User's Manual

Version 1.6

Programming Tool
for
User Programmable Terminals

to be used in CANopen - Networks
or for display terminals configured via "CANdb" (MKT-View, CDP, ..)

Document Number: 85110 (English)
Original: C:\CBProj\UptWin1\DOKU\art85110_Manual_UPT_Tool.odt

1. Version history

Version number	Date	Author	Remarks, Modifications
V0.1	03.Nov.1999	W.Büscher	Creation of this manual (english, very „preliminary“ !!)
V0.2	13.Dec.1999	W.Büscher	First external release (still preliminary). Programming Tool: Version 1.0 „beta“.
V0.3	22.Mar.2000	W.Büscher	Added a few new interpreter functions.
V0.4	31.May 2000	W.Büscher	Added a lot of new interpreter functions + text array + TX-PDOs + SYNC + „onboard“ digital I/O-Lines . **Now incompatible with „older“ software.** Programming Tool: Version 1.1 „beta“ (or later) required. First german translation of the manual now available.
V0.5	07.June 2000	W.Büscher	„General UPT Options“ implemented and described here.
V0.6	19.July 2000	W.Büscher	Added „Display Lines used as Menu Items“.
V0.7	20.Feb.2001	W.Büscher	Key combination to enter UPT setup can now be modified; how is described here..
V0.8	29.Mar.2001	W.Büscher	(new functions under construction)
V0.9	05.Sept.2001	W.Büscher	Added some interpreter functions for PDOs
V1.0	27.Feb.2002	W.Büscher	Added some notes for users of the CANdb-controlled display terminal (whatever its name will be ;-)
V1.1	2003-05-28	W.Büscher	Notes about "DriverLINX" removed. Didn't work properly under WinXP anyway ! + This document is totally outdated ... !
V1.2	2007-04-23	W.Büscher	Switched from *.doc to *.odt (odt = OpenDocumentText)
V1.3	2008-09-17	W. Büscher	Added a few fragments for the new "MKT-View II" (copied from the online help system!), including the "simple page editor".
V1.4	2011-06-08	W. Büscher	Added notes about the file transfer options
V1.5	2013-04-15	W. Büscher	Copied a few chapters from the online help
V1.6	2014-06-18	W. Büscher	Added 'CDP' (CAN Display Terminal) to this document's front cover page
V 1.6 b	2015-04-07	W. Büscher	Don't use these PDFs anymore. Don't print them on paper. Use the help system in HTML format instead, for example www.mkt-sys.de/MKT-CD/upt/help/progt_01.htm

2. Preface

This manual describes a windows program that can be used to program a special terminal called „user programmable terminal“.

There is a special variant of the programming tool called "Programming tool for CANdb display terminals". Unfortunately there is no special manual available for this yet. If you are a user of the CANdb controlled display terminal, please ignore the chapters "CANopen, SDO, PDO" and all paragraphs with the note "UPT only".

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There are no other warranties, either expressed or implied, including but not limited to implied warranties of merchantability and fitness for a particular purpose, with respect to the software, the accompanying written materials, and any accompanying hardware.

Note: In constrast to the programming tool's online-help-system (HTML), ***this document is a bit outdated !*** New functions are initially described only in the HTML-files, and later -in due course- transferred into this document, too.

3. Purpose and Terminal Features

The main purpose of the user programmable terminal is to display parameter values in a CANopen-Network.
The most important features of the terminal are:

- UPT-515: graphic LCD with 128*64 pixel
- UPT-167, MKT-View I: graphic LCD with 320*240 pixel
- MKT-View II : TFT screen with touchpanel, 480*272 pixel
- "UPT"-terminals communicate with other devices in a CANopen network
- one or more SDO servers which may be used to communicate with other devices
- one SDO client which is used for setup and program transfer
- the terminal can „listen“ to PDO channels and transmit PDO telegrams
- "MKT-Views" are parametrized using CANdb files (Database for CAN), no CANopen
- values from „input channels“ are stored in variables
- user program can evaluate or modify these variables
- display screens are arranged as „user programmable display pages“
- every display page can display up to <n> numerical parameters
- every display page can have a set of flexible „event definitions“ and „reactions“
- an event definition can be a simple „keyboard event“
- an event definition can also be a comparation of numeric values
- an event reaction can be a simple „switch command“ to an other display page

4. System requirements

The programming tool for the user programmable terminal is a windows application (W95/98, Win XP), therefore you will need a PC with windows installed. We have never tested Windows ME nor Windows 2000, but they may work as well.
Sorry, but a LINUX version of this tool is not available.

Furthermore you need:

- a CAN interface for your PC
- the newest CAN driver software which the manufacturer of the CAN interface must provide
- the windows programming tool (software by MKT Systemtechnik)

5. Installation

The programming tool will be delivered on CD-ROM, or can be downloaded from the MKT website. To install ...

- Ensure Windows (preferrably XP, not "Vista") is installed properly on your PC
- Install a CAN-Interface and the required driver software (not a produkt of MKT!)
- If you use a CAN-Interface from PEAK, you should install the newest CAN driver software from PEAK, along with Peak's "large" CAN driver called "PEAK CAN Driver V2.x" and Peak's tools like NetConfig etc. Further Info can only be provided by Peak.
- If you use one of ESD's CAN-Interfaces, install their NTCAN driver system which is supplied with the CAN interface. Carefully read ESD's manual before installing the interface, because you may seriously damage the PC/Laptop and/or the interface if you don't follow the installation procedure.
- If you use a CAN interface by Kvaser AB, install Kvaser's CAN-API (CANLIB) from the CD which should have been shipped together with the device, or install it from the Kvaser site. After that, there should be a new item named 'Kvaser Hardware' in the windows system control. Use it to configure and test your Kvaser CAN interface.
- Set the font display scaling to 100% (somewhere in the windows system menu)...
  For Users of a german windows-installation only:
  Setzen sie die Zeichenanzeige auf „Normalgröße“ (dies ist die Defaulteinstellung):
  in der Taskleiste: Start – Einstellungen – Systemsteuerung – Anzeige – Einstellungen - Schriftgröße:
  „kleine Schriftarten“ (100% = Normalgröße, 10-Punkt-Arial mit 96ppi)
  If you don't set the font display scaling to 100%, the dialog elements of the programming tool will look very ugly !
- Start „InstallUptToolX.exe“ or (depending on the target) "InstallCANdbTerminal.exe" from CD-ROM or your download-folder, and follow the instructions of the UPT-Tool-Installer.
  Note that, as of 2010, there were three different "terminal programming tools" available from MKT Systemtechnik:
  - InstallUptTool1.exe : Old programming tool, only for "UPT-515" (not for UPT-128) .
  - InstallUptTool2.exe : Programming tool for display terminals with CANopen protocol, for example UPT-128, UPT-320 (and *many* others) .
  - InstallCANdbTerminal.exe : For all devices, which use "CANdb" rather than CANopen. "CANdb" is the name of a file format (by Vector) which describes all signals in a CAN network. It is widely used in the auto*motive* sector, but not in the auto*mation* industry.
- To remove this software from your computer, use the deinstaller (start programs-UptWin1-„unwise.exe“)
- You may find this manual as a printable file in a subdirectory „Doku“.

6. Further Information

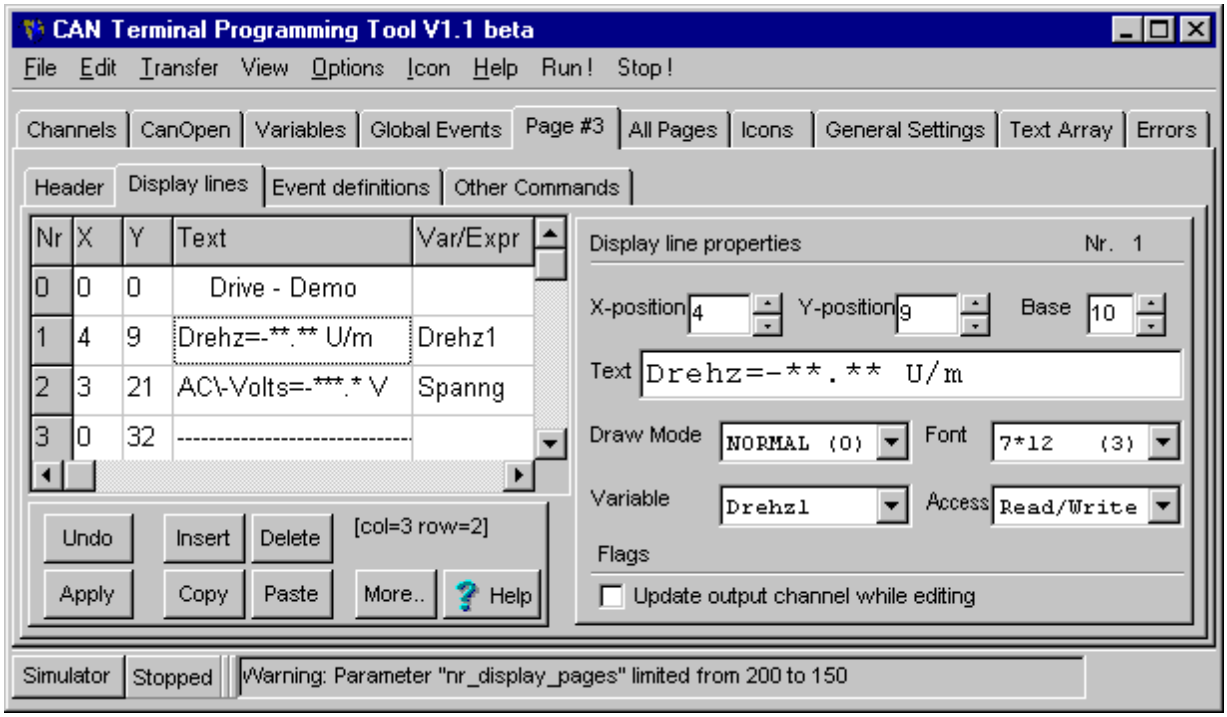
... is available in the following documents. Some of them are contained in the installation archive of the programming tool (folder "Doku"), or can be downloaded from the MKT website .

- Document Nr. 85110: Manual for the UPT programming tools
- Document Nr. 85111: Additional info for terminal parametrised via "CANdb" (e.g. MKT-View, MKT-View +, MKT-View II, and others(!)).
- Document Nr. 85113: Description of the CAN Logger(!) utility
- Document Nr. 85115: Description of the 'System Menu' (inside the terminal)
- Document Nr. 85116: Specification of download protocol (only for developers)
- Document Nr. 85118: Description of the CAN-Snooper (CAN monitor in some terminals)
- Document Nr. 85130: Introduction and first steps with the MKT-View II (coming soon..)

7. Description of the programming tool

7.1 The Main Window

The main window will be displayed immediately after starting the programming tool.



(Note: There may be more functions in the latest software release !)

It contains of several pages in a „tabbed“ style:

- Channels: define Communication Channels (PDO, SDO).
  (the programming tool for "CANdb terminals" has a tab to import CANdb files instead)
- Variables: define Variables for your application.
- Global Events: for common reactions of your application.
- Page #x: is used to define everything on a certaion display page (=”screen”).
- All Pages: displays an overview of all used pages.
- Icons: used to import icons (graphic images) into your program.
- General settings: used to display and modify some terminal settings.
- Errors: shows all kinds of errors and other messages from the system.

At the bottom of the main window you will see a status bar, which displays system information and error messages. The status bar will be explained in the next chapter.

7.2 Main Menu

The main menu is used to

- load programs from ASCII files (*.upt)
- save programs as ASCII files
- transfer programs to or from the terminal (via CAN)
- open auxiliary windows for debugging etc („View“)
- import or create new Icons for the UPT program
- start the online help system
- start and stop the system interpreter

7.3 Status Bar

At the bottom of the main window you will see the status bar, which will display some information about the current system state (e.g. „Transfer in progress“ and so on).

By clicking at the „Simulator“-button you may switch to the LCD-simulator window (if it’s not already visible).

The second panel from the left (here: „Running“) shows a quick info about the current state of the programming tool or the application program. Some possible labels are:

Running:	Your application is running (i.e. it is being executed)
Stopped:	Your application has been stopped for any reason
Transfer:	A program upload or download is in progress.

The right field in the status bar will display the last error message (if any) or other system messages. In the example shown above the last system message was an indication that the CAN interface has been successfully initialized.
You may switch to the error display page by double-clicking into the status message field.

