# Cisco Systems 3504, 5520, and 8540 Wireless LAN Controllers

## FIPS 140-2 Non-Proprietary Security Policy
**Level 1 Validation**

**Version 1.0**

**March 8, 2019**

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# 1 Introduction

## 1.1 Purpose

This is a non-proprietary Cryptographic Module Security Policy for the Cisco Systems 3504, 5520, and 8540 Wireless LAN Controllers, and Firmware 8.5; referred to in this document as controllers or the module. This security policy describes how the modules meet the security requirements of FIPS 140-2 Level 1 and how to run the modules in a FIPS 140-2 mode of operation and may be freely distributed.

## 1.2 Models

- Cisco 3504 Wireless Controller (HW: 3504)
- Cisco 5520 Wireless Controller (HW: 5520)
- Cisco 8540 Wireless Controller (HW: 8540)

FIPS 140-2 (Federal Information Processing Standards Publication 140-2 — *Security Requirements for Cryptographic Modules*) details the U.S. Government requirements for cryptographic modules. More information about the FIPS 140-2 standard and validation program is available on the NIST website at http://csrc.nist.gov/groups/STM/index.html.

## 1.3 Module Validation Level

The following table lists the level of validation for each area in the FIPS PUB 140-2.

| No. | Area Title | Level |
|---|---|---|
| 1 | Cryptographic Module Specification | 1 |
| 2 | Cryptographic Module Ports and Interfaces | 1 |
| 3 | Roles, Services, and Authentication | 2 |
| 4 | Finite State Model | 1 |
| 5 | Physical Security | 1 |
| 6 | Operational Environment | N/A |
| 7 | Cryptographic Key management | 1 |
| 8 | Electromagnetic Interface/Electromagnetic Compatibility | 1 |
| 9 | Self-Tests | 1 |
| 10 | Design Assurance | 1 |
| 11 | Mitigation of Other Attacks | N/A |
| | **Overall module validation level** | **1** |

**Table 1: Module Validation Level**

## 1.4 References

This document deals only with operations and capabilities of the Cisco Systems 3504, 5520, and 8540 Wireless LAN Controllers, in the technical terms of a FIPS 140-2 cryptographic module security policy.

For answers to technical or sales related questions, please refer to the contacts listed on the Cisco Systems website at www.cisco.com.

The NIST Validated Modules website (http://csrc.nist.gov/groups/STM/cmvp/validation.html) contains contact information for answers to technical or sales-related questions for the module.

## 1.5 Terminology

In this document, the Cisco Systems 3504, 5520, and 8540 Wireless LAN Controllers are referred to as controllers, WLC, or the modules.

## 1.6 Document Organization

The Security Policy document is part of the FIPS 140-2 Submission Package. In addition to this document, the Submission Package contains:

Vendor Evidence document
Finite State Machine
Other supporting documentation as additional references

This document provides an overview of the Cisco Systems 3504, 5520, and 8540 Wireless LAN Controllers and explains the secure configuration and operation of the module. This introduction section is followed by Section 2, which details the general features and functionality of the appliances. Section 3 specifically addresses the required configuration for the FIPS-mode of operation.

With the exception of this Non-Proprietary Security Policy, the FIPS 140-2 Validation Submission Documentation is Cisco-proprietary and is releasable only under appropriate non-disclosure agreements. For access to these documents, please contact Cisco Systems.

# 2 Cisco Systems 3504, 5520, and 8540 Wireless LAN Controllers

The Cisco 3504 Wireless Controller, designed for 802.11n and 802.11ac performance, enables system wide wireless functions in small to medium-sized enterprises and branch offices.

The Cisco 5520 and 8540 Wireless Controllers, optimized for 802.11ac Wave2 performance, provide centralized control, management, and troubleshooting for high-scale deployments in service provider and large campus deployments.

## 2.1 Cryptographic Module Physical Characteristics

Each module is a multi-chip standalone security appliance, and the cryptographic boundary is defined as encompassing the "top," "front," "back," "left," "right," and "bottom" surfaces of the case.

## 2.2 Module Interfaces

The module provides a number of physical and logical interfaces to the device, and the physical interfaces provided by the module are mapped to the following FIPS 140-2 defined logical interfaces: data input, data output, control input, status output, and power. The logical interfaces and their mapping are described in the following tables:

| Module Physical Interface | FIPS 140-2 Logical Interface |
|---|---|
| • One Multigigabit Ethernet (RJ-45)<br>• Five 1 Gigabit Ethernet Ethernet (RJ-45) | Data Input Interface |
| • One Multigigabit Ethernet (RJ-45)<br>• Five 1 Gigabit Ethernet Ethernet (RJ-45) | Data Output Interface |
| • One Multigigabit Ethernet (RJ-45)<br>• Five 1 Gigabit Ethernet Ethernet (RJ-45)<br>• Console ports (RJ-45 or mini-B USB)<br>• USB 3.0<br>• Reset button | Control Input Interface |
| • LEDs<br>• Console ports (RJ-45 or mini-B USB) | Status Output Interface |
| • Power Connector | Power Interface |

