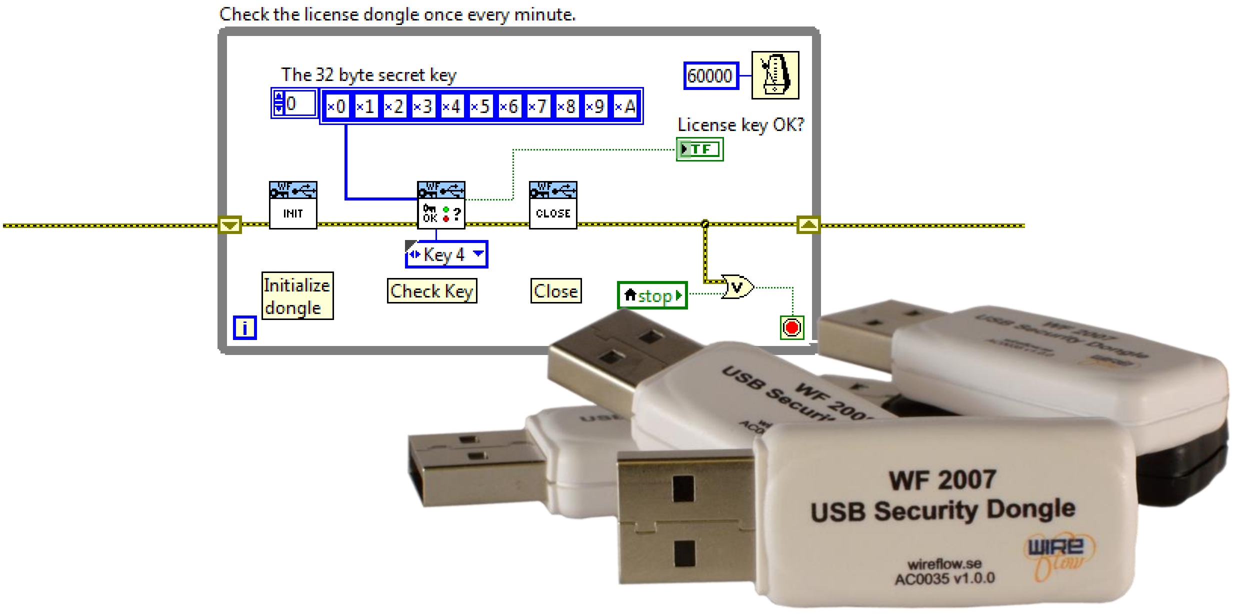
WireFlow Security Suite User's Manual

AC0045-002 rev C



WireFlow AB, 2013

Contents

Support information

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Introduction

This chapter gives a brief introduction to all parts included in the WireFlow Security Suite. If you prefer hands-on practice, you may skip this and instead go directly to the Quick guide document: “AC0045-003 WF Security Suite - Quick Guide”

The WireFlow Security Suite is a comprehensive solution that ends IP protection issues relating to unlawful copying of LabVIEW code. Not only does the Security Suite prohibit theft of code, the system also enables user identification and system feature control.

The WF Security Suite uses dongles, "hardware keys" to protect the LabVIEW applications. Software protection dongles have been used since late 1970s, and is a well-proven, intuitive and robust method to handle software licensing.

The WF Security Suite uses hardware dongles and LabVIEW software drivers based on the industry standard SHA-256 hash algorithm with 256 bit keys, guaranteeing a rock solid solution.

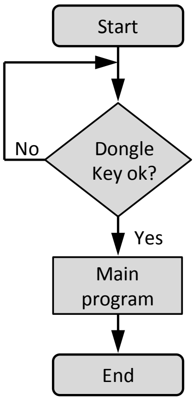
The WF Security Suite is fully compatible with all LabVIEW platforms, including LabVIEW for Windows, LabVIEW for Mac, LabVIEW Real-Time and LabVIEW FPGA.
The WireFlow dongles may thus be used to protect all LabVIEW hardware targets such as desktop PCs, PXI, Compact RIO and Compact DAQ chassis.

It is easy to protect a LabVIEW application by adding security routines to the code using the WF Security Suite LabVIEW driver. The security functionality can be anything from a simple license key check at the start-up of the application, to a complex set of functions to handle user identification and privileges or to handle demo expiration timers.

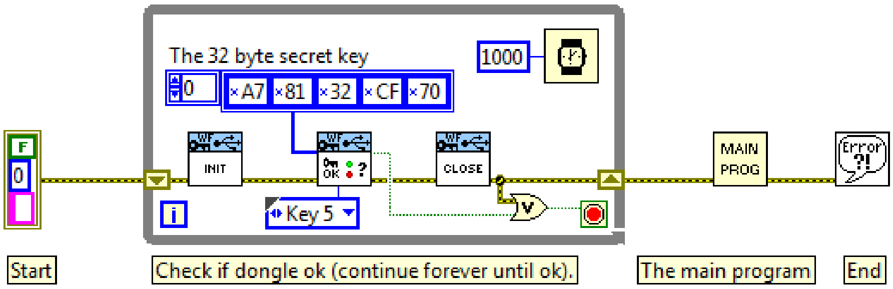
How it works

The security dongles may be thought of as an ordinary USB flash memory which cannot be read, written or duplicated by anyone that doesn't know the secret master code of the dongle. The LabVIEW developer can use this to implement a variety of security functions in the LabVIEW application. One basic security function is to make sure that the application does not start in case there is no dongle with the correct key present in the system. The flow chart and LabVIEW code for such an application would look something like this:

