
POSITIONING- AND CONTOURING CONTROL SYSTEM PA8000 OPERATING MANUAL / OM



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1 Introduction

The PA8000 (Motion Control Unit) is a multi-purpose positioning and contouring control system for machine tools, robots, handling equipment and specialized machines. Movements and process sequences can be automated by entering CNC programs and parameters.

The PA8000 is designed as an expansion board for the IBM-PC/XT/AT computer family, IPC (Industrial Personal Computer) or compatibles, and is used for controlling 1 to 3 CNC axes with either servo or stepping motors.

During development work, special attention was paid to ensuring suitability for use in an industrial environment, since it is particularly in this area that personal computers are becoming increasingly wide-spread.

This manual essentially describes the features of the hardware and software components used in the accessories included in the standard scope of delivery, and is divided into three parts:

- **OM:** Operating Manual
- **PM:** Programming and Reference Manual
- **CM:** Commissioning Manual

The *OM* describes all the PA8000 hardware and software components available in the standard scope of delivery. The user is given an overview of the PA8000's functions, the operating modes and programming methods.

The *PM* describes the various types of programming involved. This section is rounded off by a command and reference list.

The *CM* describes how to install and commission all the system components contained in the scope of delivery.

For easier comprehension, we recommend that you work through the Operating Manual first.

2 System hardware

2.1 The board PA8000

The PA8000 is a plug-in board for personal computers or compatibles of the PC, XT, AT and IPC types (Industrial Personal Computer with AT interface) and constitutes the control system's intelligence. The minimum configuration consisting of a PA8000 supports three CNC axis channels with either stepping or servo drives (DC or AC/EC). The maximum configuration supports six axis channels. For this, a slave board (Option PA8000-3) for 3 further CNC axes is plugged on the PA8000 in Sandwichtechnik.

A multi-axis system can be built up by cascading several PA8000.

The PA8000 is accommodated on a long plug-in board for IBM PC/XT/AT or compatibles PC. The communication between PC and PA8000 occurs over the PC-bus, thus ensuring high data throughput for outputting commands and reading in status information. The address of the PA8000 in the PC's I/O address area is set using DIP switches.

2.1.1 The PA8000 - CPU system

The PA8000 provides a separate transputer-based CPU system for every three axis channels. Transputers are microcomputers designed for parallel processing. The IMST805 transputer type used on the PA8000 is a 32-bit processor with integrated 64-bit floating-point arithmetic. It achieves a maximum instruction rate of 25Mips and 3.5MFlops. Its 4 serial links serve to connect further PA8000 or slave boards PA8000-03. This allows easy cascading to build up a multi-axis system. The CPU system is fitted with a local RAM of 1 MB (Megabyte) or alternatively 4 MB. This RAM can be accessed without any wait cycles (0 wait states).

2.1.2 The PA8000 - interface logic

Ein wesentliches Merkmal der PA8000-Baugruppe ist der Einsatz von modernster PLD und FPGA-Technik. FPGA-Bausteine sind im Betrieb beliebig oft umprogrammierbare Logikbausteine mit einer hohen Funktionalität. Die PA8000 stellt für jeden Achskanal ein eigener FPGA-Baustein zur Verfügung. In diesen befindet sich die Logik für die Istwerterfassung der Meßsysteme. Dazu gehört u.a. die Verarbeitung aller gängigen Inkrementalenkodern, die Verarbeitung von SSI-Absolutwertgebern, das präzise echtzeitfähige Zwischenspeichern von Positionswerten aufgrund verschiedener Bedingungen. Natürlich können auch individuell auf die Applikation abgestimmte Anpassungen realisiert werden.

The complete I/O periphery is galvanically separated from the system electronics (PC logic). The interfacing of the external components occurs according to the current guideline in industry electronics. The CPU system is interfaced to the PC bus using an INMOS-B004/B008 - compatible link interface. . This means that all transputer tools available from Messrs. INMOS (SGS-THOMSON), like the ANSI C Toolset, can likewise be run on this system.

2.1.3 Connection of the external system components

The external system components mentioned in [Chapter 2.2] like power amplifiers, limit switches, inputs and outputs are interfaced through a 50 pole SUB-D-Min connector situated on front of the board PA8000.

Three CNC axes can be connected as speed or current controllers.

The PA8000 provide three analog channels with an output voltage range of ± 10 V and 14-bit resolution (16 bits optional). These channels are electrically isolated from the PA8000's digital power supply, and are used for controlling commercially available power amplifiers, connected as speed or current controllers.

Three stepping and directional signals, each with an antivalent signal level and a control voltage of 5 V (RS422), are provided for controlling stepping motor power amplifiers.

Three pulse acquisition channels, each with a 32-bit register width, are used for position acquisition utilizing incremental coders or linear scales. Pulses are acquired either for TTL sensors or for sensors with symmetrical outputs (RS-422). The 90-degrees-phase-displaced quadrature signals generated by these sensors are electronically quadrupled and are electrically isolated from the system electronics. The maximum pulse input frequency is 5.00 MHz. The PA8000 can also evaluate a zero pulse. Die Istposition des Meßsystems kann mit Hilfe des Nullimpulses oder eines digitalen Eingangs in Registern zwischengespeichert werden. Diese Meßmethoden gestatten u.a. eine einfache Enkoderverifikation, das Setzen von Referenzmarken oder das echtzeitfähige Positionslatchen bei Meßmaschinen.

Alternativ zu den oben erwähnten Inkrementalgebern können auch alle marktgängigen SSI-Absolutwertgeber ausgewertet werden.

The PA8000 supports 16 optically decoupled inputs and 8 optically decoupled. The inputs and outputs are not specifically assigned to an axis channel and can be assigned special functions through software, like limit switch function, reference switch function, power amplifier enable, etc. All inputs and outputs which are not assigned special functions are freely programmable.

A watchdog circuit ensures safe operating states even in exceptional situations. An EEPROM is used for accepting various operating parameters, such as the output setpoint status after system power-up.

2.2 External system components

Thanks to its digital signal processing function, and the standard setpoint and actual value interfaces, the PA8000 can be used with different motor types and power amplifiers, irrespective of the output range involved.

The external components are selected to suit the application concerned, after taking into account performance class, functionality, safety considerations and cost-efficiency constraints.

All commercially available power amplifiers can be controlled using a ± 10 V setpoint value channel. The power amplifiers can be connected as speed controllers or as current amplifiers.

Both stepping and servo motors can be chosen: in this context, all motors with a position checkback feature are designated as servomotors. This category includes brushless (AC or EC) and brushgear-equipped DC motors or hydraulic motors. For positioning these motor types, a position acquisition function is required.

Rotary transducers or linear scales are generally used for this purpose. To control stepping motor power output stages, the system provides pulse and directional signals. In contrast to a servo drive, the stepping motor drives can be run without a position checkback feature.

Additional external system components can be linked to the PA8000 over digital inputs or outputs. Software planning of these inputs and/or outputs makes it possible to implement things like limit switch, reference switch, emergency stop, amplifier enable and other functions.

2.3 Types of power amplifier

Various types of power output stages can be used to provide the energy for the electric drive. All the types listed below can be controlled directly by the PA8000.

One of the features determined by the different types of power amplifiers is the characteristic control response of the controlled systems, which has to be allowed for when setting the filter parameters **Fehler! Verweisquelle konnte nicht gefunden werden..**

Note: All power amplifiers, except the stepping motor power amplifiers, are usually controlled through the analog setpoint value channels of the PA8000. Pulse and directional signals, plus their inverted pulse trains, are available for the use of stepping motor power amplifiers.

2.3.1 Speed controllers

These are the usual commercially available units used for controlling the speed of a DC or brushless DC motor. The input variable here is mostly a voltage of ± 10 V, corresponding to a speed of \pm maximum speed. The speed actual value is fed directly to the speed controller, mostly as a tacho signal. When the amplifier is enabled, the speed controller will develop a holding torque even without a setpoint value signal, i.e. the motor axis, due to the input offset, will drift away more or less slowly. The input offset can normally be set, but is temperature-dependent.

2.3.2 Current amplifiers

In contrast to the speed controller, the current amplifier does not need a tacho signal as an actual value feedback from the motor. The input setpoint value here has the significance of an armature current. Many manufacturers offer their power amplifiers as current amplifiers or speed controllers. The commercially available speed controllers can usually be quickly and easily converted into a current amplifier. Please follow the instructions of the manufacturer concerned. The amplification factor should be set so as to ensure that the maximum current you want corresponds to an input setpoint value of 10 V.

2.3.3 Voltage amplifiers

In contrast to the speed controller, the voltage amplifier does not need a tacho signal as an actual value feedback from the motor. The input setpoint value here has the significance of an armature voltage. Voltage amplifiers are not of major importance in actual practice, and are at most used for small ratings, when the motor current is limited by the armature resistance. Note that the available acceleration decreases at higher speeds.

2.3.4 Stepping motor power amplifiers

Stepping motors mostly have 2 or 5 phases or windings to be controlled. In order to ensure a rotary motion, current has to flow in the individual motor windings in a defined cycle. All the usual stepping motor power output stages available on the market will customarily satisfy these requirements, and are controlled with the input signals of pulse (one motor step per pulse) and direction (specifies the sense of rotation for the motor shaft). The above-mentioned current flow results from this input information.

3 Introduction on how to operate and program the PA8000

The PA8000 can be operated and programmed in several different ways.