**Table 2: Cisco 3504 Wireless LAN Controller Physical Interface/Logical Interface Mapping**

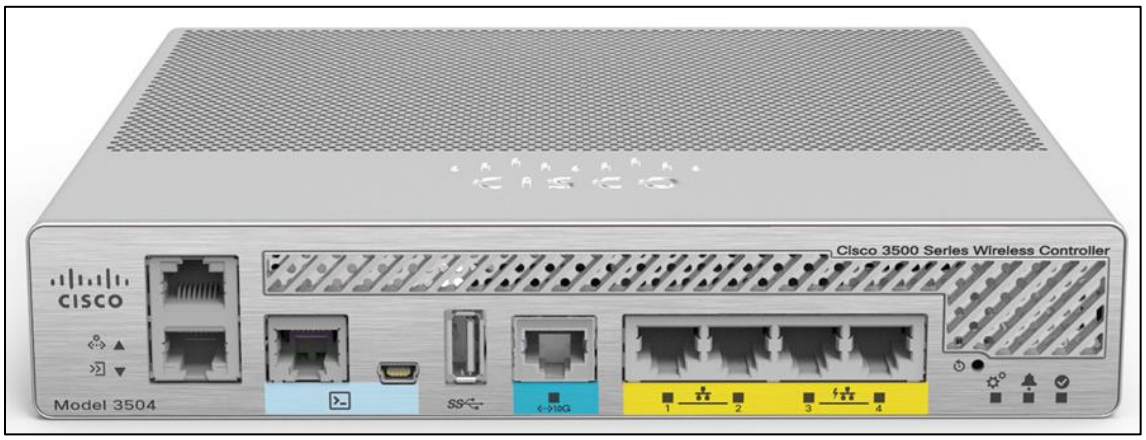



**Figure 1: Cisco 3504 Wireless LAN Controller Front Panel**

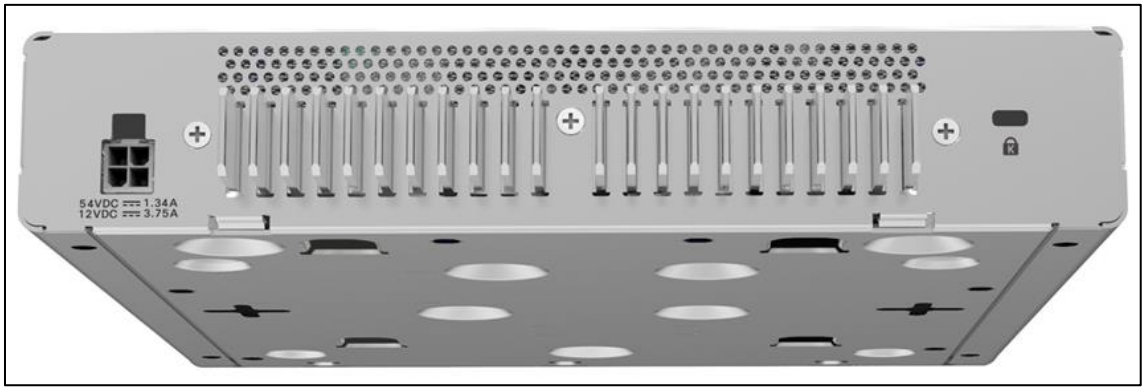
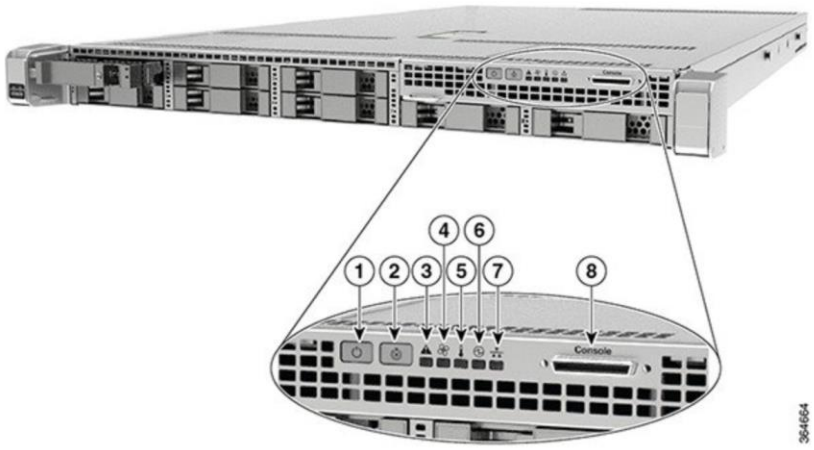



**Figure 2: Cisco 3504 Wireless LAN Controller Back Panel**

| Module Physical Interface | FIPS 140-2 Logical Interface |
|---|---|
| • Two 1/10 G SFP/SFP+ Ports<br>• Four 10/100/1000 Base-T Ports | Data Input Interface |
| • Two 1/10 G SFP/SFP+ Ports<br>• Four 10/100/1000 Base-T Ports | Data Output Interface |
| • KVM connector<br>• Serial port<br>• Power button<br>• Locator button<br>• Reset button<br>• USB ports | Control Input Interface |

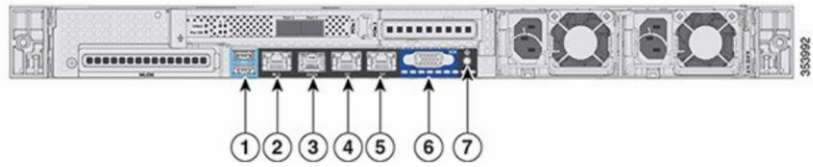
| Module Physical Interface | FIPS 140-2 Logical Interface |
|---|---|
| • LEDs<br>• VGA Connector | Status Output Interface |
| • Power Connector | Power Interface |

**Table 3 : Cisco 5520 Wireless LAN Controller Physical Interface/Logical Interface Mapping**

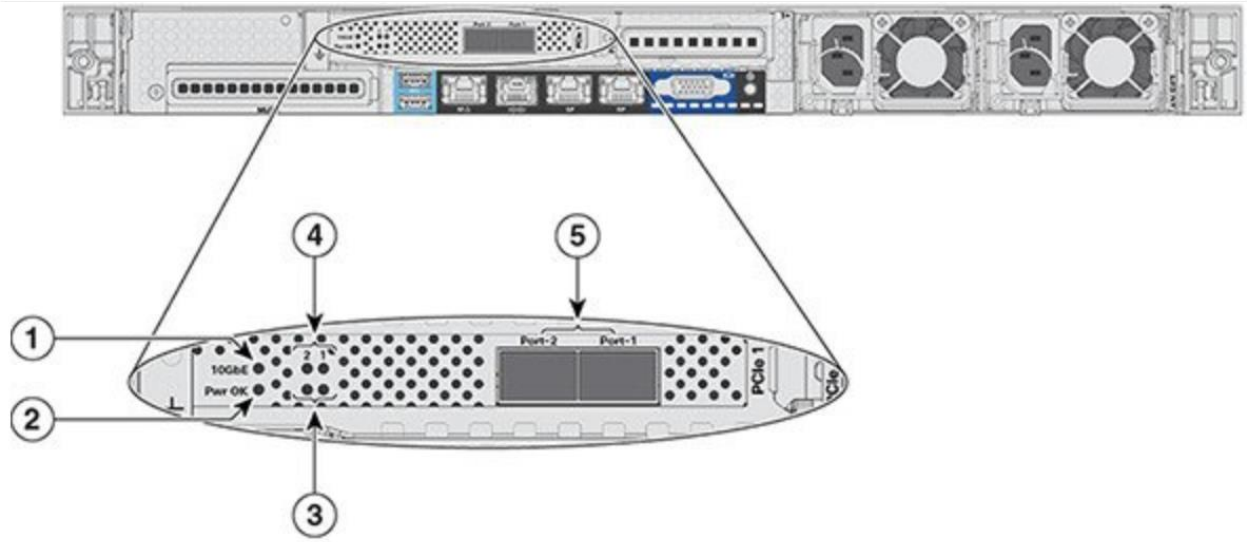



| | | | |
|---|---|---|---|
| 1 | Power button/power status LED | 5 | Temperature status LED |
| 2 | Locator (Unit identification) button LED | 6 | Power supply status LED |
| 3 | System status LED | 7 | Network link activity LED (this indicates the network activity only on Service port, RP port, and CIMC port) |
| 4 | Fan status LED | 8 | KVM connector (used with KVM cable that provides two USB 2.0, one VGA, and one serial connector) |

**Figure 3: Cisco 5520 Wireless Controller Front Panel View**




| | | | |
|---|---|---|---|
| 1 | Two Type A 3.0 USB ports | 5 | Redundancy Port (RP) |
| 2 | CIMC port 10/100/1000 Base-T | 6 | VGA Connector–Rear panel has a standard VGA port using a female D-Sub-15 Connector (does not show anything once the Cisco WLC software starts except the initial BIOS parameters. All the prints from this point onwards are available on the serial console) |
| 3 | SerialCOM Connector–Standard RS-232 Serial COM port using RJ-45 connector | 7 | ID Switch and LED |
| 4 | Ethernet Service Port (SP)–Management 10/100/1000 Base-T | | |

