Apple Inc.

Apple iOS CoreCrypto Kernel Module, v4.0 FIPS 140-2 Non-Proprietary Security Policy

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1 Introduction

1.1 Purpose

This document is a non-proprietary Security Policy for the Apple iOS CoreCrypto Kernel Module, v4.0. It describes the module and the FIPS 140-2 cryptographic services it provides. This document also defines the FIPS 140-2 security rules for operating the module.

This document was prepared in partial fulfillment of the FIPS 140-2 requirements for cryptographic modules and is intended for security officers, developers, system administrators, and end-users.

FIPS 140-2 details the requirements of the Governments of the U.S. and Canada for cryptographic modules, aimed at the objective of protecting sensitive but unclassified information.

For more information on the FIPS 140-2 standard and validation program please refer to the NIST CMVP website at http://csrc.nist.gov/groups/STM/cmvp/index.html.

Throughout the document “Apple iOS CoreCrypto Kernel Module, v4.0.” “cryptographic module”, “CoreCrypto KEXT” or “the module” are used interchangeably to refer to the Apple iOS CoreCrypto Kernel Module, v4.0.

1.2 Document Organization / Copyright

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1.3 External Resources / References

The Apple website (http://www.apple.com) contains information on the full line of products from Apple Inc. For a detailed overview of the operating system iOS and its security properties refer to [iOS] and [SEC].

The Cryptographic Module Validation Program website (http://csrc.nist.gov/groups/STM/cmvp/index.html) contains links to the FIPS 140-2 certificate and Apple, Inc. contact information.

1.3.1 Additional References

FIPS 140-2 Federal Information Processing Standards Publication, “FIPS PUB 140-2 Security Requirements for Cryptographic Modules,” Issued May-25-2001, Effective 15-Nov-2001, Location: http://csrc.nist.gov/groups/STM/cmvp/standards.html

FIPS 180-3 Federal Information Processing Standards Publication 180-3, October 2008, Secure Hash Standard (SHS)

FIPS 197 Federal Information Processing Standards Publication 197, November 26, 2001 Announcing the ADVANCED ENCRYPTION STANDARD (AES)

PKCS7 RSA Laboratories, “PKCS#7 v1.5: Cryptographic Message Syntax Standard,” 1993. Location: http://www.rsa.com/rsalabs/node.asp?id=2129

PKCS3 RSA Laboratories, “PKCS#3 v1.4: Diffie-Hellman Key Agreement Standard,” 1993. Location: http://www.rsa.com/rsalabs/node.asp?id=2126

IG NIST, “Implementation Guidance for FIPS PUB 140-2 and the Cryptographic Module Validation Program,” July 25, 2013

Location: http://csrc.nist.gov/groups/STM/cmvp/standards.html iOS iOS Technical Overview

Location: http://developer.apple.com/library/ios/#documentation/Miscellaneous/Conceptual/iPhoneOSTechOverview/Introduction/Introduction.html#//apple_ref/doc/uid/TP40007898

SEC Security Overview

Location: http://developer.apple.com/library/ios/#documentation/Security/

Conceptual/Security_Overview/Introduction/Introduction.html

SP800-57P1 NIST Special Publication 800-57, “Recommendation for Key Management – Part 1: General (Revised),” July 2012

SP800-90A NIST Special Publication 800-90A, “Recommendation for Random Number Generation Using Deterministic Random Bit Generators (Revised),” January 2012

UG User Guide

Location: http://developer.apple.com/library/ios/navigation/

1.4 Acronyms

Acronyms found in this document are defined as follows:

AES	Advanced Encryption Standard
BS	Block Size
CAVP	Cryptographic Algorithm Validation Program
CBC	Cipher Block Chaining mode of operation
CFB	Cipher Feedback mode of operation
CMVP	Cryptographic Module Validation Program
CSP	Critical Security Parameter
CTR	Counter mode of operation
DES	Data Encryption Standard
DH	Diffie-Hellmann
DMA	Direct Memory Access
DRBG	Deterministic Random Bit Generator
DS	Digest Size
ECB	Electronic Codebook mode of operation
ECC	Elliptic Curve Cryptography
EC Diffie-Hellman	DH based on ECC
ECDSA	DSA based on ECC
E/D	Encrypt/Decrypt
EMC	Electromagnetic Compatibility

