Cisco FTD FX-OS on 4K/9K Cryptographic Module

FIPS 140-2 Non Proprietary Security Policy
Level 2 Validation

Documentation Version 1.2

Last Update: February 23, 2021

1 Introduction

1.1 Purpose

This is the non-proprietary cryptographic module security policy for the Cisco FTD FX-OS on 4K/9K Cryptographic Module. The firmware version is 2.6. This security policy describes how this module meets the security requirements of FIPS 140-2 Level 2 and how to run the module in a FIPS 140-2 mode of operation. This Security Policy may be freely distributed.

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 https://csrc.nist.gov/groups/computer-security-division/security-testing-validation-and-measurement.

1.2 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	2
2	Cryptographic Module Ports and Interfaces	2
3	Roles, Services, and Authentication	3
4	Finite State Model	2
5	Physical Security	2
6	Operational Environment	N/A
7	Cryptographic Key management	2
8	Electromagnetic Interface/Electromagnetic Compatibility	2
9	Self-Tests	2
10	Design Assurance	2
11	Mitigation of Other Attacks	N/A
	Overall module validation level	**2**

Table 1 Module Validation Level

1.3 References

This document deals with the specification of the security rules listed in Table 1 above, under which the Cisco Firepower 4100 and Cisco Firepower 9300 Series will operate, including the rules derived from the requirements of FIPS 140-2, FIPS 140-2 IG and additional rules imposed by Cisco Systems, Inc. More information is available on the module from the following sources:

The Cisco Systems website contains information on the full line of Cisco Systems security. Please refer to the following website:

http://www.cisco.com/c/en/us/products/index.html
http://www.cisco.com/c/en/us/td/docs/security/firepower/fxos/roadmap/fxos-roadmap.html

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 (https://csrc.nist.gov/projects/cryptographic-module-validation-program/validated-modules) contains contact information for answers to technical or sales-related questions for the module.

1.4 Terminology

In this document, the Cisco FTD FX-OS on 4K/9K Cryptographic Module is referred to as Cisco FTD FX-OS on 4K/9K Cryptographic Module, CM, Module or the System.

1.5 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 module identified above and explains the secure layout, 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 FTD FX-OS on 4K/9K Cryptographic Module Overview

The management I/O card found in both the FPR4100 and FPR9300 units runs the Cisco Firepower eXtensible Operating System (FX-OS). The FX-OS is part of the Cisco Application Centric Infrastructure (ACI) Security Solution and provides an agile, open, high performance, scalability, visual representation of current chassis status, simplified configuration, consistent control, and simplified management. The MIO cards are the central place for all customer and management traffic as well as inter-card communications.

2.1 Cisco 4K/9K Appliances

The FPR4100 security appliance is a standalone modular security services platform with a one RU form factor. It is capable of running multiple security services simultaneously and so is targeted at the data center as a multi-service platform. It comprises a front-end "Management IO" (MIO) function and an embedded Security Service card with x86 CPU complex. The MIO cards are the central place for all customer and management traffic as well as inter-card communications.

Figure 1: FPR4100 Series

The 4100 Series has dual multi-core processors, dual AC power supply modules.

The FPR9300 security appliance is a next generation network and content security platform. Its modular standalone chassis offers high-performance and flexible I/O options that enables it to run multiple security services simultaneously. The Firepower 9300 security appliance contains a supervisor management I/O card (supervisor card) and an embedded Security Service application card. The Supervisor card provides the chassis management.

Figure 2: FPR9300 Series

Both FPR4100 and FPR9300 Series, when deployed as next-generation firewall (NGFW) appliances, contain the Cisco FTD FX-OS on 4K/9K Cryptographic Module and the embedded Cisco Firepower Threat Defense on 4K/9K Cryptographic Module. The Cisco Firepower Threat Defense on 4K/9K Cryptographic Module has been validated by the CMVP and has FIPS 140-2

certificate #3821. Thus, the sections throughout this SP detail the FIPS compliance of FTD FX-OS.

The Cisco Firepower 4100 and 9300 Series comprises the following platforms.

Cisco Firepower 4100 Security Appliances

- Cisco Firepower 4110 Security Appliance (FPR4110)
- Cisco Firepower 4115 Security Appliance (FPR4115)
- Cisco Firepower 4120 Security Appliance (FPR4120)
- Cisco Firepower 4125 Security Appliance (FPR4125)
- Cisco Firepower 4140 Security Appliance (FPR4140)
- Cisco Firepower 4145 Security Appliance (FPR4145)
- Cisco Firepower 4150 Security Appliance (FPR4150)

Cisco Firepower 9300 Security Appliances with High Performance Security Module (SM)

- Cisco Firepower 9300 with SM-24 (FPR9K-SM-24)
- Cisco Firepower 9300 with SM-36 (FPR9K-SM-36)
- Cisco Firepower 9300 with SM-40 (FPR9K-SM-40)
- Cisco Firepower 9300 with SM-44 (FPR9K-SM-44)
- Cisco Firepower 9300 with SM-48 (FPR9K-SM-48)
- Cisco Firepower 9300 with SM-56 (FPR9K-SM-56)

2.2 Cryptographic Module Characteristics

The module is contained on the Management I/O (MIO) card (Figure 3 below) in the FPR4100 and FPR9300 Series appliances. This Cryptographic Module contains the crypto services for SSHv2, SNMPv3, HTTPS/TLSv1.2 and StrongSwan (IPSec/IKEv2).

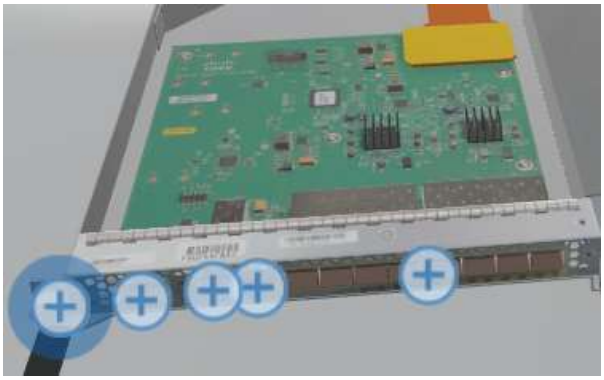


Figure 3 Management I/O card

2.3 Cryptographic Boundary

The module is a hardware, multi-chip standalone crypto module. The cryptographic boundary is defined as the 4100/9300 series chassis unit encompassing the "top," "front," "left," "right," “rear” and "bottom" surfaces of the case (the red dashed area surrounding the black box represents the module’s physical perimeter). In diagram 1, the Management I/O block (inside the blue rectangle) represents the logic section running FX-OS cryptographic module that is covered by this security document, and the FTD block (inside the red rectangle) executes the embedded Cisco Firepower Threat Defense (FTD) module covered by the report under FIPS Cert. #3821.

