Surface Mounting of Interface Connectors

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Abstract

Surface mounting of edge-mounted connectors to increase the input and output density of a system or a sub-system is growing as faster speeds and transmissions are required. Resources have been channeled to develop various requirements pertaining to the design and processing of surface mount edge-mounted connectors. This paper summarizes some of the key developments in relation to the evolution of the hard disk drive design.

Key words: Surface Mount, Connectors, Interface Standards

Introduction

Printed circuit board (PCB) connectors can be broadly classified into internal connectors and interface connectors. Mounted on the internal area of the PCB, internal connectors include sockets for integrated circuits and flexible printed circuits, headers for systems configurations and receptacles for board-to-board stacking. To meet the increasing constraints of PCB space, such connectors are designed to be fine pitch and surface mountable using standard pick and place equipment found in surface mount reflow PCB assembly lines.

Interface connectors on the other hand are mounted on the peripheral of the PCB. Such connectors are typically long and bulky and difficult to be handled by automated equipment in a PCB assembly line. Interface connectors are also called input/output (I/O) connectors since they carry signals into and out of a system or subsystem, usually for the transmission of data between a computer and a peripheral device like a hard disk drive.

Hard Disk Drives

A hard disk drive (HDD) allows data to be stored and retrieved by a microprocessor. It is the primary computer storage medium, which is made of one or more aluminum or glass platters.
Disk drives can be divided into magnetic rigid disk drives, flexible disk drives, and optical disk drives. Since most of the volumes are in the magnetic rigid disk drives segment, we refer to the magnetic rigid disk drive market as the HDD market. It is a highly competitive market. Seagate and Quantum are the two largest producers in the world, dominating 55% of the total world output. Magnetic rigid disk drives shipments totaled 89 million drives in 1995, with a forecasted shipment volumes of 104 million drives in 1996. Seagate has its own captive PCBA facility in Singapore and Malaysia while Quantum has a partnership with Matsushita Kotobuki Electronics (MKE) operating in Japan and Singapore. With high volume HDD manufacturing occurring at both companies, producing up to 12 million drives per quarter, the search to reduce cycle times and labor without impacting high quality yields is never ending.

The quality and costs associated with old through-hole processes in the PCBA area were viewed to be unsatisfactory, and the move to 100% surface mount afforded a way to eliminate these processes. Product yields would increase by leaving out the g through-hole steps, as well as the direct cost of the extra process steps, including capital costs. Table I shows the comparison of process DPMs, test yields and labour for costs for the same product. In one example, a complete 100% surface-mount process line required only 75ft. of floor space, whereas the mixed-technology process line needed 138ft.

HDDs have evolved from the 5.25 inch form factor to the present 3.5 inch, 2.5 inch and 1.8 inch form factors. One reason that costs have been reduced is through widespread use of robotic assisted assembly of subassemblies into the completed disk drive assembly. Table 2 shows the world-wide HDD shipments, by form factor. The major driver to the continued growth scenario for rigid disk drives is the desktop personal computer market, with the 3.5 inch the dominant form factor accounting for nearly 88% of all HDD shipments.

<table>
<thead>
<tr>
<th>process</th>
<th>mixed technology</th>
<th>100% surface mount</th>
</tr>
</thead>
<tbody>
<tr>
<td>screenprinting dpm</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>p&amp;p - chipshooter dpm</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>p&amp;p - ics dpm</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>reflow dpm</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>axial insertion dpm</td>
<td>151</td>
<td>-</td>
</tr>
<tr>
<td>handload dpm</td>
<td>257</td>
<td>-</td>
</tr>
</tbody>
</table>
wave soldering dpm | 65 | -
--- | --- | ---
first-pass ict yield | 93% | 97%
labour cost | x | 0.6x

Table 1: A comparison of process DPMs, test yields and labour costs for the same product.

<table>
<thead>
<tr>
<th>shipments</th>
<th>forecasts</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 to 14 inch</td>
<td>5.9</td>
</tr>
<tr>
<td>6.5 to 9.5 inch</td>
<td>11.8</td>
</tr>
<tr>
<td>5.25 inch</td>
<td>706.8</td>
</tr>
<tr>
<td>3.5 inch</td>
<td>77,775.8</td>
</tr>
<tr>
<td>2.5 to 3 inch</td>
<td>10,637.8</td>
</tr>
<tr>
<td>1.8 inch or less</td>
<td>418.8</td>
</tr>
<tr>
<td>total</td>
<td>89,556.9</td>
</tr>
<tr>
<td>percent change</td>
<td>+16.3%</td>
</tr>
</tbody>
</table>

Source: Disk Trend / June 96

Table 2: Magnetic rigid disk drives - world-wide shipments ('000).