3.1 Manual operation

For manual operation of the PA8000, you essentially use the *mcfg.exe* utility program, which forms part of the PA8000 TOOLSET software [TSW] [Chapter 4.4].

This offers the user a large number of operating modes for controlling the PA8000, including manual operator control of the complete axis system.

3.2 Programming with a PC application program (PCAP)

The user creates a user program for running on the PC, in a high-level programming language like C or *Pascal*. Commands are executed on the PA8000 from this application program using the *mcutsr.exe* TSR driver. The PC application program is in this operating mode responsible for coordinating the runs of the individual axis systems. The PC-Application Program will from now on be abbreviated to "PCAP".

Commands are transferred using predefined commands. These in turn have been implemented as TSR functions for the above-mentioned programming languages. TSR is an abbreviation for Terminate Stay Resident. This term covers the driver program *mcutsr.exe*, which is loaded as a resident program into the PC's main memory by a one-off DOS call. This kind of program file is also referred to as a TSR driver. Calling a TSR function causes a software interrupt to be executed. This interrupt in turn completes the function contained in the TSR, with the aid of an unambiguous command number, and in some cases with the aid of parameters as well.

From the user's viewpoint, the TSR functions represent merely a functional extension of the programming language involved. The function's actual "intelligence" is located in the TSR driver.

3.3 Programming as a stand-alone system (SAP)

Another option is creating programs for what is called the stand-alone operating mode. This operating mode enables an operating program previously loaded onto the PA8000 to be executed automatically, i.e. without any support from a PCAP. This means that the PC can handle other tasks. This Stand-alone Applications Program will from now on be abbreviated to "SAP".

The SAP is created by the user with the aid of an editor or the CNC-Edit editor integrated in the *mcfg.exe* utility program. The syntax for this user program is similar to that for *Pascal*, and permits simple, flexible, program creation. Once the user program has been created, what is called an "Autocode File" is generated using the NCC compiler, which is available both as a command line compiler [Chapter 4.5] and integrated in the *mcfg.exe* utility program. This autocode file can be transferred to the PA8000, and executed there automatically, i.e. without any support from the PC.

If synchronization with a PCAP running in parallel is needed, this can be implemented using commonly predefined variables, accessible in read and write modes by the PC and the PA8000 alike.

4 System-Software

This chapter describes the utility programs for the PA8000 TOOLSET software [TSW] included in the standard scope of delivery. This information is important for correct operation of the control system and for the creation of user programs.

4.1 The multitasking operating system software *rw_TOS* (*rwtos.btl*)

The multitasking operating system software [1] *rw_TOS* is located in the *rwtos.btl* file, and contains the executable transputer machine code for the PA8000 CPU system. *rw_TOS* is divided up into various tasks, which are processed simultaneously on one or more transputers, depending on the number of axes involved. To give you some background, the most important tasks will be explained in the following chapters for interested users.

[1] Notes: Multitasking means the quasi-simultaneous processing of several (multi) different tasks with a single-processor system, or simultaneous processing in the case of multi-processor systems (more than 1 transputer). The transputer supports this mechanism very efficiently, thanks to the hardware characteristics implemented, like task scheduler and multi-processor parallel processing with other transputer system over what are called transputer link channels.

The *rw_TOS* operating system software handles correct initialization and automatic, punctual execution of all tasks implemented. This means that you as the user do not need any specialized knowledge, and do not have to intervene in the ongoing process.

4.1.1 PIDF filter task

This task handles control of the motors to bring them to a desired setpoint position or speed using a digital PIDF filter. This filter is modelled on the analog filter by processing at short identical intervals. The control cycle time has been fixed at 1.28 ms for all axis channels. The data required for filter computation are likewise read in this scan cycle, and then processed. Setpoint values are also subsequently outputted over the interfacing modules.

Note: The PIDF filter works with either servo and stepping motors.

4.1.2 Ramp and interpolation task

The motors are brought to a desired target position with what are called ramp functions, with a defined acceleration and a specified maximum velocity. This job is handled by the ramp and interpolation task, which is synchronized with the PIDF filter task and is likewise executed once per scan cycle (1.28 ms) for all axes. Another function handled by this task is synchronization of several axes, so as to enable a path or space curve to be processed in interpolated mode. There are options for three different interpolation procedures: linear, circular and helical interpolations.

The PA8000 has been designed to ensure that cascading of several controls is likewise possible. There are no restrictions regarding selection of the axes involved in an interpolation procedure, neither in the standard version (up to 6 axes) nor in the multi-axis version (more than 6 axes).

Another important characteristic of the ramp and interpolation task is its second-order dynamic-response module. The ramp generation feature otherwise implemented in conventional positioning controls demands a motion stop in the desired target position. This restriction has been eliminated by implementing this dynamic-response module. You as the user can program any target velocity you want for the desired target position. The axis system is moved to the desired target position, taking into account maximum velocity and maximum acceleration, and reaches the programmed target velocity precisely in this point. This method enables motion profiles of any desired complexity to be generated.

4.1.3 PC interface task

This task forms the basis for PC application programming (PCAP programming), and executes the functions and commands called by the user. A wide range of commands is provided for this purpose. These commands are called from the PC application program, which is written in a high-level programming language.

4.1.4 Stand-alone CNC tasks

These tasks form the basis for stand-alone application programming (SAP programming) and constitute one of the PA8000's powerful characteristics. Up to four stand-alone application programs (SAP programs) can be created with the *NCC* compiler included in the scope of delivery; they are processed automatically in multi-task mode by the four CNC tasks. Since the drive monitoring function can also be handled completely by an SAP program, the PC is in this case available for other jobs.

4.1.5 Booting *rw_TOS* with the *mcbt.exe* utility program

The PA8000 operating system software *rw_TOS* is transferred to the PA8000 with the TOOLSET boot program *mcbt.exe* [Chapter 4.2], and triggers a system initialization routine (hardware reset). This load operation is required once per system start, and is concluded within a few seconds. The advantage of booting compared with a ROM-resident operating system is that client-specific modification wishes for the PA8000 operating program can be easily incorporated. As soon as the boot operation has been completed, the PA8000 is ready for operation.

4.2 The *mcbt.exe* utility program

4.2.1 Parameters for the *mcbt.exe* utility program

The *mcbt.exe* utility program [Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**] is used to load the operating system software *rwos.btl* on the PA8000. With this program, you can also perform a configuration check or to save system data anew [Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**].

This is typically done in the AUTOEXEC.BAT.

Call the program as follows:

```
mcbt {/option /option ...}
```

option = BB, BC, BD, BH, BR *n* and BS

In the following, the options are alphabetically sorted:

| | |
|---------------------|---|
| /BB <i>filename</i> | Das in <i>filename</i> spezifizierte File wird an die PA8000 übertragen. Der Suchvorgang für <i>filename</i> ist dabei wie folgt: zuerst wird im aktuellen Arbeitsverzeichnis gesucht und anschließend in den in PATH spezifizierten Directories. Sofern diese Option nicht benutzt wird, wird das File <i>rwos.btl</i> übertragen. |
| /BC | Nach dem Übertragen der Betriebssystem-Software <i>rwos.btl</i> wird die Systemdatei <i>system.dat</i> auf die PA8000 übertragen. Im Anschluß erfolgt ein Configurationscheck auf alle im Antriebssystem vorhandenen Achsen. |
| /BD | Bei auftretenden Fehlern während dem Lade-Vorgang werden ausführliche Fehlertexte am Bildschirm ausgegeben. |
| /BH | Mit dieser Option werden alle verfügbaren Kommando-Optionen am Bildschirm angezeigt. |
| /BR <i>n</i> | Mit dieser Option kann mit der Variablen <i>n</i> spezifiziert werden, wie oft die Optionen BC oder BS im Fehlerfall wiederholt werden sollen. |
| /BS | BS speichert die in der Systemdatei <i>system.dat</i> enthaltenen Daten. Sofern diese Option zusammen mit der Option BC aufgerufen wird, wird der Speichervorgang nur im Fehlerfall von BC ausgeführt. |

Example: `mcbt /BC /BS /BR 5`

Das oben gezeigte Beispiel sucht zunächst die Betriebssystem-Software *rwos.btl* im aktuellen Arbeitsverzeichnis bzw. in der Pfad-Umgebung. Diese Datei wird dann auf die PA8000 übertragen. Im Anschluß wird die Systemdatei *system.dat* auf die PA8000 übertragen und ein Configurationscheck ausgeführt. Sollte ein Konfigurationsfehler festgestellt werden, so wird der Check im Fehlerfall bis zu 5 mal wiederholt. Ist dann immer noch ein Fehler vorhanden, werden die neuen Daten auf das System übertragen und gespeichert. Auch dieser Vorgang wird im Fehlerfall bis zu 5mal wiederholt.

