Application Note

Unique Keys for ATSHA204

Features

- Use of the Atmel® ATSHA204 unique serial number and a Root Key to create a Unique Key (Diversified Key)
- Configuring the ATSHA204 with Unique Keys
- Authenticating the Unique Key using a Host ATSHA204 containing the Root Key
- Description of the Diversified Key Calculator in ACES (Atmel Crypto Evaluation Studio)
- Demonstration of Host validation using the DeriveKey command
- Demonstration of Host validation using the GenDig command
- Pseudo Code for Host validation — for systems that do not have a Host ATSHA204

Description

A unique key can be created for each Client based on its serial number and a Root Key. This is referred to as key diversification. Since each Client device is programmed with a unique secret, the Diversified Key is of less value to an attacker.

This walkthrough will configure the ATSHA204 device with a Diversified Key based on cryptographically combining a Root Key with the ATSHA204 Serial Number which is guaranteed to be unique. After configuring the Diversified Key, this walkthrough will continue with a step by step to writing this Diversified Key to the Client device.

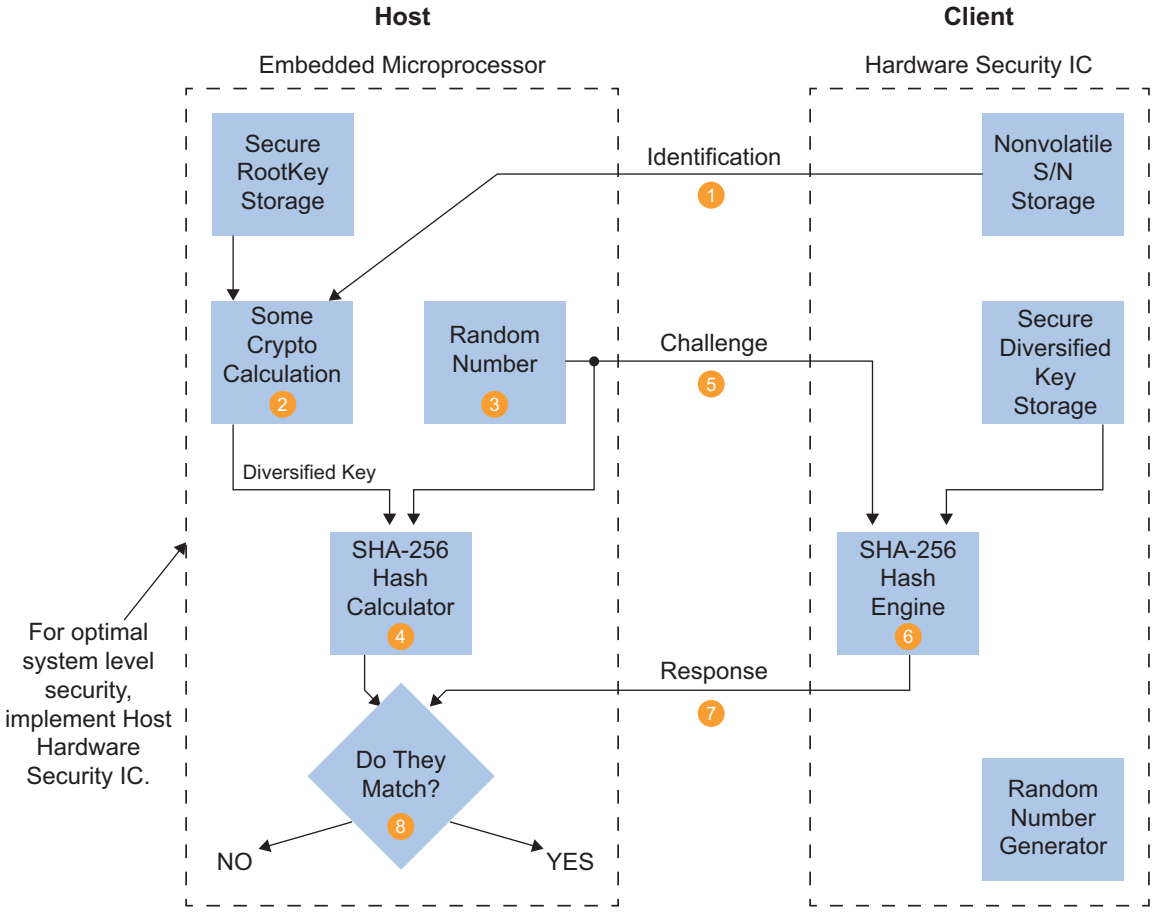
Once the Client is configured, an explanation of how a system can validate the configured key by performing a MAC on the Client Diversified then comparing the resulting digest to the digest generated by an equivalent cryptographic calculation using the Client Serial Number and the Root Key.

A demonstration of how the GenDig command or the DeriveKey command can be used by an ATSHA204 Host device to validate the ATSHA204 Client Diversified Key will also be summarized.

1. Diversified Key Description

As shown in Figure 1-1, the Host authenticates a Client Diversified Key using the Root Key that was used to calculate the Client Diversified Key. The Diversified Key calculation cryptographically combines the Client Serial Number with the Root Key that is stored on the Host. Since Diversified Keys are based on a Root Key, the Host only needs knowledge of the Client Serial Number to validate the Client Diversified Key.

Figure 1-1. Host Authenticates a Client Diversified Key Using the Root Key



Every Client has a Unique Key — Loss of One Does Not Compromise All

2. Walkthrough Steps

The steps in this section describe the process of configuring and authenticating diversified keys.