A typical disk drive is made up of two subassemblies, the head drive assembly (HDA) and the printed circuit board assembly (PCBA).

The HDA is made up of magnetic discs that are rotated by a spin motor. It has a head that magnetises and sense the magnetic field of the disk. All these are enclosed in a die cast aluminium casing, protecting the contents from damage due to handling.

The PCBA carries the circuitry relating to the data transfer, included is a connector array which provides the data transfer between the HDA and the PCBA as well as between the outside world and the PCBA where the core
logic resides. The interface connector performs the latter function.

The interfaces required between the HDD and the outside world include power and signals. Traditionally these two are separate connectors. The combo connector is created which basically integrates the two and spans the width of the drive. A simplified exploded view of a typical hard disk drive is shown in Figure 1. This provides savings in inventory and assembly costs. In some companies, even the connector used to configure the drive was also integrated with the power and signal connectors to give a 3-IN-1 Combo header. This combination is popular with 5.25 and 3.5 inch drive form factors.

A 50 position signal connector is usually used as the I/O interface of a 2.5 inch hard disk drive, while a 68 position receptacle is used as the interface connector in a 1.3 inch drive, conforming to the Personal Computers Memory Card International Association (PCMCIA) standard.

![Simplified exploded view of a 3.5 inch HDD using a 2-IN-1 combo interface connector.](image)

### Interface Standards Evolution

Facilitating the transfer of data from the processor to the HDD is the key function of the interface connector and there are standards governing this process.

When 5 1/4 inch drives were the mainstay of high volume drives, the most popular interface was ST506/ST412, which was the cheapest way of making a drive. This does not attempt to figure out what data was on the media. It simply shipped the analogue signal over to a controller, and let the controller do the data separation. The connector involved was merely a 40-pin right-angle through hole.
In an effort to reduce problems, Compaq Computer Corp contracted with Imprimis (which was later acquired by Seagate Inc) and Eastern Digital Corp (which designed the WD1003 disk controller IBM Corp used in the PC AT) to incorporate the drive controller functions right on the disk drive. This innovation was named IDE by Compaq. IDE drives offer a data transfer rate of about 3 Megabytes per second (MB/s).

The advent of the Enhanced IDE (EIDE) standard was supposed to eliminate most of the classic, cheap IDE's disadvantages compared with a competing standard called the Small Computer Serial interface (SCSI), by doubling the number of peripheral devices users can attach to one controller from two to four, and adding support for a new crop of CD-ROM and tape drives as well as larger hard drives, and also increasing the data transfer rate to 13 MB/s.

The SCSI standard is covered by the American National Standards Institute (ANSI) and has developed from SCSI-1 into SCSI-2 and now SCSI-3. It was evolved from the SASI (Shugart Associates Systems Interface) standard developed by Shugart and NCR in 1981. Different types of device can be connected in a daisy chain via a 50-pin cable both ends of which must be terminated. The SCSI-1 bus carries 8-bit data, 1-bit parity and 9-bit control lines, to provide a maximum synchronous data transfer rate of 5 MB/s. The SCSI-2 interface is a 16-bit implementation of the X-hit SCSI bus, capable of transferring data at rates up to 20 MB/s, while SCSI-3 has maximum transfer data speeds of up to 40 MB/s. Corresponding connectors specified are 50 pins for the SCSI-1 and SCSI-2 and 68 pins for SCSI-3.

Three higher end I/O standards have emerged to swap serial data between peripherals, or between a computer and peripherals. They are Fiber Channel (FC), Serial Storage Architecture (SSA) and P1394/Firewire. Fiber Channel is an ANSI X3T9.3 standard high speed serial interface, which offers a scaleable data rate per link beginning at 133 Mbits/second, up to 4.0 Gbits/ second. P1394 is a serial bus developed by Apple and Texas Instruments that allows for the connection of 63 devices at data rate speeds per link ranging from 100 to 400 Mbits/s. SSA is championed by IBM in 1993, which can transfer data at 200 Mbits/second to 400 Mbits/s, and attachment of 127 devices on a loop.

