CiA Draft Standard 405

CANopen

Interface and Device Profile for IEC 61131-3 Programmable Devices

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HISTORY

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1 Scope

This document represents the standardised CANopen Interface and Device Profile for IEC 61131-3 programmable devices like PLCs.

All the above devices use communication techniques which conform to those described in the CiA Draft Standard DS-301 (Application Layer and Communication Profile) and Draft Standard Proposal DSP-302. These documents should be consulted in parallel to this profile.

In general, generating an application implements the handling of up to five interfaces see the figure.

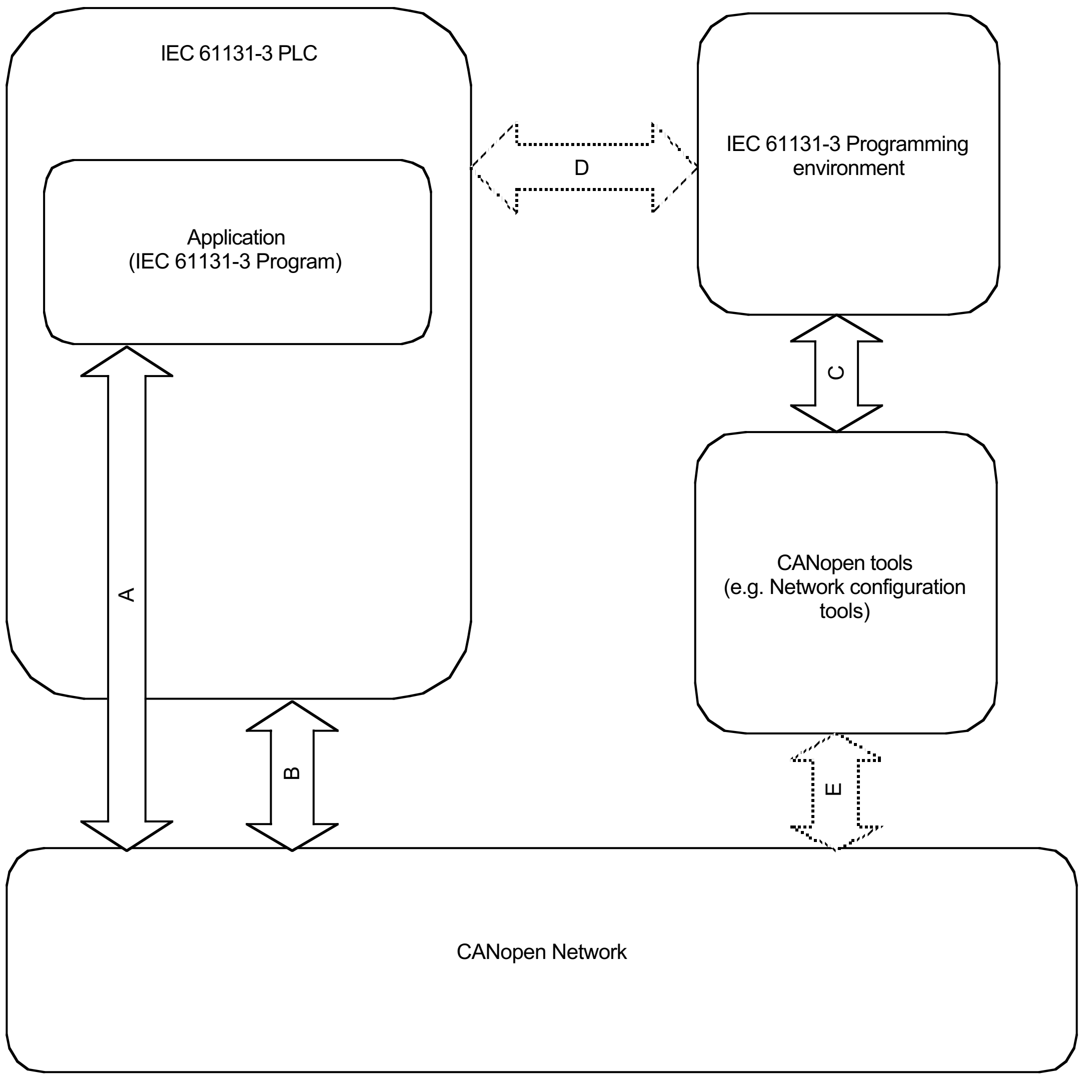

Figure 1: Interfaces

This paper covers the following interfaces

A) the access to a CANopen communication system from within an IEC 61131-3 program
   a) based on variables, i.e. access to elementary IEC 61131-3 variable objects,
   b) based on calls to function block
B) utility functions for debugging, monitoring and network management
C) interface between CANopen tools and IEC 61131-3 programming environment
All other interfaces are manufacturer specific (D) or uses CANopen services (E).

Note Figure 1 describes not necessarily the use of different tool for programming and configuration. One tool may handle both functionality and hide the interfaces.

2 References

/IEC 61131/	IEC 61131 First edition 1993-03 Programmable controllers - Part 1: general information - Part 3: programming languages - Part 5: messaging services
/DS-301/	Application Layer and Communication Profile CiA Draft Standard 301 Version 4.01, 2000-06
/DSP-302/	Framework for programmable CANopen devices CiA Draft Standard Proposal 302 Version 3.0, 2000-06
/DSP-305/	Layer Setting Services and Protocols CiA Draft Standard Proposal 305 Version 1.1, 2002-02
/DSP-306/	Electronic Data Sheet Specification for CANopen CiA Draft Standard Proposal 306 Version 1.1, 2001-06

3 Terms and definitions

3.1 Data types

IEC 61131-3 specifies three kinds of data types:

- **Elementary data types**

Length	Keywords
1 Bit	BOOL
8 Bits	SINT, USINT, BYTE
16 Bits	INT, UINT, WORD
32 Bits	DINT, UDINT, REAL, DWORD
64 Bits	LINT, ULINT, LREAL, LWORD
Implementation dependent	TIME, DATE, TIME_OF_DAY, DATE_AND_TIME, STRING

- **Generic data types**

  Generic data types group elementary data types hierarchically. They are identified by the prefix "ANY" (e.g. ANY_NUM, ANY_INT,...).

- **Derived data types**

  User- or manufacturer-specified data types (Structures). Types to match CANopen data types (e.g. CIA405UINT24, ...).

3.2 Variables

IEC-Variables can be represented symbolically or directly (%IX..., %QW ..). IEC 61131-3 knows two kinds of variables:

- **Single-element variable**

  Variable consists of one element.

- **Multi-element variable**

  Arrays and structures.

3.3 Program organization units (POU)

The POUs are the actual programming modules, an IEC program consists of. The program organisation units defined by IEC 61131-3 include function, function block, and program.

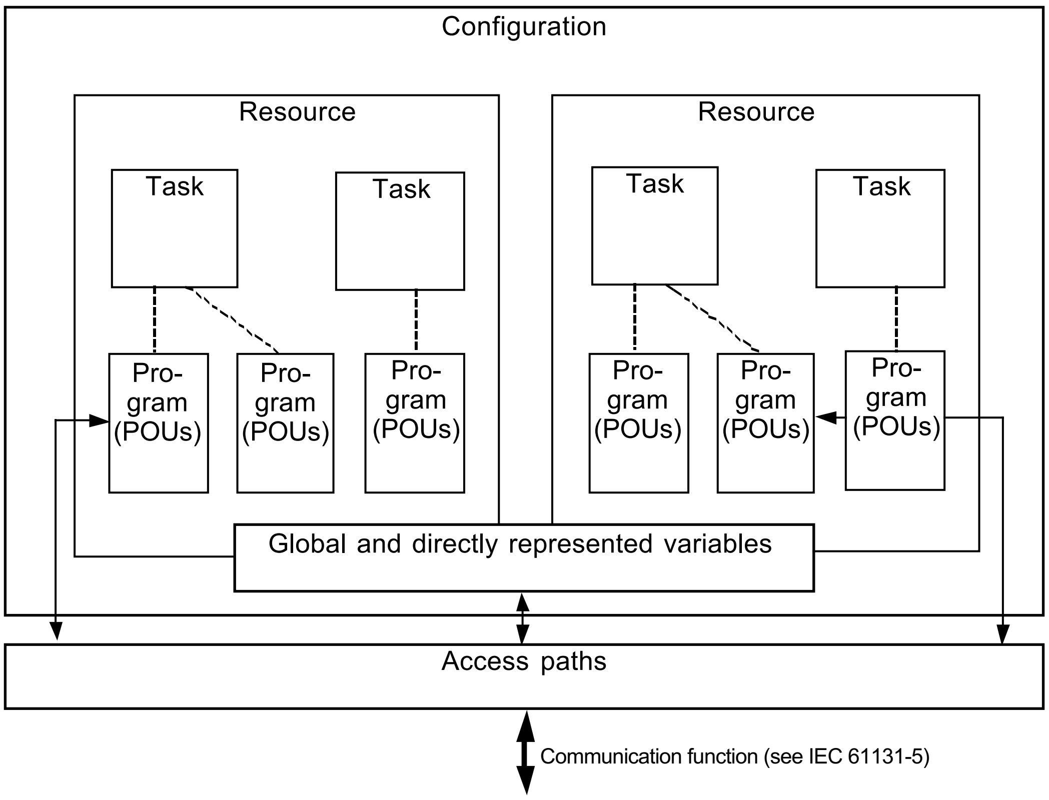

Figure 2: IEC 61131-3 software organisation

- **Function**

  A function has one or more input values and exactly one output value. It does contain no internal state information, i.e. invocation of a function with the same arguments (inputs) always yields the same value (output). A function can be executed from a program, a function block or another function.

