The Rise and Fall of eMMC Duplicators

High Performance eMMC Flash Memory Requires a High Performance Programmer

This white paper discusses the history and future of duplicators for eMMC programming in mass production. Originally adopted for low cost and high performance, recent advances in eMMC standards and significantly faster interface speeds raise questions about performance, reliability and security of duplicators. Are high performance programmers a more secure, lower cost option for today’s applications?
Executive Summary

eMMC duplicators entered the market in 2009 offering what suppliers called a revolutionary alternative to old IC programmers for large files. One of the key benefits expressed by suppliers was that duplicators no longer required a PC to complete data duplication. Rather, data content is copied directly from a master device to blank devices in target sockets. While sounding good on paper, duplicator suppliers neglected mentioning the high cost of duplicating tens of thousands of devices using the wrong Master Device. That was the customer’s problem. Also overlooked were the growing limitations that duplicators had compared to device programmers. This whitepaper provides a historical look back into the birth of eMMC duplicators, advancements in eMMC Flash memory and the technology shift from eMMC duplicators to state-of-the-art device programmers.

What is e MMC?
Embedded Multi Media Card (eMMC) is the trademark of JEDEC/MMCA. Designed for a wide range of applications in consumer and automotive electronics including handsets, tablets, navigation systems, infotainment and other industrial uses, e MMC devices contain flash memory and an embedded controller that supports error correction (ECC) in hardware.

eMMC Flash Densities Have Doubled Every Year Since 2004
In 2009 the average eMMC Flash density ranged from 2GB to 8GB. By 2014 the average eMMC Flash density had doubled to 16GB and higher. Today we see more and more electronic devices consuming 32GBytes and higher of eMMC Flash.

eMMC Interface Speeds Increase with each version
Write/Read speeds for eMMC Flash Memory are increasing for each new version. For example in 2010 the release of eMMC 4.41 devices came with a maximum write speed of ~30MB/sec. with a steady increase with each new version. Today’s eMMC 5.1 devices have a maximum write speed of 125MB/sec.

Beginning in 2009 eMMC Duplicators enter the market
Marketed as a low-cost solution, dedicated eMMC duplicators entered the marketplace. At this time 4GB to 8GBytes were considered large density devices with average write speeds around 30MB/sec. Today there are a number of different suppliers, but a common process for all is the management of Master Devices. A variety of eMMC duplicators offer limited support for only specified versions of eMMC Flash. Creating a Master Device and managing code changes requires the purchase of a desktop programmer. For early eMMC 4.3 and 4.41 devices with write speeds less that 30MB/second, eMMC duplicators were a good solution.

Sample of eMMC Duplicators
2011-2015 - Higher Performance eMMC enters the market (eMMC 4.5 and higher)

**Write speeds increase**
- eMMC 4.5 (60MB/sec)
- eMMC 5.0 (90MB/sec)
- eMMC 5.1 (110MB/sec)

**Read speeds increase**
- eMMC 4.5 (165MB/sec)
- eMMC 5.0 (275MB/sec)
- eMMC 5.1 (300MB/sec)

**Densities increase**
- 2011 - 16GBytes
- 2015 - 32GB, 64GB and higher

With Each New Version of eMMC, Duplicator **Warning Signs** Increase
Missing from the eMMC duplicator marketing collaterals, but buried in supplier user documentation one can find warning signs that can severely impact quality and performance.

<table>
<thead>
<tr>
<th>Example: Duplicator Warnings</th>
<th>Duplicator A</th>
<th>Duplicator B</th>
<th>Duplicator C</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Make sure the Master Device is correct and workable&quot;</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
</tr>
<tr>
<td>&quot;It is highly recommended that Master &amp; Target devices be the same density&quot;</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
</tr>
<tr>
<td>&quot;Turn-off power before replacing sockets&quot;</td>
<td>✓ ■ □</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
</tr>
<tr>
<td>&quot;During operation its normal for the machine to heat up&quot;</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
</tr>
<tr>
<td>&quot;Quick Erase only erases Fat 16/32 format. It will damage data in the Flash&quot;</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
</tr>
<tr>
<td>&quot;Full Erase Caution: It will damage data in the Flash&quot;</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
</tr>
<tr>
<td>&quot;To prevent data loss due to unstable Flash: Power off between copy &amp; compare (0 to 15 sec).&quot;</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
<td>✓ □ □</td>
</tr>
<tr>
<td>&quot;If the failure rate of the duplicator is high, reduce the Clock Speed to 25MHz for more stability&quot;</td>
<td></td>
<td></td>
<td>✓ □ □</td>
</tr>
<tr>
<td>&quot;Temporary power of Target Device after Copy is complete, then Power-on and begin Verify&quot;</td>
<td></td>
<td></td>
<td>✓ □ □</td>
</tr>
<tr>
<td>&quot;Always leave the (Output Clock Phase) to option zero, unless programmer hangs, then try options 1, 2 or 3&quot;</td>
<td></td>
<td></td>
<td>✓ □ □</td>
</tr>
</tbody>
</table>

For High Volume, lean production lines, the lack of determinism could be a big problem.

