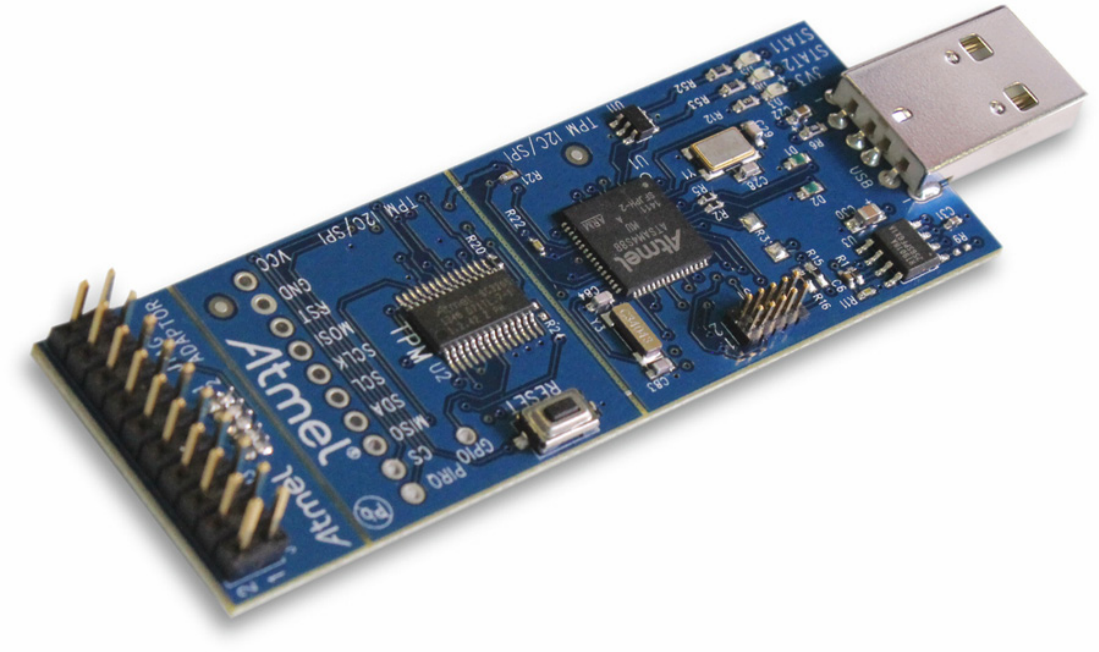
AT97SC3205T-SDK2
AT97SC3205P-SDK2

Atmel TPM I²C/SPI Development Kit

USER GUIDE



Atmel I²C/SPI Demonstration Kit

Introduction

The Atmel® TPM™ Development Kit includes examples of how to use the Trusted Platform Module (TPM) in an embedded and PC application. Source code is provided to enable an embedded designer to make quick progress in understanding and utilizing the TPM.

The TPM Development Kits are based on the Atmel SAM4S ARM® with an added I²C or SPI TPM device. The TPM demonstration code and evaluation software are included on a USB flash drive which comes with the kits. The board includes a SPI or I²C TPM, a SAMS4 processor, a board reset button, a JTAG connector, and detachable segments to allow for engineering system integration as shown in Figure 1.

Complete SAM4S ARM documentation can be found on the Atmel web site at the following link:

http://www.atmel.com/Images/Atmel_11100_32-bit-Cortex-M4-Microcontroller_SAM4S_Datasheet.pdf

This TPM Development Kit User Guide documents the features specific to the TPM and references the SAM4S ARM documentation where appropriate.

Features

The TPM kit is a custom board containing an I^{2}C TPM or SPI TPM and related circuitry connected to the SAM4S ARM board. Interface signals on the board are:

- Power
- Ground
- PIRQ
- Chip Select (CS)
- MISO
- SDA
- SCL
- SCLK
- MOSI
- RST
- GND
- V_{CC}

The following functional sections are provided on the Embedded TPM kit:

