MICROSOFT SQL SERVER

Integration Guide

Applicable Devices:

Vectera Plus

TABLE OF CONTENTS

[1] DOCUMENT INFORMATION

[1.1] DOCUMENT OVERVIEW

The purpose of this document is to provide information regarding the configuration of Futurex HSMs with Microsoft SQL Server Transparent Data Encryption (TDE) using EKM libraries. For additional questions related to your HSM, see the relevant administrator's guide.

[1.2] APPLICATION DESCRIPTION

[1.2.1] About Microsoft SQL Server

Microsoft SQL Server is a relational database management system (RDBMS) used for large-scale online transaction processing (OLTP), data warehousing, and e-commerce applications. It is also a business intelligence platform for data integration, analysis, and reporting solutions.

[1.2.2] About Transparent Data Encryption (TDE)

From Microsoft's documentation website: "Transparent Data Encryption (TDE) encrypts SQL Server data files. This encryption is known as encrypting data at rest.

To help secure a database, you can take precautions like:

- Designing a secure system.
- Encrypting confidential assets.
- Building a firewall around the database servers.

But a malicious party who steals physical media like drives or backup tapes can restore or attach the database and browse its data.

One solution is to encrypt sensitive data in a database and use a certificate to protect the keys that encrypt the data. This solution prevents anyone without the keys from using the data. But you must plan this kind of protection in advance.

TDE does real-time I/O encryption and decryption of data and log files. The encryption uses a database encryption key (DEK). The database boot record stores the key for availability during recovery. The DEK is a symmetric key. It's secured by a certificate that the server's master database stores or by an asymmetric key that an EKM module protects.

TDE protects data at rest, which is the data and log files. It lets you follow many laws, regulations, and guidelines established in various industries. This ability lets software developers encrypt data by using AES and 3DES encryption algorithms without changing existing applications."

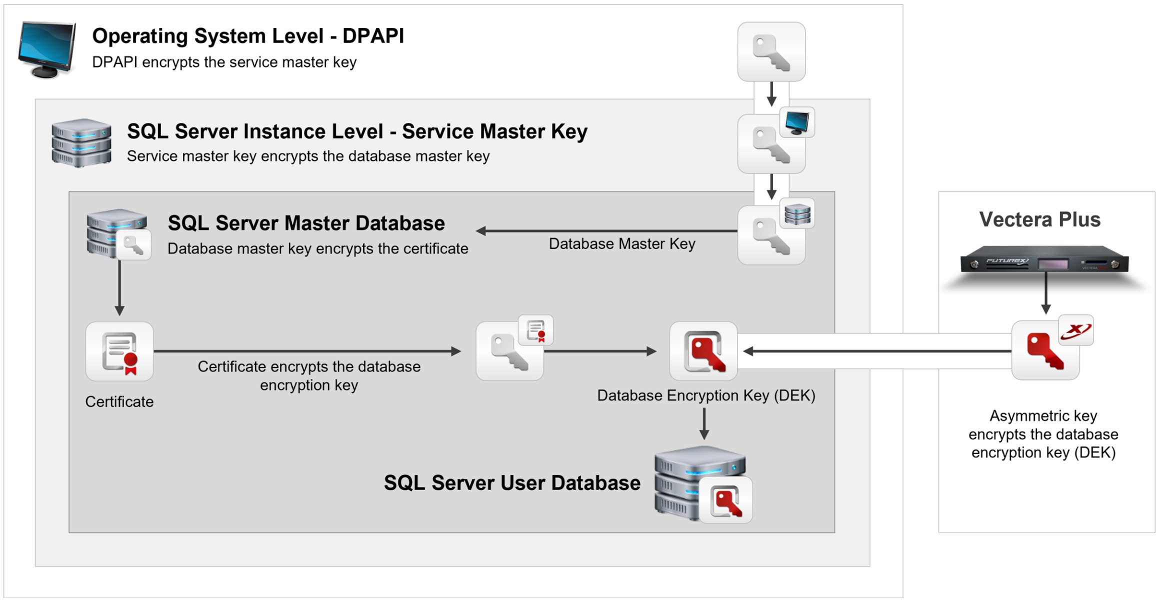
[1.2.3] Encryption Hierarchy and Integration with the Vectera Plus

Through Extensible Key Management (EKM), Microsoft SQL Server can utilize a Futurex Vectera Plus HSM for key management and encryption acceleration.

In this configuration, data can be encrypted using encryption keys that only the database user has access to on the external EKM/HSM module.

The figure below shows the architecture of TDE encryption, as well as the relationship between the SQL Server database master key and the Vectera Plus HSM.

NOTE: Only the database-level items (i.e., the database encryption key) are user-configurable when you use TDE on SQL Database.


Operating System Level - DPAPI
DPAPI encrypts the service master key
SQL Server Instance Level - Service Master Key
Service master key encrypts the database master key
SQL Server Master Database
Database master key encrypts the certificate
Database Master Key
Certificate
Certificate encrypts the database encryption key
Database Encryption Key (DEK)
SQL Server User Database
Vectera Plus
Asymmetric key encrypts the database encryption key (DEK)

[1.3] GUARDIAN INTEGRATION

The Guardian Series 3 introduces mission-critical viability to core cryptographic infrastructure, including:

- Centralize device management
- Eliminates points of failure
- Distribute transaction loads
- Group-specific function blocking
- User-defined grouping systems

Please see applicable guide for configuring HSMs with the Guardian Series 3.

[2] PREREQUISITES

Supported Hardware:

- Vectera Plus, 6.7.x.x and above

Supported Operating Systems:

- Windows 7 and above

Other:

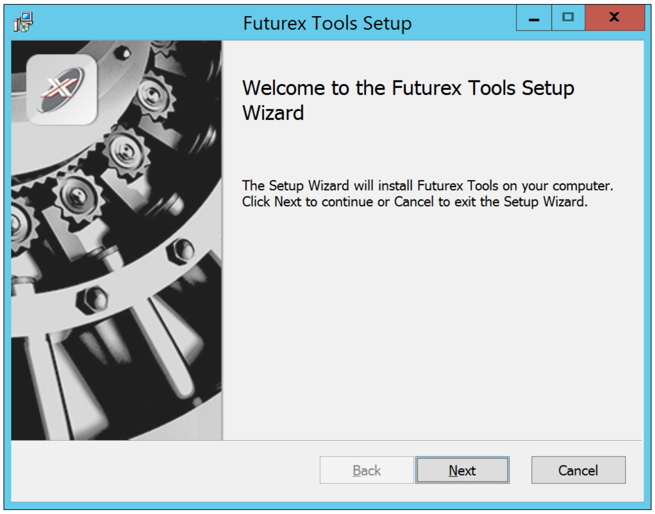
- OpenSSL
- Microsoft SQL Server
- Microsoft SQL Server Management Studio

[3] INSTALL FUTUREX EKM (FXEKM)

In a Windows environment, the easiest way to install the Futurex EKM module is using **FXTools**. FXTools can be downloaded from the Futurex Portal. Step by step installation instructions are provided below.

[3.1] INSTRUCTIONS FOR INSTALLING THE FXEKM MODULE USING FXTOOLS IN WINDOWS

- Run the FXTools Installer as an administrator



Futurex Tools Setup

Welcome to the Futurex Tools Setup Wizard

The Setup Wizard will install Futurex Tools on your computer. Click Next to continue or Cancel to exit the Setup Wizard.

FIGURE: FUTUREX TOOLS SETUP WIZARD

By default, all tools are installed on the system. A user can overwrite and choose not to install certain modules.

- **Futurex Client Tools –** Command Line Interface (CLI) and associated SDK for both Java and C.
- **Futurex CNG Module –** The Microsoft Next Generation Cryptographic Library.
- **Futurex Cryptographic Service Provider (CSP) –** The legacy Microsoft cryptographic library.
- **Futurex EKM Module –** The Microsoft Enterprise Key Management library.
- **Futurex PKCS #11 Module –** The Futurex PKCS #11 library and associated tools.
- **Futurex Secure Access Client –** The client used to connect a Futurex Excrypt Touch to a local laptop, via USB, and a remote Futurex device.

After starting the installation, all noted services are installed. If the Futurex Secure Access Client was selected, the Futurex Excrypt Touch driver will also be installed (Note this sometimes will start minimized or in the background).

After installation is complete, all services are installed in the `C:\Program Files\Futurex\` directory. The CNG Module, CSP Module, EKM Module, and PKCS #11 Module all require configuration files that are located in their corresponding directory with a `.cfg` extension. In addition, the CNG and CSP Modules are registered in the Windows Registry (`HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Cryptography\Defaults\Provider`) and are installed in the `C:\Windows\System32\` directory.

[4] INSTALL EXCRYPT MANAGER (IF USING WINDOWS)

Sections 4 and 5 of this integration guide cover the installation of Excrypt Manager and FXCLI. Excrypt Manager is a Windows application that provides a GUI-based method for configuring the HSM, while FXCLI provides a command-line-based method for configuring the HSM and can be installed on all platforms.