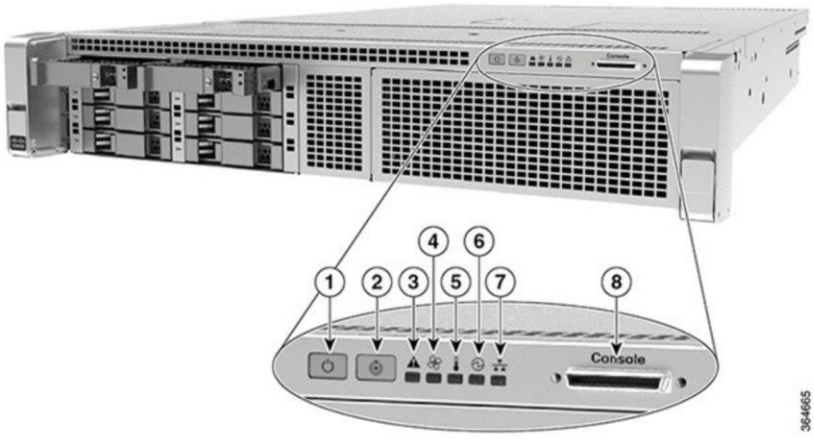



| | | | |
|---|---|---|---|
| 1 | 10 G | 4 | Port-n Link Activity |
| 2 | Pwr OK | 5 | Two 1/10 G SFP/SFP+ Ports |
| 3 | Port-n Link Status | | |

**Figure 4: Cisco 5520 Wireleess Controller Rear Panel View**

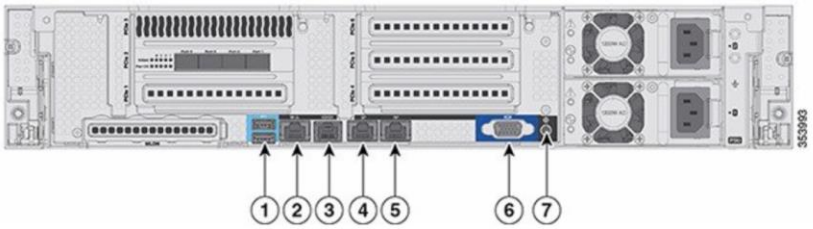
| Module Physical Interface | FIPS 140-2 Logical Interface |
|---|---|
| • Four 1/10 G SFP/SFP+ Ports<br>• Four 10/100/1000 Base-T Ports | Data Input Interface |
| • Four 1/10 G SFP/SFP+ Ports<br>• Four 10/100/1000 Base-T Ports | Data Output Interface |
| • KVM connector<br>• Serial port<br>• Power button<br>• Locator button<br>• Reset button<br>• USB ports | Control Input Interface |
| • LEDs<br>• VGA Connector | Status Output Interface |
| • Power Connector | Power Interface |

**Table 4 : Cisco 8540 Wireless LAN Controller Physical Interface/Logical Interface Mapping**

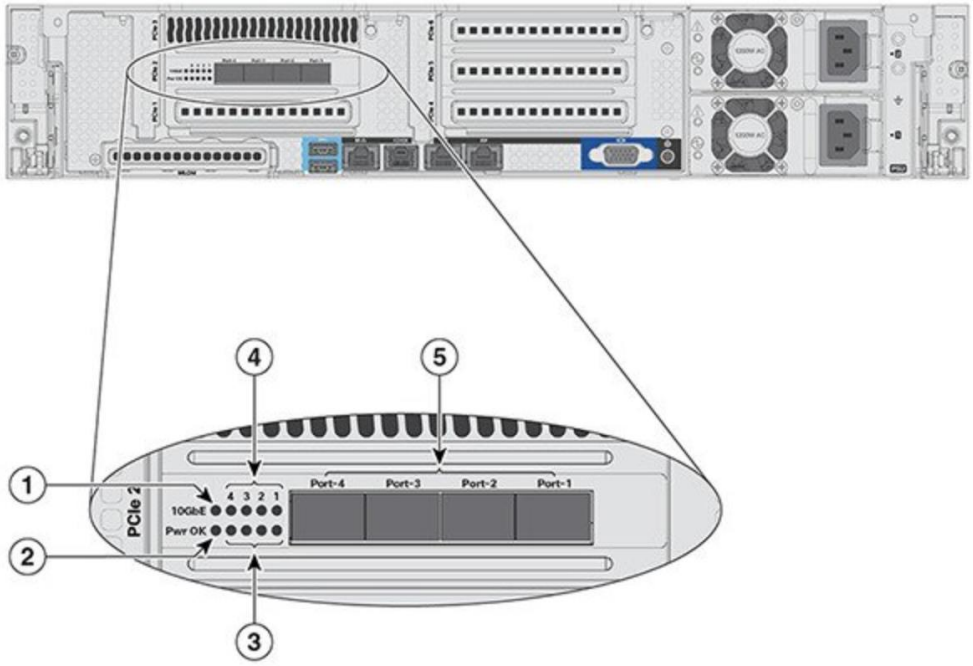



| | | | |
|---|---|---|---|
| 1 | Power button/power status LED | 5 | Temperature status LED |
| 2 | Locator (Unit identification) button LED | 6 | Power supply status LED |
| 3 | System status LED | 7 | Network link activity LED (this indicates the network activity only on Service port, RP port, and CIMC port) |
| 4 | Fan status LED | 8 | KVM connector (used with KVM cable that provides two USB 2.0, one VGA, and one serial connector) |

**Figure 5: Cisco 8540 Wireless Controller Front Panel**




| | | | |
|---|---|---|---|
| 1 | Two Type A 3.0 USB ports | 5 | Redundancy Port (RP) |
| 2 | CIMC port 10/100/1000 Base-T | 6 | • VGA Connector—Rear panel has a standard VGA port using a female D-Sub-15 Connector (does not show anything once the Cisco WLC software starts except the initial BIOS parameters. All the prints from this point onwards are available on the serial console) |
| 3 | SerialCOM Connector—Standard RS-232 Serial COM port using RJ-45 connector | 7 | ID Switch and LED |
| 4 | Ethernet Service Port (SP)—Management 10/100/1000 Base-T | | |




| | | | |
|---|---|---|---|
| 1 | 10 G | 4 | Port-n Link Activity |
| 2 | Pwr OK | 5 | Four 1/10 G SFP/SFP+ Ports |
| 3 | Port-n Link Status | | |

**Figure 6: Cisco 8540 Wireless COntroleer Rear Panel View**

## 2.3 Roles, Services and Authentication

The module supports role-based authentication. There are four roles in the module that the operators may assume in the FIPS mode:

- AP Role -This role is filled by an access point associated with the controller.
- Client Role -This role is filled by a wireless client associated with the controller.
- User Role -This role performs general security services including cryptographic operations and other approved security functions. The product documentation refers to this role as a management user with read-only privileges.
- Crypto Officer (CO) Role -This role performs the cryptographic initialization and management operations. In particular, it performs the loading of optional certificates and key-pairs and the zeroization of the module. The product documentation refers to this role as a management user with read-write privileges.

The Module does not support a Maintenance Role.