2.1 Device Configuration

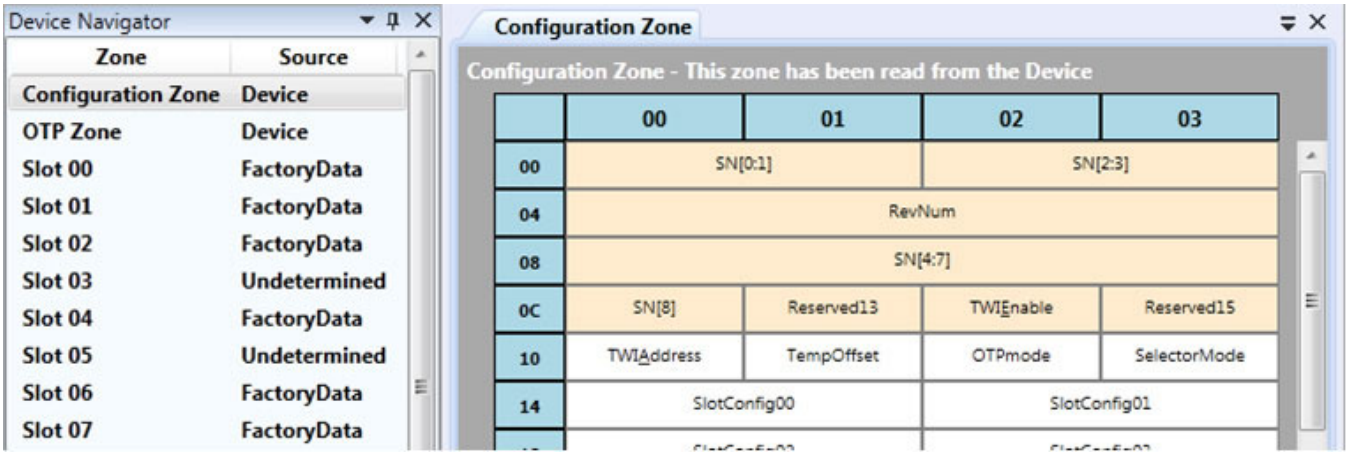
For this walkthrough, start by setting up the Configuration zone within the ATSHA204 device. This configuration will act as both a Host and Client ATSHA204. This configuration uses a single device to demonstrate the concepts; in an actual system the Host device would be separate. Table 2-1 gives both the description and configuration bytes for each slot used.

Table 2-1. Slot Configurations

Slot	Title	Description	Slot Configuration
00	Client Diversified Key	**Client Slot:** This slot will be diversified using the Serial Number and the Host Root Key.	Read – Is Secret Write – Never Bytes – 8F 8F
01	Host Target	**Host Slot:** This is the target slot defined for the DeriveKey command.	Read – Is Secret, CheckOnly Write – DeriveKey (parent 2) Bytes – 9F 32
02	Host Root Key	**Root used for key diversification:** Use the DeriveKey Command to verify the Client Diversified Key. This key is to be programmed on the Host ATSHA204.	Read – Is Secret Write – Never Bytes – 8F 8F
03	Host Root Key	**Root used for key diversification**: Use the GenDig Command to verify the Client Diversified Key. This key is to be programmed on the Host ATSHA204.	Read – Is Secret, CheckOnly Write – Never Bytes – 9F 8F

1. Launch ACES Configuration Environment (CE) with an *unlocked* ATSHA204 device (use an AT88CK101 or an AT88CK454 development kit).
2. Select ***Configuration Zone*** in the ***Device Navigator*** as shown in Figure 2-1.

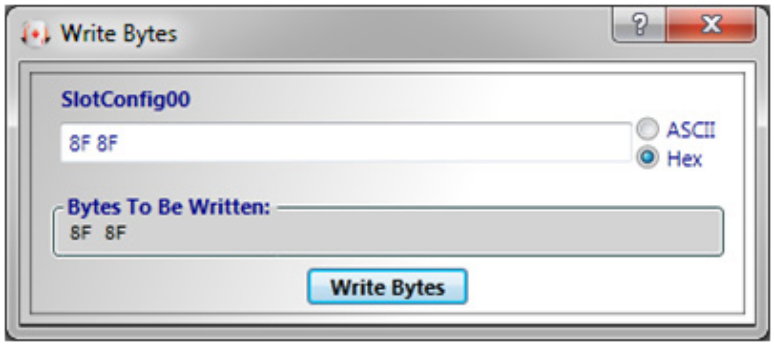
Figure 2-1. Select Configuration Zone



3. Click on the ***SlotConfig00*** memory location in the Memory map.

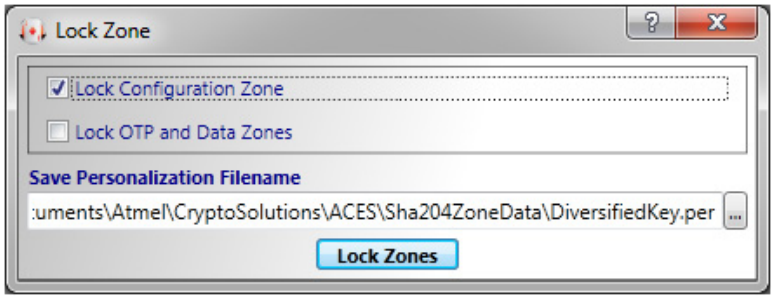
4. The ***Write Bytes*** dialog box will be displayed as shown in Figure 2-2.

Figure 2-2. Write Bytes Dialog Box — SlotConfig00



5. Type the configuration for Slot 00 in the ***SlotConfig00*** field from Table 2-1 (**8F 8F**).
   - Repeat for Slot 01 (**9F 32**).
   - Repeat for Slot 02 (**8F 8F**).
   - Repeat for Slot 03 (**9F 8F**).
6. Lock the Configuration zone.
   - Select ***Tools*** > ***Lock Zones*** from the menu.
   - The ***Lock Zone*** dialog box will be displayed as shown in Figure 2-3.
   - Select the ***Lock Configuration Zone*** check box and click on the ***Lock Zones*** button.
   - The ***Lock Successful*** message will be displayed.