Flow chart

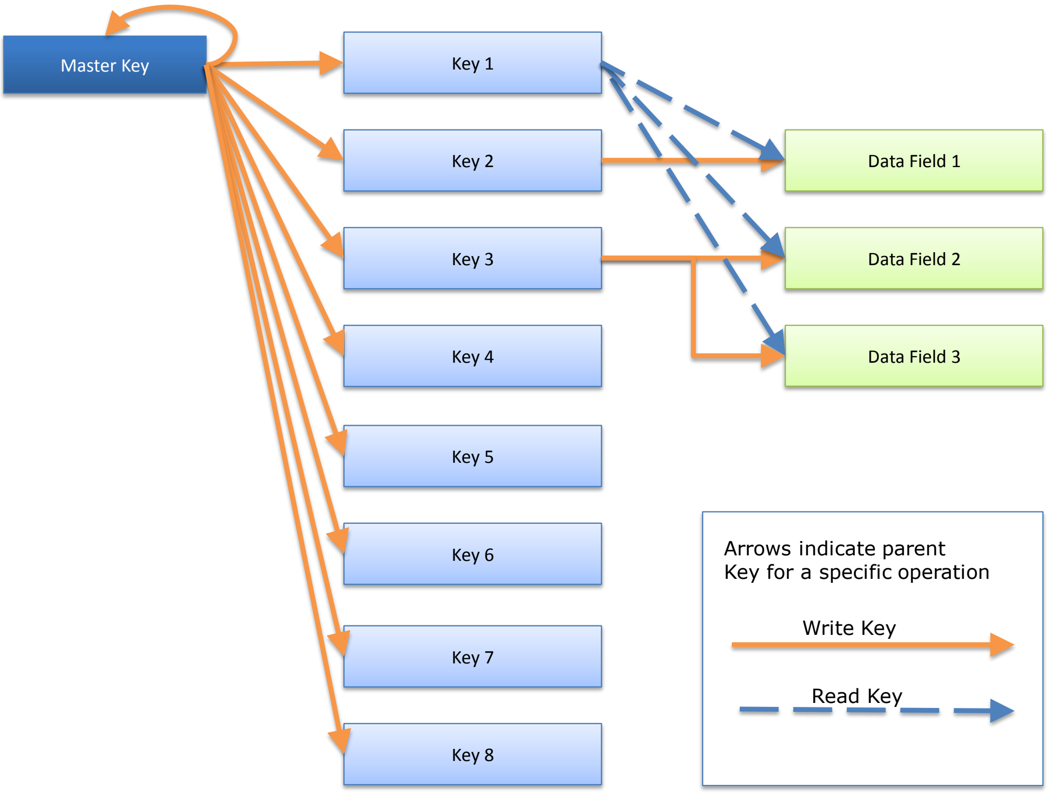


LabVIEW implementation



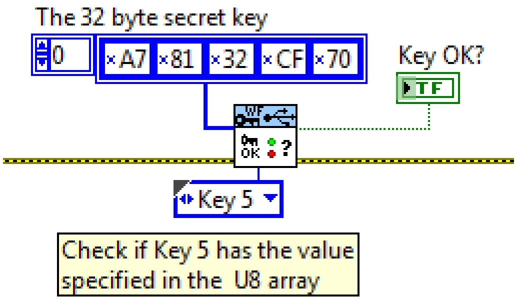
In the example above it is the LabVIEW VI *CheckCryptoKey.vi* (the one with the key symbol on the icon) that checks that the Key 5 memory in the dongle has the correct value. The communication between this LabVIEW VI and the dongle is encrypted to avoid the system being hacked. Please see chapter The technology behind the Security Suite for more details regarding this encrypted communication.
Before shipping the LabVIEW application to the end customer, the application must be built into an .exe file (or .rtexe or .lvbit etc) to make sure that the end user cannot find the secret key by analysing the source code. (Or use asymmetric keys to prevent end user to find out the secret key even if he can analyse the source code. Please see the chapter Using asymmetric keys for more information).

A mentioned before the dongle may be thought of as an ordinary USB flash memory that holds secret keys and data. The WireFlow dongles have a memory structured like this:

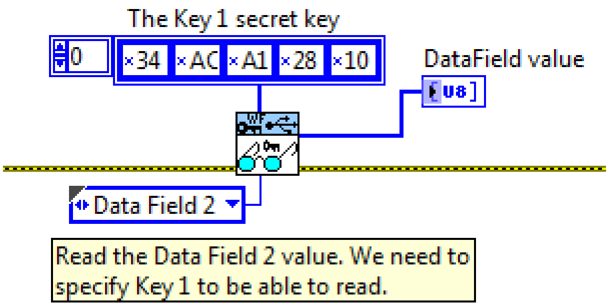


Each rectangle represents a 32 byte (256 bits) memory cell. The 9 keys can be written and "queried for match" but cannot be read. The data fields can be both written and read.

When doing a "query" it is checked if a key has a specific value. The result of this query is True or False.

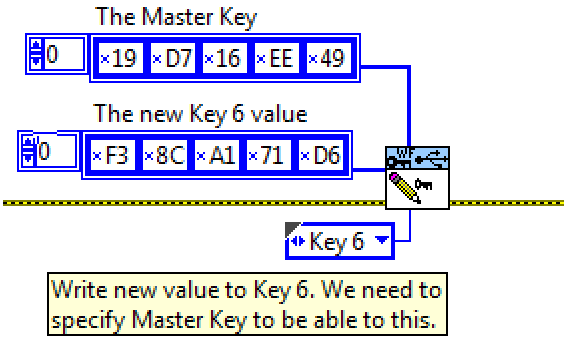


To read a data field, the value of its parent key must be specified.



Read the Data Field 2 value. We need to specify Key 1 to be able to read.

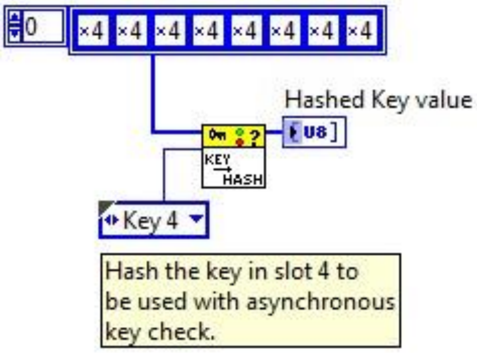
To write a new value to a key or data field, the value of its parent key must be specified.



Write new value to Key 6. We need to specify Master Key to be able to this.

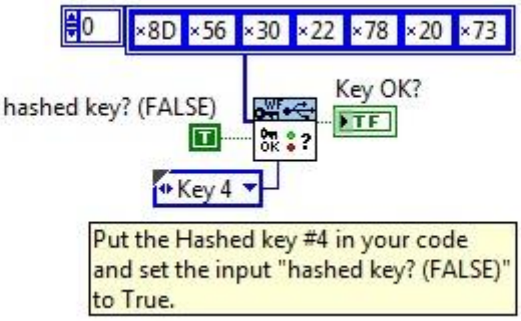
Using asymmetric keys

There is a more advanced way of protecting the secret key, by using asymmetric keys. By using asymmetric keys you never have to store the actual key in your application. This means that even if someone looks in the source code they can't manufacture their own dongles using that information. To use this function the secret key must first be run through a hash algorithm. This can be done using the VI CreateHashFromKey.vi in the Dongle Authentication driver or the hashed key can be seen in the Security Suite Programming Application (see more in the chapter on the Security Suite Programming Application).



Hash the key in slot 4 to be used with asynchronous key check.

After a hashed key is created (either in the Security Suite Programming Application or by using the authentication driver), the check should be implemented by setting the input "hashed key? (FALSE)" to true and to use the hashed key as key value.



Put the Hashed key #4 in your code and set the input "hashed key? (FALSE)" to True.

By doing this the real key will never be present in your application.

The components

The WireFlow security suite provides a complete set of components used to add software security to LabVIEW applications.

The dongles

Two types of dongles are currently available:

- The WF 2008 is an USB dongle for standard LabVIEW for Windows, Mac and Linux.
- The WF 2007 is an USB dongle for LabVIEW RT (Real Time) platforms.

The Security Suite Programming application

The programming application is a Windows application used to program and manage the dongles. It is with this application you program the secret keys into the dongles.

The LabVIEW drivers

The LabVIEW drivers are used to add software protection into your applications. There are actually two sets of drivers

- The WF USB Security dongle driver is the basic driver to communicate with the USB dongles and to do key validation etc.
- The WF Authentication module contains low level functions used by the WF USB Security dongle driver. It can be used by itself by advanced users that need advanced security functions, such as separating the dongle communication from the authentication control into separate targets etc.

The technology behind the Security Suite

This chapter will go through the basic functions of the technology that is used in the Security suite. After you read this chapter you will have a better understanding of the functions that the Security Suite offers.

SHA-256

The key functionality in the Security Suite is built around the SHA-256 algorithm. This algorithm is part of the SHA 2 family which is used throughout many different applications today.
The SHA-2 hash function is implemented in some widely used security applications and protocols, including TLS and SSL, PGP, SSH, S/MIME, Bitcoin and IPsec.

Hash functions

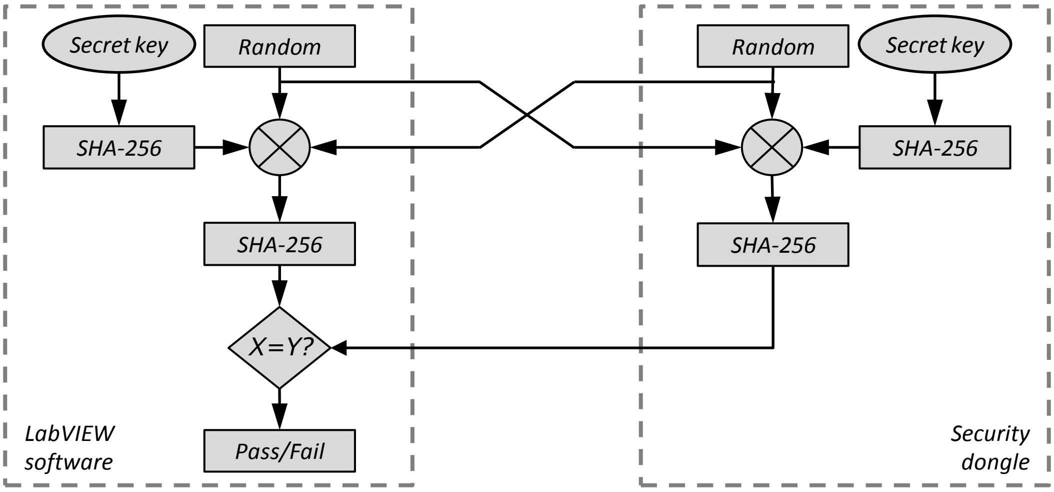
The SHA 2 family is based upon the use of hashes.
A hash function is an algorithm that transforms (hashes) an arbitrary set of data elements, such as a text file, into a single fixed length value (the hash). The computed hash value may then be used to verify the integrity of copies of the original data without providing any means to derive said original data.
As the name implies the SHA 256 is built upon hashes with the internal length of 256 bits (32 bytes).