### User Services

The services available to the User role consist of the following:

| Services & Access | Description | Keys & CSPs |
|---|---|---|
| System Status | The LEDs show the network activity and overall operational status and the command line status commands output system status. | N/A |
| Random Number Generation | Key generation and seeds for asymmetric key generation | DRBG entropy input, DRBG seed, DRBG v, DRBG Key – r, w, d |
| Key Exchange | Key exchange over Diffie-Hellman and EC Diffie-Hellman | Diffie-Hellman public key, Diffie-Hellman private key, Diffie-Hellman shared secret, EC Diffie-Hellman Public Key, EC Diffie-Hellman Private Key, EC Diffie-Hellman shared secret – w, d |
| TACACS+ | User & CO authentication to the module using TACACS+. | TACACS+ authentication secret, TACACS+ authorization secret, TACACS+ accounting secret, User password, Enable secret – w, d |
| IPSec | Secure communications between module and RADIUS server. | skeyid, skeyid_d, IKE session encryption key, IKE session authentication key, IKE ECDSA private key, IKE ECDSA public key, IPSec session encryption key, IPSec session authentication key, ISAKMP preshared – r, w,d |
| RADIUS Key Wrap | Establishment and subsequent receive 802.11 PMK from the RADIUS server. | RADIUSOverIPSecEncryptionKey, RADIUSOverIPSecIntegrityKey, RADIUS KeyWrap MACK, RADIUS AES KeyWrap KEK, RADIUS Server Shared Secret, – w, d |

| | | |
|---|---|---|
| HTTPS/TLS | • Establishment and subsequent data transfer of a TLS session for use between the module and the user.<br>• Protection of syslog messages | HTTPS TLS Pre-Master secret, HTTPS TLS Encryption Key, HTTPS TLS Integrity Key, TLS pre-master secret, TLS encryption key, TLS integrity key, TLS ECDSA private key – w, d |
| Module Read-only Configuration | Viewing of configuration settings | N/A |

**Table 5: User Services (r = read, w = write, d = delete)**

## Crypto Officer Services

The Crypto Officer services consist of the following:

| Services & Access | Description | Keys & CSPs |
|---|---|---|
| Self Test and Initialization | Cryptographic algorithm tests, firmware integrity tests, module initialization. | N/A (No keys are accessible) |
| System Status | The LEDs show the network activity and overall operational status and the command line status commands output system status. | N/A (No keys are accessible) |
| Random Number Generation | Key generation and seeds for asymmetric key generation | DRBG entropy input, DRBG seed, DRBG v, DRBG Key – r, w, d |
| Key Exchange | Key exchange over Diffie-Hellman and EC Diffie-Hellman | Diffie-Hellman public key, Diffie-Hellman private key, Diffie-Hellman shared secret, EC Diffie-Hellman Public Key, EC Diffie-Hellman Private Key, EC Diffie-Hellman shared secret – w, d |
| TACACS+ | User & CO authentication to the module using TACACS+. | TACACS+ authentication secret, TACACS+ authorization secret, TACACS+ accounting secret, User password, Enable secret – w, d |
| IPSec | Secure communications between module and RADIUS server. | skeyid, skeyid_d, IKE session encryption key, IKE session authentication key, IKE ECDSA private key, IKE ECDSA public key, IPSec session encryption key, IPSec session authentication key, IPSec authentication key, IPSec encryption key, ISAKMP preshared – r, w,d |
| Zeroization | Zeroize CSPs and cryptographic keys by cycling power to zeroize all cryptographic keys stored in SDRAM. The CSPs (password, secret, engineID) stored in Flash can be zeroized by overwriting with a new value. | All Keys and CSPs will be destroyed |
| Module Configuration | Selection of non-cryptographic configuration settings | N/A |
| SNMPv3 | Non-security related monitoring by the CO using SNMPv3 | snmpEngineID, SNMPv3 Password, SNMP session key – w, d |
| SSH | • Establishment and subsequent data transfer of a SSH session for use between the module and the CO. | SSH encryption key, SSH integrity key, SSH ECDSA private key – w, d |

| | | |
|---|---|---|
| HTTPS/TLS | • Establishment and subsequent data transfer of a TLS session for use between the module and the CO.<br>• Protection of syslog messages | HTTPS TLS Pre-Master secret, HTTPS TLS Encryption Key, HTTPS TLS Integrity Key, TLS pre-master secret, TLS encryption key, TLS integrity key, TLS ECDSA private key – w, d |
| DTLS Data Encrypt | Enabling optional DTLS data path encryption for Office Extended AP's | DTLS Pre-Master Secret, DTLS Master Secret, DTLS Encryption/Decryption Key (CAPWAP session keys), DTLS Integrity Keys, DTLS ECDSA private key – w, d |
| RADIUS Key Wrap | Establishment and subsequent receipt of 802.11 PMK from the RADIUS server. | RADIUSOverIPSecEncryptionKey, RADIUSOverIPSecIntegrityKey, RADIUS KeyWrap MACK, RADIUS AES KeyWrap KEK, RADIUS Server Shared Secret, – w, d |

**Table 6: Crypto Officer Services (r = read, w = write, d = delete)**

## AP and Client Services

The AP and Client services consist of the following:

| Services & Access | Description | Keys & CSPs |
|---|---|---|
| MFP (AP Role) | Generation and subsequent distribution of MFP key to the AP over a CAPWAP session. | Infrastructure MFP MIC Key, cscoCCDefaultMfgCaCert – w, d |
| Local EAP Authenticator (Client Role) | Establishment of EAP-TLS or EAP-FAST based authentication between the client and the Controller. | TLS Pre-Master Secret, TLS Encryption Key, TLS Integrity Key, TLS ECDSA private key – w, d |
| 802.11 (AP Role) | Establishment and subsequent data transfer of an 802.11 session for use between the client and the access point | 802.11 Pre-Shared Key (PSK), 802.11 Pairwise Transient Key (PTK), 802.11 Group Temporal Key (GTK), 802.11 Key Confirmation Key (KCK) 802.11 Key Encryption Key (KEK), 802.11 Pairwise Transient Key (PTK) – w, d |
| RADIUS Key Wrap (AP and Client Role) | Establishment and subsequent receipt of 802.11 PMK from the RADIUS server. | RADIUS KeyWrap MACK, RADIUS AES KeyWrap KEK – w, d |

**Table 7: AP and Client Services (r = read, w = write, d = delete)**

## User and CO Authentication

The Crypto Officer role is assumed by an authorized CO connecting to the module via CLI. The OS prompts the CO for their username and password, if the password is validated against the CO's password in memory, the user is allowed entry to execute CO services. The password feedback mechanism does not provide information that could be used to determine the authentication data.

CO passwords must be at least eight (8) characters long, including at least one letter and at least one number character, in length (enforced procedurally). If six (6) integers, one (1) special character and one (1) alphabet are used without repetition for an eight (8) digit PIN, the probability of randomly guessing the correct sequence is one (1) in 251,596,800 (this calculation is based on the assumption that the typical standard American QWERTY computer keyboard has 10 Integer digits, 52 alphabetic characters, and 32 special characters providing 94 characters to choose from in total. The calculation should be 10×9×8×7×6×5×32×52 = 251,596,800). Therefore, the associated probability of a successful random attempt is approximately 1 in 251,596,800, which is less than the 1 in 1,000,000 required by FIPS 140-2.

**AP Authentication**
The module performs mutual authentication with an access point through the CAPWAP protocol.

RSA has a modulus size of 2048 bit, thus providing 112 bits of strength. An attacker would have a 1 in $2^{112}$ chance of randomly obtaining the key, which is much stronger than the one in a million-chance required by FIPS 140-2. To exceed a one in 100,000 probability of a successful random key guess in one minute, an attacker would have to be capable of approximately $5.2x10^{33}$ attempts per minute, which far exceeds the operational capabilities of the modules to support.

