i.MX8 SHE API

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1	Module Index	1
	1.1 Modules	1
2	Module Documentation	1
	2.1 Error codes	1
	2.1.1 Detailed Description	2
	2.1.2 Enumeration Type Documentation	2
	2.2 SHE keys	3
	2.2.1 Detailed Description	3
	2.3 SHE+ key extension	4
	2.3.1 Detailed Description	4
	2.3.2 Macro Definition Documentation	4
	2.4 Key store provisioning	5
	2.4.1 Detailed Description	5
	2.4.2 Macro Definition Documentation	5
	2.4.3 Function Documentation	6
	2.5 Session	7
	2.5.1 Detailed Description	7
	2.5.2 Function Documentation	7
	2.6 MAC	8
	2.6.1 Detailed Description	8
	2.6.2 Macro Definition Documentation	8
	2.6.3 Function Documentation	8
	2.7 AES-CBC	10
	2.7.1 Detailed Description	10
	2.7.2 Macro Definition Documentation	10
	2.7.3 Function Documentation	10
	2.8 AES-ECB	12
	2.8.1 Detailed Description	12
	2.8.2 Function Documentation	12
	2.9 Key export	15
	2.9.1 Detailed Description	15
	2.9.2 Function Documentation	15
	2.10 RNG	16
	2.10.1 Detailed Description	16
	2.10.2 Function Documentation	16
	2.11 Status Register	18
	2.11.1 Detailed Description	18
	2.11.2 Function Documentation	18
	2.12 UID	19
	2.12.1 Detailed Description	19
	2.12.2 Function Documentation	19

1 Module Index

	2.13 Cancel	20
	2.13.1 Detailed Description	20
	2.13.2 Function Documentation	20
Inc	dex	21
1	Module Index	
1.1	Modules	
He	ere is a list of all modules:	
	Error codes	1
	SHE keys	3
	SHE+ key extension	4
	Key store provisioning	5
	Session	7
	MAC	8
	AES-CBC	10
	AES-ECB	12
	Key export	15
	RNG	16
	Status Register	18
	UID	19
	Cancel	20
2	Module Documentation	
2.1	Error codes	
En	umerations	
	• enum she_err_t { ERC_NO_ERROR = 0x0, ERC_SEQUENCE_ERROR = 0x1, ERC_KEY_NOT_AVAILABLE = 0x2, ERC_KEY_INVALID = 0x3, ERC_KEY_EMPTY = 0x4, ERC_NO_SECURE_BOOT = 0x5, ERC_KEY_WRITE_PROTECTED = 0x6, ERC_KEY_UPDATE_ERROR = 0x7.	

```
ERC_RNG_SEED = 0x8,

ERC_NO_DEBUGGING = 0x9,

ERC_BUSY = 0xA,

ERC_MEMORY_FAILURE = 0xB,

ERC_GENERAL_ERROR = 0xC }
```

2.1.1 Detailed Description

Error codes returned by SHE functions.

2.1.2 Enumeration Type Documentation

2.1.2.1 she_err_t

enum she_err_t

Enumerator

ERC_NO_ERROR	Success.
ERC_SEQUENCE_ERROR	Invalid sequence of commands.
ERC_KEY_NOT_AVAILABLE	Key is locked.
ERC_KEY_INVALID	Key not allowed for the given operation.
ERC_KEY_EMPTY	Key has not beed initialized yet.
ERC_NO_SECURE_BOOT	Conditions for a secure boot process are not met.
ERC_KEY_WRITE_PROTECTED	Memory slot for this key has been write-protected.
ERC_KEY_UPDATE_ERROR	Key update did not succeed due to errors in verification of the messages.
ERC_RNG_SEED	The seed has not been initialized.
ERC_NO_DEBUGGING	Internal debugging is not possible.
ERC_BUSY	A function of SHE is called while another function is still processing.
ERC_MEMORY_FAILURE	Memory error (e.g. flipped bits)
ERC_GENERAL_ERROR	Error not covered by other codes occured.

2.2 SHE keys 3

2.2 SHE keys

Macros

- #define **SHE_KEY_1** (0x04)
- #define **SHE_KEY_2** (0x05)
- #define **SHE_KEY_3** (0x06)
- #define **SHE_KEY_4** (0x07)
- #define **SHE_KEY_5** (0x08)
- #define **SHE_KEY_6** (0x09)
- #define **SHE_KEY_7** (0x0a)
- #define SHE_KEY_8 (0x0b)
- #define SHE_KEY_9 (0x0c)
- #define **SHE_KEY_10** (0x0d)
- #define **SHE_RAM_KEY** (0x0e)

2.2.1 Detailed Description

Identifiers for SHE keys.