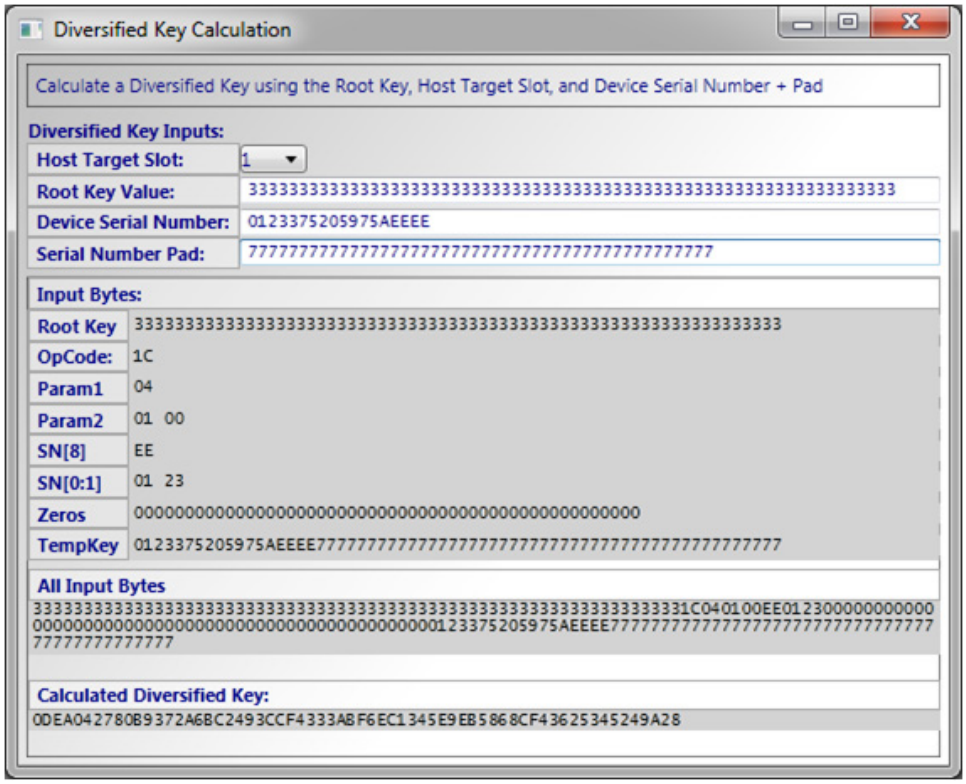
Figure 2-3. Lock Zone Dialog Box



7. Launch ***Diversified Key Calculation*** dialog box.
   - Select ***Tools*** > ***Calculate Diversified Keys*** from the menu.
   - The ***Diversified Key Calculation*** dialog box will be displayed as shown in Figure 2-4.

     Note: This dialog box dynamically updates the calculated Diversified Key as inputs are modified.
   - The calculation used for this dialog box is defined by the DeriveKey command.