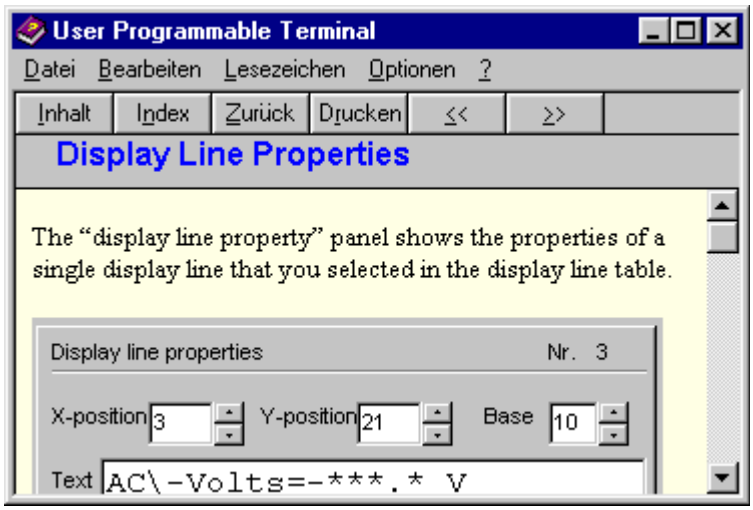
For debugging purposes you may also send a command string to the system command interpreter by typing it into the status message field.

7.4 The Online-Help-System

You will always find the latest information about the UPT programming tool in the online help system, which works like most other windows applications.

The screenshot on the right shows an example for the online-help-system.

If you are not familiar with this system, you should consult a Windows™ manual.



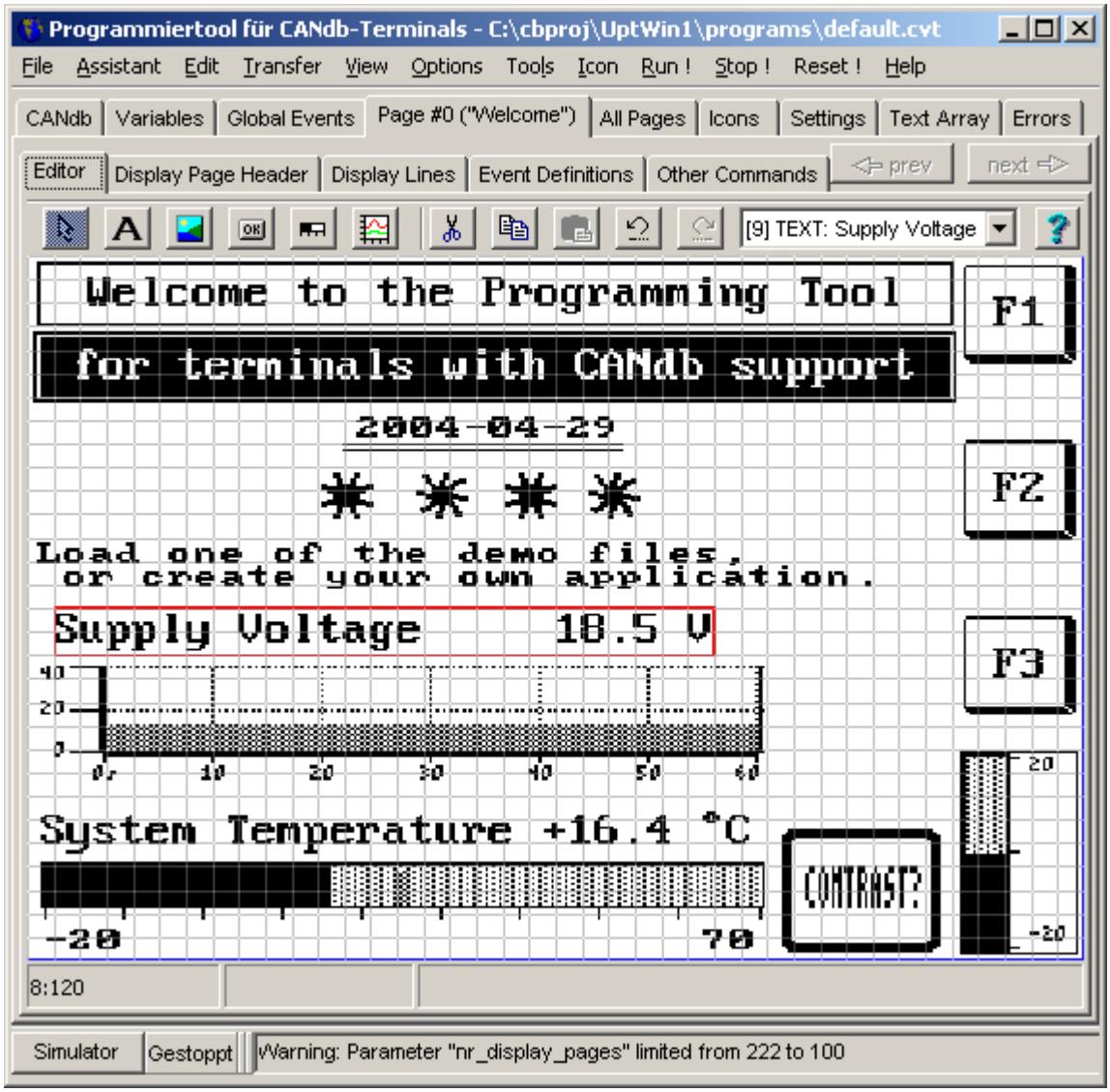
You may start the Online-Help-System by

- clicking at the menu entry „Help“ in the main menu to get an overview of all topics in the help file,
- clicking at any „Help“-Button to get help on a particular dialog,
- pressing F1 to get context-sensitive help on the dialog-element that has the input focus,
- pressing F2 to get command-specific help about any command of the UPT’s command-interpreter.

If you have problems because Windows™ cannot find the help file, you may enter the complete path and file name for the help file in the „General Settings“-tab (see chapter 7.17 for details).

7.5 The Simple Page Editor

The "simple page editor" is an alternative, and possibly simpler, method to edit or create the graphic user interface in your application. An application contains various display pages, which can be modified on the tabsheets of the programming tool as shown below.
As already mentioned, a complete reference can be found in the *online help system* of the programming tool.



The toolbar of the "simple" page editor contains these buttons :

(Arrow or Pointer tool) : Move or modify items on the screen.
Hold the mouse pressed and move it, to change the position.
Use the CTRL-key, or pull a marker frame (start in an empty region on the screen) to select multiple items at once. Single-click on an item to select it (for cut / copy / paste operations).
Double-click on an item to open a special property editor for it .

A (Text tool) : Insert a simple alphanumeric TEXT line on the screen.
First select this tool (click at the symbol in the toolbar).
Single-click into the screen to place a new text item there.

After that, a special dialog opens where you can edit the new item.

 (Icon tool) : Insert an Icon (symbol; bitmap graphics).
Use this tool to insert small bitmap graphics ("Icons") on the display page.
Note: Before you can insert bitmaps here, they must be imported on the tabsheet "Icons" in the programming tool.
After inserting an icon, you can modify its appearance (colour, zoom, different symbols depending on the value of a variable, etc). Use the arrow tool for this, and double-click on the icon in the editor screen.

 (Button tool) : Insert a graphic button.
First select this tool, then click into the screen to add a button.
After that, a special dialog opens where you can edit the button.

 (Bargraph tool) : Insert a bargraph.
First select this tool, then click into the screen to add a bargraph.
After that, you can modify the bargraph in a special dialog window.

 (Button tool) : Insert a diagram.
After selecting this tool, click into the screen to add a diagram.

 (Cut tool) : Cut out the selected item.
First select the item which you want to remove (with the Arrow tool),
then select the "Cut" tool (scissors).
When cutting, the selected item is copied into an internal clipboard-like memory, but this is not the windows clipboard.

 (Copy tool) : Copy the selected item.
First select the item which you want to copy (with the Arrow tool),
then select the "Copy" tool.
The selected item is copied into an internal clipboard-like memory, but this is not the windows clipboard.

 (Paste tool) : Paste item into selection.
First select the item which you want to overwrite (with the Arrow tool).
If you don't want to overwrite a selected item, select nothing.
The item stored in the internal clipboard-like memory will be pasted to the screen.
If an item was selected (marked with a red selection frame), it will be replaced with the "pasted" item.
If no item was selected, the item will be inserted at the position of the insert cursor, which is marked with a small red dot.
The insertion cursor can be set (before inserting an item) with a short click into a non-occupied screen area. After inserting an element, the insertion cursor will be moved down (or right, at the bottom of the screen), depending on the size of the object which has been inserted, so that there will be no overlap. It's easy to fill a page with equally spaced items this way.

 (Undo tool) : Undo recent operation(s).

Click this 'UNDO'-button to undo the recent operation.
In the page editor, up to 20 (?) operations can be undone, because they are saved in an undo-history.
Caution: If you exit from the current page in the editor, the changes cannot be "undone" anymore !

 (Redo tool) : Redo recent undo-operation(s) aka "un-undo".
Click the 'REDO'-button to undo the recent und-operation.
In the page editor, up to 20 (?) undo-operations can be undone, there is an extra buffer for this.
Caution: If you exit from the current page in the editor, the changes can neither be "undone" nor "redone" anymore !

The selected object is marked with a red(?) frame in the drawing area.

The combo box in the editor's toolbar allows you to select individual display elements (in addition to selecting them with the arrow tool). This may be necessary for example, if a display element is completely obscured by another, and cannot be selected with the mouse directly.

Selecting an object in the drawing area (with the arrow tool) will automatically select that object in the combo box, too. The entries in the combo box can be interpreted as follows :

[line number] ELEMENT-TYPE : element-text

Example (from the screenshot at the begin of this chapter) :

[9] TEXT : Supply Voltage

which means:
The currently selected display item is defined in line number 9 (an array-index; numbering starts at zero);
the item is a simple TEXT (alphanumeric);
the display text begins with the string "Supply Voltage".

Graphic controls can be aligned to an 8 * 8 pixel grid. To show this grid, or let a coordinate snap to the grid, select "Option"..."Page Editor" in the programming tool's main menu. If the option "Snap coordinates to 8*8 pixel grid" is active, the upper left corner of an object will be aligned to the nearest grid point when moving the object with the mouse.

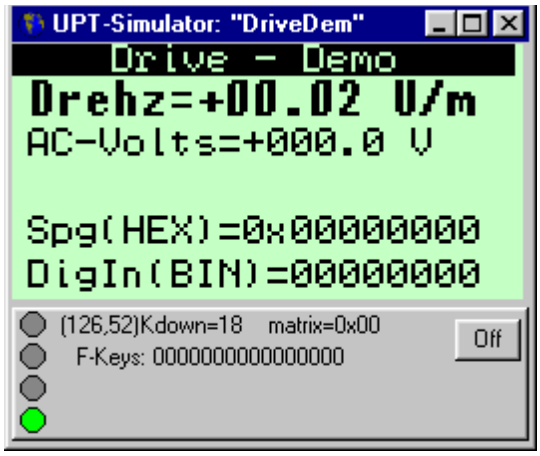
At the time of this writing, the following display elements were supported by the "simple" page editor:

- TEXT : simple text, with or without variables (use asterisks as placeholder characters)
- ICON : small bitmap graphics ("symbols")
- BUTTON : graphic button
- BARGRAPH
- DIAGRAM : Y(t) or X/Y diagram

Other 'special' functions, or graphic items, can be created or modified as explained in the *online help system* of the programming tool (which, by the way, will always be more up-to-date than this document).

7.6 LCD simulator window

The LCD simulator window is used to show the contents of the LCD screen, which you will see later after uploading your application into the user programmable terminal.



In most cases this window will display the current page.

As long as the LCD simulator window has the „input focus“ (blue title background), all keyboard inputs will be passed on to the terminal simulator.
This allows you to test your programmed event handlers etc.

The LCD simulator window can be moved and sized independent of the main window. You may even maximize it to a real „full screen view“.

On the panel at the bottom of the simulator window you can see the current state of some LEDs and the user-programmable function keys. The appearance of this window will change in future versions of the programming tool. There may also be a display for optional „onboard“ I/O-lines of the UPT.

By clicking into the LCD simulator window, you can select (or move) a single text display line. The MAIN window of the programming tool will automatically switch to the display definition tab where you can modify all properties of the selected line.

Holding the left mouse button pressed on a visible display line in the simulated display while slowly moving the mouse allows to move the display line aroud (only works for normal text display lines from chapter 7.10.2, not for general graphic commands like „line“, „rectangle“ from chapter 8.6).

7.7 System Command Interpreter

The system command interpreter is a part of the UPT firmware, but almost the same code is also implemented in the programming tool. Most of your „user program“ is executed by the system command interpreter. The system command interpreter is used to evaluate formulas, event definitions and to execute complex graphic commands (they all will be explained later). A description of some commands can be found in the appendix.