ECDSA P-256 provides 128 bits of strength and P-384 provides 192 bits of strength. An attacker would have a 1 in $2^{128}$ chance of randomly obtaining the key, which is much stronger than the one in a million-chance required by FIPS 140-2. To exceed a one in 100,000 probability of a successful random key guess in one minute, an attacker would have to be capable of approximately $3.4x10^{38}$ attempts per minute, which far exceeds the operational capabilities of the modules to support.

**Client Authentication**
The module performs mutual authentication with a wireless client through EAP-TLS or EAP-FAST protocols. EAP-FAST is based on EAP-TLS and uses EAP-TLS key pair and certificates.

RSA has modulus size of 2048 bit, thus providing 112 bits of strength. An attacker would have a 1 in $2^{112}$ chance of randomly obtaining the key, which is much stronger than the one in a million-chance required by FIPS 140-2. To exceed a one in 100,000 probability of a successful random key guess in one minute, an attacker would have to be capable of approximately $5.2x10^{33}$ attempts per minute, which far exceeds the operational capabilities of the modules to support.

ECDSA P-256 provides 128 bits of strength and P-384 provides 192 bits of strength. An attacker would have a 1 in $2^{128}$ chance of randomly obtaining the key, which is much stronger than the one in a million chance required by FIPS 140-2. To exceed a one in 100,000 probability of a successful random key guess in one minute, an attacker would have to be capable of approximately $3.4x10^{38}$ attempts per minute, which far exceeds the operational capabilities of the modules to support.

## 2.4 Non-FIPS Approved Services

- SSHv1 with RC4 and HMAC-MD5
- SNMP v1 and v2
- IPSec/IKEv2 with Diffie-Hellman 768-bit/1024-bit modulus, EC Diffie-Hellman 163/192 curves

The above services shall not be used in the FIPS approved mode of operation.

## 2.5 Unauthenticated Services

An unauthenticated operator may observe the System Status by viewing the LEDs on the module, which show network activity and overall operational status. A solid green LED indicates normal operation and the successful completion of self-tests. The module does not support a bypass capability.

## 2.6 Cryptographic Algorithms

The module implements a variety of approved and non-approved algorithms.

### Approved Cryptographic Algorithms

The modules support the following FIPS 140-2 approved algorithm implementations, CiscoSSL FOM 6.2, CN7240 Data Path (Firmware version: FP-CRYPTO-7.0.0), and OCTEON II CN6700/CN6800 Series Die (Hardware version: CN6870).

| Algorithm[1] | Cisco SSL FOM (3504) | Cisco SSL FOM (5520) | Cisco SSL FOM (8540) | CN7240 (3504) | CN6870 (5520/8540) |
|---|---|---|---|---|---|
| AES 128/192/256 (ECB, CBC, CFB1, CFB8, CFB128, CTR, CMAC, GCM, CCM, KW, KWP, OFB, XTS) | 5683 | 5674 | 5675 | | |
| AES 128/192/256 (ECB, CBC, GCM) | | | | 3301 | 2346 |
| SHA (SHA-1/224/256/384/512) | 4555 | 4545 | 4546 | 2737 | 2023 |
| HMAC SHA (SHA-1, SHA-224/256/384/512) | 3784 | 3776 | 3777 | 2095 | 1455 |
| DRBG (AES CTR-128/192/256) | 2299 | 2293 | 2294 | | |
| RSA ((KeyGen; SigGen9.31/PKCS1.5/PSS, SigVer9.31/PKCS1.5/PSS) 2048/3072 bits) | 3058 | 3053 | 3054 | | |
| ECDSA (KeyPair, PKV, SigGen, SigVer (NIST curves P-256, P-384 and P-521)) | 1540 | 1536 | 1537 | | |
| CVL (SP800-135) (IKEv2, TLS, SSH, SNMP) | 2076 | 2058 | 2060 | | |
| CVL (SP800-56A) (ECC CDH, KAS FFC) | 2075 | 2057 | 2059 | | |
| KBKDF (SP800-108) | 239 | 236 | 237 | | |

**Table 8: Approved Cryptographic Algorithms**

[1] Not all algorithms/modes tested on the CAVP validation certificates are implemented in the module

- KTS (AES Cert. #5683, #5674, #5675; key wrapping provides between 128 and 256 bits of encryption strength;

Note:

- CVL Cert. # 2076, #2058, #2060 supports the KDF (key derivation function) used in each of IKEv2, TLS, SSH and SNMPv3 protocols.
- IKEv2, TLS, SSH and SNMPv3 protocols have not been reviewed or tested by the CAVP and CMVP. Please refer IG D.11, bullet 2 for more information.
- There are algorithms, modes, and keys that have been CAVs tested but not implemented by the module. Only the algorithms, modes/methods, and key lengths/curves/moduli shown in this table are implemented by the module.

### Non-Approved Cryptographic Algorithms but Allowed in FIPS mode

The module supports the following non-approved, but allowed cryptographic algorithms:

- Diffie-Hellman (CVL Cert. #2076, #2058, #2060, key agreement; key establishment methodology provides 112 bits of encryption strength)
- EC Diffie-Hellman (CVL Certs. #2075, #2076, #2057, #2058, #2059 and #2060, key agreement; key establishment methodology provides 128 or 192 bits of encryption strength)
- RSA (key wrapping; key establishment methodology provides between 112 and 128 bits of encryption strength)
- MD5 (MD5 is allowed in DTLS)
- NDRNG

### Non-Approved Cryptographic Algorithms

- Diffie-Hellman (less than 112 bits of encryption strength)
- EC Diffie-Hellman (less than 112 bits of encryption strength)
- HMAC-MD5
- RC4

## 2.7 Cryptographic Key Management

Cryptographic keys are stored in plaintext form, in flash for long-term storage and in SDRAM for active keys. The RADIUS KeyWrap KEK, RADIUS KeyWrap MACK keys, 802.11 KEK, the Pre-shared key (PSK), RADIUS Server Shared Secret, ISAKMP pre-shared, TACACS+ authentication secret, TACACS+ accounting secret are input by the CO in plaintext over a local

console connection. The PMK is input from the RADIUS server encrypted with the AES key wrap protocol or via IPSec. RSA public keys are output in plaintext in the form of X.509 certificates. The CAPWAP session key is output wrapped with the AP's RSA key, and the MFP MIC key and 802.11 PTK, 802.11 GTK are output encrypted with the CAPWAP session key. Asymmetric key establishment is used in the creation of session keys during EAP-TLS and EAP-FAST. Any keys not explicitly mentioned are not input or output. Key generation and seeds for asymmetric key generation is performed as per SP 800-133 Scenario 1. The DRBG is seeded with a minimum of 256 bits of entropy strength prior to key generation.