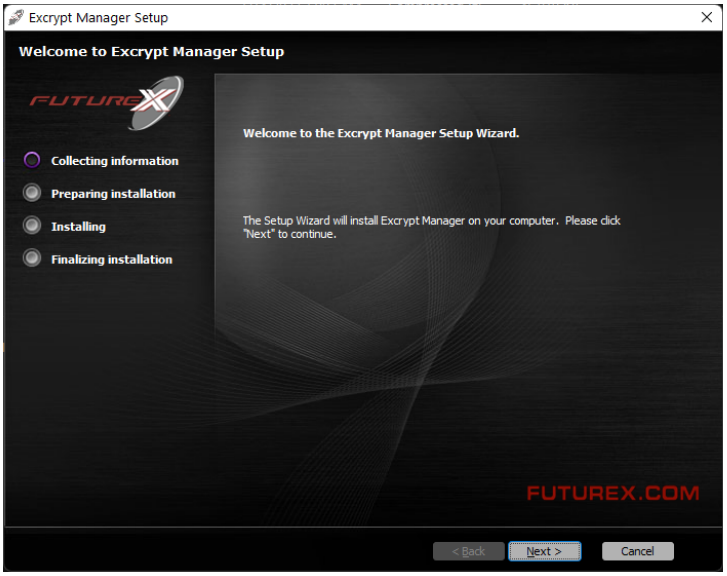
Note: If you will be configuring the Vectera Plus from a Linux computer, you can skip this section. If you will be configuring the Vectera Plus from a Windows computer, installing FXCLI in the next section is still required because FXCLI is the only method that can be used to configure TLS certificates in section 6.7.

Note: Install Excrypt Manager on the workstation you will use to configure the HSM.

Note: If you plan to use a Virtual HSM for the integration, all configurations will need to be performed using either FXCLI, the Excrypt Touch, or the Guardian Series 3.

Note: The Excrypt Manager version must be from the 4.4.x branch or later to be compatible with the HSM firmware, which must be 6.7.x.x or later.

To install Excrypt Manager, run the Excrypt Manager installer as an administrator and follow the prompts in the setup wizard to complete the installation.



Excrypt Manager Setup

Welcome to Excrypt Manager Setup

Welcome to the Excrypt Manager Setup Wizard.

The Setup Wizard will install Excrypt Manager on your computer. Please click "Next" to continue.

FIGURE: EXCRYPT MANAGER SETUP WIZARD

The installation wizard prompts you to specify where you want to install Excrypt Manager. The default location is C:\Program Files\Futurex\Excrypt Manager\. After choosing a location, select **[Install]**.

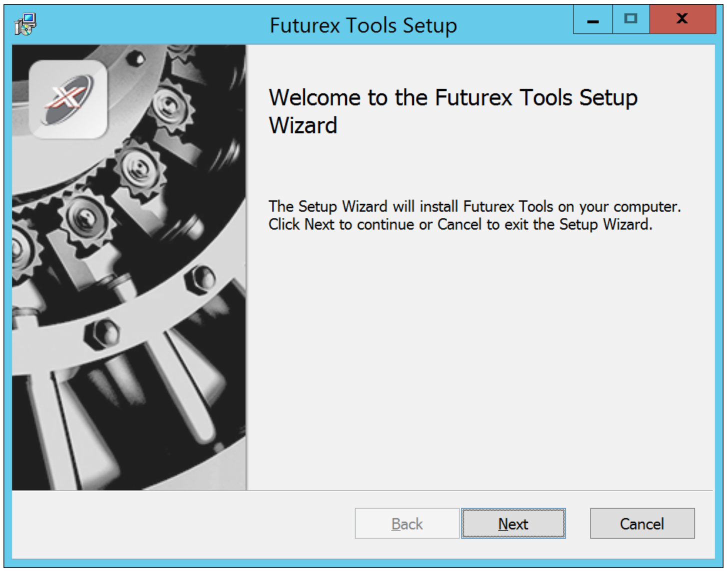
[5] INSTALL FUTUREX COMMAND LINE INTERFACE (FXCLI)

Note: Install FXCLI on the workstation you will use to configure the HSM.

[5.1] INSTALLING FXCLI IN WINDOWS

As mentioned in section 3, the FXTools installation package includes Futurex Client Tools (FXCLI). Similar to the Futurex PKCS #11 (FXPKCS11) module, the easiest way to install FXCLI on Windows is by installing FXTools. You can download FXTools from the Futurex Portal.

To install FXCLI, run the Futurex Tools installer as an administrator and follow the prompts in the setup wizard to complete the installation.



Welcome to the Futurex Tools Setup Wizard

The Setup Wizard will install Futurex Tools on your computer. Click Next to continue or Cancel to exit the Setup Wizard.

FIGURE: FUTUREX TOOLS SETUP WIZARD

The setup wizard installs all tools on the system by default. You can override the defaults and choose not to install certain modules. The installation provides the following services:

- **Futurex Client Tools**:Command Line Interface (CLI) and associated SDK for both Java and C.
- **Futurex CNG Module**:The Microsoft Next Generation Cryptographic Library.
- **Futurex Cryptographic Service Provider (CSP)**:The legacy Microsoft cryptographic library.
- **Futurex EKM Module**:The Microsoft Enterprise Key Management library.
- **Futurex PKCS #11 Module**:The Futurex PKCS #11 library and associated tools.
- **Futurex Secure Access Client**:A client used to connect a Futurex Excrypt Touch to a local laptop through USB, which can then connect to a remote Futurex device.

[5.2] INSTALLING FXCLI IN LINUX

Download FXCLI

You can download the appropriate FXCLI package files for your system from the Futurex Portal.

If the system is **64-bit**, select from the files marked **amd64**. If the system is **32-bit**, select from the files marked **i386**.

If running an OpenSSL version in the **1.0.x** branch, select from the files marked **ssl1.0**. If running an OpenSSL version in the **1.1.x** branch, select from the files marked **ssl1.1**.

Futurex offers the following features for FXCLI:

- Java Software Development Kit (**java**)
- HSM command line interface (**cli-hsm**)
- KMES command line interface (**cli-kmes**)
- Software Development Kit headers (**devel**)
- YAML parser used to parse bash output (**cli-fxparse**)

Install FXCLI

To install an rpm package, run the following command in a terminal:

```
$ sudo rpm -ivh [fxcl-xxxx.rpm]
```

To install a deb package, run the following command in a terminal:

```
$ sudo dpkg -i [fxcl-xxxx.deb]
```

Running FXCLI

To enter the HSM FXCLI prompt, run the following command in a terminal:

```
$ fxcli-hsm
```

After entering the FXCLI prompt, you can run **help** to list all of the available FXCLI commands.

[6] CONFIGURE THE FUTUREX HSM

In order to establish a connection between the PKCS #11 library and the Futurex HSM, a few configuration items need to first be performed, which are the following:

NOTE: All of the steps in this section can be completed through either Excrypt Manager or FXCLI (if using a physical HSM rather than a virtual HSM). Optionally, steps 4 through 6 can be completed through the Guardian Series 3, which will be covered in Appendix A.

1. Connect to the HSM via the front USB port (**NOTE**: If you are using a virtual HSM for the integration you will have to connect to it over the network either via FXCLI, the Excrypt Touch, or the Guardian Series 3)
    a. Connecting via Excrypt Manager
    b. Connecting via FXCLI
2. Validate the correct features are enabled on the HSM
3. Setup the network configuration
4. Load the Futurex FTK
5. Configure a Transaction Processing connection and create a new Application Partition
6. Create a new Identity that has access to the Application Partition created in the previous step
7. Configure TLS Authentication. There are two options for this:
    a. Enabling server-side authentication
    b. Creating client certificates for mutual authentication