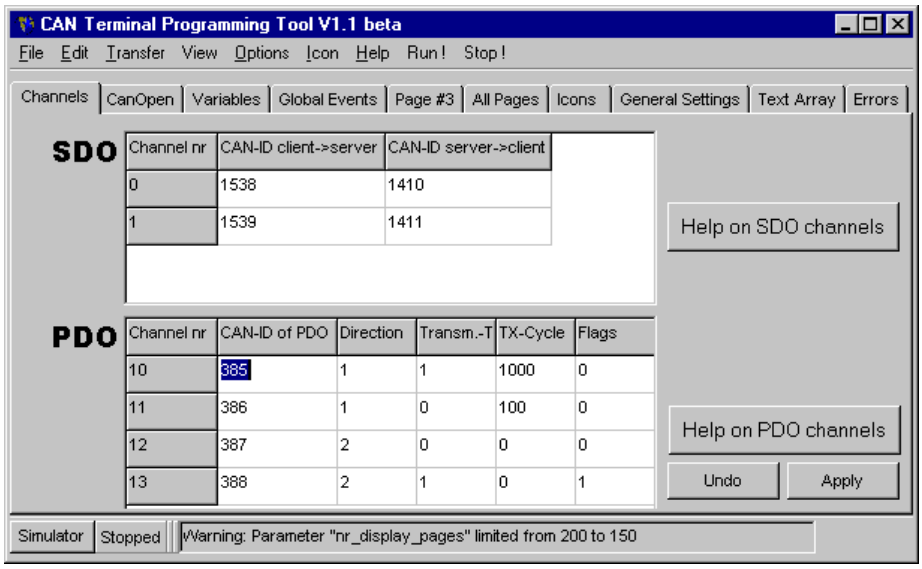
You may enter a system command in the status line, where usually error messages and warnings are displayed. This feature is only intended for experienced users and for debugging purposes.

Some of the commands that you can enter are directed to the display list interpreter and may result in „strange“ behaviour of the program (see help system for detailed info).

All commands that cannot be processed by the programming tool will be directed to the terminal’s interpreter. The format of these commands will be equivalent to the syntax of event-reactions.

7.8 Communication Channels

This page is used to define the communication channels which the terminal uses to exchange data with other devices on the CANopen network.



There are different types of communication channels:

- SDO channel (Service Data Object)
  a „slow“device-to-device connection which allows to exchange data from a device’s object dictionary.
- PDO channel (Process Data Object)
  a „fast“ communication channel that is used to transfer process data with a high priority, for example digital inputs, analogue values from sensors etc.
- CANdb-Messages (only for a few special variants)
  Quite similar as a CANopen-RPDO, but any CAN-identifier can be used. CANdb-***signals*** and -***messages*** are defined in a CAN-database file. Up to 64 signals can be contained in a message. Channel number "30" identifies a variable which is connected to a CANdb-***signal***.

Note that the terminal can only „listen“ to PDO channels. It can not request the transmission of a PDO from another device via RTR (because this may cause a lot of trouble ...)

You have to define at least one communication channel for every device that the terminal shall communicate with. The channels will later be used to transfer values from other devices into the variables of your terminal program.

7.8.1 SDO channels

SDO channels provide a „slow“device-to-device connection which allows to exchange data from a device’s object dictionary.

You have to define the CAN-identifiers of all SDO-channels which the terminal shall use to communicate with other devices. You will find the Identifier values in the description of the device that transmits a particular SDO or in the CANopen Draft Standard 301 (CiA „DS301“). Most I/O-devices use a „pre-defined connection set“ with the following definitions for the SDO’s CAN-Identifier (which DS301 calls „COB-IDs“).

SDO(server->client) :	CAN-Identifier	= (1408+node-ID)	= 1409...1535
SDO(client->server) :	CAN-Identifier	= (1536+node-ID)	= 1537..1663

All CAN-Identifiers here are decimal values. The „client->server“-ID will be transmitted from the client (which is the UPT) to the server (which may be an I/O-module) to initiate a transfer („request“). The „server->client“-ID will be transmitted back from the server to the client („answer“).
The „node ID“ is a number between 1 and 127, on many simple I/O-devices it can be set via DIP-switch.

Always be aware:

An SDO connection is just a „point-to-point“ link between two partners. You must take extra care to use only SDO connections that are not yet occupied by other devices. If a simple I/O-device only has one SDO channel and this SDO is already occupied by an other device (maybe a PLC, SPS, a servo drive or something else), you can **not** connect the UPT to this device via „active“ SDO request because this would cause severe collisions on the network (same CAN-ID transmitted by several devices, SDO protocol violations etc.).

In the User Programmable Terminal, a variable can be connected via SDO to an other device in the network.

7.8.2 PDO channels

PDO channels provide a „fast“ communication channel that is used to transfer process data with high priority, for example digital inputs, analogue values from sensors etc.

You have to define the CAN-identifiers of all PDO-channels which the terminal shall transmit or receive. You will find the Identifier values in the description of the device that transmits a particular PDO or in the CANopen Draft Standard 301 (CiA „DS301“). Most I/O-devices use a „pre-defined connection set“ with the following definitions for the PDO’s CAN-Identifier (which DS301 calls „COB-IDs“).

PDO1(tx) :	CAN-Identifier	= (384+node-ID)	= 385...511
PDO1(rx) :	CAN-Identifier	= (512+node-ID)	= 513...639
PDO2(tx) :	CAN-Identifier	= (640+node-ID)	= 641...767
PDO2(rx) :	CAN-Identifier	= (768+node-ID)	= 769...895

All CAN-Identifiers here are decimal values. Note that „tx/rx“ in this table has to be seen from the I/O-devices point of view, so the „tx“ PDO’s are transmitted by an I/O-module and can be received by the UPT. The possible values for node-IDs are 1..127. Simple devices like I/O-Modules often use a DIP-switch to set the node-ID.

Example: You want to receive the state of digital inputs of an I/O-Module. The I/O-Module uses its PDO1(tx) to transmit process data, which contain the digital inputs. The node-ID of the I/O-Module is set to „1“, so the resulting CAN-Identifier will be (384+1)=385(decimal).
To receive this PDO with the UPT, you want to use the first PDO-channel of the UPT. Just enter the value „385“ in the column „CAN-ID of PDO“.
Set the „Direction“-Column to „Receive“ (from the UPT’s point of view). The UPT is now able to receive a PDO with this identifier, and you may define variables that use the PDO data as „input values“.

In the User Programmable Terminal, a variable can (now) be connected either to a „TX“-PDO or an „RX“-PDO. A variable can never be connected to two channels at the same time. But you may connect several variables to a PDO-channel.

Caution !

In a CANopen-network, one CAN-Identifier may only be transmitted by one single device in the net. So ***you*** have to make sure that all PDO channels transmitted by the UPT will never be transmitted by „anyone else“.

Some components of a PDO channel definition are described in the following chapters. For a detailed (and up-to-date) explanation you should read the Help-System of the UPT Programming Tool.

7.8.2.1 PDO Transmission Direction

Since April 2000, the UPT515 supports Reception and Transmission of PDOs.
Therefore you have to specify, if a PDO channel shall receive(1), transmit(2) or be passive(0).

Note: „Transmit“ and „Receive“ has to be seen from the UPT’s point of view.

7.8.2.2 PDO Transmission Type

Since April 2000, the UPT515 supports different types of PDO transmission.
The PDO transmission type is defined by a numerical value. It is taken from CiA DS301.
You may find more information on this in CiA Draft Standard 301, Version 4.0 (16.6.1999), Page 9-83 in the description of Objects 1400h-15FFh (PDO Communication Parameter), Table 54, „Description of transmission type“:

Transmission Type	Cyclic	Acyclic	Synchronous	Asynchronous	RTR only
0		X	X		
1-240	X		X		
241-251 reserved					
252			X		X
253				X	X
254				X	
255				X	

A transmission type of zero means that the message shall be transmitted synchronously with the SYNC object but not periodically (??..).
A value between 1 and 240 means that the PDO is transferred synchronously and cyclically, the transmission type indicating the number of SYNC which are necessary to trigger PDO transmissions/receptions.
The transmission types 252 and 253 mean that the PDO is only transmitted on remote transmission request. The UPT515 treats both 252 and 253 exactly the same way.
Transmission type 254 is „manufacturer specific“ (which is not defined yet).
Transmission type 255 is „defined in the decive profile“ (which does not exist here).

Note: By the time of this writing, the UPT515 did not support all of the transmission types shown above. The Simulator inside the UPT Programming Tool does not support any „real time“ PDO-Transfer at all, because the CAN-Controller used in the PC’s CAN-Interface is not compatible to the Controller in the „real“ UPTs.

7.8.2.3 PDO-Definition-„Flags“

These „Flags“ have been implemented for „very special PDOs“. You can see them on the Communication Channel Definition screen on page 19.

Only the ***last*** PDO channel can be configured to be a „System State PDO“ by setting the FLAG value to „1“ (? see Online-Help-System ?).
The „System State PDO“ has the following contents:

- Byte[0] = UPT run mode („Status“??) ... please ***ignore*** this byte !!
- Byte[1] = digital Inputs of the UPT
- Byte[2] = current display page of the UPT
- Byte[3] = Key-Matrix[0], the „first“ 8 keys of the keyboard driver.
- Byte[4] = Key-Matrix[1], the „next“ 8 keys of the keyboard driver.

You should leave all flags „zero“ to use flexible TX-PDO-Mapping from Variables.

7.8.3 Communication channels for CANdb - signals

(Not for CANopen, but exclusively for the "mobile bus" used in the automotive area)

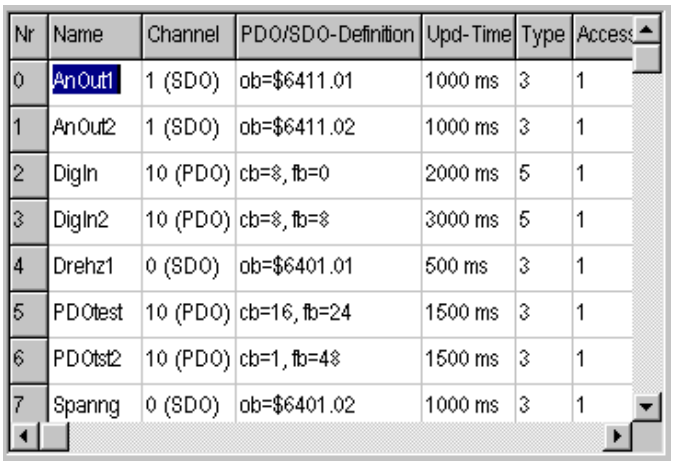
Channel number 30 is reserved as a "dummy" for all UPT-variables connected to a CANdb-compatible ***signal***.

CANdb means "database for CAN". In a CAN database file (extension *.DBC) so-called ***messages*** and ***signals*** are defined (and some other objects which are ignored here).
The programming tool has the possibility to import DBC-files and convert some of the information contained in a DBC file into the definition of an ***UPT-variable***.

Detailed information on how to achieve this can **only** be found in the online help system of the programming tool. Switch to the tab sheet "CANdb" and hit the Help-button on that page.

7.9 Application Variables

This page is used to define all variables which the terminal will use to show and modify parameters.



Nr	Name	Channel	PDO/SDO-Definition	Upd-Time	Type	Access
0	AnOut1	1 (SDO)	ob=$6411.01	1000 ms	3	1
1	AnOut2	1 (SDO)	ob=$6411.02	1000 ms	3	1
2	DigIn	10 (PDO)	cb=8, fb=0	2000 ms	5	1
3	DigIn2	10 (PDO)	cb=8, fb=8	3000 ms	5	1
4	Drehz1	0 (SDO)	ob=$6401.01	500 ms	3	1
5	PDOtest	10 (PDO)	cb=16, fb=24	1500 ms	3	1
6	PDOtst2	10 (PDO)	cb=1, fb=48	1500 ms	3	1
7	Spannng	0 (SDO)	ob=$6401.02	1000 ms	3	1

Variable properties are:

- Name
- Channel
- PDO/SDO – definition
- Update – Time
- Data Type
- Access Rights
- Flags
- Default Value
- Minimum Value
- Maximum Value
- Factor, Divisor, Offset

Most of your variables will be connected to a communication channel, but they can also be used as internal variables which keep temporary values etc.

