Functional description | EN

TF5200 | TwinCAT 3 CNC

CNC Program encryption
Notes on the documentation

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It is essential that the documentation and the following notes and explanations are followed when installing and commissioning the components.

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Icons used and their meanings
This documentation uses the following icons next to the safety instruction and the associated text. Please read the (safety) instructions carefully and comply with them at all times.

Icons in explanatory text
1. Indicates an action.
   ⇒ Indicates an action statement.

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>☢️</td>
<td>Indicates an action.</td>
</tr>
<tr>
<td>🚨</td>
<td>Indicates an action statement.</td>
</tr>
</tbody>
</table>

**DANGER**

**Acute danger to life!**
If you fail to comply with the safety instruction next to this icon, there is immediate danger to human life and health.

**CAUTION**

**Personal injury and damage to machines!**
If you fail to comply with the safety instruction next to this icon, it may result in personal injury or damage to machines.

**NOTE**

**Restriction or error**
This icon describes restrictions or warns of errors.

- **Tips and other notes**
  This icon indicates information to assist in general understanding or to provide additional information.

General example
Example that clarifies the text.

NC programming example
Programming example (complete NC program or program sequence) of the described function or NC command.

- **Specific version information**
  Optional or restricted function. The availability of this function depends on the configuration and the scope of the version.
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1 Overview

Task
Controller/machine manufacturers supply encrypted NC programs that end-users are not allowed to modify and cannot view.

The NC kernel processes encrypted NC programs.

Properties
An encrypted NC program is recognised by its file extension. A key used for encryption and decryption must be defined for every file extension. Every file extension and the associated key define an encryption group.

A file is recognised as encrypted if its extension matches one of the encryption group file extensions. The CNC uses the associated key to decrypt the file automatically during NC program decoding.

The **program ISGCrypter** can be used for encryption. The examples shown here are taken from the program.

Display
You can decrypt the encrypted NC program using the "ISGEncrypt.dll" library with the decode_cnc_file() method, provided the necessary key is known.

To display the decrypted NC program, a user interface (HMI) is required to integrate the "ISGEncrypt.dll" tool.

Parametrisation
The user can define 3 different encryption groups. The keys are transmitted by CNC objects to the NC kernel at controller start-up or before program start.

The file extensions assigned to the keys are configured in the channel parameter list.

Links to other documents
For the sake of clarity, links to other documents and parameters are abbreviated, e.g. [PROG] for the Programming Manual or P-AXIS-00001 for an axis parameter.

For technical reasons, these links only function in the Online Help (HTML5, CHM) but not in pdf files since pdfs do not support cross-linking.
2 Description

Initialisation

The following steps are required to use an encrypted NC program:

1. An NC program is encrypted with an individual key and saved to a folder.
2. The file extension is entered in the channel parameter list as an encrypted file type for the corresponding channel.
3. In parallel to the file extension, the associated key used to encrypt the file is entered in the NC kernel. Make the entry by using a write operation to a CNC object. This can be executed by the PLC.

Sequence

When an NC program is invoked, the NC kernel detects from the extension whether it is encrypted. If the NC program is detected as encrypted, the kernel decrypts it using the specified key. If the file extension is defined as not encrypted, the program is processed as a normal NC program.

NOTE

If the key is incorrect, the file is still decrypted. The NC kernel attempts to process the file and this then results in a syntax error.

CNC diagnosis

Entries of NC program parts in the CNC diagnostic data "diag_data.txt" are encrypted by a key from the controller manufacturer, i.e. they are not visible to users.

Flow chart

![Encryption/decryption flow chart of an NC program](image)

Figure 1: Encryption/decryption flow chart of an NC program
Figure 2: Displaying an encrypted NC program
3 Encryption groups and configuration

Groups

The user can define 3 different encryption groups for the NC kernel. Each of these groups consists of a pair comprising a key and a file extension. A key can contain a maximum of 56 characters plus '0'.

A file extension must consist of 1 to 3 characters. When the NC kernel loads an NC program, it checks whether the extension of the NC program is entered in one of these 3 groups. If this is the case, the NC kernel decrypts the NC program with the associated key of the applicable group.

Default configuration

Users can use the groups as they wish. The pair assignment of key and file extension is depicted in the table below:

<table>
<thead>
<tr>
<th>Group</th>
<th>Key</th>
<th>Channel parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>mc_encryption_key_0</td>
<td>encryption_extension[0] P-CHAN-00283</td>
</tr>
<tr>
<td>2</td>
<td>mc_encryption_key_1</td>
<td>encryption_extension[1] P-CHAN-00283</td>
</tr>
<tr>
<td>3</td>
<td>mc_encryption_key_2</td>
<td>encryption_extension[2] P-CHAN-00283</td>
</tr>
</tbody>
</table>

3.1 Channel parameter list

Parameterisation options for file extensions in the channel parameter list

The table below shows an example of a setting for the extensions in the channel parameter list. The file extensions for groups 1 to 3 (index 0, 1, 2) can be set.

