Implementation of Security in Actel Antifuse FPGAs

FuseLock™

Introduction

Design security is a growing concern for system designers in today's highly competitive technology marketplace. When faced with the question of how to best protect valuable designs and critical intellectual property from theft, many designers turn to Actel's antifuse FPGAs. Actel's nonvolatile antifuse FPGAs do not require a start-up bitstream, eliminating the possibility of configuration data being intercepted or copied. This ability to lock in the user's design also prevents in-system errors and accidental data erasures that otherwise may occur during download. In addition to the FuseLock™ advantage, Actel FPGAs also offer the inherent security of the architecture itself. The antifuses that form the interconnections within an Actel FPGA are extremely small and densely distributed throughout the device (over 53 million on the largest Actel device). Furthermore, the fuses do not leave an observable signature that can be electrically probed or visually inspected. With these safeguards, Actel devices are virtually immune to copying and reverse engineering.

Fuse Technology on Actel Antifuse FPGAs

Depending upon the architecture selected, Actel antifuse FPGAs utilize a number of different fuse elements. Table 1 provides an overview of the different fuses used for each antifuse family.

Table 1 • *Fuse Types of Actel Antifuse FPGAs*

Fuse Types for all Actel Devices (Except ACT 1 and 40MX)	Fuse Types for ACT 1 and 40MX Devices
Array	Array
Security	Program
	Probe

Described below are the differences between these fuse types:

- Array Fuses: Used to build the metal-to-metal interconnect that creates nonvolatile, low power, high performance paths in the Actel antifuse architecture
- Security Fuse: Used to prevent unauthorized probing of an Actel FPGA. Also prevents further programming of the device
- Program Fuse: Prevents additional data from being programmed into the device (ACT 1 and 40MX only)
- Probe Fuse: Used to prevent probing of an Actel FPGA (ACT 1 and 40MX only)

JTAG Boundary Scan can be used if the security, probe, and programmed fuses are programmed.

Securing Actel Antifuse FPGAs

In order to secure an Actel antifuse device from unwanted probing, it is necessary to program the internal security fuse. The security fuse can be set on any Actel device once the unit has been programmed. This revolutionary ability to program the security fuse after programming array fuses allows the user to verify a design with the Debugger or Silicon Explorer diagnostic tool prior to permanently locking the device. Extended verification can continue through multiple design iterations, with the assurance that once a given design has been verified, Actel's proprietary security fuses can be programmed to secure the device from further probing.

The ACT 1 and 40MX families contain two security fuses unique to their architecture: a Probe and a Program function. Programming the Probe fuse disables the probe circuitry, which also disables the use of the Debugger and Silicon Explorer diagnostic tools. This effectively prevents unauthorized users or potential attackers from compromising a design. In addition, programming the Program fuse prevents further programming of the device. This ensures devices will not be inadvertently programmed twice or deliberately overwritten for malicious reasons. Figure 1 on page 2, Figure 2 on page 2, Figure 3 on page 3, and Figure 4 on page 3 show how to use Actel's Silicon Sculptor programming software to secure Actel antifuse FPGAs. Figure 5 on page 4 and Figure 6 on page 4 show the same feature for the Activator 2/2S programming software.

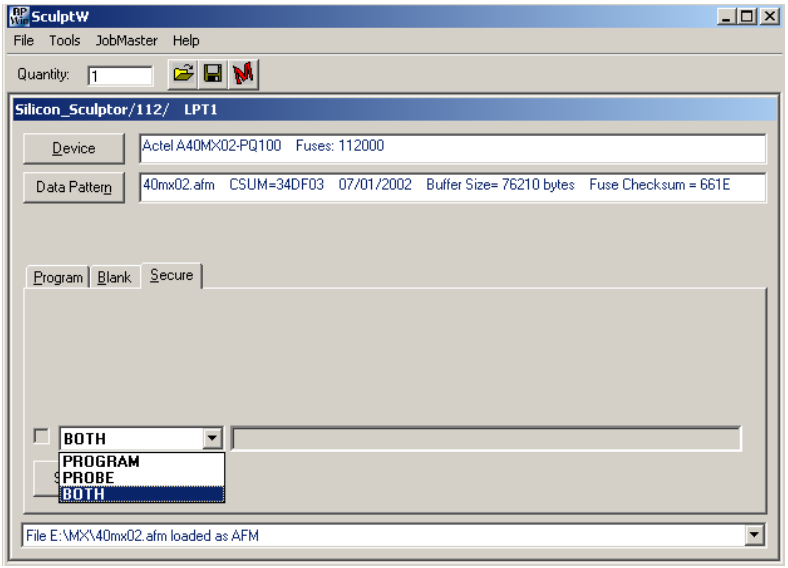

Figure 1 • *Programming Probe and Program Circuitry in Silicon Sculptor Software (Windows)*