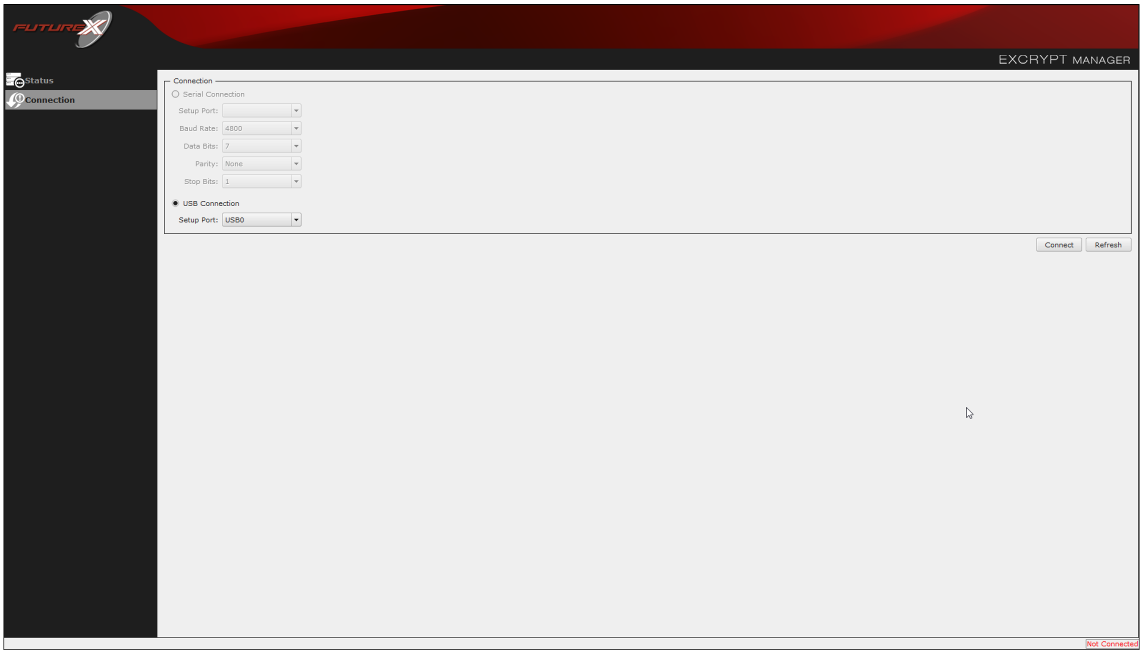
Each of these action items is detailed in the following subsections.

[6.1] CONNECT TO THE HSM VIA THE FRONT USB PORT

For both Excrypt Manager and FXCLI you need to connect your laptop to the front USB port on the HSM.

Connecting via Excrypt Manager

Open Excrypt Manager, click “Refresh” in the lower right-hand side of the Connection menu. Then select “USB Connection” and click “Connect”.



Connection

○ Serial Connection

Setup Port:

Baud Rate: 4800

Data Bits: 7

Parity: None

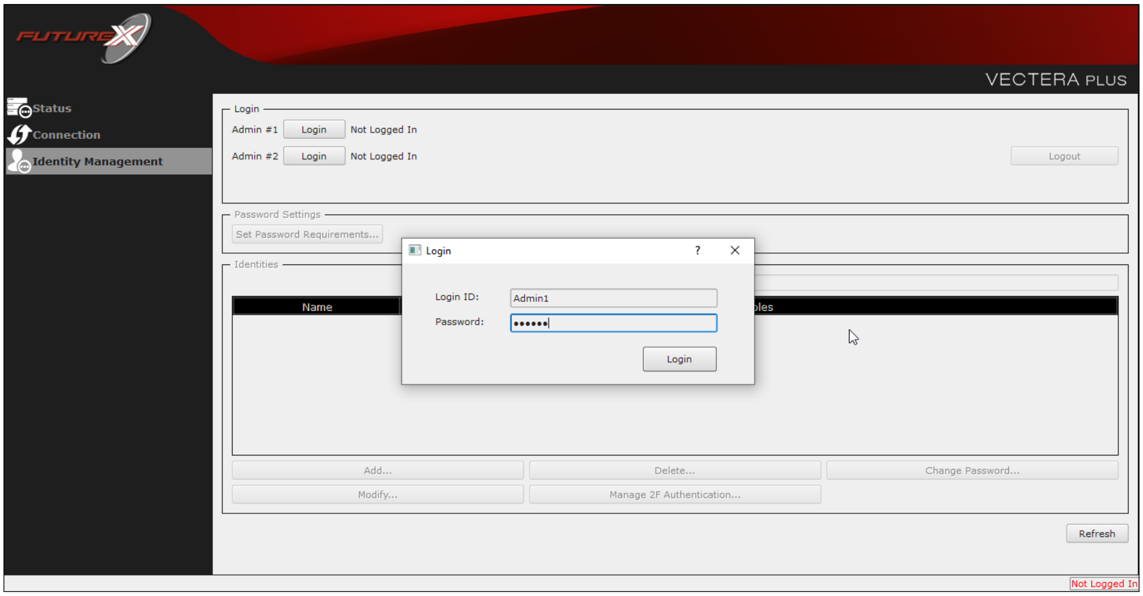
Stop Bits: 1

● USB Connection

Setup Port: USB0

Not Connected

Login with both default Admin identities.



Login

Admin #1 Login Not Logged In

Admin #2 Login Not Logged In

Login

Login ID: Admin1

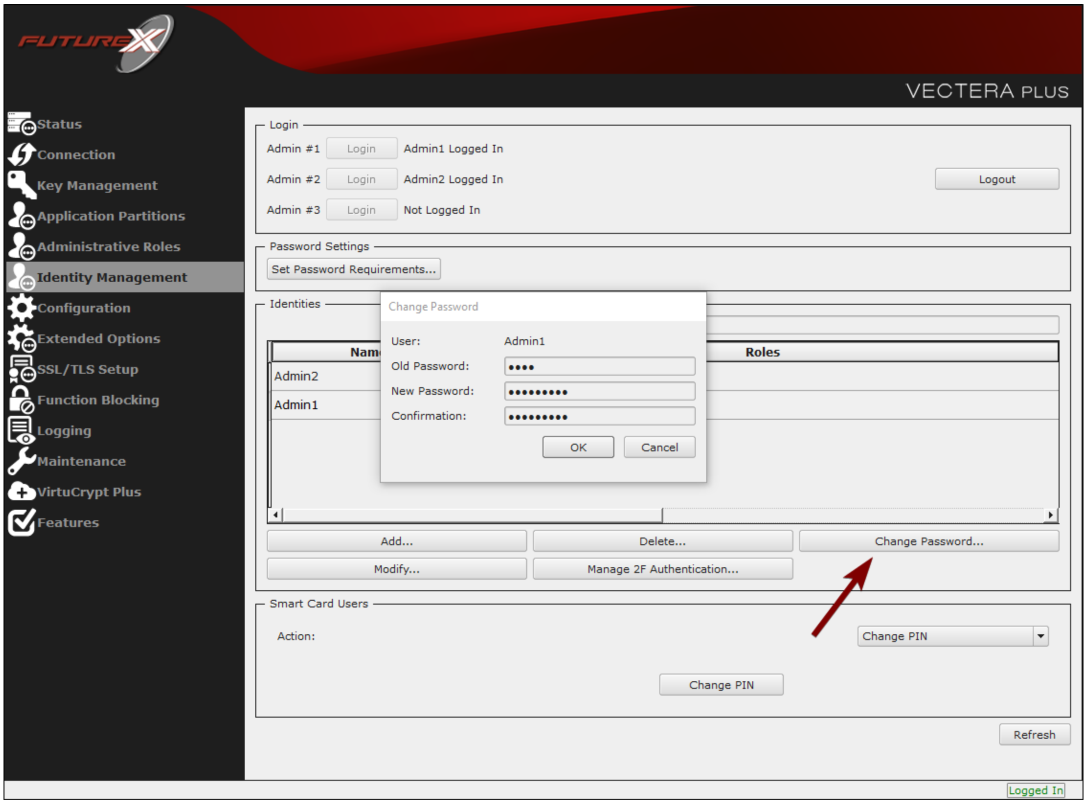
Password: ••••••

Login

Not Logged In

The default Admin passwords (i.e. “safe”) must be changed for both of your default Admin Identities (e.g. “Admin1” and “Admin2”) in order to load the major keys onto the HSM.

To do so via Excrypt Manager navigate to the Identity Management menu, select the first default Admin identity (e.g. "Admin1"), then click the "Change Password..." button. Enter the old password, then enter the new password twice, and click "OK". Perform the same steps as above for the second default Admin identity (e.g. "Admin2").



Login
Admin #1 Login Admin1 Logged In
Admin #2 Login Admin2 Logged In
Admin #3 Login Not Logged In

Password Settings

Identities

Name	Roles
Admin2	
Admin1	

Change Password
User: Admin1
Old Password: ••••
New Password: •••••••••
Confirmation: •••••••••
OK Cancel

Smart Card Users
Action: Change PIN

Connecting via FXCLI

Open the FXCLI application and run the following commands:

```
$ connect usb
$ login user
```

NOTE: The **"login"** command will prompt for the username and password. You will need to run it twice because you must login with both default Admin identities.

The default Admin passwords (i.e. "safe") must be changed for both of your default Admin Identities (e.g. "Admin1" and "Admin2") in order to load the major keys onto the HSM.

The following FXCLI commands can be used to change the passwords for each default Admin Identity.

```
$ user change-password -u Admin1
$ user change-password -u Admin2
```

NOTE: The user change-password commands above will prompt you to enter the old and new passwords. It is necessary to run the command twice (as shown above) because the default password must be changed for both default Admin identities.

