



# **SYSTEM SPECIFICATION**

**CNC Series**

**PA 8000e**

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# 1 INTRODUCTION

## Superior Capability in Technology and Productivity

The **PA 8000e CNC** provides you with innovative high performance technology to handle the ever increasing demands of today's automation industry. PA's modern and fully open CNC architecture using a single powerful Pentium IV CPU gives you leading edge CNC performance and flexibility.

The **PA 8000e CNC** fulfills all technical requirements from standard to high tech applications. A variety of performance levels and technology functions is available. A high performance CNC control does not have to be high-priced anymore. The compact and modular **PA 8000e CNC** provides you with the performance you need at an excellent price / performance ratio.

## Modularity

Matching the **PA 8000e CNC** to your requirements a variety of hardware components such as a 12,1" TFT-display, optionally with Touch screen, different I/O components allow various customized configurations.

## PC Technology

The **PA 8000e CNC series** is based on standard PC-technology integrated on an industrial level. Through the standard PC motherboard with the powerful Pentium IV processor running the standard **MS-Windows 2000** operating system plus the **Real Time Kernel**, the PA 8000e is open to the PC components manufactured world wide. This way, e.g., a modern **browserbased** human machine interface was readily incorporated. Moreover, there is the possibility to have 18 GB or more of NC program memory by means of PC hard disk technology.



All types of communications ranging from simple serial interfaces to a complex network environment are available. Aided by the standard PC operating system you can integrate your own PC software such as NC programming tools, statistical programs, visual programs etc. in your control.

### **Truly Open CNC**

Based on a truly open architecture (including the CNC kernel) you can integrate, in a very secure and efficient manner, your application specific knowledge and proprietary software routines written in Visual C++ into the CNC. Your unique CNC functionality can be integrated into the CNC operating system with PA's highly efficient software tools called „Compile Cycles“. In addition to such unique software, third party PC based hardware and software can be integrated due to the standard PCI-bus system used.

### **Application Experience and Knowhow**

From 2 axes turning to complex milling machines the **PA 8000e CNC** fulfills a wide range of application requirements. A long list of standard functionality i.e. compensations as well as high tech functions like lock ahead make the **PA 8000e** an extremely versatile CNC.

### **High speed machining**

An important factor in machine tool productivity is the feed rate. New machine concepts and new tooling technologies require accurate and responsive controls with continuously increasing feed rates. Extremely short block cycle times (up to 7200 blocks/sec.) and specific control algorithms and communication functions are required for high speed machining. **“Adaptive Look Ahead“** analyzes multiples of 50 NC blocks ahead in real-time and calculates the maximum achievable feed rate for complex machining requirements staying within the programmed parameters and constraints.



## Accuracy

The demands for increased productivity, higher accuracy and better surface finish are continuously increasing. For higher accuracy and better part finish the productivity of the machine tool should not be sacrificed. The **PA 8000e CNC** provides a solution to compensate for the machine kinematics, environmental conditions and various other factors which cause errors in the machining process. With the **PA 8000e** and its software tool **"FACTS"** (**F**ast, **A**Ccura**T**e and **S**mooth) you can achieve an optimum in accuracy, execution speed and surface finish.

## Human Machine Interface

Using six clearly defined modes of operation and a simple and clean-cut menu driven operation via soft keys, the machine operator will find the operation of the **PA 8000e** easy to learn and use. By means of the window technology, the information is presented where it is needed on the screen.