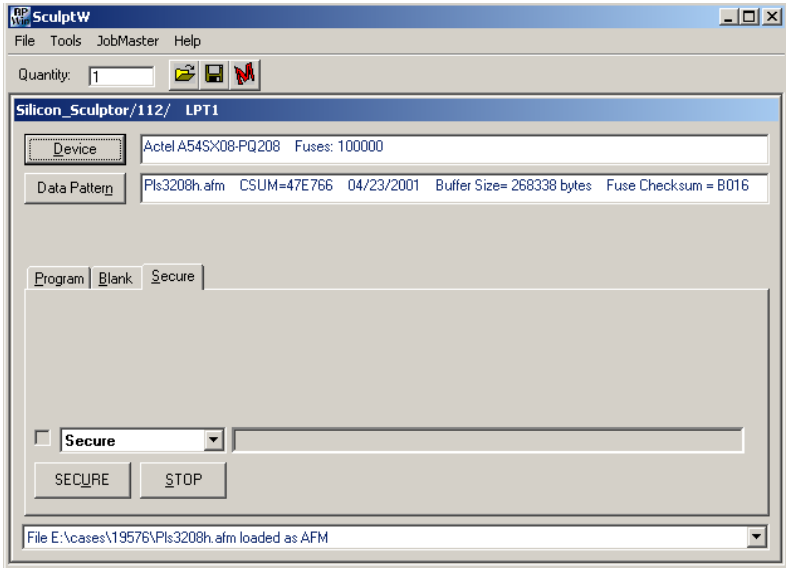

Figure 2 • *Programming Security Fuse in Silicon Sculptor Software (Windows)*

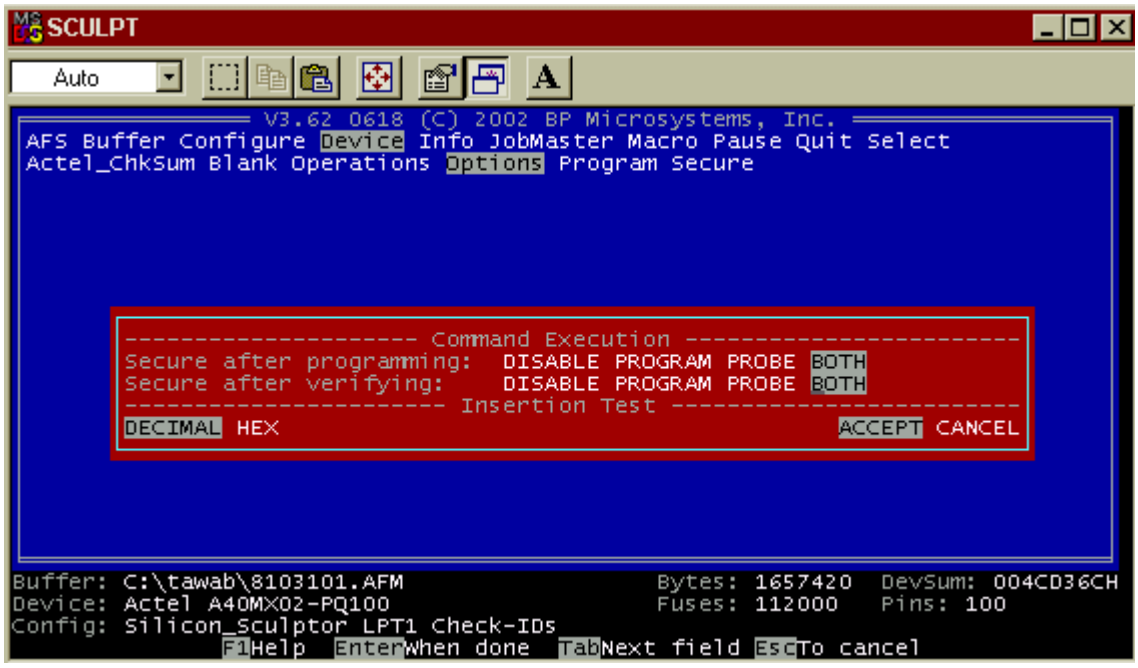

Figure 3 • *Programming Probe and Program Circuitry in Silicon Sculptor Software (Dos)*