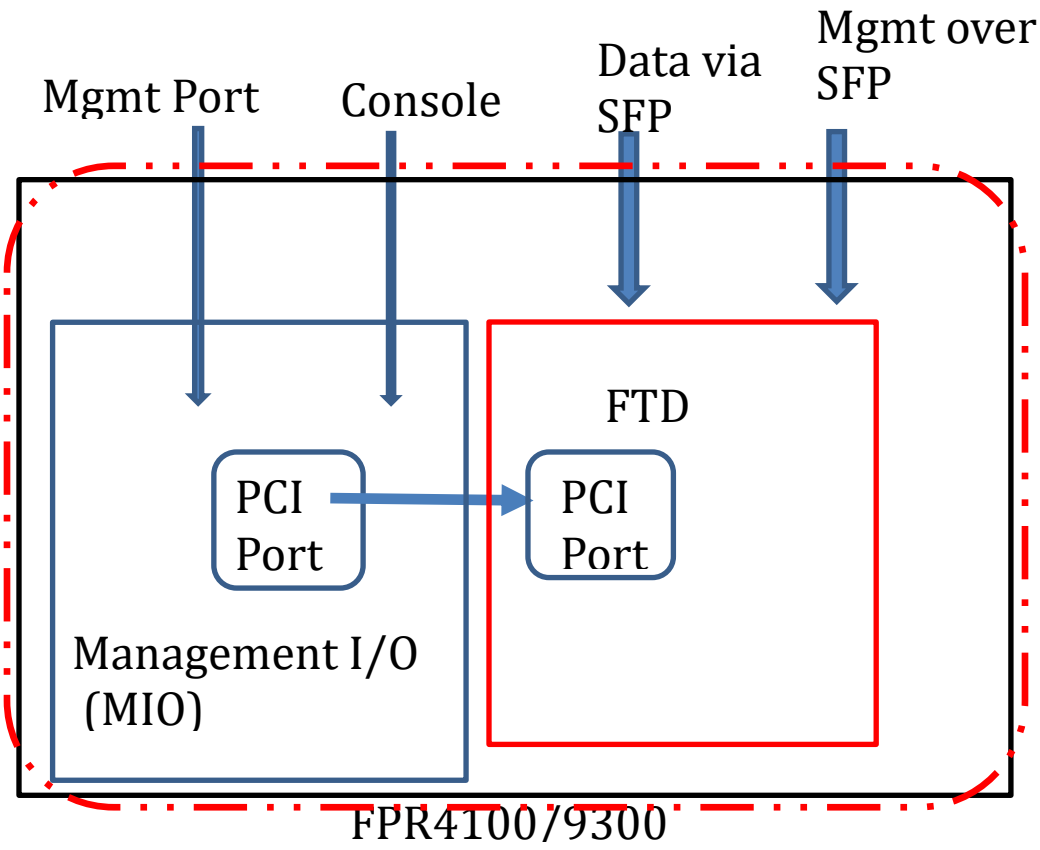


Diagram 1 Block Diagram

2.4 Module Interfaces

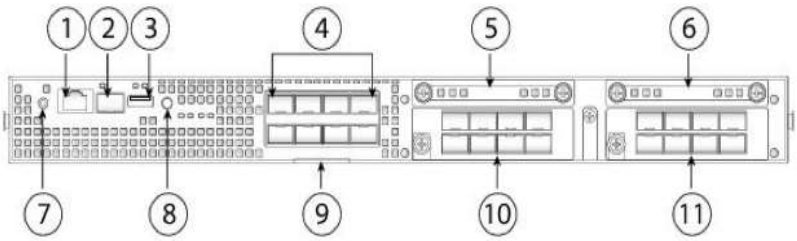
The module provides a number of physical and logical interfaces to the device, and the physical interfaces provided by the module are mapped to the following FIPS 140-2 defined logical interfaces: data input, data output, control input, status output, and power. The module provides no power to external devices and takes in its power through normal power input/cord. The logical interfaces and their mapping are described in the following table:

FIPS 140-2 Logical Interface	FPR4100 and FPR9300 Physical Interfaces
Data Input	MGMT (Management) Port RJ-45 Console Port SFP/SFP+ (1G/10G) Ethernet Port RJ-45 Gigabit Ethernet Ports
Data Output	MGMT (Management) Port RJ-45 Console Port SFP/SFP+ (1G/10G) Ethernet Port RJ-45 Gigabit Ethernet Ports
Control Input	MGMT (Management) Port RJ-45 Console Port SFP/SFP+ (1G/10G) Ethernet Port RJ-45 Gigabit Ethernet Ports
Status Output	MGMT (Management) Port RJ-45 Console Port SFP/SFP+ (1G/10G) Ethernet Port RJ-45 Gigabit Ethernet Ports LEDs

Table 2 Hardware/Physical Boundary Interfaces

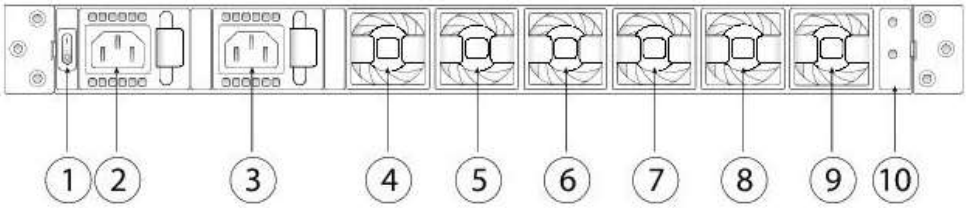
Note: The USB port on each module will be disabled by covering the TEL label.

FPR4100 Series Front



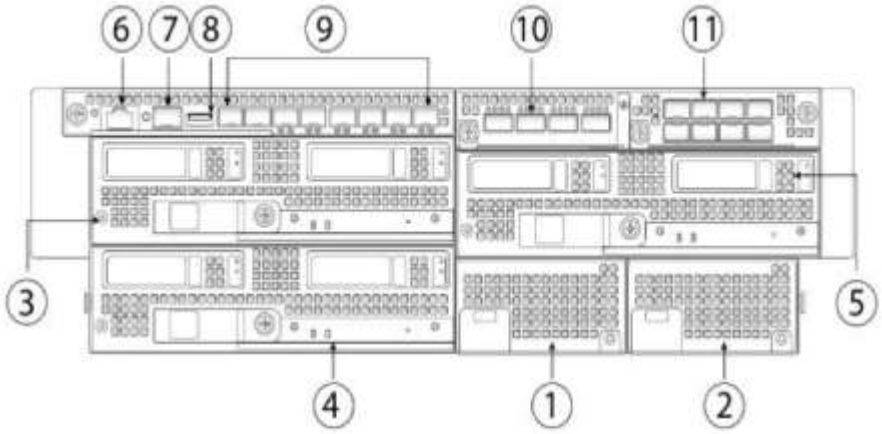
1	RJ-45 console port	2	1 Gigabit Ethernet management port
3	Type A USB port	4	Eight fixed SFP+ (1G/10G) ports are provided (network module slot 1) Gigabit Ethernet 1/1 through 1/8 labeled left to right, top to bottom
5	SSD 1	6	SSD 2
7	Power LED	8	Locator LED
9	Pull out label card	10	Network Module (network module slot 2) **Note** The 10G network module is shown.
11	Network Module (network module slot 3) **Note** The 10G network module is shown.		

FPR4100 Rear



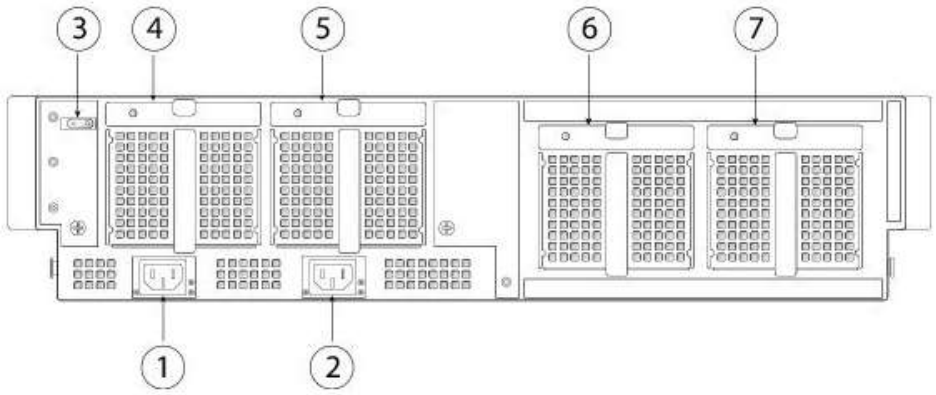
1	Power on/off switch	**2**	Power supply module 1
3	Power supply module 2	**4**	Fan module 1
5	Fan module 2	**6**	Fan module 3
7	Fan module 4	**8**	Fan module 5
9	Fan module 6	**10**	Location for the two-post grounding lug **Note** The two-post grounding lug is included in the accessory kit.