4.2.2 Return values of the *mcbt.exe* utility program

The *mcbt.exe* utility program can return following error numbers:

| Error number | Description |
|--------------|---|
| 0 | No error |
| 1 | Unvalid function code by calling <i>txbf()</i> |
| 2 | File not found by calling <i>txbf()</i> |
| 3 | Path not found by calling <i>txbf()</i> |
| 4 | Too many files open by calling <i>txbf()</i> ; |
| 5 | Access refused by calling <i>txbf()</i> |
| 6 | Unvalid file handle by calling <i>txbf()</i> |
| 12 | Unvalid access by calling <i>txbf()</i> |
| 20 | CNC file too large by calling <i>txbf()</i> |
| 21 | Unvalid file type by calling <i>txbf()</i> |
| 25 | TSR driver |
| 26 | Wrong TSR driver |
| 27 | Wrong <i>rw_TOS</i> software |
| 30 | Max. erlaubte Länge des Boot-File-Namen überschritten |
| 31 | Boot file name expected |
| 32 | Ungültige Anzahl von Wiederholungen |
| 40 | Kommando-Zeilen-Länge überschritten |
| 41 | System file <i>system.dat</i> not found |
| 42 | Internal <i>spwanvp()</i> error |
| 43 | Boot error in program <i>iserver.exe</i> |
| 100 | Configuration error |
| all others | unvalid |

These errors numbers are saved in the environment variable *ERRORLEVEL* and can be interpreted in the *AUTOEXEC.BAT*, for example.

An error description can be displayed on the screen with the option */BD*.

4.3 The TSR driver *mcutsr.exe*

The *mcutsr.exe* program file is an MS-DOS device driver, which establishes the link between a PC application program and the PA8000. It is in this driver that the entire data transport between PC and PA8000 is executed. The commands and functions implemented in the driver are called by means of software interrupts in the high-level languages *C* or *PASCAL*. For this purpose, function libraries are provided, which as far as you are concerned constitute merely an extension of the existing programming language.

Since *mcures.exe* has been encoded completely in Assembler, not much PC main memory is used, and data transport is executed very quickly.

4.3.1 Activating the TSR driver *mcutsr.exe*

To enable the utility and user programs to be processed, *mcutsr.exe* has to be loaded into the PC's main memory before these programs are executed. This is done by using a DOS-convention call (execute *mcfg.exe*). After this call, the TSR driver has been loaded as a resident program in the PC's main memory. It need be called only once per system start. This means the call could also be made from the *AUTOEXEC.BAT* batch file, for example.

4.4 The *mcfg.exe* utility program

The *mcfg.exe* utility program is implemented in SAA standard as a menu system with windowing technique and mouse support; it offers a user-friendly environment for developing SAP programs, plus a powerful commissioning, diagnostic and configuration interface.

The individual menus and their functions will be discussed briefly at this point. For more detailed descriptions, please consult the relevant manuals and chapters.

The *mcfg.exe* utility program requires the *system.dat*, *mcfg.dat* and *mcfg.lnf* files, which must be located in the current working directory or in the path environment!

In addition, the BGI graphics driver files must be contained in the current working directory or in the path environment variable set with BGIPATH .

When you start *mcfg.exe*, the system displays all axis channels at which the *cef* error flag has been set.

This error results from data inconsistency between the system file (*system.dat*) and the board(s) PA8000.

One way to eliminate the error is to save in the [Save Changes] menu.

4.4.1 Operating *mcfg.exe*

mcfg.exe can be operated with and without mouse support. Various windows can be placed wherever you want on the screen in mouse mode, and reduced or increased in size. You make your menu selection either with the mouse, or with the [↑] and [↓] keys and then pressing the ENTER key. You also have an option for making your selection by entering the letter highlighted in the menu name.

Various menu fields permit you to select parameters by pressing the space bar.

To move a screen window, proceed as follows: first position the mouse cursor on the [Menu name]. If the window can be moved, the mouse cursor will change to a '+' character. In this case, you can move the window for as long as you keep the mouse button pressed down.

To alter the size of a window, either click on the menu corners or the menu edge, and simultaneously pull in the direction you want. Here, too, a change in the mouse cursor character indicates that you have an option for altering the window size.

4.4.1.1 Help screens

Various menus are explained in more detail using help screens. In some cases, even the help text is field-referenced. If any help text exists for the menu or field you want, it will appear after you press the [F1] function key.

4.4.1.2 Selecting the axis channels

Various menu functions are axis-specific. In these cases, you select the axis you want with the [F2] function key. The axis channel last selected is retained in memory even after you have quit the *mcfg.exe* file.

4.4.1.3 Selecting the CNC task number

Various menu functions are task-specific. You select the task number you want with the [F3] function key. The task number last selected is retained in memory even after you have quit the *mcfg.exe* file.

4.4.1.4 Batch programming

The *mcfg.exe* utility program includes an option for batch programming. In this case, all information stored in the *mcfg.ply* file will be executed automatically. This covers all keyboard entries and mouse cursor movements.

4.4.1.4.1 Generating the batch file *mcfg.ply*

The batch file *mcfg.ply* is generated automatically by the following call:

```
mcfg kbr
```

All keyboard entries and mouse cursor movements executed in *mcfg.exe* are stored in the *mcfg.ply* file. This file can then be viewed with a text editor, and altered if necessary. There is also an option for inserting a {PAUSE} instruction. This will make the batch mode program halt for a very short moment. In addition, the {PROMPT} instruction ensures that the batch program is not continued until a keyboard entry has been made.

Note: Since in *mcfg.ply* all keyboard actions, including quitting the program, are saved in memory, you as the user have to remove the actions involved from *mcfg.ply*, in order to achieve a desired screen status.

4.4.1.4.2 Running the batch file *mcfg.ply*

Execution of the batch mode program *mcfg.ply* is initiated as follows:

```
mcfg kbp
```

4.4.2 Editing software parameters [Software Parameters]

This menu is used for editing axis-specific motor and system parameters. The parameters involved are system-specific default values for the individual axis channels. Most parameters can also be interrogated and set during run time using special read and write commands.

As mentioned above, you can select an axis number with the F2 function key.

4.4.2.1 Symbolic axis name

Each axis channel can be assigned a symbolic axis name *Symbolic name of axis* {sn} with up to 10 characters. This axis name is one of the features automatically defined in the *rw_SymPas* programming language as well.

4.4.2.2 Motor type

The *Motor-Type* {mt} parameter can be used to choose between stepping and servo drives. You select the motor type you want with the space bar. Motor-type-specific parameters are specified in the [Edit Motor spec. Parameters] menu.

4.4.2.3 Axis type

The *Axis-Type* {at} parameter cannot be selected. It is obtained automatically by selecting the counter unit of the gear factor {gf}. If the unit concerned is a distance unit (mm, m, inch ..), the axis type is specified as translatory. If angular units (rad, deg ..) are selected, the axis type is specified as rotational.

Note: If an interpolated procedure for more than one axis is demanded, the axes involved must be of the same type.

4.4.2.4 Unit for displaying the position registers

In the *Position register display unit* field, you can select a display unit used internally for *mcfg.exe*. If position setpoint values or position actual values are displayed in the various status windows [Chapter 4.3.8.1 and 4.3.8.3], the display will allow for this unit.

4.4.2.5 Display accuracy for the position registers

In the *Display precision* field, you can specify the precision of the position registers described above. The value entered specifies the number of places after the decimal point.

4.4.2.6 Encoder slits or number of steps for stepping motor axes

When you specify the number of encoder slits *# Encoder-Slits {slsp}*, you must also specify a unit. You can parameterize both rotational (angular decoders or rotary transducers) and translatory (linear scales) pulse measuring systems. This value is quadrupled internally, since the PA8000's evaluation electronics also perform a quadrupling operation.

With stepping motor systems, this value *# Step-Pulses* is not quadrupled. The actual value here corresponds to the number of stepping pulses outputted.

4.4.2.7 Gear factor

The *Gear Factor {gf}* parameter specifies a step-up or step-down ratio between actual-value pulse acquisition and feed travel or angle of rotation. The gear factor is completed by a denominator and counter unit. The denominator unit selected is used to specify two system variables. The first of these is the axis type, which is defined either as translatory (linear axes) for distance units or as rotational (round, rotary axes) for angular units. Secondly, the unit selected is also the basic unit for all axis-specific motion commands (*jog* commands) and their profile parameters (velocities and accelerations, described below).

4.4.2.8 Jog (rapid traverse) parameters

The jog (rapid traverse) parameters specify the axis-specific limit data for rapid-traverse positioning mode. These are acceleration *Maximum jog acceleration {jac}*, velocity *Maximum jog velocity {jvl}* and target velocity *Jog target velocity {jtv}*. It is usual to set the target velocity to 0.

4.4.2.9 Home (reference travel) parameters

The home (reference travel) parameters *{hac}* and *{hvl}*, like the rapid-traverse parameters, specify the limit data for the reference point search run. They are utilized automatically with all *home* commands as parameters for profile generation. Usually, the home velocity *Maximum home velocity* is only a fraction of the jog velocity, particularly when the reference switch is located near a limit switch.

4.4.2.10 Maximum position error

The *Maximum position error {mpe}* parameter is used to specify the maximum permitted deviation between the setpoint and actual position of the motor axis. If this value is exceeded, this error will not affect profile generation and position control, but it will be displayed in the *axst* axis status register. Reaction to this status register can be either event-controlled or by query.

Note: The position error monitoring function will be executed only when the position control loop is closed and a value greater than zero is specified for *{mpe}*.