2.3 SHE+ key extension

Macros

```
• #define SHE_KEY_DEFAULT (0x00)
```

- #define SHE_KEY_N_EXT_1 (0x10)
- #define SHE_KEY_N_EXT_2 (0x20)
- #define SHE_KEY_N_EXT_3 (0x30)
- #define SHE_KEY_N_EXT_4 (0x40)

2.3.1 Detailed Description

Identifiers for the SHE key extension.

2.3.2 Macro Definition Documentation

```
2.3.2.1 SHE_KEY_DEFAULT
```

```
#define SHE_KEY_DEFAULT (0x00)
```

no key extension: keys from 0 to 10 as defined in SHE specification.

```
2.3.2.2 SHE_KEY_N_EXT_1
```

```
#define SHE_KEY_N_EXT_1 (0x10)
```

keys 11 to 20.

2.3.2.3 SHE_KEY_N_EXT_2

```
#define SHE_KEY_N_EXT_2 (0x20)
```

keys 21 to 30.

2.3.2.4 SHE_KEY_N_EXT_3

```
#define SHE_KEY_N_EXT_3 (0x30)
```

keys 31 to 40.

2.3.2.5 SHE_KEY_N_EXT_4

```
#define SHE_KEY_N_EXT_4 (0x40)
```

keys 41 to 50.

2.4 Key store provisioning

Macros

- #define SHE_STORAGE_CREATE_SUCCESS 0u
- #define SHE_STORAGE_CREATE_WARNING 1u
- #define SHE_STORAGE_CREATE_UNAUTHORIZED 2u
- #define SHE STORAGE CREATE FAIL 3u
- #define SHE_STORAGE_NUMBER_UPDATES_DEFAULT 300u

Functions

uint32_t she_storage_create (uint32_t key_storage_identifier, uint32_t authentication_nonce, uint16_t max
 —updates_number, uint8_t *signed_message, uint32_t msg_len)

2.4.1 Detailed Description

2.4.2 Macro Definition Documentation

2.4.2.1 SHE_STORAGE_CREATE_SUCCESS

```
#define SHE_STORAGE_CREATE_SUCCESS Ou
```

New storage created succesfully.

2.4.2.2 SHE_STORAGE_CREATE_WARNING

```
#define SHE_STORAGE_CREATE_WARNING lu
```

New storage created but its usage is restricted to a limited security state of the chip.

2.4.2.3 SHE_STORAGE_CREATE_UNAUTHORIZED

```
#define SHE_STORAGE_CREATE_UNAUTHORIZED 2u
```

Creation of the storage is not authorized.

2.4.2.4 SHE_STORAGE_CREATE_FAIL

```
#define SHE_STORAGE_CREATE_FAIL 3u
```

Creation of the storage failed for any other reason.

2.4.2.5 SHE_STORAGE_NUMBER_UPDATES_DEFAULT

```
#define SHE_STORAGE_NUMBER_UPDATES_DEFAULT 300u
```

default number of maximum number of updated for SHE storage.

2.4.3 Function Documentation

2.4.3.1 she_storage_create()

Creates an empty SHE storage.

Must be called at least once on every device before using any other SHE API.

A signed message must be provided to replace an existing key store. This message is not necessary under some conditions related to chip's lifecycle.

Note that the signed message is not yet supported. should be forced to NULL.

Parameters

key_storage_identifier	key store identifier
authentication_nonce	user defined nonce to be used as authentication proof for accesing the key store.
max_updates_number	maximum number of updates authorized on this new storage. This parameter has the goal to limit the occupation of the monotonic counter used as anti-rollback protection. If the maximum number of updates is reached, SHE still allows key store updates but without updating the monotonic counter giving the opportunity for rollback attacks. Always forced to 300 in the current release.
signed_message	pointer to a signed message authorizing the operation (NULL if no signed message to be used)
msg_len	length in bytes of the signed message

Returns

2.5 Session 7

2.5 Session

Functions

- struct she_hdl_s * she_open_session (uint32_t key_storage_identifier, uint32_t authentication_nonce, void(*async_cb)(void *priv, she_err_t err), void *priv)
- void she close session (struct she hdl s *hdl)

2.5.1 Detailed Description

2.5.2 Function Documentation

2.5.2.1 she_open_session()

Initiate a SHE session. The returned session handle pointer is typed with the struct "she_hdl_s". The user doesn't need to know or to access the fields of this struct.

