

Keysight Technologies

Flash Programming with the Keysight Utility Card versus Deep Serial Memory Programming

Case Study

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Introduction

This case study compares the flash programming performances of the Keysight Technologies, Inc. *Medalist* i3070 Series 5 in-circuit tester (ICT) with utility card flash programming solution against the Teradyne in-circuit tester with deep serial memory programming solution.

In this case study, an 8 Mbits flash device is fully programmed, and detailed comparisons on the programming time from both the Keysight and Teradyne solutions are discussed. This paper also illustrates how the Keysight utility card flash programming solution can be applied in throughput multiplier mode to improve throughput tremendously, validating it as a viable flash programming solution in a high-volume production environment.

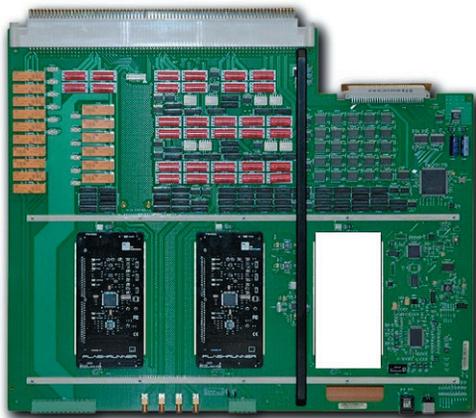


Figure 1. Keysight utility card with programming modules

Project Details

Board type: Set-top box printed circuit board assembly

Fixture: 2-up dual-well fixture

Device: AT26DF081A - 8 Mbits Flash device - Full image programming

Keysight tester: *Medalist i3070 Series 5 – Two modules (mod 3 and 2) with four double-density pin cards each*
ASRU revision C with Control XTP
Running in throughput multiplier mode with dual-well sharing wiring
Only one Keysight utility card was installed with two SMH FlashRunner (FR) modules in module 3, slot 11, to perform flash programming in parallel (throughput mode)

Teradyne tester: TestStation with Ultra124 pin boards and deep serial memory (128 MB)

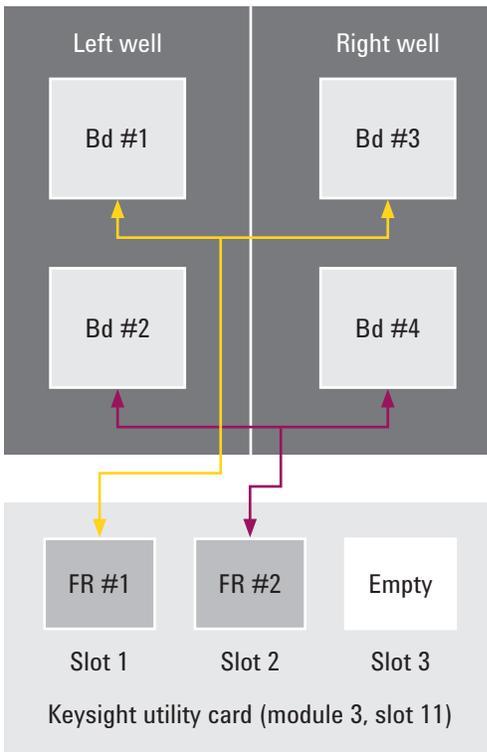


Figure 2. Block diagram connections from FR Modules on the Keysight utility card to devices under test

Flash Programming Test Time Comparison

From the flash programming test time comparison table below, the Keysight solution is almost twice as fast as the Teradyne solution. This means that given the same amount of time, Keysight will be able to program twice the number of boards as Teradyne. As such, the manufacturer can use fewer testers and fixtures to meet the required customer production volume.

Table 1. ICT + Programming test time comparison for two boards

Testplan option	Operations	Keysight programming test time for two boards (in seconds)	Teradyne programming test time for two boards (in seconds)
1	ICT + CRC + Serialization (production board with CRC passed)	11.6	22
1	ICT + CRC + EPV + Serialization (production board with CRC failed)	32.5	60
2	ICT (exclude Bscan) + EBPV + Serialization (consumer board)	30.3	56*
3	ICT + EBPV + Serialization Option 3 (RMA board)	31.1	57*

* Estimated test time based on results from Option 1

Based on test time calculations, the customer will *require seven Teradyne testers and fixtures* to meet production volume, whereas the customer will *only require four Keysight testers and fixtures* to achieve that.

Note:

- Serialization includes Serial Number, Hardware Version ID, Unit Identifier, etc.
- E = Erase
- B = Blank Check
- P = Program
- V = Verify
- EBPV means performing Erase, Blank Check, Program and Verify operations with FR programming module
- CRC = Cyclic redundancy check
- RMA = Return merchandise authorization

Flexibility of Flash Programming with the Keysight Utility Card

In this project, the customer has different programming requirements for the ICT station, depending on whether it is a fresh production board or a failure board from various test stations. Three test options are created in the testplan to address the customer's needs to test these different types of boards.