Table 3 summarises the various standards and how the corresponding connectors are defined. In all the standards, only the portion where mating with an external cable is defined. The portion where the connector needs to be soldered to the PCB is left to the ingenuity of the connector supplier to provide the lowest cost solution.

<table>
<thead>
<tr>
<th>data width</th>
<th>devices</th>
<th>distance</th>
<th>transfer rates</th>
<th>connector pins</th>
</tr>
</thead>
<tbody>
<tr>
<td>ide 16-bit parallel</td>
<td>2</td>
<td>0.457m</td>
<td>3 mb/s</td>
<td>40p</td>
</tr>
<tr>
<td>eide 16-bit</td>
<td>4</td>
<td>0.457m</td>
<td>13 mb/s</td>
<td>40p</td>
</tr>
</tbody>
</table>
### Table 3: HDD interface standards

<table>
<thead>
<tr>
<th>Interface</th>
<th>Type</th>
<th>Speed</th>
<th>Transfer Rate</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel</td>
<td>8-bit</td>
<td>7</td>
<td>6m</td>
<td>5 mb/s, 50p</td>
</tr>
<tr>
<td>Fast 8-bit</td>
<td>8-bit</td>
<td>7</td>
<td>6m</td>
<td>10 mb/s, 50p</td>
</tr>
<tr>
<td>Wide 16-bit</td>
<td>16-bit</td>
<td>15</td>
<td>6m</td>
<td>20 mb/s, 68p</td>
</tr>
<tr>
<td>Fast 8-bit</td>
<td>8-bit</td>
<td>4</td>
<td>3m</td>
<td>20 mb/s, 68p/80p, ssa</td>
</tr>
<tr>
<td>Fast 16-bit</td>
<td>16-bit</td>
<td>4</td>
<td>3m</td>
<td>40 mb/s, 68p/80p, ssa</td>
</tr>
<tr>
<td>Serial 127</td>
<td>serial</td>
<td>20</td>
<td>40 mb/s</td>
<td>6p</td>
</tr>
<tr>
<td>Serial 127</td>
<td>serial</td>
<td>30</td>
<td>40 mb/s</td>
<td>100 mb/s, 40p, ssa</td>
</tr>
<tr>
<td>Serial 63</td>
<td>serial</td>
<td>4.5</td>
<td>50 mb/s</td>
<td>6p</td>
</tr>
</tbody>
</table>

Hard disk drives interfaces use connectors around the 2.54mm (0.100 inch) standard spacing or pitch, as well as the 2.0mm (0.079 inch), and the 1.27mm (0.050 inch) pitch, depending on the physical dimensions of the disk, and is governed by the Small Form Factor Committee.

Today, the IDE and SCSI interfaces constitute most of the volume of drives introduced in the market due to the dominance of personal computer systems where the most cost effective solution is used. Figure 2 shows the forecasted shipments of 3.5 inch HDDs in 1996 by the type of drives.

![Figure 2: Forecasted shipments of 3.5 inch HDDs in 1996 by type of interfaces of the drives.](image)

### Interface Connectors

Interface connectors are typically edge mounted, long, bulky and subjected to abuse. Their mating portion must also conform to industry standards. As a result, the selection of materials for the plastic housing, terminal base metal, terminal plating material, connector assembly process is subjected to very different considerations from those of internal connectors.

### Types of Solder Tails
The terminals in an interface connector has three portions - the mating portion, the embedded portion and the solder tails. Figures 3 and 4 show a typical signal terminal and a typical power terminal pulled out from the connector housing respectively.

**The mating portion of the terminal is clearly defined by the standards.**

The portion of the terminal which is embedded in the housing will contain the retention barbs. The retention barbs will hold the terminal in place when the connector is mated and unmated. This portion is defined by the connector manufacturer.

Solder tails refer to the portion of the terminal which is soldered to the PCB. They can be either through-hole type, straddle mount or single sided surface mount type.

![Figure 3: Typical signal terminal design.](image)

**Solder Tails - Through-Hole Type**

Through-hole (TH) solder tails are soldered onto the PCB through the wave soldering process or the paste-in-hole reflow process. In both processes, holes in the PCB must be drilled to accommodate the solder tails of the TH connector. The solder tail length is very critical in the TH connector, as too short a length will not give a good solder joint, and too long a length will push away the solder paste.