4.4.2.11 Software limits

For each motor axis, you can define a left-hand (*Software limit left side* {sl}) and a right-hand (*Software limit right side* {slr}) software limit. If this limit is exceeded, you can use a parameter to specify how this error state is to be handled. You have the following options:

| | |
|--------|---|
| NOFUNC | (No Function) The software limit will be ignored. |
| TOM | (Turn Off Motor) No value will be outputted on the setpoint value channel in the case of servo drives, since the axis would move deeper into the limit switch area. In the case of speed controllers, this means a speed setpoint value of 0 with a corresponding holding torque. But in the case of current amplifiers, this means a current setpoint value of 0 and thus no holding torque. If the position setpoint value is smaller than the current position, the axis will be moved in uncontrolled mode. If the position setpoint value is smaller than the limit position, the limit switch status will be cancelled again. |
| SMA | (Stop Motor Abruptly). Die Achse wird an der angegebenen Endlagenposition in Lageregelung abrupt festgehalten. Ein weiteres Verfahren über die Software-Endlage hinaus wird verhindert. Wenn der Positionssollwert die Endlagenposition unterschreitet wird der Endschalterzustand wieder aufgehoben. |
| SMD | (Stop Motor Deceleration) hinzugekommen. Beim Ansprechen dieser Software-Endlage wird die Achse automatisch mit der achsspezifischen Verzögerung {sdec} auf Geschwindigkeit 0 abgebremst und dann in Lageregelung gehalten. Ein weiteres Verfahren über die Endlage hinaus wird verhindert. Wenn der Positionssollwert die Endlagenposition unterschreitet, wird der Endschalterzustand wieder aufgehoben. Dieser Funktionstyp wird insbesondere bei unterlagerten Drehzahlregelkreisen und Schrittmotorantrieben bevorzugt |

4.4.2.12 In-position window

You can use the *In position window* {ipw} parameter to specify when the *ip* flag is set in the *axst* register. This flag is set after the end of the profile has been reached (*pe* flag in *axst*) and if the position differential between setpoint and actual positions of the motor axis as specified in {ipw} is violated downwards. All PA8000 digital outputs planned with the IP function are set or reset like the *ip* flag.

Note: In-position window monitoring takes place only when a value greater than zero has been specified for {ipw}.

4.4.2.13 Zero offsets

Each axis channel can be assigned five different *zero offsets*. You can use the SAP and PCAP commands *azo()* to activate the offset parameter you want for the axis channels selected. Zero offsets serve to specify a new system of coordinates without having to influence the actual machine zero.

4.4.2.14 Filter parameters

For these parameters, a distinction is made between stepping and servo drives. For servo drive axes, a PIDF filter parameter set can be set with the coefficients {kp} for proportional amplification, {ki} for integral-action coefficient, {kd} for derivative-action coefficient and {kpl} for an additional phase lead. The factors {kfca} and {kfcv} can be used to specify compensation parameters for current amplifiers and/or speed controllers. These enable axis positioning to be made almost free of position error, even at high acceleration values. You set the filter in accordance with the particulars given in the CM/Chapter 5.2. In the case of stepping motor systems, you need specify only the {kp} filter parameter, which should normally be set to the value 0.04.

4.4.2.15 Manipulated variable limitation

In the case of servo axes, you can use the {maxmcp} and {minmcp} variables to limit the manipulated-variable output to the maximum and minimum values you want. It is usual to set the maximum value to 10 V and the minimum value to -10 V. If you reduce the maximum values, this means the manipulated variable for the power amplifier is reduced too. In the case of speed controllers, this means a reduction in the speed manipulating range, and in the case of current amplifiers a reduction in the torque range.

4.4.2.16 Manipulated variable compensation

In the case of servo axes with hydraulic motors, you can use the {mcpcp} and {mcpcn} variables to set a compensation voltage for the manipulated-variable output. In closed-loop control mode, these are the minimum output voltages on the analog setpoint value channel. The system-entailed switch-on hysteresis at valves customarily used for controlling the hydraulic motors can thus be suppressed. No compensation voltage is normally required with all other types of servo motors.

4.4.2.17 Inverting the manipulated variable

You can use the *Invert motor command port* parameter to invert the sign of the manipulated variable (Motor-Command-Port) in the case of servo axes. You will find this particularly helpful when there is a phase distance in the controlled system. Determinant factors for the phase angle between manipulated variable and angle actual value include the polarity of the motor lines and encoder signals or mechanical components like the gear unit.

4.4.2.18 Changing the count direction

The *Change encoder count direction* parameter is used to invert the count direction for the pulse acquisition channels. You will find this particularly helpful when there is a phase distance in the control system.

4.4.2.19 Polarity of the index signal

You can use the *Polarity of index pulse* parameter to specify the polarity of the zero-track signal (index pulse) of a pulse encoder.

Note: The current status of the zero-track signal is also displayed in the [Dialog Functions Menu][Show Inputs / Status ..] menu.

4.4.2.20 Start-stop frequency

This parameter is not supported at present.

4.4.2.21 Pulse acquisition with stepping motor systems

Normally, stepping motor axes are controlled in what is called open-loop mode. This means that the motor system follows a setpoint frequency, and actual position always has to coincide with the computed setpoint position.

As an option, you can use this parameter to involve in the drive system a pulse encoder built onto the stepping motor system. This will also enable you to run the stepping motor axis in closed-loop mode, which is helpful in certain circumstances (this parameter is not supported at present).

4.4.3 Editing the hardware parameters

This menu is used for axis-specific planning of the hardware characteristics for the PA8000's digital inputs and outputs.

4.4.3.1 PA8000 digital inputs [Edit PA8000 Input Configuration]

All digital inputs can be assigned a special function in the *Special Function* field. The special function becomes operative whenever the correspondingly planned digital input is activated. The significance and operation of all possible special functions are explained below:

| | |
|---------|--|
| NOFUNC | (No Function) The input does not have a special function. It serves merely as a user-programmable digital input. |
| REF | (Reference Switch) The inputs planned with this function act as reference or stop switches. If while special reference travel commands (e.g. <i>jhl()</i> command) are being executed a digital input planned for this function is activated, e.g. by a reference switch (cam), the selected axis channel will be decelerated to a velocity of 0 with the axis-specific reference-travel deceleration. |
| LSL_TOM | (Limit Switch Left Turn Off Motor) The inputs planned with this function operate as left-hand hardware limit switches. When this input responds, there will in the case of servo drives be no value outputted on the setpoint value channel which would move the axis further into the limit switch area. In the case of speed controllers this means a speed setpoint value of 0 with a corresponding holding torque. But in the case of current amplifiers this means a current setpoint value of 0 and thus no holding torque. The limit switch is normally tripped by movement in a negative direction and exceeding the relevant limit. If the position setpoint value is smaller than the current position, the axis continues to move uncontrolled. If the position setpoint is smaller than the position at which the limit switch was detected, the limit switch status is cancelled again. |
| LSL_SMA | (Limit Switch Left Stop Motor Abruptly). This input likewise functions as a left-hand hardware limit switch, but when activated causes the axis to be held at its current position in position control operating mode. Movement beyond the limit position is prevented. If the position setpoint value is smaller than the limit position, the limit switch status is cancelled again. |
| LSR_TOM | (Limit Switch Right Turn Off Motor) The mode of operation here is identical to that for LSL_TOM, except that this limit switch is planned for the right-hand limit. |
| LSR_SMA | (Limit Switch Right Stop Motor Abruptly). The mode of operation here is identical to that for LSL_SMA, except that this limit switch is planned for the right-hand limit. |
| EO | <p>(Emergency Out) This input signals that an emergency stop button incorporated in the drive system has been pressed.</p> <p>Note: This input has no effect on the drive system. It is at the user's discretion how he/she reacts to this event.</p> <p>This signal can be evaluated by interrogation [PM/Chapter 4.4.27, <i>rdaxst()</i>] or by means of an EVENT handler [PM/Chapter 6.4.1].</p> |

| | |
|---------|--|
| DR | (Drive Ready) This input signals whether the power amplifier connected to this channel is showing operational readiness. This signal can be evaluated by interrogation [PM/Chapter 4.4.27, <i>rdaxst()</i>] or by means of an EVENT handler [PM/Chapter 6.4.2]. |
| UI | (User Input) This input has no effect on the drive system. Since an EVENT handler is provided for this type of input as well, the alternative cyclical interrogation (polling) of inputs can be dispensed with. This signal can be evaluated by interrogation [PM/Chapter 4.4.27, <i>rdaxst()</i>] or by means of an EVENT handler [PM/Chapter 6.4.6]. |
| LSL_SMD | (Limit Switch Left Stop Motor (with) Deceleration) Die mit dieser Funktion projektierten Eingänge funktionieren als linke Hardware-Endschalter. Beim Ansprechen dieses Eingangs wird die Achse automatisch mit der achsspezifischen Verzögerung { <i>sdec</i> } auf Geschwindigkeit 0 abgebremst und dann in Lageregelung gehalten. Ein weiteres Verfahren über die Endlage hinaus wird verhindert. Das Ansprechen des Endschalters erfolgt üblicherweise beim Verfahren in negative Richtung und Überschreiten der entsprechenden Endlage. Wenn der Positionssollwert die Position unterschreitet, wird der Endschalterzustand wieder aufgehoben. Dieser Funktionstyp wird insbesondere bei unterlagerten Drehzahlregelkreisen und Schrittmotorantrieben bevorzugt. Anmerkung: Die Verzögerung <i>sdec</i> muß so bestimmt werden, daß ein sicheres Anhalten des Antriebes gewährleistet ist, ohne daß die Motorachse in eine mechanische Begrenzung läuft und dadurch evt. Schäden verursacht. Zur Absicherung des Antriebes sollten zusätzlich Hardware-Begrenzungsschalter eingesetzt werden, welche die Leistungsverstärker nur in die erlaubte Fahrtrichtung freischalten. |
| LSR_SMD | (Limit Switch Right Stop Motor (with) Deceleration) Die Funktionsweise ist mit LSL_SMD identisch, bis auf den Unterschied, daß dieser Endschalter für Endlage rechts projektiert wird. |
| LP | (Latch Position) Beim Aktivieren dieses Eingangs wird die Ist-Position { <i>rp</i> } der entsprechenden Motor-Achse zwischengespeichert. Sofern ein Latch-Vorgang ausgelöst wurde, ist das <i>lpsf</i> -Flag des <i>axst</i> -Registers gesetzt. Dann kann mit dem PCAP-Befehl <i>rdlp()</i> [Kapitel 1.8] oder über den SAP-Achsenqualifizierer <i>lp</i> die zwischengespeicherte Position eingelesen werden. Das <i>lpsf</i> -Flag wird durch den Einlesevorgang automatisch gelöscht. Die maximale Verzögerung des Latch-Vorganges beträgt 2 Abtastintervalle (2.56ms). |