Option 1:

Normal production runs with pre-programmed flash loaded on board. ICT will perform CRC test on the flash device to determine if the correct firmware is pre-programmed.

If CRC test failed, meaning either a wrong firmware or no firmware is pre-programmed, then: Erase + Program + Verify operations will be performed on the flash device.

Option 2:

Shipped (boards which pass functional test) board will have JTAG lock feature enabled; meaning ICT boundary scan test for this board will not work anymore. Hence, an option is created to skip boundary scan tests and re-program the flash device in ICT: Erase + Blank Check + Program + Verify operations will be performed. Field returned boards (referred to as consumer boards) will go through this option.

Option 3:

Functional test station will alter some of the bits in the flash device. Hence, an option is created to skip CRC test and re-program the flash device in ICT: Erase + Blank Check + Program + Verify operations will be performed. Functional failed board (which they called RMA board) going for ICT again will go through this option.

Offline Pre-Programming versus In-System Programming

The customer has an offline pre-programming station to pre-program the flash device before feeding it into the SMT line. The table below shows a comparison of the programming time between the offline pre-programming station and flash programming with the Keysight utility card solution.

Table 2. Programming test time comparison between an offline pre-program station and in-system flash programming with the Keysight utility card

Programming method	Program + verify
Offline pre-program station	35 seconds
Utility card flashing programming	14.5 seconds

On the offline pre-programming station, it takes 35 seconds to program and verify one single flash device.

The Flashrunner script is modified so that it only performs the Program and Verify operations; and it takes 14.5 seconds to complete the programming via running the script in testplan.

The Keysight utility card can perform the Program + Verify of the flash device faster than the customer's existing offline programming station. The customer may need to carry out detailed planning for the overall throughput of the surface mount technology line, versus their existing ICT throughput to consider moving all flash programming to the ICT stage; however, the above vast improvement in flashing throughput definitely makes it a *lower barrier to overcome when considering migrating all flashing to the ICT stage.*

Keysight Throughput Multiplier Mode

The Keysight throughput multiplier feature has always been a key differentiator for customers selecting the ideal ICT solution for their needs. Flash programming on the Keysight utility card can also be configured to run in throughput mode, to perform programming on multiple boards or multiple devices.

Table 3. ICT + programming test time comparison (for one single board)

	Keysight test time for one single board (in seconds)	Teradyne test time for one single board (in seconds)
ICT only	4.9	4.4
Erase	5.359	7.219
Blank Check	4.375	5.094
Program	7.297	10.75
Verify	7.484	5.109

The comparison table above shows the test time for a single board. With throughput multiplier mode used on two boards, Keysight's solution can test almost twice as fast as the Teradyne solution, as per the results shown in Table 1.

The Keysight ICT and utility card flash programming solution can provide greater flexibility to customers, compared to the Teradyne ICT solution with deep serial memory programming solution, which does not have the throughput multiplier mode.

In this project, the customer only needed one utility card and two FR modules to perform the flash programming in throughput mode.

Key Learning

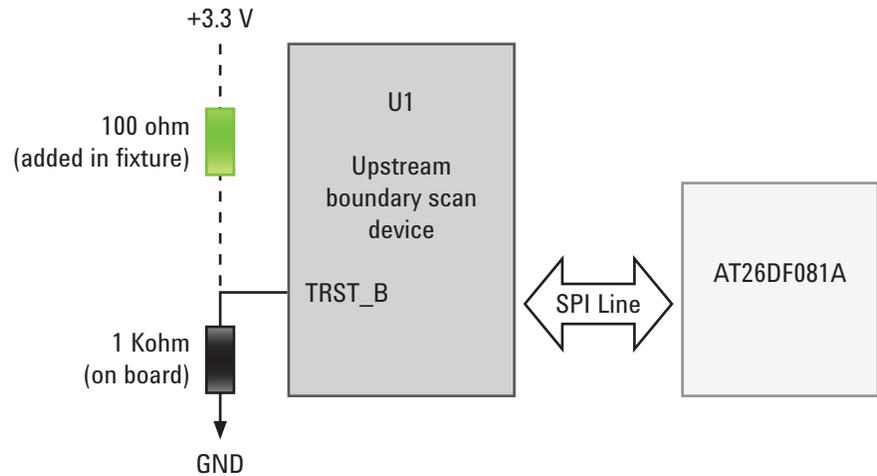


Figure 3. Block diagram of Flash device and upstream boundary scan device

In the course of this case study, there is some key learning, which we thought would be useful to share with readers.

In this program, the AT26DF081A flash device was connected to an upstream boundary scan device. Programming to the AT26DF081A flash device would be impossible without the proper disabling of the upstream boundary scan device. The boundary scan disable test was generated and executed just before the programming. However, the programming still failed.