- **Function block**

  A function block has one or more input values and one or more output values. Multiple instances (copies) of a function block are allowed. A function block keeps its internal state information. It can be executed from a program or another function block.

- **Program**

  This POU type represents the "main program". Instances of programs can only be created within resources (by a task).

3.4 Configuration elements

The configuration corresponds to a programmable controller system as defined in IEC 61131-3-1. A configuration contains one or more resources, each of which contains one or more programs executed under the control of zero or more tasks.

- **Global variable**

  A variable whose scope is global (Scope of a declaration applying to all POUs within a resource or configuration).

- **Resource**

  "Signal processing function" and its "man-machine interface" and "sensor and actuator interface functions ", as defined in IEC 61131-3-1. Normally a resource means one PLC's central processing unit.

- **Task**

  A task is defined as an execution control element which is capable of invoking, either on a periodic basis or upon the occurence of the rising edge of a specific Boolean variable, the execution of a set of program organization units, which can include programs and function blocks.

- **Access path**

  The association of a symbolic name with a variable for the purpose of open communication.

3.5 Access to network variables definition

In a network programmable nodes can be characterized as a process having input variables and output variables. The set of variables will be arguments of the program and hence will be only known in a final state when the program has been written. The arguments must be handled as variables located in the object dictionary.

This profile uses the terms and definitions of /DSP-302/ "Framework for programmable CANopen Devices". It defines the usage of network variables in a way independent of the type of the programmable device. Here, some restrictions are made for IEC 61131-3 programmable devices.

3.6 CANopen profile-specific definitions

CANopen provides the ability to identify the profile of a node. Therefore the CANopen Communication Profile /DS-301/ specifies an object 1000h ("Device Type"). The object 1000h is a 32 Bit word, subdivided into two 16 Bit words. The LSB contains the profile number, the MSB contains additional information. For a device, following these specification the profile number is set to 405. The additional information (MSB) is set to 0 and is reserved for further use by CiA. The profile does not define a default mapping.

4 Data types

IEC 61131-3 and CANopen define different data types. The following table defines the assignment of types that are equivalent and that are usable as network variables. For a handling of these data types in a file format it is useful to assign numbers to the data type. The table starts with the data types that are defined in CANopen and uses the same coding. Additional data types of IEC 61131-3 start with A0H.

IEC 61131-3	CANopen	Data width (bit)	Encoding (Hex)
BOOL	Boolean	1	01
SINT	Integer8	8	02
INT	Integer16	16	03
CIA405INT24	Integer24	24	10
DINT	Integer32	32	04
CIA405INT40	Integer40	40	12
CIA405INT48	Integer48	48	13
CIA405INT56	Integer56	56	14
LINT	Integer64	64	15
USINT	Unsigned8	8	05
UINT	Unsigned16	16	06
CIA405UINT24	Unsigned24	24	16
UDINT	Unsigned32	32	07
CIA405UINT40	Unsigned40	40	18
CIA405UINT48	Unsigned48	48	19
CIA405UINT56	Unsigned56	56	1A
ULINT	Unsigned64	64	1B
REAL	Float	32	08
BYTE	Unsigned8	8	A4
WORD	Unsigned16	16	A5
DWORD	Unsigned32	32	A6
LWORD	Unsigned64	64	A7

Table 1: Data types

The following data types are equivalent, but cannot be transferred via PDOs:

IEC 61131-3	CANopen	Encoding (Hex)
TIME	Time_Difference	0D
DATE	Time_Of_Day	0C
TIME_OF_DAY	Time_Of_Day	0C
STRING	Visible String	09

Table 2: Data types not transferable via PDO

The following IEC 61131-3 data types do have no equivalent in CANopen: LREAL, DATE_AND_TIME,. The following CANopen data types do have no equivalent in IEC 61131-3: Octet String, Domain.

4.1 Data type conversion functions

Type conversion functions shall be defined as in IEC 61131-3 (i.e. <from>_TO_<to>, e.g. CIA405uint24_TO_DINT) in both directions for the following combinations:

Type1	Type2
CIA405INT24	DINT
CIA405INT40	LINT
CIA405INT48	LINT
CIA405INT56	LINT
CIA405UINT24	UDINT
CIA405UINT40	ULINT
CIA405UINT48	ULINT
CIA405UINT56	ULINT
CIA405UINT24	DWORD
CIA405UINT40	LWORD
CIA405UINT48	LWORD
CIA405UINT56	LWORD

Table 3: Data type conversion functions

4.2 Data type representation issues

CANopen defines a certain representation for data types, while IEC 61131-3 does not. If the IEC 61131-3 system can use the same representation as defined in CANopen, there will be no problem. The strategy of this standard is as follows:

a) Data of the network (typically PDOs) made available to the IEC 61131-3 as network variables through entries in the range A000-AFFF, typically mapped into the process image of the IEC 61131-3 system shall be presented to the IEC 61131-3 in the IEC 61131-3 system's native (platform dependent, potentially CANopen non-compliant) data representation. The CANopen data type of these data items is known to the CANopen kernel, all necessary conversions will have to be done before putting the value into the process image resp. after retrieving it from the process image.

b) All other data, for which the data type is potentially unknown to the CANopen kernel and/or the IEC 61131-3 application (e.g. SDO data) shall be presented to the IEC 61131-3 system in standard CANopen data format as a stream of raw bytes. Conversion functions shall be supplied to convert this data representation to native IEC 61131-3 format, but the knowledge about the data type has to be available at run-time.

Refer Chapter 8.4.2 for application notes.

5 Accessing CANopen from within IEC 61131-3

As mentioned in the introduction, this paper covers two methods of accessing the CANopen network:

1. Variable-based access, accessing individual variables from within the IEC 61131-3 program according to the Network Variables of /DSP-302/.
2. Function block based access, calling function blocks to write and/or read data. This is implemented with SDO access.
3. Additional management functions for processing Emergency, LSS and Network state information.

5.1 Variable based access

All objects located in the range A000h - AFFFh of the object dictionary of a node shall be visible as variables to an application on that node programmed within IEC 61131-3. Which kind of variables are being used, e.g.

- directly represented variables
- external variables
- parameters (of programs or function blocks)

shall be left to the IEC 61131-3 implementation.

5.1.1 Definition of the data direction

The terms input and output are defined in the Framework for Programmable Devices /DSP-302/. An input has the CANopen data direction ro, an output has the CANopen data direction wo (rww respectively) as with every other device type, too.

Hint:

This definition comes from the network point of view. This shall be explained in Figure 3 by an example for transferring a physical input:

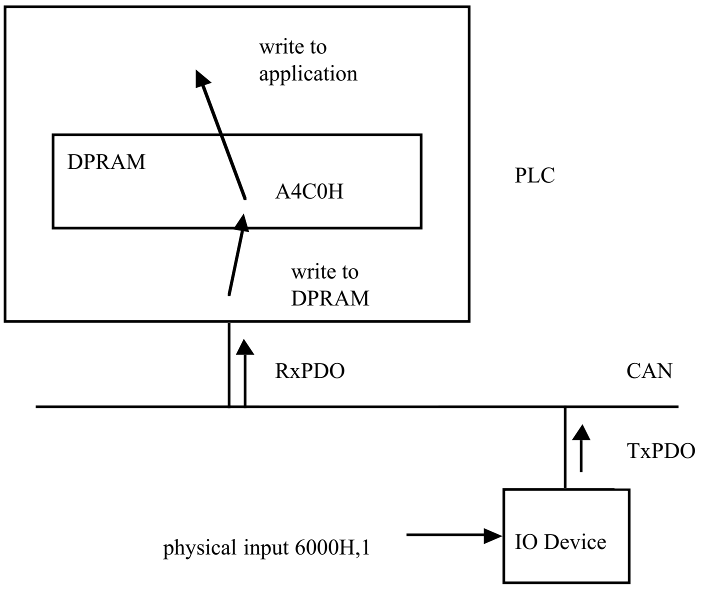

Figure 3: Direction of Network Variables

The object A4C0H is defined as an output, since another device can write values to it, which is (from the CANopen point of view) the same as writing a value to a digital output. If the device has a physical output or a software, that deals with these values - is in principle no difference. So one can use the terminology of “writing values to the PLC application”.

From the PLC programmers point of view, the application will read the value – this is the same as if it would read the digital input lines directly without having a bus between.

5.1.2 Object dictionary entries for IEC 61131-3 variables

The Framework for Programmable Devices /DSP-302/ defines the usage of so-called segments. It leaves the concrete placement of the segments open. To ease implementations and for a much easier usage of software from different manufacturers, the usage of the segments is specified for IEC 61131-3 programmed devices: The segments are placed in the index range A000h -AFFFh. This allows any device of another profile (e.g. I/O device or drive unit) to use the standard object dictionary entries of that profile and additionally use the Network Variables.