FPR9300 Series Front



1	Power supply module PSU-1	2	Power supply module PSU-2
3	Security Module 1	4	Security Module 3
5	Security Module 2	6	RJ-45 console port
7	1 Gigabit Ethernet management port	8	USB port
9	Eight 10 Gigabit Ethernet data ports (Gigabit Ethernet 1/1 through 1/8)	10	Network Module (network module slot 2)
11	Network Module (network module slot 3)		

FPR9300 Series Rear



1	Power feed for PSU-2	2	Power feed for PSU-1
3	On/Off switch	4	Fan module FAN-1
5	Fan module FAN-2	6	Fan module FAN-3
7	Fan module FAN-4		

In addition, for details of the Cryptographic Boundary and the associated physical/logical interfaces of the embedded FTD cryptographic module, please refer to the Security Policy under FIPS Cert. #3821 for more information.

2.5 Roles, Services, and Authentication

The appliances can be accessed in one of the following ways:

- SSHv2
- HTTPS/TLSv1.2
- IPSec/IKEv2
- SNMPv3

Authentication is identity-based. As required by FIPS 140-2, there are two roles that operators may assume: a Crypto Officer role and a User role. The module upon initial access to the module authenticates both of these roles. The module also supports RADIUS and TACACS+ as another means of authentication, allowing the storage of usernames and passwords on an external server as opposed to using the module's internal database for storage.

The User and Crypto Officer passwords and all other shared secrets must each be at least eight (8) characters long, including at least one six (6) alphabetic characters, (1) integer number and one (1) special character in length (enforced procedurally). See the Secure Operation section for more information. Given these restrictions, the probability of randomly guessing the correct sequence is one (1) in 6,326,595,092,480 (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 52x52x52x52x52x52x32x10 = 6,326,595,092,480. Therefore, the associated probability of a successful random attempt is approximately 1 in 6,326,595,092,480, which is less than the 1 in 1,000,000 required by FIPS 140-2.

In addition, for multiple attempts to use the authentication mechanism during a one-minute period, under the optimal modern network condition, if an attacker would only get 60,000 guesses per minute. Therefore, the associated probability of a successful random attempt during a one-minute period is 60,000/ 6,326,595,092,480 = 1/105,443,251, which is less than 1 in 100,000 required by FIPS 140-2.

Additionally, when using RSA based authentication, RSA key pair has modulus size of 2048 bits, thus providing 112 bits of strength. Assuming the low end of that range, 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 chances 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 $8.65x10^{31}$ ($2^{112}/60 = 8.65 \times 10^{31}$) attempts per second, which far exceeds the operational capabilities of the module to support.

2.6 User Services

A User enters the system by either Console port, SSHv2, HTTPS/TLSv1.2 or SNMPv3. The User role can be authenticated via either Username/Password or RSA based authentication method. The module prompts the User for username and password. If the password is correct, the User is allowed entry to the module management functionality. The other means of accessing the console is via an IPSec/IKEv2 session. This session is authenticated either using a shared secret or RSA digital signature authentication mechanism. The services available to the User role accessing the CSPs, the type of access – read (r), write (w) and zeroized/delete (d) – and which role accesses the CSPs are listed below:

Services	Description	Keys and CSPs Access
Status Functions	View the module configuration, routing tables, active sessions health, and view physical interface status.	N/A
Terminal Functions	Adjust the terminal session (e.g., lock the terminal, adjust flow control).	N/A
Directory Services	Display directory of files kept in flash memory.	N/A
Self-Tests	Execute the FIPS 140 start-up tests on demand.	N/A
IPSec VPN	Negotiation and encrypted data transport via IPSec VPN.	DRBG entropy input, DRBG seed, DRBG V, DRBG key, Operator password, Diffie-Hellman private key, Diffie-Hellman public key, Diffie-Hellman Shared Secret, EC Diffie-Hellman private key, EC Diffie-Hellman public key, EC Diffie-Hellman Shared Secret, skeyid, skeyid_d, SKEYSEED, IKE session encryption key, IKE session authentication key, ISAKMP preshared, IKE authentication private Key, IKE authentication public key, IPSec encryption key and IPSec authentication key (r, w, d)
SSHv2 Functions	Negotiation and encrypted data transport via SSHv2.	DRBG entropy input, DRBG seed, DRBG V, DRBG key, Operator password, Diffie-Hellman private key, Diffie-Hellman public key, Diffie-Hellman Shared Secret, EC Diffie-Hellman private key, EC Diffie-Hellman public key, EC Diffie-Hellman Shared Secret, SSHv2 private key, SSHv2 public key and SSHv2 session key and SSHv2 integrity key (r, w, d)
HTTPS Functions (TLSv1.2)	Negotiation and encrypted data transport via HTTPS/TLSv1.2.	DRBG entropy input, DRBG Seed, DRBG V, DRBG Key, Operator password, TLS RSA private key, TLS RSA public key, TLS pre-master secret, TLS master secret, TLS encryption keys and TLS integrity key (r, w, d)

Table 3 User Services

2.7 Crypto Officer Services

A Crypto Officer enters the system by accessing the Console port, SSHv2, HTTPS/TLSv1.2 or SNMPv3. The CO role can be authenticated via either Username/Password or RSA based authentication method. A Crypto Officer may assign permission to access the Crypto Officer role to additional accounts, thereby creating additional Crypto Officers.

The Crypto Officer role is responsible for the configuration of the module. The services available to the Crypto Officer role accessing the CSPs, the type of access – read (r), write (w) and zeroized/delete (d) – and which role accesses the CSPs are listed below:

Services	Description	Keys and CSPs Access
Configure the Security	Define network interfaces and settings, create command aliases, set the protocols the router will support, enable interfaces and network services, set system date and time, change factory default user name/password and load authentication information.	DRBG entropy input, DRBG Seed, DRBG V, DRBG Key, Diffie-Hellman private key, Diffie-Hellman public key, Diffie-Hellman Shared Secret, EC Diffie-Hellman private key, EC Diffie-Hellman public key, EC Diffie-Hellman Shared Secret, SSHv2 private key, SSHv2 public key and SSHv2 session key, SSHv2 integrity key, ISAKMP preshared, Operator password, Enable password, IKE session encryption key, IKE session authentication key, IKE authentication private Key, IKE authentication public key, IPSec encryption key, IPSec authentication key, TLS RSA private key, TLS RSA public key, TLS pre-master secret, TLS master secret, TLS encryption keys, TLS integrity key SNMPv3 password and SNMPv3 session key (r, w, d)
Firmware integrity	Execute firmware integrity verification	Integrity test key (r, w, d)
Configure External Authentication Server	Configure Client/Server authentication	RADIUS secret, TACACS+ secret (r, w, d)
Define Rules and Filters	Create packet Filters that are applied to User data streams on each interface. Each Filter consists of a set of Rules, which define a set of packets to permit or deny based on characteristics such as protocol	Operator password, Enable password (r, w, d)