Figure 2-4. Diversified Key Calculation Dialog Box

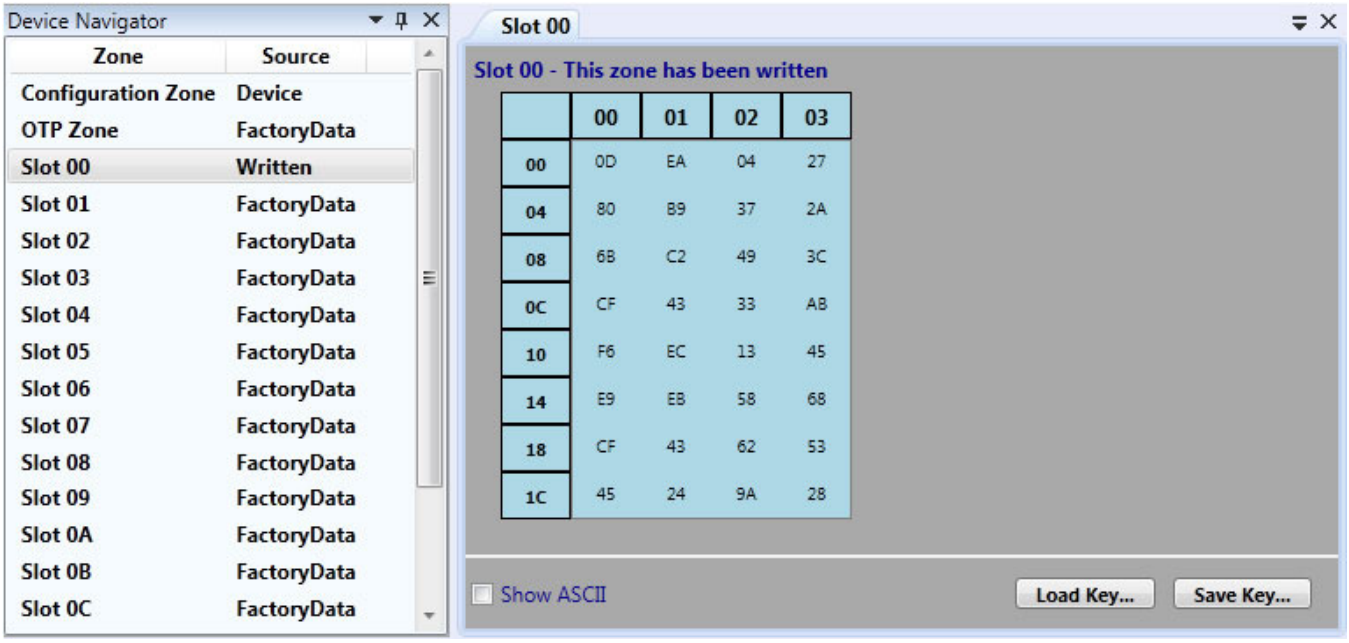


8. Set the ***Diversified Key Inputs*** as per the configuration shown in Table 2-1.
   - Set the ***Host Target Slot*** to **1**.
   - Set the ***Root Key Value*** to all threes (Use unique secret here if you have one).
   - The ***Device Serial Number*** will be read from the device and pre-loaded.
   - Set the ***Serial Number Pad*** to all sevens (Any pad is ok. Typically all zeros).
9. The ***Input Bytes*** refer to the bytes that will be passed to the Atmel ATSHA256 engine.
   - The bytes and byte order are defined in the GenDig command.
   - The TempKey is the SN + SnPad which can be initialized with the Nonce command.
10. The calculated Diversified Key is the result that should be written to the Client Diversified Key (Slot 00).

    Note: This calculation cryptographically combines the Root Key and the Device Serial Number.
    - Leave the ***Diversified Key Calculation*** dialog box open for later use.

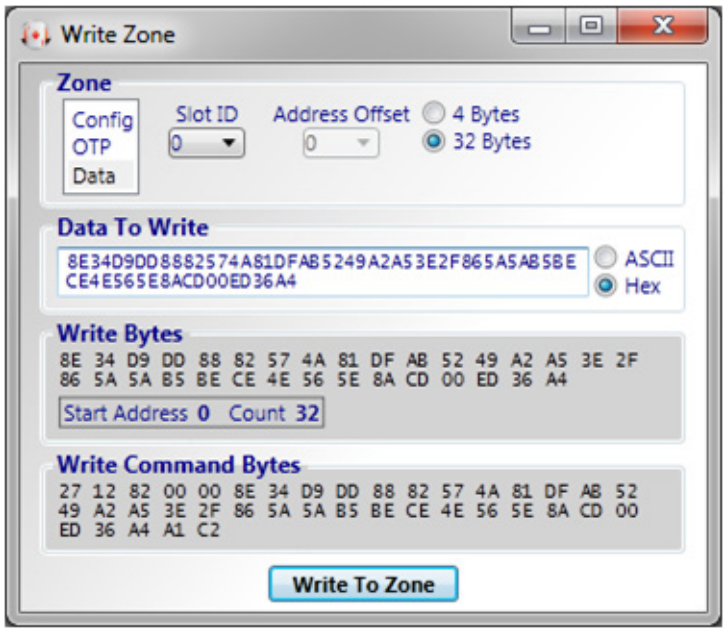
11. Select ***Slot 00*** in the ***Device Navigator*** as shown in Figure 2-5.

Figure 2-5. Slot 00 Showing Diversified Key Data



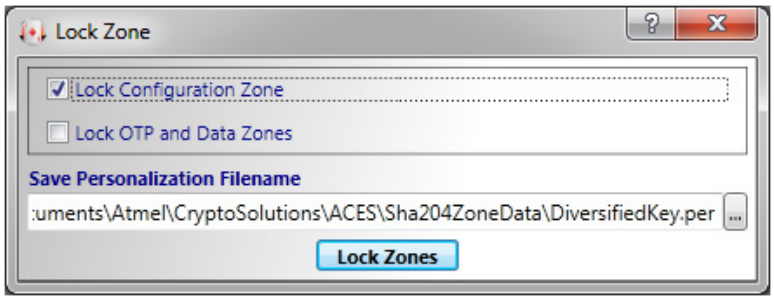
12. Client Configuration — Write the calculated Diversified Key into Slot 00 of the ATSHA204.
    - Triple-click on the calculated Diversified Key data in the ***Calculated Diversified Key*** dialog box to select all the data.
    - Copy the data into the clipboard.
    - Click on any location in the Memory zone. The ***Write Zone*** dialog box will be displayed as shown in Figure 2-6.
    - Paste the Diversified Key data into the ***Data to Write*** field.
    - Click on the ***Write To Zone*** button.
13. Host Configuration — Write Root Key into Slot 02 and Slot 03 of the ATSHA204. Follow these steps to write the Root Key (all threes or unique key) that was used to generate the Diversified Key.
    - Click on any location in the Slot 02 Memory zone. The ***Write Zone*** dialog box will display as shown in Figure 2-6.
    - Paste the Root Key data (all threes or unique key) into the ***Data to Write*** field.
    - Click on the ***Write To Zone*** button.
    - Repeat these Write steps for Slot 03.

Figure 2-6. Write Zone Dialog Box — Write Slot 00



14. Lock the OTP and Data zones.
    - Select the ***Tools*** > ***Lock Zones*** menu.
    - The ***Lock Zone*** dialog box will be displayed as shown in Figure 2-7.
    - Select the ***Lock OTP and Data Zones*** check box and click on the ***Lock Zones*** button.
    - The ***Lock Successful*** message will be displayed.

Figure 2-7. Diversified Key Calculation Dialog Box



2.2 Validating the Diversified Key

The Diversified Key has now been configured into the Client (Slot 00).

Note: The Diversified Key *uses* the Root Key in the cryptographic calculation that generated it — the Client does not need to *have* the RootKey programmed into it.

```
DiversifiedKey = SHA256(RootKey, SerialNumber, ...)
```

In addition to when the Host has knowledge of the RootKey, only the `SerialNumber` needs to be available to generate the `DiversifiedKey`. Since the `SerialNumber` can be read from each ATSHA204 Client, the Host can validate the Diversified Key in one of several different ways:

- Using the DeriveKey command on a ATSHA204 programmed with the Root Key (e.g. Slot 02).
- Using the GenDig command on a ATSHA204 programmed with the Root Key (e.g. Slot 03).
- Using the system code that has access to the Root Key. For most systems, this technique is *not* recommended.