Inputs:

Start-Index	**Data Type**	**Direction**
A000H	Integer8	ro
A040H	Unsigned8	ro
A080H	Boolean	ro
A0C0H	Integer16	ro
A100H	Unsigned16	ro
A140H	Integer24	ro
A180H	Unsigned24	ro
A1C0H	Integer32	ro
A200H	Unsigned32	ro
A240H	Float (32)	ro
A280H	Unsigned40	ro
A2C0H	Integer40	ro
A300H	Unsigned48	ro
A340H	Integer48	ro
A380H	Unsigned56	ro
A3C0H	Integer56	ro
A400H	Integer64	ro
A440H	Unsigned64	ro

Table 4: Input network variables

Outputs:

Start-Index	Data Type	Direction
A480H	Integer8	rww
A4C0H	Unsigned8	rww
A500H	Boolean	rww
A540H	Integer16	rww
A580H	Unsigned16	rww
A5C0H	Integer24	rww
A600H	Unsigned24	rww
A640H	Integer32	rww
A680H	Unsigned32	rww
A6C0H	Float (32)	rww
A700H	Unsigned40	rww
A740H	Integer40	rww
A780H	Unsigned48	rww
A7C0H	Integer48	rww
A800H	Unsigned56	rww
A840H	Integer56	rww
A880H	Integer64	rww
A8C0H	Unsigned64	rww

Table 5: Output network variables

This distribution described according to the /DSP-302/ description rules is given in the Appendix.

The entries MaxCnt, missing in the list above, depend on the available memory of the device. For a further simplification, the EDS files for devices following DS-405 are allowed to omit this description. This is marked by setting additionally the second bit of the entry DynamicChannelsSupported of section DeviceInfo:

```
[DeviceInfo]
....
DynamicChannelsSupported=3
```

5.1.3 Variable names

Object dictionary entries which have names that are no legal variable names for IEC 61131-3 shall not be usable to the IEC 61131-3 system. No automatic renaming is defined by this paper.

5.2 Function block based access

IEC 61131-3 Function blocks

This chapter describes standard function blocks to access CANopen from IEC 61131-3. All function blocks and data types defined in this chapter are optional in the sense of CANopen standardisation.

The following table can be used by IEC 61131-3 compliant systems to state the features covered:

Nr.	Data type
1	CIA405_DEVICE
2	CIA405_SDO_ERROR
3	CIA405_EMCY_ERROR
4	CIA405_STATE
5	CIA405_TRANSITION_STATE
6	CIA405_CANOPEN_KERNEL_ERROR

Table 6: New data types

Nr.	Function block
1	CIA405_RECV_EMCY_DEV
2	CIA405_RECV_EMCY
3	CIA405_SDO_WRITE4
4	CIA405_SDO_WRITE7
5	CIA405_SDO_WRITE14
6	CIA405_SDO_WRITE21
7	CIA405_SDO_READ4
8	CIA405_SDO_READ7
9	CIA405_SDO_READ14
10	CIA405_SDO_READ21
11	CIA405_GET_LOCAL_NODE_ID
12	CIA405_GET_STATE
13	CIA405_GET_CANOPEN_KERNEL_STATE
14	CIA405_NMT
15	CIA405_SDO_WRITE
16	CIA405_SDO_READ

Table 7: Function blocks

5.2.1 General function block design issues

5.2.1.1 Naming conventions

A specific prefix shall be given to all function block and data type names defined herein. Currently ‘CIA405’ is used as that prefix.

5.2.1.2 Data types vs. data length

It is possible to represent transmission of data of arbitrary length within IEC 61131-3. However, the interfaces to functions blocks allowing for that may be quite more difficult to use and understand. Therefore different functions blocks are defined herein, for the transmission of a fixed (maximum) amount of data each as well as blocks for arbitrary length.

5.2.1.3 User defined data types

User defined data types are used to represent items of CANopen in IEC 61131-3.

5.2.1.4 Time out

The interface is designed such that it is possible to wrap the calls with a timer block to implement time-outs. Additionally, it is allowed that lower level CANopen software implement their own time-outs and report such as errors to the caller.

5.2.1.5 Additional parameters

Some systems may support or require additional information in the function blocks. For example a PLC may have several CAN channels. In that case the function blocks will require the channel number of the service. It is allowed to add these parameters to the function blocks.

Applications depending on that will always have to be adapted, if the environment is changed. So the freedom of additional parameters will not lead to really new compatibility/portability problems.

5.2.2 Data types

The following data types shall be used with the standard function blocks:

Type CIA405_DEVICE shall represent the Node ID of a device:

```
TYPE
  CIA405_DEVICE: USINT (0..127);
END_TYPE
```

Figure 4: Type CIA405_DEVICE

Type CIA405_SDO_ERROR shall represent error information as defined in /DS-301/:

```
TYPE
  CIA405_SDO_ERROR: UDINT;
END_TYPE
```

Figure 5: Type CIA405_SDO_ERROR

Type CIA405_EMCY_ERROR contains emergency error information, as specified in /DS-301/:

```
TYPE
  CIA405_EMCY_ERROR : STRUCT
        EMCY_ERROR_CODE : WORD;
        ERROR_REGISTER : BYTE;
        ERROR_FIELD : ARRAY [1..5] of BYTE;
  END_STRUCT;
END_TYPE
```

Figure 6: Type CIA405_EMCY_ERROR

Type CIA405_STATE describes the state of the CANopen network layer, as defined in /DS-301/. The states INIT, RESET_COMM, RESET_APP, PRE_OPERATIONAL, STOPPED, OPERATIONAL correspond to the same states in /DS-301/. The State UNKNOWN shall be used, if the actual state of the device is not known (in example, if no guarding of the device is performed). The state NOT_AVAIL shall be used, if it is known, that the device is not available (in example, if guarding is performed and the device does not answer).

```
TYPE
  CIA405_STATE : (
        INIT,
        RESET_COMM,
        RESET_APP,
        PRE_OPERATIONAL,
        STOPPED,
        OPERATIONAL,
        UNKNOWN,
        NOT_AVAIL
  );
END_TYPE
```

Figure 7: Type CIA405_STATE

Type CIA405_TRANSITION_STATE describes the state transitions of the CANopen network layer, as defined in /DS-301/:

```
TYPE
  CIA405_TRANSITION_STATE : (
        START_REMOTE_NODE,
        STOP_REMOTE_NODE,
        ENTER_PRE_OPERATIONAL,
        RESET_NODE,
        RESET_COMMUNICATION
  );
END_TYPE
```

Figure 8: Type CIA405_TRANSITION_STATE

Type CIA405_CANOPEN_KERNEL_ERROR contains error information about the CANopen Kernel.

```
TYPE
  CIA405_CANOPEN_KERNEL_ERROR : WORD;
END_TYPE
```

Figure 9: Type CIA405_CANOPEN_KERNEL_ERROR

Description of the CIA405_CANOPEN_KERNEL_ERROR value range:

Value	**Description**
0000h	no error
0001h	Other error (see further error registers)
0002h	Data overflow
0003h	Time out
0004h - 000Fh	Reserved for further SDO errors
0010h	CAN Bus off
0011h	CAN Error Passive
0012h - 001Fh	Reserved for further internal Kernel errors

0021h - 00FFh	Manufacturer specific
0100h - FFFFh	Reserved by CiA

Table 8: Error codes for type CIA405_CANOPEN_KERNEL_ERROR

5.2.3 SDO access

5.2.3.1 SDO write

```
FUNCTION_BLOCK CIA405_SDO_WRITE4
  VAR_INPUT
        DEVICE : CIA405_DEVICE;
        INDEX : WORD;
        SUBINDEX : BYTE;
        ENABLE : BOOL;
        DATA : ARRAY [ 1..4]  of BYTE;
        DATALENGTH : USINT;
        END_VAR
  VAR_OUTPUT
        CONFIRM  : BOOL := FALSE;
        ERROR : CIA405_CANOPEN_KERNEL_ERROR;
        ERRORINFO : CIA405_SDO_ERROR;
  END_VAR
END_FUNCTION_BLOCK
```

Figure 10: Function block CIA405_SDO_WRITE4

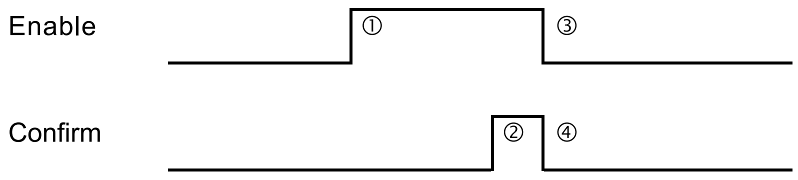

Figure 11: CIA405_SDO_WRITE4 typical timing diagram

Figure 11 shows a typical timing diagram for CIA405_SDO_WRITE4. After all data is provided to the inputs, ENABLE is set to TRUE ①. The SDO will be sent, and when the CANopen software reports success to the function block, output CONFIRM will be changed to TRUE ②. The caller will see this and change ENABLE to FALSE ③, which in turn will cause output CONFIRM to change to FALSE ④.