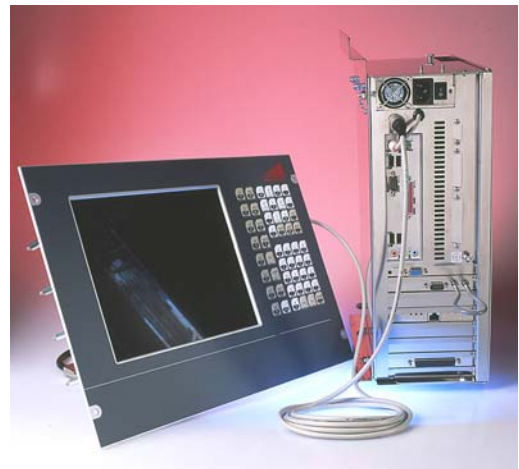


## 2 CHARACTERISTICS

		S	HS	HSB
Blocks / sec. (ISO)		900	1800	7200
KV-Factor (typ.) up to		4	7	15
Numbers of axes	Basic	4	4	4
	Max.	16	32	32
Dyn. block buffer (blocks)	Basic	50	50	50
	Max.	1000	1000	1000
NC-memory CMOS[KB] / HD[GB]	Basic	128/18	128/18	128/18
	Max.	872/18	872/18	872/18
PLC-memory (KB)	Basic	64	64	64
	Max.	256	256	256
Inputs/outputs with PAMIO	Basic	24/16	24/16	24/16
	Max.	792/528	792/528	792/528

### 3 GENERAL SYSTEM OVERVIEW

The PA 8000e in its standard configuration is a compact device comprising one single unit including an operator's station with display and an IPC. Optionally, the CNC can be supplied without operator's station.



PA 8000e and 19" Panel with 12,1" TFT  
as compact device

PA 8000e and separate 19" Panel with  
12,1" TFT

### 4 OPERATOR'S ELEMENTS

#### Operator's module with 10,4", 12,1" and 15" color flat screen display

- SVGA 800 x 600 (10,4" and 12,1"), 1024x768 \*(15")
- Membrane switch keyboard with short stroke keys (10,4" and 12,1")
- Mode selection keys (10,4" and 12,1")
- Soft keys (10,4" and 12,1")
- Numeric keypad (10,4" and 12,1")
- Touch screen at 15", optional for 12,1"





### **Teach-In-Panel**

- LC-Display
- ASCII-Keypad
- Mode selection
- Functions-Softkeys

## **5 OPERATION**

The **PA 8000e CNC** has 6 different operating modes which are selected by means of soft keys. Alternatively they may be selected through a pointing device, i.e. a cursor, mouse or alternative means:

### **MANUAL**

- Continuous jog
- Machine zero (Referencing)
- Auxiliary functions
- Play-Back
- Incremental jog
- Teach-in
- Hand wheel function
- Retract

### **AUTOMATIC**

- Program selection
- Program test
- Hand wheel in Automatic mode
- Program process 1 (continuous)
- Program process 2 (single block)
- Path graphics

### **DATA**

- Select
- Load
- Save
- Device select
- Edit
- Modify
- Manage
- Load/save application data

### **INFORMATION**

- Version
- Diagnostics
- Active PLC program
- Status treatment
- System commands
- Logbook



## **SYSTEM**

- Display functions
- Station (Channel) selection
- Operation
- Settings

## **SETUP**

- PLC
- Machine setup
- MMI setup
- Logic analyzer

# **6 DISPLAY / DIAGNOSTICS**

## **Display Languages**

- German
- English
- Other languages on request

## **NC Axis Information**

- Position
- Direction
- Output voltage
- Distance to go
- Active offsets
- Velocity
- Lag (following error)
- Position loop gain
- End position
- Offset values

## **Stored data information**

- NC programs
- WIN 2000 programs
- Radius compensation
- File attributes
- PLC programs
- Tool length offsets
- Zero offsets

## **Status Information**

- Auxiliary functions
- Active block
- Active G codes
- PLC interface
- Active NC program status
- Active subprogram
- Program repetition
- Active PLC program



### **System Memory**

- Memory size for both CNC and WIN 2000 system
- Memory space available
- Number of part programs
- Program size

### **Logic Analyzer**

- Digital Logic Analyzer Function
- Frequency analysis
- System identification
- Print function
- Analog Logic Analyzer Function
- Function generator
- Recording function

### **Interfaces / Data Ports**

- CNC  $\leftrightarrow$  PLC interface
- Serial interfaces
- External device definition
- PLC  $\leftrightarrow$  machine interface
- Serial interface setup