EMI	Electromagnetic Interference
FIPS	Federal Information Processing Standard
FIPS PUB	FIPS Publication
GCM	Galois/Counter Mode
HMAC	Hash-Based Message Authentication Code
HW	Hardware
IPCU	iPhone Configuration Utility
KAT	Known Answer Test
KEK	Key Encryption Key
KEXT	Kernel extension
KDF	Key Derivation Function
KO 1	Triple-DES Keying Option 1: All three keys are independent
KPI	Kernel Programming Interface
KS	Key Size (Length)
MAC	Message Authentication Code
NIST	National Institute of Standards and Technology
OFB	Output Feedback (mode of operation)
OS	Operating System
PBKDF	Password-based Key Derivation Function
PWCT	Pair Wise Consistency Test
RNG	Random Number Generator
SHS	Secure Hash Standard
SW	Software
Triple-DES	Triple Data Encryption Standard
TLS	Transport Layer Security

2 Cryptographic Module Specification

2.1 Module Description

The Apple iOS CoreCrypto Kernel Module, v4.0 is a software cryptographic module running on a multi-chip standalone mobile device.

The cryptographic services provided by the module are:

- Data encryption / decryption
- Generation of hash values
- Message authentication
- Signature generation/verification
- Random number generation
- Key derivation
- Key generation

2.1.1 Module Validation Level

The module is intended to meet requirements of FIPS 140-2 security level 1 overall. The following table shows the security level for each of the eleven requirement areas of the validation.

FIPS 140-2 Security Requirement Area	Security Level
Cryptographic Module Specification	1
Cryptographic Module Ports and Interfaces	1
Roles, Services and Authentication	1
Finite State Model	1
Physical Security	N/A
Operational Environment	1
Cryptographic Key Management	1
EMI/EMC	1
Self Tests	1
Design Assurance	1
Mitigation of Other Attacks	1

Table 1: Module Validation Level

2.1.2 Module components

In the following sections the components of the Apple iOS CoreCrypto Kernel Module, v4.0 are listed in detail. There are no components excluded from the validation testing.

2.1.2.1 Software components

CoreCrypto has a KPI layer that provides consistent interfaces to the supported algorithms. These implementations include proprietary optimizations of algorithms that are fitted into the CoreCrypto framework.

The CoreCrypto KEXT is linked dynamically into the iOS kernel.

2.1.2.2 Hardware components

There are no hardware components within the cryptographic module boundary.

2.1.3 Tested Platforms

The module has been tested on the following platforms:

Manufacturer	Model	Operating System
Apple Inc.	iPhone4 with Apple A4 CPU	iOS 7.0
Apple Inc.	iPhone4S with Apple A5 CPU	iOS 7.0
Apple Inc.	iPad (3rd Generation) with Apple A5 CPU	iOS 7.0
Apple Inc.	iPhone5 with Apple A6 CPU	iOS 7.0

Marketing name for iPad (3rd generation) is ‘New iPad’.

Table 2: Tested Platforms

2.2 Modes of operation

The Apple iOS CoreCrypto Kernel Module, v4.0 has an Approved and Non-Approved Mode of operation. The Approved Mode of operation is configured in the system by default. If the device boots up successfully then CoreCrypto KEXT has passed all self-tests and is operating in the Approved Mode. Any calls to the Non-Approved security functions listed in Table 4 will cause the module to assume the Non-Approved Mode of operation.

The module transitions back into FIPS mode immediately when invoking one of the approved ciphers as all keys and Critical Security Parameters (CSP) handled by the module are ephemeral and there are no keys and CSPs shared between any functions. A re-invocation of the self-tests or integrity tests is not required. Even when using this FIPS 140-2 non-approved mode, the module configuration ensures that the self-tests are always performed during initialization of the module.