CSPs below are stored in plaintext in both SDRAM and Flash.

| Key/CSP Name | Algorithm | Description | Key Size | Storage | Zeroization |
|---|---|---|---|---|---|
| **General Keys/CSPs** | | | | | |
| DRBG entropy input | SP 800-90A CTR_DRBG | HW-based entropy source output used to construct seed | 256-bits | SDRAM | Power cycle |
| DRBG seed | SP 800-90A CTR_DRBG | Input to the DRBG that determines the internal state of the DRBG. Generated using DRBG derivation function that includes the entropy input from a hardware-based entropy source. | 384 bits | SDRAM | Power cycle |
| DRBG V | SP 800-90A CTR_DRBG | Internal V value used as part of SP 800-90A CTR_DRBG | 128 bits | SDRAM | Power cycle |
| DRBG Key | SP 800-90A CTR_DRBG | This is the 256-bit DRBG key used for SP 800-90A CTR_DRBG | 256 bits | SDRAM | Power cycle |
| cscoCCDefaultMfgCaCert | rsa-pkcs1-sha2 | Verification certificate, used with CAPWAP to validate the certificate that authenticates the access point generated/installed at manufacturing | 2048 | Flash | Overwrite with new certificate |
| Diffie-Hellman public key | Diffie-Hellman (Group 14) | The public key used in Diffie-Hellman (DH) exchange | 2048 bits | SDRAM | Power cycle |
| Diffie-Hellman private key | Diffie-Hellman (Group 14) | The private key used in Diffie-Hellman (DH) exchange | 224 bits | SDRAM | Power cycle |

| Key/CSP Name | Algorithm | Description | Key Size | Storage | Zeroization |
|---|---|---|---|---|---|
| Diffie-Hellman shared secret | Diffie-Hellman (Group 14) | The shared key used in Diffie-Hellman (DH) Exchange. Created per the Diffie-Hellman protocol | 2048 bits | SDRAM | Power cycle |
| EC Diffie-Hellman public key | Diffie-Hellman (Groups 19 and 20) | P-256 and P-384 public key used in EC Diffie-Hellman exchange. This key is derived per the Diffie-Hellman key agreement. | P-256 and P-384 | SDRAM (plaintext) | Power cycle |
| EC Diffie-Hellman private key | Diffie-Hellman (Groups 19 and 20) | P-256 and P-384 private key used in EC Diffie-Hellman exchange. Generated by calling the SP 800-90A CTR-DRBG. | P-256 and P-384 | SDRAM (plaintext) | Power cycle |
| EC Diffie-Hellman shared secret | Diffie-Hellman (Groups 19 and 20) | P-256 and P-384 shared secret derived in EC Diffie-Hellman exchange | P-256 and P-384 | SDRAM (plaintext) | Power cycle |
| RADIUS Server Shared Secret | Shared secret | This is the shared secret between the RADIUS server and Controller. Entered by the Crypto Officer in plaintext form and stored in plaintext form. | 22 bytes | Flash | Overwrite with new secret |
| RADIUSOverIPSecEncryptionKey | AES-CBC, AES-GCM | AES-128/AES-256 encryption/decryption key, used in IPSec tunnel between module and RADIUS to encrypt/decrypt EAP keys. | 128 or 256 bits | SDRAM | Power cycle |
| RADIUSOverIPSecIntegrityKey | HMAC | Integrity/authentication key, used in IPSec tunnel between module and RADIUS | 160-384 bits | SDRAM | Power cycle |
| User password | Shared Secret | Identity based authentication data for user | Variable (8+ characters) | Flash | Overwrite with new password |

| Key/CSP Name | Algorithm | Description | Key Size | Storage | Zeroization |
|---|---|---|---|---|---|
| Enable secret | Secret | Identity based authentication data for CO | Variable (8+ characters) | Flash | Overwrite with new secret |
| TACACS+ authentication secret | Shared secret | This is the authentication shared secret between the TACACS+ server and Controller. Entered by the Crypto Officer in plaintext form and stored in plaintext form. | 64 bytes | Flash | Overwrite with new secret |
| TACACS+ authorization secret | Shared secret | This is the authorization shared secret between the TACACS+ server and Controller. Entered by the Crypto Officer in plaintext form and stored in plaintext form. | 64 bytes | Flash | Overwrite with new secret |
| TACACS+ accounting secret | Shared secret | This is the accounting shared secret used for authentication between the TACACS+ server and Controller. Entered by the Crypto Officer in plaintext form and stored in plaintext form. | 64 bytes | Flash | Overwrite with new secret |
| **IKEv2/IPSEC** | | | | | |
| skeyid | HMAC | It was derived by using 'ISAKMP pre-shared' and other non-secret values through the key derivation function defined in SP800-135 KDF (IKEv2). | 160-384 bits | SDRAM | Power cycle |

| Key/CSP Name | Algorithm | Description | Key Size | Storage | Zeroization |
|---|---|---|---|---|---|
| skeyid_d | HMAC | It was derived by using skeyid, Diffie-Hellman shared secret and other non-secret values through key derivation function defined in SP800-135 KDF (IKEv2). | 160-384 bits | SDRAM | Power cycle |
| IKE session encryption key | AES-CBC, AES-GCM | The IKE session encrypt key is derived by using skeyid_d, Diffie-Hellman shared secret and other non-secret values through the key derivation functions defined in SP800-135 KDF (IKEv2). Used for IKE payload protection | 256-bit AES | SDRAM | Power cycle |
| IKE session authentication key | HMAC | The IKE session) authentication key is derived by using skeyid_d, Diffie-Hellman shared secret and other non-secret values through the key derivation functions defined in SP800-135 KDF (IKEv2). Used for payload integrity verification. | 160-384 bits | SDRAM | Power cycle |
| IKE ECDSA public key | ECDSA | P-256 and P-384 generated by calling the SP 800-90A CTR-DRBG. | P-256 and P-384 | SDRAM (plaintext) | Power cycle |
| IKE ECDSA private key | ECDSA | P-256 and P-384 generated by calling the SP 800-90A CTR-DRBG. | P-256 and P-384 | SDRAM (plaintext) | Power cycle |
| ISAKMP pre-shared | Shared secret | This shared secret was manually entered by CO for IKE pre-shared key-based authentication mechanism. | 8 chars | Flash | Overwrite with new secret |

| Key/CSP Name | Algorithm | Description | Key Size | Storage | Zeroization |
|---|---|---|---|---|---|
| IPSec authentication key | HMAC | The IPsec authentication key is derived via using the KDF defined in SP800-135 KDF (IKEv2). Used to authenticate the IPSec peer. | 160 bits | SDRAM | Power cycle |
| IPSec encryption key | AES-CBC, AES-GCM | The IPsec encryption key is derived via a key derivation function defined in SP800-135 KDF (IKEv2).Used to Secure IPSec traffic. | 256-bit AES | SDRAM | Power cycle |
| **DTLS** | | | | | |
| DTLS Pre-Master Secret | Shared Secret | Generated by approved DRBG for generating the DTLS encryption key | 48 bytes | SDRAM | Power cycle |
| DTLS Master Secret | Shared Secret | Derived from DTLS Pre-Master Secret. Used to create the DTLS encryption and integrity keys | 48 bytes | SDRAM | Power cycle |
| DTLS Encryption/Decryption Key (CAPWAP session keys) | AES-CBC, AES-GCM | Session Keys used to e/d CAPWAP control messages | 128-256 bits | SDRAM | Power cycle |
| DTLS Integrity Keys | HMAC- | Session keys used for integrity checks on CAPWAP control messages | 160-384 bits | SDRAM | Power cycle |
| DTLS ECDSA private key | ECDSA | P-256 and P-384 generated by calling the SP 800-90A CTR-DRBG. | P-256 and P-384 | SDRAM (plaintext) | Power cycle |
| **SNMPv3** | | | | | |
| snmpEngineID | Shared secret | 32-bits | Unique string to identify the SNMP engine | Flash | Overwrite with new engine ID |
| SNMPv3 Password | Shared Secret | This secret is used to derive HMAC-SHA1 key for SNMPv3 Authentication | 32 bytes | Flash | Overwrite with new password |