### **User information box**

- Error messages in legible text
- Time and date display
- Help messages in legible text

### **Machine Parameters**

- Legible machine parameters
- Edit machine parameters
- Input/output of machine parameters



## 7 AXES / AXIS FUNCTION

**Basic 4 axes simultaneous up to 32 axes simultaneous**

**Choice of analog interface or/and digital interface ( SERCOS )**

	analog	SERCOS
Measurement frequency after quadruplication	20 MHz	depends on drive
Measurement resolution	freely selectable	freely selectable
Output Signal	$\pm 10$ V DC 16 Bit, 5mA	Digital via fiber cable

### Maximum feedrate

Resolution of 10 $\mu$ m:	12.000 m/min
Resolution of 1 $\mu$ m	1.200 m/min
Resolution of 0,1 $\mu$ m:	120 m/min

### CNC Channels

Up to 8 CNC channels with total max. 64 axes

### Axis Types

- Parallel axis logic
- Gantry axis logic
- Oscillation axis logic
- Rotary axis reset
- Spindle /rotary axis switchable

### Transformations

- 5-Axis-Transformation
- 4-Axis-Transformation
- 3-Axis-Transformation
- Polartransformation



- Barrelcurvetransformation

### **Distance Control**

- 3D distance control

### **Tangential Control**

- 3D tangential control of rotary axis

### **Axis Control**

- Velocity override via external analog or digital signal
- Adaptive Look Ahead 3D
- Adaptive A<sup>2</sup>RT 3D

### **Axis Dependent Analog Output**

- Power control via axis channel

### **Automatic Drift Compensation**

### **Positioning Axis Logic**

- Positioning axis logic for 200 NC blocks
- Positioning axis logic for 600 NC blocks

### **Spindle Control**

- Analog:
  - with / without feedback
  - Automatic gear step selection
  - Additional spindles

### **Measurement Functions**

- Probe Logic
- Software for distance encoded feedback
- Sequencing override through digital measurement signal



## 8 MEMORY

NC memory ( buffered CMOS-RAM)	128 KB up to 872 KB
NC programs	up to 200
Programm number	6 digits (CMOS) 16 digits (Harddisk)
NC memory on hard disk	18 GB
Dynamischer block bufferr	50 - 1000 blocks
PLC programmemory	64 - 1000 KB
Cycle parameters	up tp 9999
Setup data	50 KB

## 9 COMPENSATIONS

- Tool compensation
  - Tool length compensation 128 sets
  - Tool radius compensation 128 sets
- 3D cutter length / radius compensation
- Lead screw error compensation up to 16000 points
- Backlash compensation
- Zero offsets
- External compensation via PLC
- Access to compensations via cycle programming



## 10 PROGRAMMING

- Subprograms (up to 4 levels)
- Automatic syntax checking
- Decimal point programming
- Compensation programming
- Programming simultaneous during program execution
- Teach-In function

### NC Programming

#### G-codes

G 000	Rapid traverse
G 001	Linear interpolation with feed rate
G 002	Circular interpolation (cw)
G 003	Circular interpolation (ccw)
G 012	Circular interpolation (cw) with radius
G 013	Circular interpolation (ccw) with radius
G2/G3	Helical interpolation
G 004	Dwell time in msec
G 005	Spline definition
G 006	Spline interpolation
G 007	Tangential circular interpolation
	Helix interpolation
G 008	Ramping function at block transition
	Look ahead „off“
G 009	No ramping function at block transition
	Look ahead on
G 010	Stop dynamic block preprocessing