The specification is as follows:

1. With a rising edge on input ENABLE, the function block will sample the inputs and initiate the transmission of the SDO specified in DATA and DATALENGTH to the recipient specified with DEVICE, INDEX and SUBINDEX. The value of DEVICE is limited to a range of 1 to 127. For access to the local object dictionary it is allowed to use the value 0 for DEVICE.
2. With TRUE on input ENABLE, the function block is allowed to continue execution. If a result is reported on the call by lower level CANopen software, outputs CONFIRM, ERROR and ERRORINFO are set accordingly.
3. With a falling edge on input ENABLE the function block will terminate. If the transmission did not finish yet, it will be aborted if possible. Outputs CONFIRM and ERROR will both be set to FALSE respectively "no error".
4. With a FALSE on input ENABLE, the function block will return immediately and not take any action.

The result of a writing operation is reported (immediately after the writing call or afterwards) in outputs CONFIRM, ERROR and ERRORINFO with a rising edge on either CONFIRM or ERROR. In case of ERROR is equal to 1 (other error), ERRORINFO will give more specified information on the cause. This is especially true for the occurrence of an SDO Abort. Then ERRORINFO contains the Abort code.

It cannot be assumed in general that this function can synchronously complete; rather, it should be possible to have this function continue to be executed while the call to CIA405_SDO_WRITE4 returns and the PLC program is continued. Therefore, the result of a call may be available only several cycles after a rising edge has been applied to ENABLE.

5.2.3.2 SDO write for different data lengths

In addition to CIA405_SDO_WRITE4 , function blocks

- CIA405_SDO_WRITE7,
- CIA405_SDO_WRITE14,
- CIA405_SDO_WRITE21,
- etc.

may be implemented with the same interface as CIA405_SDO_WRITE4, except that the upper limit of the array on input DATA shall be changed to 7, 14, or 21 respectively. The first element of the array represents the first data byte of the data stream transmitted with an CIA405_SDO_WRITEx function block.

5.2.3.3 SDO write for arbitrary length

This function block can be used as alternative to the CIA_SDO_WRITEx functions blocks. It supports the arbitrary length of data.

```
FUNCTION_BLOCK CIA405_SDO_WRITE
  VAR_INPUT
        DEVICE : CIA405_DEVICE;
        INDEX : WORD;
        SUBINDEX : BYTE;
        ENABLE : BOOL;
        DATA : ANY
        DATALENGTH : USINT;
  END_VAR
  VAR_OUTPUT
        CONFIRM  : BOOL := FALSE;
        ERROR : CIA405_CANOPEN_KERNEL_ERROR;
        ERRORINFO : CIA405_SDO_ERROR;
  END_VAR
END_FUNCTION_BLOCK
```

Figure 12: Function block CIA405_SDO_WRITE

The behaviour and timing is the same as with CIA405_SDO_WRITE4.

5.2.3.4 SDO read

```
FUNCTION_BLOCK CIA405_SDO_READ4
  VAR_INPUT
        DEVICE : CIA405_DEVICE;
        INDEX : WORD;
        SUBINDEX : BYTE;
        ENABLE : BOOL;
  END_VAR
  VAR_OUTPUT
        DATA : ARRAY [ 1..4] of BYTE;
        DATALENGTH : USINT;
        CONFIRM : BOOL;
        ERROR : CIA405_CANOPEN_KERNEL_ERROR;
        ERRORINFO : CIA405_SDO_ERROR;
  END_VAR
END_FUNCTION_BLOCK
```

Figure 13: Function block CIA405_SDO_READ4

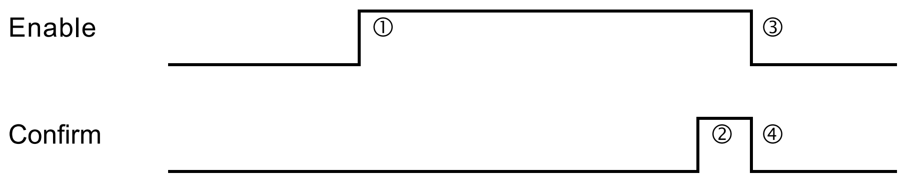

Figure 14: CIA405_SDO_READ4 typical timing diagram

Figure 14 shows a typical timing diagram for CIA405_SDO_READ4. After all data is provided to the inputs, ENABLE is set to TRUE ①. The SDO will be received, and when the CANopen software reports success to the function block, output CONFIRM will be changed to TRUE ②. The caller will see this and change ENABLE to FALSE ③, which in turn will cause output CONFIRM to change to FALSE ④.

The specification is as follows:

1. With a rising edge on input ENABLE, the function block will sample the inputs and initiate the transmission of the SDO specified with DEVICE, INDEX and SUBINDEX. The value of DEVICE is limited to a range of 1 to 127. For access to the local object dictionary it is allowed to use the value 0 for DEVICE.
2. With TRUE on input ENABLE, the function block is allowed to continue execution. If a result is reported on the call by lower level CANopen software, outputs CONFIRM, DATA and DATALENGTH (in case of success) or ERROR and ERRORINFO (in case of failure) are set accordingly.
3. With a falling edge on input ENABLE the function block will terminate. If the transmission did not finish yet, it will be aborted if possible. Outputs CONFIRM and ERROR will both be set to FALSE respectively "no error".
4. With a FALSE on input ENABLE, the function block will return immediately and not take any action.

Like with CIA405_SDO_WRITE4, it cannot be assumed that this function can be completed before the call to CIA405_SDO_READ4 returns. Therefore, the result may be available several cycles after the receiving call.

5.2.3.5 SDO read for different data lengths

In addition to CIA405_SDO_READ4, function blocks

- CIA405_SDO_READ7,
- CIA405_SDO_READ14,
- CIA405_SDO_READ21,
- etc.

may be implemented with the same interface as CIA405_SDO_READ4, except that the upper limit of the array on output DATA shall be changed to 7, 14, or 21 respectively. The first element of the array represents the first data byte of the data stream transmitted with an CIA405_SDO_READx function block.

If a function block receives more data than specified, the ERROR output signals this with the error code 0002h ("data overflow"). It is application dependent to use this fragment of data or not.

5.2.3.6 SDO read for arbitrary length

This function block can be used as alternative to the CIA_SDO_READx functions blocks. It supports the arbitrary length of data.

```
FUNCTION_BLOCK CIA405_SDO_READ
  VAR_INPUT
        DEVICE : CIA405_DEVICE;
        INDEX : WORD;
        SUBINDEX : BYTE;
        ENABLE : BOOL;
  END_VAR
  VAR_OUTPUT
        DATA : ANY;
        DATALENGTH : USINT;
        CONFIRM : BOOL;
        ERROR : CIA405_CANOPEN_KERNEL_ERROR;
        ERRORINFO : CIA405_SDO_ERROR;
  END_VAR
END_FUNCTION_BLOCK
```

Figure 15: Function block CIA405_SDO_READ

The behaviour and timing is the same as with CIA405_SDO_READ4.

5.2.4 Other function blocks

5.2.4.1 Own node id

Function block CIA405_GET_LOCAL_NODE_ID returns the own node ID.

```
FUNCTION_BLOCK CIA405_GET_LOCAL_NODE_ID
  VAR_INPUT
        ENABLE : BOOL;
  END_VAR
  VAR_OUTPUT
        CONFIRM : BOOL;
        DEVICE : CIA405_DEVICE;
  END_VAR
END_FUNCTION_BLOCK
```

Figure 16: Function block CIA405_ GET_LOCAL_NODE_ID

5.2.4.2 Query state

Function block CIA405_GET_STATE returns the current state of a CANopen network device:

```
FUNCTION_BLOCK CIA405_GET_STATE
  VAR_INPUT
        DEVICE : CIA405_DEVICE;
        ENABLE : BOOL;
  END_VAR
  VAR_OUTPUT
        CONFIRM : BOOL;
        STATE : CIA405_STATE;
  END_VAR
END_FUNCTION_BLOCK
```

Figure 17: Function block CIA405_ GET_STATE

The usage and behaviour of ENABLE and CONFIRM is the same like with CIA405_SDO_WRITE4. Refer to Figure 11. If the state is not known, the function block returns with the state UNKNOWN. This will occur, if the device is not guarded and Heartbeat is not running. If Guarding is performed and the device does not answer or it is known for other reasons, that the device is not available, the functions returns the state NOT_AVAIL. The value of DEVICE is limited to a range of 1 to 127. If DEVICE is 0 or equal to the own Node-ID, the function block returns the state of the local communication process.

Function block CIA405_GET_CANOPEN_KERNEL_STATE returns the current state of the CANopen Kernel:

```
FUNCTION_BLOCK CIA405_GET_CANOPEN_KERNEL_STATE
  VAR_INPUT
        ENABLE : BOOL;
  END_VAR
  VAR_OUTPUT
        CONFIRM : BOOL;
        STATE : CIA405_CANOPEN_KERNEL_ERROR;
  END_VAR
END_FUNCTION_BLOCK
```

Figure 18: Function block CIA405_ GET_CANOPEN_KERNEL_STATE

The usage and behaviour of ENABLE and CONFIRM is the same like with CIA405_GET_STATE.