	ID, addresses, ports, TCP connection establishment, or packet direction.	
View Status Functions	View the appliance configuration, routing tables, active sessions health, temperature, memory status, voltage, packet statistics, review accounting logs, and view physical interface status.	N/A
HTTPS/TLS (TLSv1.2)	Configure HTTPS/TLS parameters, provide entry and output of CSPs.	DRBG entropy input, DRBG Seed, DRBG V, DRBG Key, TLS RSA private key, TLS RSA public key, TLS pre-master secret, TLS master secret, TLS encryption keys and TLS integrity key (r, w, d)
IPSec VPN Functions	Configure IPSec VPN parameters, provide entry and output of CSPs.	DRBG entropy input, DRBG Seed, DRBG V, DRBG Key, Diffie-Hellman private key, Diffie-Hellman public key, Diffie-Hellman Shared Secret, EC Diffie-Hellman private key, EC Diffie-Hellman public key, EC Diffie-Hellman Shared Secret, SAKMP preshared, skeyid, skeyid_d, SKEYSEED, IKE session encryption key, IKE session authentication key, IKE authentication private Key, IKE authentication public key, IPSec encryption key and IPSec authentication key (r, w, d)
SSHv2 Functions	Configure SSHv2 parameter, provide entry and output of CSPs.	DRBG entropy input, DRBG Seed, DRBG V, DRBG Key, Diffie-Hellman private key, Diffie-Hellman public key, Diffie-Hellman Shared Secret, EC Diffie-Hellman private key, EC Diffie-Hellman public key, EC Diffie-Hellman Shared Secret, SSHv2 private key, SSHv2 public key and SSHv2 session key and SSHv2 integrity key (r, w, d)
Self-Tests	Execute the FIPS 140 start-up tests on demand.	N/A
User services	The Crypto Officer has access to all User services.	Operator password (r, w, d)
SNMPv3 Functions	Configure SNMPv3 MIB and monitor status.	SNMPv3 Password and SNMPv3 session key (r, w, d)
Zeroization	Zeroize cryptographic keys/CSPs by running the zeroization methods classified in table 6, Zeroization column.	All CSPs (d)

Table 4 Crypto Officer Services

2.8 Non-FIPS mode Services

The cryptographic module in addition to the above listed FIPS mode of operation can operate in a non-FIPS mode of operation. This is not a recommended operational mode but because the associated RFC's for the following protocols allow for non-approved algorithms and non-approved key sizes a non-approved mode of operation exist. So those services listed above with their FIPS approved algorithms in addition to the following services with their non-approved algorithms and non-approved keys sizes are available to the User and the Crypto Officer. Prior to using any of the Non-Approved services in Section 2.8, the Crypto Officer must zeroize all CSPs which places the module into the non-FIPS mode of operation.

Services [1]	Non-Approved Algorithms
SSH	Hashing: MD5 MACing: HMAC MD5 Symmetric: DES Asymmetric: 768-bit/1024-bit RSA (key transport), 1024-bit Diffie-Hellman
IPsec	Hashing: MD5 MACing: HMAC MD5 Symmetric: DES, RC4 Asymmetric: 768-bit/1024-bit RSA (key transport), 1024-bit Diffie-Hellman
TLS	Symmetric: DES, RC4 Asymmetric: 768-bit/1024-bit RSA (key transport), 1024-bit Diffie-Hellman

Table 5 Non-approved algorithms in the Non-FIPS mode services

Neither the User nor the Crypto Officer are allowed to operate any of these services while in FIPS mode of operation.

To put the module back into the FIPS mode from the non-FIPS mode, the CO must zeroize all Keys/CSPs used in non-FIPS mode, and then strictly follow up the steps in section 3 of this document to put the module into the FIPS mode.

All services available can be found at Cisco Firepower 4100/9300 FXOS Firepower Chassis Manager Configuration Guide, 2.6(1) (Last Modified: 2020-07-02). https://www.cisco.com/c/en/us/td/docs/security/firepower/fxos/fxos261/web-guide/b_GUI_FXOS_ConfigGuide_261.pdf. This site lists all configuration guides.

2.9 Unauthenticated Services

The services for someone without an authorized role are to view the status output from the module's LED pins and cycle power.

In addition, for details regarding the Roles, Services and Authentication provided by the embedded cryptographic module, please refer to the Security Policy under FIPS Cert. #3821 for more information.

2.10 Cryptographic Key/CSP Management

The module administers both cryptographic keys and other critical security parameters such as passwords. All keys and CSPs are protected by the password-protection of the Crypto Officer role login, and can be zeroized by the Crypto Officer. Zeroization consists of overwriting the memory that stored the key or refreshing the volatile memory. Keys are both manually and electronically distributed but entered electronically. Persistent keys with manual distribution are used for pre-shared keys whereas protocols such as IKE, TLS, SNMP and SSH are used for electronic distribution.

All pre-shared keys are associated with the CO role that created the keys, and the CO role is protected by a password. Therefore, the CO password is associated with all the pre-shared keys. The Crypto Officer needs to be authenticated to store keys. Only an authenticated Crypto Officer

[1] These approved services become non-approved when using any non-approved algorithms or non-approved key or curve sizes. When using approved algorithms and key sizes these services are approved.

can view the keys. All Diffie-Hellman (DH)/ECDH keys agreed upon for individual tunnels are directly associated with that specific tunnel only via the IKE protocol. RSA Public keys are entered into the module using digital certificates which contain relevant data such as the name of the public key's owner, which associates the key with the correct entity.

The entropy source falls into IG 7.14, Scenario #1a: A hardware module with an entropy-generating NDRNG inside the module's cryptographic boundary. The entropy source provides at least 256 bits of entropy to seed SP800-90a DRBG for the use of key generation.

Name	CSP Type	Size	Description/Generation	Storage	Zeroization
DRBG entropy input	SP800-90A CTR_DRBG (AES 256)	384-bits	This is the entropy for SP 800-90A CTR_DRBG. Software based entropy source used to construct seed.	DRAM (plaintext)	Power cycle the device
DRBG Seed	SP800-90A CTR_DRBG (AES 256)	384-bits	Input to the DRBG that determines the internal state of the DRBG. Generated using DRBG derivation function that includes the entropy input.	DRAM (plaintext)	Power cycle the device
DRBG V	SP800-90A CTR_DRBG (AES 256)	128-bits	The DRBG V is one of the critical values of the internal state upon which the security of this DRBG mechanism depends. Generated first during DRBG instantiation and then subsequently updated using the DRBG update function.	DRAM (plaintext)	Power cycle the device
DRBG Key	SP800-90A CTR_DRBG (AES 256)	256-bits	Internal critical value used as part of SP 800-90A CTR_DRBG. Established per SP 800-90A CTR_DRBG.	DRAM (plaintext)	Power cycle the device
Diffie-Hellman Shared Secret	DH	2048 - 4096 bits	The shared secret used in Diffie-Hellman (DH) exchange. Established per the Diffie-Hellman key agreement.	DRAM (plaintext)	Power cycle the device
Diffie Hellman private key	DH	224 – 384 bits	The private key used in Diffie-Hellman (DH) exchange. This key is generated by calling SP800-90A DRBG.	DRAM (plaintext)	Power cycle the device
Diffie Hellman public key	DH	2048 - 4096 bits	The public key used in Diffie-Hellman (DH) exchange. This key is derived per the Diffie-Hellman key agreement. Note that the public key is a cryptographic key, but not considered a CSP.	DRAM (plaintext)	Power cycle the device
EC Diffie-Hellman Shared Secret	ECDH	P-256, P-384, P-521 Curves	The shared secret used in Elliptic Curve Diffie-Hellman (ECDH) exchange. Established per the Elliptic Curve Diffie-Hellman (ECDH) protocol.	DRAM (plaintext)	Power cycle the device