The module contains multiple implementations of the same cipher as listed below. If multiple implementations of the same cipher are present, the module selects automatically which cipher is used based on internal heuristics.

Approved security functions are listed in Table 3. Column four (“Val. No.”) of Table 3 lists the validation numbers obtained from NIST based on the successful CAVP testing of the cryptographic algorithm implementations on the platforms referenced in Table 2.

Refer to http://csrc.nist.gov/groups/STM/cavp/index.html for the current standards, test requirements, and special abbreviations used in the following table:

Approved Security Functions to be used in the Approved Mode of Operation

Cryptographic Function	Standards	Usage / Description	Val. No.		
			A4 CPU	A5 CPU	A6 CPU
Triple-DES	ANSIX9.52-1998 FIPS 46-3 SP 800-67 SP 800-38A	Encryption / decryption with all keys independent Block chaining modes: ECB, CBC	1527	1528	1529

Cryptographic Function	Standards	Usage / Description	Val. No.		
			A4 CPU	**A5 CPU**	**A6 CPU**
	Appendix E				
AES	FIPS 197 SP 800-38A	Generic-software implementation (non-optimized): Encryption / decryption Key sizes: 128 bits, 192 bits, 256 bits Block chaining modes: ECB, CBC	2496	2497	2498
		Optimized assembler implementation: Encryption / decryption Key sizes: 128 bits, 192 bits, 256 bits Block chaining modes: CBC	2493	2494	2495
SHS	FIPS 180-3	Generic-software implementation (non-optimized): SHA-1 (BYTE-only) SHA-224 (BYTE-only) SHA-256 (BYTE-only) SHA-384 (BYTE-only) SHA-512 (BYTE-only)	2113	2114	2115
		Optimized-software implementation: SHA-1 (BYTE-only) SHA-224 (BYTE-only) SHA-256 (BYTE-only)	2167	2169	2171
ECDSA	FIPS 186-2 ANSI X9.62	PKG: curves P-256, P-384 PKV: curves P-256, P-384 SIG(gen): curves P-256, P-384 SIG(ver): curves P-256, P-384	425	426	427
HMAC	FIPS 198	Generic-software implementation (non-optimized): KS<BS, KS=BS, KS>BS HMAC-SHA-1 HMAC-SHA-224 HMAC-SHA-256 HMAC-SHA-384 HMAC-SHA-512	1535	1536	1537
		Optimized-software implementation: KS<BS, KS=BS, KS>BS HMAC-SHA-1 HMAC-SHA-224	1588	1590	1592

Cryptographic Function	Standards	Usage / Description	Val. No.		
			A4 CPU	A5 CPU	A6 CPU
		HMAC-SHA-256			
Counter DRBG	SP 800-90A	Generic-software implementation of AES (non-optimized) AES with 128 bit key size	350	351	352
PBKDF	SP 800-132	Password based key derivation according using HMAC with SHA-1 or SHA-2 as pseudorandom function	Vendor Affirmed		

Table 3: Approved Security Functions

CAVEAT: The module generates cryptographic keys whose strengths are modified by available entropy – 160-bits.

Non-Approved or non-compliant Security Functions used in the Non-Approved Mode of Operation:

Cryptographic Function	Usage / Description	Note
DES	Encryption and decryption: key size 56 bits; Used for NFS support in the racoon IPSec cipher suite as a last resort when AES and Triple-DES ciphers are not supported by the remote end.	Non-Approved
MD5	Hashing Digest size 128 bit	Non-Approved
ECDSA	PKG: curves P-192, P-224, P-521 PKV: curves P-192, P-224, P-521 SIG(gen): curves P-192, P-224, P-521 SIG(ver): curves P-192, P-224, P-521	Non-compliant
RSA	PKCS#1 v1.5 SIG(ver) Key sizes (modulus): 1024 bits, 1536 bits, 2048 bits, 3072 bits, 4096 bits Hash algorithms: SHA-1, SHA-224, SHA-256, SHA-384, SHA-512	Non-compliant
CAST5	Encryption and decryption: key sizes 40 to 128 bits in 8-bit increments	Non-Approved
Blowfish	Encryption and decryption	Non-Approved
BitGen1	Proprietary mechanism for bit-generation	Non-Approved