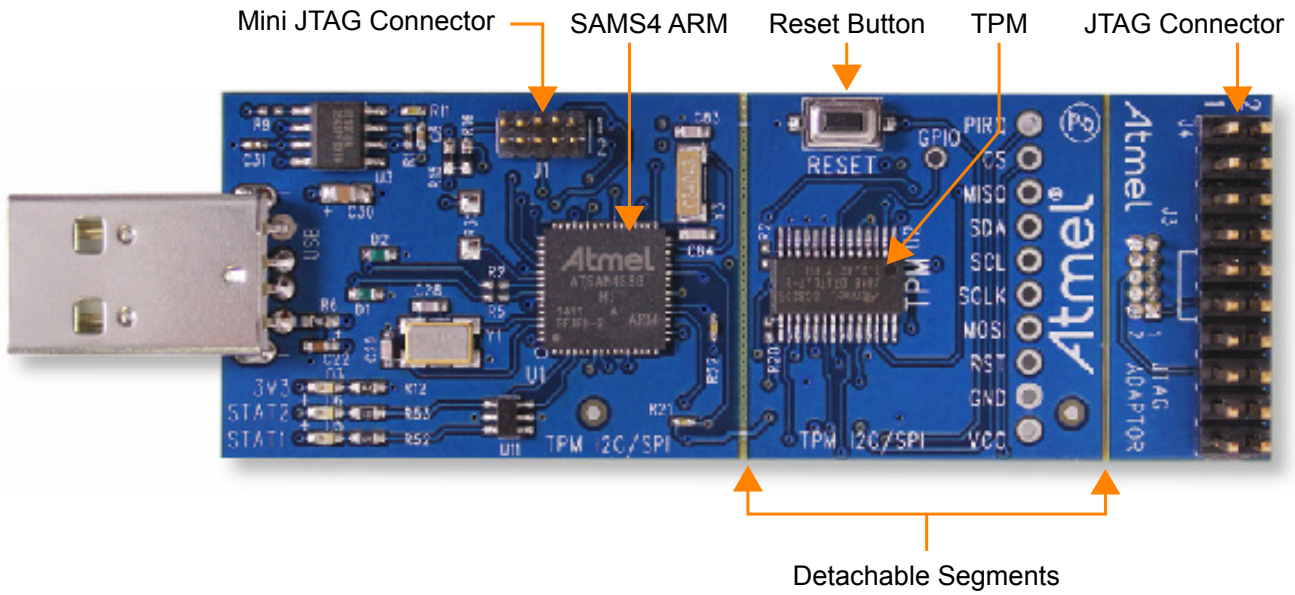
- AT97SC3205 I^{2}C or SPI Atmel TPM
- TPM Reset Switch
- RC Reset Delay
- Decoupling Capacitors
- Pull-Up and Pull-Down Resistors
- Test Points

USB Drive

The included USB drive includes the following:

- User Guide
- Source Code of the Demo
- Hex Images for Reloading the Demo (If Necessary)
- Kit Schematics

Figure 1. Atmel I^{2}C/SPI Demonstration Kit



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TPM Overview

Power

The TPM receives power from the SAM4S ARM through the interface headers. During normal use, the SAM4S ARM is powered through the USB device connection, which doubles as both a power source and communication interface to the SAM4S ARM. The SAM4S ARM provides 5V to 3.3V regulated power for the TPM.

Reset Button

The reset button resets the TPM. Pressing the reset button will only send a Power-On-Reset (POR) signal to the TPM.

In-System Programming

The SAM4S ARM provided with the TPM differs from a standard SAM4S ARM in that the pre-programmed application software loaded in Flash memory is the TPM demonstration software, not the SAM4S ARM demonstration software.

The USB bootloader remains pre-programmed in ROM memory. This bootloader may be used to either reload the TPM demonstration software images or to load the SAM4S ARM demonstration software. The kit has a JTAG connector that can be detached from the kit and connected to the mini JTAG connector on the board. This will allow the reprogramming of the SAM4S ARM.

The TPM demonstration software must remain loaded in Flash memory in order to execute the I^2C TPM demo.

Instructions on how to utilize the FLexible In-system Programmer (“FLIP”) software in tandem with the USB bootloader to load SPI, I^2C, or additional application software can be found in the SAM4S ARM Datasheet. A copy of the FLIP installer is downloadable from www.atmel.com.

For more advanced in-system programming techniques, the In-System Programmer SAM JTAG ICE combined with Atmel Studio® can be utilized over the provided JTAG interface port to exercise complete programming control over the processor.

If a software update is required on the TPM, and the customer does not have a SAM-ICE JAG, the SAM-BA tool can be downloaded using the following Atmel link:

http://www.atmel.com/tools/atmelsam-bain-systemprogrammer.aspx

Contact crypto@atmel.com for software update instructions.