[6.2] FEATURES REQUIRED IN HSM

In order to establish a connection between the PKCS #11 Library and the Futurex HSM, the HSM must be configured with the following features:

- **PKCS #11** -> Enabled
- **Command Primary Mode** -> General Purpose (GP)

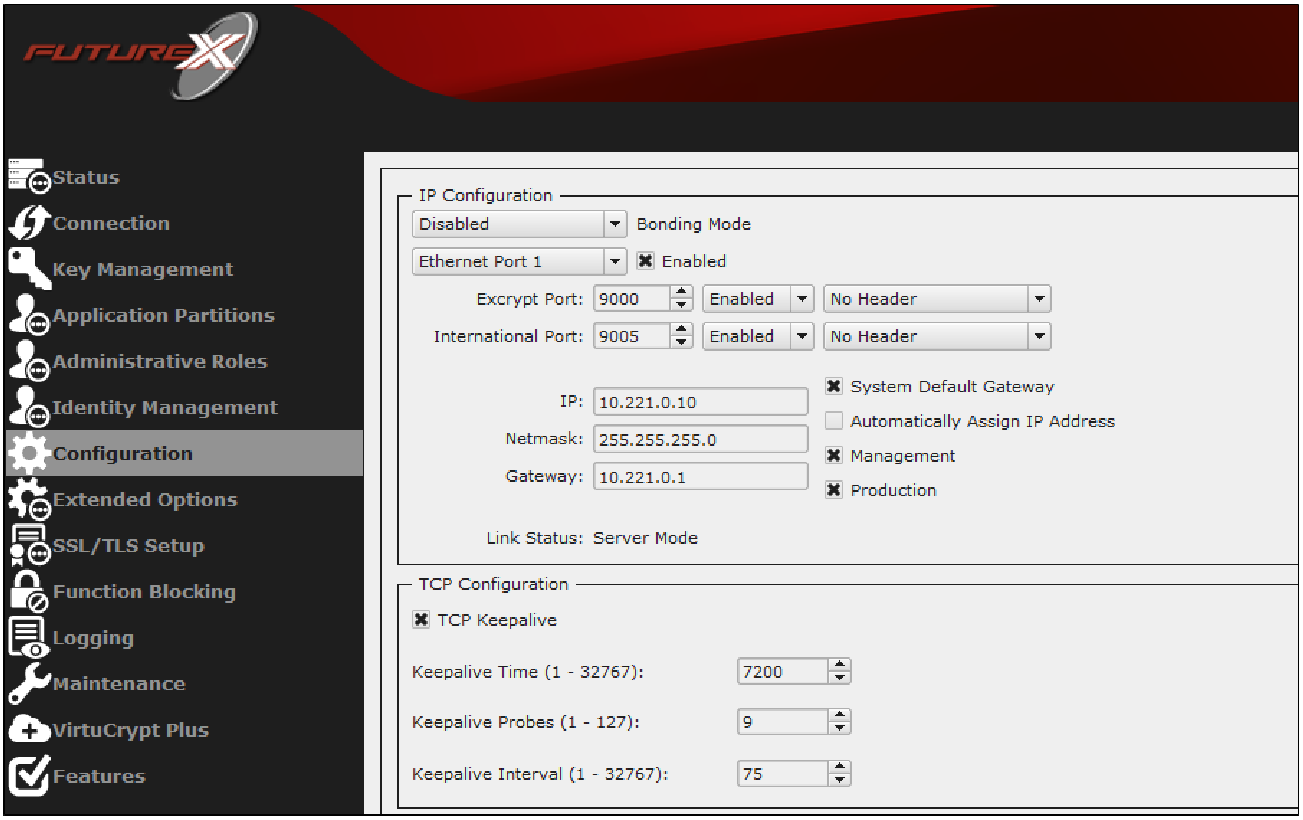
NOTE: For additional information about how to update features on your HSM, please refer to your HSM Administrator's Guide, section **"Download Feature Request File"**.

NOTE: Command Primary Mode = General Purpose, will enable the option to create the FTK major key in the HSM. This key will be required to be able to use the PKCS #11 library to communicate with the HSM. For detailed information about how to load major keys in HSMs please refer to your HSM Administrator's Guide.

[6.3] NETWORK CONFIGURATION (HOW TO SET THE IP OF THE HSM)

For this step you will need to be logged in with an identity that has a role with permissions ***Communication:Network Settings****. The default Administrator role and Admin identities can be used.*

Navigate to the *Configuration* page. There you will see the option to modify the IP configuration, as shown below:



IP Configuration

Disabled Bonding Mode

Ethernet Port 1 ☒ Enabled

Excrypt Port: 9000 Enabled No Header

International Port: 9005 Enabled No Header

IP: 10.221.0.10

Netmask: 255.255.255.0

Gateway: 10.221.0.1

☒ System Default Gateway

☐ Automatically Assign IP Address

☒ Management

☒ Production

Link Status: Server Mode

TCP Configuration

☒ TCP Keepalive

Keepalive Time (1 - 32767): 7200

Keepalive Probes (1 - 127): 9

Keepalive Interval (1 - 32767): 75

Alternatively, the following **FXCLI** command can be used to set the IP for the HSM:

```
$ network interface modify --interface Ethernet1 --ip 10.221.0.10 --netmask 255.255.255.0 --gateway
10.221.0.1
```

NOTE: The following should be considered at this point:

- All of the remaining HSM configurations in this section can be completed using the Guardian Series 3 (please refer to Appendix A for instructions on how to do so), with the exception of the final subsection that covers how to create connection certificates for mutual authentication.
- If you are performing the configuration on the HSM directly now, but plan to add the HSM to a Guardian later, it may be necessary to synchronize the HSM after it is added to a Device Group on the Guardian.
- If configuration through a CLI is required for your use-case, then you should manage the HSMs directly.

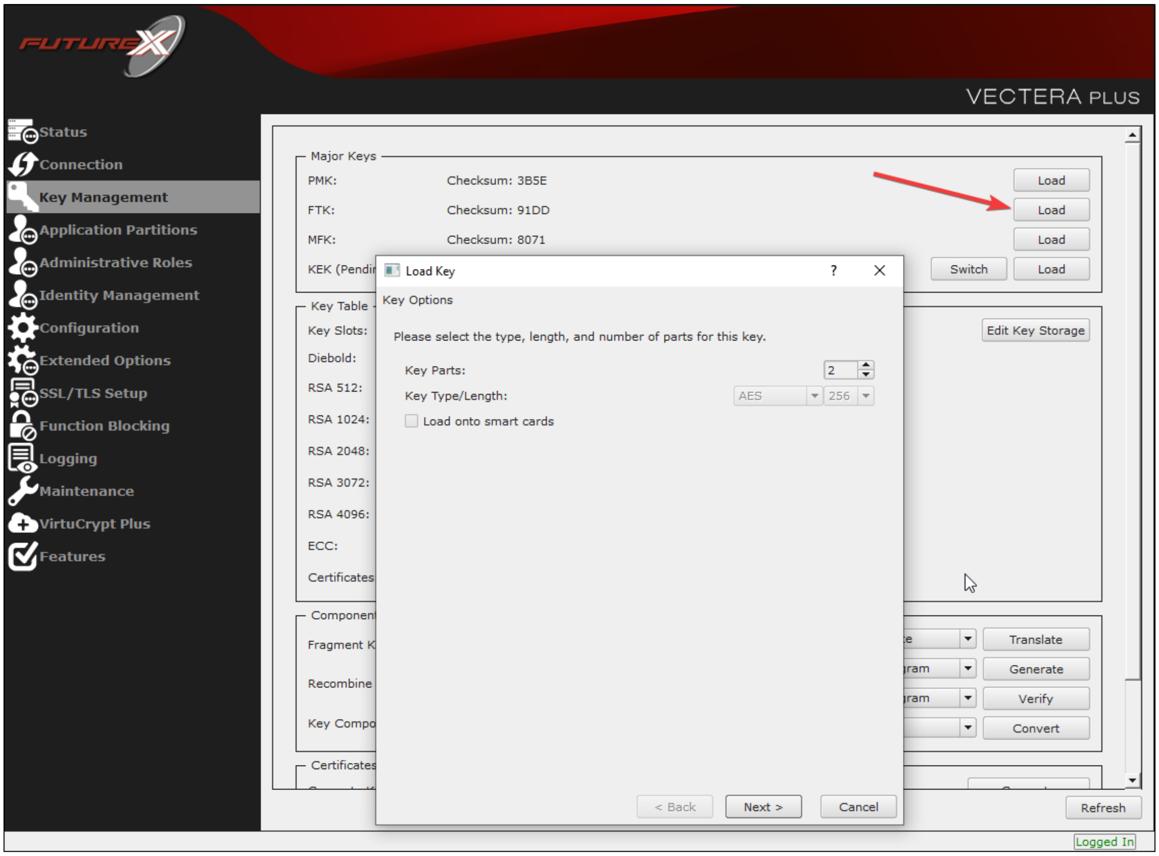
[6.4] LOAD FUTUREX KEY (FTK)

*For this step you will need to be logged in with an identity that has a role with permissions **Major Keys:Load**. The default Administrator role and Admin identities can be used.*

The FTK is used to wrap all keys stored on the HSM used with PKCS #11. If using multiple HSMs in a cluster, the same FTK can be used for syncing HSMs. Before an HSM can be used with PKCS #11, it must have an FTK.