**Does Duplication put your Intellectual Property (IP) at Risk?**
Intellectual property theft is on the rise and companies must develop strategies to protect their rights and not put their business at risk. Imagine if a competitor gets their hands on your product code, clones it and starts implementing your product features into their own product. Intellectual Property (IP) is so valuable, that many businesses list it among their assets on their balance sheet. It’s critical to develop an effective production strategy to protect your IP and safeguard the unique product features that differentiate your product from all competitive offerings.

eMMC Duplicators rely upon a master device that is un-encrypted and could be removed quickly from your plant. Is this risk something you should tolerate in your factory?
The $10M Duplication Error
What would be the cost of incorrectly programming thousands of devices with the wrong master file? How easy would it be to incorrectly use the wrong device when changing device masters in a duplicator?

A production operator at a high volume consumer electronics manufacturer selected the wrong set of Master Devices for mass duplication into a new model. Before the operator’s mistake was discovered, the manufacturer had built thousands of products containing the wrong software and shipped them to customers where they failed during activation. All the faulty products had to be identified and withdrawn from distribution channels. That one mistake, not counting embarrassment and loss of good will, cost the manufacturer over 10 million dollars. Depending on where an error is detected, costs can range from $25K to over $10M.

Humans are not perfect. The more complex the task, the more likelihood there is for error, and manufacturing lines are no exception. In today’s complex manufacturing environment, getting accurate information into programmable devices requires that people and processes get every step right—from the software engineer who creates the data file and associates it to a master device, to the operator who selects that master device set for mass duplication. Unfortunately with Duplicators, master device management is a high risk process for Human Error.

Technology Shift from eMMC Duplicators to High Performance Programmers
The technology shift away from eMMC Duplicators to High Performance Programmers is underway. A disruptive new programming platform delivering managed and secure programming has captured the attention of eMMC users around the world.

In addition, the benefits of programming automation are replacing old manual duplication processes eliminating the potential high cost of human error.

The fact is duplicators have not kept pace with performance improvements for eMMC 4.5 technologies and higher.

Business managers are making smarter business decisions based on the total cost of programming and not just one element, cost. Managers are looking at programming speeds, setup times, throughput, capacity, floor space requirements, flexibility, consumables, inventory float and labor cost.
Data I/O’s Introduces its new revolutionary programming platform, LumenX™

In August of 2015, Data I/O introduced LumenX™ a revolutionary programming platform delivering Managed and Secure Programming with unrivaled performance for leading high density eMMC devices maximizing production throughput for the lowest total cost of programming.

Unlike duplicators, the LumenX™ programmer provides Managed and Secure programming from design through manufacturing for highest quality.

Best in Class Security

The LumenX™ Data Management Software bundles the algorithm with the customer’s data file(s) and job setting into a secure programming environment. The programming Job is protected from corruption eliminating opportunities for operator error. Data for end user programming jobs are secured and cannot be corrupted or modified from point of creation to the point of programming. The LumenX™ platform even allows for personalized algorithms with specific settings which can be pre-set to meet unique customer requirements.

Traceability Software

The LumenX™ Programming Platform offers comprehensive Traceability Software enabling users to gather programming statistics and details with Job Tracking/Job Logging software. An optional Barcode scanning system minimizes operator error with automated file downloads. The LumenX™ Programmer features secure Job creation and transmission eliminating all the security risks typically associated with duplicators and Master device management.

PSV7000 with LumenX™ Programmers — Revolutionary Value

The LumenX™ programmer is expertly integrated into the PSV7000 automated programming system with industry leading programming capacity, up to 112 eMMC parts simultaneously.

One PSV7000 system with LumenX™ programmers replaces up to 3 alternative offline automated systems reducing the cost of programming by up to 3 times.

Test engineers are adopting the PSV7000 with LumenX™ to free up valuable test time and eliminate production bottlenecks associated with programming large files at test.

The benefits of one automated programming system feeding multiple production lines supports the Lean Thinking Principles that help production managers control cost.
LumenX™ Programming Platform - Advantages over Duplicators

Using master devices is an inherent process risk
Since duplicator users must insert master devices with the correct data and settings which look just like any other sample of the device whether it is blank or programmed with a different data file or different settings, there are many opportunities for human error.

- The LumenX™ programmer has internal cache memory for data storage, there are no master devices.

Master devices cannot be transferred digitally
When code changes, a new master device is created in a lab or office, these devices are then released to the factory floor, which could cause a big delay in implementing the change.

- With the LumenX™ programmer, first article Jobs are created and tested on the LumenX™-Desktop then posted to a server for quick access on the factory floor.