The Channel-Number also defines the TYPE of a communication channel:

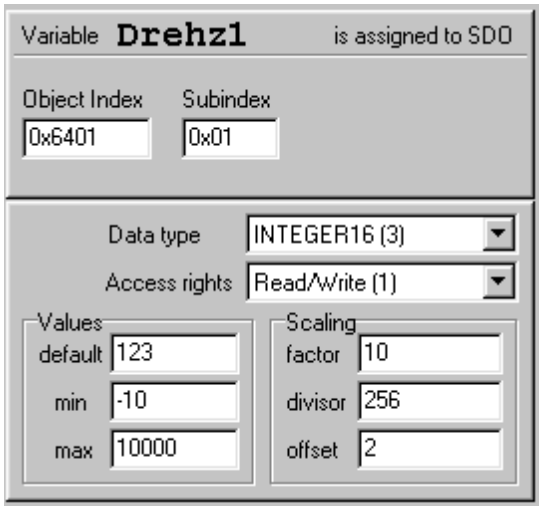
- Channel 0..9 is used for SDO-Client-channels (or „future Reserve“),
- Channel 10..19 is used for PDO-channels (also with „Reserve“),
- Channel 20.29 will be used for a special serial communication link in future,
- Channel 30 is used for signals defined in a CANdb file,
- Channel 255 means „this variable is not connected to any communication channel“.

The other columns of a variable-definition will be explained later.

7.9.1 Variables on SDO channels

A variable can be „connected“ to an object in an other device in the network via SDO channel.

The „objects“ of a CANopen-device are located in a so-called dictionary. Every object of this dictionary is defined by its Object-Index and Subindex .
These parameters are defined on the following panel, which will be visible if the current variable is connected to an SDO-channel:



To „connect“ a variable to an object of a CANopen-device, you have to define:

- the SDO channel number (which connects the UPT to a certain device)
- the index and subindex of the CANopenobject
- data type, access rights, min/max-values, scaling etc like any other variable

7.9.1.1 Usage of Index and Subindex for SDO variables

For a variable which is connected to an SDO channel, you have to define an index and a subindex.
The „objects“ of a CANopen-device are located in a so-called dictionary. Every object of this dictionary is defined by its Object-Index and Subindex.
The Object-Index is a 16-bit-number which is usually defined in hexadecimal format. Hexadecimal Numbers always have to be entered beginning with the „0x“ or „$“-prefix, otherwise the interpreter would treat them as decimal numbers.
The Subindex is an 8-bit-number which is often used for arrays or structured objects.
For example, a DS401-type module with 5 digital inputs may have an Object 0x6020 which contains the state of the digital inputs. Subindex 0 of this object will have the content „5“ to indicate that there are 5 digital inputs, subindex 1 will hold the actual state of the first digital input, subindex 2 the state of the second input and so on.

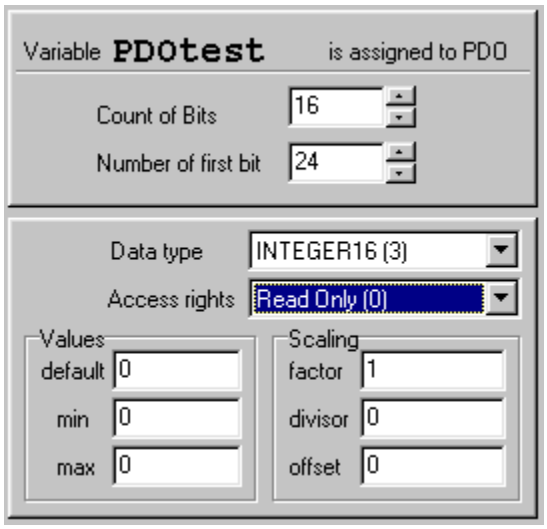
Index and Subindex of CANopen-Objects are often defined in a device’s manual. But for many objects you may also find the required information in a so-called Device Profile . There are device profiles for different types of CANopen-devices, for example:

DS401: Device Profile for I/O Modules

You may obtain these profiles at CiA (Can in Automation, www.can-cia.de) if you need.

7.9.2 Variables on PDO channels

The input of a variable can be connected to a part of a PDO channel (a PDO can carry up to 8 bytes of information, and you will usually only use a part of that data field).



To „connect“ a variable to a PDO channel, you have to define these parameters on a special dialog panel:

- the „UPT-internal“ number of the PDO channel
- the number of data bits that shall be transferred from the PDO into the variable
- the number of the fist data bit in the PDO (which is the least significant bit, starting with bit 0)
- data type, access rights, min/max-values, scaling etc like any other variable

Notes:

- only 1-bit-parameters can be read from any bit-position in the PDO.
- 8-, 16-, 24- or 32-bit-Parameters must start on a BYTE boundary in the PDO data field, so the „number of the first bit in the PDO“ must be a multiple of 8.
- Parameters with more than 8 databits are always transferred in „low to high-byte-order“.
- If the Programmiertool detects obvious Errors, for example conflicting data types and value ranges, it will mark some of the edit-fields with red color and issue a warning message.

7.10 Page Definitions

The Page Definition tab is used to define a single display page that you will see on the LCD screen of the programmable terminal.

A display page consists of

- a header definition
- some text-display-definitions
- some graphic display commands (and other specials)
- some event-definitions (see chapter 7.12)

To switch to an other page of your terminal program, you may use the page overview, where you can see all pages that you have already programmed (see chapter 7.15).

7.10.1 Page Definition Header

The Page Definition Header contains general information about a display page.

Some of these options are:

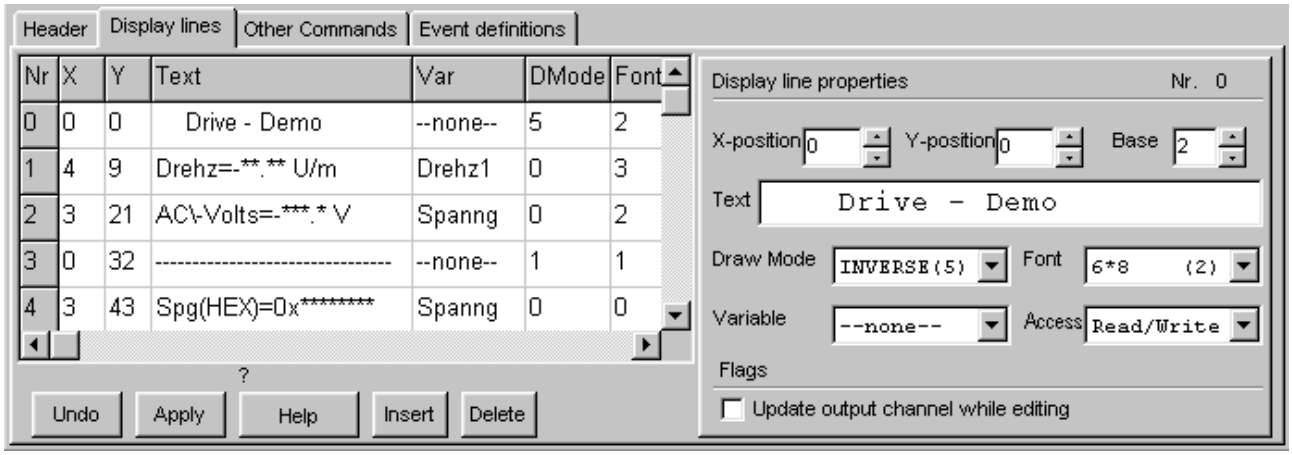
- Always redraw this page completely

If this option is checked (activated), the whole page will always be updated completely. This requires quite a lot of CPU time but may be necessary if you use overlapping graphics or moving graphics. A complete screen update always includes erasing the screen, so there will be no remaining „rubbish“ on the display if you let an icon move across the screen.
A typical display-update with the option „always redraw“ takes about 250ms (on terminals with an 8051-compatible CPU and a 128*64-pixel graphic display). This results in a display update-rate of about 4 screens per second (depending on the complexity of the screen).

If „always redraw page“ is not activated, only the text lines with modified contents may be updated to save some CPU time. A typical display update-rate will be about 10 screens per seconds (but this depends very much on the number of display-lines with flexible contents).

7.10.2 Definition of Display Lines

To define lines of text that you want to display on the terminal’s LCD screen, you may use the tab display lines on the page definition sheet.



The table on the left shows all currently defined display lines on the current display page.

The „property“-panel on the right shows more detailed information about one single display line.

You may edit the properties of a display line in the table or on the property panel, the information will always be updated on both parts.

If the simulated LCD screen is visible, you will immediately see the effects of the changes to a display line. For example, if you change the Y-Position of a display string via up/down-scroller in the display line property panel, you will the text moving on the simulated LCD screen.

The currently edited display line can be marked in the LCD simulator window with a thin dotted frame.

If some graphic elements or text lines on the screen overlap, you should be aware of their drawing order (see chapter 7.10.6). The order of the definition lines can be modified with the mouse. Hold the left button pressed while moving the mouse in the column "Nr" up or down. A black horizontal bar shows the location where the moved entry will be inserted when the mouse button is released. This row-moving procedure is also possible in some other tables of the programming tool.

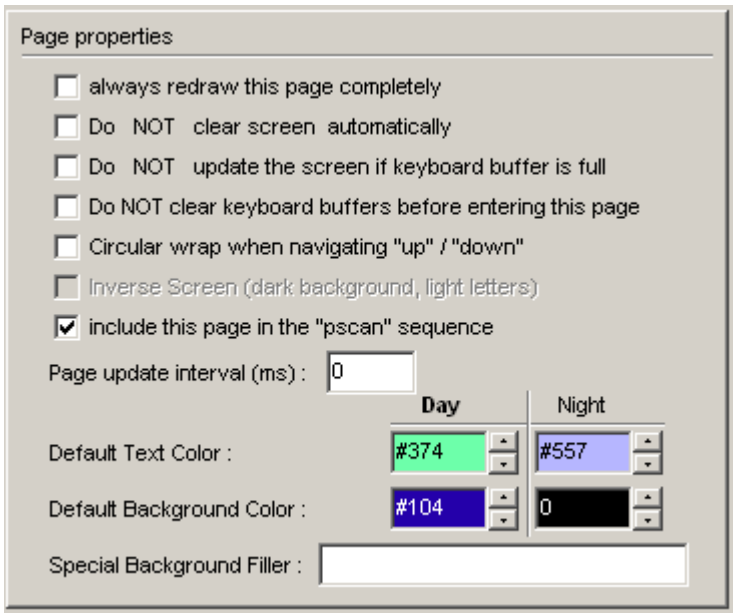
The button „Insert“ is used to insert a display-line (at the current position in the grid).
The button „Delete“ removes the display line which is currently marked in the grid.

Some „special“ functions for editing display lines may be found by clicking into the grid with the right mouse-button. A popup-menu will open and show you all possible options.

7.10.3 Colours

For devices with colour display (like MKT-View II) the programming tool allows you to select individual colours for each display element (Text, Button, Bargraph, etc).

But we recommend, that for most display elements, you set the individual colour to "-1" in the programming tool's edit field. Colour value -1 (minus one) means "use the page's default colour", which is defined on the tabsheet "Display Page Header" like in the example below. Assigning colours this way means that most (if not all) display elements on a page share the same foreground- and background colour. This greatly simplifies to switch between day- and night-design as explained in the programming tool's built-in ONLINE HELP SYSTEM .



7.10.4 The Format String in display lines

A „format string“ is one of the display line properties of a display line definition.
The format string can...

- be a simple constant text string
- contain special „place holders“ like „****“ for numeric digits
- be used to show icons (in backslash sequences like „\iMyIcon“)

Special characters in a format string are:

`*`
: will be replaced by a numerical digit or a string expression

`-`
: will be replaced with the sign of a numeric value (+,-)

`\\`
: displays a single backslash

`\-`
: displays a "-"-character

`\cN`
: sets the text-color to (N)

`\CN`
: sets the background-color to (N)

`\mN`
: switches the draw mode for all following letters

`\i<Icon-Name>[,<Invert-Flag>]`
: Inserts an Icon (see below)

Some format string - examples:

```
Voltage= *****.** V
Icons: \iF_ok,kd0 \iF_no \iF_stop
DrawModes: \m0 Normal \m5 Invers \m8 Blink
```

Inserting Icons in a display line:

See the second example. Here three icons (named „F_ok“, „F_no“ and „F_stop“) are inserted in a single display line. Each icon will be treated as a „letter“ when shown on the screen. That means, if you change the X,Y-position of the display line you will also move all icons of that line.
You may also use an optional „state“-expression to invert the icon’s color depending on a numerical argument (after the icon’s name, separated by comma). This feature has been implemented to simplify graphic „function keys“ just above the Keys F1..F4. In the example, the Icon „F_ok“ will be inverted as soon as the first function key is pressed (because the expression „kd0“ is TRUE while F1 is pressed).

Notes:

- If the Icon in a „\i<Icon-Name>“-sequence is unknown (because it is not defined on the Icon Page), the sequence will be displayed as normal text.