4.4.3.2 Inverting the PA8000 digital inputs

All PA8000 digital inputs can be axis-specifically inverted by means of the software. You make the selection you want in the *Invert Input* field with the space bar or by means of mouse clicks. NC or NO contacts can thus be operated at the inputs involved without the need for any additional hardware. The information on whether an input is to be inverted or not is stored on the PA8000 EEPROM.

Note: In the factory, all inputs of the PA8000's system electronics have been planned without inversion. The inputs are activated when a voltage of +24 V is applied.

4.4.3.3 PA8000 digital outputs [Edit PA8000 Output Configuration]

All digital outputs can be assigned a special function in the *Special Function Field*. The significance and operation of these special functions are explained below:

- | | |
|--------|---|
| NOFUNC | (No Function) The output has no special function. It serves merely as a programmable digital output. |
| PAE | <p>(Power Amplifier Enable) This output is set whenever the corresponding axis channel is switched into position control. Er dient zur Freischaltung der externen Leistungsverstärkerbaugruppe. This is caused by the <i>cl()</i> command. The output is reset as soon as the position control is switched off. This is the case, for example, with the <i>ra()</i>, <i>rs()</i> or <i>ol()</i> command. Die Freischaltung der Leistungsverstärker wird z.B. in folgenden Situationen benötigt: Bei Störsituationen oder wegen der bei Drehzahlregelgeräten systembedingten Offsetdrift.</p> <p>Anmerkung: Alle Ausgänge werden bei einem Hardware-Rücksetzvorgang, welcher bei Power-On, Power-Fail oder Reset ausgelöst wird, sofort hardwaremäßig rückgesetzt. Die marktgängigen Leistungsverstärker werden mit einem potentialfreien Relaiskontakt freigeschaltet. Dieses könnte durch einen PAE-projektierten Ausgang angesteuert werden.</p> <p>Pro Achskanal wird ein potentialfreier Relaiskontakt (Schließer) am 10-poligen FB-Steckverbinder X11 zur Verfügung gestellt. Dieser Relaiskontakt ist werksseitig mit PAE-Funktion projiziert.</p> |
| IP | (in position) This output is set whenever the axis channel involved has reached the end of its profile, and in addition the actual position and the setpoint position are within the position window specified in {ipw} [Chapter 4.4.2.12]. |
| MPE | (maximum position error) This output is set when the position error specified in {mpe} is exceeded [Chapter 4.4.2.10]. |

4.4.3.4 Initial state of the PA8000 digital outputs

All digital outputs can be assigned a default value in the *Set/Reset Output* field. This value is outputted after power-up, especially after booting, or a hardware reset of the PA8000's system electronics. During the reset operation, 0 V is outputted at all digital outputs.

Der Grundzustand der Digitalausgänge kann achsspezifisch gesetzt werden. Jedoch ist der Wert „1“ oder „gesetzt“ dominant, d.h. wenn auf einer beliebigen Achse „Set“ aktiviert ist, ist die Bedeutung der anderen Achsprojektierungen nicht mehr von Bedeutung.

4.4.4 Editing the board parameters [PA8000 Board-Parameters]

The settings for and significance of these parameters are described in the installation chapter for the PA8000 [OM/Chapter 3].

4.4.5 Editing the configuration parameters

Various presettings for the *mcfg.exe* utility program are made in this menu.

4.4.5.1 Parameters for dialog function, CNC task status d[CNC task-Status Parameter]

The COMMON INTEGER Variable (CI0.. CI9) is used in various applications as bit-coded diagnostic or command registers. In these cases, you will find it helpful to represent the registers as hexadecimal numbers. In this menu you can choose between decimal and hexadecimal display of the CI variables.

4.4.5.2 Set trajectory parameters [Set CNC-specific parameters]

This menu is identical to the special function [Setup][Set CNC-specific parameters] in the editor environment [Chapter 4.4.7.9.9.1].

4.4.6 Graphical system analysis [Graphic Analysis Menu]

Another important characteristic of the *mcfg.exe* utility program is the option for displaying various axis-specific controlled and process variables on screen in graphic form. To achieve maximized resolution, the screen is switched to graphic mode for this purpose.

4.4.6.1 Graph selection [Graph Display Setup]

In this menu, you can specify various particulars for graph selection and colour assignment. You can display the setpoint and actual values for position and velocity. The y-axis (distance/angle and velocities) is always scaled in the colours of the actual values. You select the graphs you want and the colour assignments by means of mouse clicks or with the space bar.

4.4.6.2 Scaling of graphic screen [Graph Scale Parameters]

This menu is used for scaling the graphic output. You can specify scaling for position actual and setpoint values, and for velocity setpoint and actual values. For recording the actual and setpoint values, you have 1000 measured values available in each case; this number enables a recording duration of 1.28s (1000 * scan time) to be achieved. If you want the recording duration to be greater than this value, the PA8000 inserts wait times between the individual measuring times. This means you can have recordings of any duration you want. Punctual latching and data saving are here performed on the PA8000. A latch operation can thus be started, and the result displayed on-screen one hour later, for example.

Note: For an alteration in the distance or angle unit to become operative in the scaling, relatching must be performed before display on the graphic screen. However, the distance limit values, time units and time limit values can also be altered at will without any need to relatch.

4.4.6.3 Recording axis movements [Graph Latch Menu]

In this menu, you can select an operating mode for graphical assessment of an axis's positioning and control response. In addition, you can edit the filter parameters of the specified axis channel [F2 = axis channel selection]. However, an alteration in parameters will not become operative until the [Update Filter] menu function has been activated. The parameters for the operating modes described below are edited in the [Edit Parameters] menu. The latch operation [Latch Start] causes the operating mode selected in each case to be executed, and the axis data to be recorded as described above.

4.4.6.3.1 [NOTHING] operating mode

Latching in this operating mode saves the current status of the axis channel selected.

4.4.6.3.2 [Open Loop System Response] operating mode

In this operating mode, a pulse with selected voltage and duration is outputted on the axis channel selected. The control loop is opened in this operating mode. This means that the controlled system's step response is recorded, and this step response can be used to dimension the controller parameters.

4.4.6.3.3 [Closed Loop System Response] operating mode

In this operating mode, the position control loop of the axis channel selected is closed. The motor is brought to the target position by the specified traverse path. But this is done without acceleration and deceleration ramps, i.e. with the axis-specific maximum system acceleration. This enables the position controller's transient response to be checked and optimized.

4.4.6.3.4 Operating mode [Motion Profile System Response]

This operating mode is particularly suitable for assessing the control and positioning response of the axis channel selected. The motor is moved with the specified system parameters, either absolutely, or relatively with the aid of the trapezoidal speed profile. The usual procedure is first to optimize the control response by customizing the filter parameters with small acceleration and velocity parameters. For this purpose, you want setpoint and actual value curves to coincide as closely as possible in the graphics display. Provided the filter parameters have been matched to the system, the limit values for acceleration and velocity can be determined with this operating mode. Here, too, you should in turn aim for a small setpoint/actual-value differential for optimized positioning response.

This operating mode is also suitable for experimental determination of the compensation parameters {kfca} and {kfcv}. For this purpose, the other filter parameters are set to 0. The compensation parameters {kfca} and {kfcv} are now set so as to ensure that the curves for setpoint and actual values coincide as closely as possible. This adjustment procedure should be carried out at medium acceleration.

4.4.6.4 [Display Graphic Screen]

The graphs selected will be displayed on-screen with the appropriately specified scaling parameters. Scaling for the vertical axis is always made in the colours of the actual values.

For graphical assessment of the axis-specific positioning and control response, the following points must also be taken into consideration: the setpoint values, in contrast to the actual values, are always available with decimal places. This means that the graphs (especially at high resolution) may exhibit great differences, particularly in the case of the velocity graphs, since these are computed by differentiation from the travel data. A system-entailed offset between setpoint and actual values must likewise be allowed for, since the actual values are never available until the beginning of a new scan interval. In spite of these restrictions, the graphic output function provides a simple and effective option for optimizing the positioning and control response of the drive axes.

You can quit graphics output using the mouse quit function or by pressing the [ESC] key.