The implementation in the Security Suite

The WireFlow Security Suite uses SHA-256 in conjunction with random numbers to make the password comparison. Two slightly different sequences are used depending on the type of key that is used, i.e. symmetric or asymmetric keys. (*Note that this is a schematic picture and may not exactly represent every input and output of every step in the process.*)

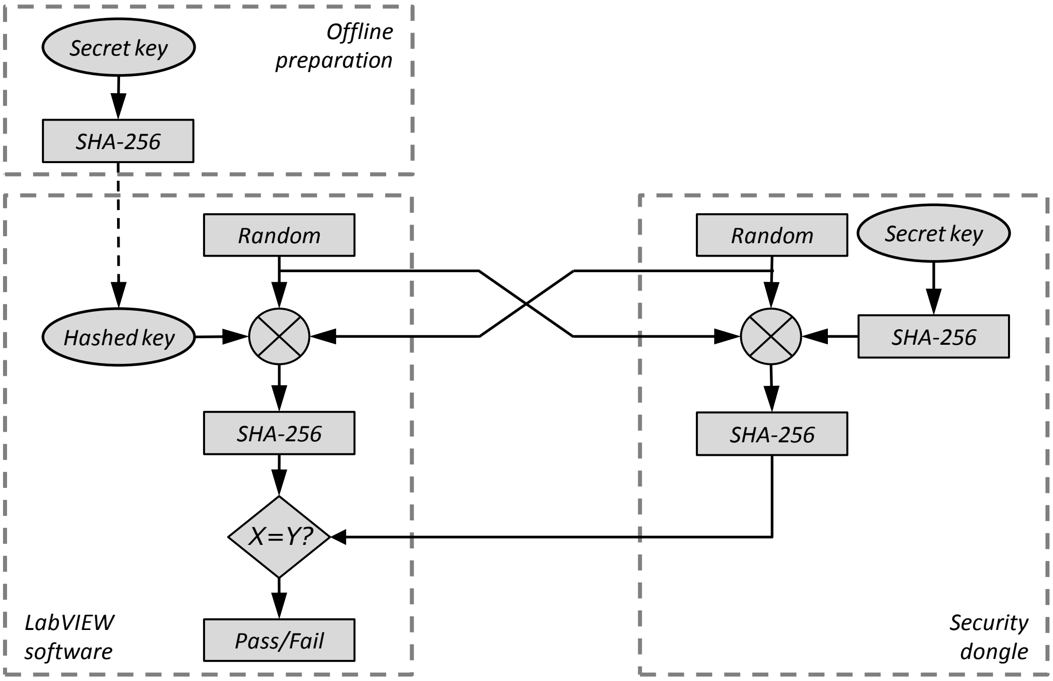
Symmetric keys

1. Both the dongle and the LabVIEW driver generate a random number and these numbers are sent to each other. The use of random numbers will make the SHA-256 result different every time it’s run, thus making sniffing on the interface between the dongle and the LabVIEW code useless as there will be a different result every time.
2. Both the dongle and the LabVIEW code combine the secret key and the two random values created in step 1.
3. A SHA-256 calculation is made on the result from step 2.
4. The driver gets the result from the SHA-256 from the dongle and compares this to its own SHA-256 result. If the secret key has the same value in both dongle and driver, then the SHA-256 results will match.



Asymmetric keys

The difference here compared to the symmetric keys is that the hash of the secret key is done offline in advance for the LabVIEW part. Since only the hashed key is stored in the LabVIEW software the secret key cannot be obtained even if studying the LabVIEW source code.



The USB Hardware

The USB security dongles used a dedicated crypto chip for secure storage of the secret keys. An embedded processor handles the interface between the cryptochip and the USB interface.

Inside the crypto chip there are twelve 32 byte (256 bits) memory cells. Nine of these are used for keys that may be written and "queried for match" but may not be read. Three data fields may be written and read.

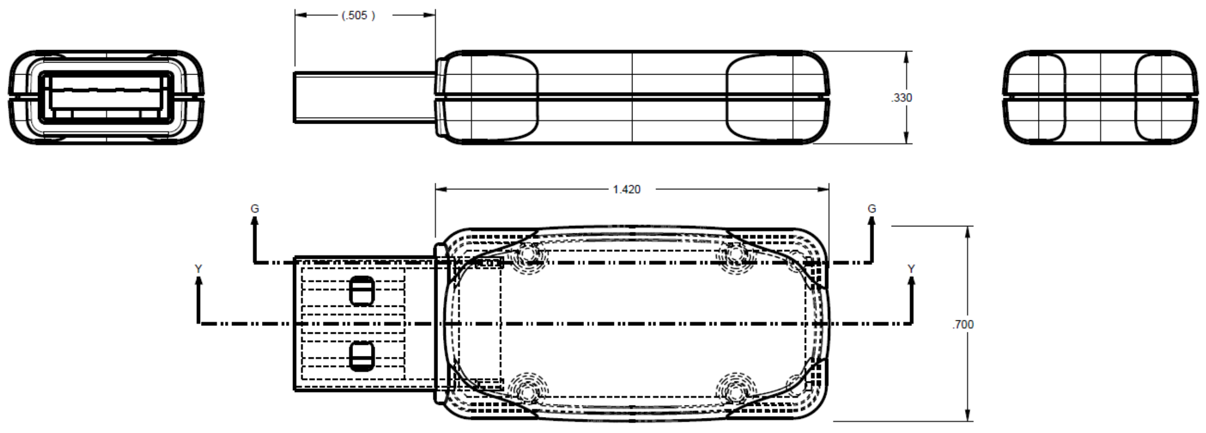
Each memory cell has a guaranteed life of 100.000 write cycles

When dongles are shipped from WireFlow they have a factory setting like this:

Memory cell	Factory setting
Master Key	Encrypted value
Key 1	0x01, 0x01, 0x01, 0x01 .....
Key 2	Encrypted value
Key 3	Encrypted value
Key 4	0x04, 0x04, 0x04, 0x04 .....
Key 5	0x05, 0x05, 0x05, 0x05 .....
Key 6	0x06, 0x06, 0x06, 0x06 .....
Key 7	0x07, 0x07, 0x07, 0x07 .....
Key 8	Encrypted value
Data Field 1	0xD1, 0xD1, 0xD1, 0xD1 .....
Data Field 2	0xD2, 0xD2, 0xD2, 0xD2 .....
Data Field 3	0xD3, 0xD3, 0xD3, 0xD3 .....

The cells that have "Encrypted value" in the factory setting can only be reprogrammed using the WF Security Suite Programming Application. Think of it as a kind of activation of the dongles that is needed before they can be used.