Each of these validations of the Diversified Key will be demonstrated.

2.2.1 Validation Pseudo Code

The first validation technique that will be examined is the Pseudo Code Host. This technique is *not* recommended since most systems, the Root Key must be used in the clear and cannot be stored securely in firmware. This section is useful for secure microprocessors and to illustrate the calculations that are performed internally in the ATSHA204.

Diversified Key Validation Pseudo Code — System Code with RootKey

```
// Initialize the communication
sha204p_init();

// Set the Client device
sha204p_set_device_id(CLIENT_ID);

// Wake up the ATSHA204
sha204c_wakeup();

// Function Prototype: resultBuf = sha204m_execute(command, param1, param2,
data)

// Read the first 32 bytes from the config zone to get the Client Serial Number
snRead = sha204m_execute(SHA204_READ, 0x80, 0x00, 0x00);

// Parse the Client SerialNumber
serialNumber = snRead[0:3] + snRead[8:12];

// Generate a random number on the Host for the 32 byte challenge
randChal = sha204m_execute(SHA204_RANDOM, 0x00, 0x0000, null);

// Execute a MAC Command on the ATSHA204 & save the digest
param1Mac = 0x00;
param2Mac = [00, 00];
deviceDigest = sha204m_execute(SHA204_MAC, param1Mac, param2Mac, randChal);
```

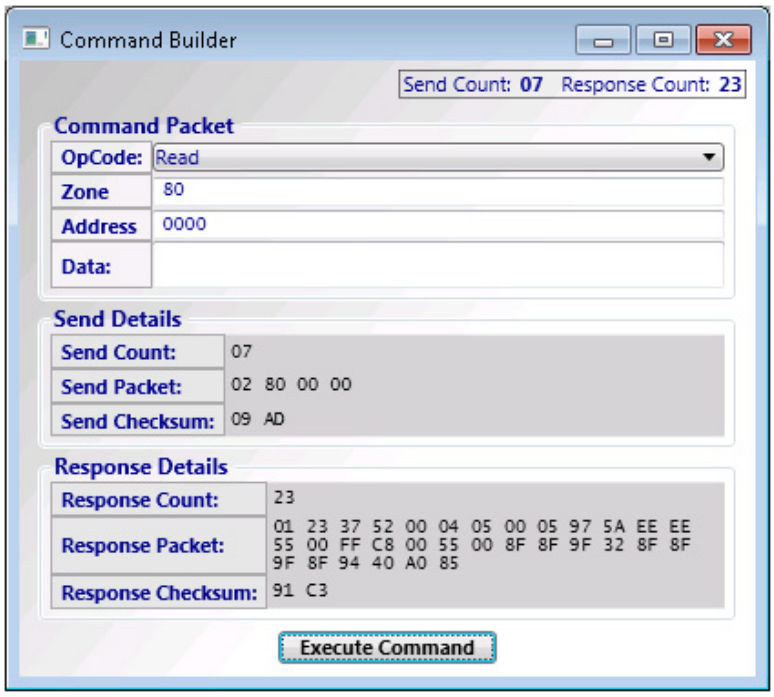
```
// Calculate the Diversified Key using the DeriveKey calculation & a soft SHA-
256
rootKey = ... // 32 byte secret here
opCodeDk = 0x1C;
param1 = 0x04;
param2 = ... // 2 byte slot ID here (LSB byte order 0x0X 00)
sn8 = ... // 1 byte SN[8] here
sn01 = ... // 2 bytes SN[0:1] here
zeros = ... // 25 bytes of 0's here
snPad = ... // 23 bytes of pad here
divKey =
sha256(rootKey+opCode+param1+param2+sn8+sn01+zeros+serialNumber+snPad);

// Execute a MAC on the calculated Diversified Key
// using the calculation of ATSHA204 MAC Command & a soft SHA-256
opCodeMac = 0x08;
otpZeros = [00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00]; // 13 bytes of
zeros
sn23 = [00, 00]; // 2 bytes SN[2:3], use zeros
sn47 = [00, 00, 00, 00]; // 4 bytes SN[4:7], use zeros
macBytes =
divKey+randChal+opCodeMac+param1Mac+param2Mac+otpZeros+sn8+sn47+sn01+sn23;
softDigest = sha256(macBytes);

// Compare the resulting digests from the ATSHA204 & the soft MAC
match = deviceDigest == softDigest;
```

2.2.2 Read Client Serial Number and Execute the MAC Command

The next two methods involve using ACES with Step 1.; read the SerialNumber and Step 2.; execute the MAC Command on the Diversified Key slot.