Name	CSP Type	Size	Description/Generation	Storage	Zeroization
EC Diffie Hellman private key	ECDH	P-256, P-384, P-521 Curves	Used in establishing the session key for an IPSec session. The private key used in Elliptic Curve Diffie-Hellman (ECDH) exchange. This key is generated by calling SP 800-90A DRBG	DRAM (plaintext)	Power cycle the device
EC Diffie Hellman public key	ECDH	P-256, P-384, P-521 Curves	Used in establishing the session key for an IPSec session. The public key used in Elliptic Curve Diffie-Hellman (ECDH) exchange. This key is established per the EC Diffie-Hellman key agreement. Note that the public key is a cryptographic key, but not considered a CSP.	DRAM (plaintext)	Power cycle the device
skeyid	Keying material	160 bits	A shared secret known only to IKE peers. It was established via key derivation function defined in SP800-135 KDF and it will be used for deriving other keys in IKE protocol implementation.	DRAM (plaintext)	Power cycle the device
skeyid_d	Keying material	160 bits	A shared secret known only to IKE peers. It was derived via key derivation function defined in SP800-135 KDF (IKEv2) and it will be used for deriving IKE session authentication key.	DRAM (plaintext)	Power cycle the device
SKEYSEED	Keying material	160 bits	A shared secret known only to IKE peers. It was derived via key derivation function defined in SP800-135 KDF (IKEv2) and it will be used for deriving IKE session authentication key.	DRAM (plaintext)	Power cycle the device
IKE session encryption key	Triple-DES/AES	Triple-DES 192 bits or AES 128/192/256 bits	The IKE session (IKE Phase I) encrypt key. This key is derived via key derivation function defined in SP800-135 KDF (IKEv2).	DRAM (plaintext)	Automatically when IPsec session is terminated
IKE session authentication key	HMAC-SHA-256/384/512	256-512 bits	The IKE session (IKE Phase I) authentication key. This key is derived via key derivation function defined in SP800-135 KDF (IKEv2).	DRAM (plaintext)	Automatically when IPsec session is terminated
ISAKMP preshared	Shared Secret	Variable 8 plus characters	The secret used to derive IKE skeyid when using preshared secret authentication. This CSP is entered by the Crypto Officer.	NVRAM (plaintext)	Procedurally erase the secret
IKE authentication private Key	RSA	RSA (2048 bits)	RSA private key used in IKE authentication. This key is generated by calling SP800-90A DRBG.	NVRAM (plaintext)	Zeroized by RSA keypair deletion command

Name	CSP Type	Size	Description/Generation	Storage	Zeroization
IKE authentication public key	RSA	RSA (2048 bits)	RSA public key used in IKE authentication. This key is derived in compliance with FIPS 186-4 RSA key pair generation method in the module. Note that the public key is a cryptographic key, but not considered a CSP.	NVRAM (plaintext)	Zeroized by RSA keypair deletion command
IPsec encryption key	Triple-DES/AES/AES-GCM	Triple-DES 192 bits or AES 128/192/256 bits	The IPsec (IKE phase II) encryption key. This key is derived via a key derivation function defined in SP800-135 KDF (IKEv2).	DRAM (plaintext)	Automatically when IPsec session is terminated
IPsec authentication key	HMAC-SHA-256/384/512	256-512 bits	The IPSec (IKE Phase II) authentication key. This key is derived via a key derivation function defined in SP800-135 KDF (IKEv2).	DRAM (plaintext)	Automatically when IPsec session is terminated
Operator password	Password	8 plus characters	The password of the User role. This CSP is entered by the User.	NVRAM (plaintext)	Overwrite with new password
RADIUS secret	Shared Secret	16 characters	The RADIUS shared secret. Used for RADIUS Client/Server authentication. This CSP is entered by the Crypto Officer.	NVRAM (plaintext)	Procedurally erase the secret
TACACS+ secret	Shared Secret	16 characters	The TACACS+ shared secret. Used for TACACS+ Client/Server authentication. This CSP is entered by the Crypto Officer.	NVRAM (plaintext)	Procedurally erase the secret
SSHv2 private key	RSA	2048 bits modulus	The SSHv2 private key used in SSHv2 connection. This key is generated by calling SP 800-90A DRBG.	NVRAM (plaintext)	Zeroized by RSA keypair deletion command
SSHv2 public key	RSA	2048 bits modulus	The SSHv2 public key used in SSHv2 connection. This key is derived in compliance with FIPS 186-4 RSA key pair generation method in the module. Note that the public key is a cryptographic key, but not considered a CSP	NVRAM (plaintext)	Zeroized by RSA keypair deletion command
SSHv2 session key	Triple-DES/AES	Triple-DES 192 bits or AES 128/192/256 bits	This is the SSHv2 session key. It is used to encrypt all SSHv2 data traffics traversing between the SSHv2 Client and SSHv2 Server. This key is derived via key derivation function defined in SP800-135 KDF (SSH).	DRAM (plaintext)	Automatically when SSH session is terminated
SSHv2 integrity key	HMAC-SHA-1	160 bits	Used for SSH connections integrity to assure the traffic integrity. This key is derived via key derivation function defined in SP800-135 KDF (SSH).	DRAM (plaintext)	Automatically when SSH session is terminated

Name	CSP Type	Size	Description/Generation	Storage	Zeroization
TLS RSA private key	RSA	2048 bits	Identity certificates for the security appliance itself and also used in TLS session negotiations. This key is generated by calling SP 800-90A DRBG.	NVRAM (plaintext)	Zeroized by RSA keypair deletion command
TLS RSA public key	RSA	2048 bits	Identity certificates for the security appliance itself and also used in TLS session negotiations. This key is derived in compliance with FIPS 186-4 RSA key pair generation method in the module. Note that the public key is a cryptographic key, but not considered a CSP.	NVRAM (plaintext)	Zeroized by RSA keypair deletion command
TLS pre-master secret	keying material	At least eight characters	Keying material used to derive TLS master secret during the TLS protocol implementation. This key is entered into the module in cipher text form, encrypted by RSA public key.	DRAM (plaintext)	Automatically when TLS session is terminated
TLS master secret	keying material	48 Bytes	Keying material used to derive other HTTPS/TLS keys. This key was derived from TLS pre-master secret during the TLS session establishment	DRAM (plaintext)	Automatically when TLS session is terminated
TLS encryption keys	Triple-DES/AES/AES-GCM	Triple-DES 192 bits or AES 128/192/256 bits	Used in HTTPS/TLS connections to protect the session traffic. This key was derived in the module.	DRAM (plaintext)	Automatically when TLS session is terminated
TLS integrity key	HMAC-SHA-256/384/512	256-512 bits	Used for TLS integrity to assure the traffic integrity. This key was derived in the module.	DRAM (plaintext)	Automatically when TLS session is terminated
SNMPv3 password	Shared Secret	256 bits	Used to authenticate the SNMPv3 operator. This key is entered by Crypto Officer.	NVRAM (plaintext)	Procedurally erase the password
SNMPv3 session key	AES	128 bits	Used to protect SNMP traffic. This key is derived via key derivation function defined in SP800-135 KDF (SNMPv3).	DRAM (plaintext)	Power cycle the device
Integrity test key	RSA-2048 Public key	2048 bits	A hard coded key used for firmware power-up integrity verification.	Hard coded for firmware integrity testing	Zeroized by reinstalling a new image

Table 6 Cryptographic Keys and CSPs

In addition, for details of the Cryptographic Keys and CSPs provided by the embedded cryptographic module, please refer to the Security Policy under FIPS Cert. #3821 for more information.

2.11 Cryptographic Algorithms

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

Approved Cryptographic Algorithms

The module supports the following FIPS 140-2 approved algorithm implementations:

Algorithm	Cisco Security Crypto (Firmware)
AES (128/192/256 bits CBC, GCM)	C784
Triple-DES (CBC, 3-key)	C784
SHS (SHA-1/256/384/512)	C784
HMAC (SHA-1/256/384/512)	C784
RSA (PKCS1_V1_5; KeyGen, SigGen, SigVer; 2048 bits)	C784
CTR_DRBG (AES-256)	C784
CVL Component (TLSv1.2, SSHv2, IKEv2 and SNMPv3)	C784
CKG (vendor affirmed)	

Table 7 Approved Cryptographic Algorithms and Associated Certificate Number

Notes:

- There are some algorithm modes that were tested but not used by the module. Only the algorithms, modes, and key sizes that are implemented by the module are shown in this 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 operations of one of the two parties involved in the TLS key establishment scheme were performed entirely within the cryptographic boundary of the module being validated. 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. The operations of one of the two parties involved in the IKE key establishment scheme shall be performed entirely within the cryptographic boundary of the module being validated. 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.
- Each of TLS, SSH and IPSec protocols governs the generation of the respective Triple-DES keys. Refer to RFC 5246 (TLS), RFC 4253 (SSH) and RFC 6071 (IPSec) for details relevant to the generation of the individual Triple-DES encryption keys. The user is responsible for ensuring the module limits the number of encryptions with the same key to 2^{20}.
- No parts of the SSH, TLS, SNMP and IPSec protocols, other than the KDFs, have been tested by the CAVP and CMVP.