Dimensions



Electromagnetic Compatibility

The USB security dongles meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- SS EN 61326-1:2013 Electrical equipment for measurement
- FCC Part 15 Emissions

CE Compliance CE

The USB security dongles meets the essential requirements of applicable European Directives as follows:

- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

The WF 2007

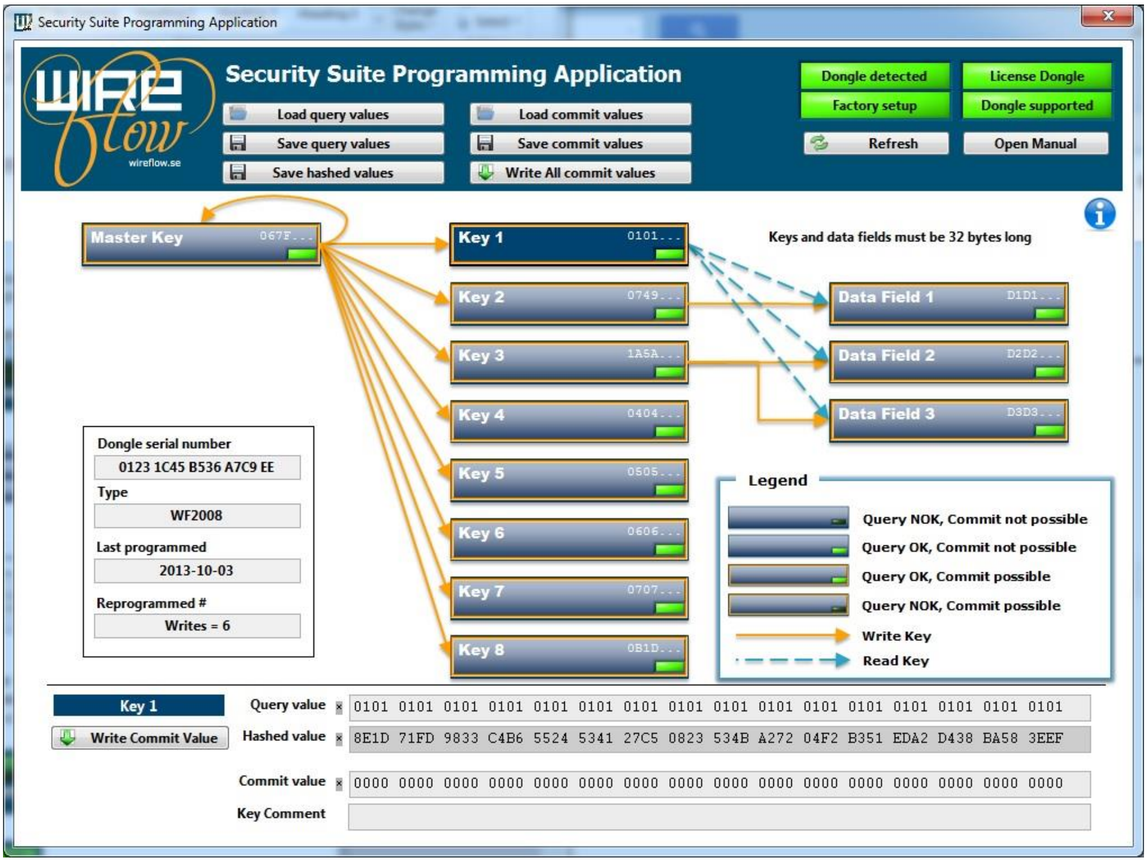
The WF 2007 is the key to use if you want to protect a LabVIEW RT (Real Time) application. It will work on any RT target such as cRIO, PXI or desktop targets as long as there is a free USB slot.

The WF 2008

The WF 2008 will work on any LabVIEW targets such as standard PC/MAC or Linux machine with a spare USB slot. It will also work on for example a PXI controller running Windows.

Security Suite Programming Application

When receiving your dongles from WireFlow they have to be programmed with your specific secret key(s). The Programming application is the tool to help you manage this.
This chapter will guide you through the steps of that process.



Keys and data fields must be 32 bytes long

Dongle serial number: 0123 1C45 B536 A7C9 EE
Type: WF2008
Last programmed: 2013-10-03
Reprogrammed #: Writes = 6

Query value: 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101 0101
Hashed value: 8E1D 71FD 9833 C4B6 5524 5341 27C5 0823 534B A272 04F2 B351 EDA2 D438 BA58 3EEF
Commit value: 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000
Key Comment:

Requirements

LabVIEW 2011 runtime, download here
NI-VISA (version >=5.4), download here

Installation and licensing

The Security Suite Programming Application may be downloaded from www.wireflow.se.
Run the installer and follow the online instructions for installation.
The setup file doesn't include LabVIEW 2011 runtime or the required NI-VISA driver but they can be found on NI's webpage for download (if you have LabVIEW 2011 or later installed they are probably already installed).

Besides installing the application, you will also need to install the WF USB dongle device driver for Windows.
The device driver is an .inf file that can be found on your computer in the folder:
`C:\ProgramData\WireFlow\WF Security Suite\Device driver\Windows Device driver`
The device driver .inf file can also be downloaded from www.wireflow.se.

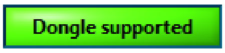
Follow the installation instruction located together with the .inf file.

To be able to program your dongles with new keys you will have to acquire a license for the tool. The license will come in the form of a USB dongle (what else :-) as seen in the picture below.

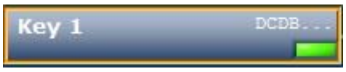
There are different options for the License dongle depending which USB HW you want to program. Either you buy a license where you will be able to program WF 2007, WF 2008 or you buy the option to program both the WF 2007 and WF 2008. You will only be able to program the type of dongles that you acquired license for.
For pricing information please go to www.wireflow.se

Description of the front panel objects

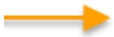
Load query values	Loads query values from file.
Save query values	Saves current query values to file
Save hashed values	Save current hashed values to file
Load commit values	Load commit values from file
Save commit values	Saves current commit values to file
Write All commit values	Write all current commit values to the dongle
Refresh	Makes a forced refresh on all dongles.
Open Manual	Opens this manual
ℹ	Gives you information about the Programming Application and inserted dongles. Use this information if you need to create a trouble report.
Dongle detected	Indicates if a dongle (WF2007, WF2008) is detected.
Factory setup	Indicates that the detected dongle has factory default values
License Dongle	Lit when a (black) License Dongle is detected in the system


Dongle supported

Lit when there is a correct license on the License Dongle to program the detected dongle (WF2007, WF2008)

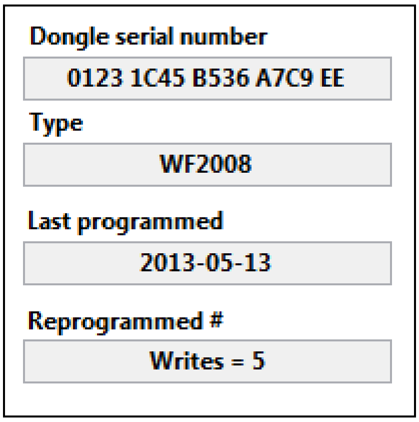


Each of these boxes represent a memory cell in the crypto chip. In this case it is the Key 1 cell. The *DCDB...* indicates the two first bytes of the in total 32 byte long so-called Query value. The green LED indicates that the Query value is matched to the content of the cell. This means that when LED is green we know the value of the cell, i.e. the query value. If LED is off, we do not know the content of the cell. We cannot read the content. We can only provide a query value and then check if it is a match or not. You may notice that the box has an orange outline. This indicates that you may write a new data to the cell. Precondition for this is that you have a correct query value for the parent cell.



This is a "write-arrow". It indicates which key/box that must have a green LED in order to be able to write a new value into the cell. Note that the Master key is very important. As long as you know the master key you can re-program the dongle. If you lose the Master key you can no more re-program the dongle.

This is a "read-arrow". It indicates which key/box that must have a green LED in order to be able to read the value from the cell.


Dongle serial number

0123 1C45 B536 A7C9 EE

Type

WF2008

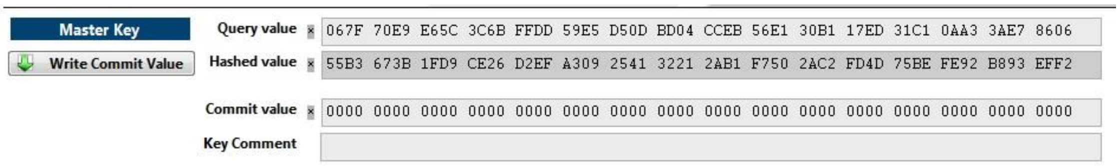
Last programmed

2013-05-13

Reprogrammed #

Writes = 5

Shows information on the detected dongle



Query value 067F 70E9 E65C 3C6B FFDD 59E5 D50D BD04 CCEB 56E1 30B1 17ED 31C1 0AA3 3AE7 8606

Hashed value 55B3 673B 1FD9 CE26 D2EF A309 2541 3221 2AB1 F750 2AC2 FD4D 75BE FE92 B893 EFF2

Commit value 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000

Key Comment

The dongle management field is located in the lower part of the application. It is here that you can analyse and re-program the 32 bytes in a specific cell.