NOTE: This process can also be completed using FXCLI, the Excrypt Touch, or the Guardian Series 3. For more information about how to load the FTK into an HSM using these tools/devices, please see the relevant Administrative Guide.

After logging in, select *Key Management*, then "Load" under FTK. Keys can be loaded as components that are XOR'd together, M-of-N fragments, or generated. If this is the first HSM in a cluster, it is recommended to generate the key and save to smart cards as M-of-N fragments.



PMK: Checksum: 3B5E

FTK: Checksum: 91DD

MFK: Checksum: 8071

KEK (Pendi

Key Slots:

Diebold:

RSA 512:

RSA 1024:

RSA 2048:

RSA 3072:

RSA 4096:

ECC:

Certificates

Fragment K

Recombine

Key Compo

Load Key

Key Options

Please select the type, length, and number of parts for this key.

Key Parts: 2

Key Type/Length: AES 256

□ Load onto smart cards

Alternatively, the following **FXCLI** commands can be used to load an FTK onto an HSM.

If this is the first HSM you are setting up you will need to generate a random FTK. Optionally, you can also load it onto smart cards simultaneously with the -m and -n flags.

```
$ majorkey random --ftk -m [number_from_2_to_9] -n [number_from_2_to_9]
```

If it's a second HSM that you're setting up in a cluster then you will load the FTK from smart cards with the following command:

```
$ majorkey recombine --key ftk
```

[6.5] CONFIGURE A TRANSACTION PROCESSING CONNECTION AND CREATE AN APPLICATION PARTITION

*For this step you will need to be logged in with an identity that has a role with permissions **Role:Add, Role:Assign All Permissions, Role:Modify, Keys:All Slots**, and **Command Settings:Excrypt**. The default Administrator role and Admin identities can be used.*

NOTE: For the purposes of this integration guide you can consider the terms "Application Partition" and "Role" to be synonymous. For more information regarding Application Partitions, Roles, and Identities, please refer to the relevant Administrator's guide.

Configure a Transaction Processing Connection

Before an application logs in to the HSM with an authenticated user, it first connects via a “Transaction Processing” connection to the **Transaction Processing** Application Partition. For this reason, it is necessary to take steps to harden this Application Partition. The following three things need to be configured for the Transaction Processing partition:

1. It should not have access to the “All Slots” permissions
2. It should not have access to any key slots
3. Only the PKCS #11 communication commands should be enabled

Go to *Application Partitions*, select the Transaction Processing Application Partition, and click Modify.

Under the "Permissions" tab, leave the top-level **Keys** permission checked, but uncheck the **All Slots** sub permission.

Under the "Key Slots" tab you need to ensure that there are no key ranges specified. By default, the Transaction Processing Application Partition has access to the entire range of key slots on the HSM.

Lastly, under the “Commands” tab make sure that only the following **PKCS #11 Communication commands** are enabled:

- **ECHO**: Communication Test/Retrieve Version
- **PRMD**: Retrieve HSM restrictions
- **RAND**: Generate random data
- **HASH**: Retrieve device serial
- **GPKM**: Retrieve key table information
- **GPKS**: General purpose key settings get/change
- **GPKR**: General purpose key settings get (read-only)

Alternatively, the following **FXCLI** commands can be used to remove all permissions and key ranges that are currently assigned to the **Transaction Processing** role and enable only the PKCS #11 Communication commands:

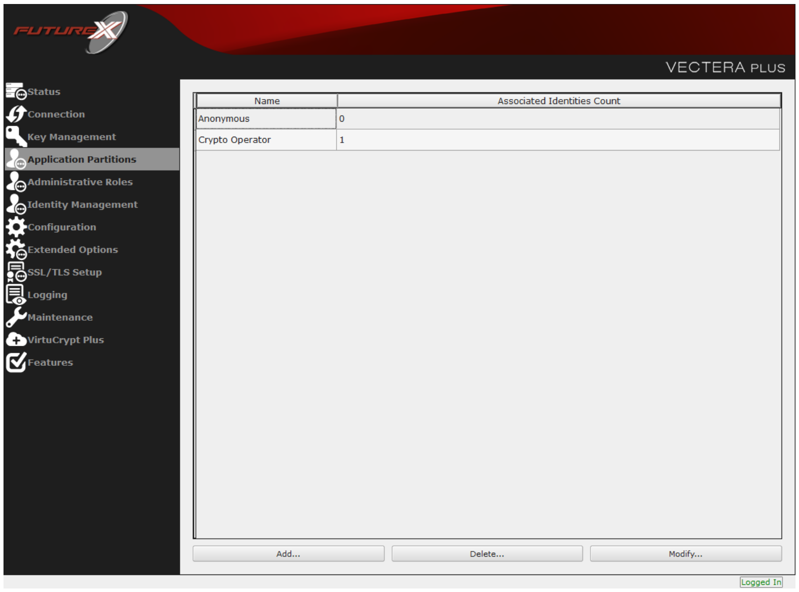
```
$ role modify --name Anonymous --clear-perms --clear-key-ranges
```

```
$ role modify --name Anonymous --add-perm "Keys" --add-perm Excrypt:ECHO --add-perm Excrypt:PRMD --
add-perm Excrypt:RAND --add-perm Excrypt:HASH --add-perm Excrypt:GPKM --add-perm Excrypt:GPKS --
add-perm Excrypt:GPKR
```

Create an Application Partition

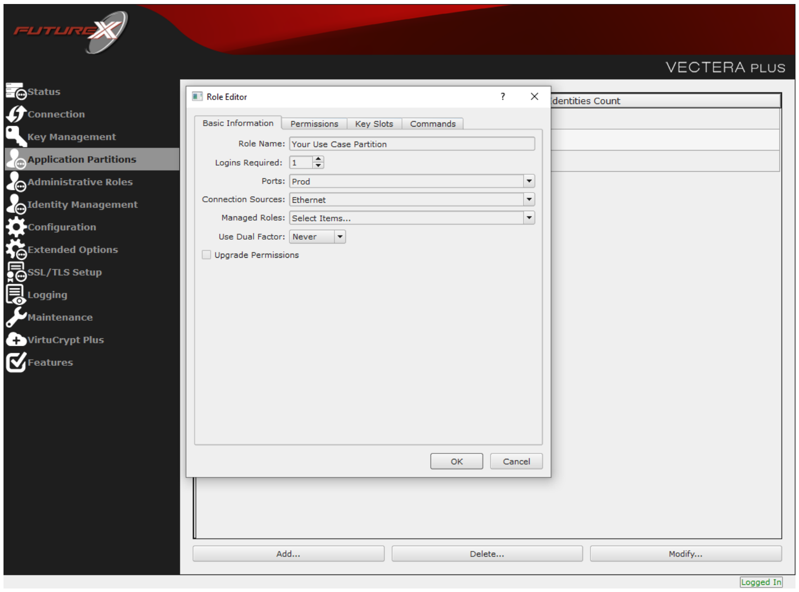
In order for application segregation to occur on the HSM, an Application Partition must be created specifically for your use case. Application partitions are used to segment the permissions and keys on an HSM between applications. The process for configuring a new application partition is outlined in the following steps:

Navigate to the *Application Partitions* page and click the "Add" button at the bottom.



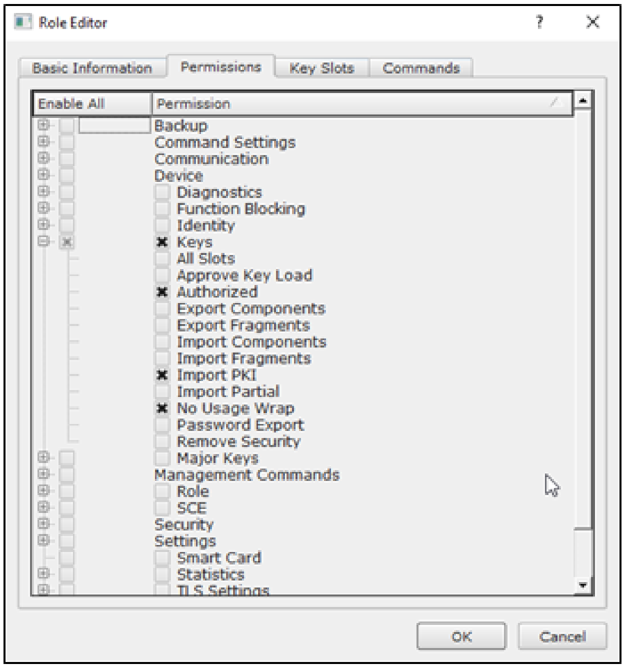
Name	Associated Identities Count
Anonymous	0
Crypto Operator	1

Fill in all of the fields in the *Basic Information* tab exactly how you see below (except for the *Role Name* field). In the *Role Name* field, specify any name that you would like for this new Application Partition. *Logins Required* should be set to "1". *Ports* should be set to "Prod". *Connection Sources* should be configured to "Ethernet". The *Managed Roles* field should be left blank because we'll be specifying the exact Permissions, Key Slots, and Commands that we want this Application Partition/Role to have access to. Lastly, the *Use Dual Factor* field should be set to "Never".