5.2.4.3 Network management

Function block CIA405_NMT controls network management functions of one or all CANopen nodes.

```
FUNCTION_BLOCK CIA405_NMT
  VAR_INPUT
        DEVICE : CIA405_DEVICE;
        STATE : CIA405_TRANSITION_STATE;
        ENABLE : BOOL;
  END_VAR
  VAR_OUTPUT
        CONFIRM : BOOL
        ERROR : CIA405_CANOPEN_KERNEL_ERROR;
  END_VAR
END_FUNCTION_BLOCK
```

Figure 19: Function block CIA405_ NMT

Within this function block it is allowed to assign DEVICE the value 0. This means that all nodes of the network will enter the selected state.

5.2.4.4 Receive emergency object from a specific device

```
FUNCTION_BLOCK CIA405_RECV_EMCY_DEV
   VAR_INPUT
         DEVICE : CIA405_DEVICE;
         ENABLE : BOOL;
   END_VAR
   VAR_OUTPUT
         CONFIRM  : BOOL;
         ERROR : CIA405_CANOPEN_KERNEL_ERROR;
         ERRORINFO : CIA405_EMCY_ERROR;
   END_VAR
END_FUNCTION_BLOCK
```

Figure 20: Function block CIA405_RECV_EMCY_DEV

CIA405_RECV_EMCY_DEV will check if an emergency object (/DS-301/) has been received from DEVICE. If so, and no error occurred, output CONFIRM is changed to TRUE and ERROR to 0. If an error occurred (either during reception of this emergency object or without such an emergency object arriving), CONFIRM is set to FALSE and ERROR is set to the responding error value and the cause is specified in ERRORINFO. One emergency object shall be reported only once. The value of DEVICE is limited to a range of 1 to 127.

5.2.4.5 Emergency object from any device

```
FUNCTION_BLOCK CIA405_RECV_EMCY
   VAR_INPUT
         ENABLE : BOOL;
   END_VAR
   VAR_OUTPUT
         CONFIRM  : BOOL;
         DEVICE : CIA405_DEVICE;
         ERROR : CIA405_CANOPEN_KERNEL_ERROR;
         ERRORINFO : CIA405_EMCY_ERROR;
   END_VAR
END_FUNCTION_BLOCK
```

Figure 21: Function block CIA405_RECV_EMCY

CIA405_RECV_EMCY will check if an emergency object (/DS-301/) has been received from any device. If so, and no error occurred, output CONFIRM is changed to TRUE and ERROR to 0 and DEVICE is set to the ID of the device sending the emergency object. If an error occurred (either during reception of this emergency object or without such an emergency object arriving), CONFIRM is set to FALSE and ERROR is set to the responding error and the cause is specified in ERRORINFO. One emergency object shall be reported only once.

6 Tool integration

This chapter defines the information exchange between software packages concerning the network variables. Typical software packages in this context are the IEC 61131-3 programming system and network configuration / network project planning system. Both systems may be integrated in one software. In that case, the information exchange can be handled internally. In the other case there exist two separate software packages, that have the task to exchange some required information in a standardized way:

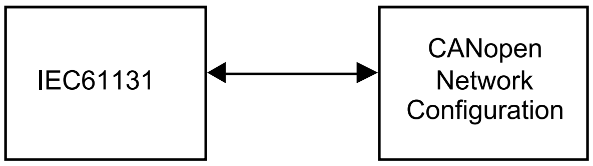

Figure 22: Correlation between programming and network configuration

6.1 Basic concept

The described mechanism is based on the assumption that at one time only one tool is active. This means that only one tool has the right to write the information to the files. On a multitasking operating system for example all tools can run at the same time but only one tool is allowed to modify the project data by writing to the project files at the same time.

Further it is assumed that all necessary configuration information of a CANopen network is stored in DCF files (file based operating system). These files and formats are already defined within /DS-301/ specification. All used tools must be able to have read and write access to these EDS and DCF files. It is necessary that each tool works with the same files at one location. The way the access is handled depends on the used operating system.

In order to specify all nodes appearing in a network a special file called „Nodelist“ shall be created. The format of this file is the same as the format of an EDS/DCF file (Windows ini file). To manage the read/write access to the DCF files one more file called „Access Handler“ shall be created.

Whenever a tool wants to modify the files „Nodelist“, „Access Handler“ and DCF it shall check for existence first.

Refer chapter 8.4.4 for application notes.

6.2 Node list

This file contains all nodes within a network. The way this file is accessed by the tools depends on the used operating system. For a file based system this means to show the tools the path and the filename. This location must be the same where all DCF files are stored.

With the minimum information of the „Nodelist“ a tool is able to ask the user for each node’s DCF, EDS and how to establish a read or write access. Further entries are for support of more than one network.

To allow tools an automatic access to the „Nodelist“ the following filename is specified:

„nodelist.cpj“

The following entries are specified:

[Sections] and entries	Description
[Topology]	Optional, if this section is missing the tools can assume that there is at least one network with the number 1.
NetName =	Optional name for a net. This is helpful for a tool to give the user assistance by identifying the net.
Nodes = 0x02	Mandatory, number of nodes within the net. The range of the number is from 1 to 127. The number is to be read as a hexadecimal number with leading 0x.
NodeXPresent = 0x01	Mandatory for each existing node. X specifies the CANopen Node number within the network. X is coded decimal with no leading zeros (e.g. Node1Present, Node10Present, Node127Present). A value of 0x01 means the node X is present. A value of 0x00 or missing entry means the node is not present. All other values are reserved.
NodeXName = Node1	Optional node name. This is for tools to help the user to identify the node. X is coded decimal with no leading zeros (e.g. Node1Name, Node10Name, Node127Name).
NodeXDCFName = Node1.dcf	Optional DCF filename for this node. The filename should be written without path information. This entry is helpful for tools based on a file system. X is coded decimal with no leading zeros (e.g. Node1DCFName, Node10DCFName, Node127DCFName).
EDSBaseName = path	Optional path to the EDS files. This entry is helpful for tools based on a file system.

Table 9: Entries in Nodelist file

Further sections and entries may exist. It is the responsibility of the tool manufacturers to avoid collisions in the naming of sections and entries. For the syntax definition of section, entry and the entry values refer /DSP-306/.

6.3 Access handler

The file „Access Handler“ handles the read and write access to the DCF files. The „Access Handler“ is a simple file without sections and entries. The only information is the name of the locking tool. If a tool wants to get the write access it can open the file exclusively. After writing to the DCF files the tool has to release the file. If a tool was blocked by another it can inform the user with detailed information about the locking tool.

The filename of this „Access Handler“ is „lock“.

Content	Description
„Name of the tool“	Optional, name of the tool that has the read/write access.

7 Utility functions

7.1 Remote functions between resources

7.1.1 Down-/Upload

The program download mechanism is defined in /DSP-302/.

7.2 Object dictionary entries

Modern programming systems provide users with project management, device configuration, test and debug units. For testing and debugging the following entries are defined, which can be evaluated by tools (e.g. configuration, SCADA systems). The following approach is a combination of the CANopen project and the IEC 61131 configuration hierarchy. A CANopen project consists of at least one or more PLCs in one network.

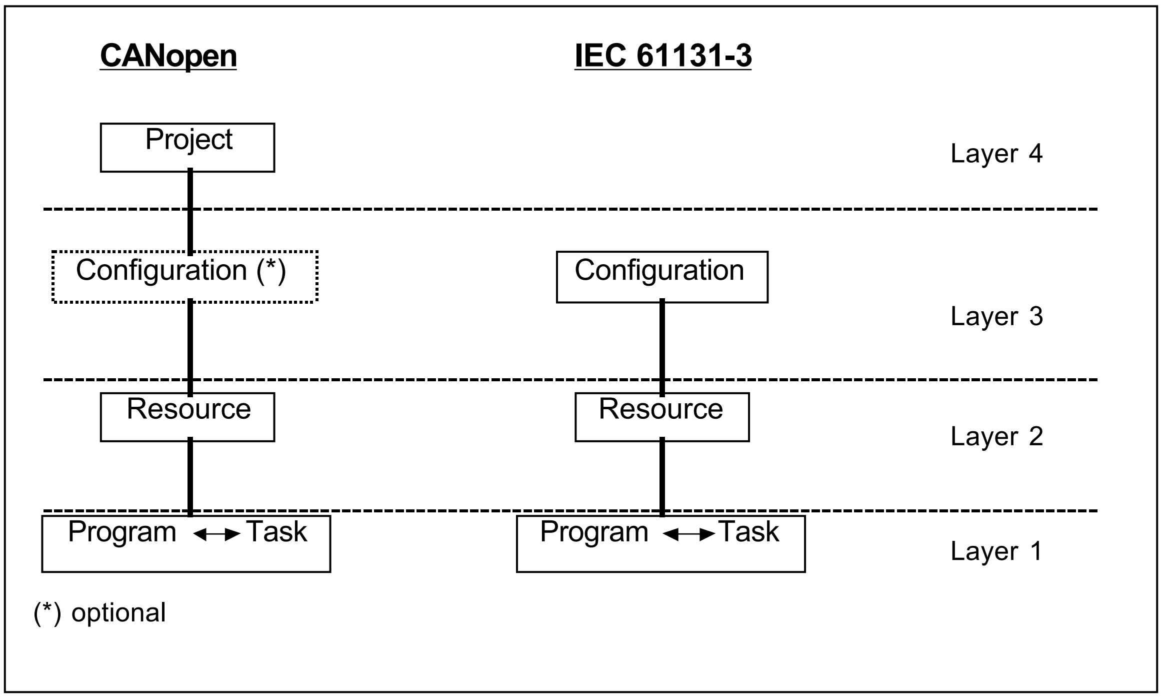

Figure 23: Project structure

Objects defined in this chapter, that have the data type visible string use strings with the fixed length of 32 characters. The character representation is used from the IEC 61131-3 chapter 2.1.