It’s also where you can see the hashed value of the current Query value. This value should be used in your application if you are using asymmetric keys.

Using the program

Since the program cannot read data cells from the dongles, but only query and check values it is important to know the content of the dongle to be able to re-program the dongle. Therefore make sure to always keep track of the values you program into a dongle. You can use the Save commit values button to save your programmed values to file.

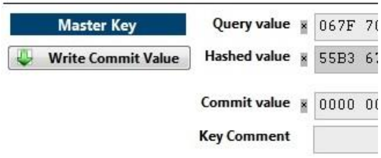
Factory setting

When a dongle is shipped from WireFlow it has a factory setting, please see chapter The USB Hardware.

When a dongle is detected by the WF programming application it will always check for the factory setting. If a factory default value is detected then the program will automatically fill in this value into the Query value field. The program also knows how to decrypt the three cells that are encrypted in the factory setting. The only way to decrypt the cells that are encrypted in the factory setting is to use the WF Programming Application to decrypt it.

Managing a dongle

In the dongle management field in the lower part of the application, you can see the text Master Key in the top left corner.



Query value 067F 7

Hashed value 55B3 6

Commit value 0000 0

Key Comment

This indicates that it is the Master Key that is now selected. To select another cell, just click on the desired box in the memory overview layout.

To check if a specific cell has a specific value you should enter the 32 byte value in the Query field (and press Return). Now check if the green LED in the corresponding box turns on or off. If it is on then you have the correct value in the Query field.

In the Hashed value field you can see the hashed value of the current Query value. The hashed value should be used instead of the Query value when using asymmetric keys.

To write a new value to a cell you must first make sure that the cell has an orange border around the box. You will get this by entering the correct Query value of the parent key. Just follow the orange write-arrow backwards to find the parent key.
When you have the orange border make sure to select the cell that you want to write to. Now fill in the desired data in the Commit value. Press the Write Commit value button to write to the key.

The Key comment can be used for descriptive text. This will not be programmed into the dongle. It is a text only used by this program. The comment will be stored in the configuration files when pressing Save query values or Save commit values.

Configuration files

When you have programmed a dongle the way you want, it is possible to store this configuration in a configuration file.
To be sure to save the data for all fields, you should fill in data for all cells in the Commit field. When this is done you can save all commit data to file by pressing Save commit values.

If you are going to create several dongles with this setup then you just insert a new dongle (with factory setting). The tool will notice that it is a with factory setting and will automatically fill in the correct Query values and turn on all the green LED's.
Now press Load commit values and then press Write All to program a new dongle identical to the one you did when you saved the configuration file.

Note that the query file format is identical to the commit file format. This means that you can do a Save commit values and then read the same file with Load query values. This feature can be used to copy data from one dongle to another etc.

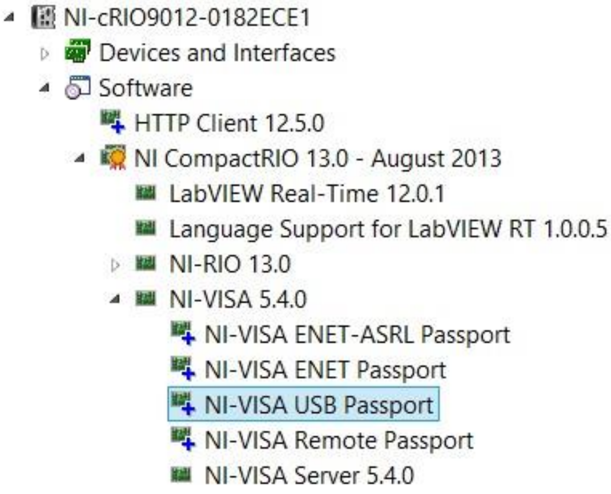
The WF USB Security dongle driver

This easy-to-use LabVIEW driver is used to add security functions to LabVIEW applications.

Requirements

LabVIEW (version >= 2011)
NI-VISA (version >=5.4)
VI Package Manager (for installation)

NI-VISA USB Passport (Needed for RT targets only)



```
NI-cRIO9012-0182ECE1
  Devices and Interfaces
  Software
    HTTP Client 12.5.0
    NI CompactRIO 13.0 - August 2013
      LabVIEW Real-Time 12.0.1
      Language Support for LabVIEW RT 1.0.0.5
      NI-RIO 13.0
      NI-VISA 5.4.0
        NI-VISA ENET-ASRL Passport
        NI-VISA ENET Passport
        NI-VISA USB Passport
        NI-VISA Remote Passport
        NI-VISA Server 5.4.0
```

Installation

The WF USB Security dongle driver may be downloaded from www.wireflow.se. For the installation you will need the VI Package Manager which may be downloaded from www.ni.com or from jki.net. The installation procedure is quite straightforward. Just follow the online instructions.

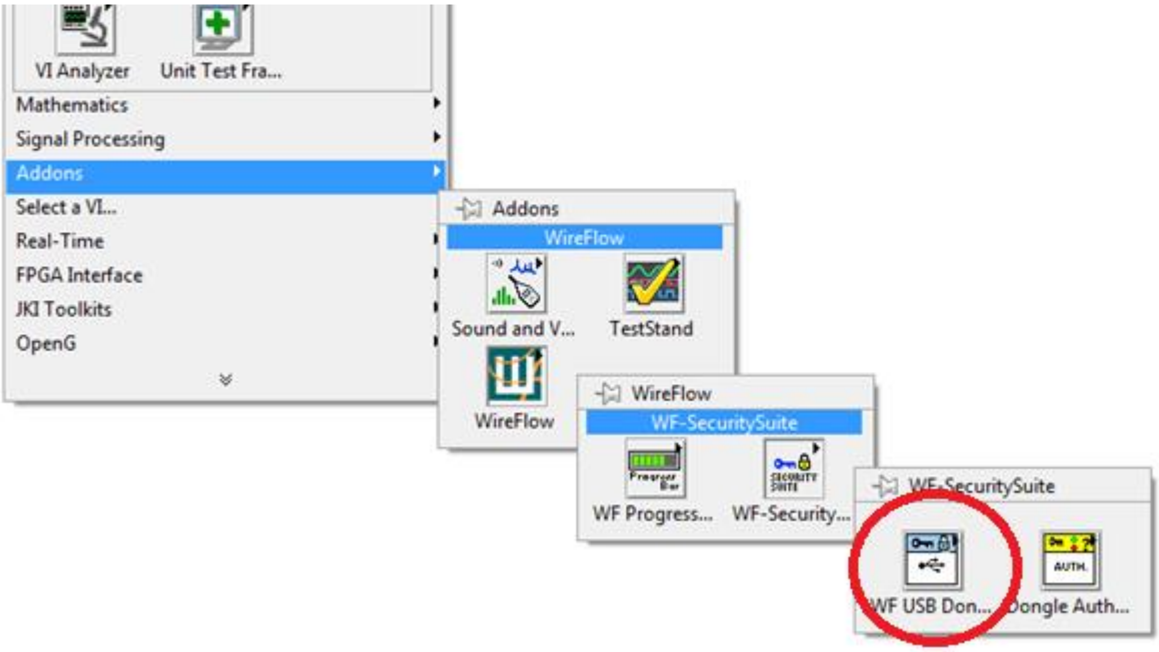
Note that the WF USB Security dongle driver uses functions included in the WF Authentication module, so you must install that driver also. It may also be downloaded www.wireflow.se.