- You should activate the option „always redraw this page completely“ in the page definition header, if you use „invertable“ icons in a display line. Reason: The interpreter may not notice that the state of the <Invert-Flag> has changed because the Invert-Flags are evaluated only if a display line is „redrawn“.
- You should activate the option „always redraw this page completely“ in the page definition header, if you use the „\m<Draw-Mode>“-sequence in a format string and <DrawMode> is a variable expression. Reason: Same as above.
- If you want to „separate“ multiple Icons in a single display line, use the space character. The width of the spaces depends on the standard font used for this display line. Use the „4*6-pixel-font“ for a „good resolution“.
- If you just want to draw a single Icon with ***variable*** coordinates, use the icon-command instead of a backslash-sequence in a format-string.

7.10.5 Using Display Lines as Menu Items

Some Display Lines can also be used to implement a simple „selection“ menu.

For this purpose, set the Flag „**This line is a menu item**“ in the display line properties of a display line definition. This turns a normal „display line“ into a „menu item“ which can be seleced using the CURSOR keys.

Next, define what the UPT firmware shall do if the User presses the ENTER key on that menu item. In most applications, this will be a goto-command to an other display page. Example:

`g"Menu2"` (assuming there is a display page called „Menu2“ in your program)

This command has to be entered in the „Var/Expression“ column of a display page definition.

There are some UPT interpreter functions that give you additional control over this kind of menu:

- mi : returns the line number (index, 0..n) of the current menu item.
- mm: returns the current menu mode. It may be one of the following values:
  0 = Menu is „Off“, that means the menu selection bar is invisible
  1 = Mode „Selecting“, that means the menu selection bar is visible, the user may move the selection between all „menu items“ on the current page using the cursor.
  Other „modes“ are only valid for numeric edit field, for example 2 = „editing the value“.

There are also some „SET“-Procedures for this kind of menus, which have the same names as the „GET“-Functions:

- mi(<new_item>) allows setting the „current“ menu item under program control
- mm(<new_mode>) allows setting the „current“ menu mode under program control

You may find an example for this kind of menus in the file \programs\NEWMENUS.UPT .

Note: If you use a Display Line as a Menu Item, you cannot show the contents of a numerical parameter in that line !

7.10.6 Overlapping graphics

For some special effects you may place some visible elements (text or graphics) in front of other visible elements.
For example, there may be a large icon in the background and a little text display line in front of the icon.
To achive this effect, the icon must be drawn first and the text must be drawn afterwards. The sequence (or „drawing order“) is defined by the row number in the screen definition tables.
Any element with the row number „0“ will be drawn first, the element number „1“ will be drawn second and so on.

When using overlapping graphics, you should always activate the option „redraw page completely“ in the page definition header.

7.11 Definition of special display commands

The following „special“ display commands are used to display graphic elements on the LCD.

icon (ic)	draws a small image („icon“)
line (li)	draws a line
pixel (pi)	sets a single pixel
frame(fr)	draws a rectangular frame
fill_rect(fi)	draws a solid rectangular shape

To set some additional parameters that affect the graphic drawing commands, you may use the following commands:

draw mode(dm)	sets the draw mode

These commands may be entered in an abbreviated form into one command line. A more detailed description of all system interpreter commands can be found in chapter 8.6.

If some graphic elements or text lines on the screen overlap, you should be aware of their drawing order (see chapter 7.10.6).

You will find a detailed (and up-to-date) description of all interpreter-commands **only** in the online help system of the programming tool.

7.12 Defining Events – an overview

An „event“ is the occurrence of a special situation that you want to handle in your terminal program.
An event can be:

- User presses or releases a certain key on the terminal
- The value of a variable exceeds a certain value (may have been received via CAN)
- One bit of a variables is set to a certain value
- and more combinations..

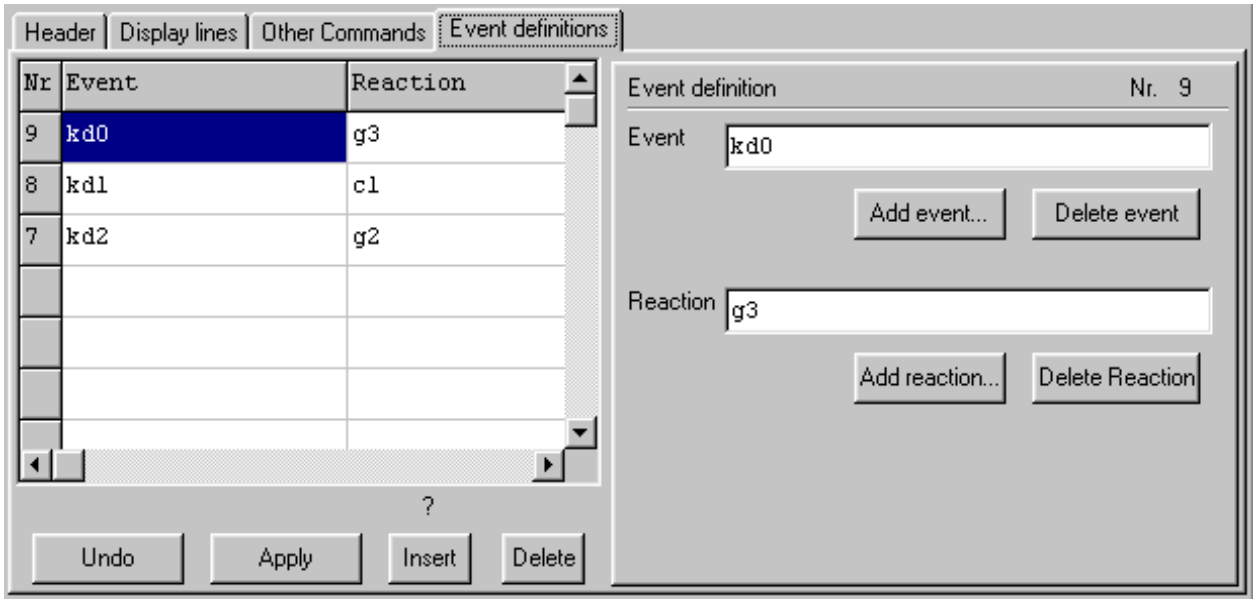
For every event you also have to define a special „event reaction“ on every display page where the event shall be handled.
Possible event reactions are:

- Switching to an other display page
- Setting a certain variable to a certain value (which may be sent via CAN)

For the definition of events we use a simple event definition language, but you may also define events for a display page by selecting them from a list in the UPT programming tool. The programming tool will then generate the interpreter code automatically.

7.13 The event definition tab

To define events and reactions, the programming tool has the following tab sheet:



In this example there are only a few keyboard event definitions.

7.13.1 Defining Events – the definition language

To define events in your UPT application, you may use this event-definition-language.

Event-Type	Parameter (if required)	Description
kd	**key-name**	**user has pressed a key**
ku	**key-name**	**user has released a key**
kb	**key-name**	**buffered keystroke**
kh		**any key has been hit (system key)**
kc		**reads and removes system key from buffer**
cb		**CAN-Error: Bus Off**
ce		**CAN-Error (severe)**
cw		**CAN-Warning**
ch		**CAN-hardware fault**
co		**CAN-Error: Overflow**
ct		**CAN-Error on transmit**
t0 ... t3		**User-timer**TimerCommands **(nr. 0...3) has run off**
pe		**Current page has just been entered (Page Enter)**
pq		**Current page will soon be left (Page Quit)**

(Note: There will certainly be more event-functions. Check the Help System of the programming tool !)

The terminal’s interpreter evaluates the event definition as a boolean expression. You may also use more complex numeric expressions as event definitions.

If the result of an event-definition (or expression) is non-zero, the system interpreter executes the corresponding reaction method. An event reaction method is (internally) coded a string of interpreter commands.

A more detailed and up-to-date description of the event-definition language can be found in the help system of the programming tool.

A short description of numerical expressions can be found in chapter 8.1.1 of this document.

7.14 Global Events

You may define global events for situations that are independent of the current display. For example, you may wish to „call“ a certain display page whenever there is a severe error on the CAN-Bus. This can be achieved by the following example:

```
Event-Def.: ce (which means: "if there is a Can Error"...)
Reaction:   c"CanError"   (.. call the page "CanError")
```

Define this Event and it’s reaction method on the „Global Event“ page, so you don’t have to define it on every used page (remember, the number of lines on a page is limited !).

There are some rules for global events that you should use:

- Use global events for all events that would otherwise be equal on every page definition.
- Don’t use display output commands in the reaction methods of global events, because this might „interfere“ with the screen output of some of your pages.
- If you defined a certain event as a global event (like „ce“ in the example above), you should not define this event again as a „local“ event on any display page. However, defining an event twice does not hurt the event handler. If multiple event definitions are TRUE at the same time, all their correspondig reaction methods are executed.

7.15 Display Page Overview

The Page Overview tab shows an overview of all pages that are currently defined in your terminal application.

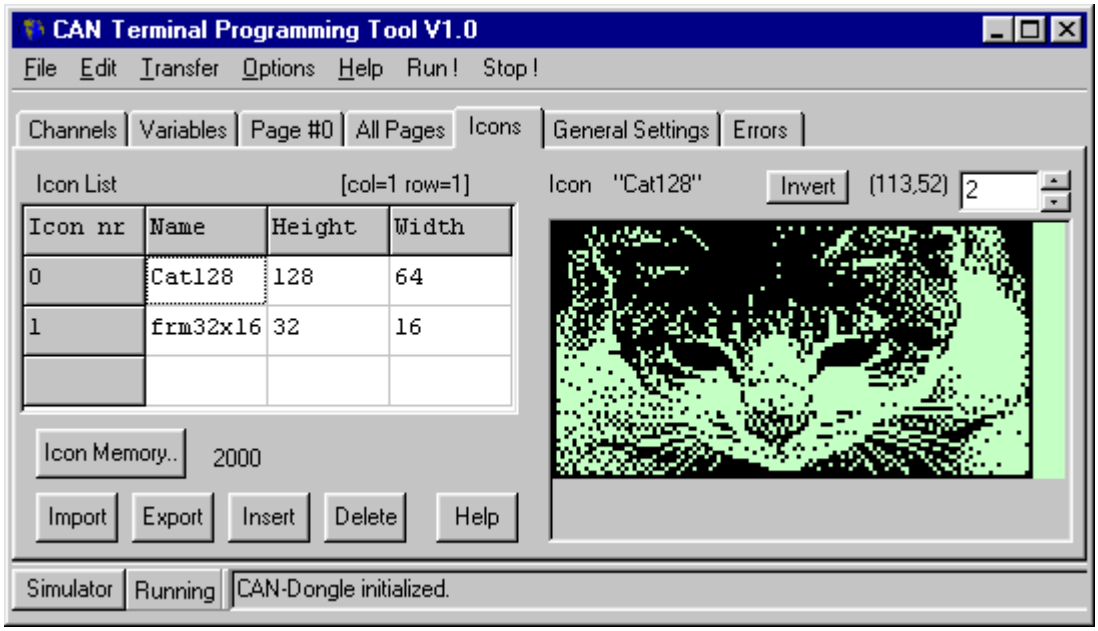
You may click on any of the page icons to switch to the page definition sheet, where you can modify the page’s contents.

Double-Clicking on one of the pages here will also switch to the display-page-definition sheet.

The current display-page is marked by a colored frame. This mark will also be switched, if the UPT-simulator lets your application run and executes *goto* or *call* – commands. You may stop this with the command „Stop!“ in the main menu of the programming tool.

7.16 The Icon page

The Icon Page is used to import and browse icons for your application.



You may import icons from monochrome windows bitmap files.

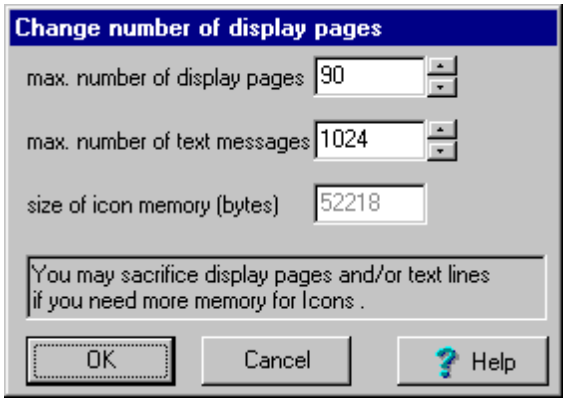
If the device supports color bitmaps (like „UPT167 Color“), you can also import color bitmaps. In this case, you must use the ‚Import color bitmap‘ function from the main menu, not the ‚Import‘ button on the icon page. Take a look into the help system for details on color bitmaps in the UPT.

Before you can load icons into your application, you must reserve memory for the icons. This is done with a special dialog.

7.16.1 Reserving memory for icons (and other special features)

Icons and page definitions share the same memory inside the user programmable terminal.
Therefore you have to sacrifice some pages if you want to use icons in your application.