4.4.7 The CNC-Edit text editor [Editor C N C - E D I T]

The CNC Edit editor installed in the integrated development environment *mcf*.exe has been specifically designed for creating source texts. You can, however, also create these source text files using a different text editor .

The editor is intended for creating SAP programs.

You can use the [F10] function key to activate various "special commands" from the editor. These include loading and saving *rw_SymPas* program files, plus compiling and executing the files concerned.

4.4.7.1 The header line of the editor window

Since it's possible to edit up to three text files simultaneously in the editor environment, the corresponding filenames are displayed in the header lines of the editor windows concerned.

4.4.7.2 The status line

is the bottommost line of the editor, and is structured as follows:

```
Current File:motion.src  R:  1 C:   1 INS  Press [F10] for commands.
```

Key:

| | |
|---------------------------|---|
| Current File: | specifies the name and suffix of the file currently being processed in the editor. The default extension for the filename is <i>.src</i> . |
| R: | (Row) The program here displays the number of the line in which the cursor is currently located. The first line of a text has the number 1. Counting is referenced to the beginning of the text, and not to the cursor's position inside the window. |
| C: | (Colon) indicates the cursor's current column position, and is likewise referenced to the source text. |
| INS (OVR): | means that currently the "Insert mode" is activated. Newly entered characters are inserted into the existing text from the cursor's position, while text to the right of this position will be correspondingly shifted. You can switch between insert ("INS") and overwrite ("OVR") modes using the [ALT] [I] key command. In the latter case, old text will be replaced (overwritten) by the new entries from the cursor's position onwards. |
| Press [F10] for commands: | as already mentioned above, various "special commands" can be executed during the editing operation. |

If more than one editor window is open simultaneously, the status line for the currently active text window is determinant.

4.4.7.3 Editor commands

The most important commands are those for moving the cursor.
CNC-Edit also provides a series of additional options, which are listed in the tables below:

Table 1: Editor command overview: basic cursor movements

| Function | Key(s) |
|----------------------|--------|
| Character leftwards | [←] |
| Character rightwards | [→] |
| Line upwards | [↑] |
| Line downwards | [↓] |
| Page up | [PgUp] |
| Page down | [PgDn] |

Table 2: Editor command overview: extended cursor movements

| Function | Key(s) |
|-------------------|------------------------------|
| Beginning of line | [Home] |
| End of line | [End] |
| Beginning of text | [Ctrl][PgUp] or [Ctrl][Home] |
| End of text | [Ctrl][PgDn] or [Ctrl][End] |

Table 3: Editor command overview: insert and delete

| Function | Taste(n) |
|-----------------------------------|------------------|
| Insert mode ON/OFF | [ALT][I] |
| Delete character to the left | [BS] (Backspace) |
| Delete character under cursor | [DEL] |
| Insert line (when insert mode ON) | [Return] |

Table 4: Editor command overview: block operations

| Function | Key(s) |
|--|----------|
| Line block marking ON/OFF | [ALT][M] |
| Column block marking ON/OFF | [ALT][C] |
| Copy marked block into clipboard | [ALT][K] |
| Copy marked block into clipboard and then delete | [ALT][D] |
| Copy block from clipboard | [INS] |
| Delete marked block | [DEL] |

Table 5: Overview of editor commands: various

| Function | Key(s) |
|---------------------------------|----------|
| Tabulator (corr. to 8 charact.) | [⇔] |
| Find text | [ALT][S] |
| Find and replace text | [ALT][R] |

4.4.7.4 Basic movements of the cursor

4.4.7.4.1 Character to the left[←]

Moves the cursor one character to the left, without changing this character. When the left edge of the line is reached, the cursor will move one line upwards at the next [←], provided there is in fact another line above.

4.4.7.4.2 Character to the right [→]

Moves the cursor one character to the right, without changing this character. When the cursor reaches the right-hand edge of the screen, the entire content of the screen is shifted five characters to the left. When the right end of the line is reached, the cursor will move one line downwards at the next [→], provided there is in fact another line below

4.4.7.4.3 One line up [↑]

Moves the cursor one line upwards. When the topmost line in the window has been reached, the window contents will be scrolled one line downwards.

4.4.7.4.4 One line down [↓]

Moves the cursor one line downwards. When the bottommost line in the window has been reached, the window contents will be scrolled one line upwards.

4.4.7.4.5 Page up [PgUp]

Moves the cursor one screen page towards the beginning of the text.

4.4.7.4.6 Page down[PgDn]

Moves the cursor one screen page towards the end of the text.

4.4.7.5 Extended cursor movements

4.4.7.5.1 Beginning of line[Home]

Moves the cursor to the outermost left-hand margin, i.e. into the text column (COL 1.)

4.4.7.5.2 Line End [End]

Moves the cursor to the right-hand end of the current line, i.e. to the position of the last character (blanks are ignored). If the line is wider than the window, the program will perform the appropriate horizontal scrolling.

4.4.7.5.3 Beginning of text [Ctrl][PgUp] or [Ctrl][Home]

Sets the cursor on the first character of the text.

4.4.7.5.4 End of text [Ctrl][PgDn] or [Ctrl][End]

Sets the cursor on the last character of the text.

4.4.7.6 Insert and delete

4.4.7.6.1 Insert mode ON/OFF [ALT][I]

When you are entering text, this command gives you an option for switching over between two basic modes - Insert and Overwrite. The default setting when the CNC Editor is activated is "Insert". In this mode, when you enter characters, those parts of the text to the right of the cursor will be shifted correspondingly. But if the editor is in overwrite mode, new entries will replace the text to the right of the cursor character by character, and the overwritten text will be lost. In this mode, pressing the [Return] key will not insert a new line, it will simply move the cursor. The editor's status line will show you which mode is currently active.

4.4.7.6.2 Delete character to the left [BS] (BS = Backspace)

Independently of the overwrite mode, the cursor is shifted one column to the left, and deletes the character located there. Text located to the right of the cursor will automatically be moved one column to the left. You can also use this command to delete line breaks.

4.4.7.6.3 Delete character under cursor [DEL]

Deletes the character on which the cursor is located, and shifts all characters located to the right of the cursor's position one column to the left. You can also use this command to delete line breaks.

4.4.7.6.4 Insert line [Return]

Inserts a line break at the cursor's position, and moves the cursor to column 1 of the newly inserted line. In overwrite mode, no new line will be inserted - all that happens is that the cursor is moved to column 1 in the next line.

4.4.7.7 Block operations

4.4.7.7.1 Line block marking ON/OFF [ALT][M]

This switches the line block marking function on and off. When the marking feature is switched on, you use the cursor keys to mark the line block you want. To deselect block marking again, use the [ALT][M] key combination.

4.4.7.7.2 Column block marking ON/OFF [ALT][C]

This switches the column block marking function on and off. When the marking feature is switched on, you use the cursor keys to mark the column block you want. To deselect block marking again, use the [ALT][C] key combination.

4.4.7.7.3 Copy marked block into clipboard [ALT][K]

You use this key combination to copy a previously marked block into a clipboard.

4.4.7.7.4 Copy marked block into clipboard [ALT][D]

You use this key combination to copy a previously marked block into a clipboard and then delete it.

4.4.7.7.5 Copy block from clipboard [INS]

The memory contents of the clipboard are inserted at the current position of the cursor.
So to copy a line block, proceed as follows:

- Mark the beginning of your block with [ALT][M]
- Use the cursor keys to select your block
- Copy the block into the clipboard with [ALT][K]
- Deselect the marked block with [ALT][M]
- Move the cursor to the position in the text you want
- Insert the text with [Ins]

Moving a block is performed in the same way as copying a block, except for the "Copy block to clipboard" command [ALT][K]. Instead of this, you use the [ALT][D] key combination.

If you have more than one editor window opened, you can also copy text sections from one editor to another.

4.4.7.7.6 Delete marked block [Del]

You use this key to delete a previously marked block. The contents of the clipboard remain unchanged.

4.4.7.8 Various options

4.4.7.8.1 Tabulator [⇐⇒]

Sets the cursor to the next tab position. These positions are fixed, and are eight characters apart (Columns 1, 9, 17, etc.).

4.4.7.8.2 Find text [ALT][S]

You can use this command to find a sequence of up to 50 characters inside a text. If the text string you are looking for is not found, the program will output a "Pattern not found." message. The search operation can be aborted using the [ESC] key.

4.4.7.8.3 Find and replace text[ALT][R]

This command can be used to find and replace a sequence of not more than 50 characters inside a text. If the text string to be replaced is not found, the program will output a "Pattern not found." message. Otherwise you have to make an additional entry prior to text replacement. You have three different options for this:

- | | |
|-------------------|---|
| Enter [Y] Yes : | The search string found will be replaced by the text you want. The text will then be searched further towards its end. |
| Enter [N] No: | The search string found will not be replaced. The text will then be searched further towards its end. |
| Enter [G] Global: | All search strings found will be automatically replaced by the text you want, without any further query, as far as the end of the text concerned. |

You can abort the find-and-replace operation using the [ESC] key.

4.4.7.9 Special functions of the CNC-Edit editor

In the editor environment, you will find a menu bar with various special functions, which you can activate using the F10 function key or a mouse. The various special functions involved are described below.

4.4.7.9.1 File menu

This menu contains the functions for managing source text files (select, load, save and print).