G 011	Stop interpolation during block preprocessing
G 014	Polar coordinate programming, absolute
G 015	Polar coordinate programming, relative
G 016	Definition of the pole point
G 017	Selection of the X, Y - plane
G 018	Selection of the Z, X - plane
G 019	Selection of the Y, Z - plane
G 020	Selection of a freely definable plane
G 021	Parallel axes „on“
G 022	Parallel axes „off“
G 024	Safe zone programming; lower limit values
G 025	Safe zone programming; upper limit values
G 026	Safe zone programming „off“
G 027	Safe zone programming „on“
G 033	Thread cutting with constant pitch
G 034	Thread cutting with dynamical pitch
G 035	Oscillation activating
G 036	
G 037	
G 038	Mirror imaging „on“
G 039	Mirror imaging „off“
G 040	Path compensations „off“
G 041	Path compensation left of the work piece contour;
G 042	Path compensation right of the work piece contour;
G 043	Path compensation left of the work piece contour with altered approach
G 044	Path compensation right of the work piece contour with altered approach
G 050	Scaling





G 051	Part rotation; programming in degrees
G 052	Part rotation; programming in radiants
G 053	Zero offset off
G 054	Zero offset #1
G 055	Zero offset #2
G 056	Zero offset #3
G 057	Zero offset #4
G 058	Zero offset #5
G 059	Zero offset #6
G 063	Feed / spindle override not active
G 066	Feed / spindle override active
G 070	Inch format active
G 071	Metric format active
G 072	Interpolation with precision stop „off“
G 073	Interpolation with precision stop „on“
G 074	Home position
G 075	monitoring curvature acceleration on
G 076	programmable curvature acceleration „on“
G 077	programmable curvature acceleration „off“
G 078	Tangency function „on“ (rotational axis orientation on 2D contour)
G 079	Tangency function „off“
G 080	Drilling cycle „off“
G 081	Drilling to final depth
G 082	Spot facing with dwell time
G 083	Deep hole drilling
G 084	Thread cutting with balanced chuck
G 085	Reaming



G 086	Boring
G 087	Reaming with measuring stop
G 088	Boring with spindle stop
G 089	Boring with intermediate stop
G 090	Absolute programming
G 091	Incremental programming
G 092	Position register preset
G 093	Constant tool circumference velocity „on“ (grinding wheel)
G 094	Feed in mm / min
G 095	Feed per revolution
G 096	Constant cutting speed „on“
G 097	Constant cutting speed „off“
G 098	Positioning axis signal to PLC
G 100	Polar/Cylindrical transformation OFF
G 101	Polar transformation ON
G 102	Cylindrical transformation ON
G 103	
G 104	
G 105	Polar transformation on alternative axes address
G 106	Cylindrical transformation on alternative axes address
G 107	
G 108	
G 109	
G 110	Power control axis selection / channel
G 111	Power control pre-selection V1, F1, T1 / channel 1
G 112	Power control pre-selection V2, F2, T2 / channel 1
G 113	Power control pre-selection V3, F3, T3 / channel 1



G 114	Power control pre-selection	T4 /	channel 1
G 115	Power control pre-selection	T5 /	channel 1
G 116	Power control pre-selection	T6 /	pulsing output
G 117	Power control pre-selection	T7 /	pulsing output
G 120	Axis transformation ; orientation change of linear interpolating roundaxis		
G 121	Axis transformation; orientation change in a plane		
G 130	Axis transformation; programming of the type of the orientation change		
G 131	Axis transformation; programming of the type of the orientation change		
G 132	Axis transformation; programming of the type of the orientation change		
G 133	lag free thread cutting „on“		
G 134	lag free thread cutting „off“		
G 135	Distance control - axis selection		
G 140	Axis transformation; orientation designation work piece fixed coordinates		
G 141	Axis transformation; orientation designation active coordinates		
G 150	Real-time cutter-radius compensation „off“		
G 151	Real-time cutter-radius compensation right of the path		
G 152	Real-time cutter-radius compensation left of the path		
G 160	ART activation		
G 161	ART learning function for velocity factors „on“		
G 162	ART learning function deactivation		
G 163	ART learning function for acceleration factors		
G 164	ART learning function for acceleration changing		
G 165	Command filter „on“		
G 166	Command filter „off“		
G 170	Digital measuring signals; block transfer		with hard stop
G 171	Digital measuring signals; block transfer		without hard stop
G 172	Digital measuring signals; block transfer		with smooth stop