| Key/CSP Name | Algorithm | Description | Key Size | Storage | Zeroization |
|---|---|---|---|---|---|
| SNMPv3 session key | AES-CFB | 128-bit | Encrypts SNMPv 3 traffic | SDRAM | Power cycle |
| **HTTPS/TLS** | | | | | |
| HTTPS TLS Pre-Master secret | Shared secret | Shared secret created using asymmetric cryptography from which new HTTPS session keys can be created. | 48 bytes | SDRAM | Power cycle |
| HTTPS TLS Encryption Key | AES-CBC, AES-GCM | AES key used to encrypt TLS data | 128 and 256 bits | SDRAM | Power cycle |
| HTTPS TLS Integrity Key | HMAC | HMAC key used for HTTPS integrity protection | 160-384 bits | SDRAM | Power cycle |
| TLS Pre-Master Secret | Shared secret | Shared secret used to generate new TLS session keys. | 48 byte | SDRAM | Power cycle |
| TLS Encryption Key | AES-CBC, AES-GCM | Symmetric AES key for encrypting TLS. | 128 and 256 bits | SDRAM | Power cycle |
| TLS Integrity Key | HMAC | Used for TLS integrity protection. | 160-384 bits | SDRAM | Power cycle |
| TLS ECDSA private key | ECDSA | P-256 and P-384 generated by calling the SP 800-90A CTR-DRBG. | P-256 and P-384 | SDRAM (plaintext) | Power cycle |
| Infrastructure MFP MIC Key | AES-CMAC, AES-GMAC | This key is generated in the module by calling FIPS approved DRBG and then is transported to the Access Point (AP) protected by DTLS Encryption/Decryption Key. The Access Point (AP) uses this key with sign management frames when infrastructure MFP is enabled. | 128 and 256 bits | SDRAM | Power cycle |

| Key/CSP Name | Algorithm | Description | Key Size | Storage | Zeroization |
|---|---|---|---|---|---|
| **802.11** | | | | | |
| 802.11 Pre-Shared Key (PSK) | Shared secret | This is the shared secret used for 802.11 client authentication. | 63 bytes | Flash | Overwrite with new secret. |
| 802.11 Pairwise Master Key (PMK) | HMAC | The PMK is transferred to the module, protected by RADIUS AES KeyWrap key. Used to derive the Pairwise Transient Key (PTK) for 802.11 communications | 160-384 bits | SDRAM | Power cycle |
| 802.11 Key Confirmation Key (KCK) | HMAC | The KCK is used by IEEE 802.11 to provide data origin authenticity in the 4-Way Handshake and Group Key Handshake messages. | 160-384 bits | SDRAM | Power cycle |
| 802.11 Key Encryption Key (KEK) | AES Key Wrap | The KEK is used by the EAPOL-Key frames to provide confidentiality in the 4-Way Handshake and Group Key Handshake messages. | 128 and 256 bits | SDRAM | Power cycle |
| 802.11 Pairwise Transient Key (PTK) | AES-CCM, AES-GCM | The PTK is the 802.11 session key for unicast communications. This key is derived using the SP 800-108 KDF from the PMK and then is transported into the Access Point (AP) protected by DTLS Encryption/Decryption Key. The Access Point (AP) uses this key with AES-CCM function to implement 802.11 unicast communications service. | 128 and 256 bits | SDRAM | Power cycle |

| Key/CSP Name | Algorithm | Description | Key Size | Storage | Zeroization |
|---|---|---|---|---|---|
| 802.11 Group Temporal Key (GTK) | AES-CCM, AES-GCM | The GTK is the 802.11 session key for broadcast communications. This key is generated in the module by calling FIPS approved DRBG and then is transported into the Access Point (AP) protected by DTLS Encryption/Decryption Key. The Access Point (AP) uses this key with AES-CCM function to implement 802.11 broadcast communications service. | 128 and 256 bits | SDRAM | Power cycle |
| RADIUS AES KeyWrap KEK | AES-ECB | This key is used by the RADIUS Keywrap service to protect the PMK for the 802.11 protocol. | 16 bytes | SDRAM | Power cycle |
| RADIUS KeyWrap MACK | HMAC-SHA1 | The MAC key used by the RADIUS Keywrap service to authenticate RADIUS traffic. | 16 bytes | SDRAM | Power cycle |
| **SSHv2** | | | | | |
| SSH Encryption Key | AES-CBC, AES-GCM | Symmetric AES key for encrypting SSH. | 128 and 256 bits | SDRAM | Power cycle |
| SSH Integrity Key | HMAC | Used for SSH integrity protection. | 160-384 bits | SDRAM | Power cycle |
| SSH ECDSA Private Key | ECDSA | P-256 and P-384 generated by calling the SP 800-90A CTR-DRBG. | P-256 and P-384 | SDRAM | Power cycle |

**Table 9: Cryptographic Keys and CSPs**

Note 1 to table: The KDF infrastructure used in DTLS v1.2 is identical to the ones used in TLS v1.2, which was certified by CVL Cert. #2076, #2058 and #2060.

Note 2 to table: The module's AES-GCM implementation conforms to IG A.5 scenario #1 following RFC 5288 for TLS and RFC 7296 for IPSec/IKEv2. The module is compatible with

TLSv1.2 and provides support for the acceptable GCM cipher suites from SP 800-52 Rev1, Section 3.3.1. The counter portion of the IV is set by the module within its cryptographic boundary. When the IV exhausts the maximum number of possible values for a given session key, the first party, client or server, to encounter this condition will trigger a handshake to establish a new encryption key. In case the module's power is lost and then restored, a new key for use with the AES GCM encryption/decryption shall be established. The module uses RFC 7296 compliant IKEv2 to establish the shared secret SKEYSEED from which the AES GCM encryption keys are derived. When the IV exhausts the maximum number of possible values for a given session key, the first party, client or server, to encounter this condition will trigger a handshake to establish a new encryption key. In case the module's power is lost and then restored, a new key for use with the AES GCM encryption/decryption shall be established.

Note 3 to table: No parts of the SSH, TLS and IPSec protocols, other than the KDFs, have been tested by the CAVP and CMVP.

## 2.8 Self-Tests

The modules include an array of self-tests that are run during startup and periodically during operations to prevent any secure data from being released and to insure all components are functioning correctly.