Cryptographic Function	Usage / Description	Note
BitGen2	Proprietary mechanism for bit-generation	Non-Approved
BitGen3	Proprietary mechanism for bit-generation	Non-Approved
RC4	Encryption and decryption	Non-Approved
OMAC (One-Key CBC MAC)	MAC generation	Non-Approved

Table 4: Non-Approved or Non-compliant Security Function

The encryption strengths included in Table 4 for the key establishment methods are determined in accordance with FIPS 140-2 Implementation Guidance [IG] section 7.5 and NIST Special Publication 800-57 (Part1) [SP800-57P1].

Note: A Non-Approved function in Table 4 is that the function implements a non-Approved algorithm, while a Non-compliant function is that the function implements an Approved algorithm but the implementation is not validated by the CAVP.

2.3 Cryptographic Module Boundary

The physical boundary of the module is the physical boundary of the iOS device (i.e. iPhone or iPad) that contains the module. Consequently, the embodiment of the module is a multi-chip standalone cryptographic module.

The logical module boundary is depicted in the logical block diagram given in Figure 1.

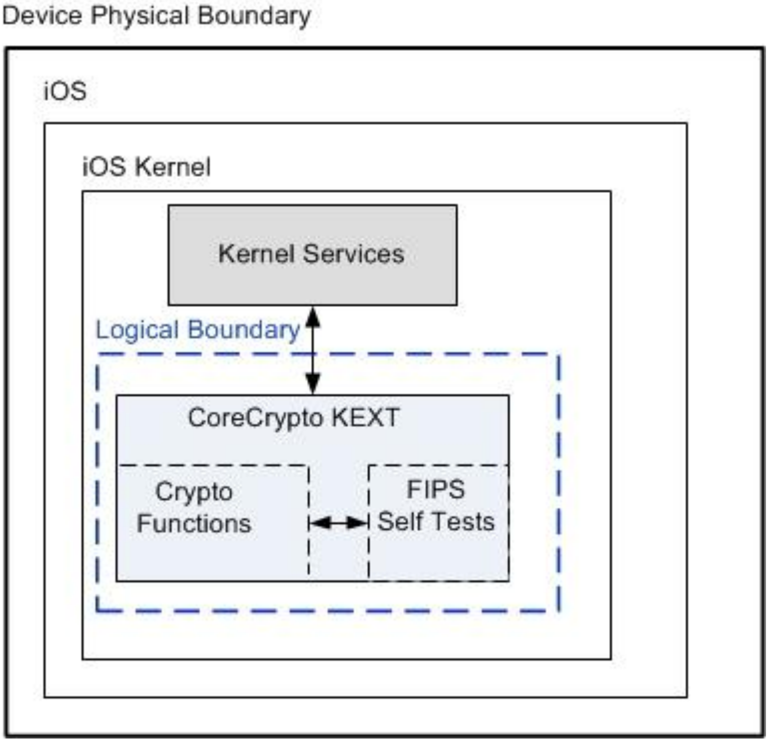

Figure 1: Logical Block Diagram

2.4 Module Usage Considerations

A user of the module must consider the following requirements and restrictions when using the module:

- When using AES-GCM, the caller must use the module's DRBG to generate at least 96 bits of random data that is used for the IV of AES-GCM. The caller is permitted to add additional deterministic data to that IV value in accordance with SP800-38D section 8.2.2. Users should consult SP 800-38D, especially section 8, for all of the details and requirements of using AES-GCM mode. In case the module's power is lost and then restored, the key used for the AES GCM encryption/decryption shall be re-distributed.
- When using AES, the caller must obtain a reference to the cipher implementation via the functions of ccaes_[cbc|ecb]_[encrypt|decrypt]_mode.
- When using SHA, the caller must obtain a reference to the cipher implementation via the functions ccsha[1|224|256|384|512]_di.