Debugging

For more advanced development and debugging techniques, the Atmel In-System Programmer SAM-ICE JTAG combined with the Atmel Studio and the Atmel Studio GCC C Complier can be utilized over the provided JTAG interface port to exercise complete development and debugging control over the SAM4S processor.

Demonstration Software

To start the demonstration software, follow the below steps:

1. Connect the TPM Demo Kit to an available USB port:
   a. Insert the USB drive into the computer, and allow Windows to recognize the drive.
   b. Install the ***Atmel_devices_cdc.inf*** file from the USB drive. The steps include the following:
      - Open ***Device Manager***.
      - Select ***CDC unknown device***.
      - From the ***Device Manager*** main menu, select *Action* > ***Update Driver Software…***.
      - Select ***Browse my computer*** for ***Driver Software…button***.
      - Browse to the ***.inf*** file folder on the USB drive.
   c. Install the TPM Demo Kit driver software. The TPM Demo Kit device should show as a COM PORT in the Device Manager.
2. Launch a terminal emulation software of your choice. The serial default connection default settings are:
   – Baud rate: 9,600
   – Data: 8 bit
   – Stop: 1 bit
   – Parity: None
   – Flow control: None
   – Echo Type Characters locally (*if available*).
3. Associate the terminal emulation software with the virtual COM port established by connecting the TPM Demo Kit to the system.
4. Activate the demonstration software by pressing any key while in the active terminal emulation software window. The below demonstration selection menu should appear.

Demonstration Menu Selections

Available commands:

```
1)  TPM_Startup(ST_CLEAR)
2)  TPM_ContinueSelfTest
3)  TPM_CreateEKPair
4)  TPM_TakeOwnerShip (sequence)
5)  TPM_CreateWrapKey
6)  TPM_Loadkey
7)  TPM_Seal (sequence)
a)  TPM_UnSeal (sequence)
b)  TPM_Sign (sequence)
c)  TPM_VerifySign
d)  TPM_GetPubKey
t)  TPM_GetCapability(versionVal)
u)  TPM_Reset (clears authSessions)
v)  TPM_FlushSpecifc - keyHandle
w)  TPM_ForceClear (sequence)
x)  enable/activate TPM (sequence)
y)  disable/deactivate TPM (sequence)
z)  display known keys

Please pick a command:
```

Pressing the indicated numeral or letter beside each menu selection initiates transmission of a TPM command or command sequence to the TPM and reception of the TPM command response or responses back.

Details regarding these Trusted Computed Group (“TCG”) TPM Commands can be found in the “TPM Main Part 3 Commands” specification, located at: https://www.trustedcomputinggroup.org/specs/TPM/ and on the USB drive located in the ***TCG Docs*** folder.

Initial One-Time Setup

To ensure the TPM is in a know state, the below sequence is recommended. This sequence will clear any data that may have been loaded during manufacturing and testing of the kit. It will allow the user to complete the first steps that would have been completed during the initial manufacturing process of a TPM device.

1. Selection 1 - `TPM_Startup` (ST_CLEAR)
2. Selection w - `TPM_ForceClear` (Sequence)
3. Selection x - `Enable/Activate TPM` (Sequence)
4. Selection 3 - `TPM_TakeOwnership` (Sequence)

It is important that these four demo commands be executed in the order listed above. See Section, “Demo Menu Commands” below, for additional details on each command.

The kits are shipped with a pre-generated Endorsement Key which includes an X.509 certificate.

Only one Endorsement Key can be created during the lifetime of a TPM. Attempting to execute Seletction 3 - `TPM_CreateEKPair` command will respond with `TPM_DISABLED_CMD` return code of `0x00000008` indicating that an Endorsement Key already resides on the TPM.

After `TPM_TakeOwnership`, the user should create and load keys that will enable the user to sign, verify signatures, seal and unseal data, along with exploring other demo functionality. See section, “Demo Menu Commands” below for more detailed information regarding the available options.

Demo Menu Commands

Selection 1 - TPM_Startup (ST_CLEAR)

The `TPM_Startup` command initiates a startup on the TPM. This is the first command that must be executed after a TPM is powered-up or reset. In this case, the demo provided version of `TPM_Startup` is `TPM_ST_CLEAR`.

`TPM_Startup`(`TPM_ST_CLEAR`) does not actually clear the TPM. It is a fresh start where all variables go back to their default or non-volatile state.