4.4.7.9.1.1 Load and save text files [Load File, Save File]

For loading [Load File] and saving [Save File] program files, you can make your selection using the [+] key or the ENTER key. You must then confirm your selection using the load or save command. The .src file suffix is always proposed for selection. But you can also make your selection by specifying the complete filename. As soon as a load command is given, the current editor contents will be lost. So you have to save them beforehand if you want to retain them.

When the [Print File] command is given, the current memory content of the editor is outputted into the printer connected at the LPT1 port.

4.4.7.9.1.2 Open additional editor window [Add Edit Window]

In certain cases, you may find you want to edit more than one source text file simultaneously. You can use the [Add Edit Window] function to open up to three text windows on the screen at the same time. The [Load File] function mentioned above can be used to load the text files you want into these windows. The corresponding filenames are displayed in the header line of these editor windows. You have an option for copying text sections from one editor to another using the block operations described in Chapter 4.4.7.7.

4.4.7.9.1.3 Close current editor window [Close Edit Window]

The [Close Edit Window] option is used to close the editor window currently selected, provided at least two editor windows are currently open. The ongoing text content of this editor window will not, however, be lost.

4.4.7.9.1.4 Select next editor window [Next Edit Window]

The [Next Edit Window] function is used to select the next editor window. But you can also make your selection by clicking the mouse on the editor window frame.

4.4.7.9.1.5 Leave editor environment [Quit]

You use the [Quit] menu function to terminate the editor operation concerned. The editor contents remain unchanged until you quit the TOOLSET program *mcfg.exe*.

If one (or more) source text file(s) has/have been altered, the system will remind you again of this/these change(s) when you quit the *mcfg.exe* program, and offer you a chance to save it/them.

Note: The [Save Changes] option in the main menu does not save any editor source text files!

4.4.7.9.2 Screen menu

4.4.7.9.2.1 Change size of editor window [Zoom]

The zoom function switches the text editor over to a small or large screen window, depending on the current editor size.

4.4.7.9.2.2 Delete current text in the editor window [Wipe Screen]

The [Wipe Screen] function is used to delete the entire editor content (without saving it beforehand).

4.4.7.9.3 Compile menu

This menu calls up the integrated NCC compiler, and compiles the contents of the editor currently selected. If the compiler finds a faulty source text line, an error message will be outputted with the type and line of the error concerned. After you have acknowledged the error, the editor cursor will be positioned on the faulty line.

4.4.7.9.3.1 Syntactical SAP program check [Syntax Check]

The [Syntax Check] option merely triggers a syntax check on the source text program.

4.4.7.9.3.2 Syntax check and generation of a CNC file [File]

The [File] option is identical to [Syntax Check], but given an error-free compiling run will additionally generate a file with the current source text filename and the suffix *.cnc*. This file can, for example, be transferred to the CNC task by a PC application program with the load command *txbf()* [PM/Chapter 4.4.75], and executed there in stand-alone mode. If the SAP program does not contain a *#TASK* statement, the CNC file for the currently selected Task Number [F3] will be generated.

You can also generate a CNC file using the command line compiler *ncc.exe* [Chapter 4.5].

4.4.7.9.4 Run menu

This menu is used for program tracing of one or more CNC tasks.

4.4.7.9.4.1 Start program trace for a CNC task [Trace current selected CNC task]

The [Trace Current Selected CNC Task] function is identical to the function described in the preceding chapter [Compile][File], but additionally with the aid of the PCAP command *txbf()* [PM/Chapter 4.4.75], loads the generated CNC file onto the PA8000, and causes the CNC to automatically execute the CNC program currently contained in the editor, with the aid of the PCAP command *startcnct()* [PM/Chapter 4.4.72]. Provided the load operation has been successfully executed, the source text line currently being processed by the CNC task will be marked in the editor window, thus indicating the processing sequence of the CNC program file. The source text line marked is brought into the active section of the editor screen window, and in addition the corresponding source text line number is shown in the status line. You can abort the trace operation at any time by means of the [ESC] key.

If there is no *#TASK* statement in the SAP program, the CNC file is generated for the Task Number [F3] currently selected, and processed in the corresponding task.

4.4.7.9.4.2 Stop current selected CNC task

The "Stop current selected CNC task" option causes the CNC tasks selected [F3] to no longer continue to process the CNC file currently loaded. In this context, please note that enabled EVENT handling procedures will no longer be processed either.

4.4.7.9.4.3 Continue CNC task [Continue Trace in Current CNC task]

The [Continue Trace in current CNC task] option is used to continue the program currently loaded in the CNC task [F3]. For this purpose, however, the system first checks whether the editor source text program is consistent with the CNC file loaded. If this is the case, then the current source text line is in turn marked, and displayed in the active screen area of the editor.

4.4.7.9.5 Restart all CNC tasks

This menu function starts all CNC tasks (0 to 3). All CNC programs loaded are started from the beginning of the program concerned.

4.4.7.9.6 Stop all CNC tasks [Stop all CNC tasks]

All CNC tasks are stopped, and the CNC programs filed there are halted.

4.4.7.9.7 Continue all CNC programs [Continue all CNC tasks]

All stopped CNC programs will be continued with this function.

4.4.7.9.8 Spooler menu

The spooler options can be used to start [Start...], stop, and delete [Delete...] the commands currently being spooled. The commands are triggered synchronously for all axes in which there are spooled commands.

4.4.7.9.9 Setup menu

4.4.7.9.9.1 Set path parameters [Set CNC-specific parameter]

This menu is used to enter CNC-specific program data like path acceleration and path velocity. These parameters can, however, also be programmed using predefined *system parameters* in the SAP application program.

This menu is provided as part of the configuration parameter menu [Chapter 4.4.5.1].

4.4.7.9.9.2 Set compiler operating mode (in preparation!) [Set Compiler Mode]

This menu can be used to choose between the two programming languages *rw_SymPas* and G-Code programming (in broad conformity with DIN 66025 or RS-274). The *NCC* compiler executes syntactic checking for the programming language selected.

4.4.7.9.9.3 Select CNC task

This menu can be used to select a Task Number (0 to 3), which is required for task control and CNC file generation.

4.4.7.9.10 Display menu

This menu is used to display CNC-task-specific information on the screen.

4.4.7.9.11 System menu

This menu can be used to close [Close ...] or open [Open ...] the position control loops of all axes. There is also an option, using the reset statement [Reset ...] for resetting all axis channels. Internally, [Reset ...] will cause any CNC program running to be stopped with the PCAP command *stopcnct()* [PM/Chapter 4.4.74]. The PA8000 will then be reset with the PCAP command *rs()* [Chapter 4.4.67].

4.4.8 Dialog Functions Menu

You can use this menu to interrogate various states of the PA8000, set outputs, reset axis channels, and start traversing profiles.

4.4.8.1 Display axis status [Open Axis Status Window]

This menu option opens an axis-specific status window for the axis channel currently selected [F2]. The window can be placed anywhere you want on the screen, and reduced or increased in size. You can also display more than one status window on the screen for different axes simultaneously.

Structure of the axis status window [ACTUAL VALUES]

| Name | Significance |
|--------|--|
| Axis # | Number of the axis channel selected. |
| Name | Symbolic axis name {sn} [Chapter 4.4.2.1]. |
| {DP} | Desired Position (setpoint position). The display allows for the unit and precision selected [Chapters 4.4.2.1 and 4.4.2.5]. |
| {RP} | Real position (actual position). As for {DP}. |
| {AXST} | This field displays the bit-coded <i>axst</i> status register in hexadecimal notation [PM/Chapter 4.4.27, <i>rdaxst()</i>]. |
| {LSM} | Spool area in bytes freely available at present. |

4.4.8.2 Terminate axis status display [Close Axis Status Window]

This menu option closes the status window of the axis channel currently selected [F2].

4.4.8.3 Axis status report [Display Axis Status Report]

This menu option causes various status information to be displayed for all axis channels included in the system. You as the user are given a fast overview of the status of the entire drive system. This display is provided in 40-column mode, so that it can be read off even from a good way away.

Structure of the axis status report [AXIS STATUS REPORT]

| Name | Significance |
|-----------------|---|
| Axis-Name | Symbolic axis name {sn} [Chapter 4.4.2.1] |
| Actual Position | Actual position {rp}. This display allows for the unit and precision selected [Chapters 4.4.2.4 and 4.4.2.5]. |
| Flag L | A hardware or software limit switch has been detected. |
| Flag M | The maximum permitted position error has been exceeded. |
| Flag C | Axis is currently in position control mode. |
| Flag P | The profile end has been reached. |

4.4.8.4 Display bit information on axis status register *axst* [Display Detailed Axis Status]

This function is used to display the ongoing status of the axis-specific [F2] *axst* register. The display results from the bit information filed in the *axst* register. The first column (S-column) shows the ongoing status of the bit concerned. The bit information involved is described in more detail using its bit number in the *axst* word, its symbolic names, and its function. The last column (Error/Status) indicates whether the bit involved is an error flag or a status flag.

4.4.8.5 Display the PA8000 digital inputs and ASM status [Show Inputs / Status of PA8000]

This function is used to display the current status of the PA8000 digital inputs and various status information on the axis channel selected [F2].