3 Cryptographic Module Ports and Interfaces

The underlying logical interfaces of the module are the C language Kernel Programming Interfaces (KPIs). In detail these interfaces are the following:

- Data input and data output are provided in the variables passed in the KPI and callable service invocations, generally through caller-supplied buffers. Hereafter, KPIs and callable services will be referred to as “KPI.”
- Control inputs which control the mode of the module are provided through dedicated parameters, namely the kernel module plist whose information is supplied to the module by the kernel module loader.
- Status output is provided in return codes and through messages. Documentation for each KPI lists possible return codes. A complete list of all return codes returned by the C language KPIs within the module is provided in the header files and the KPI documentation. Messages are documented also in the KPI documentation.

The module is an iOS kernel extension optimized for library use within the iOS kernel and does not contain any terminating assertions or exceptions. Once the module is loaded into the iOS kernel its cryptographic functions are made available to iOS Kernel services only. Any internal error detected by the module is reflected back to the caller with an appropriate return code. The calling iOS Kernel service must examine the return code and act accordingly. There are two notable exceptions: (i) ECDSA does not return a key if the pair-wise consistency test fails; (ii) the DRBG algorithm loops a few iterations internally if the continuous test fails, eventually recovering from the error or causing a shutdown if the problem persists.

The function executing FIPS 140-2 module self-tests does not return an error code but causes the system to crash if any self-test fails – see Section 9.

The module communicates error status synchronously through the use of documented return codes (indicating the module’s status). It is the responsibility of the caller to handle exceptional conditions in a FIPS 140-2 appropriate manner.

Caller-induced or internal errors do not reveal any sensitive material to callers.

Cryptographic bypass capability is not supported by the module.

4 Roles, Services and Authentication

This section defines the roles, services and authentication mechanisms and methods with respect to the applicable FIPS 140-2 requirements.

4.1 Roles

The module supports a single instance of the two authorized roles: the Crypto Officer and the User. No support is provided for multiple concurrent operators or a maintenance operator.

Role	General Responsibilities and Services (details see below)
User	Utilization of services of the module listed in sections 2.1 and 4.2
Crypto Officer (CO)	Utilization of services of the module listed in sections 2.1 and 4.2

Table 5: Roles

4.2 Services

The module provides services to authorized operators of either the User or Crypto Officer role according to the applicable FIPS 140-2 security requirements.

Table 6 contains the cryptographic functions employed by the module in the Approved Mode. For each available service it lists, the associated role, the Critical Security Parameters (CSPs) and cryptographic keys involved, and the type(s) of access to the CSPs and cryptographic keys.

CSPs contain security-related information (secret and private cryptographic keys, for example) whose disclosure or modification can compromise the main security objective of the module, namely the protection of sensitive information.

The access types are denoted as follows:

- R: the item is read or referenced by the service
- W: the item is written or updated by the service
- Z: the persistent item is zeroized by the service

Service	Roles		CSPs & crypto keys	Access Type
	USER	CO		
Triple-DES encryption and decryption *Input:* plaintext, IV, key *Output:* ciphertext Decryption *Input:* ciphertext, IV, key *Output:* plaintext	X	X	Secret key	R

Service	**Roles**		**CSPs & crypto keys**	**Access Type**
	USER	CO		
AES encryption and decryption *Input:* plaintext, IV, key *Output:* ciphertext Decryption *Input:* ciphertext, IV, key *Output:* plaintext	X	X	Secret key	R
Secure Hash Generation *Input:* message *Output:* message digest	X	X	None	N/A
HMAC generation *Input:* HMAC key, message *Output:* HMAC value of message	X	X	Secret HMAC key	R
ECDSA signature generation and verification Signature generation *Input:* message m, q, a, b, X_G, Y_G, n, the SHA algorithm (SHA-1/SHA-224/SHA-256/SHA-384/SHA-512) sender's private key d *Output:* signature of m as a pair of r and s Signature verification *Input:* received message m', signature in form on r' and s' pair, q, a, b, X_G, Y_G, n, sender's public key Q, the SHA algorithm (SHA-1/SHA-224/SHA-256/SHA-384/SHA-512) *Output:* pass if the signature is valid, fail if the signature is invalid	X	X	ECDSA key pair	R W