`TPM_Startup` can only be executed once after the TPM is powered-up or reset, returning a `TPM_SUCCESS` return code of `0x00000000`. If `TPM_Startup` is executed again, it will return a `TPM_INVALID_POSTINIT` return code of `0x00000026`. Any attempt to execute other commands prior to the `TPM_Startup` command will also return the error code `TPM_INVALID_POSTINIT`.

Selection 2 - TPM_ContinueSelfTest

The TPM_ContinueSelfTest command requests the TPM to complete the self-test of all TPM cryptographic resources when convenient (i.e. when no other commands are being issued to the TPM). This command is not required on the I^2C TPM since the I^2C TPM automatically completes all self-test functions on a power-up or reset.

This command is required after a TPM_Startup on the SPI Interface TPM and is provided in the demo as an example of how to execute it on the TPM.

The expected return code after executing the TPM_ContinueSelfTest command is TPM_SUCCESS 0x00000000.

Selection 3 - TPM_CreateEKPair

The TPM_CreateEndorsementKeyPair command self-generates the Endorsement Key Pair (EK) on the TPM.

While the EK is being generated, the message ***waiting for TPM response...*** is displayed. Although normally only a few seconds, since key generation is non-deterministic, EK generation can take up to five minutes.

The first time TPM_CreateEndorsementKeyPair is executed, resulting in the generation of an Endorsement Key Pair, the TPM will return a TPM_SUCCESS return code of 0x00000000. Subsequent executions of TPM_CreateEndorsementKeyPair will return a TPM_DISABLED_CMD return code of 0x00000008. The inclusion of this command sequence is to demonstrate and verify that an Endorsement Key is present on the TPM.

Selection 4 - TPM_TakeOwnerShip (Sequence)

The TPM_TakeOwnership command takes or establishes the owner of the TPM, generating a new Storage Root Key (SRK). The demo command, TPM_TakeOwnerShip, is a sequence comprised of the following:

1. A check is made to ensure the EK has been generated on the TPM. If not, then TPM_CreateEndorsementKeyPair is executed first.
2. The TPM_GetCapability command is executed to ensure that an owner is not currently present on the TPM.
3. Enter a value for the Owner authorization at the prompt ***enter owner Auth:***. Choose a passphrase of up to 40 characters.
4. The TPM_BindV20 command is utilized to encrypt the Owner Auth.
5. Enter a value for the SRK authorization at the prompt ***enter SRK Auth:***. Choose a passphrase of up to 40 characters.
6. The TPM_BindV20 command is utilized to encrypt the SRK Auth.
7. A TPM_OIAP command is executed to establish an authorization session.
8. The TPM_TakeOwnership command is executed.
9. While the SRK is being generated, the message ***Please wait. Generating SRK...*** is displayed. Since key generation is non-deterministic, SRK generation can take seconds or up to five minutes.
10. If TPM_TakeOwnership is successful, the TPM responds back with the public portion of the SRK and a TPM_SUCCESS return code of 0x00000000.

TPM_TakeOwnerShip cannot be successfully executed again unless the owner has been cleared by the TPM_ForceClear command.

Selection 5 - TPM_CreateWrapKey (Sequence)

The TPM_CreateWrapKey command generates a RSA Key pair. Ownership must be taken or established on the TPM before TPM_CreateWrapKey can generate a RSA Key pair.

The demo command, TPM_CreateWrapKey, is a sequence comprised of the following:

1. If no keys are loaded on the TPM, the TPM_CreateWrapKey automatically uses the SRK as the parent key. If keys are loaded on the TPM, then choose either a previously loaded key or the SRK as the parent key.

```
Make the selection at the prompt:
      known keyHandles:
          1: XX XX XX XX
          2: XX XX XX XX
          X: XX XX XX XX
      pick a parent key (0=SRK):
```