A further group also exists. This group is permanently specified by the controller or machine manufacturer and is used for the encryption of self-created NC programs (e.g. cycles). These NC programs have the extension "ecy". It is recommended not to re-use this extension for new user-defined definitions.

<table>
<thead>
<tr>
<th>Channel parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>encryption_extension[0]</td>
<td>enc</td>
</tr>
<tr>
<td>encryption_extension[1]</td>
<td>od</td>
</tr>
<tr>
<td>encryption_extension[2]</td>
<td>e</td>
</tr>
</tbody>
</table>
3.2 ADS Service (Automation Device Specification)

Set keys via CNC objects

The keys for encryption groups must be set via CNC objects. Refer to the example below on how to address objects via the index group and index offset.

You can also set them online using the ISG object browser of the CNC.

As a security measure, all keys are only displayed hidden.

Access to encryption

All groups are accessible as shown in the example below. The arrays can be written via CNC objects.

Channel 1:

Task: COM

IDXGRP := 16#00020101 (channel 1)
IDXOFFS := 16#00000094 (mc_encryption_key_0)
IDXGRP := 16#00020101 (channel 1)
IDXOFFS := 16#00000095 (mc_encryption_key_1)
IDXGRP := 16#00020101 (channel 1)
IDXOFFS := 16#00000096 (mc_encryption_key_2)

Function block

Transfer takes place using the function block ADSWRITE(). The following applies to the example above:

fb_AdsWrite( NETID := ":",
PORT := 553,
IDXGRP := 16#00020101,
IDXOFFS := 16#00000094,
SRCADDR := ADR(mc_encryption_key_0),
LEN := SIZEOF (mc_encryption_key_0),
WRITE := TRUE
(* fb_AdsWrite.TMOUT*)
);

NOTE

When you write CNC objects, note that you may have to insert a ":0" at the string end.
4 Library methods

ISGEncryption.dll

This auxiliary DLL includes the methods for encrypting and decrypting NC programs.

- encode_cnc_file()
- decoder_cnc_file()
- get_version()

The library was designed for the European/Western character set. If different character sets are used, it may result in unforeseen side effects.

4.1 Encryption

The specified input file is fully encrypted with the specified key and is saved as the output file.

```c
long encode_cnc_file (char *pIn, char *pOut,
                      char* encryption_key, char* err_buffer)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>pIn</td>
<td>char*</td>
<td>Name for input file</td>
</tr>
<tr>
<td>pOut</td>
<td>char*</td>
<td>Name for output</td>
</tr>
<tr>
<td>encryption_key</td>
<td>char*</td>
<td>Key</td>
</tr>
<tr>
<td>err_buffer</td>
<td>char*</td>
<td>Buffer for error messages:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Key is longer than 56 characters&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;No key defined&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Could not open input file&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Could not open output file&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If a blank string is entered, no error occurred.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A maximum of 256 characters can be transmitted.</td>
</tr>
</tbody>
</table>

Return values

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>Maximum key length exceeded.</td>
</tr>
<tr>
<td>-1</td>
<td>Key missing.</td>
</tr>
<tr>
<td>0&lt;x</td>
<td>Encryption of x characters successful.</td>
</tr>
</tbody>
</table>

4.2 Decryption

The specified file is decrypted with the specified key and written to the buffer "pDest".