If you reduce the number of pages in your application, there will be more memory for icons.
As an example, if the terminal has enough memory for 50 display pages but you decide to use only 40, there will be about (50-40) * 1600 Bytes that you can use for icons.
Since April 2000, a part of the memory can also be used to store a „text array“ (see chapter 7.18).



Click on the „Icon Memory“ – button (on the icon page) to start this dialog for reserving icon memory.

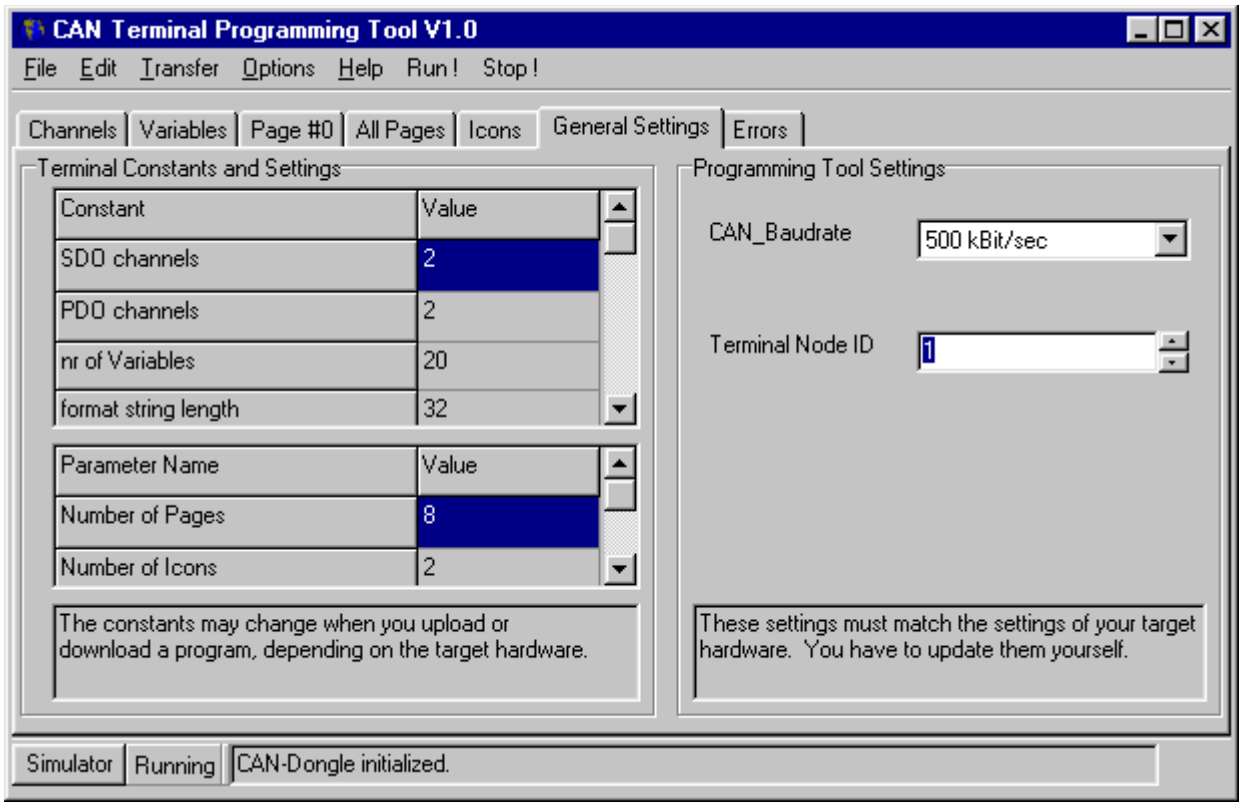
Since the introduction of the „Text Array“, the size of FLASH-memory for icons also depends on the number of text-array-lines („text messages“).

Note: The „size of icon memory“ displayed in the dialog box is the available FLASH-memory that could be used for icons. If you have problems with a display-page with many different icons, the possible reason is a shortage of RAM-memory inside the „real“ UPT (The programming tool does not know how much RAM will be available in the „real“ UPT when a particular display page is visible). At the present time, the UPT’s firmware cannot „unload“ Icons from its RAM if there is too few RAM to load more icons from ROM !

7.17 General Settings

The General Settings are used to define or display some basic features that do not depend on your terminal application.

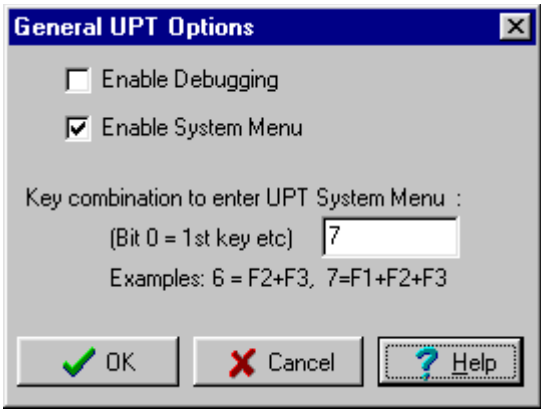
This includes
- CAN – Baudrate to establish a connection to the programmable terminal
- Terminal node ID



The settings *Terminal Node ID* and *CAN-Baudrate* must match the settings in the terminal, if you want to upload programs successfully.
In the terminal „UPT515“ you have to check these settings in the terminal’s *setup-menu*, which you may enter (for firmware-release 29-May-2000) after simultaneously pressing F2 and F3. Use the cursor keys to find the menu-entries „CAN-Baudrate“ and „Modul/NodeID“ in the UPT515 to check or modify these parameters. After modifying the parameters in the UPT515 you have to save the new settings permanently with the „Save & Exit“-function (second entry in the system menu) !

7.17.1 General UPT Options

The General UPT Options – dialog can be used to set some settings that will be transferred into the UPT when you upload your application. It can be started from the main menu or by clicking into the corresponding field in the „General Settings“ – table.



The option **Enable System Menu** may be turned off if you are shure that you do not need the UPT’s system menu functions (because you need the key-combination F2+F3 yourself or you don’t want that the user enters the system menu).
Even if „Enable System Menu“ is turned off, you may still enter the UPT’s system menu if you hold F2+F3 during power-on.

The option **Enable Debugging** was intended to be used by the programmer of the UPT firmware only (because he didn’t have a target debugger). You should leave this option off.

The **key combination to enter the UPT’s system menu** can now be changed from the programming tool, because the old (fixed) combination F2+F3 collided with the application of a customer. Be careful with this option, because not all key combinations can be detected by some targets (especially those with multiplexed keyboard hardware). If you entered an ‚impossible‘ key combination, you can only enter the UPT’s system menu by pressing F2+F3 *during power-on*.

7.18 The Text Array Page

The Text Array is used to define an array of single text lines that you may use in your application to display „text messages“ depending on a numerical value.

To use a text array, you have to define how much memory shall be used for text lines. You must sacrifice some „display pages“ to get more „text lines“. This is done with the same dialog as for icons, see chapter 7.16.1.

To read lines from the text-array in your application, you may call some string functions in text display commands (see online help on „sa[]“ and „sr[]“).

You will find a simple example for text arrays in the file „demo1.upt“ (or later).

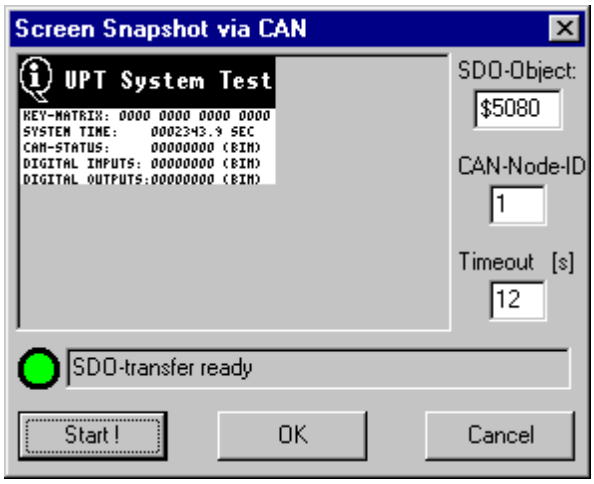
7.19 The Error Page

The error page is used to display any errory that may occur during programming or transfer of the program into the User Programmable Terminal.

If errors occurr during program upload or download, you may find some hex-coded SDO error codes in the error display. A table of most common SDO error codes can be found in the appendix of this manual (chapter 11.1) .

7.20 Screen Snapshot via CAN

To generate a printed documentation for the user of your UPT application, you may include „screen photographs“ of the terminal’s displays. You don’t need a camera for that purpose, it is possible to take a screen „snapshot“ via CAN-Bus.
Start the „Snapshot“ dialog from the „Transfer“ menu of the programming tool.



The parameters on the right side are used for the communication between the tool and the terminal. You will usually not have to modify these values (only if you want to make snapshots from devices that are **not** UPTs).

All you have to do is click on the „Start !“-button to freeze the actual LCD-contents in an internal buffer of the connected terminal. The buffered data will then be transferred to the snapshot utility (pixel by pixel). After completion of the transfer, you may click „OK“ to save the received image as a bitmap-file, or click „CANCEL“ to discard the received image (=close dialog without saving).

The „Screen-Snapshot via CAN“ does not work (yet?) for color terminals, because they don’t have enough memory to ‚buffer‘ a complete video screen internally.

8. The *Display* Interpreter

Note: The *Display* Interpreter is available in all of MKT's programmable devices, even in the ancient 'UPT 515'. It must not be confused with the *Script Language*, which is something completely different, and not compatible with the display interpreter (because the script is compiled rather than interpreted). Details about the script language can be found in document #85122 .

8.1 General syntax

8.1.1 Numeric Expressions

The UPT’s firmware includes an interpreter for numeric expressions. These expressions may be used as

- complex event definitions, i.e. comparisons
- calculated values for variable assignments
- parameters for some system commands

Some examples for numeric expressions:

```
(Voltage * 100 ) / 230
(Voltage > 230)      ( a comparison, usable for events)
(ce & kd0)           ( CAN-Error  AND  (F1 pressed)   )
```

Expressions may consist of

- Numbers
- Operators
- Variables
- Function Calls

8.1.1.1 Numbers

The numeric interpreter accepts numbers in the following formats:

- decimal with optional „#“-prefix
- hexadecimal with „0x“ or „$“-prefix („C“ or Pascal style)
- binary with „%“-prefix

Any number may also have a signum (+ or -) which should precede the base prefix.
Hexadecimal digits may be upper- or lower case.

Some examples for numbers:

```
12345     -12345     #12345
0x0ABCD   -0xABCD    $ABCD
%010101
```

Note: The numeric interpreter does not support floating point values, only 32-bit signed integer values. Therefore, -123.45 is not an allowed number.

8.1.1.2 Numeric Operators

The numeric interpreter can handle the following simple operators (operators with two „inputs“ and one „output“):

```
+    Add
-    Subtract
*    Multiply
/    Divide (w/o fraction)
%    Modulo (calculate the fraction from a division)

==   compare: equal
<>   compare: not equal
<    compare: less
<=   compare: less or equal
>    compare: higher
>=   compare: higher or equal

&    bitwise AND
&&   boolean AND
|    bitwise OR
||   boolean OR
^    bitwise EXOR

~    bitwise NOT (prefix)
!    boolean NOT (prefix)
```

A very special operator from the „C“-Programming language is the „arithmetic if-then-else statement“:

Syntax: `<arg1>?<arg2>:<arg3>`
Function:
if (<arg1> is not zero)
then result:=<arg2> ;
else result:=<arg3>

Boolean operators return either TRUE or FALSE, which are the values 1 and 0 here.
Inputs for boolean operators are TRUE if the argument is not zero and FALSE if the argument is zero.
The priority of the operators determines the evaluation sequence. The interpreter only knows two different priority levels, with the lower level for add, subtract, compare, „or“ etc and the higher level for multiply, divide, modulo, „and“. In case of doubt, you should use braces. A braced subexpression will always be evaluated with the highest priority.

8.1.1.3 Numeric Variables

The numeric interpreter can only recognize variable name that begin with an upper-case letter (this greatly simplifies the analyses for slow CPUs like 8051-compatible processors).

In the „UPT515“, names of variables must never exceed 8 characters length.

Usually the input of variables originates from a communication channel. But you may also assign new values to a variable with the „@“-command of the command interpreter.