Service	Roles		CSPs & crypto keys	Access Type
	USER	CO		
Random number generation *Input:* Entropy Input, Nonce, Personalization String *Output:* Returned Bits	X	X	Entropy input string, Seed, V and K	R W Z
PBKDF *Input:* encrypted key and password *Output:* plaintext key or *Input:* plaintext key and password *Output:* encrypted data	X	X	Secret key, password	R W Z
AES key import *Input:* key *Output:* N/A	X	X	Secret key	R
Triple-DES key import *Input:* key *Output:* N/A	X	X	Secret key	R
HMAC key import *Input:* key *Output:* N/A	X	X	HMAC key	R
Release all resources of symmetric crypto function context *Input:* context *Output:* N/A	X	X	AES / Triple-DES key	Z
Release all resources of hash context *Input:* context *Output:* N/A	X	X	HMAC key	Z
Release all resources of asymmetric crypto function context *Input:* context *Output:* N/A	X	X	Asymmetric keys (ECDSA)	Z
Reboot	X	X	N/A	N/A
Self-test	X	X	Software integrity key	R
Show Status	X	X	None	N/A

Table 6: Cryptographic Services and Roles

4.3 Operator authentication

Within the constraints of FIPS 140-2 level 1, the module does not implement an authentication mechanism for operator authentication. The assumption of a role is implicit in the action taken.

The module relies upon the operating system for any operator authentication.

5 Physical Security

The Apple iOS CoreCrypto Kernel Module, v4.0 is intended to operate on a multi-chip standalone platform used as a mobile device. The mobile device is comprised of production grade components and a production grade enclosure.

6 Operational Environment

The following sections describe the operational environment of the Apple iOS CoreCrypto Kernel Module, v4.0.

6.1 Applicability

The Apple iOS CoreCrypto Kernel Module, v4.0 operates in a modifiable operational environment per FIPS 140-2 level 1 specifications. The module is included in iOS 7.0, a commercially available general-purpose operating system executing on the hardware specified in section 2.1.3.

6.2 Policy

The operating system is restricted to a single operator (concurrent operators are explicitly excluded).

FIPS Self-Test functionality is invoked along with mandatory FIPS 140-2 tests when the module is loaded into memory by the operating system**.**

7 Cryptographic Key Management

The following section defines the key management features available through the Apple iOS CoreCrypto Kernel Module, v4.0.

7.1 Random Number Generation

The module uses a FIPS 140-2 approved deterministic random bit generator (DRBG) based on a block cipher as specified in NIST SP 800-90A (CTR_DRBG using AES-128 in counter mode). Seeding is obtained by read_random (a true random number generator). read_random obtains entropy from interrupts generated by the devices and sensors attached to the system and maintains an entropy pool. The TRNG feeds entropy from the pool into the DRBG on demand. The TRNG provides 160-bits of entropy.

7.2 Key / CSP Generation

The following approved key generation methods are used by the module:

- The Approved DRBG specified in section 7.1 is used to generate cryptographic secret keys for symmetric key algorithms (AES, Triple-DES) and message authentication (HMAC).
- The module provides PBKDF-based key generation services in the Approved Mode.
- The approved DRBG specified in section 7.1 is used to generate secret asymmetric key pairs for the ECDSA algorithm.

The module does not output any information or intermediate results during the key generation process. The DRBG itself is single-threaded.

The cryptographic strength of the 192 and 256 bit AES keys as well as the ECDSA keys for the curve P-384, as modified by the available entropy, is limited to 160-bits.