- In accordance with FIPS 140-2 IG D.12, the cryptographic module performs Cryptographic Key Generation as per scenario 1 of section 5 in SP800-133. The resulting generated seed used in the asymmetric key generation is the unmodified output from SP800-90A DRBG.

Non-FIPS Approved Algorithms Allowed in FIPS Mode

The module supports the following non-FIPS approved algorithms which are permitted for use in the FIPS approved mode:

- Diffie-Hellman (CVL Cert. #C784, key agreement; key establishment methodology provides between 112 and 150 bits of encryption strength)
- EC Diffie-Hellman (CVL Cert. #C784, key agreement; key establishment methodology provides between 128 and 256 bits of encryption strength)
- NDRNG
- RSA (key wrapping; key establishment methodology provides 112 bits of encryption strength)

Non-Approved Cryptographic Algorithms

The module supports the following non-approved cryptographic algorithms that shall not be used in FIPS mode of operation:

- DES
- Diffie-Hellman (key agreement; key establishment methodology less than 112 bits of encryption strength; non-compliant)
- HMAC MD5
- HMAC-SHA-1 is not allowed with key size under 112-bits
- MD5
- RC4
- RSA (key wrapping; key establishment methodology less than 112 bits of encryption strength; non-compliant)

In addition, the embedded cryptographic module under FIPS Cert. #3821 also provides the following FIPS approved algorithm certificates and non-approved algorithms.

Approved Cryptographic Algorithms from Embedded Module

The module supports the following FIPS 140-2 approved algorithm implementations:

	Algorithms		
	Cisco Security Crypto (Firmware)	On-board Chip (Cavium Nitrox III)	On-board Chip (Cavium Nitrox V)
AES (128/192/256 CBC, GCM)	4905/C784	2034/2035	C1026
Triple-DES (CBC, 3-key)	2559/C784	1311	C1026
SHS (SHA-1/256/384/512)	4012/C784	1780	C1026
HMAC (SHA-1/256/384/512)	3272/C784	1233	C1026
RSA (KeyGen, SigGen and SigVer; PKCS1_V1_5; 2048bits)	2678/C784		
ECDSA (PKG, SigGen and SigVer; P-256, P-384, P-521)	1254/C784		
CTR_DRBG (AES-256)	1735/C784		
HASH_DRBG (SHA-512)		197	C1026
CVL Component (IKEv2, TLSv1.2, SSHv2)	1521/C784		
CKG (vendor affirmed)			

Table 8 Approved Cryptographic Algorithms and Associated Certificate Number

Notes:

- There are some algorithm modes that were tested but not implemented by the module. Only the algorithms, modes, and key sizes that are implemented by the module are shown in this 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 operations of one of the two parties involved in the TLS key establishment scheme were performed entirely within the cryptographic boundary of the module being validated. 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. The operations of one of the two parties involved in the IKE key establishment scheme shall be performed entirely within the cryptographic boundary of the module being validated. 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.
- No parts of the SSH, TLS and IPSec protocols have been tested with the exception of the protocols associated algorithms and KDFs.
- Each of TLS, SSH and IPSec protocols governs the generation of the respective Triple-DES keys. Refer to RFC 5246 (TLS), RFC 4253 (SSH) and RFC 6071 (IPSec) for details relevant to the generation of the individual Triple-DES encryption keys. The user is responsible for ensuring the module limits the number of encryptions with the same key to 2^{20}.
- In accordance with FIPS 140-2 IG D.12, the cryptographic module performs Cryptographic Key Generation as per section 6 in SP800-133. The resulting generated seed used in the asymmetric key generation are the unmodified output from SP800-90A DRBG.

Non-FIPS Approved Algorithms Allowed in FIPS Mode from Embedded Module

The embedded module supports the following non-FIPS approved algorithms which are permitted for use in the FIPS approved mode:

- Diffie-Hellman (CVL Certs. #1521 and #C784, key agreement; key establishment methodology provides between 112 and 150 bits of encryption strength)
- EC Diffie-Hellman (CVL Cert. #1521 and #C784, key agreement; key establishment methodology provides between 128 and 256 bits of encryption strength)
- RSA (key wrapping; key establishment methodology provides 112 bits of encryption strength)

- NDRNG

Non-Approved Cryptographic Algorithms from Embedded Module

The embedded module supports the following non-approved cryptographic algorithms that shall not be used in FIPS mode of operation:

- Diffie-Hellman (key agreement; key establishment methodology less than 112 bits of encryption strength; non-compliant)
- DES
- HMAC MD5
- MD5
- RC4
- RSA (key wrapping; key establishment methodology less than 112 bits of encryption strength; non-compliant)
- HMAC-SHA1 is not allowed with key size under 112-bits

2.12 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 ensure all components are functioning correctly.

Self-tests performed

- POSTs
  - AES CBC Encrypt/Decrypt KATs
  - AES GCM KAT
  - DRBG KAT (Note: DRBG Health Tests as specified in SP800-90A Section 11.3 are performed)
  - Firmware Integrity Test (using RSA 2048 with SHA-512)
  - HMAC-SHA-1 KAT
  - HMAC-SHA-256 KAT
  - HMAC-SHA-384 KAT
  - HMAC-SHA-512 KAT
  - RSA KATs (separate KAT for signing; separate KAT for verification)
  - SHA-1 KAT
  - Triple-DES CBC Encrypt/Decrypt KATs
- Conditional tests
  - RSA PWCT
  - CRNGT to SP800-90A DRBG
  - CRNGT to NDRNG (entropy source)

The security appliances perform all power-on self-tests automatically when the power is applied. All power-on self-tests must be passed before a User/Crypto Officer 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 security appliances from passing any data during a power-on self-test failure. In the unlikely event that a power-on self-test fails, an error message is displayed on the console followed by a security appliance reboot.

In addition, for details of the Self-Tests conducted by the embedded cryptographic module, please refer to Security Policy under FIPS Cert. #3821 for more information.

2.13 Physical Security

The FIPS 140-2 level 2 physical security requirements for the modules are met by the use of opacity shields covering the front panels of modules to provide the required opacity and tamper evident seals to provide the required tamper evidence.