For version numbers the data type unsigned32 is used. The higher word includes the major number and the lower word the minor number, both are BCD coded.

The following object entries have to support the read access, the write access is optional.

To avoid consistence conflicts with CANopen tools during network configuration (download) the following objects should support the „ObjFlags“ entry in the EDS/DCF with the „Refuse write on download“ bit (bit 0) set. Imagine a CANopen tool writes a configuration over the CAN bus to a node. For the tool it is not possible to suppress explicit writing on the following entries. But this objects are handled generally by the IEC 61131 programming tool. So it is not guaranteed that the information in the DCF matches these configuration. Note the solution with the „ObjFlags“ entry specified in /DSP-306/.

7.2.1 Project name

Typical network projects consist of at least one configuration. The assignment between configurations and projects could be done by the project name.

Object Description

Index	9800H
Name	Project_Name
Object Code	VAR
Data Type	Visible String

Value Description

Object Class	Optional
Access	R (optional W)
PDO Mapping	No
Value Range	Visible String
Mandatory Range	No
Default Value	No

7.2.2 Configuration

The configuration includes a list of all resources used in a PLC system. A configuration will be identified by its name and version.

Configuration definition structure

Index	Subindex	Field in Configuration_Def Record	Data Type
0080H	0H	Number of supported entries	Unsigned8
	1H	Configuration_Name	Visible String
	2H	Configuration_Version	Unsigned32
	3H	Number_Of_Resources	Unsigned8

Detailed object description

Index	9501H
Name	Configuration
Object Code	RECORD
Number of Elements	3
Data Type	Configuration_Def

Value description

Sub-Index	0H
Description	Number of entries
Object class	Optional
Access	RO
PDO Mapping	No
Value Range	1H - 3H
Mandatory Range	No
Default Value	3H

Sub-Index	1H
Description	Configuration_Name
Object class	Optional
Access	R (optional W)
PDO Mapping	no
Value Range	Visible String
Mandatory Range	No
Default Value	No

Sub-Index	2H
Description	Configuration_Version
Object class	Optional
Access	R (optional W)
PDO Mapping	no
Value Range	Unsigned32
Mandatory Range	no
Default Value	no

Sub-Index	3H
Description	Number_Of_Resources
Object class	optional
Access	R (optional W)
PDO Mapping	no
Value Range	Unsigned8
Mandatory Range	no
Default Value	no

7.2.3 Resources

The declaration of resources provides a mechanism to allocate tasks and programs to a resource (e.g. PLC CPU). A resource will be identified by its name and version. The task handle is a reference to the first task on a resource.

Resource definition structure

Index	Subindex	Field in Resource_Def Record	Data Type
0081H	0H	Number of supported entries	Unsigned8
	1H	Resource_Name	Visible String
	2H	Resource_Version	Unsigned32
	3H	Number_Of_Tasks	Unsigned8
	4H	Task_Handle	Unsigned32

Detailed object description

Index	9600H - 96FFH
Name	Resource
Object Code	RECORD
Number of Elements	4
Data Type	Resource_Def

Value description

Sub-Index	0H
Description	Number of supported entries
Object class	Optional
Access	RO
PDO Mapping	No
Value Range	Unsigned8
Mandatory Range	4
Default Value	No

Sub-Index	1H
Description	Resource_Name
Object class	Optional
Access	R (optional W)
PDO Mapping	No
Value Range	Visible String
Mandatory Range	No
Default Value	No

Sub-Index	2H
Description	Resource_Version
Object class	Optional
Access	R (optional W)
PDO Mapping	No
Value Range	Unsigned32
Mandatory Range	No
Default Value	No

Sub-Index	3H
Description	Number_Of_Tasks
Object class	Optional
Access	R (optional W)
PDO Mapping	No
Value Range	Unsigned8
Mandatory Range	No
Default Value	No

Sub-Index	4H
Description	Task_Handle
Object class	Optional
Access	R (optional W)
PDO Mapping	No
Value Range	Unsigned32
Mandatory Range	No
Default Value	No

7.2.4 Task

A task will be identified by its name or identifier. The task types cyclic, event and timertask are supported.

Representation of the Values: cyclic = 0x0, event = 0x1, timertask = 0x2

Task definition structure

Index	Subindex	Field in Task_Def Record	Data Type
0082H	0H	Number of supported entries	Unsigned8
	1H	Task_Name	Visible String
	2H	Task_Identifier	Unsigned32
	3H	Task_Types	Unsigned32
	4H	Task_Priority	Unsigned32
	5H	Time_Intervall	Unsigned32

Detailed object description

Index	9700H - 97FFH
Name	Task
Object Code	RECORD
Number of Elements	5
Data Type	Task_Def

Value description

Sub-Index	0H
Description	Number of supported entries
Object class	Optional
Access	RO
PDO Mapping	No
Value Range	Unsigned8
Mandatory Range	No
Default Value	No

Sub-Index	1H
Description	Task_Name
Object class	Optional
Access	R (optional W)
PDO Mapping	No
Value Range	Visible String
Mandatory Range	No
Default Value	No

Sub-Index	2H
Description	Task_Identifier
Object class	Optional
Access	R (optional W)
PDO Mapping	No
Value Range	Unsigned32
Mandatory Range	No
Default Value	No

Sub-Index	3H
Description	Task_Type
Object class	Optional
Access	R (optional W)
PDO Mapping	No
Value Range	Unsigned32
Mandatory Range	No
Default Value	No

Sub-Index	4H
Description	Task_Priority
Object class	Optional
Access	R (optional W)
PDO Mapping	No
Value Range	Unsigned32
Mandatory Range	No
Default Value	No

Sub-Index	5H
Description	Time_Interval
Object class	Optional
Access	R (optional W)
PDO Mapping	No
Value Range	Unsigned32
Mandatory Range	No
Default Value	No