Loading master devices require operator intervention
When a new device or new set of data is required for duplicators, an operator must be relied upon to grab the right master devices and then spend time doing the changeover along with ensuring that each master socket gets the correct master device.

- The PSV7000 with LumenX™ programmers can be automated to ensure the right job is selected using a bar-code scanner

Duplicates are not designed for Automation
eMMC Duplication is not a lean manufacturing process. The concept of lean thinking implies doing more with less. Time is money and factory managers are evaluated on their ability to maximize production utilization and efficiency. Unfortunately, duplicators waste valuable time and resources as operators are required to exchange master devices to support new production runs.

- The LumenX™ Platform is Designed for Automation
  Using a high speed automated handler can be a big labor cost savings compared to many people doing manual operations or using inferior handlers that cannot keep up with the PSV7000. PSV7000 also increases quality levels by eliminating many of the errors associated with manual operations. The LumenX™ + FlashCORE combination supported in PSV7000 is extremely flexible to handle any type of device. Also, PSV7000 was developed by Data I/O, which means we have fully integrated the management and security features of the programmer into the system SW and applications

Programmers Provide Data Logs
Data logs are created by LumenX™ programmer that help ensure the correct data is being programmed, assists with error diagnosis, and enables traceability for the customer. Not all Duplicators provide this data.

- LumenX™ log files are available to view programming job statistics
So far, all duplicators program only eMMC
Having a single purpose machine is not cost effective if you need to program any other types of devices
- The PSV7000 supports LumenX™ and FlashCORE III supporting for tens of thousands of devices

Duplicators can’t deal with dynamic data like serial numbers
Duplicators only read data from one device and put it into another set of devices. Dynamic data is a foreign concept.
- LumenX programmers have the capability to support the management of dynamic data such as serialization

Duplicators can’t program microcontrollers
Many micros have special areas or settings that cannot be read, but greatly affect the functionality of the device. Many micros need to be secured once they are programming which could not be supported by a duplicator.
- Microcontrollers have special areas or settings that cannot be read but affect the functionality of the device.
- Microcontrollers may need to be secured once programmed which is not supported by a duplicator.

Duplicators can’t do anything besides simple duplication
If anything custom is desired, from special features to lifetime testing to special data reporting to communication with the factory, LumenX™ can handle it. Duplicators cannot.
- If anything custom is required, including special features, lifetime testing, special data reporting and/or communicating with the factory, LumenX can handle it. Duplicators cannot.

Semiconductor Industry Embraces Data I/O’s Revolutionary LumenX™ Programmer

Cypress Semiconductor
“Cypress Semiconductor Corporation has onsite device support engineers trained and ready to support Data I/O’s new LumenX™ programming platform” said Adam Fogle, Sr. Manager of Failure Analysis with Cypress Semiconductor Corporation. “The LumenX™ programmer delivers superior programming performance for our latest eMMC devices with algorithms written to our product specifications. Our mutual customers have expressed their appreciation for the superior support that Cypress Semiconductor Corporation and Data I/O deliver as a team”

Micron Technology
“Micron Technology, a world leader in the semiconductor industry, is pleased to support Data I/O’s new LumenX programming platform through product sampling,” said Bob Baltar, applications engineering director with Micron Technology, Inc. “The LumenX programmer delivers proven programming performance for our latest e.MMC 4.5, 4.51, and 5.0 devices. Micron Technology and Data I/O have a longstanding history of working together to ensure that programming algorithms for all Micron products are developed and tested according to the specifications.”

SK Hynix
“SK hynix, a leader in semiconductor memory solutions, is pleased to support the announcement of Data I/O’s new LumenX™ programming platform” said Kevin Widmer, SK hynix America Vice President of Technical Marketing, “The LumenX™ platform has demonstrated impressive programming performance on our latest eMMC 4.5 and 5.0 devices. We will continue to work closely with Data I/O engineers to ensure SK hynix customers can take advantage of the programming throughput of the LumenX™ system.”

Toshiba Semiconductor
Toshiba Semiconductor & Storage Products Company and Data I/O Corporation, have a long standing history of collaboration and teamwork to ensure the highest quality programming for our mutual customers. Data I/O’s new LumenX™ programming system delivers the highest programming speed performance (at-the-speed-of-the-device) with programming algorithms developed according to our specification for Toshiba’s latest e-MMC™ 4.5, 5.0 and 5.1 devices.
Summary

As eMMC technology evolves, the quality of the tools used to program today's faster, higher density devices are improving as well. OEM's are looking to protect their intellectual property as it moves from central headquarters to remote production facilities around the world. The high risk of managing master devices has all but made eMMC duplicators obsolete. As labor rates climb the move from manual processes including eMMC duplication are being replaced with flexible high performance automated programming systems. Growth industries like automotive infotainment have quality standards and requirements that eMMC duplicators cannot meet. These requirements include traceability, security, managing dynamic data such as serialization and waste management. In addition, today programming equipment must support lean thinking principles while delivering the lowest total cost of programming.