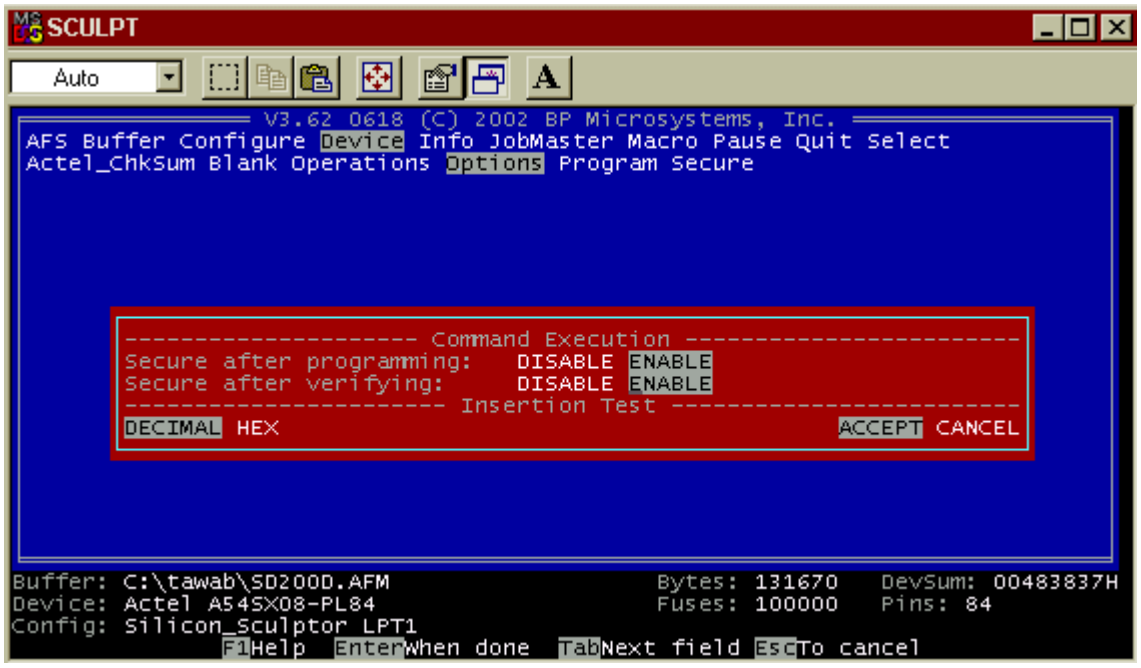

Figure 4 • *Programming Security Fuse in Silicon Sculptor Software (Dos)*

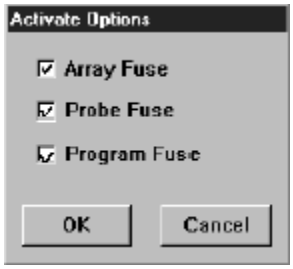

Figure 5 • *Activator Option to Program Probe and Program Fuses for ACT1 and 40MX FPGAs*

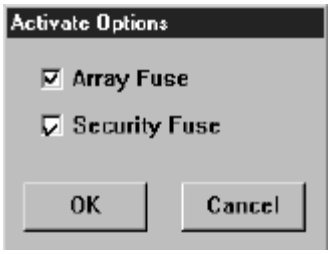

Figure 6 • *Activator Option to Program Security Fuses for Other FPGAs*

Verifying the Status of the Security Fuse in an Actel Antifuse FPGA

To verify the status of the security fuse in an Actel device, there are two unique flows depending upon the type of programmer and programming software used to program that device. The following description details the steps necessary to verify the state of the security fuse using both Silicon Sculptor with Sculptor software and Activator 2/2S with Windows Programming Software.

Silicon Sculptor and Sculptor Software

To verify the state of the security fuse using Silicon Sculptor, it is necessary to insert the programmed device in the appropriate Silicon Sculptor adapter module and to run the programming software. After selecting the device type, the correct Actel Checksum test will run. The software will return a response similar to the one shown below identifying the state of the security fuse.

```
User ID: 0
Checksum: <device checksum>
The security fuse is programmed.
```

The line "The security fuse is programmed" will not be present if the security fuse is not programmed.

For ACT1 and 40MX devices, both the Program and Probe fuses should be programmed to enable security. When the Actel checksum command is executed, the software will respond with the following message:

```
User ID: 0
Checksum: <device checksum>
Both Probe and Program Fuses are programmed!
```

Activator 2/2S with Windows Programming Software

To check the status of the security fuse using Activator, a Blank check should be executed from the top line menu of the Windows Programming software. Table 2 describes the software feedback when the blank check is done.

Table 2 • *Software Response After Blank Check*

STATUS	SIGNATURE	CHECKSUM	SECURITY
Not blank	<silicon signature>	23F2	1*

Note: **The "Security" heading will indicate whether the security fuse is programmed (value =1) or not (value = 0).*

Automatically Programming of the Security Fuse

To automatically program the security fuse, configure the .afm file in Actel antifuse devices using the Silicon Sculptor software. In order to program the security fuse as the default in Actel antifuse devices using the Silicon Sculptor software, the .afm file should be modified in the following way:

The header of the .afm file contains the following line:

```
|VAR PROGSECFUSE <NOT-SET>
```

This line should be replaced with:

```
|VAR PROGSECFUSE <S>
```

Conclusion

Actel has included security by design in all of our antifuse FPGAs. Designers can take advantage of Actel's superior security with several easy steps using Actel's programmer and programming software. These steps will ensure a valuable design or critical Intellectual Property is protected from unauthorized interference, possible corruption, or being illegally copied.

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