3A to 5A per ball. When the current is passed through a contact, temperature rise can be observed. Typically a contact's current capacity is specified as 3A continuous at 20C rise. Socket contact technology that accommodates this requirement has to be selected properly.

Another factor plays significant role in IC testing is temperature requirement. In the characterization test, a typical IC goes through extreme temperature range. Socket contact that operates in the wide temperature range is critical for the successful test. Last, but not least is the life cycle of the socket. It is specified in terms of the number of ICs that can be tested in a particular socket without degradation. This is a tricky one as the environment and other combination factors determine the true life cycle due to normal wear as well as due to the cleaning frequencies.

Socket Technologies	Bandwidth (GHz) -1dB insertion loss	Life Cycle (# of insertions)	Operating Temeprature (deg C)	Continuous current capacity (A) @<20C rise	Avg Contact resistance (mOhms)	Force per pin (g)
Embedded wire elastomer 0.75mm thick	27	2K	-35 to +100	2	25	35
Embedded wire elastomer 0.5mm thick	30.5	2K	-35 to +100	2	25	35

Embedded wire elastomer 0.25mm thick	>40	2K	-35 to +100	2	30	35
Stamped spring contact 0.4mm pitch	31.7	50K	-55 to +180	1.5	35	17
Stamped spring contact 0.5mm pitch	15.7	500K	-55 to +180	3	35	31
Stamped spring contact 1mm pitch	21.9	500K	-55 to +180	4	35	19
Silver particle elastomer	>40	1K	-55 to +155	4	30	70
Silver particle elastomer with protective overlay	40	500K	-55 to +155	4	30	70
Silver button elastomer	75	1K	-55 to +160	5	30	70

Various socket contact technologies (Table 1) available in today's market include embedded wire-on elastomer, silver particle elastomer, plated flex circuit capped elastomer, gold plated diamond particle interconnects, stamped contacts, spring contacts, hybrid contacts, and other variations. Also socket features such as small footprint, easy chip replacement, easy mounting methodology, moving socket from board-to-board and low cost are the factors to be considered before finalizing a socket for IC testing.

A single contact technology cannot satisfy all requirements for IC testing throughout its life cycle. Selecting a socket that has replaceable modules of different contact technologies to accommodate all the test requirements of IC life cycle is a fruitful solution. Socket footprint defines component proximity to IC. Series resistors, capacitors, tuning inductors and others need to be placed minimal distance from IC in GHz applications. Also socket footprint standardization will pave way for overall low cost of test per IC.

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