In the wave soldering process, it is common practice for weights to be put on
the component to be soldered. This is because the surface tension of the wave-front of the solder wave is sufficient to displace the components to be soldered if it is not adequately retained on the PCB by virtue of their own weight. Since interface connectors are edge mounted which presents a bulky over-hanging mass, tilting comes into play when the TH interface connector is inserted into the PCB by means of a clearance fit.

To overcome the above problems, most TH connectors possess built-in retention features that help them to anchor themselves onto the PCB. These retention features can come in the front of a retention kink on the solder-tail or a plastic locator that originates from the plastic housing of the connector.

![Figure 5: Kinked retention feature in solder tail.](image)

![Figure 6: Retentive Plastic Locator](image)

In both cases, interference fitting is employed either between the kinked solder-tail or the retentive plastic locator and its corresponding PCB hole. Figure 7 shows a hard disk drive using a right-angle through-hole interface connector.

![Figure 7: A hard disk drive using a right-angle through-hole I/O connector.](image)
Solder Tails - Straddle Mount Type

Straddle mount solder tails use the same terminals as the through hole solder tails. They involve two sets of solder tails straddling the PCB. Unfortunately, this process involves a two-step screen printing of solder paste for each side of the PCB. In Seagate Singapore, for example, this process involves an offline manual screen print operation which was eliminated with a single sided surface mount solder tail design with straddle mount type of housing.

Figure 8 shows a hard disk drive using an interface connector with straddle mount solder tails. The straddle-mount interface connector is mounted along an edge of the circuit board, with the solder tails of the terminals engageable with contact pads on both sides of the board adjacent the edge. This mode of PCB mounting exploits the full effect of the retentive kinking on each solder-tail. In this way, the connector can be firmly attached to the PCB prior to the soldering process without tilting.

![Figure 8: Unmounted printed circuit board of a hard disk drive using a straddle-mount I/O connector.](image)

The pitch or spacing between solder-tails of the straddled mount connector can be maintained at a sparse 2.54mm (0.100 inch). This is because both sides of the PCB are utilised for electrically connecting the component to the PCB. The advantage of a straddle mount housing is to prevent z-axis movement perpendicular to the plane of the PCB. Furthermore, less via holes are needed to interconnect the various layers in the PCB.

One of the problems encountered with straddle mount connectors is that soft solder paste is removed from vital portions of the board contact pads if there is a sliding engagement between the tails and the pads during positioning of the board and the connector in such a straddle mount condition. It is desirable to have a predetermined contact force between the solder tails and the board contact pads, in a direction normal to the board, to provide good electrical contact points. On the other hand, it is desirable to have zero or minimal forces between the solder tails and the contact pads while positioning the solder tails on the contact pads to prevent the soft solder paste from being wiped off the contact pads which can result in defective solder interfaces or short circuiting between adjacent contact pads. To improve the yield, solder paste is not printed on the whole length of the solder
pads, but mostly on the end of the solder pads on which the tip of the solder tails will rest when it is loaded properly on the PCB. The solder paste will then form good solder fillets during reflow via capillary attraction.

Experiments have also been carried out on solder-tails pre-loaded with solder. However, this approach is expensive, and produces inconsistent yields as fresh solder is not guaranteed depending on how long the part has been on the shelf.

Solder Tails - Surface Mount Type

Unlike TH solder tails which require holes to be drilled on the PCB in order that electrical connections can be formed, the surface mount solder-tails rest on their corresponding solder-pads on the PCB. By incorporating SM design with the interface connector, many of the obstacles that challenged the TH version with regards to efficient PCB mounting can be overcome. As all the components (integrated circuit packages and connectors) are surface mounted, one sided PCB and a one-step screen printing of solder paste is used to reduce process cost.

To convert the TH interface connector for the 3.5 inch HDD to a surface mount version, many factors were considered during the development where the connector manufacturer worked extensively with the manufacturing engineers. As a result, the Seagate version evolved into a connector with a straddle mount housing and single-sided surface mount solder-tails while the Quantum version evolved into a connector with press-fit pegs incorporated into the housing and single-sided surface mount solder-tails.