It only needs to store this pointer and pass it to every calls to other APIs within the same SHE session.

Note that asynchronous API is currently not supported. async_cb and priv pointers must be set to NULL.

Parameters

key_storage_identifier	key store identifier
authentication_nonce	user defined nonce used as authentication proof for accesing the key store
async_cb	user callback to be called on completion of a SHE operation
priv	user pointer to be passed to the callback

Returns

pointer to the session handle.

2.5.2.2 she_close_session()

Terminate a previously opened SHE session

Parameters

hdl pointer to the session handler to be closed.

2.6 MAC

Macros

- #define SHE MAC SIZE 16u
- #define SHE_MAC_VERIFICATION_SUCCESS 0u
- #define SHE_MAC_VERIFICATION_FAILED 1u

Functions

- she_err_t she_cmd_generate_mac (struct she_hdl_s *hdl, uint8_t key_ext, uint8_t key_id, uint16_
 t message_length, uint8_t *message, uint8_t *mac)
- she_err_t she_cmd_verify_mac (struct she_hdl_s *hdl, uint8_t key_ext, uint8_t key_id, uint16_t message_
 length, uint8_t *message, uint8_t *mac, uint8_t mac_length, uint8_t *verification_status)
- 2.6.1 Detailed Description
- 2.6.2 Macro Definition Documentation

```
2.6.2.1 SHE MAC SIZE
```

```
#define SHE_MAC_SIZE 16u
```

size of the MAC generated is 128bits.

2.6.2.2 SHE_MAC_VERIFICATION_SUCCESS

```
#define SHE_MAC_VERIFICATION_SUCCESS Ou
```

indication of mac verification success

2.6.2.3 SHE_MAC_VERIFICATION_FAILED

```
#define SHE_MAC_VERIFICATION_FAILED 1u
```

indication of mac verification failure

2.6.3 Function Documentation

2.6.3.1 she_cmd_generate_mac()

Generates a MAC of a given message with the help of a key identified by key_id.

2.6 MAC 9

Parameters

hdl	pointer to the SHE session handler
key_ext	identifier of the key extension to be used for the operation
key_id	identifier of the key to be used for the operation
message_length	lenght in bytes of the input message. The message is padded to be a multiple of 128 bits by SHE.
message	pointer to the message to be processed
mac	pointer to where the output MAC should be written (128bits should be allocated there)

Returns

error code

2.6.3.2 she_cmd_verify_mac()

```
she_err_t she_cmd_verify_mac (
    struct she_hdl_s * hdl,
    uint8_t key_ext,
    uint8_t key_id,
    uint16_t message_length,
    uint8_t * message,
    uint8_t * mac,
    uint8_t mac_length,
    uint8_t * verification_status )
```

Verifies the MAC of a given message with the help of a key identified by key_id.

Parameters

hdl	pointer to the SHE session handler
key_ext	identifier of the key extension to be used for the operation
key_id	identifier of the key to be used for the operation
message_length	lenght in bytes of the input message. The message is padded to be a multiple of 128 bits by SHE.
message	pointer to the message to be processed
mac	pointer to the MAC to be compared (implicitely 128 bits)
mac_length	number of bytes to compare (must be at least 4)
verification_status	pointer to where write the result of the MAC comparison

Returns

2.7 AES-CBC

Macros

• #define SHE_AES_BLOCK_SIZE_128 16u

Functions

- she_err_t she_cmd_enc_cbc (struct she_hdl_s *hdl, uint8_t key_ext, uint8_t key_id, uint32_t data_length, uint8_t *iv, uint8_t *plaintext, uint8_t *ciphertext)
- she_err_t she_cmd_dec_cbc (struct she_hdl_s *hdl, uint8_t key_ext, uint8_t key_id, uint32_t data_length, uint8_t *iv, uint8_t *ciphertext, uint8_t *plaintext)
- 2.7.1 Detailed Description
- 2.7.2 Macro Definition Documentation

```
2.7.2.1 SHE_AES_BLOCK_SIZE_128
```

```
#define SHE_AES_BLOCK_SIZE_128 16u
```

size in bytes of a 128bits CBC block

2.7.3 Function Documentation

2.7.3.1 she_cmd_enc_cbc()

CBC encryption of a given plaintext with the key identified by key_id.