If a variable is used as an „application variable“ (which is connected to a communication channel), you may access any of the following components :

- .fl reads the „flag“-field of a variable,
- .ut reads the „update timer“ of a variable,
- .in reads the latest „input value“ from a communication channel,
- .ed reads the „edited value“ which is currently visible on the display,
- .ou reads the latest „output value“ for a communication channel,
- .de reads the „default value“ from the variable definition table,
- .mi reads the „minimum value“ from the variable definition table,
- .ma reads the „maximum value“ from the variable definition table,
- .fa reads the scaling factor from the variable definition table,
- .di reads the scaling divisor from the variable definition table,
- .of reads the scaling offset from the variable definition table,
- .uo checks the „output update flags“ of the variable.

If you don’t specify a component name (or forget the dot after the variable name), the interpreter uses the „edited value“ of the variable. The „edited value“ is also the only part of a variable that you can modify directly by assigning a value.

8.1.1.4 Numeric Functions

The numeric interpreter can only recognize function names that begin with a lower-case letter (this greatly simplifies the analyses for slow CPUs like 8051-compatible processors).
All „Events“ can be evaluated as a part of an expression, because they are internally treated as functions. The only difference between event-polling functions and the following functions is, that event functions always return a boolean value, while „normal“ functions return a numeric value.
The following functions return numeric values:

`cs:` CAN-Status, bitcoded status of the CAN-controller
`tv0 ... tv3 :` Timer Values of the user-programmable timers
`ti:` global time, incremented every 100ms

`kd,ku,kb`: Keyboard Functions. See chapter 7.13.1 (events).
`lim`(value,min,max) : Limit-function.

```
    returns:  value, if (value>=min) and (value<=max)
              min,   if (value<min)
              max,   if (value>max).
```

`pn`: reads the current page number.
`inp`: reads the current state of the UPT‘s digital inputs.
`out`: reads(!) the current state of the UPT‘s digital outputs.
`pdo`: some functions to control PDO-channels. See next chapter(s).
`syn`: some functions to control the CANopen-SYNC-message. See next chapter(s).

An up-to-date overview of all numeric functions can ***only*** be found in the help-system of the programming tool !

8.1.1.5 PDO Functions of the UPT-Interpreter

The numeric interpreter has some built-in functions that can be used to access the PDO-Channels. Some of these functions may be used for event definitions or as part of numeric expressions. You do not need these functions to read values from a received PDO or put values into a transmitted PDO (connect Variables to a PDO-channel to do this !)

All PDO-functions described here require an „index“ to define which PDO-channel shall be used. You may use `pdo0, pdo1, pdo2` or `pdo3`. If you want to use a flexible index, use an expression like `pdo[PdoNr]` or similar.
A dot (.) is used to separate the keyword „pdo“ from the pdo structure component as described later. Most three-letter-component-names may be abbreviated by the first letter, for example `pdo[0].cnt` is the same as `pdo[0].c` etc.

`pdo[N].cnt`

Returns the value of a counter. Use this function to find out how often a particular PDO has been received or transmitted since power-on.

`pdo[N].cyc`

Returns the cycle time for the transmission of a PDO in milliseconds. You can also assign a new TX cycle time for a PDO using a formal assignment like this: pdo[0].cyc = 1234 .
The TX cycle is similar to the "PDO Event Timer" as described in CANopen DS301 V4.0, see object 0x1400 subindex 5.

`pdo[N].dat[I]`

Returns the current value of the [I]th data byte from PDO-channel N. You will usually connect a variable to a PDO to extract one or more data bytes from the PDO’s data field (so you usually do not need this function, only for very „special“ cases !).
Can also be modified as a formal assignment.

`pdo[N].id`

Returns the current CAN identifier used for a PDO.
You can also set a new CAN identifier for a PDO using a formal assignment like this: pdo[0].id = 2047. BUT YOU SHOULD BE EXTREMELY CAREFUL WITH THIS BECAUSE THE UPT'S INTERPRETER DOES NOT VERIFY DURING RUN-TIME IF A VALID CAN-ID IS USED.

`pdo[N].rcv`

This numeric function checks if a PDO telegram has been received since the last function call.
The flag will be reset internally by reading it. This function is intended to be used in event definitions only. This function can be used for „watch“ or „guarding“-purposes like the „syn.rcv“-function.

`pdo[N].trn`

This numeric function checks if a PDO telegram has been transmitted since the last function call.

The flag will be reset internally by reading it. This function is intended to be used in event definitions only.

pdo[N].tx

Procedure to trigger the transmission of a PDO (immediately).

pdo[N].mod

This numeric function checks if a PDO telegram has been modified and not yet transmitted.
Returns: TRUE = The PDO’s data-field has been modified but not been transmitted yet
FALSE= The PDO’s data-field has not been modified since the last transmission.

pdo[N].syn

This numeric function returns the count of SYNC intervals of a paricular PDO channel since its last transmission (or evaluation). This counter is internally required for CANopen-Transmission-Types 2..241. See DS301 for more information.

8.1.1.6 SYNC Functions of the UPT-Interpreter

The numeric interpreter has some built-in functions, that can be used to control or receive the CANopen-SYNC-Message. Some of these functions may be used for event definitions or as part of numeric expressions.

You do ***not*** need these functions if you simply want to receive SYNC messages (all PDO-channels with synchronous transmission check SYNC-messages theirselves)

`syn.rcv (abbreviated as syn.r )`

This numeric function checks if a SYNC telegram has been received since the last function call.
The flag will be reset internally by reading it. This function is intended to be used in event definitions only.
For example, you may create a special „watcher“ for periodic SYNC receptions. Define „syn.rcv“ as a global event and a timer-start-command like „ts0(50)“ as the corresponding reaction. This will (re)start Timer 0 for 500ms on every SYNC reception. Define annother global event („t0“) and reaction (like g“NoSync“). Create a display page named „NoSync“. This page will be displayed when the UPT does not receive SYNC telegrams anymore.

`syn.cnt (abbreviated as syn.c )`

This numeric function returns the value of a counter for all SYNC telegrams. You may use this value for testing purposes (for example, to find out if the UPT received any SYNC telegrams at all without resetting the „syn.rcv“-flag).

8.2 String Functions

In May 2000, a „text-array“ has been implemented. Some string functions can be used to read single lines from this text array.

Most of the string functions will begin with the letter „s“ to tell them from numeric functions.
At the present time (May 2000), string functions can only be called from text-display-commands (see chapter 7.10.2).

sa[<text-array-INDEX>]

Returns one line of the Text-Array specified by its array-index.

sr[<text-array-REFERENCE>]

Returns one line of the Text-Array specified by the user-reference-number.
The REFERENCE-Number is entered into the text-array along with the text string (see chapter 7.18). Text-Reference-Numbers may be any 32-bit-values, they do not even have to be sorted. The Interpreter performs a simple „linear“ search for the reference-number.
This makes the „sr[]“-Function a very efficient tool to convert arbitrary „error codes“ into „text messages“ on the screen.

(Maybe there are more functions which have not yet been described here...
check the Help System of the UPT Programming Tool if there‘s more info !)

8.3 Interpreter Commands

The UPT’s firmware has a built-in system interpreter which is used for:
- event reaction methods, which are usually „goto“ or „call“ -commands
- graphic output commands for complex display pages
- commands to control signal LEDs ,
- commands to control the four „User“-timers
- assign command to set a new value of a variable

Some interpreter commands (procedures) expect a list of parameters, others don’t require any parameters.

Most parameters can be numeric expressions .
For testing purposes you may send commands to the interpreter using the status bar of the programming tool (or via the new „Test/Command“-window).

8.4 Program control commands

8.4.1 Goto, Call and Return

These commands for the UPT’s built-in command interpreter are used to switch between pages of your application. All of these commands must be entered in abbreviated form (single letter).

Syntax:

```
goto:   g<page-number> or g”page-name”
call:   c<page-number> or c”page-name”
return: r
```

Goto and **Call** both switch to another display page, which may be defined by the page-number or (preferrably) by the page-name.

Call also saves the number of the current (old) page on a special „call-stack“ before switching to the new page. The „called“ page may switch later switch back to the „calling“ page using the „return“ command.

Call + **Return** should always be used together. If you enter a page with a „call“, you should also „return“ to the caller and not jump back to the caller with a „goto“ (this would cause an overflow of the call stack, furthermore it does not make too much sense).

The reason to use **Call** & **Return** instead of **Goto** is when many different callers use a common „subpage“ (like a „subroutine“). After the „subroutine“ has done its work (for example display an error message and wait for a key), the normal operation can resume.

Note: Neither **Goto** nor **Call** have an effect if the target (=new page) is the „current“ (=old) page.

8.5 The assign-command

This command is used to assign a new value for a variable.

Syntax:

```
@<Varname> = <expression>
```

Example:

```
@Ypos=(Voltage*63)/230
```

Notes:

- You can only assign values to variables that have been defined in the variable table.
- You should not assign values to variables that get their values from a communication channel.

8.6 Graphic output commands

8.6.1 The ICON-command (ic)

This graphic command is used to draw a small picture („icon“) on the screen.

Syntax:
ic(<icon-name>, <x-position>, <y-position>)

The icon-name must match the name that you defined on the icon-page. Otherwise the display-list-interpreter inside the programming too will generate an error.

8.6.2 The LINE-command (li)

This graphic command is used to display a graphic line on the screen.

Syntax:
li(<x1>, <y1>, <x2>, <y2>, ...)

8.6.3 The PIXEL-command (pi)

This graphic command is used to display a single pixel on the screen.

Syntax:
pi(<x>, <y>)

8.6.4 The FRAME-command (fr)

This graphic command is used to display a rectangular frame on the screen.
The interior of the frame will not be affected by this command (it remains unchanged).

Syntax:
fr(<x1>, <y1>, <x2>, <y2>)

where
x1 = left border
y1 = top
x2 = right border
y2 = bottom

8.6.5 The FILL RECTANGLE-command (fi)

This graphic command is used to fill a rectangular shape on the screen.

Syntax:
fi(<x1>, <y1>, <x2>, <y2> [, <pattern0>, <pattern1>])

where
x1 = left border
y1 = top
x2 = right border
y2 = bottom
pattern0, pattern1 = optional filling pattern, default=0xFF=solid.

All „old“ contents of the rectangular area will be overwritten by this command, unless you use a draw mode that does not write both display „pages“ (=blink phases).

The optional filling pattern allows drawing rectangles with different shades. Both patterns are 8-Bit-Masks, where a „1“-Bit will be „set“, a „0“-Bit will be reset. <Pattern0> will be used to fill all even graphic lines, <Pattern1> will be used to fill all odd graphic lines. Some examples of useful filling patterns are:

fi(10,10,30,20, 0xFF, 0xFF)	will draw a „solid „black“ rectangle
fi(10,22,30,30, 0xFF, 0x00)	will draw a rectangle that consists of horizontal lines
fi(10,32,30,40, 0x55, 0x55)	will draw a rectangle that consists of thin vertical lines
fi(10,42,30,50, 0x55, 0xAA)	will draw a „50 percent gray shaded“ rectangle

If you omit the filling patterns, the interpreter assumes that you want to draw a solid rectangle (the used filling pattern will be „0xFF, 0xFF“ then).

8.6.6 The Draw Mode-command (dm)

This graphic command is used to set the draw mode for all following graphic output commands. The display in the UPT-515 has two „video-pages“, which are alternated every 0.5 seconds to achieve „Blink“-Effects etc.

Syntax:
dm(<new draw mode>)

valid parameters for the draw mode are:
0: Standard-output into both video-pages
1: „Page1“, output only into page 1
2: „Page2“, output only into page 2
3: Blink1 (draw into page1, erase in page 2)
4: Blink2 (draw into page2, erase in page 1)
5: inverse output into both video-pages
6: inverse output only into page 1
7: inverse output only into page 2
8: Inverse blinking 1 (page 1 normal, page 2 inverse)
9: Inverse blinking 2 (page 1 invers, page 2 normal)

Note: Color displays do not have two video pages. Some draw modes are not available on such displays (for example the UPT-167 „COLOR“).

8.7 Other Interpreter Commands

8.7.1 The “led”-Command

The UPT’s firmware of some variants of the User Programmable Terminal has one command to control the a built-in signal-LEDs.

Syntax:
led(<led-number>, <led-blink-pattern>)
or abbreviated:
le (<led-number> , <led-blink-pattern>)

Parameters:
<led-number> is the index of the LED that shall be switched: 0=1st LED, 1=2nd LED, ...
<led-output-pattern> is an eight-phase-code for the LED blink „rhythm“. Every bit of this pattern controls a 100ms-Interval. After a cycle of 8 * 100ms the whole cycles starts again from the beginning. All LED-blink-cycles are „synchonized“: that means, if two LEDs have the same blink-pattern they will flash exactly at the same time.
Here are some useful blink patterns:

```
0x00      LED is OFF (this is the default state after power-on)
0xFF      LED is permanently ON
0xF0      LED blinks slowly:  400ms ON, 400ms OFF and so on.
0x55      LED blinks quickly: 100ms ON, 100ms OFF and so on.
0x01      LED gives short flash pulses:  100ms ON,  700ms OFF...
```

8.7.2 The “out”-Command

This command is used to control the state of the UPT’s built-in digital outputs.
There are two different „flavours“ of this command:

`out(<8-bit-value>)`

This format is used to control all digital outputs at once. Bit 0 controls the first output and so on.