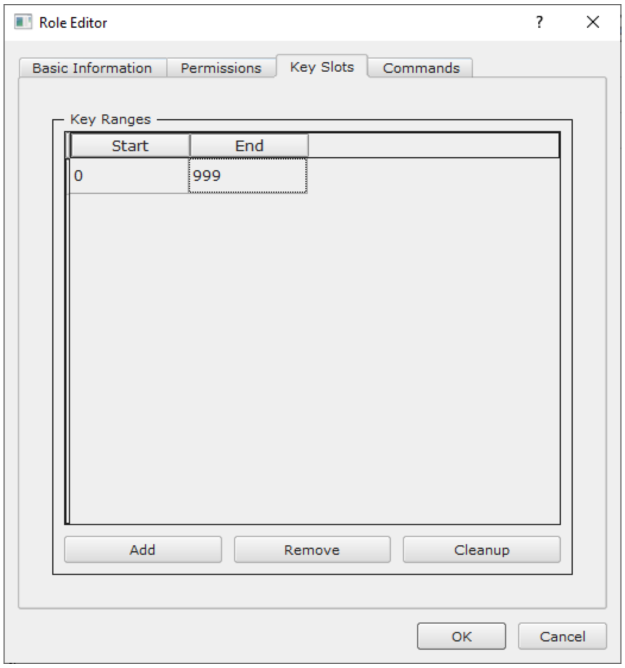
Role Name: Your Use Case Partition
Logins Required: 1
Ports: Prod
Connection Sources: Ethernet
Managed Roles: Select Items...
Use Dual Factor: Never
□ Upgrade Permissions

Under the "Permissions" tab, select the key permissions shown in the screenshot below. The **Authorized** permission allows for keys that require login. The **Import PKI** permission allows trusting an external PKI, which is used by some applications to allow for PKI symmetric key wrapping (It is not recommended to enable unless using this use case). The **No Usage Wrap** permission allows for interoperable key wrapping without defining key usage as part of the wrapped key (This is only recommended if exchanging keys with external entities or using the HSM to wrap externally used keys).



- Backup
- Command Settings
- Communication
- Device
  - ☐ Diagnostics
  - ☐ Function Blocking
  - ☐ Identity
  - ☒ Keys
    - ☐ All Slots
    - ☐ Approve Key Load
    - ☒ Authorized
    - ☐ Export Components
    - ☐ Export Fragments
    - ☐ Import Components
    - ☐ Import Fragments
    - ☒ Import PKI
    - ☐ Import Partial
    - ☒ No Usage Wrap
    - ☐ Password Export
    - ☐ Remove Security
  - ☐ Major Keys
- Management Commands
  - ☐ Role
  - ☐ SCE
- Security
- Settings
  - ☐ Smart Card
  - ☐ Statistics
  - ☐ TLS Settings

Under key slots, it is recommended that you create a range of 1000 total keys (here we've specified the key range 0-999), which do not overlap with another Application Partition. Within this range, there must be ranges for both symmetric and asymmetric keys. If more keys are required by the application, configure accordingly.



Start	End
0	999

Based on application requirements there are particular functions that need to be enabled on the Application Partition in order to utilize the HSMs functionality. For the SQL Server integration, the commands listed below need to be enabled. These can be enabled under the "Commands" tab.

PKCS #11 Communication Commands

- **ECHO**: Communication Test/Retrieve Version
- **HASH**: Retrieve device serial
- **GPKM**: Retrieve key table information
- **GPKS**: General purpose key settings get/change

Key Operations Commands

- **GRSA**: Generate RSA Private and Public Key
- **LRSA**: Load key into RSA Key Table

Data Encryption Commands

- **GPSR**: General purpose RSA encrypt/decrypt or sign/verify with recovery

Alternatively, the following **FXCLI** commands can be used to create the new Application Partition and enable all of the functions that are needed:

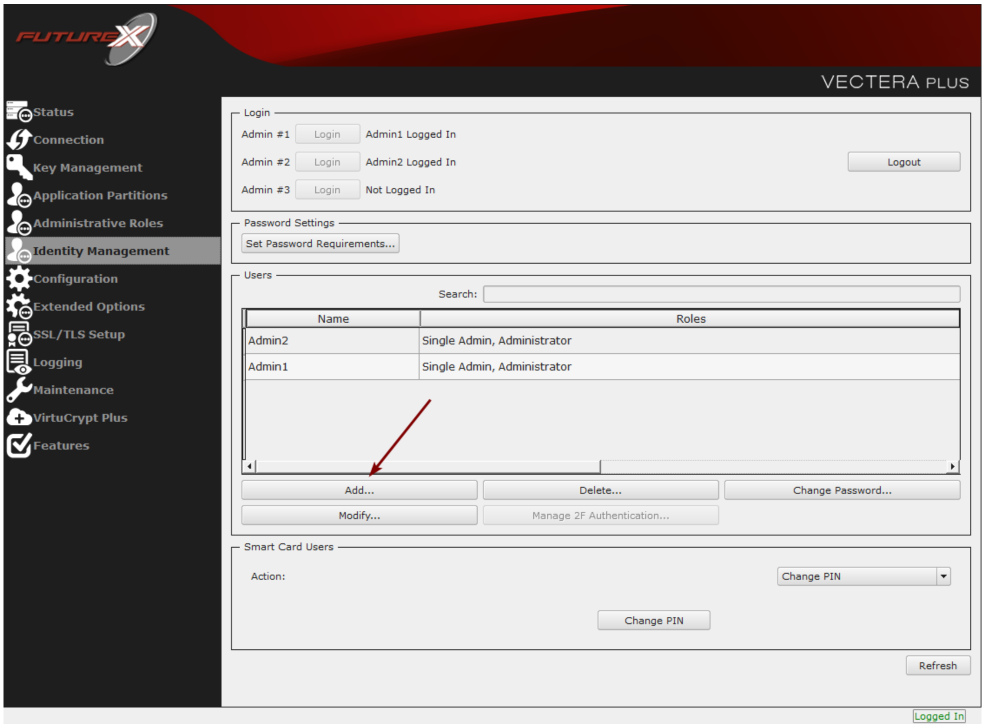
```
$ role add --name Role_Name --application --key-range (0,999) --perm "Keys:Authorized" --perm "Keys:Import PKI" --perm "Keys:No Usage Wrap"
```

```
$ role modify --name [role_name] --clear-perms --add-perm Excrypt:ECHO --add-perm Excrypt:HASH --add-perm Excrypt:GPKM --add-perm Excrypt:GPKS --add-perm Excrypt:GRSA --add-perm Excrypt:LRSA --add-perm Excrypt:GPSR
```

[6.6] CREATE NEW IDENTITY AND ASSOCIATE IT WITH THE NEWLY CREATED APPLICATION PARTITION

*For this step you will need to be logged in with an identity that has a role with permissions **Identity:Add**. The default Administrator role and Admin identities can be used.*

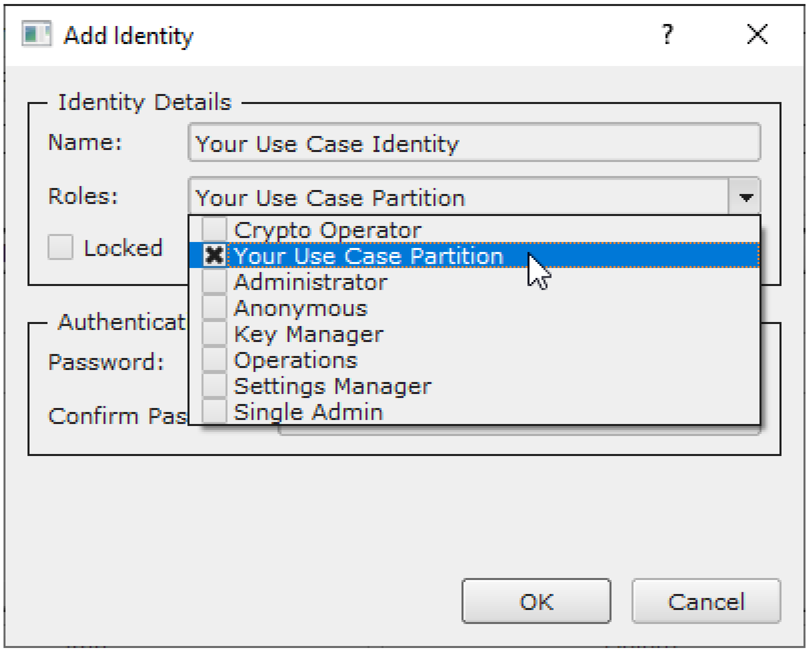
A new identity must be created, which will need to be associated with the Application Partition created in the previous step. To create this new identity, go to *Identity Management*, and click “Add”.