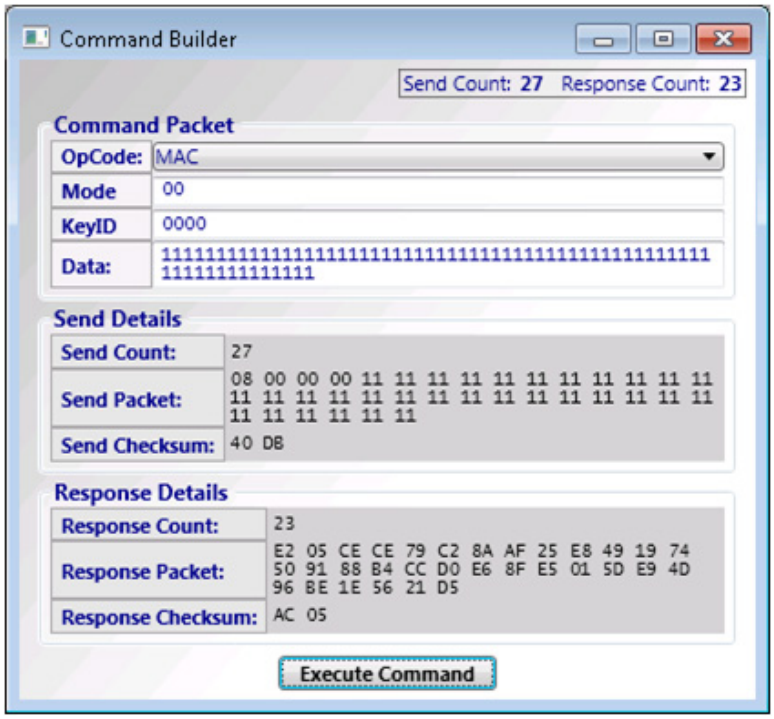
1. Execute Read — Read the Serial Number
   - Select the ***Tools*** > ***Command Builder*** menu.
   - The ***Command Builder*** dialog box will be displayed as shown in Figure 2-8.
   - In the ***OpCode*** drop down list, select the ***Read*** command.
   - Set the ***Zone*** to **80** (= 00 and 80) which indicates 32 byte read from the Configuration zone.
   - Set the ***Address*** to **0000**.
   - Click on the ***Execute Command*** button.
   - The ***Response Packet*** field will contain the bytes that were read.
2. Isolate the SerialNumber.
   - The nine byte serial number are bytes [0:3] and [8:12].
   - For this example: 0123375205975AEEEE.

Figure 2-8. Read SerialNumber — Command Builder



3. Execute MAC — Obtain the Digest for the Diversified Key slot.
   - Leave the ***Command Builder*** dialog box open.
   - In the ***OpCode*** drop down list, select the ***MAC*** command.
   - Set the ***Mode*** to **00**.
   - Set the ***KeyID*** to **0000**.
   - Set the ***Data*** to the input challenge (all ones here).
   - Click on the ***Execute Command*** button.
   - The ***Response Packet*** field will contain the digest.

Figure 2-9. MAC — Command Builder

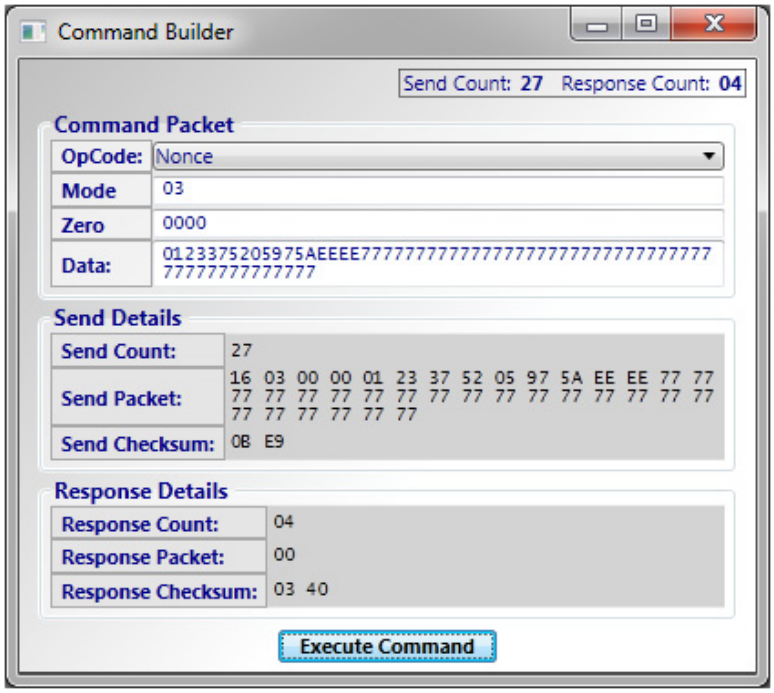


2.3 Validate Using the GenDig Command

To validate the Client, follow the following steps using the GenDig Command. This sequence represents the Host sequence that will be performed to validate the Client.

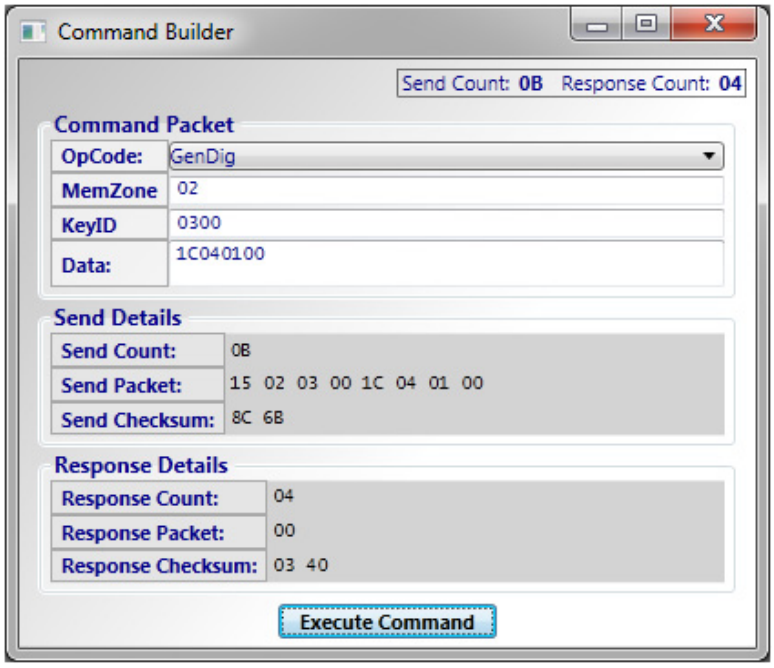
1. Execute Nonce — Initialize TempKey with SerialNumber + SnPad.
    - Select the ***Tools*** > ***Command Builder*** menu.
    - The ***Command Builder*** dialog box will be displayed as shown in Figure 2-10.
    - In the ***OpCode*** drop down list, select the ***Nonce*** command.
    - Set the ***Mode*** to **03** which indicates the pass-through mode.
    - Set the ***Data*** to SerialNumber + SnPad.
    - Click on the ***Execute Command*** button.
    - The ***Response Packet*** field will contain **00**, indicating success.