`out(<output_nr>, <new_state> )`

This format is used to control the state of one single output.

Examples:

```
out($FF)     turns all outputs on
out($00)     turns all outputs off
out(0, 1)    turns the first output on
out(3, 0)    turns the fourth output off
out(out^$02) inverts the state of the second output.
```

Notes:

- There is not only an output-**command** to **set** the digital outputs, but also a **function** named „out“ that **reads back** the current state of the digital outputs.
- Not all devices used as „User Programmable Terminal“ have own digital outputs. To access outputs on a remove I/O-module, you must use a communication channel.
- Perhaps your UPT515 only has four digital outputs and six digital inputs.
- The UPT’s digital inputs and outputs are „simulated“ by the programming tool. The state of the outputs is displayed as round shapes in the simulator window.

8.7.3 Timer commands and functions

The UPT’s firmware has some built-in functions and procedures to control four „User Timers“. These timers can be used to generate time intervals of up to 65534*100ms (which is more than one hour). These timers are intended to produce events , but you may also use them for any other purpose.

Timer procedures:

ts0 ... ts3 (timer start)

Starts one of the four „User Timers“ for a given time interval. The timer will count down from the starting value to zero, when it generates a timer event. Starting a timer again before it reaches zero will prevent the timer event. The maximum time for a user timer is 65534 (* 100 ms).
Syntax: ts0(<timer starting value in 100ms>)
Example: ts0(40) starts the first timer for a time of 4 seconds. After 4 seconds there will be a „t0“ event which you can handle on one of your event definitions (global or local).

tr0 ... tr3 (timer reset)

Resets one of the four „User Timers“. This will stop the timer and prevent the generation of a timer event. Internally, a timer that has been reset contains the value 0x0FFFF which means „stopped“. This value is the default value for all timers after power-on.

Timer functions:

t0 ... t3

Checks if a user-timer has „run off“, that means Timer 0 ... Timer 3 has been decremented from 1 to 0 . Returns: Zero (=FALSE) if the timer is not running or has not yet reached zero,
One (=TRUE) if the timer has counted down to zero (where it stops)

tv0 ... tv3 (timer value)

Reads the current value of a user-timer. This value runs from the started value down to zero (decremented every 100 ms).

ti (global time)

Reads the current „system clock“ as a 32-bit value. The system clock is a 32-bit-counter incremented every 100 ms. It does not depend on the four „user“-timers and can neither be stopped nor modified by the user program. After more than 6 years of uninterrupted operation of the User Programmable Terminal, this value will become negative because it will be incremented from ((2 power 31)-1) to (2 power 31) which is a negative value for 32-bit-Numbers. After power-on of the UPT, the global time always starts at zero.
Some demo-programs use this function to show a company logo for a short while after power-on.

9. CANopen objects

Note: This chapter only applies to devices which use the CANopen protocol.
There are other devices (for example, the "MKT-View" terminal) which do not use CANopen, and use low-level CAN communication described in a CAN database ("CANdb file").

9.1 CANopen objects for Digital I/O-Modules

CiA DS401 specifies the CANopen Device Profile for I/O-Modules. If you want to connect any of these objects via SDO to a variable of your terminal program, you have to know the object’s index and subindex. Here are **some** of the specified objects:

Index (hex)	Name	Subindizes	Type	Access
0x6000	Read State [of] 8 Input Lines	0,1 .. max.4	Unsigned8	ro
0x6006	Input Interrupt Mask [for] 8 Input Lines, any change	0, 1.. max.4	Unsigned8	rw
0x6020	Read State [of] 1 Input Line	0, 1.. max.32	Unsigned8, Boolean	ro
0x6100	Read State [of] 16 Input Lines	0, [1, 2]	Unsigned16	ro
0x6120	Read State [of] 32 Input Lines	0, max. 1	Unsigned32	ro
0x6200	Write State [for] 8 Output Lines	0, 1..max.4	Unsigned8	rw
0x6206	Fault Mode [for] 8 Output Lines	0, 1..max 4	Unsigned8	rw
0x6207	Fault State [for] 8 Output Lines	0, 1..max 4	Unsigned8	rw
0x6220	Write State [for] 1 Ouput Line	0, 1.. max.32	Unsigned8, Boolean	rw
0x6250	Fault Mode [for] 1 Output Line	0, 1..max.32	Unsigned8, Boolean	rw
0x6260	Fault State [for] 1 Output Line	0, 1..max.32	Unsigned8, Boolean	rw
0x6300	Write State [for] 16 Output Lines	0, 1..max.2	Unsigned8, Unsigned16	rw
0x6306	Fault Mode [for] 16 Output Lines	0, 1..max 2	Unsigned8, Unsigned16	rw
0x6307	Fault State [for] 16 Output Lines	0, 1..max 4	Unsigned8, Unsigned16	rw
0x6320	Write State [for] 32 Output Lines	0, max.1	Unsigned8, Unsigned32	rw
0x6326	Fault Mode [for] 32 Output Lines	0, max 1	Unsigned8, Unsigned32	rw
0x6327	Fault State [for] 32 Output Lines	0, max 1	Unsigned8, Unsigned32	rw

9.2 CANopen objects for Analog I/O-Modules

CiA DS401 specifies the CANopen Device Profile for I/O-Modules with analog inputs and/or outputs. If you want to connect any of these objects via SDO to a variable of your terminal program, you have to know the object’s index and subindex. Here are **some** of the specified objects:

Index (hex)	Name	Subindizes	Type	Access
0x6401	Reads value of the input channel (not converted)	0 1 [... 4]	Unsigned 8 Unsigned16	ro
0x6411	Writes value of the output channel (not converted)	0 1 [... 4]	Unsigned8 Unsigned 16	rw
0x6420	Set Analogue Input Range	0 1 [... 4]	Unsigned8 Unsigned 16	rw
0x6421	Determines which events cause an interrupt for a specific channel	0 1 [... 4]	Unsigned 8 Unsigned 8	rw
0x6423	Globally enable/disable Interrupt	0	Boolean	rw
0x6424	When enabled, interrupt triggered when analogue input rises above this value (not converted)	0 1 [... 4]	Unsigned8 Unsigned 32	rw
0x6425	When enabled, interrupt triggered when analogue input falls below this value (not converted)	0 1 [... 4]	Unsigned8 Unsigned 32	rw
0x6426	When enabled, interrupt triggered when analogue changes by more than thisvalue from previous reading (rising or falling) (not converted)	0 1 [...4]	Unsigned8, Unsigned 32	rw
0x6443	Output Fault Mode	0,1	Unsigned8	rw
0x6444	Default Output Fault value (unconverted)	0 1	Unsigned 8 Unsigned 32	rw

More information about these objects can be found in DS401.

9.3 CANopen objects inside the UPT

All information inside the User Programmable Terminal can be accessed via CAN-Bus as part of the manufacturer specific profile of a CANopen object dictionary. The programming tool uses these objects to transfer your „user program“ into the terminal.
As you upload or download a program into/from the terminal, there may be some error messages with a CANopen-index in the range of 0x5100 to 0x57FF. The possible cause for such errors may be a compatibility problem between an „old“ terminal and a „new“ programming software (or vice versa). The following table may help to trace such errors:

CANopen-Index	Contents
0x5080	MKT's CAN snapshot utility
0x5101	Constants (max number of variables, etc.)
0x5102	Names of the terminal's keys
0x5103	General Settings (number of display pages, etc.)
0x5104	Run Mode (Run, Stop, Transfer etc)
0x5105	current Display-Page
0x5106	Save Permanent (transfers RAM data to FLASH or EEPROM)
0x5180	global Events-Definitions (as strings)
0x5200..52ff	SDO-Channel-Definitions (as strings)
0x5300..53ff	PDO-Kanal-Definitions (as strings)
0x5400..54ff	Variable-Definitions (as strings)
0x5500..55ff	Display-Page-Definitions (as strings)
0x5600..56FF	Icon-Definitions (hex-coded strings)
0x5700..57FF	Text-Array-Definitions (strings)
0x5800..58FF	reserved for other 'arrays' (numeric)
0x5C00..5C0F	reserved for onboard frequency counter etc

The data format of the definition-tables is very similar to the text-file-format that is used to save your UPT-program on a disk drive. In fact, we use the same conversion routines in the UPT as in the programming tool.

Since May 2001, some UPT firmware versions have a few objects from the CANopen communication profile implemented (DS301, Object index range 0x1000 – 0x1BFF). These objects only exist to detect a UPT device in a network. It is impossible to modify UPT settings via these objects. The PDO communication- and mapping objects do not carry useful information yet.

CANopen-Index	Contents	
0x1000	Device Type	(Only DS301 at the moment)
0x1018	Identity Object	
0x1018.1	MKT's vendor ID	(0x004D4B54)
0x1018.2	Product Code	(70055=UPT515, etc)
0x1018.3	Revision Number	(ex: 0x00010002 = V01.02)
0x1018.4	Serial Number	(expect this to be ZERO)

10. Transferring the application into the programmable device

To transfer the display application (*.upt or *.cvt) into the programmable device ("display"), you have different choices depending on the available hardware. Details about this can only be found in the Online Help System (HTML) . Here just a few examples:

- Transfer via memory card (SD or Compact Flash)
- Transfer via RS-232 (unfortunately, this reliable and easy-to-use interface has been replaced with the flawed, unreliable, and utterly complex USB on most PCs...)
- Transfer via CAN bus (requires a CAN bus interface, or another device equipped with a CAN-via-UDP server which can act as a bridge between Ethernet (LAN) and CAN)
- Transfer directly via Ethernet (LAN)

In addition to the application (*.upt, *.cvt), other files may have to be loaded into the device, for example certain audio files, user defined fonts, etc. If you don't have a memory card reader connected to your PC, you can used the file transfer utility which is integrated in the programming tool. Details about this 'File Transfer Utility' are also in the online help system; see document filetransfer_01.htm (englisch) or filetransfer_49.htm (deutsch).

11. Error Messages

11.1 SDO error codes

Here are some error codes that may occur during program upload or download.

Most of these error codes are taken from CANopen DS301 V4.
Some of these errors may also be caused by external devices on the CAN bus.
For a more sophisticated explanation of these errors you should check the CiA literature or other CAN protocol descriptions.

```
Error Code     Meaning
0x05030000 TOGGLE-BIT NOT ALTERNATED
0x05040000 SDO-PROTOCOL TIMED OUT
0x05040001 COMMAND SPECIFIER NOT VALID OR UNKNOWN
0x05040002 INVALID BLOCK SIZE
0x05040003 INVALID SEQUENCE NUMBER
0x05040004 CRC ERROR
0x05040005 OUT OF MEMORY
0x06010000 UNSUPPORTED ACCESS TO AN OBJECT
0x06010001 ATTEMPT TO READ A WRITE-ONLY OBJECT
0x06010002 ATTEMPT TO WRITE A READ-ONLY OBJECT
0x06010047 UNSUPPORTED ACCESS, INTERNAL INCOMPATIBLE
0x06020000 OBJECT DOES NOT EXIST IN DICTIONARY
0x06040041 OBJECT CANNOT BE MAPPED TO THE PDO
0x06040042 MAPPED OBJECTS WOULD EXCEED PDO LENGTH
0x06040043 GENERAL PARAMETER INCOMPATIBILITY
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0x06040047 GENERAL INTERNAL INCOMPATIBILITY
0x06060000 ACCESS FAILED DUE TO HARDWARE ERROR
0x0606002F ACCESS FAILED DUE TO CAN ERROR
0x06070010 DATA TYPES DO NOT MATCH
0x06070010 LENGTH OF PARAM DOES NOT MATCH
0x06070012 LENGTH OF PARAM TOO HIGH
0x06070013 LENGTH OF PARAM TOO LOW
0x06090011 SUBINDEX DOES NOT EXIST
0x06090030 VALUE RANGE EXCEEDED
0x06090031 VALUE RANGE TOO HIGH
0x06090032 VALUE RANGE TOO LOW
0x06090036 MAXIMUM VALUE IS LESS THAN MINIMUM VALUE
0x08000000 GENERAL ERROR
0x08000020 DATA CANNOT BE TRANSFERRED TO APPLICATION
0x08000021 .. due to local control
0x08000022 .. due to device state
0x08000023 OBJECT DIRECTORY GENERATION FAILS
```