Device driver for Windows

To be able to run the code against the USB dongles on Windows platform you also need to install the WF USB dongle device driver for Windows.
The device driver is an .inf file that can be found on your computer in the folder:
`C:\ProgramData\WireFlow\WF Security Suite\Device driver\Windows Device driver`
The device driver .inf file can also be downloaded from www.wireflow.se.
Follow the installation instruction located together with the .inf file.

Installed items

The driver VIs are found in the functions palette:



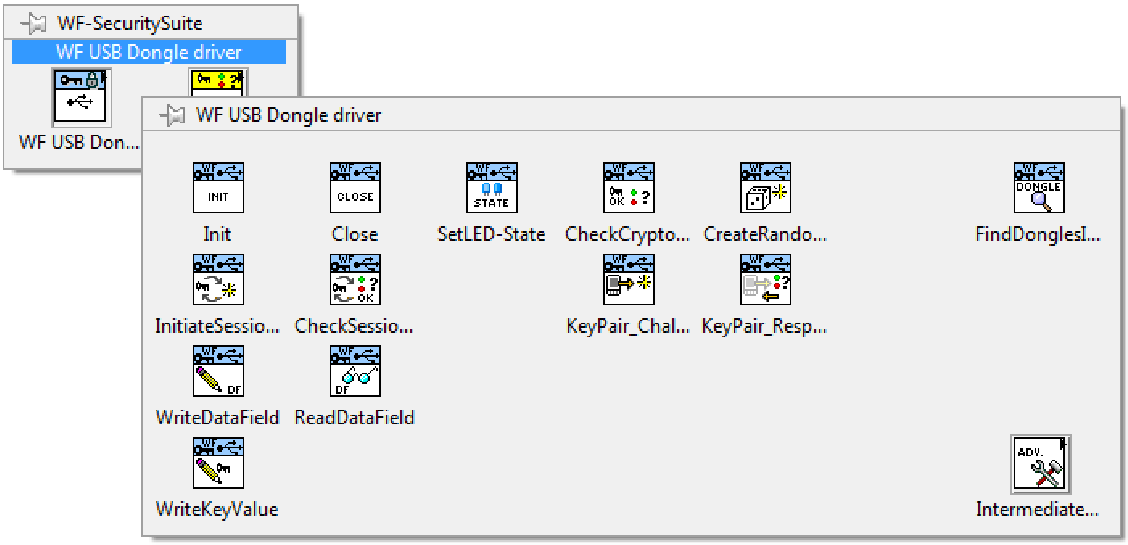
The user's manual is installed and found under the menu >Help >WireFlow

Some developers tools are found under the menu >Tools >WireFlow

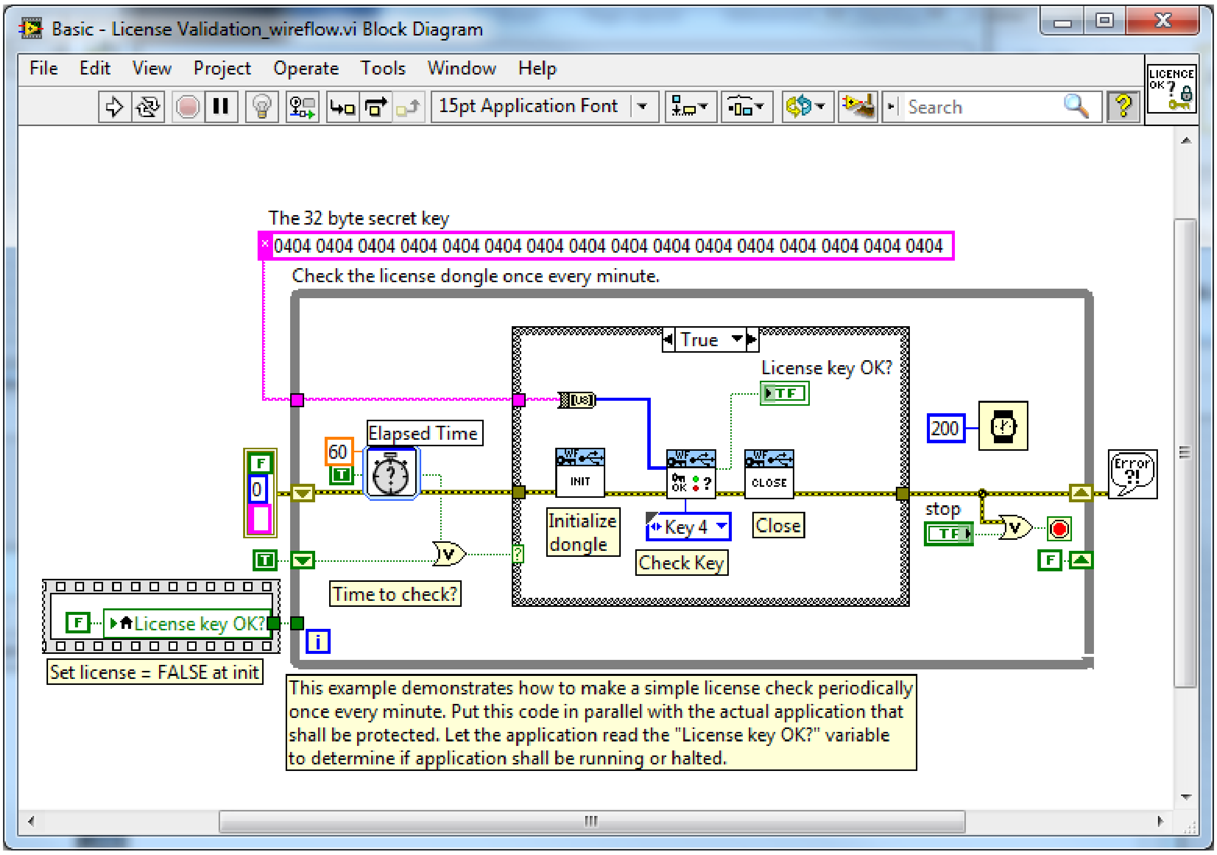
Examples are found under the menu >Help > Find Examples...
To find the examples select the Search tab and then perform a search for the keywords “dongle” or “WireFlow”

The basic VIs

The basic VIs are found in the tools palette:



- There are two VIs for connecting and disconnecting to a dongle (Init and Close).
- There are two VIs for writing and reading to the data fields (WriteDataField and ReadDataField).
- There are VIs for writing and checking key values (WriteKeyValue and CheckCryptoKey). Remember that key values cannot be read, only checked.
- There is one VI for changing the behaviour of the internal LED in the HW called SetLED-State.
- There are two VIs to initiate and check a Session Key, i.e. a key only used in the session.
- There are two VIs to be used for remote/offline challenge response, e.g. to validate a communication link
- There is one VI to create cryptographically safe random number.
- Finally there is one VI called FindDonglesInSystem which can be used for the rare case that your application should need to use multiple dongles in the same system.



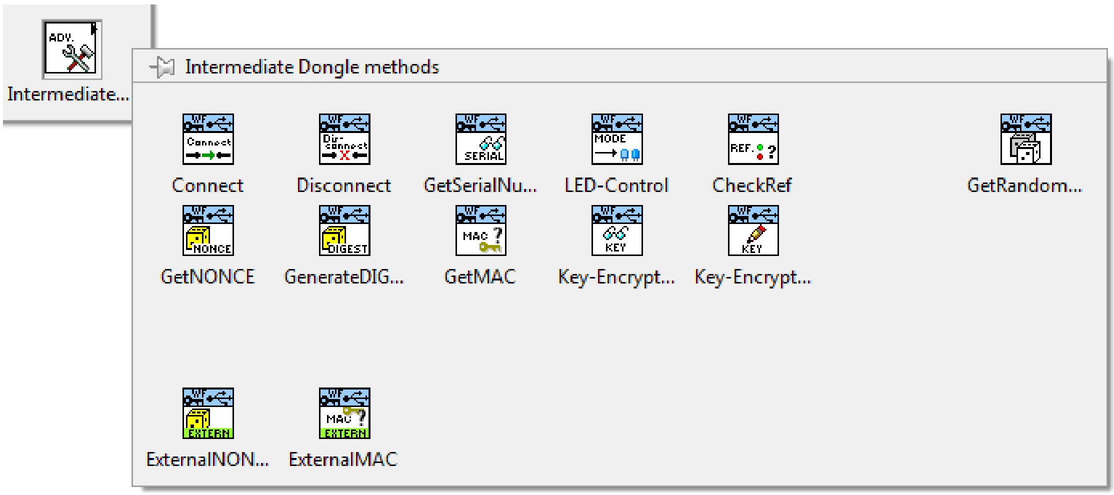
This example demonstrates how to make a simple license check periodically once every minute. Put this code in parallel with the actual application that shall be protected. Let the application read the "License key OK?" variable to determine if application shall be running or halted.