G 175	SERCOS identnumber writing
G 176	SERCOS identnumber reading
G 180	Axis transformation „off“
G 181	Axis transformation „on“ with not rotated coordinate system
G 182	Axis transformation „on“ with rotated / displaced coordinate system
G 183	Axis transformation; definition of the coordinate system
G 184	Axis transformation; programming tool dimensions
G 185	realtime tool length compensation
G 186	Look ahead; corner acceleration; circle tolerance
G 188	Activation of the positioning axes
G 190	Diameter programming deactivation
G 191	Diameter programming „on“ and display of the contact point
G 192	Diameter programming; only display contact point diameter
G 193	Diameter programming; only display contact point actual axes center point
G 200	Corner smoothing „off“
G 201	Corner smoothing „on“ with defined radius
G 202	Corner smoothing „on“ with defined corner tolerance
G 203	Corner smoothing with defined radius up to max. tolerance
G 210	Power control axis selection / channel 2
G 211	Power control pre-selection V1, F1, T1 / channel 2
G 212	Power control pre-selection V2, F2, T2 / channel 2
G 213	Power control pre-selection V3, F3, T3 / channel 2
G 214	Power control pre-selection T4 / channel 2
G 215	Power control pre-selection T5 / channel 2
G 270	Turning finishing cycle
G 271	Stock removal in turning
G 272	Stock removal in facing



G 274	End phase peck drilling cycle
G 275	Outer diameter/internal diameter drilling cycle
G 276	Multiple thread cutting cycle
G 310	Power control axes selection / channel 3
G 311	Power control pre-selection V1, F1, T1/ channel 3
G 312	Power control pre-selection V2, F2, T2/ channel 3
G 313	Power control pre-selection V3, F3, T3/ channel 3
G 314	Power control pre-selection T4/ channel 3
G 315	Power control pre-selection T5/ channel 3
	Programmable acceleration
	Toolmanagement



## 10.1 Cycle Programming

- Programming tool with 200 to 10.000 parameters
- Allocation of parameters values with NC addresses
- Execution control of the NC program
- Output signal programming
- Verification of input signals
- Arithmetic and trigonometric functions
- Boolean programming functions
- Jump commands
- Repeat commands



## **INTEGRATED IEC 1131-3 SOFT PLC**

### **Languages**

- Ladder Diagram (included in basic)
- Structured text (included in basic)
- Function blocks (optional)
- Instruction List (optional)
- Step Sequence (optional)

### **Inputs**

- up to 792 /PAMIO

### **Outputs**

- up to 528 /PAMIO

### **PLC-memory**

- 64 KB up to 1MB ( about 160.000 instructions )

### **Data memory**

- 64 KB, non-retentive ( up to 256kB),  
Real, Integer, Timer, Boolean variables

### **Data memory**

- 4KB, retentive

### **I/O definition**

- Bit/Byte, WORD, DWORD

### **C++ routines**

- Custom routines written in C++ may be integrated

## PA Modular-I/O (PAMIO)

### PAMIO-Modulbox

- PAMIO Module Box contains one or two modules which can be plugged into each other side by side. Module box snaps onto DIN rail. Can alternatively be connected via cable

### PAMIO-Modul 24/16

- 24 Inputs 24VDC  
16 Outputs 24V/0,7A DC (max. 4A per connector)

### PAMIO-Modul 4AD4DA

- 4 analog inputs 12 bit
- 4 analog outputs 16 bit

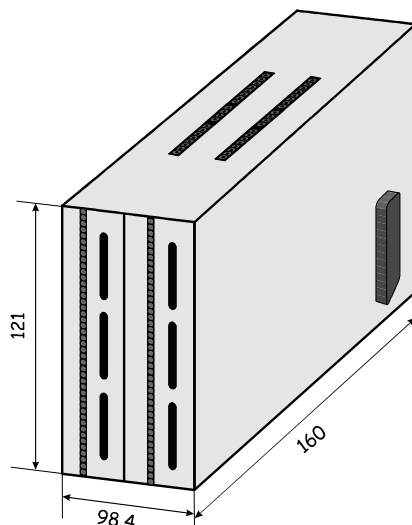
### PAMIO-Modul 4ENC4A

- 4 Encoder inputs
- 4 analog inputs 12 bit
- 4 analog outputs 16 bit

Through a line driver, the system can span maximum 35 m from the control to the farthest I/O module.