2. A TPM_OSAP command is executed to establish an authorization session.
3. Enter a value for the key migration Auth at the prompt ***enter key migration Auth:***. Choose a passphrase of up to 40 characters.
4. Enter a value for the key usage Auth at the prompt ***enter key usage Auth:***. Choose a passphrase of up to 40 characters.
5. Choose a type for the key, storage, or signing, at the prompt ***please pick a key type:***.
6. Choose whether the key is migrateable or non-migrateable, at the prompt ***please pick a key option:***.
7. Choose whether the key's authDataUsage is TPM_AUTH_ALWAYS or TPM_AUTH_NEVER, at the prompt ***please pick a key option:***.
8. While the key is being generated, the message ***waiting for TPM response...*** is displayed. Since key generation is non-deterministic, key generation can take seconds or up to five minutes.
9. If the TPM_CreateWrapKey command is successful, the TPM responds back with the public portion of the key, the encrypted private portion of the key, and a TPM_SUCCESS return code of 0x00000000.
10. The key is now generated, but must be stored so it can be later loaded by TPM_LoadKey2. The demo supports five cache slots 1 thru 5 in the SAM4S FLASH memory for the temporary storage of keys or other data. Choose a cache slot for storage of the key at the prompt ***store key in which cacheSlot (1-5)?***.
    These five cache slots are Last In First Out ("LIFI") and may be overwritten when the stored data is no longer needed.

Selection 6 - TPM_Loadkey (Sequence)

The TPM_LoadKey2 command loads a previously created key into the TPM for further use. The demo command, TPM_Loadkey, is a sequence comprised of the following:

1. Choose a cache slot from which to load the key at the prompt ***load key from which cacheSlot (1-5)?***.
2. A TPM_OIAP command is executed to establish an authorization session.

3. If no keys are loaded on the TPM, TPM_LoadKey2 automatically uses the SRK as the parent key. If keys are loaded on the TPM, then choose either a previously loaded key or the SRK as the parent key.

```
Make the selection at the prompt:
known keyHandles:
      1: XX XX XX XX
      2: XX XX XX XX
      X: XX XX XX XX
pick a parent key (0=SRK):
```

   Selecting the incorrect parent key will result in a TPM_LoadKey2 failure, and the TPM will return a TPM_DECRYPT_ERROR return code of 0x00000021.

4. The key is then loaded from the selected cache slot.
5. A successful execution of TPM_LoadKey2 returns a TPM_SUCCESS return code of 0x00000000, along with the TPM_KEY_HANDLE.

Selection 7 - TPM_Seal (Sequence)

The TPM_Seal command encrypts private objects that can only be decrypted on the current platform by using the TPM_Unseal command. Optional current or future configuration information indicated by the PCR registers can be included in the Seal operation. PCR configuration included in the Seal process is presently not supported in this demo. The demo command, TPM_Seal, is a sequence comprised of the following:

1. If no keys are loaded on the TPM, TPM_Seal automatically uses the SRK as the sealing key. If keys are loaded on the TPM, then choose either a previously loaded key or the SRK as the sealing key.

```
Make the selection at the prompt:
known keyHandles:
      1: XX XX XX XX
      2: XX XX XX XX
      X: XX XX XX XX
pick a sealing key (0=SRK):
```

   The only allowed sealing keys are non-migrate able storage keys. Selecting a non-storage key as a sealing key will result in a TPM_Seal failure, and the TPM will return a TPM_INVALID_KEYUSAGE return code of 0x00000024.

2. A TPM_OSAP command is executed to establish an authorization session.
3. Enter an authorization value for the sealed blob at the prompt ***enter auth value for sealed blob:***. Choose a passphrase of up to 40 characters.
4. Enter the data to seal at the prompt ***enter data to seal (40 chars max):***. Choose data to seal of up to 40 characters.
5. A successful execution of the TPM_Seal command returns a TPM_SUCCESS return code of 0x00000000, along with the encrypted data blob.
6. The encrypted data blob must be stored so it can be later decrypted by the TPM_Unseal command. The demo supports five cache slots 0 thru 4 in SAM4S FLASH memory for the temporary storage of keys or other data. Choose a cache slot for storage of the data blob at the prompt ***store data blob in which cacheSlot (1-5)?***. These five cache slots are LIFI (Last In First Out) and may be overwritten when the stored data is no longer needed.