Parameters

hdl	pointer to the SHE session handler
key_ext	identifier of the key extension to be used for the operation
key_id	identifier of the key to be used for the operation
data_length	lenght in bytes of the plaintext and the cyphertext. Must be a multiple of 128bits.
iv	pointer to the 128bits IV to use for the encryption.
plaintext	pointer to the message to be encrypted.
ciphertext	pointer to ciphertext output area.

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2.7 AES-CBC 11

Returns

error code

2.7.3.2 she_cmd_dec_cbc()

CBC decryption of a given ciphertext with the key identified by key_id.

Parameters

hdl	pointer to the SHE session handler
key_ext	identifier of the key extension to be used for the operation
key_id	identifier of the key to be used for the operation
data_length	lenght in bytes of the plaintext and the cyphertext. Must be a multiple of 128bits.
iv	pointer to the 128bits IV to use for the decryption.
ciphertext	pointer to ciphertext to be decrypted.
plaintext	pointer to the plaintext output area.

Returns

2.8 AES-ECB

Macros

• #define SHE_KEY_SIZE 16u /** SHE keys are 128 bits (16 bytes) long. */

Functions

- she_err_t she_cmd_enc_ecb (struct she_hdl_s *hdl, uint8_t key_ext, uint8_t key_id, uint8_t *plaintext, uint8_t *ciphertext)
- she_err_t she_cmd_dec_ecb (struct she_hdl_s *hdl, uint8_t key_ext, uint8_t key_id, uint8_t *ciphertext, uint8_t *plaintext)
- she_err_t she_cmd_load_key (struct she_hdl_s *hdl, uint8_t key_ext, uint8_t key_id, uint8_t *m1, uint8_t *m2, uint8 t *m3, uint8 t *m4, uint8 t *m5)
- she_err_t she_cmd_load_plain_key (struct she_hdl_s *hdl, uint8_t *key)

2.8.1 Detailed Description

2.8.2 Function Documentation

2.8.2.1 she_cmd_enc_ecb()

ECB encryption of a given plaintext with the key identified by key_id.

Parameters

hdl	pointer to the SHE session handler
key_ext	identifier of the key extension to be used for the operation
key_id	identifier of the key to be used for the operation
plaintext	pointer to the 128bits message to be encrypted.
ciphertext	pointer to ciphertext output area (128bits).

Returns

error code

2.8.2.2 she_cmd_dec_ecb()

2.8 AES-ECB 13

```
uint8_t key_ext,
uint8_t key_id,
uint8_t * ciphertext,
uint8_t * plaintext )
```

ECB decryption of a given ciphertext with the key identified by key_id.

Parameters

hdl	pointer to the SHE session handler
key_ext	identifier of the key extension to be used for the operation
key_id	identifier of the key to be used for the operation
ciphertext	pointer to 128bits ciphertext to be decrypted.
plaintext	pointer to the plaintext output area (128bits).

Returns

error code

2.8.2.3 she_cmd_load_key()

```
she_err_t she_cmd_load_key (
    struct she_hdl_s * hdl,
    uint8_t key_ext,
    uint8_t key_id,
    uint8_t * m1,
    uint8_t * m2,
    uint8_t * m3,
    uint8_t * m4,
    uint8_t * m5)
```

Update an internal key of SHE with the protocol specified by SHE.

Parameters

hdl	pointer to the SHE session handler
key_ext	identifier of the key extension to be used for the operation
key_id	identifier of the key to be used for the operation
m1	pointer to M1 message - 128 bits
m2	pointer to M2 message - 256 bits
m3	pointer to M3 message - 128 bits
m4	pointer to the output address for M4 message - 256 bits
m5	pointer to the output address for M5 message - 128 bits

Returns

2.8.2.4 she_cmd_load_plain_key()

Load a key as plaintext to the RAM_KEY slot without encryption and verification.

Parameters

hdl	pointer to the SHE session handler
key	pointer to the plaintext key to be loaded - 128bits

Returns

2.9 Key export

2.9 Key export

Functions

```
• she_err_t she_cmd_export_ram_key (struct she_hdl_s *hdl, uint8_t *m1, uint8_t *m2, uint8_t *m3, uint8_t *m4, uint8_t *m5)
```

- 2.9.1 Detailed Description
- 2.9.2 Function Documentation
- 2.9.2.1 she_cmd_export_ram_key()

```
she_err_t she_cmd_export_ram_key (
    struct she_hdl_s * hdl,
    uint8_t * m1,
    uint8_t * m2,
    uint8_t * m3,
    uint8_t * m4,
    uint8_t * m5 )
```

exports the RAM_KEY into a format protected by SECRET_KEY.