7.2.5 Start/Stop (Program/Task)

see /DSP-302/

7.2.6 Debugging/Monitoring

see /DSP-302/

8 Appendix (informative)

8.1 Detailed description of network variable segments

```
[DynamicChannels]
NrOfSeg=36
; -------- Boolean ---------
Type1=1
Dir1=ro
Range1=0xA080-0xA0BF
PPOffset1=0, 1
; -------- Integer8 ---------
Type2=2
Dir2=ro
Range2=0xA000-0xA03F
PPOffset2=0
; ------- Usigned8 --------
Type3=5
Dir3=ro
Range3=0xA040-0xA07F
PPOffset3=0
; ------- Integer16 --------
Type4=3
Dir4=ro
Range4=0xA0C0-0xA0FF
PPOffset4=0
; ------ Unsigned16-------
Type5=6
Dir5=ro
Range5=0xA100-0xA13F
PPOffset5=0
; ------- Integer24 --------
Type6=0x10
Dir6=ro
Range6=0xA140-0xA17F
PPOffset6=0
; ------ Unsigned24-------
Type7=0x16
Dir7=ro
Range7=0xA180-0xA1BF
PPOffset7=0
; ------- Integer32 --------
Type8=4
Dir8=ro
Range8=0xA1C0-0xA1FF
PPOffset8=0
; ------ Unsigned32-------
Type9=7
Dir9=ro
Range9=0xA200-0xA23F
PPOffset9=0
; ------- Integer40 --------
Type10=0x12
Dir10=ro
Range10=0xA2C0-0xA2FF
PPOffset10=0
; ------ Unsigned40-------
Type11=0x18
Dir11=ro
Range11=0xA280-0xA2BF
PPOffset11=0
; ------- Integer48 --------
Type12=0x13
Dir12=ro
Range12=0xA340-0xA37F
PPOffset12=0
;------ Unsigned48 ------
Type13=0x19
Dir13=ro
Range13=0xA300-0xA33F
PPOffset13=0
;-------- Integer56--------
Type14=0x14
Dir14=ro
Range14=0xA3C0-0xA3FF
PPOffset14=0
;------ Unsigned56 ------
Type15=0x1A
Dir15=ro
Range15=0xA380-0xA3BF
PPOffset15=0
;-------- Integer64--------
Type16=0x15
Dir16=ro
Range16=0xA400-0xA43F
PPOffset16=0
;------ Unsigned64 ------
Type17=0x1B
Dir17=ro
Range17=0xA440-0xA47F
PPOffset17=0
;---------- Float ----------
Type18=8
Dir18=ro
Range18=0xA240-0xA27F
PPOffset18=0


;-------- Boolean: --------
Type19=1
Dir19=rww
Range19=0xA500-0xA53F
PPOffset19=0, 1
;---------Integer8---------
Type20=2
Dir20=rww
Range20=0xA480-0xA4BF
PPOffset20=0
;------- Unsigned8 ------
Type21=5
Dir21=rww
Range21=0xA4C0-0xA4FF
PPOffset21=0
;-------- Integer16--------
Type22=3
Dir22=rww
Range22=0xA540-0xA57F
PPOffset22=0
;------ Unsigned16 ------
Type23=6
Dir23=rww
Range23=0xA580-0xA5BF
PPOffset23=0
;-------- Integer24--------
Type24=0x0x10
Dir24=rww
Range24=0xA5C0-0xA5FF
PPOffset24=0
;------ Unsigned24 ------
Type25=0x16
Dir25=rww
Range25=0xA600-0xA63F
PPOffset25=0
;------- Integer32 --------
Type26=4
Dir26=rww
Range26=0xA640-0xA67F
PPOffset26=0
;------ Unsigned32 ------
Type27=7
Dir27=rww
Range27=0xA680-0xA6BF
PPOffset27=0
;------- Integer40 --------
Type28=0x12
Dir28=rww
Range28=0xA740-0xA77F
PPOffset28=0
;------ Unsigned40 ------
Type29=0x18
Dir29=rww
Range29=0xA700-0xA73F
PPOffset29=0
;------- Integer48 --------
Type30=0x13
Dir30=rww
Range30=0xA7C0-0xA7FF
PPOffset30=0
;------ Unsigned48 ------
Type31=0x19
Dir31=rww
Range31=0xA780-0xA7BF
PPOffset31=0
;------- Integer56 --------
Type32=0x14
Dir32=rww
Range32=0xA840-0xA87F
PPOffset32=0
;------ Unsigned56 ------
Type33=0x1A
Dir33=rww
Range33=0xA800xA83F
PPOffset33=0
;------- Integer64 --------
Type34=0x15
Dir34=rww
Range34=0xA880-0xA8BF
PPOffset34=0
;------ Unsigned64-------
Type35=0x1B
Dir35=rww
Range35=0xA8C0-0xA8FF
PPOffset35=0
;---------- Float-----------
Type36=8
Dir36=rww
Range36=0xA6C0-0xA6FF
PPOffset36=0
```

8.2 IEC 61131-3 object dictionary overview

The following table shows all objects, affected by these specification.

Index (hex)	Object	Name	Type	Acc.	M/O
0080H	DEFSTRUCT	Configuration_Name			
0081H	DEFSTRUCT	Resource_Def			
0082H	DEFSTRUCT	Task_Def			
1000H	VAR	Device type	Unsigned32	RO	M
9501H	RECORD	Configuration	Configuration_Def	RW	O
9600H	RECORD	1st Resource	Resource_Def	RW	O
9601H	RECORD	2nd Resource	Resource_Def	RW	O
:					
96FFH	RECORD	255th Resource	Resource_Def	RW	O
9700H	RECORD	1st Task	Task_Def	RW	O
9701H	RECORD	2nd Task	Task_Def	RW	O
:					
97FFH	RECORD	255th Task	Task_Def	RW	O
9800H	VAR	Project_Name	Visible String	RW	O
A000H	ARRAY	1st Dynamic Integer8	Integer8	RO	O
:					
A03FH	ARRAY	64th Dynamic Integer8	Integer8	RO	O
A040H	ARRAY	1st dynamic Unsigned8	Unsigned8	RO	O
:					
A07FH	ARRAY	64th Dynamic Unsigned8	Unsigned8	RO	O
A080H	ARRAY	1st Dynamic Boolean	Boolean	RO	O
:					
A0BFH	ARRAY	64th Dynamic Boolean	Boolean	RO	O
A0C0H	ARRAY	1st Dynamic Integer16	Integer16	RO	O
:					
A0FF0H	ARRAY	64th Dynamic Integer16	Integer16	RO	O

A100H	ARRAY	1st Dynamic Unsigned16	Unsigned16	RO	O
:					
A13FH	ARRAY	64th Dynamic Unsigned16	Unsigned16	RO	O
:					
:					
A440H	ARRAY	1st Dynamic Unsigned64	Unsigned64	RO	O
:					
A47FH	ARRAY	64th Dynamic Unsigned64	Unsigned64	RO	O
A480H	ARRAY	1st Dynamic Integer8	Integer8	RWW	O
:					
A4BFH	ARRAY	64th Dynamic Integer8	Integer8	RWW	O
:					
:					
A8C0H	ARRAY	1st Dynamic Unsigned64	Unsigned64	RWW	O
:					
A8FFH	ARRAY	64th Dynamic Unsigned64	Unsigned64	RWW	O

Table 10: List of object dictionary entries

8.3 Example DCF file

This is not a complete DCF. Only several specific entries for the DS405 are listed.

```
[DeviceInfo]
...
DynamicChannelsSupported=3
...
[DynamicChannels] ; optional since DynamicChannelsSupported=3
NrOfSeg=36        ; see application notes
Type1=1
Dir1=ro
Range1=0xA080-0xA0BF
PPOffset1=0,1
...
Type36=8
Dir36=rww
Range36=0xA6C0-0xA6FF
PPOffset36=0
...
[OptionalObjects]
1=0xA000
...
[A000]            ; Integer8 RO
SubNumber=3
ParameterName=Integer8_RO_Variables
ObjectType=8

[A000Sub0]
ParameterName=NrOfSupportedObjects
ObjectType=0x7
DataType=0x0005
AccessType=ro
DefaultValue=2
PDOMapping=0

[A000Sub1]
ParameterName=<NameOfProcessVariable1>
ObjectType=0x7
DataType=0x0002
AccessType=ro
DefaultValue=
PDOMapping=1

[A000Sub2]
ParameterName=<NameOfProcessVariable2>
ObjectType=0x7
DataType=0x0002
AccessType=ro
DefaultValue=
PDOMapping=1
...
```

8.4 Application notes

8.4.1 Network variables

The usage of the dynamic index assignment of the network variables implies, that the object dictionary area contains arrays with gaps. For example an array may have two sub-objects 1 and 5.

8.4.2 Data type representation issues

In chapter 4.2 the internal data type representation is specified to be partially CANopen non-compliant. If this happens, there may be different data representation of the same data values.

Example:

A PLC may have a byte ordering opposite to CANopen. When transferring a network variable of data type Unsigned16 with value 1 via a PDO according to 4.2 the process picture will contain the following value:

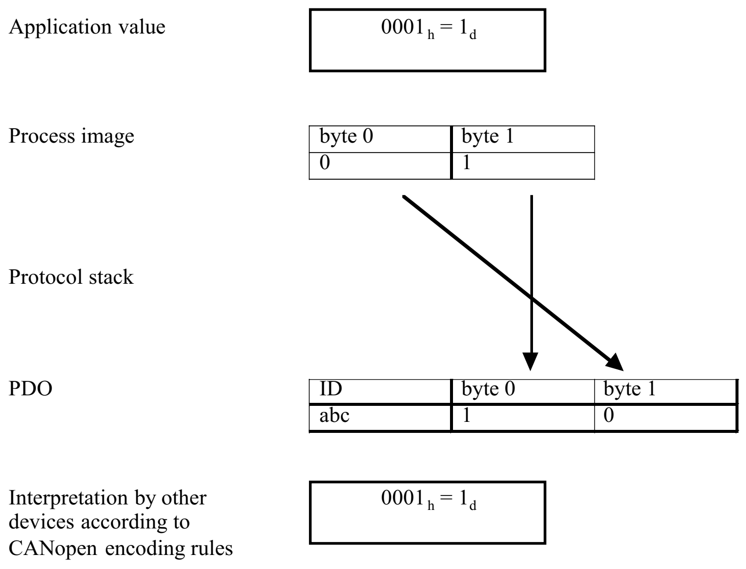

Figure 24: Data representation with PDO on CANopen non-compliant PLCs

When transferring the same value via SDO, there is another situation:

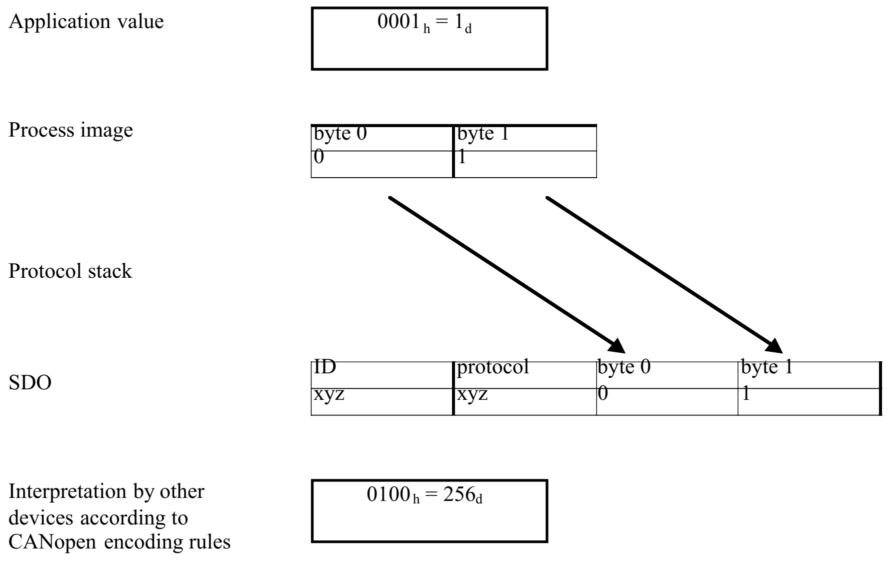

Figure 25: Data representation with SDO on CANopen non-compliant and compliant PLCs

It is the responsibility of the application / user to consider this. The manufacturer of a PLC may decide to make the byte-re-ordering as an own task upon the protocol stack. This will avoid the problem, but will need much more system resources.