The following is a list of many of the concerns that were addressed in the development process:

- finished product quality and reliability must not be compromised.
- finished product total cost must be reduced.
- process yields must be better than before
- rework of misregistered or unsoldered solder tails must be defined.
- stencils for registering paste must be developed to ensure adequate paste exists for soldering the surface mount connector leads without sacrificing paste deposition for other components, such as 25-mil QFPs (quad flat packs).

As its name implies, the single-in-line SM interface connector has its leads mounted on only one side of the PCB. As such, the pitch or spacing between the solder-tail of this connector would be doubly dense as compared to the straddle-mount type. The advantage of such a design would be to free up the underside of the PCB for the mounting of other components. It also eliminates the need to screen print solder paste on both sides of the board. The downside of such a design would be its reliance entirely on the plastic retentive features that originate from the housing of the connector for firm attachment of the component to the PCB. Obviously, the retentive force of the component to the PCB would be weaker as compared to the straddle-mount
connector since there are more solder tails with kinks than there can be plastic retentive features.

Although the plastic peg serves to correctly position the connector on the PCB, solderability problems exist due to coplanarity of the solder tails. Since "perfect" coplanarity of the surface mount solder tails is not generally attainable, connectors of this type will rest on the PCB supported only by the lowest contact portions, resulting in a gap between the substrate and the higher contact portions. The greater this gap, the greater the risk of a poor or non-existent solder connection between the connector and the PCB. Most SM solder tails adhere to the industry standard of 0.1 mm (0.004 inch) maximum coplanarity. On the other hand, most PCB manufacturers will guarantee up to only 0.25mm (0.010 inch) per inch warpage. This would give a worse case of 0.99mm (0.039 inch) of clearance between a solder tail and the 3.5 inch PCB, and with a solder paste thickness of 0.76mm (0.030 inch), there would be an unsoldered connection.

The 3-IN-1 combo header solder tails, by design, are "preloaded" which means that the retention pegs will press the solder tails to be in contact with the PCB in order to overcome coplanarity issues. This design eliminates the dependence on manufacturing control of coplanarity given the fact that the 3-IN-1 combo header is 90mm long and involves 3 different terminal shapes being bent to conform to the same datum! This design is also called the down-force concept.

![Figure 9: Hard disk drive using a surface-mount I/O connector.](image)

Longer "J" shaped solder tails are used to allow self alignment with solder pads during reflow, and a better formed solder joint. "J" shaped solder tails have the lead-in to prevent solder tails hitting the PCB during mounting.

**Terminal Base Materials**

The selection of an appropriate base contact material for the I/O connector depends on the following characteristics of the contact design:

- Best cost to meet required performance
- Sufficient contact force
- Engagement wipe vs length of wipe
- Durability of 100 mating cycles minimum
- Current of 1.0 Amp maximum for data pin, and 2.5 Amp maximum for signal pin.

The power, signal and configuration pins are usually made of either brass or phosphor bronze.

**Types of Plating**

Power pins are usually plated with 100 µin minimum (µin) tin or tin lead (90-10) over 50 µin min nickel underplate. Configuration and signal pins are usually duplex plated, with different plating on the contact area and the solder tail area. The contact area is usually plated with 15 µin min palladium nickel and 3 µin min gold flash over 50 µin min nickel underplate. Alternatively, 30 µin min palladium nickel with 3 µin min gold could have been used as the overplate. Or 8 µin min gold is used as the overplate, as in the Quantum specifications.

A nickel undercoat provides 1000 times lower diffusion compared with copper. Nickel forms a non-migrating film which significantly reduces the effects of porosity and act as a diffusion barrier against the contamination of precious metals by base metal constituents. It also provides a hard supporting layer, improves plating durability and provides a barrier against corrosion migration.

Reel-to-reel or strip plating is usually employed for the simplex plated power pins, and selective plating for the duplex pins.

**Types of Housing**

Just like the terminals, only the mating portion of the housing is defined by the standards. The back portion is again left to the ingenuity of the connector manufacturer to provide the best possible reliable solution with respect to the disk drive design.

One of the most critical issues with an interface connector is that it is subjected to user abuse as the corresponding half of the connector is mated with it. During mating, any relative movement between the interface connector and the circuit board will induce stress in the solder tails. Such movement may occur when the drive unit is inserted and removed from the host computer. Repeated insertions may cause the solder joints and solder tails to fatigue and break, thereby rendering the disk drive inoperable.