Selection a - TPM_UnSeal (Sequence)

The TPM_Unseal command decrypts private objects which been encrypted on the current platform by TPM_Seal. If optional current or future configuration information indicated by the PCR registers were included in the Seal operation, then there must be a match with the present PCR values in order for the TPM_Unseal command to succeed. The demo command, TPM_UnSeal, is a sequence comprised of the following:

1. If no keys are loaded on the TPM, TPM_Unseal automatically uses the SRK as the sealing key. If keys are loaded on the TPM, then choose either the previously loaded storage key or the SRK that was used to seal the data blob as the sealing key.

```
Make the selection at the prompt:
known keyHandles:
      1: XX XX XX XX
      2: XX XX XX XX
      X: XX XX XX XX
pick a sealing key (0=SRK):
```

2. A TPM_OIAP command is executed to establish an authorization session.
3. A TPM_OIAP command is executed to establish an authorization session.
4. Enter an Auth value for the sealed blob at the prompt ***enter auth value for sealed blob:***. This must be the same passphrase of up to 40 characters used to seal the blob.
5. Choose a cache slot from which to load the data blob to unseal at the prompt ***unseal blob from which Slot (1-5)?***.
6. A successful execution of the TPM_Unseal command returns a TPM_SUCCESS return code of 0x00000000, along with the unsealed data. An unsuccessful decryption of the data blob returns a TPM_DECRYPT_ERROR return code of 0x00000021.

Selection b - TPM_Sign (Sequence)

The TPM_Sign command signs an input digest and returns the resulting digital signature. The demo command, TPM_Sign, is a sequence comprised of the following:

1. A TPM_OIAP command is executed to establish an authorization session.
2. TPM_Sign requires a signing key be created with the TPM_CreateWrapKey command and loaded on the TPM with TPM_LoadKey2 before a digest can be signed. Choose a previously loaded signing key.

```
Make the selection at the prompt:
known keyHandles:
1: XX XX XX XX
2: XX XX XX XX
X: XX XX XX XX
pick a signing key:
```

   The only allowed keys for signing are signing keys. Selecting a non-signing key as a signing key will result in a TPM_Sign failure, and the TPM will return a TPM_INVALID_KEYUSAGE return code of 0x00000024.

3. Enter the digest to sign at the prompt ***enter data to sign (40 chars max):***. Choose data to sign of up to 40 characters.
4. A successful execution of TPM_Sign returns a TPM_SUCCESS return code of 0x00000000, along with the digital signature.

5. The signature must be stored so it can be later verified by TPM_VerifySignature. The demo supports five cache slots 1 thru 5 in the EEPROM memory for the temporary storage of keys or other data. Choose a cache slot for storage of the signature at the prompt ***store signature in which cacheSlot (1-5)?***.These five cache slots are LIFI and may be overwritten when the stored data is no longer needed.

Selection c - TPM_VerifySign (Sequence)

The Atmel Specific TPM_VerifySignature TPM command verifies an input digital signature and returns success or failure. The TPM is provided with the digital signature, the digest that was signed, and the public key needed to verify the signature. The demo command, TPM_VerifySign, is a sequence comprised of the following:

1. A TPM_OIAP command is executed to establish an authorization session.
2. Choose the signing key that was used to create the signature.

```
Make the selection at the prompt:
known keyHandles:
      1: XX XX XX XX
      2: XX XX XX XX
      X: XX XX XX XX
select a keyHandle:
```

3. Enter the digest that was signed at the prompt ***enter signature verification data (40 chars max):***. This must be the same digest of up to 40 characters that was signed.
4. Choose the cache slot from which to load the signature to verify at the prompt ***verify sign using signature from which cacheSlot (1-5)?***.
5. A successful execution of the TPM_ VerifySignature command returns a TPM_SUCCESS return code of 0x00000000, along with the message ***signature verification complete!***. An unsuccessful verification of the digital signature returns a TPM_INAPPROPRIATE_SIG return code of 0x00000027.

Selection d - TPM_GetPubKey (Sequence)

The TPM_GetPubKey command returns the public portion of a loaded key. The demo command, TPM_GetPubKey, is a sequence comprised of the following:

1. An OIAP is executed to establish an authorization session.
2. If no keys are loaded on the TPM, TPM_GetPubKey will abort with the failure message ***getPubKey failed!***. If keys are loaded on the TPM, then read the public portion of a loaded key by selecting the keyHandle.

```
Make the selection at the prompt:
known keyHandles:
      1: XX XX XX XX
      2: XX XX XX XX
      X: XX XX XX XX
select a keyHandle:
```

3. A successful execution of TPM_GetPubKey returns a TPM_SUCCESS return code of 0x00000000, along with the public portion of the selected loaded key.