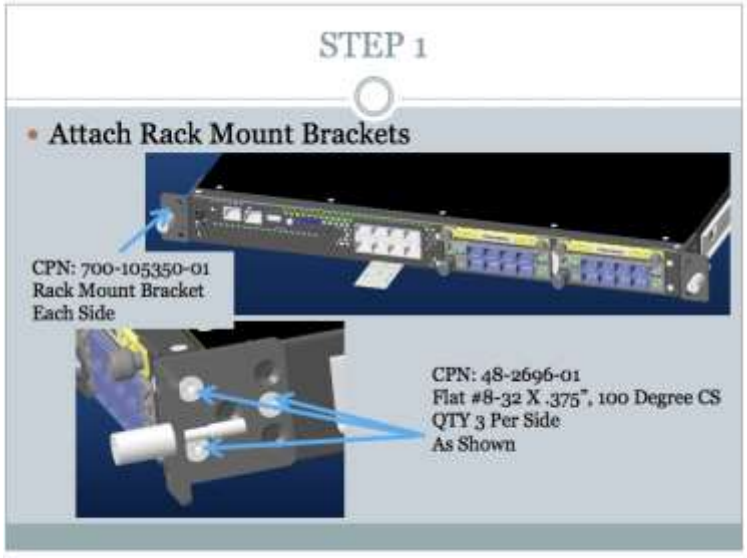
Opacity Shield Security

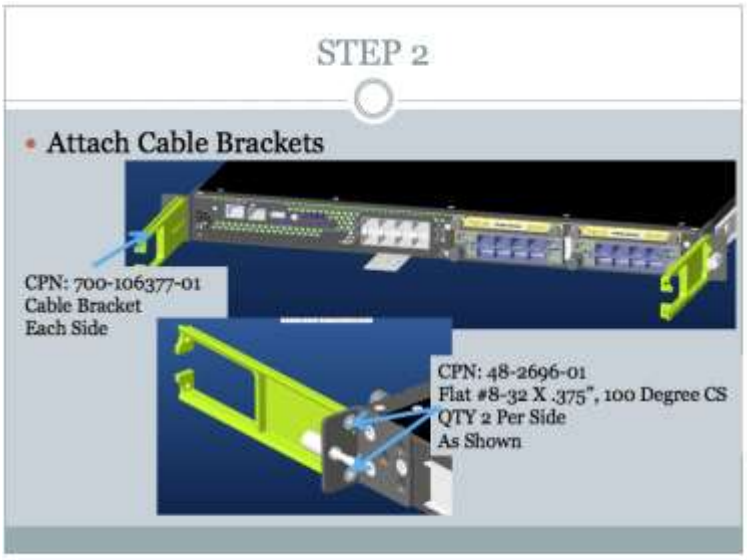
The following table shows the tamper labels and opacity shields that shall be installed on the modules to operate in a FIPS approved mode of operation. The CO is responsible for using, securing and having control at all times of any unused tamper evident labels. Actions to be taken when any evidence of tampering should be addressed within the site security program.

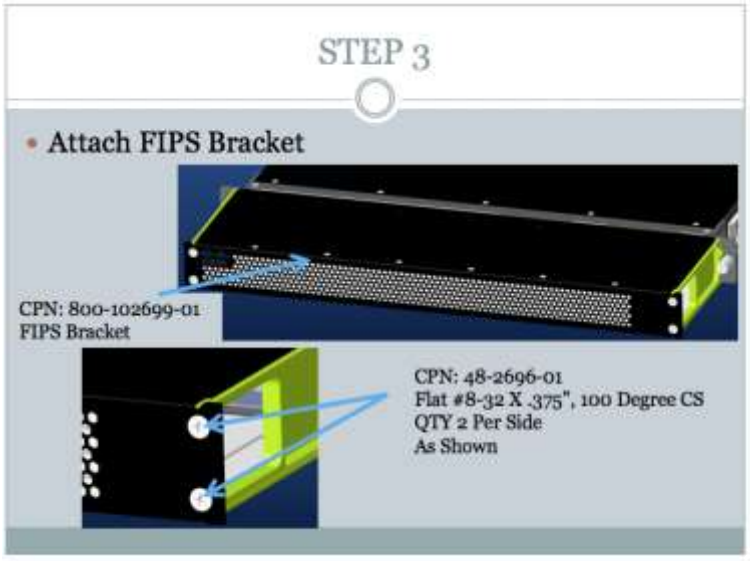
Models	Number Tamper labels	Tamper Evident Labels	Number Opacity Shields	Opacity Shields
FPR4110, FPR4115, FPR4120, FPR4125, FPR4140, FPR4145, FPR4150	15	Cisco_TEL.FIPS_Kit	1	69-100250-01
FPR9300-SM24, FPR9300-SM36, FPR9300-SM40, FPR9300-SM44, FPR9300-SM48, FPR9300-SM56	12	Cisco_TEL.FIPS_Kit	1	800-102843-01

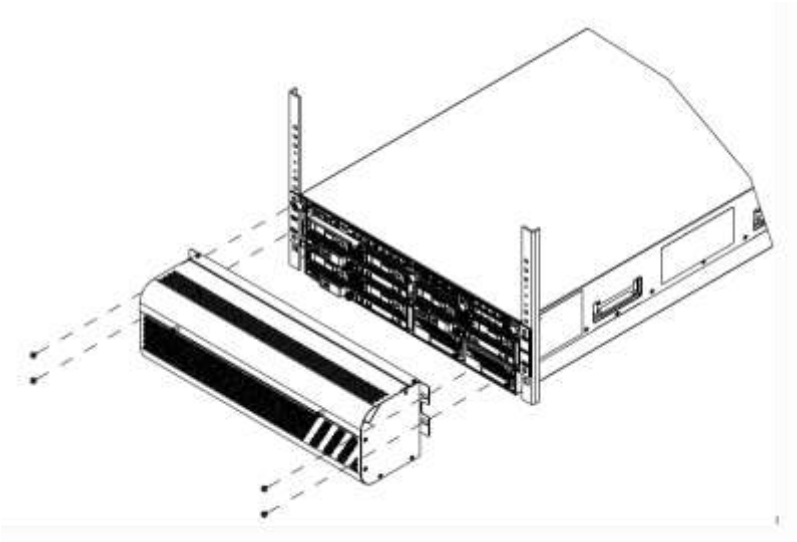
Opacity Shield installation

FPR4100









Inspection of the opacity shields should be incorporated into facility security postures to include how often to inspect and any recording of the inspection. It is recommended 30 days but this is the facilities Security Manager decision.

Tamper Evidence Label (TEL) placement

The tamper evident seals (hereinafter referred to as tamper evident labels (TEL)) shall be installed on the security devices containing the module prior to operating in FIPS mode. TELs shall be applied as depicted in the figures below. Any unused TELs must be securely stored, accounted for, and maintained by the CO in a protected location.

Should the CO have to remove, change or replace TELs for any reason, the CO must examine the location from which the TEL was removed and ensure that no residual debris is still remaining on the chassis or card. If residual debris remains, the CO must remove the debris using a damp cloth.

Any deviation of the TELs placement such as tearing, misconfiguration, removal, change, replacement or any other change in the TELs from its original configuration as depicted below by unauthorized operators shall mean the module is no longer in FIPS mode of operation. Returning the system back to FIPS mode of operation requires the replacement of the TEL as depicted below and any additional requirement per the site security policy which are out of scope of this Security Policy.

To seal the system, apply tamper-evidence labels as depicted in the figures below.

Figure 4: FPR4100 Front view (no TEL present on front)

Figure 5: FPR4100 Right Side

(Right side has TEL #1 overlapping top and side)

Figure 6: FPR4100 Left Side

(Left side has TEL #2 overlapping top and side)

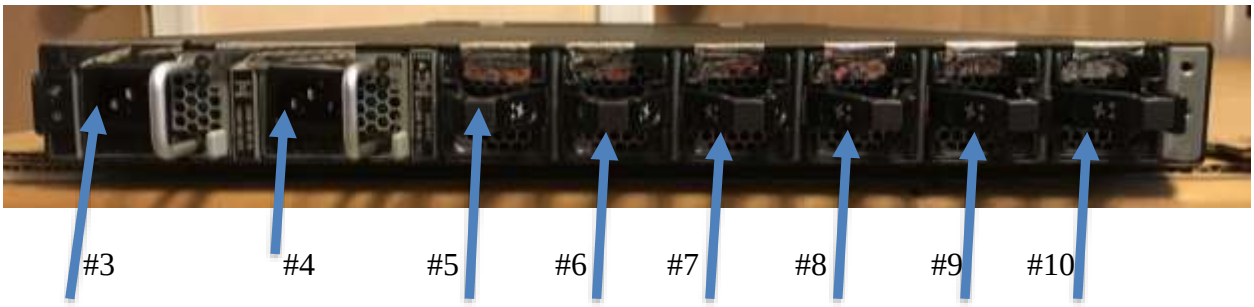


Figure 7: FPR4100 Rear view

(Rear has TEL #3, #4, #5, #6, #7, #8, #9 and #10 overlapping top and plug-in)