7.3 Key / CSP Establishment

The module provides key establishment services in the Approved Mode through the PBKDFv2 algorithm. The PBKDFv2 function is provided as a service and returns the key derived from the provided password to the caller. The caller shall observe all requirements and should consider all recommendations specified in SP800-132 with respect to the strength of the generated key, including the quality of the password, the quality of the salt as well as the number of iterations. The implementation of the PBKDFv2 function requires the user to provide this information.

7.4 Key / CSP Entry and Output

All keys are imported from, or output to, the invoking kernel service running on the same device. All keys entered into the module are electronically entered in plain text form. Keys are output from the module in plain text form if required by the calling kernel service. The same holds for the CSPs.

7.5 Key / CSP Storage

The Apple iOS CoreCrypto Kernel Module, v4.0 considers all keys in memory to be ephemeral. They are received for use or generated by the module only at the command of the calling kernel service. The same holds for CSPs.

The module protects all keys, secret or private, and CSPs through the memory protection mechanisms provided by iOS, including the separation between the kernel and user-space. No process can read the memory of another process. No user-space application can read the kernel memory.

7.6 Key / CSP Zeroization

Keys and CSPs are zerorized when the appropriate context object is destroyed or when the device is powered down. Additionally, the user can zeroize the entire device directly (locally) or remotely, returning it to the original factory settings.

8 Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC)

The EMI/EMC properties of the Apple iOS CoreCrypto Kernel Module, v4.0 are not meaningful for the software library. The devices containing the software components of the module have their own overall EMI/EMC rating. The validation test environments have FCC, part 15, Class B rating.

9 Self Tests

FIPS 140-2 requires that the module perform self-tests to ensure the integrity of the module and the correctness of the cryptographic functionality at start up. In addition, the DRBG requires continuous verification. The FIPS Self Tests functionality runs all required module self tests. This functionality is invoked by the iOS Kernel boot process upon device startup. If the self-tests succeed, the Apple iOS CoreCrypto Kernel Module, v4.0 instance is maintained in the memory of the iOS Kernel on the device and made available to each calling kernel service without reloading. All self-tests performed by the module are listed and described in this section.

9.1 Power-Up Tests

The following tests are performed each time the Apple iOS CoreCrypto Kernel Module, v4.0 starts and must be completed successfully for the module to operate in the FIPS Approved Mode. If any of the following tests fails the device shuts down automatically. To rerun the self-tests on demand, the user may reboot the device.

9.1.1 Cryptographic Algorithm Tests

Algorithm	Modes	Test
Triple-DES	CBC	KAT (Known Answer Test) Separate encryption / decryption operations are performed
AES implementations selected by the module for the corresponding environment AES-128, AES-192, AES-256	ECB, CBC	KAT Separate encryption / decryption operations are performed
DRBG	N/A	KAT
SHA implementations selected by the module for the corresponding environment SHA-1, SHA-224, SHA-256, SHA-384, SHA-512	N/A	KAT
HMAC-SHA-1, HMAC-SHA-224, HMAC-SHA-256, HMAC-SHA-384, HMAC-SHA-512	N/A	KAT
ECDSA	SIG(ver), SIG(gen)	pair-wise consistency test

Table 7: Cryptographic Algorithm Tests

9.1.2 Software / firmware integrity tests

A software integrity test is performed on the runtime image of the Apple iOS CoreCrypto Kernel Module, v4.0. The CoreCrypto's HMAC-SHA256 is used as an Approved algorithm for the integrity test. If the test fails, then the device powers itself off.

9.1.3 Critical Function Tests

No other critical function test is performed on power up.

9.2 Conditional Tests

The following sections describe the conditional tests supported by the Apple iOS CoreCrypto Kernel Module, v4.0.

9.2.1 Continuous Random Number Generator Test

The Apple iOS CoreCrypto Kernel Module, v4.0 performs a continuous random number generator test, whenever CTR_DRBG is invoked.

In addition, the seed source implemented in the operating system kernel also performs a continuous self test.

9.2.2 Pair-wise Consistency Test

The Apple iOS CoreCrypto Kernel Module, v4.0 generates asymmetric ECDSA key pairs and performs all required pair-wise consistency tests (signature generation and verification) with the newly generated key pairs.