Admin #1 Login Admin1 Logged In
Admin #2 Login Admin2 Logged In
Admin #3 Login Not Logged In

Name	Roles
Admin2	Single Admin, Administrator
Admin1	Single Admin, Administrator

Specify a name for the new identity, and in the Roles dropdown select the name of the Application Partition created in the previous step. This will associate the new Identity with the Application Partition that you created.



Name: Your Use Case Identity

Roles: Your Use Case Partition

Alternatively, the following **FXCLI** command can be used to create a new Identity and associate it with the role that was created:

```
$ identity add --name Identity_Name --role Role_Name --password safest
```

This new identity must be set in fxpkcs11.cfg file, in the following section:

```
#HSM crypto operator identity name
<CRYPTO-OPR>    [insert name of identity that you created]    </CRYPTO-OPR>

# Production connection
<PROD-ENABLED>    YES        </PROD-ENABLED>
<PROD-PORT>        9100        </PROD-PORT>
```

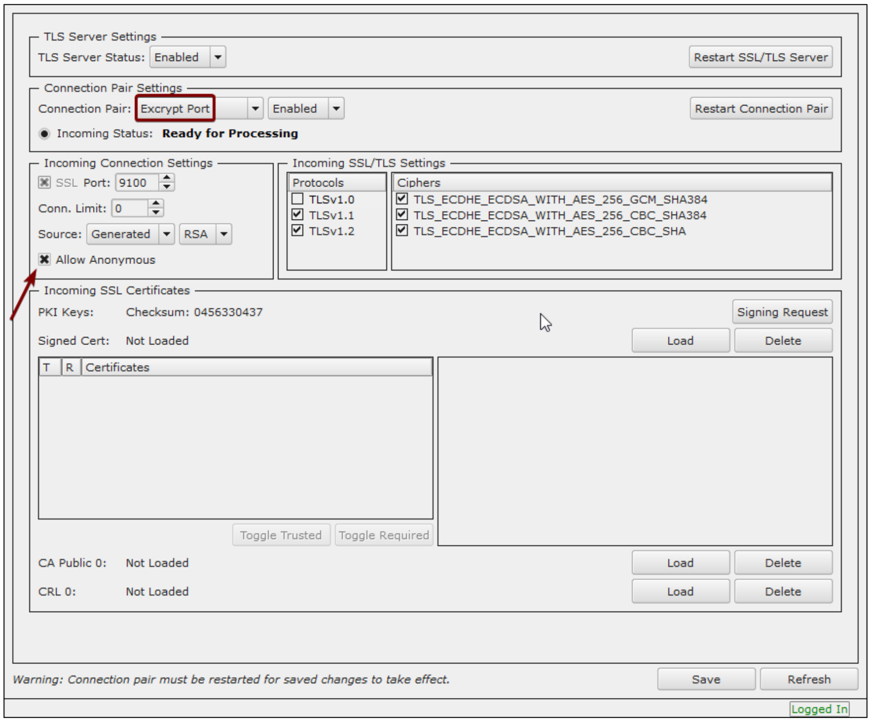
NOTE: Crypto Operator in the fxpkcs11.cfg file must match exactly the name of the identity created in the HSM.

[6.7] CONFIGURE TLS AUTHENTICATION

*For this step you will need to be logged in with an identity that has a role with permissions **Keys:All Slots, Management Commands:Certificates, Management Commands:Keys, Security:TLS Sign**, and **TLS Settings:Upload Key**. The default Administrator role and Admin identities can be used.*

Enable Server-Side Authentication (Option 1)

Mutually authenticating to the HSM using client certificates is recommended, but server-side authentication is also supported. To enable server-side authentication go to *SSL/TLS Setup*, then select the Excrypt Port and enable the “Allow Anonymous” setting.



TLS Server Settings
TLS Server Status: Enabled

Connection Pair Settings
Connection Pair: Excrypt Port Enabled
● Incoming Status: **Ready for Processing**

Incoming Connection Settings
☒ SSL Port: 9100
Conn. Limit: 0
Source: Generated RSA
☒ Allow Anonymous

Incoming SSL/TLS Settings

Protocols	Ciphers
☐ TLSv1.0	☑ TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384
☑ TLSv1.1	☑ TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA384
☑ TLSv1.2	☑ TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA

Incoming SSL Certificates
PKI Keys: Checksum: 0456330437
Signed Cert: Not Loaded

T	R	Certificates

CA Public 0: Not Loaded
CRL 0: Not Loaded

Warning: Connection pair must be restarted for saved changes to take effect.

Alternatively, the following **FXCLI** command can be used to enable server-side authentication with the “Allow Anonymous” SSL/TLS setting:

```
$ tls-ports set -p "Excrypt Port" --anon
```

Create Connection Certificates for Mutual Authentication (Option 2)

Mutually authenticating to the HSM using client certificates is recommended, and enforced by default. In the example below, FXCLI is utilized to generate a CA that then signs the HSM server certificate and a client certificate. The client keys and CSR are generated in Windows PowerShell with OpenSSL. For other options for managing certificates required for mutual authentication with the HSM, please review the relevant Administrator's guide.

Find the **FXCLI** program that was installed with FXTools, and run it as an administrator.

Things to note:

- For this example, the computer running FXCLI is connected to the front port of the HSM. Remote management is possible however, using the HSMs Web Portal, or the Excrypt Touch.
- For commands that create an output file, if you do not specify a file path (as is the case here) it will save the file to the directory from which the FXCLI program is executed.
- Using user-generated certificates requires a PMK to be loaded on the HSM.
- If you run **help** by itself it will show a full list of available commands. You can see all of the available options for any given command by running the command name followed by **help**.

```
# Connect your laptop to the HSM via the USB port on the front, then run this command.
$ connect usb
```

```
# Log in with both default Admin identities. This command will prompt for the username and pass-
word. You will need to run this command twice.
$ login user
```

```
# Generate TLS CA and store it in an available key slot on the HSM
$ generate --algo RSA --bits 2048 --usage mak --name TlsCaKeyPair --slot next
```

```
# Create root certificate
$ x509 sign \
    --private-slot TlsCaKeyPair \
    --key-usage DigitalSignature --key-usage KeyCertSign \
    --ca true --pathlen 0 \
    --dn 'O=Futurex\CN=Root' \
    --out TlsCa.pem
```

```
# Generate the server keys for the HSM
$ tls-ports request --pair "Excrypt Port" --file production.csr --pki-algo RSA
```

```
# Sign the server CSR with the newly created TLS CA
$ x509 sign \
    --private-slot TlsCaKeyPair \
    --issuer TlsCa.pem \
    --csr production.csr \
    --eku Server --key-usage DigitalSignature --key-usage KeyAgreement \
    --ca false \
    --dn 'O=Futurex\CN=Production' \
    --out TlsProduction.pem
```

```
# Push the signed server PKI to the production port on the HSM
$ tls-ports set --pair "Excrypt Port" \
    --enable \
    --pki-source Generated \
    --clear-pki \
    --ca TlsCa.pem \
    --cert TlsProduction.pem \
    --no-anon
```

***NOTE**: The following OpenSSL commands will need to be run from Windows PowerShell, rather than from the FXCLI program.*

```
# Generate the client keys
$ openssl genrsa -out privatekey.pem 2048
```

```
# Generate client CSR
$ openssl req -new -key privatekey.pem -out ClientPki.csr -days 365
```

Using FXCLI, sign the CSR that was just generated using OpenSSL.

```
# Sign the client CSR under the root certificate that was created
$ x509 sign  \
 --private-slot TlsCaKeyPair \
 --issuer TlsCa.pem \
 --csr ClientPki.csr \
 --eku Client --key-usage DigitalSignature --key-usage KeyAgreement \
 --dn 'O=Futurex\CN=Client' \
 --out SignedPki.pem
```

Switch back to Windows PowerShell for the remaining commands.

```
# Use OpenSSL to create a PKCS#12 file that can be used to authenticate, as a client, using our
PKCS #11 library
$ openssl pkcs12 -export -inkey privatekey.pem -in SignedPki.pem -certfile TlsCa.pem -out PKI.p12
```

[7] EDIT THE FUTUREX EKM CONFIGURATION FILE

The `fxekm.cfg` file allows the user to set the FXEKM library to connect to the HSM. To edit, run a text editor as an Administrator and edit the configuration file accordingly. Most notably, the fields shown below must be set inside the **<HSM>** section (note that the full `fxekm.cfg` file is not included).