Current input and status information on the PA8000 [PA8000 INPUTS / STATUS]

| Name | Significance |
|--------|---|
| {digi} | Status of the PA8000 digital inputs. Fehler! Verweisquelle konnte nicht gefunden werden.. |
| {digi} | Field NDX: If an incremental sensor with zero track (Index) is being used, its status will likewise be displayed Fehler! Verweisquelle konnte nicht gefunden werden.. |
| {digi} | Field EE: Sofern ein Fehler des Meßwerterfassungssystems vorliegt, wird dies hier angezeigt Fehler! Verweisquelle konnte nicht gefunden werden.. |
| {digi} | Field NDXL: Hier wird ein Flankenübergang von NDX angezeigt. Fehler! Verweisquelle konnte nicht gefunden werden.. |
| {digi} | Field STRBL: Hier wird ein Flankenübergang des Strobosignals angezeigt Fehler! Verweisquelle konnte nicht gefunden werden.. |
| {epc} | Number of EEPROM programming cycles Fehler! Verweisquelle konnte nicht gefunden werden.. |
| {edv} | Signals the validity of the EEPROM data Fehler! Verweisquelle konnte nicht gefunden werden.. |
| {pfe} | Signals that the operating voltage has dropped under 4.75 V. This flag is set to „1“ everytime the PC is powered up. Fehler! Verweisquelle konnte nicht gefunden werden.. |
| {wdog} | Signals that the board has been reset owing to a watchdog error Fehler! Verweisquelle konnte nicht gefunden werden.. |
| {iae} | Invalid Access Error. This flag signals an internal unallowed access error. Fehler! Verweisquelle konnte nicht gefunden werden.. |

4.4.8.6 Display CNC task status and common variables [Show CNC task Status / Variables]

This screen window contains current status information on the CNC task and common variables.

Status information for the CNC task [CNC-TASK_STATUS / COMMON VARIABLES]

| Name | Significance |
|-----------------------|--|
| Error-Nr | If an error has been caused by an SAP program, then an internal system error number is displayed in this field. The SAP program will in this case be halted.. |
| Error-Line | If the above-described Error Number is not equal to 0, then the line number of the SAP program in which the error has occurred will additionally be displayed in this field. |
| Current Program | If an SAP program has been transferred to the PA8000, the filename involved is displayed here |
| Running / Not Running | If an SAP program is being processed, the display is switched to <i>Running</i> .. |
| Running in task # | This is the CNC Task Number in which the current SAP program is being processed. ([F3] = Task Number selection) |
| Stack | Displays stack area (bytes) of the CNC task freely available at present |
| Current source line # | Displays the source text number currently being executed. |
| Common Variables | The current state of all freely available common integers and common |
| CI0..CI99 and | double variables is displayed here. |
| CD0 .. CD99 | Fehler! Verweisquelle konnte nicht gefunden werden., Fehler! Verweisquelle konnte nicht gefunden werden. u. Fehler! Verweisquelle konnte nicht gefunden werden. |

4.4.8.7 Edit the PA8000 digital outputs [Edit Outputs of PA8000]

This menu can be used to set or reset the PA8000 digital outputs of the axis channel currently selected [F2] **Fehler! Verweisquelle konnte nicht gefunden werden.** You use mouse clicks or press the space bar to set or reset the outputs. To confirm the action you want, you must then quit the field you have selected.

Note: the selected axis channel [F2] has no meaning for the setting or resetting of the outputs; all outputs can be addressed through the different axis channels of the board.

4.4.8.8 Execute point-to-point movements

This menu enables you to run a fast check on the drive selected. The axis channel selected [F2] can be moved absolutely to the target position (angle) you want or relatively by the specified traverse distance (angle). In this context, please note the information provided on the PA8000 position controller [PM/Chapter 2.1] and on PA8000 profile generation [PM/Chapter 2.2].

Parameters for the point-to-point motions [MOVING PARAMETERS]

| Name | Function |
|-----------------|--|
| Axis # | Displays the axis number of the currently selected axis channel, with which the point-to-point motion is executed [F2]. |
| Drive Mode | Selection of traversing mode. ABSOLUTE means that the distance or angle particular specified in <i>Position</i> is referenced to the machine zero, and the motion is directly to <i>Position</i> . RELATIVE means that, starting from the current position, the movement is made relatively (also incrementally) by the distance or angle particular specified in <i>Position</i> . |
| Acceleration | Acceleration value for the point-to-point motion concerned allowing for the units selected. |
| Velocity | Maximum velocity value for the point-to-point motion concerned, allowing for the units selected. |
| Target velocity | Target velocity for the point-to-point motion concerned, allowing for the units selected. |
| Position | Target position (angle) or relative traversing path (angle) |
| Start Motion | Starts the motion profile, allowing for the above-specified parameters. But to enable the motion to be executed, the position control loop must be closed (<i>Close Loop</i>). |
| Open Loop | Open position control loop. Causes a currently running profile to be aborted. In addition, the value 0 is outputted on the setpoint value channel. All PA8000 digital outputs planned with the PAE function are de-activated. |
| Close Loop | Close position control loop. The actual position is accepted as the setpoint position All PA8000 digital outputs planned with the PAE function are activated. |
| Exit | Terminates this menu. |

4.4.8.9 System reset [System Reset]

This menu can be used for axis-specific reset [F2] and a complete system reset. Please consult [PM / Chapter 4.4.25 - *ra()*] to see how *Reset selected axis* works. Please consult [PM / Chapter 4.4.58 - *rs()*] to see how *Reset whole system* works.

4.4.9 Automatic Functions Menu

In this menu, you can start, stop and continue CNC programs. These CNC programs are autocode files which have been generated automatically by compiling SAP source text programs in the CNC Editor environment [Chapter 4.4.7] or by means of the command line compiler *ncc.exe* [Chapter 4.5].

The CNC programs are created for a particular CNC task during compilation of the SAP source text file, by utilizing a compiler control command (#TASK) or by selecting a CNC Task Number (function key [F3] in the *mcfg.exe* program). Up to 4 different CNC programs can be processed simultaneously. CNC tasks 0 to 3 are available for this purpose.

The functions described below can also be accessed, for example, under the special functions of the CNC-Edit editor [Chapter 4.4.7.9].

4.4.9.1 Download CNC-Program

In this menu, you can first select a CNC file. To do this, you use the [+] key or the ENTER key. In order to activate the program you have selected, you have to conclude your selection with the *Download File* command. The file suffix *.cnc* is always proposed for file selection.

The *Download* command transfers the CNC file you have selected to the PA8000; this file also contains the information as to what CNC task this autocode file has to be transferred to. The task concerned is halted beforehand. This status remains operative after transfer as well.

4.4.9.2 Restart CNC task [Restart current selected CNC task]

This menu function starts the currently selected CNC task, which you can select using the [F3] function key. The CNC program loaded there is started from its beginning.

4.4.9.3 Stop CNC task [Stop current selected CNC task]

The currently selected CNC task [F3] is halted, and thus the CNC program filed there is stopped.

4.4.9.4 Continue CNC task [Continue current selected CNC task]

You can use this function to continue a stopped CNC program.

4.4.9.5 Restart all CNC tasks

This menu function starts all CNC tasks (0 to 3). All CNC programs loaded are started from the beginning of the program concerned.

4.4.9.6 All CNC tasks

All CNC tasks are halted, and the CNC programs filed there are stopped.

4.4.9.7 Continue all CNC programs [Continue all CNC tasks]

All stopped CNC programs are continued with this function.

4.4.9.8 System reset

This menu is identical to the menu described in Chapter 4.4.8.9.

4.4.10 Save system data [Save Changes]

The [Save Changes] menu is used to file all hardware and software parameters in the *system.dat* system file. In addition, the *mcutsr.exe* TSR driver is patched. This must, like *system.dat*, be located in the current working directory or in the path environment.

The save operation also ensures that various system information is filed in resident memory on the PA8000, and the complete drive system is reset. . The system information saved includes for example the types of motors, the inverted inputs, etc.... If an error occurs during saving, the [CONFIG. ERROR] screen mask appears.

After the save operation, the reprogrammed system data are available on the PA8000.

Please note: After a boot operation (execution of *mcbt.exe*), the system data must be transferred at least once to the PA8000, so that the operating program (*rwtos.btl*) can be run on the PA8000. They are loaded either from the PCAP user program or from the *mcfg.exe* utility program. In *mcfg.exe* and in the various example programs the *system.dat* system file is transferred only once!

4.5 The ncc.exe utility program

The *ncc.exe* command line compiler can be used to generate stand-alone application programs (SAP programs) directly from the DOS level. The compiler is completely identical to the NCC compiler incorporated in *mcfg.exe*, and is called as follows:

NCC filename [Option]

The text file with the name *filename* must contain an SAP program. The ending ".src" is automatically assumed as a file extension name. The various options *[Option]* are explained below, and must be separated from each other by blanks.

If error-free compiling has proved possible, then an autocode file with the filename *filename.cnc* is created in the current directory. If an error occurs, compiling will be aborted, and the faulty line number will be displayed on the screen, together with an error text.

The NCC command line compiler options *[Option]* currently provided are as follows:

| Option | Funktion |
|--------|--|
| FS | (Full System) The system does not check how many axes are actually present in the system, i.e. up to 18 different axis designators can be referenced. The default names of these axis designators are A1 .. A18. |
| SC | (Syntax Check) The system executes only a compiler run, without generating a CNC file. This is primarily done for syntax-checking the SAP source text program |
| TSK x | (Task Selection, x = 0..3) The autocode file is generated for Task x. But if the SAP program contains a <i>{TASK}</i> compiler command, the <i>TSK x</i> parameter is ignored. |