The structural integrity of the solder tails can be improved by mounting the connector to the printed circuit board with screws. Requiring screws increases the assembly time and cost of the drive unit. It would be desirable to have an interface connector that is rigidly mounted to the PCB without
using any fasteners as hold down features.

As such, the most cost effective method is to utilise the housing design such that the hold-down feature is an integral part of the housing. In this case, the hold-down feature will come with me housing as moulded without additional processes of adding the fasteners.

The 3-IN-1 Combo header developed for the Quantum drive utilises the concept of two plastic pegs which are an integral part of the housing. The plastic pegs form a retentive hook when sat properly in the PCB slot provided, and holds the interface connector to the PCB. Great care was taken in the design to hold the interface connector to the PCB.

Too little retention to the PCB is of no use and may result in open circuit conditions or intermittancies should the surface mount solder tails and their respective contact portions "float” off the circuit traces or move off their requisite positions while moving through the conveyor belt, prior to soldering.

On the other hand, too much retention can cause excessive insertion Force and make assembly of the connector to the PCB difficult, if not impossible. Furthermore, in the case of robotic or automated assembly of the connector, the PCB or components on the PCB may be damaged if excessive force is used to insert and assemble an improperly aligned connector.

This type of housing usually needs to be placed onto the PCB vertically from the top, and force has to be exerted to sit the connector firmly onto the PCB.

On the other hand, the 3-IN-1 combo header developed for the Seagate drives utilises the concept of straddle-mounted plastic pegs. The plastic pegs include 'ribs' which are easily crushed during insertion and an interference fit is achieved to hold the off-balanced connector in position until reflow soldering is completed. The ribs also permit an acceptable interference fit within the PCB for a wide range of dimensional tolerances typical of PCBs.

At the same time, the solder tails exert a force on the PCB, and since the surface mount solder tails extend only along a single edge of the housing, the force exerted by the solder tails acts to rock or rotate the housing from its desired position, pivoting about the retention pegs. Again the interference fitted straddle housing peg prevents this from occurring.

**Housing Materials**

True SM process compatibility requires careful consideration of housing materials. The Heat Deflection Temperature (HDT) of connector housing materials should be greater than the maximum temperature the component will experience during reflow process. Good design practice dictates that housing materials should be capable of withstanding 260°C (even though reflow process temperatures are decreasing in the industry). For instance, Seagate’s SM Connector specification calls for a capability of 260 degrees C
Based on these criteria, five types of housing materials have been identified as reflow compatible:

- Polyphenylene Sulfide (PPS)
- Polydimethylenecyclohexance Terephthalate (PCT)
- Liquid Crystal Polymer (LCP)
- Polyphthalamide (PPA)
- Nylon 4,6

Seagate used to specify Nylon 4,6 as their 1/O connectors' housing material. However, Nylon's high rate of water absorption of 1.6% @ 50% RH, 23 degrees Celsius, caused bristling problems on the production line if not pre-baked. Therefore, Seagate decided to evaluate a new type of housing material to eliminate the pre-bake process. Both PPS and PPA were evaluated, and PPA was finally chosen as PPS has higher incidence of housing wall cracking due to insertion & withdrawal of the power cable during electrical testing of the device. On the other hand, Quantum has always been specifying PPS as their requested housing material without any concerns of the cracking issue. Choice of PPS or PPA housing depends on the manufacturing assembly process, as well as cost of the material.

**Interface Connector Assembly Process**

The interface connector can either be inserted moulded or post-inserted. Figures 10 and 11 show both of these processes. The advantage of the insert moulded process is that it is a one-stop process whereby the pins are loaded in a 2.54mm (0.100 inch) grid, and then the housing is moulded around the pins, followed by the bending and kinking of the solder tails. This is a better cost alternative to the post-inserted process, which requires separate moulding, and assembling machines. However, it is a tough challenge of bending both top and bottom rows of pins in the 2.54mm (0.100 inch) grid, over a length of 90mm, to get a pitch of 1.27mm (0.050 inch) solder tails with a coplanarity of 0.1mm (0.004 inch). At the same time, the challenge of post-inserted assembly is not to be underestimated. It is not easy bending three different types of terminals, both single and double rows, over a length of 90mm, to get coplanarity of 0.1mm (0.004 inch). Few companies can achieve it consistently, and this is the reason FCI is one of the major suppliers to Seagate and Quantum, the two largest HDD companies in the world.
Figure 10: Insert-moulded process flow chart for assembling an I/O connector.
Packaging of the Connector

I/O connectors can be packaged in extruded tubes, plastic tray or cartridge. The preferred packaging media is dependent upon the customers’ process requirements. Tape and reel is out of the question due to width and height constraints.