### PAMIO- Module Box

- PAMIO-Module Box







## 11 INTEGRATED PERSONAL COMPUTER

- ATX Motherboard
- Intel PENTIUM P IV Processor
- 128 MB RAM min.
- 1,44 MB, 3,5"-System-Floppylaufwerk
- System-hard disk, 20 GB min.
- MS-Windows 2000 Operatingsystem
- PA-Realtime-Kernel

## 12 Communication

### Interfaces

- 1 x RS 232 C (V24) to connect Teach Panel, ext. Modem, PC, ...
- 1 x Centronics for printer
- PS/2 mouse port
- PS/2 keyboard port
- 2 x USB

**Data I/O simultaneously with program execution**

**Continuous downloading of part programs**

### LAN-network

- Ethernet

### Field-bus interfaces

- InterBus-S
- Profi-Bus-DP
- CAN Open
- DeviceNet



## 13 SAFETY FUNCTIONS

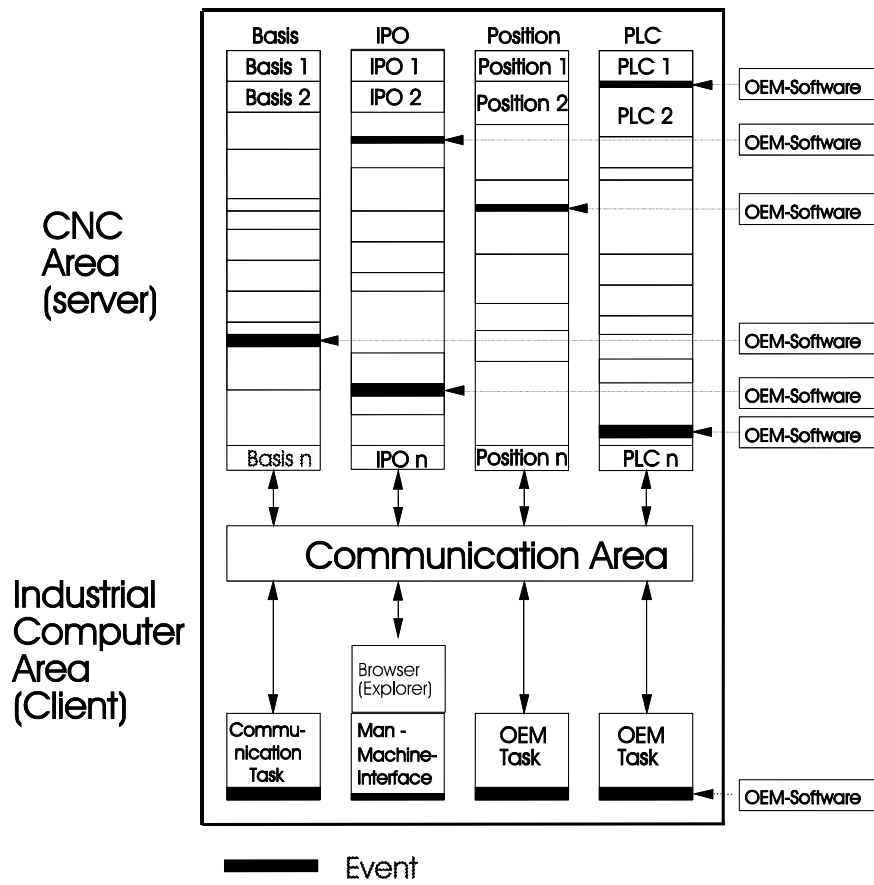
- **Integrated Diagnostic Functions:**
  - Internal CNC voltage monitoring
  - Processor activity
  - Battery voltage monitoring for CMOS backup
  - Electric noise monitoring
  - Processor watchdog timer monitoring
  - CMOS memory
  - RAM memory
  - Hard disk
  - Bus systems
  - Temperature monitoring
  