Selection t - getCapability_versionVal

The TPM_GetCapability command returns current information regarding the TPM. The demo version of TPM_GetCapability has a TPM_CAPABILITY_AREA of TPM_CAP_VERSION_VAL and returns a TPM_CAP_VERSION_INFO structure.

A successful execution of TPM_GetCapability (TPM_CAP_VERSION_VAL) returns a TPM_SUCCESS return code of 0x00000000, along with the TPM_CAP_VERSION_INFO structure.

Selection u - TPM_Reset (Clears authSessions)

The TPM_Reset command releases all resources associated with existing authorization sessions.

A successful execution of TPM_Reset returns a TPM_SUCCESS return code of 0x00000000, along with releasing all authorization session resources.

If another command sequence returns an error code of 0x000015, which indicates that all of the authorization sessions are active, this command must be executed to clear those existing authorization sessions.

Selection v - TPM_FlushSpecific (keyHandle)

The TPM_FlushSpecific command flushes a specific handle from the TPM, releasing the associated resources. The demo command, TPM_FlushSpecific, is limited to the flushing of key handles:

1. If no keys are loaded on the TPM, the TPM_FlushSpecific command will abort with the failure message ***flushKey failed!***. If keys are loaded on the TPM, then choose the key that needs to be flush.

```
Make the selection at the prompt:
known keyHandles:
      0: XX XX XX XX
      1: XX XX XX XX
      X: XX XX XX XX
pick a key to flush:
```

2. A successful execution of TPM_FlushSpecific flushes the selected key and returns a TPM_SUCCESS return code of 0x00000000.

Selection w - TPM_ForceClear (Sequence)

The TPM_ForceClear command performs the Clear operation under physical presence. All TPM state information will be cleared. The demo command, TPM_ForceClear, is a sequence comprised of the following:

1. Assert Physical Presence by executing the TSC_PhysicalPresence command, setting TPM_STCLEAR_FLAGS.physicalPresence to ***TRUE***.
2. Execute the TPM_ForceClear command, clearing the ***TPM***.
3. A successful execution of TPM_ForceClear returns a TPM_DISABLED return code of 0x00000007, along with clearing the TPM, disabling the TPM, and requesting deactivation of the TPM at the next reset.

Selection x - Enable/Activate TPM (Sequence)

This demo sequence will enable and activate the TPM.

1. Assert Physical Presence: Execute the `TSC_PhysicalPresence` command, setting `TPM_STCLEAR_FLAGS.physicalPresence` to ***TRUE***.
2. Enable the TPM: Execute the `TPM_PhysicalEnable` command setting `TPM_PERMANENT_FLAGS.disable` to ***FALSE***.
3. Request activation of the TPM at the next reset. Execute the `TPM_PhysicalSetDeactivated (FALSE)` command, setting `TPM_PERMANENT_FLAGS.deactivated` to ***FALSE***.

Selection y - Disable/Deactivate TPM (Sequence)

This demo sequence will disable and deactivate the TPM.

1. Assert Physical Presence: Execute the `TSC_PhysicalPresence` command, setting `TPM_STCLEAR_FLAGS.physicalPresence` to ***TRUE***.
2. Request deactivation of the TPM at the next reset. Execute the `TPM_PhysicalSetDeactivated (TRUE)` command, setting `TPM_PERMANENT_FLAGS.deactivated` to ***TRUE***.
3. Disable the TPM. Execute the `TPM_PhysicalDisable` command, setting `TPM_PERMANENT_FLAGS.disable` to ***TRUE***.

Selection z - Display Known Keys

This demo command displays the handles for all loaded keys. The resulting keyHandles display is as follows:

```
known keyHandles:
      0: XX XX XX XX
      1: XX XX XX XX
      X: XX XX XX XX
```

Technical Support

For technical support on the TPM Development Kit please contact the local Atmel Field Sales representative or email crypto@atmel.com.

For technical support on the Atmel SAM4S ARM, please reference the, “Atmel SAM4S ARM Hardware User Guide” for technical support information.

Hardware Reference Design

Schematics

Schematics of the I^2C and SPI TPM kit PCB in PDF format are found on the included USB Flash Drive in the ***Documentation*** folder, and are also available on the Atmel website. Please reference the “SAM4S ARM Hardware User Guide” for the SAM4S ARM schematics.

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Revision History

Doc Rev.	Date	Comments
8528D	05/2014	Update template, logos, disclaimer, and overall user guide to include the AT97SC3205T/P kits.

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