The diagram above shows how easy it can be to implement a check that a dongle with the correct key is inserted into the system. Just do; Init, CheckCryptoKey and Close.

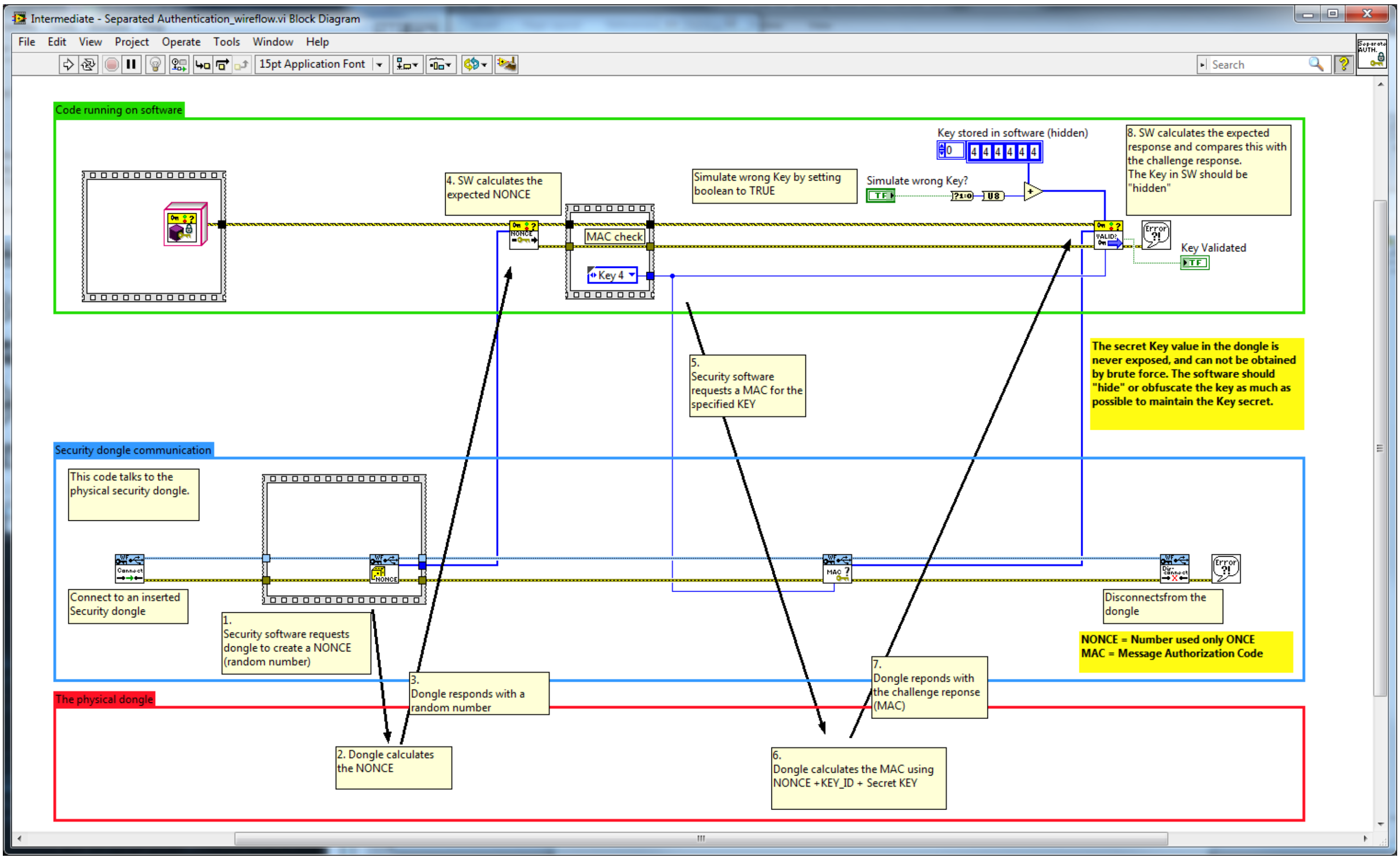
Please also study the other basic examples found under >Help > Find Examples... They will give examples on how to implement user identification, demo time expiration etc.

The intermediate VIs

The intermediate VIs are found in this palette:



These VIs are available for users that need to do more advanced functions. With these VIs you can for example manage systems with multiple dongles. You can check if a dongle is still active etc.
You can also use these VIs together with VIs from the WF Authentication module library to create advanced applications that separate the authentication functions from the USB dongle communication. By doing like this it is for example possible to check that a specific dongle is inserted on a specific computer elsewhere. It can for example be used for user identification on remote machines etc.
The following example illustrates how this kind of application can be implemented.



4. SW calculates the expected NONCE

Simulate wrong Key by setting boolean to TRUE

8. SW calculates the expected response and compares this with the challenge response.
The Key in SW should be "hidden"

5.
Security software requests a MAC for the specified KEY

The secret Key value in the dongle is never exposed, and can not be obtained by brute force. The software should "hide" or obfuscate the key as much as possible to maintain the Key secret.

This code talks to the physical security dongle.

Connect to an inserted Security dongle

1.
Security software requests dongle to create a NONCE (random number)

3.
Dongle responds with a random number

2. Dongle calculates the NONCE

6.
Dongle calculates the MAC using NONCE +KEY_ID + Secret KEY

7.
Dongle reponds with the challenge reponse (MAC)

Disconnectsfrom the dongle

NONCE = Number used only ONCE
MAC = Message Authorization Code

To gain more knowledge on the intermediate VIs please read the VI info for each VI and study the intermediate examples available under >Help > Find Examples...

The WF Authentication module

The Authentication module is responsible for the encoding/decoding as well as the calculation of expected results for a Key check.

Although this driver is able to run stand-alone it is designed to be used with hardware from the WF Security Suite. The standard user of the WireFlow security Suite will not use these VIs directly. Instead he will only use these VIs indirect via the more easy to use WF USB Security dongle driver