8.4.3 EDS

The usage of "DynamicChannelsSupported=3" implies not to support all possible CANopen data types with a device. If the device supports only some of these data types (e.g. BOOL, 1-, 2- and 4 Byte wide types), this can be coded by using the section "DynamicChannels".

It is not allowed to redefine the section "DynamicChannels" of a 405 Profile. Tools are allowed to presuppose the objects as defined in these specification and it is recommended that tools, support the 405 Profile, do not interpret data types other than specified. A reason to enter the section "DynamicChannels" in a EDS/DCF is to support tools without knowledge of the 405 Profile (e.g. DSP-302 Tools) or to give information, what data types are supported or to supply the information of the implemented size of the segments.

For these reasons it is strongly recommended to include the section “DynamicChannels” in the EDS.

8.4.4 Tool integration

This mechanism allows all kind of tools to use the Project files. Users can work with programming environments, debugging tools and project planing tools or only simple node specific configuration tools. Each tool has full access to all information. Further there is no consistency problem between different files.

The locking mechanism is available on every disk operating system used in practice.

Definition of variables may be done in the Programming System. In that case the Network Configuration has to be informed about the name, type and address of these variables, since the Network Configuration is responsible for setting-up the appropriate communication channels for transferring the data contents. The other possibility is the generation of variables in the Network Planning System. This is useful on setting-up a network with distributed intelligence, where the interface between the separate processes has to be defined. In that case a possibility is required to transfer information about the generated variables to the Programming System of each programmable device of that network.

Chapter 6 specifies the data exchange via DCF according to Figure 26.

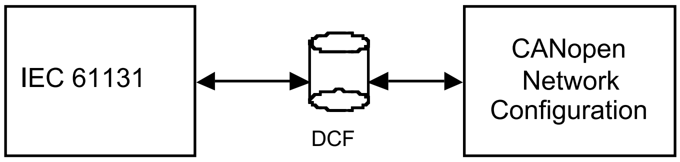

Figure 26: Information exchange via DCF

Some programming systems may not support DCF file formats. In practice it even may be not possible to extend them. But normally they will provide a possibility of data exchange in any other file format. For example this may be something like an include file written in IEC 61131-3 syntax itself (such as DTY). For fulfilling the specification in chapter 6 it is possible to use a converter module as shown in Figure 27.

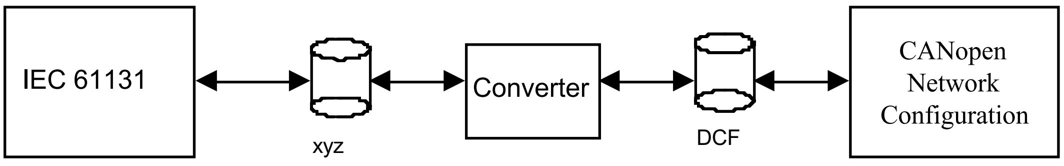

Figure 27: Data exchange using converter module

Version 1.0 of DSP-405 defined mechanisms for data exchange via DCF and a file format called NVX. For compatibilty reasons the usage of NVX can be interpreted in a way, that the converter is part of the programming system as well as of the Network Configuration System. This is illustrated in Figure 28.

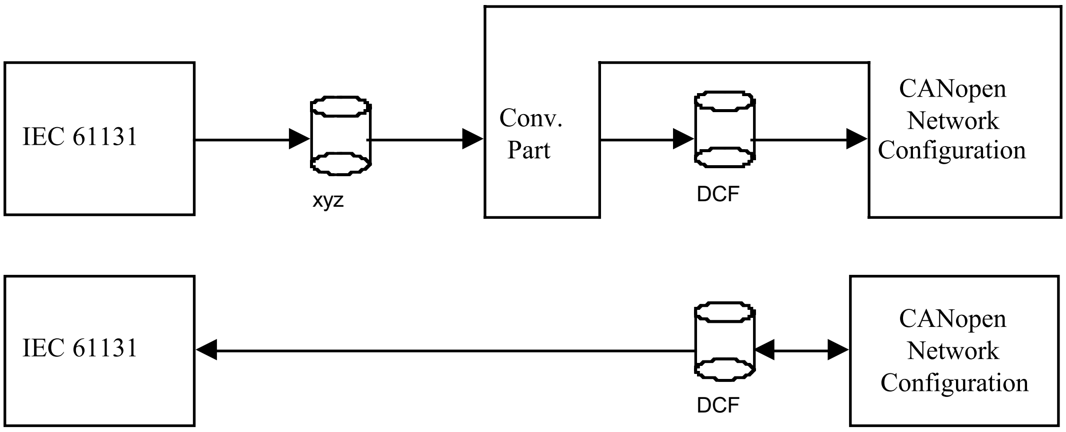

Figure 28: Compatibility for NVX format

To allow the denotation of a device specific tool already by the device manufacturer the EDS may contain a description, which tools are to be used. On creating a DCF from that EDS, this tool description will be copied.

The description start with a section `[ Tools]` containing the entry `Items` with the number of tools supported. Each tool is described in a section `[ Toolx]` with x as decimal counter (1..Items). These sections contain the entries `Name` and `Command` giving the symbolic name and the concrete command. Further entries may exist. Manufacturers are responsible to avoid naming collisions. Command line parameters are not specified here. They depend on the converters.

The example shows a converter

```
[ Tools]
Items=1

[ Tool1]
Name=Convert DCF to DTY
Command=DCF2DTY $DCF $NAME.DTY
```

8.5 IEC 61131-3 sample code

To give a better impression of how the IEC 61131-3 defined items will be used in a typical application, here is one (non-normative) sample program:

```
PROGRAM HeatControl
VAR_EXTERN
      (* How to map variables between process image and CANopen will *)
      (* be very system dependent, this is just one possible way     *)
      Temperature: CIA405INT24;
      VentilatorSpeed: CIA405UINT48;
END_VAR
VAR_GLOBAL
      MaxTemperature: DINT := 21;
      Slow : ULINT := 300;     (* whatever unit *)
      Fast : ULINT := 800;     (* same unit     *)
END_VAR

      LD Temperature
      CIA405INT24_TO_DINT
      GT MaxTemperature
      JMPC cooler

      (* seems not to hot, so run ventilator slow *)
      LD Slow
      ULINT_TO_CIA405UINT48
      ST VentilatorSpeed
      JMP go_on

cooler:
      (* seems to be hot, run ventilator faster *)
      LD Fast
      ULINT_TO_CIA405UINT48
      ST VentilatorSpeed

go_on:
      (* rest of program *)
END_PROGRAM
```

8.6 Implementation models for IEC 61131-3 data type support

Data types CIA405INT24 etc. as mentioned before are not standard with IEC 61131-3. How these are made available to the user is left to implementation, the following chapter describes several possible options. All these models are non-normative, serving only for a better understanding

8.6.1 Native support

One possible implementation is to integrate support for these data types defined above into the IEC 61131-3 programming system. No conversions should be necessary then, the new data types can be integrated into the IEC 61131-3 hierarchy of data types, allowing all built-in instructions and many overloaded system functions to be used for these data types (ADD, EQ, MAX, ...).

Problem: Some effort to implement.

8.6.2 Padding to next best match

The new data types may be defined by using the closest matching IEC 61131-3 native type, e.g. TYPE CIA405INT48: LINT; END_TYPE;

Problem: Memory space is wasted. Value of IEC 61131-3 may exceed limits of CANopen representation. Which instance shall handle this and how? Necessary padding bytes might impose problems on IEC 61131-3 memory mapping (e.g. process image).

8.6.3 Using arrays or struct

The new types may be defined using a array (or structure) of individual bytes:

```
TYPE CIA405INT48: array[1..6] of BYTE; END_TYPE;
```

or

```
TYPE CIA405INT48: STRUCT b1,b2,b3,b4,b5,b6: BYTE; END_TYPE;
```

Applications using only data types and conversion functions as defined in chapters before can be truly portable to different systems, no matter which of these three implementation models be used. Applications using details depending on any of these implementations (applying an ADD to one of these types, accessing individual elements of this array or relying on out-of-range behaviour) might not be portable.