Figure 2-10. Nonce — Command Builder



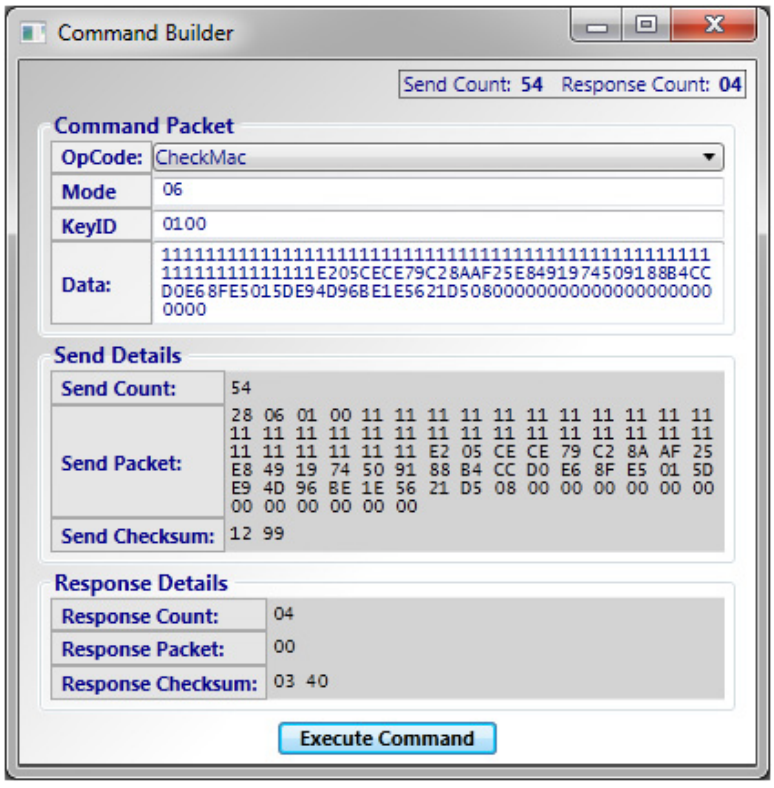
2. Execute GenDig — Initialize TempKey with the Diversified Key.
    - Leave the ***Command Builder*** dialog box open.
    - In the ***OpCode*** drop down list, select the ***GenDig*** command.
    - Set the ***MemZone*** to **02** which indicates the Data zone.
    - Set the ***KeyID*** to **0300** (LSB). This is the Host slot configured for GenDig validation of the Diversified Key.
    - Set the ***Data*** to **1C040100**. This is ***OtherData*** for GenDig that makes the crypto calculation the same as DeriveKey.
    - Click on the ***Execute Command*** button.
    - The ***Response Packet*** field will contain **00**, indicating success.

Figure 2-11. GenDig — Command Builder



3. Execute CheckMac — Compare Client Digest with the MAC of the calculated Diversified Key (now in TempKey).
   - Leave the ***Command Builder*** dialog box open.
   - In the ***OpCode*** drop down list, select the ***CheckMac*** command.
   - Set the ***Mode*** to **06** (= 04 and 02). Use TempKey and match TempKey source flag.
   - Set the ***KeyID*** to **0100**. This value is ignored by CheckMac when using TempKey.
   - Set the ***Data*** to Challenge + Response + OtherData.
     - Challenge = All ones.
     - Response = Digest result from the client MAC command.
     - OtherData = 08 (MAC OpCode) + 00 00 00 00 00 00 00 00 00 00 00 00 (12 bytes of 00).
   - Click on the ***Execute Command*** button.
   - The ***Response Packet*** field will contain **00**, indicating that the digests match.