Requirements

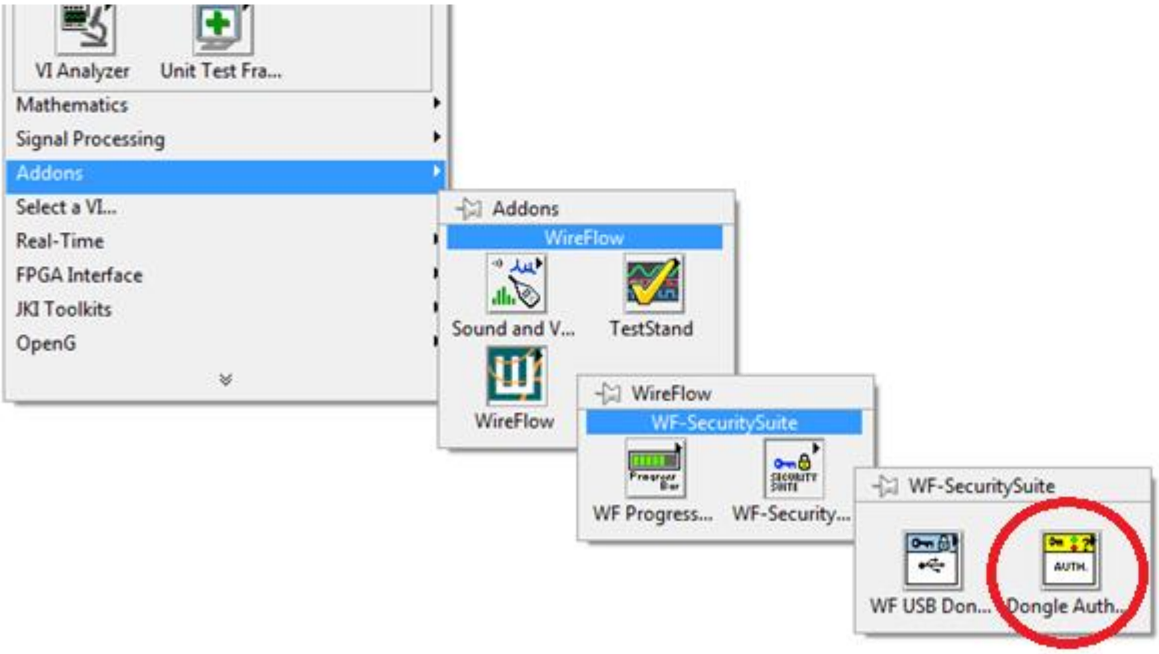
LabVIEW (version >= 2011)
VI Package Manager (for installation)

Installation

The WF Authentication module may be downloaded from www.wireflow.se. For the installation you will need the VI Package Manager which may be downloaded from www.ni.com or from jki.net. The installation procedure is quite straight forward. Just follow the online instructions.

Installed items

The module VIs are found in the functions palette:

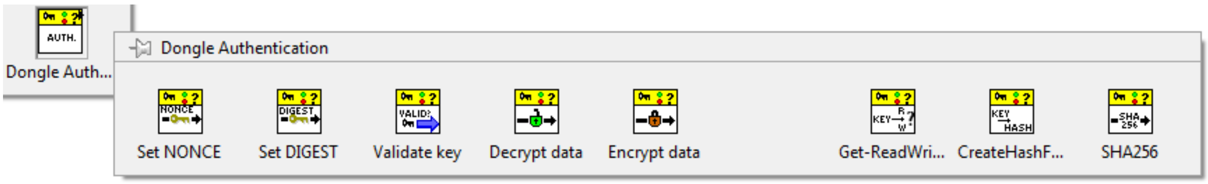


The user's manual is installed and found under the menu >Help >WireFlow

Examples are found under the menu >Help > Find Examples...
To find the examples select the Search tab and then search on the keyword dongle or WireFlow

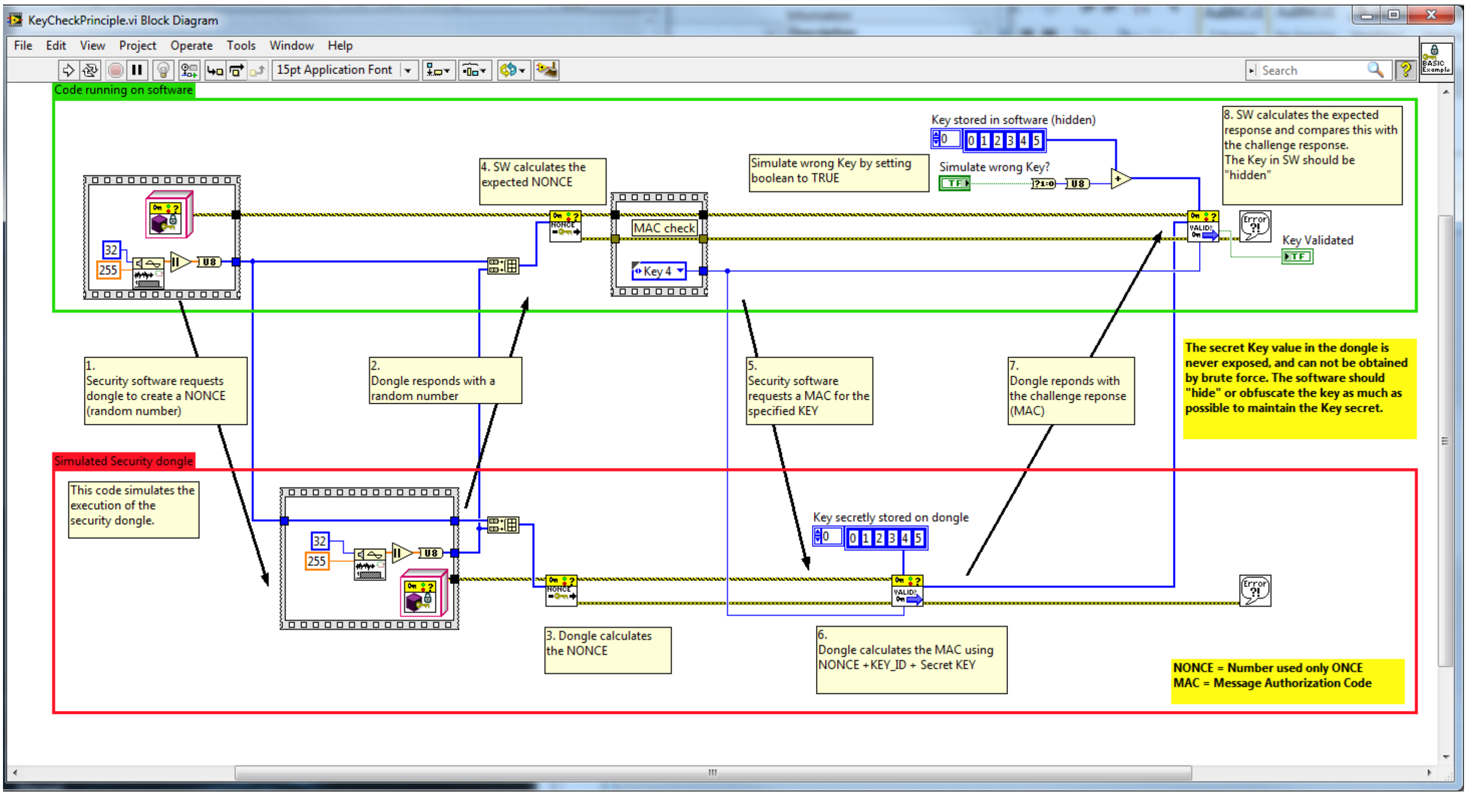
The VIs

The VIs are found in the tools palette:



As mentioned before these VIs are normally not used directly by the application programmer, instead they are used as subVIs for the WF USB Security dongle driver.
To learn how to use these VIs directly please read the VI info for each VI and study the example available under >Help > Find Examples...

The following advanced example shows how the VIs are used to communicate with a simulated hardware dongle.


KeyCheckPrinciple.vi Block Diagram
File Edit View Project Operate Tools Window Help
15pt Application Font
Search
BASIC Example
Code running on software
32
255
U8
NONCE
MAC check
Key 4
Key stored in software (hidden)
0
0 1 2 3 4 5
Simulate wrong Key?
TF
?1:0
U8
VALID?
Error ?!
Key Validated
TF
Simulated Security dongle
Key secretly stored on dongle

4. SW calculates the expected NONCE

Simulate wrong Key by setting boolean to TRUE

8. SW calculates the expected response and compares this with the challenge response.
The Key in SW should be "hidden"

1.
Security software requests dongle to create a NONCE (random number)

2.
Dongle responds with a random number

5.
Security software requests a MAC for the specified KEY

7.
Dongle reponds with the challenge reponse (MAC)

The secret Key value in the dongle is never exposed, and can not be obtained by brute force. The software should "hide" or obfuscate the key as much as possible to maintain the Key secret.

This code simulates the execution of the security dongle.

3. Dongle calculates the NONCE

6.
Dongle calculates the MAC using NONCE +KEY_ID + Secret KEY

NONCE = Number used only ONCE
MAC = Message Authorization Code