4. Maximizing Throughput on Automated Programming Systems

For high volume production facilities to lower cost-per-device, throughput with APS systems is critical.

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Why is throughput the name of the game for high volume programming? Simply put, the more throughput (devices per hour or DPH) the lower cost-per-device achieved. Moore's law states that device memory capacity will double every 18 months, and as device density increases so do programming times. This coupled with the growth of the programmable semiconductor market, makes keeping pace with the production needs of state-of-the-art electronics manufacturers more challenging than ever.
Manufacturers using programmable devices continually strive to reduce production costs, improve lead times and maintain quality. This is why it is critical for high volume production facilities to get the most throughput out of their automated programming systems, resulting in lower cost-per-device. Flash Memory component density growth and lower power consumption requirements are forcing programmer vendors to stay on the cutting edge by incorporating the latest in automation and programming technology into their automated programming systems (APS).
Contributing Factors to Overall Throughput
Several factors contribute to overall throughput on fine pitch component automated programming systems. The two most critical factors are handling time and programming time. Each APS will have a specified maximum throughput number. This number represents that maximum mechanical speed of the handling equipment. The actual throughput achieved when programming devices will be dependent on several factors, including the size of the part (number of bytes). Other contributing factors include: component alignment, ease of use, job changeover, operator efficiency, programming yield, equipment maintenance and uptime, and pick and place (PNP) accuracy.
There are ways to optimize and/or minimize each of these contributors to obtain the best possible throughput performance from your APS.
Programming time per device is an important contributor to throughput gain and benchmarks are frequently requested to aid in determining throughput. Programming vendors should strictly adhere to the device manufacturers programming specification. Because of this you might think that all programmers would have the same programming times for a particular device. However, this is not the case. Depending on the architecture of the programming hardware and communications, a lot of &quotoverhead&quot may be required to get the job done and can increase programming times significantly. Not all vendors are created equal in this department. When comparing programming times among vendors it is important to do an apples-to-apples comparison. In other words, specify what

operations you would like quoted; erase, program and verify or just program and verify. Make sure all vendors quote the same operations or your comparison will not be accurate. When requesting a programming time for a particular device, clarify what operations are to be performed.

Handler speed is another major contributor to overall throughput. Handler speed refers to the time it takes to pick and place a device. Some handlers use motors that are considerably faster than others. The distance between input/output media and the programming sites also affect handler time. Most vendors will quote the maximum throughput possible for a particular handling system. This is throughput achieved when the handler is running at optimal speed and the programming time is short enough so that there is always a part ready to be picked or placed, and when the I/O medium is in close proximity to the programming sockets.

Component alignment methods are most commonly performed with vision technology. Each component is measured and aligned before placement without touching the leads. Some vendors still use awkward mechanical techniques to align the part, but because this frequently causes lead damage it is not recommended. The best method for obtaining repeatable placement accuracy is on-the-fly vision centering. This is accomplished by mounting the vision camera on the PNP head and aligning the part as it is moved from one location to another. BP Microsystems, Inc. was the first to use vision centering starting in 1995, and continues to use the on-the-fly method on all fine pitched automated programming systems.

Other competitive equipment must pick the part and move it over the vision system for alignment. Because this extra step happens in series, this method greatly reduces throughput. If you multiply the seconds it takes the PNP to move to the alignment camera by the number of parts programmed, you can see that this is a significant amount of time that detracts from the overall throughput of a job.

Another way in which component alignment can drag down throughput is when the locations for picking and placing are not properly taught. This will cause frequent alignment errors, which can be easily corrected. The easier a system is to setup and teach, the less likely these types of failures are to happen.

Operator efficiency can have a significant affect on throughput numbers. Systems may sit idle during a programming job waiting for blank parts or because some other event has occurred requiring attention. Operators can help lower your cost-per-device by staying alert to the needs of the system while a job is in progress. Job setup and changeover is dependent on how easy it is to use, teach, change sockets, setup peripherals and load parts, and how quickly your operator can perform all of these tasks.

Failures due to improper teaches can significantly impact overall throughput of a job. For example many continuity failures occur repeatedly on the same socket because the part placement was not taught accurately. Common practice is to wait until a job is over and run the parts through again. This usually results in successfully programmed parts, but lowers throughput. It is better in the long run to take the time to re-teach a location or locations to improve job throughput. Every time a part is rejected, the handler time for that failed part lowers throughput.

Bad or damaged devices from the manufacturer can also affect throughput. Any time failed parts are handled throughput is reduced.

One might think that adding programming sockets will always result in more throughput. However, this is not the case; systems with faster programming times and faster handling times out-perform systems that may have more sockets. The

BP-4600, for example, from BP Microsystems has a maximum of 11 programming sockets but will out-perform other systems that have as many as 48 programming sockets.

Formula for Calculating Cost Per Device:

Amortized cost of APS = Total Price (including options) / Years amortized
+ Cost to operate = Hours per year * Labor rate (fully burdened)
= Total cost per year including amortization

Devices per year = Throughput (DPH) * % utilization * Hours per year
Cost Per Device = Total Cost per year / Devices per year

Another important feature that will improve throughput is the automatic optimization of programming sites. Not all automated programming systems have this capability. Well-designed systems will use only the number of sockets necessary to achieve maximum throughput. For some programming times, throughput can actually be lowered by eliminating the additional handling time used traveling to additional sockets when there are already parts waiting to be picked. Devices with short programming times may require less than the maximum socket configuration of your system. On systems that have this feature, it is better to start a job with all available sockets and let the system do the optimization, rather than to have your operators guess the number of sockets and locations needed to achieve the highest throughput. In addition, Concurrent programming architecture, patented by BP Microsystems, improves throughput by starting programming on each device as it is inserted in the socket, making the most efficient use of handling and programming time. Traditional methods wait until all the sockets are loaded and program the parts simultaneously, letting the system remain idle while waiting for all the parts to complete programming.

Things to Look For to Get Optimum Throughput:

Fast programming times - (Program & Verify 32 Mb
Flash in 20 sec.)
High mechanical throughput - (over 1,000 DPH)
On-the-fly component alignment
Independent I/O options for lower changeover times
Speed of repair for less downtime
Operator training and ease of use
High placement accuracy to avoid programming
failures due to bent leads

Periodic maintenance (PM) and the general condition of mechanical components can also affect the throughput of your APS. Manufacturers typically provide a recommended PM schedule for customers to follow. Well maintained equipment will not only ensure performance, it will extend the service life of the machine. Worn or dirty sockets can cause low programming yields. Cleaning sockets daily, even just blowing the dust and debris clear with compressed air can make a difference. Sockets do wear out and must be replaced as part of routine maintenance. for this reason BP Microsystems socket modules have a &quotsocket odometer&quot, which tracks the number of insertions per socket and can be reset when the socket is replaced. In addition to the APS, it is important to perform recommended PM for all peripheral hardware including feeders, laser marker, and label marker. By properly

scheduling and performing maintenance on your equipment, you will minimize unexpected downtime and job interruption due to mechanical failure.

Conclusion

While semiconductor manufacturers have recently made progress reducing programming times per byte by 10%, real gains in throughput are left to APS equipment manufacturers. Achievements in lowering cost per device can be accomplished with high performance automated programming equipment. APS manufacturers should look to the future when designing equipment ensuring they get maximum performance out of their handling and programming systems. An automated programming system designed for the future will allow for easy upgrades to increase performance whether through new programming technology or new handler technology, maximizing your investment well into the future.

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