Upon troubleshooting, we realized that the SPI lines (namely SI, SO, CS and SCK) were not disabled despite the fact that the boundary scan disable test was executed and passed. After further analysis, we realized that the TRST_B line of the upstream boundary scan device was pulled down (via 1 Kohm) to Gnd. This means the boundary scan device had been put to JTAG Reset state rather than remaining in the Disable state immediately after the boundary scan Disable test was executed.

To overcome this issue, a small pulled up resistor (100 ohm) to +3.3 V was added into the fixture. This prevented the boundary scan device from always staying in its JTAG Reset state. With that, the program worked perfectly.

In conclusion, it is critical that the upstream devices to the flash device are properly disabled to ensure programming success.

Real-time Advantages of the Keysight Solution

More coverage with Keysight VTEP technology

- Keysight has installed VTEP for U5000 (340 pins) BGA device while Teradyne has not. Both Keysight and Teradyne are running boundary scan tests on U5000 devices. However, not all pins of U5000 have a boundary scan cell; some of them are linkage cells, meaning they are not part of the boundary scan chain and will not be covered in boundary scan tests. *Keysight's VTEP on the U5000 device provides additional open coverage for at least 25 pins on the U5000, in comparison to Teradyne solution.*

Good transportability

- The Keysight utility card flash programming solution has been validated in the Keysight Singapore R&D lab. At the customer site, it took less than two hours to bring up the utility card flash programming solution, exhibiting good test transportability. And that includes deploying the tester to load in the Keysight utility card and upgrading a dual boot system to software revision 08.00p. The Keysight utility card flash programming worked in the first run at the customer site as expected.

Great flexibility and ease of use

- In the early stage of production run, the Keysight test program captured a couple of boards with wrong pre-programmed firmware with CRC test. Immediately, several options were created on the fly to meet customer production gaps and needs; to cater for device re-flash if CRC test failed.
- The customer was concerned about the possibility of wrong scanning sequence of serial numbers, especially when two boards were being tested at any one time and the serial number was programmed as part of the dynamic data into the flash device. (Note that dynamic data is still programmed through a standard 3070 digital test, while the large firmware image is programmed through the Keysight utility card flash programming solution.) Additional barcodes were physically pasted on the fixture, to reduce the chances of wrong scanning by operators. The testplan was further modified to handle this sequencing and to prompt the operator with an error message if a wrong sequence was detected. For instance, if two identified serial numbers were scanned for two boards, it would give a prompt error and the operator would need to re-scan both serial numbers again.

Tremendous throughput breakthrough

- It takes 30 seconds for a standard Keysight digital test with Flash70 feature to perform a full programming suite (Erase, Blank Check, Program and Verify) of 8 Mbit data to the AT26DF081A flash device. With the Keysight utility card flash programming solution, the programming time improved tremendously, taking only 23.5 seconds to complete the full programming suite.

Who Should Consider Using Keysight Utility Card Flash Programming?

If you are currently producing boards with low node counts and require flash programming, you should seriously consider the Keysight utility card flash programming solution to improve your production throughput.

With low node counts requiring less than one module resource, it is highly possible that one additional utility card can be added into your tester configuration to perform programming, without the need to consider coverage loss due to the one pin card being replaced with the utility card.

You can also upgrade the tester from single-module resources to two-module resources to perform throughput testing for two boards. With our *Keysight throughput multiplier* feature, customers can expect almost twice the production throughput in comparison to one module. The Keysight utility card flash programming solution can be performed in throughput multiplier mode as well.

In addition, building a 2-up dual-well fixture with the *Keysight dual-well shared wiring* feature will maximize tester resources, and production throughput can be improved to the next level with zero or reduced board handling time.

Considerations for Utility Card Flash Programming Implementation

1. The Keysight utility card will take up one slot in the tester configuration.
2. Design-for-Test for upstream devices must be taken into consideration for proper disabling.
3. DFT for flash device programming must be taken into consideration, meaning test access must be made available to data, address and control lines of the flash device.

Considerations 2 and 3 are not unique to flash programming with the utility card – they should be considered in all projects for proper disabling and test coverage, even for those where programming is not required.

Conclusions

- The Keysight utility card flash programming solution is faster than the Teradyne deep serial memory programming solution.
- With the Keysight throughput multiplier feature and the appropriate utility card configuration to perform ICT plus programming in throughput mode, the advantage of the Keysight solution over Teradyne is significant and obvious. The Teradyne solution is not running in throughput mode.
- The Keysight utility card flash programming solution is faster than the customer's offline programming station, making it a lower barrier for customers to move offline flash programming to programming at the ICT stage.
- With the Keysight utility card flash programming solution, we can address customer needs and gaps in offline programming. It is capable of performing re-programming for return boards and can double up as a check point to verify data content pre-programmed at the offline programming station.

The results presented in this case study show that the Keysight utility card flash programming solution is faster and definitely a viable option for manufacturers looking to increasing throughput and lowering their cost of programming.

For more details on the Keysight utility card, please refer to available literatures on www.keysight.com/find/utility

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