9.2.3 SP800-90A Assurance Tests

The Apple iOS CoreCrypto Kernel Module, v4.0 performs a subset of the assurance tests as specified in section 11 of SP800-90A, in particular it complies with the mandatory documentation requirements and performs know-answer tests and prediction resistance.

9.2.4 Critical Function Test

No other critical function test is performed conditionally.

10 Design Assurance

10.1 Configuration Management

Apple manages and records source code and associated documentation files by using the revision control system named “Git.”

Apple module hardware data, which includes descriptions, parts data, part types, bills of materials, manufacturers, changes, history, and documentation are managed and recorded. Additionally, configuration management is provided for the module’s FIPS documentation.

The following naming/numbering convention for documentation is applied.

<evaluation>_<module>_<os>_<mode>_<doc name>_<doc version (##.##)>

Example: FIPS_CORECRYPTO_IOS_KS_SECPOL_01.01

Document management utilities provide access control, versioning, and logging. Access to the Git repository (source tree) is granted or denied by the server administrator in accordance with company and team policy.

10.2 Delivery and Operation

The CoreCrypto KEXT is built into iOS. For additional assurance, it is digitally signed. The Approved Mode is configured by default and cannot be changed by a user.

10.3 Development

The Apple crypto module (like any other Apple software) undergoes frequent builds utilizing a“train”philosophy. Source code is submitted to the Build and Integration group (B & I). B & I builds, integrates and does basic sanity checking on the operating systems and apps that they produce. Copies of older versions are archived offsite in underground granite vaults.

10.4 Guidance

The following guidance items are to be used for assistance in maintaining the module’s validated status while in use.

10.4.1 Cryptographic Officer Guidance

The Approved Mode of operation is configured in the system by default and cannot be changed. If the device boots up successfully then CoreCrypto KEXT has passed all self-tests and is operating in the Approved Mode.

10.4.2 User Guidance

As above, the Approved Mode of operation is configured in the system by default and cannot be changed. If the device boots up successfully then CoreCrypto KEXT has passed all self-tests and is operating in the Approved Mode.

Kernel programmers that use the module API shall not attempt to invoke any API call directly and only adhere to defined interfaces through the kernel framework.

11 Mitigation of Other Attacks

The module protects against the utilization of known Triple-DES weak keys. The following keys are not permitted:

{0x01,0x01,0x01,0x01,0x01,0x01,0x01,0x01},

{0xFE,0xFE,0xFE,0xFE,0xFE,0xFE,0xFE,0xFE},

{0x1F,0x1F,0x1F,0x1F,0x0E,0x0E,0x0E,0x0E},

{0xE0,0xE0,0xE0,0xE0,0xF1,0xF1,0xF1,0xF1},

{0x01,0xFE,0x01,0xFE,0x01,0xFE,0x01,0xFE},

{0xFE,0x01,0xFE,0x01,0xFE,0x01,0xFE,0x01},

{0x1F,0xE0,0x1F,0xE0,0x0E,0xF1,0x0E,0xF1},

{0xE0,0x1F,0xE0,0x1F,0xF1,0x0E,0xF1,0x0E},

{0x01,0xE0,0x01,0xE0,0x01,0xF1,0x01,0xF1},

{0xE0,0x01,0xE0,0x01,0xF1,0x01,0xF1,0x01},

{0x1F,0xFE,0x1F,0xFE,0x0E,0xFE,0x0E,0xFE},

{0xFE,0x1F,0xFE,0x1F,0xFE,0x0E,0xFE,0x0E},

{0x01,0x1F,0x01,0x1F,0x01,0x0E,0x01,0x0E},

{0x1F,0x01,0x1F,0x01,0x0E,0x01,0x0E,0x01},

{0xE0,0xFE,0xE0,0xFE,0xF1,0xFE,0xF1,0xFE},

{0xFE,0xE0,0xFE,0xE0,0xFE,0xF1,0xFE,0xF1}.