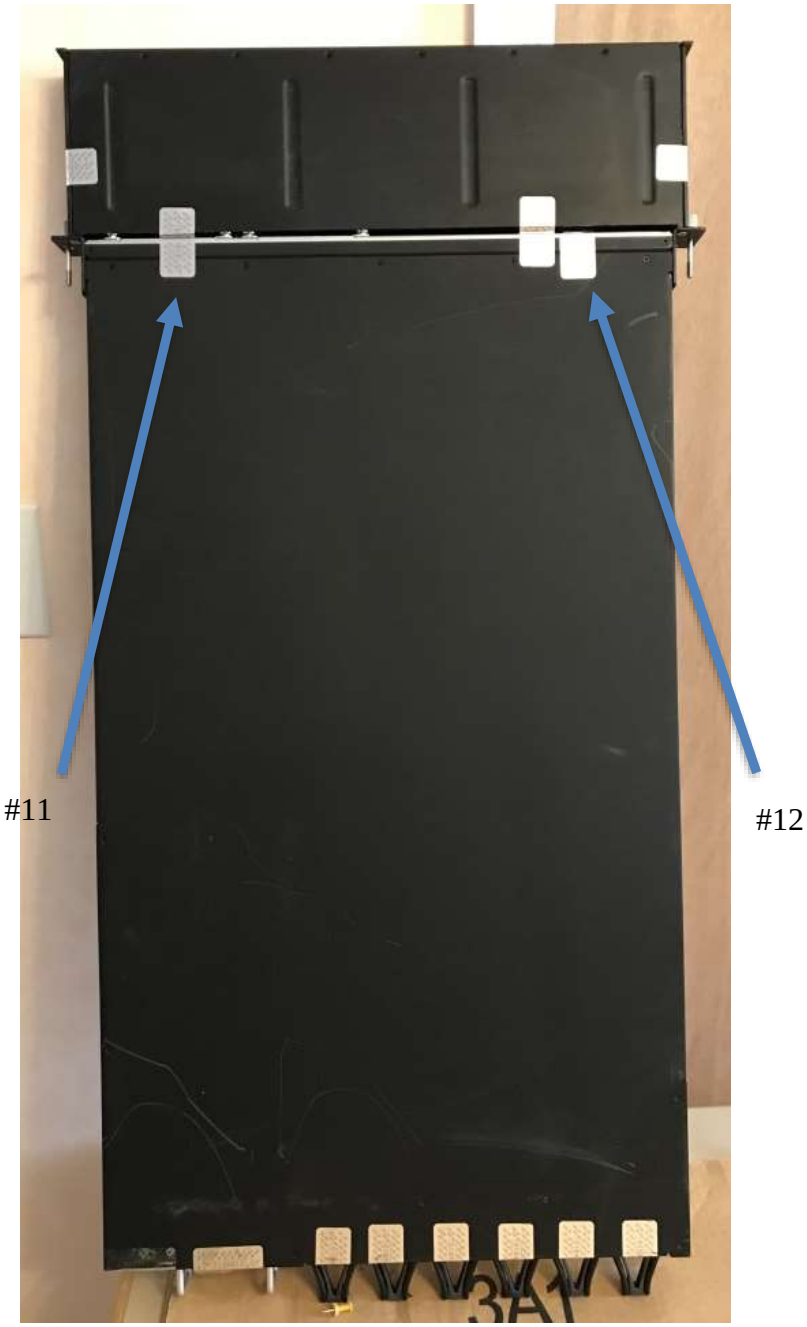


Figure 8: FPR4100 Top view

(Top shows TEL #11 and #12 overlapping opacity shield and 4000 chassis, also present is TEL #1,2,3,4,5,6,7,8,9,10)

Figure 9: FPR4100 Bottom view

(Bottom shows TEL #13 and # 14 overlapping opacity shield and 4000 chassis)

Figure 10: FPR9300 Front view

(Front opacity shield has TEL #1 and #2)

Figure 11: FPR9300 Right view (Right side has no TELs)

Figure 12: FPR9300 Left view (Left side has no TELs)

Figure 13: FPR9300 Rear view

(Rear has TEL #3, #4, #5, #6, each overlapping chassis and plug-in and #7 on bottom)

Figure 14: FPR9300 Top view

(Top has TEL #8 and #9 overlapping opacity shield and top of chassis, also present is TEL #3, #4, #5 and #6 listed on Back view. TEL #12 partially obscured inside the opacity shield, overlapping front of chassis and top of chassis covering the USB)

Figure 15: FPR9300 Bottom view

(Bottom has TEL #10 and #11 overlapping opacity shield and bottom of chassis, also present is TEL #7 overlapping bottom and back of plug-in)

Please note that the 4100 and 9300 series modules provide the above described level 2 physical security protections.

Appling Tamper Evidence Labels

Step 1**:** Turn off and unplug the system before cleaning the chassis and applying labels.

Step 2: Clean the chassis of any grease, dirt, or oil before applying the tamper evident labels. Alcohol-based cleaning pads are recommended for this purpose.

Step 3: Apply a label to cover the security appliance as shown in figures above and allow the label to cure for a minimum of 12 hours.

The tamper evident seals are produced from a special thin gauge vinyl with self-adhesive backing. Any attempt to open the device will damage the tamper evident seals or the material of the security appliance cover. Because the tamper evident seals have non-repeated serial numbers, they may be inspected for damage and compared against the applied serial numbers to verify that the security appliance has not been tampered with. Tamper evident seals can also be inspected for signs of tampering, which include the following: curled corners, rips, and slices. The tamper evidence shall appear if the label was peeled back.

Inspection of the tamper seals should be incorporated into facility security to include how often to inspect and any recording of the inspection. It is recommended 30 days but this is the facilities Security Manager decision.

3 Secure Operation

The module meets all the Level 2 requirements for FIPS 140-2. The module is shipped only to authorized operators by the vendor, and 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 FIPS-approved mode. Operating this module without maintaining the following settings will remove the module from the FIPS approved mode of operation.

3.1 Crypto Officer Guidance - System Initialization

The module was validated with FX-OS version 2.6. This is the only allowable image for FIPS-approved mode of operation.

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

Step 1: The Crypto Officer must install opacity shields as described in Section 2.13 of this document.

Step 2: The Crypto Officer must apply tamper evidence labels as described in Section 2.13 of this document.

Step 3: Power on the system

Step 4: When prompted, log in with the username **admin** and the password **cisco123**.
you have chosen to setup a new Security Appliance.
Continue? (yes/no): **y**

Enter the password for "admin": **[enter new password]**
Confirm the password for "admin": **[enter new password again]**

Step 5: Install for Smart Licensing for Triple-DES/AES licenses to require the security appliances to use Triple-DES and AES (for data traffic and SSH).

Step 6: Enable "FIPS Mode" to allow the security appliances to internally enforce FIPS-compliant behavior, such as run power-on self-tests and conditional test, using the following command:

security # [enable | disable] fips-mode
security # commit-buffer
security # connect local-mgmt
security # reboot

Step 7: After step 4, please issue the following command to verify the FIPS mode:

security # show fips-mode

Note: the output from 'show fips-mode' should be "FIPS Mode Admin State: Enabled"

Step 8: Generated the SSH host key by using the following commands.

system/services # delete ssh-server host-key
system/services # commit-buffer
system/services # set ssh-server host-key rsa 2048
system/services # commit-buffer
system/services # create ssh-server host-key
system/services # commit-buffer
system/services # show ssh-server host-key

Step 9: If using a RADIUS/TACACS+ server for authentication, please configure an IPSec/TLS tunnel to secure traffic between the module and the RADIUS/TACACS+ server. The RADIUS/TACACS+ shared secret must be at least 8 characters long.

Step 10: Reboot the security appliances.

In addition, for the Secure Operations steps required for the embedded cryptographic module, please refer to the Security Policy under FIPS Cert. #3821 for more information.