Trays are usually used when the I/O connectors are manually placed onto the PCBs by operators, or they are manually put onto a jig for automatic pick-up by a robotic arm for placement onto the PCBs.

Trays are usually used when the process is using a pick-and-place machine.
that has automatic tube feeder. Cartridges are used in Seagate because of their process has been configured such that the I/O connector is dropped off the cartridge one by one, and then pushed towards a track for automatic loading onto the edge of a PCB.

**Interface Connector Placement**

A continuous flow manufacturing to minimise off-line processes has always been a goal for manufacturing engineers. Connector placement has traditionally been done off-line and, in most cases, by hand. While using robotic equipment to place connectors is not a new technique, using the same equipment to place connectors and semiconductors is. Thus, connectors design and the placement tool design must be selected very carefully.

Pick-and-Place (P&P) machines generally utilise two methods of picking components from their raw packaging. They are the visual suction method and the visual chucking method.

For the visual suction method, the Pick-and-Place machine must first capture the plan profile of the suction surface of the component. This suction surface can be an inherent flat surface on the component (example: the top surface of a micro-processor) or a dedicated area of flatness that has been specially provided on the component (example: pick-up caps).

In either case, the entire suction surface must be visually captured by the imaging system on the P&P machine in order that the component can be consistently recognised. While the top surface of a typical interface connector affords the P&P machines with the required flatness, most imaging systems are not able to capture the entire plan profile of a typical I/O connector simply due to the magnitude of its Lengthwise dimension. For a 3.5 inch form factor drive, a typical interface connector would, in fact, traverse the entire width of the PCB. The weight of the connector would also be a consideration for the suction force. This method is usually employed with a connector housing which has removable ears used to allow the 3-IN-1 Combo Header to rest on the PCB without tilting. In this case, the need for retention by the plastic pegs is eliminated. On the other hand, the dependence on the coplanarity of the solder-tails is critical now since there is no retentive force to counteract the force of the lowest solder tails from lifting up the rest. The tabs are subsequently removed upon successful reflow as the PCBs are being singulated. This design while effective, does incur additional cost of the extra PCB space needed to support the 3-IN-1 Combo Header.

The visual chucking method employs the use of four movable jaws (chucks) at the gripper unit of the Pick-and-Place machine. Four jaws are required for accurate and consistent central location of the component to be picked. Ideally, the length-to-width ratio of the plan profile of the component is 1:1. That is, a component that has a square for its plan profile would be optimised
for interfacing with the gripper unit. This would prove to be a further barrier as the length-to-width ratio is typically 12:1 for a typical I/O connector designed for a 3.5 inch drive. In this method, a limited amount of force can be exerted on the connector to achieve a press fit condition.

In the third type of interface connector placement, the parts are supplied in tubes which fit into dedicated connector placement machines. Here the PCB is slotted into the straddle connector housing after the paste screening process. No P&P machine is used. This is possible given the high volume and dedicated lines used to manufacture the drives. Utilising pick & place machines would require a multi-functioned version and would incur too long a process time.

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**Process Issues**

Typical detects are unsoldered connection, bent leads or lifted leads, tilting of I/O connectors, misalignment of I/O connectors and cold joints. Problems like bent leads or lifted leads, misalignment of connectors, are usually caused by handling. To minimize these problems, automated pick and place of connectors is achieved via robotic placement arm or mechanical chuck or in-house designed machines.

At the end of the assembly process, every assembled PCB will go through an in-circuit test (ICT) as well as a visual inspection test. This will eliminate all unsoldered connection problems.

**Summary**

Interface connectors of hard disk drives evolved from using two separate connectors for power and signal, to a combined 2-IN-1 connector for both power and signal transmission, to a 3-IN-1 connector incorporating both power, configuration and signal pins. At the same time, interface connectors switched from through-hole to straddle mount to surface mount versions in order for hard disk drives to benefit from the cost savings offered by surface mount technology. The challenges of surface mount interface connectors dictate an innovative connector supplier who has the experience to consistently supply reliable parts. FCI Electronics meets this need.

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