- **Operator guidance through soft keys**
- **Syntax check during NC program inputs**
- **Checksum test**
- **Software limit switches**
- **Comprehensive CNC status and machine status display via PLC**
- **Read , write-, and clear protection for NC-programs**
- **Protected programs**
- **Password protection (up to 10 levels)**

# 14 SYSTEM ACCESS

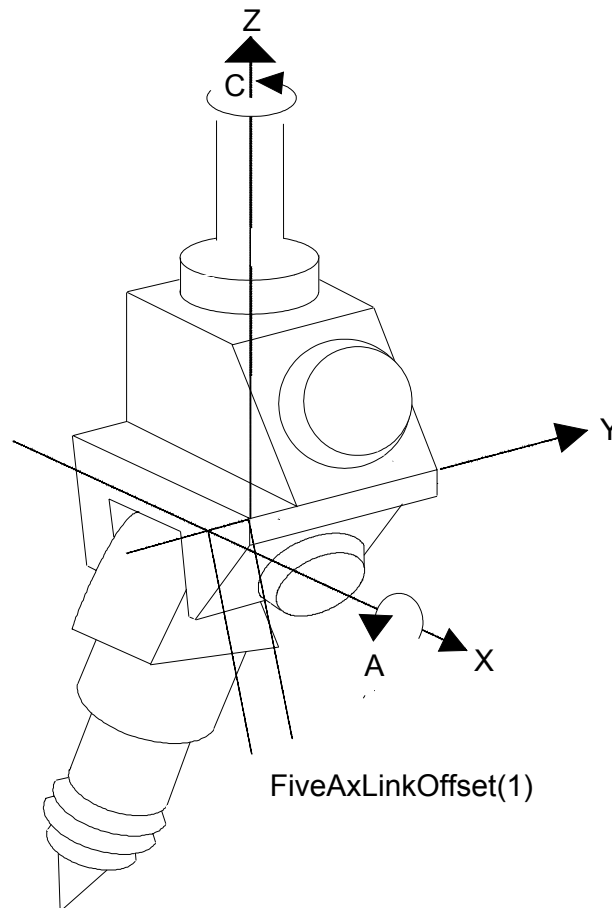
## Via PA Compile-Cycles in C++

Development set

Compile Cycle CNC Kernel library



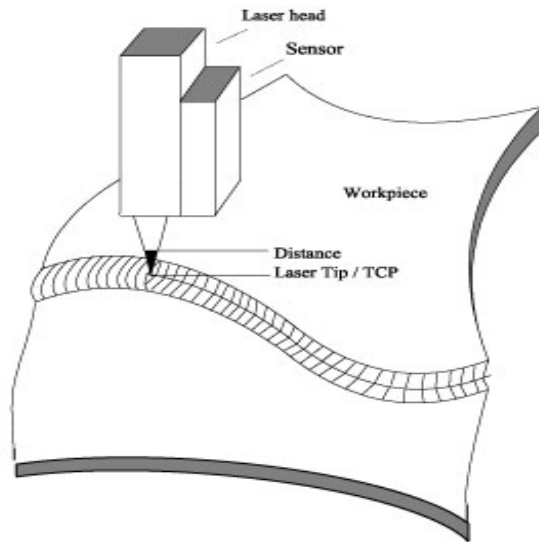
## 5-Axes-Transformation



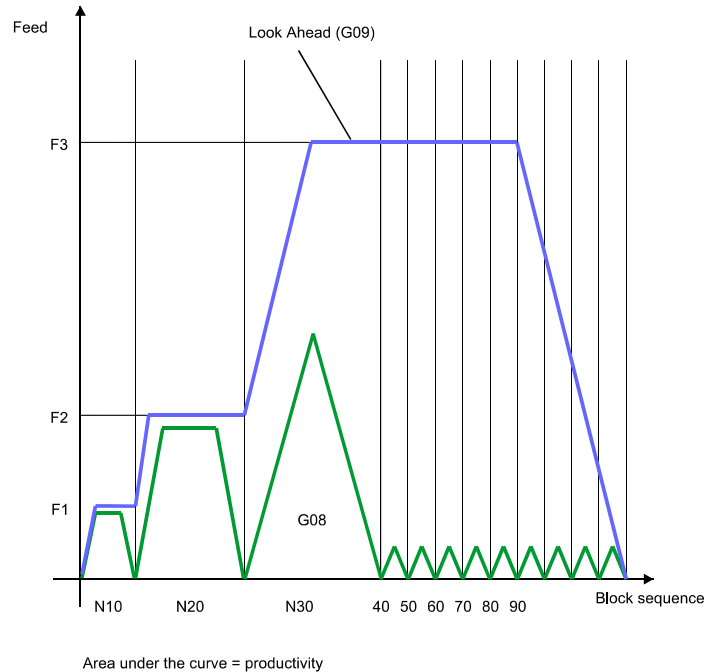
### Properties of the 5 AxisTransformation

- Definition of Tool Center Point
- Definition of a speed limitation point on the tool
- Programming based on machine coordinate system
- Programming based on user defined coordinate system
- TCP programming in the original coordinate system
- TCP programming in a rotated and shifted coordinate system
- Linear interpolation A, B, C axes
- Rotation of the tool vector in a plane
- Programming of the tool orientation by rotary axis positions or by vectors

### 3D Distance Control



## Adaptive Look Ahead



- Adaptive Look Ahead results: Error free block transitions