```c
long decode_cnc_file (unsigned char *pDest, char *pName, long offset,
                      long length, char *decryption_key,
                      char *err_buffer)
```
### Parameter

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>pDest</td>
<td>unsigned char*</td>
<td>Buffer for output</td>
</tr>
<tr>
<td>pName</td>
<td>char*</td>
<td>Name for input file</td>
</tr>
<tr>
<td>offset</td>
<td>long</td>
<td>Offset for reading in the input file</td>
</tr>
<tr>
<td>length</td>
<td>long</td>
<td>Read length</td>
</tr>
<tr>
<td>decryption_key</td>
<td>char*</td>
<td>Key</td>
</tr>
<tr>
<td>err_buffer</td>
<td>char*</td>
<td>Buffer for the following error messages:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Key is longer than 56 characters&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;No key defined&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;File offset was negative&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;File length was negative&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If a blank string is entered, no error occurred. A maximum of 256 characters can be transmitted.</td>
</tr>
</tbody>
</table>

### Return values

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>Maximum key length exceeded.</td>
</tr>
<tr>
<td>-3</td>
<td>Offset parameter is negative.</td>
</tr>
<tr>
<td>-2</td>
<td>Length parameter is negative.</td>
</tr>
<tr>
<td>-1</td>
<td>Key missing.</td>
</tr>
<tr>
<td>0&lt;x</td>
<td>Decryption of x characters successful.</td>
</tr>
</tbody>
</table>
4.3 Version number

The file version of the dll can be determined with the library method get_version(). This is the same version that is obtainable by right-clicking File => Properties => Details (see the figure below).

![Figure 3: Determining the dll file version](image)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Name</th>
<th>Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pDest</td>
<td>unsigned char*</td>
<td>Buffer for version string</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Return values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
</tr>
<tr>
<td>TRUE</td>
</tr>
<tr>
<td>FALSE</td>
</tr>
</tbody>
</table>
5 Use of the dll in a test GUI

An example of C#/.NET is provided below. This shows the use of ISGEncryption.dll by an example application in the figure below.

![GUI screenshot](image)

Figure 4: Description of the GUI (= Graphical User Interface)

5.1 Instructions and description of the example application

<table>
<thead>
<tr>
<th>Index</th>
<th>Meaning</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Password</td>
<td>This is the password to encrypt/decrypt the NC program. The password may consist of 1 to 56 characters. However, we recommend min. 8 characters. The password is not stored in the encrypted program. Its validity is not verified later. In other words, an invalid password during decryption does not lead to an abort but the program cannot be correctly encrypted nor is it readable.</td>
</tr>
<tr>
<td>2</td>
<td>Output directory</td>
<td>Besides the default directory (= directory of source file), you can select a different folder. If you use a different directory than that of the source file, tick the box below. If selected, all decrypted/encrypted files are saved here.</td>
</tr>
<tr>
<td>3</td>
<td>Encrypted files</td>
<td>File extension for encrypted files; *.ecy is the default. The file extension is also the file filter for decryption. Files with this extension are automatically detected as encrypted and decrypted at start.</td>
</tr>
<tr>
<td>4</td>
<td>NC files</td>
<td>Files with this extension are automatically detected as NC files and encrypted at start.</td>
</tr>
<tr>
<td>5</td>
<td>Add file</td>
<td>Add one or several files to the list to be processed (see in the window below).</td>
</tr>
<tr>
<td>6</td>
<td>Delete marked list entries</td>
<td>Marked list entries are removed from the program.</td>
</tr>
<tr>
<td>7</td>
<td>Open log directory</td>
<td>Open the directory containing the log files. The log files are generated in the selected language when they are encrypted or decrypted.</td>
</tr>
<tr>
<td></td>
<td>Start</td>
<td>Start of encryption or decryption. All entries in the list are processed, regardless of whether elements are marked in the list or not. First remove files from the list if they are not to be processed.</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>9</td>
<td>Add folder</td>
<td>Add the contents of an entire folder with the file filter (4) of the list to be processed (see window below).</td>
</tr>
<tr>
<td>10</td>
<td>Delete list</td>
<td>Removes all current entries from the encryption/decryption list.</td>
</tr>
<tr>
<td>11</td>
<td>Source file</td>
<td>Indicates what course files are encrypted/decrypted.</td>
</tr>
<tr>
<td>12</td>
<td>Destination file</td>
<td>Indicates the destination files created for encryption/decryption.</td>
</tr>
<tr>
<td>13</td>
<td>Status</td>
<td>The current status for encrypting/decrypting the file.</td>
</tr>
<tr>
<td>14</td>
<td>Link</td>
<td>Link to the output file folder.</td>
</tr>
<tr>
<td>15</td>
<td>Marked files</td>
<td>Number of marked elements / total number of elements</td>
</tr>
<tr>
<td>16</td>
<td>ISG Crypter Version</td>
<td>Program version.</td>
</tr>
<tr>
<td>17</td>
<td>DLL version</td>
<td>Version of the dll for decryption.</td>
</tr>
<tr>
<td>18</td>
<td>Language</td>
<td>Set the required language. The possible languages are 'German', 'English', 'Russian', 'Italian', 'Spanish', 'French', 'Japanese' and 'Chinese'. The English terms are kept even when the language is changed.</td>
</tr>
</tbody>
</table>

### 5.2 Encryption example

![Image of ISG CNC Editor](image)

**Figure 5:** View of the source file with readable code
Procedure to encrypt a file

The file in the figure “View of the source file with readable code” is encrypted. ISGEncryption.dll must be in the same folder as the example application.

1. In this case, choose "asdf" as the password.
2. Select "Encrypt_Example.enc" (in the same folder as the input file) as the output file.
3. The result should be similar to the figure “Encrypted files”.
4. Select the output file with "Decrypt File".
5. Enter 0 for "Start" and 16 for "Length".
6. Click "Show" should return the same output as in the figure “Source data”.

Figure 6: Encrypted file with encrypted code
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