NOTE: The Futurex EKM library expects the FXEKM config file to be in a certain location (`C:\Program Files\Futurex\fxekm\fxekm.cfg`), but that location can be overwritten using an environment variable (`FXPKCS11_CFG`).

```
<HSM>
    # Which PKCS11 slot
    <SLOT>                  0                       </SLOT>
    <LABEL>                 Futurex                 </LABEL>

    # HSM crypto operator user name
    <CRYPTO-OPR>            [identity_name]              </CRYPTO-OPR>

    # Connection information
    <ADDRESS>               10.0.8.30     </ADDRESS>
    <PROD-PORT>             9100                    </PROD-PORT>
    <PROD-TLS-ENABLED>      YES                     </PROD-TLS-ENABLED>
    <PROD-TLS-ANONYMOUS>    NO                      </PROD-TLS-ANONYMOUS>
#    <PROD-TLS-CA>           /home/user/tls/root.pem        </PROD-TLS-CA>
#    <PROD-TLS-CA>           /home/user/tls/sub1.pem   </PROD-TLS-CA>
    <PROD-TLS-KEY>          /home/user/tls/PKI.p12     </PROD-TLS-KEY>
    <PROD-TLS-KEY-PASS>     safest                  </PROD-TLS-KEY-PASS>

    # YES = This is communicating through a Guardian
    <FX-LOAD-BALANCE>       NO                      </FX-LOAD-BALANCE>
</HSM>
```

In the **<SLOT>** and **<LABEL>** fields we specify to use PKCS11 slot 0 and assign it the label "Futurex".

In the **<CRYPTO-OPR>** field, the name of the identity that was created for the application partition needs to be specified.

In the **<ADDRESS>** field, the IP of the HSM that the PKCS #11 library will connect to is specified.

The **<PROD-PORT>** field declares that the PKCS #11 library will connect to Production port 9100.

The **<PROD-TLS-ANONYMOUS>** field defines whether the PKCS #11 library will be authenticating to the server or not.

The **<PROD-TLS-KEY>** field defines the location of the client private key. Supported formats for the TLS private key are PKCS #1 clear private keys, PKCS #8 encrypted private keys, or a PKCS #12 file that contains the private key and certificates encrypted under the password specified in the **<PROD-TLS-KEY-PASS>** field.

Because a PKCS #12 file is defined in the **<PROD-TLS-KEY>** field in this example, it is not necessary to define the signed client cert with the **<PROD-TLS-CERT>** tag, or the CA cert/s with one or more instances of the **<PROD-TLS-CA>** tag.

If a Guardian is being used to manage HSMs in a cluster, the **<FX-LOAD-BALANCE>** field must be defined as "YES". If a Guardian is not being used it should be set to "NO".

For additional details, reference the Futurex EKM technical reference found on the Futurex Portal.

[8] CONFIGURING EKM ON THE SQL SERVER

This section will cover the steps needed to enable EKM on the SQL Server and register the Futurex EKM provider.

[8.1] ENABLE THE EKM PROVIDER OPTION

In order to use the Futurex EKM provider, the EKM provider option must first be enabled on the SQL Server.

1. Open the SQL Server Management Studio application.
2. Connect to the SQL Server.
3. Open a Query window and execute the following:

```
sp_configure 'show advanced', 1
GO
RECONFIGURE
GO
sp_configure 'EKM provider enabled', 1
GO
RECONFIGURE
GO
```

[8.2] REGISTER THE FUTUREX EKM PROVIDER

1. Open a new Query window in SQL Server Management Studio and execute the following:

```
CREATE CRYPTOGRAPHIC PROVIDER FuturexEkmProvider
    FROM FILE = 'C:\Program Files\Futurex\fxekm\fxekm.dll';
GO
```

If you encounter the error, `Cannot initialize cryptographic provider. Provider error code: 1. (Failure - Consult EKM provider for details)`, you need to switch the **Server Authentication** type to **Windows Authentication**. Right click on the DB server and select **Properties** and click the **Security** tab. Change the **Server Authentication** type from **SQL & Windows Authentication** to **Windows Authentication**.

[9] ENABLING TDE ON SQL SERVER USING EKM

This section will cover the steps needed to enable transparent data encryption (TDE) in SQL Server to protect a database encryption key by using an asymmetric key stored on the Futurex EKM/HSM module.

NOTE: All of the following commands need to be run inside a Query window in SQL Server Management Studio.

1. Create a credential that will be used by system administrators.

```
CREATE CREDENTIAL EkmCredential
       WITH
               IDENTITY = 'crypto1',
               SECRET = 'safest'
       FOR CRYPTOGRAPHIC PROVIDER FuturexEkmProvider;
GO
```

   NOTE: The values set in the `IDENTITY` and `SECRET` fields should be the name and password of the identity created on the Vectera Plus that is specified in the FXEKM configuration file (i.e., `fxekm.cfg`).

2. Add the credential to a high privileged user such as your own domain login in the format [DOMAIN\login[.

```
ALTER LOGIN [WIN-Q4E6RG9BSOL\Administrator]
       ADD CREDENTIAL EkmCredential;
GO
```

3. Create an asymmetric key stored inside the Futurex EKM provider.

```
USE master;
GO
CREATE ASYMMETRIC KEY EkmAsym
       FROM PROVIDER FuturexEkmProvider
       WITH
               ALGORITHM = RSA_1024,
               PROVIDER_KEY_NAME = 'EkmAsym';
GO
```

4. Create a credential that will be used by the Database Engine.

```
CREATE CREDENTIAL EkmEngineCredential
       WITH
               IDENTITY = 'crypto1',
               SECRET = 'safest'
       FOR CRYPTOGRAPHIC PROVIDER FuturexEkmProvider;
GO
```

   NOTE: The values set in the `IDENTITY` and `SECRET` fields should be the name and password of the identity created on the Vectera Plus that is specified in the FXEKM configuration file (i.e., `fxekm.cfg`).

5. Create a login that will use the asymmetric key stored inside the Futurex EKM provider.

```
CREATE LOGIN EkmLogin
    FROM ASYMMETRIC KEY EkmAsym;
GO
```

6. Set the login to be able to use the database engine credential.

```
ALTER LOGIN EkmLogin
    ADD CREDENTIAL EkmEngineCredential;
GO
```

7. Create a new example database, add a table to it, then insert information into the table.

   NOTE: Database encryption operations cannot be executed on master, model, tempdb, msdb, or resource databases.

```
CREATE DATABASE exampleDB;
GO
USE exampleDB;
GO
CREATE TABLE users (
       id INT NOT NULL PRIMARY KEY,
       name VARCHAR(64),
       password VARCHAR(128),
       ssn VARCHAR(32)
);
GO
INSERT INTO users (id, name, password, ssn) VALUES (1, 'SomeGuy', 'blah', '000-00-0000'), (2,
'SomeGal', 'password', '000-00-0000'), (3, 'TestUser', 'test123', '000-00-0000');
GO
```

8. Create a database encryption key for the 'exampleDB' database.

```
USE exampleDB;
GO
CREATE DATABASE ENCRYPTION KEY
       WITH
               ALGORITHM = AES_128
       ENCRYPTION BY SERVER ASYMMETRIC KEY EkmAsym;
GO
```

9. Enable transparent data encryption on the 'exampleDB' database.

```
ALTER DATABASE exampleDB
       SET ENCRYPTION ON;
GO
```

10. Check if data can be decrypted.

    NOTE: Restart SQL Server service with the HSM offline, then check if the following command fails. If it does, then TDE is set up correctly. If the HSM is online, the command should succeed.

```
USE exampleDB;
SELECT * FROM users;
```

APPENDIX A: XCEPTIONAL SUPPORT

In today’s high-paced environment, we know you are looking for timely and effective resolutions for your mission-critical needs. That is why our Xceptional Support Team does whatever it takes to ensure you have the best experience and support possible. Every time. Guaranteed.

- 24x7x365 mission critical support
- Level 1 to level 3 support
- Extremely knowledgeable subject matter experts

At Futurex, we strive to supply you with the latest data encryption innovations as well as our best-in-class support services. Our Xceptional Support Team goes above and beyond to meet your needs and provide you with exclusive services that you cannot find anywhere else in the industry.

- Technical Services
- Onsite Training
- Virtual Training
- Customized Consulting
- Customized Software Solutions
- Secure Key Generation, Printing, and Mailing
- Remote Key Injection
- Certificate Authority Services

Toll-Free: 1-800-251-5112

E-mail: support@futurex.com

ENGINEERING CAMPUS

864 Old Boerne Road
Bulverde, Texas, USA 78163
Phone: +1 830-980-9782
+1 830-438-8782
E-mail: info@futurex.com

XCEPTIONAL SUPPORT

24x7x365
Toll-Free: 1-800-251-5112
E-mail: support@futurex.com

SOLUTIONS ARCHITECT

E-mail: solutions@futurex.com