Parameters

hdl	pointer to the SHE session handler	
m1	pointer to the output address for M1 message - 128 bits	
m2	pointer to the output address for M2 message - 256 bits	
m3	pointer to the output address for M3 message - 128 bits	
m4	pointer to the output address for M4 message - 256 bits	
m5	pointer to the output address for M5 message - 128 bits	

Returns

2.10 RNG

Macros

- #define SHE ENTROPY SIZE 16u
- #define SHE_RND_SIZE 16u

Functions

- she_err_t she_cmd_init_rng (struct she_hdl_s *hdl)
- she_err_t she_cmd_extend_seed (struct she_hdl_s *hdl, uint8_t *entropy)
- she_err_t she_cmd_rnd (struct she_hdl_s *hdl, uint8_t *rnd)
- 2.10.1 Detailed Description
- 2.10.2 Function Documentation

2.10.2.1 she_cmd_init_rng()

initializes the seed and derives a key for the PRNG. The function must be called before CMD_RND after every power cycle/reset.

Parameters

```
hdl pointer to the SHE session handler
```

Returns

error code

2.10.2.2 she_cmd_extend_seed()

extends the seed of the PRNG by compressing the former seed value and the supplied entropy into a new seed which will be used to generate the following random numbers. The random number generator has to be initialized by CMD_INIT_RNG before the seed can be extended.

Parameters

hdl	pointer to the SHE session handler pointer to the entropy vector (128bits) to use for the operation	
entropy		

2.10 RNG 17

Returns

error code

2.10.2.3 she_cmd_rnd()

returns a vector of 128 random bits. The random number generator has to be initialized by CMD_INIT_RNG before random numbers can be supplied.

Parameters

	hdl	pointer to the SHE session handler	
rnd pointer to the output address for		pointer to the output address for the generated 128bits random vector	

Returns

2.11 Status Register

Functions

```
• she_err_t she_cmd_get_status (struct she_hdl_s *hdl, uint8_t *sreg)
```

- 2.11.1 Detailed Description
- 2.11.2 Function Documentation

2.11.2.1 she_cmd_get_status()

returns the content of the status register

Parameters

hdl	pointer to the SHE session handler
sreg	pointer to the output address for status register(8bits)

Returns

2.12 UID 19

2.12 UID

Macros

- #define SHE_CHALLENGE_SIZE 16u /* 128 bits */
- #define **SHE_ID_SIZE** 15u /* 120 bits */

Functions

she_err_t she_cmd_get_id (struct she_hdl_s *hdl, uint8_t *challenge, uint8_t *id, uint8_t *sreg, uint8_←
t *mac)

2.12.1 Detailed Description

2.12.2 Function Documentation

2.12.2.1 she_cmd_get_id()

returns the identity (UID) and the value of the status register protected by a MAC over a challenge and the data.

Parameters

hdl	pointer to the SHE session handler	
challenge	pointer to the challenge vector (128bits)	
id	pointer to the output address for the identity (120bits)	
sreg	pointer to the output address for status register(8bits)	
mac	pointer to the output address for the computed MAC (128bits)	

Returns

2.13 Cancel

Functions

```
• she_err_t she_cmd_cancel (struct she_hdl_s *hdl)
```

- 2.13.1 Detailed Description
- 2.13.2 Function Documentation

```
2.13.2.1 she_cmd_cancel()
```

interrupt any given function and discard all calculations and results.