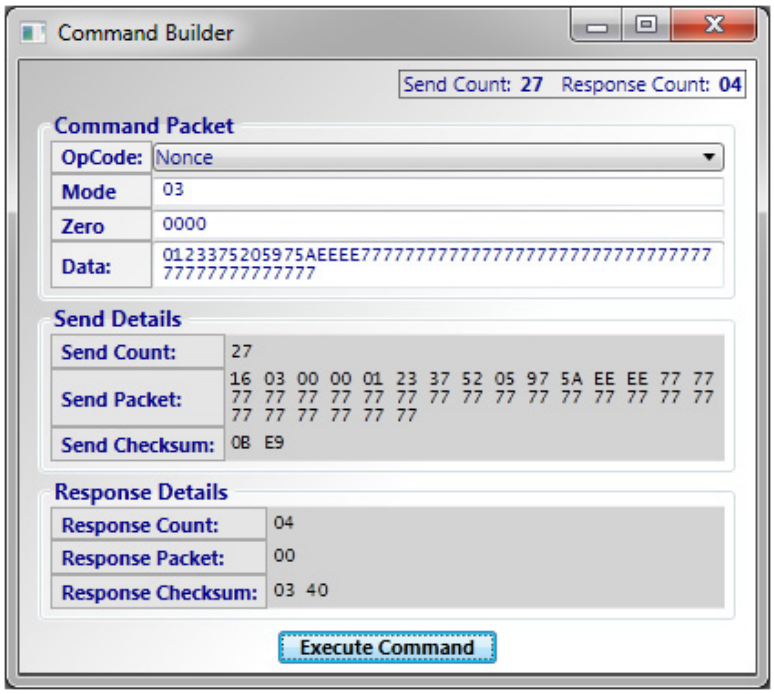
Figure 2-12. CheckMac — Command Builder



2.4 Validate Using the DeriveKey Command

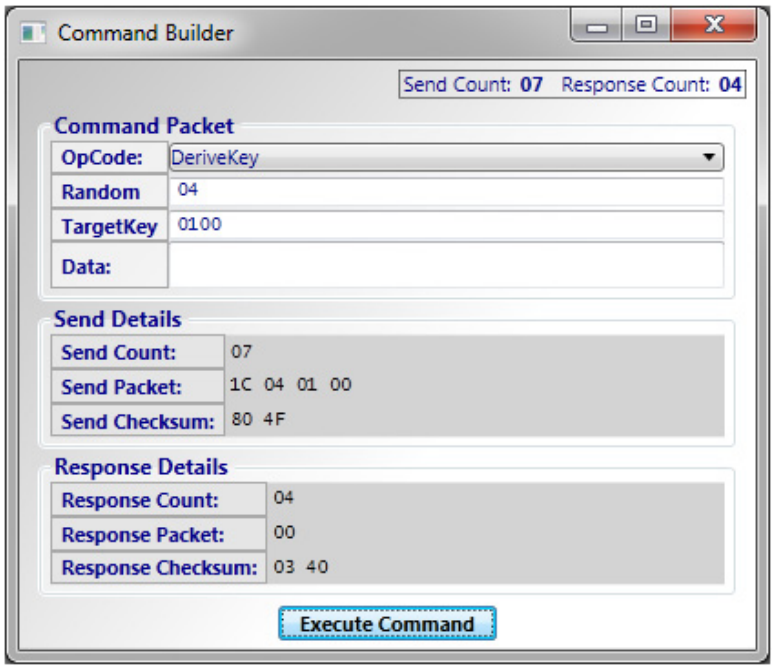
1. Execute Nonce — Initialize TempKey with SerialNumber + SnPad.
   - Select the ***Tools*** > ***Command Builder*** menu.
   - The ***Command Builder*** dialog box will be displayed as shown in Figure 2-13.
   - In the ***OpCode*** drop down list, select the ***Nonce*** command.
   - Set the ***Mode*** to **03**, which indicates the pass-through mode.
   - Set the ***Data*** to SerialNumber + SnPad.
   - Click on the ***Execute Command*** button.
   - The ***Response Packet*** field will contain **00**, indicating success.

Figure 2-13. Nonce — Command Builder



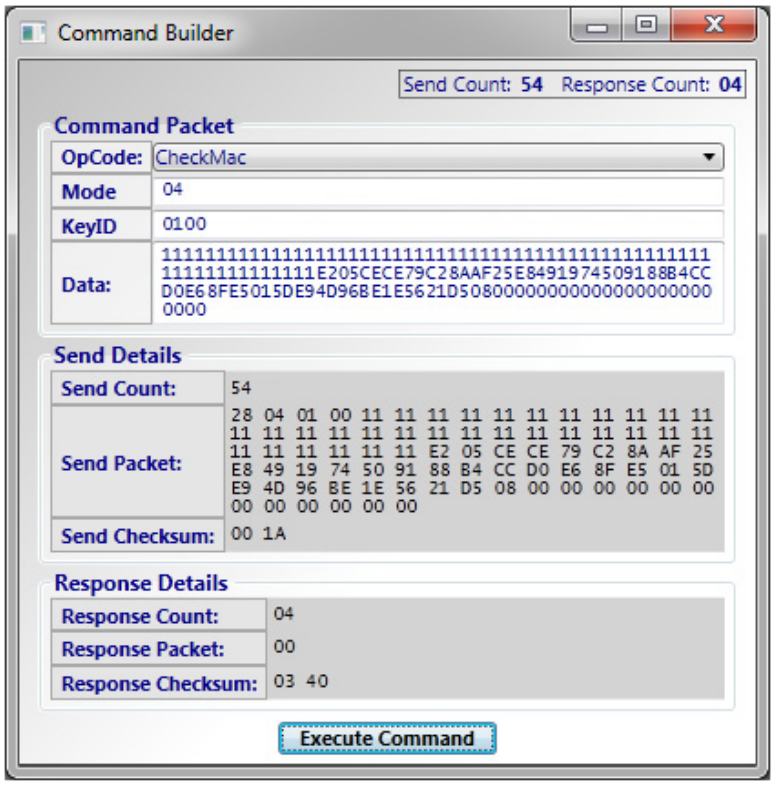
2. Execute DeriveKey — Write the Client Diversified Key into a Slot on the Host.
   - In the ***OpCode*** drop down list, select the ***DeriveKey*** command.
   - Set the ***Random*** to **04**. This matches the TempKey source flag of pass-through mode.
   - Set the ***TargetKey*** to **0100** (LSB). This Host slot is configured for a DeriveKey target.
   - Click on the ***Execute Command*** button.
   - The ***Response Packet*** field will contain **00**, indicating success.

Figure 2-14. DeriveKey — Command Builder



3. Execute CheckMac — Compare Client Digest with the MAC of the derived Diversified Key (now in Slot 01).
   - Leave the ***Command Builder*** dialog box open.
   - In the ***OpCode*** drop down list, select the ***CheckMac*** command.
   - Set the ***Mode*** to **06** (= 04 and 02). Use TempKey and match TempKey source flag.
   - Set the ***KeyID*** to **0100**. This value is ignored by CheckMac when using TempKey.
   - Set the ***Data*** to Challenge + Response + OtherData.
     - Challenge = All ones.
     - Response = Digest result from the client MAC command.
     - OtherData = 08 (MAC OpCode) + 00 00 00 00 00 00 00 00 00 00 00 00 (12 bytes of 00).
   - Click on the ***Execute Command*** button.
   - The ***Response Packet*** field will contain **00**, indicating that the digests match.

Figure 2-15. CheckMac — Command Builder



3. Revision History

Doc. No.	Date	Comments
8841A	04/2013	Initial document release.

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