Power On Self-Tests Performed:

- Firmware Integrity Test RSA 2048 with SHA-512
- CiscoSSL FOM algorithm implementation
    - AES encryption KAT
    - AES decryption KAT
    - AES CCM encryption KAT
    - AES CCM decryption KAT
    - AES GCM encryption KAT
    - AES GCM decryption KAT
    - SHA-1 KAT
    - SHA-256 KAT
    - HMAC SHA-1 KAT
    - HMAC SHA-256 KAT
    - HMAC SHA-384 KAT
    - HMAC SHA-512 KAT
    - ECDSA sign and verify KATs
    - ECDH KAT
    - RSA sign and verify KATs
    - SP 800-90A DRBG KAT
    - SP 800-90A Section 11 Health Tests
    - KDF IKEV2 KAT
    - KDF TLS KAT

        - KDF SSH KAT
        - KDF SNMP KAT
- CN7240 algorithm implementation (3504)
    - AES encryption KAT
    - AES decryption KAT
    - SHA-1 KAT
    - SHA-224 KAT
    - SHA-256 KAT
    - SHA-384 KAT
    - SHA-512 KAT
    - HMAC SHA-1 KAT
    - HMAC SHA-224 KAT
    - HMAC SHA-256 KAT
    - HMAC SHA-384 KAT
    - HMAC SHA-512 KAT
- CN6870 algorithm implementation (5520/8540)
    - AES encryption KAT
    - AES decryption KAT
    - SHA-1 KAT
    - SHA-224 KAT
    - SHA-256 KAT
    - SHA-384 KAT
    - SHA-512 KAT
    - HMAC SHA-1 KAT
    - HMAC SHA-224 KAT
    - HMAC SHA-256 KAT
    - HMAC SHA-384 KAT
    - HMAC SHA-512 KAT

The module performs all power-on self-tests automatically at boot. All power-on self-tests must be passed before a role can perform services. The power-on self-tests are performed after the cryptographic systems are initialized but prior to the initialization of the LAN's interfaces; this prevents the module from passing any data during a power-on self-test failure.

Conditional Tests Performed:

- Continuous Random Number Generator Test for the FIPS-approved DRBG
- Continuous Random Number Generator Test for the non-approved NDRNG
- ECDSA pairwise consistency test
- RSA pairwise consistency test

# 3 Secure Operation

The module meets all the Level 1 requirements for FIPS 140-2. The module is shipped only to authorized operators by the vendor, and the modules are shipped in Cisco boxes with Cisco adhesive, so if tampered with the recipient will notice. Follow the setting instructions provided below to place the module in a FIPS-approved mode. Operating this module without maintaining the following settings will remove the module from the FIPS approved mode of operation.

It should also be noted that the module is shipped to the customer site without the firmware pre-installed on the device. This means that the module arrives at the customer in a non-compliant state until such time as the Crypto Officer has performed the following steps:

- downloaded the module's correct FIPS firmware image (via a secure method from https://software.cisco.com/)
- verified the integrity of the firmware image file (by calculating an MD5 or a SHA512 checksum value of the downloaded image file and comparing it with values provided on the Cisco download page),
- installed the firmware onto the module, and
- has performed all of the correct initialization steps (see below) after which time the module will then be in a FIPS compliant state.

Only after a successful completion of all required FIPS POSTs in the FIPS compliant state, will the module be considered to be in a FIPS-approved mode of operation.

The module was validated with firmware version 8.5 with Cisco FOM 6.2 and CN7240 Datapath (This is the only allowable image for FIPS-approved mode of operation.). Follow the setting instructions provided below to place the module in FIPS-approved mode. Operating the module without maintaining the following settings will remove the module from the FIPS approved mode of operation.

The Crypto Officer must configure and enforce the following initialization steps:

1. Enable FIPS Mode of Operations

   The following CLI command places the controller in FIPS mode of operations, enabling all necessary self-tests and algorithm restrictions:

   **> config switchconfig fips-prerequisite enable**

2. Configure HTTPS Certificate

   The following command configures the controller to use the manufacture-installed Cisco device certificate for the HTTPS server. It must be executed after enabling FIPS mode of operations:

   **> config certificate use-device-certificate webadmin**

3. Configure Authentication Data

   All users shall have a password containing 8 or more characters, including numbers and letters. A crypto officer can use the following CLI command to set user passwords:

   **>config mgmtuser password** *username password*

   Note that this and all subsequent configuration steps may also be performed through HTTPS. However, only the CLI commands are included in this document. It is the Crypto Officer's responsibility to securely deliver the password over to User.

4. Configure Communications with RADIUS

   Communications between the controller and RADIUS may be configured for RADIUS KeyWrap or IPSec.

5. RADIUS KeyWrap and MACK Keys

   The following CLI commands configure the RADIUS shared secret and AES-key wrap KEK and MACK:

   **> config radius auth add** *index ip-address port* **hex** *secret*
   **> config radius auth keywrap add hex** *kek mack index*
   **> config radius auth keywrap enable**

6. IPSec/IKEv2

   Optionally, the controller may be configured to communicate with RADIUS via IPSec. Refer to the document at the following link for additional instructions:

   http://www.cisco.com/en/US/products/ps6366/products_tech_note09186a0080a829b8.shtml

   In addition, please be aware that AES is the only allowed symmetric algorithm used in IPSec/IKEv2 encryption/decryption operations in FIPS mode.

7. Configure Pre-shared Keys for 802.11

   802.11 Pre-shared key (PSK) is an optional mode permitted by this security policy. Generation of pre-shared keys is outside the scope of this security policy, but they should be entered as 64 hexadecimal values (256 bits) by the following command syntax:

   **> config wlan security wpa akm psk enable** *index*
   **> config wlan security wpa akm psk set-key hex** *key index*

   Refer to Cisco Wireless LAN Controller Configuration Guide for additional instructions.

8. Configure Ciphersuites for 802.11

The following CLI commands create a wireless LAN, configure it to use WPA2, associate it with a RADIUS server, and enable it:

> **config wlan create index** *profile_name ssid*
> **config wlan radius_server auth add** *index radius-server-index*
> **config wlan enable** *index*

9. Configure SNMPv3

   Only SNMPv3 with HMAC-SHA-1 is permitted by this security policy. The user passwords shall be selected to be 8 or more characters, including numbers and letters. This has been tested and is FIPS compliant.

   The following CLI commands enable SNMPv3 with HMAC-SHA1:

   > **config snmp version v1 disable**
   > **config snmp version v2c disable**
   > **config snmp version v3 enable**
   > **config snmp v3user create** *username* **<ro|rw> hmacsha aescfb128** *authkey encryptkey*

10. Configure TACACS+ secret

    The crypto officer may configure the module to use TACACS+ for authentication, authorization and accounting. Configuring the module to use TACACS+ is optional. If the module is configured to use TACACS+, the Crypto-Officer must define TACACS+ shared secret keys that are at least 8 characters long. The following CLI command configures TACACS+ for authentication (auth), authorization (athr) and accouting (acct):

    **>config tacacs <auth|athr|acct> add** *index ip port* **<ascii|hex>** *secret*

    Refer to the Cisco Wireless LAN Controller Configuration Guide for additional instructions.

11. Configure Data DTLS (optional)

    The crypto officer may configure the module to use CAPWAP data encryption. CAPWAP data packets encapsulate forwarded wireless frames. Configuring the module to use CAPWAP data encryption is optional.

    The following CLI commands enable DTLS data encryption for access points on the controller:

    To enable or disable data encryption for all access points or a specific access point, enter this command:

a. **>config ap link-encryption** {**enable** | **disable**} {**all** | *Cisco_AP*}

When prompted to confirm that you want to disconnect the access point(s) and attached client(s), enter

**b. >Y**

To save your changes, enter this command:

**c. >save config**

Refer to the Cisco Wireless LAN Controller Configuration Guide for additional instructions.

12. Save and Reboot

After executing the above commands, you must save the configuration and reboot the system:

a. **save config**
b. **reset system**