Parameters

hdl pointer to the SHE session handler

Returns

Index

AES-CBC, 10 SHE_AES_BLOCK_SIZE_128, 10 she_cmd_dec_cbc, 11 she_cmd_enc_cbc, 10 AES-ECB, 12 she_cmd_dec_ecb, 12 she_cmd_enc_ecb, 12 she_cmd_load_key, 13 she_cmd_load_plain_key, 13	she_cmd_export_ram_key, 15 Key store provisioning, 5 she_storage_create, 6 SHE_STORAGE_CREATE_FAIL, 5 SHE_STORAGE_CREATE_SUCCESS, 5 SHE_STORAGE_CREATE_UNAUTHORIZED, 5 SHE_STORAGE_CREATE_WARNING, 5 SHE_STORAGE_NUMBER_UPDATES_DEFAULT, 5
Cancel, 20	MAC, 8
she_cmd_cancel, 20	she_cmd_generate_mac, 8
5110_0111d_5d11001; 20	she_cmd_verify_mac, 9
ERC_BUSY	SHE_MAC_SIZE, 8
Error codes, 2	
ERC_GENERAL_ERROR	SHE_MAC_VERIFICATION_FAILED, 8
Error codes, 2	SHE_MAC_VERIFICATION_SUCCESS, 8
•	PNC 16
ERC_KEY_EMPTY	RNG, 16
Error codes, 2	she_cmd_extend_seed, 16
ERC_KEY_INVALID	she_cmd_init_rng, 16
Error codes, 2	she_cmd_rnd, 17
ERC_KEY_NOT_AVAILABLE	0 : 7
Error codes, 2	Session, 7
ERC_KEY_UPDATE_ERROR	she_close_session, 7
Error codes, 2	she_open_session, 7
ERC_KEY_WRITE_PROTECTED	SHE keys, 3
Error codes, 2	SHE+ key extension, 4
ERC_MEMORY_FAILURE	SHE_KEY_DEFAULT, 4
Error codes, 2	SHE_KEY_N_EXT_1, 4
ERC_NO_DEBUGGING	SHE_KEY_N_EXT_2, 4
Error codes, 2	SHE_KEY_N_EXT_3, 4
ERC_NO_ERROR	SHE_KEY_N_EXT_4, 4
Error codes, 2	SHE_AES_BLOCK_SIZE_128
ERC_NO_SECURE_BOOT	AES-CBC, 10
Error codes, 2	she_close_session
ERC_RNG_SEED	Session, 7
Error codes, 2	she_cmd_cancel
ERC_SEQUENCE_ERROR	Cancel, 20
Error codes, 2	she_cmd_dec_cbc
Error codes, 1	AES-CBC, 11
ERC_BUSY, 2	she_cmd_dec_ecb
ERC_GENERAL_ERROR, 2	AES-ECB, 12
ERC KEY EMPTY, 2	she_cmd_enc_cbc
ERC KEY INVALID, 2	AES-CBC, 10
ERC KEY NOT AVAILABLE, 2	she_cmd_enc_ecb
ERC KEY UPDATE ERROR, 2	AES-ECB, 12
ERC KEY WRITE PROTECTED, 2	she_cmd_export_ram_key
ERC MEMORY FAILURE, 2	Key export, 15
ERC NO DEBUGGING, 2	she_cmd_extend_seed
ERC NO ERROR, 2	RNG, 16
ERC_NO_SECURE_BOOT, 2	she_cmd_generate_mac
ERC_RNG_SEED, 2	MAC, 8
ERC_SEQUENCE_ERROR, 2	she_cmd_get_id
she_err_t, 2	UID, 19
3110_011_1, 2	she_cmd_get_status
Key export, 15	Status Register, 18
noy expert, 10	Status Hogistor, 10

22 INDEX

```
she_cmd_init_rng
    RNG, 16
she_cmd_load_key
    AES-ECB, 13
she_cmd_load_plain_key
    AES-ECB, 13
she cmd rnd
    RNG, 17
she_cmd_verify_mac
    MAC, 9
she_err_t
    Error codes, 2
SHE_KEY_DEFAULT
    SHE+ key extension, 4
SHE_KEY_N_EXT_1
    SHE+ key extension, 4
SHE KEY N EXT 2
    SHE+ key extension, 4
SHE_KEY_N_EXT_3
    SHE+ key extension, 4
SHE KEY N EXT 4
    SHE+ key extension, 4
SHE_MAC_SIZE
    MAC, 8
SHE_MAC_VERIFICATION_FAILED
    MAC, 8
SHE_MAC_VERIFICATION_SUCCESS
    MAC, 8
she open session
    Session, 7
she_storage_create
    Key store provisioning, 6
SHE_STORAGE_CREATE_FAIL
    Key store provisioning, 5
SHE_STORAGE_CREATE_SUCCESS
    Key store provisioning, 5
SHE_STORAGE_CREATE_UNAUTHORIZED
    Key store provisioning, 5
SHE_STORAGE_CREATE_WARNING
    Key store provisioning, 5
SHE_STORAGE_NUMBER_UPDATES_DEFAULT
    Key store provisioning, 5
Status Register, 18
    she_cmd_get_status, 18
UID, 19
    she_cmd_get_id, 19
```