- Adaptive Look Ahead analyzes up to several hundred subsequent NC blocks
- Adaptive Look Ahead monitors the acceleration and deceleration values set for each axis
- Adaptive Look Ahead assures that the dynamic limits of the machine will never be exceeded
- Adaptive Look Ahead recognizes peaks in the velocity profile caused by geometry and F word changes. Acceleration and deceleration over multiple NC blocks
- Adaptive Look Ahead recognizes peaks in the velocity profile caused by geometry and F word changes. Acceleration and deceleration over multiple NC blocks
- Continuous axis movement
- Adaptive Look Ahead calculates the maximum path velocity with consideration of the programmed F word, the programmed accuracy and the dynamic machine limits

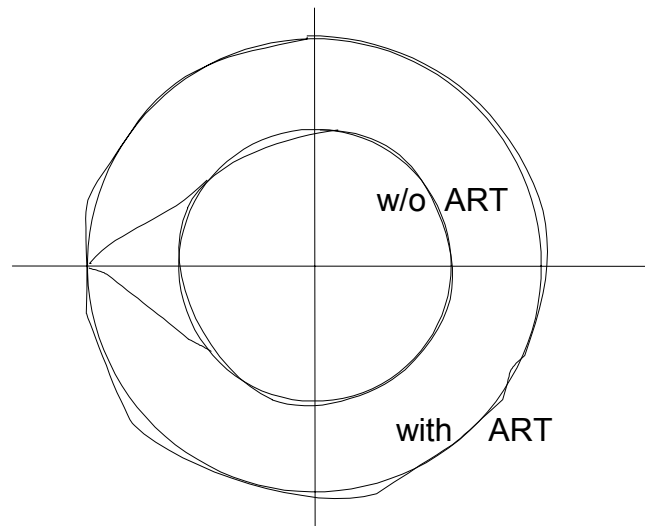
## Advanced Regulation Technology A<sup>2</sup>RT

2 Axis Cylindrical Grinder

$V_b = 5 \text{ m/min}$

Roundness Test

$a = 0,5 \text{ m/s}^2$



Scale: 1mm of the figure equivalent to 0,001 mm on the workpiece

### With "Adaptive ART" Contouring without Servo Lag

Adaptive ART learns the characteristics of all axes

Adaptive ART learns continuously

Adaptive ART supports the gain for movement in both directions

Adaptive ART compensates different gains of motors

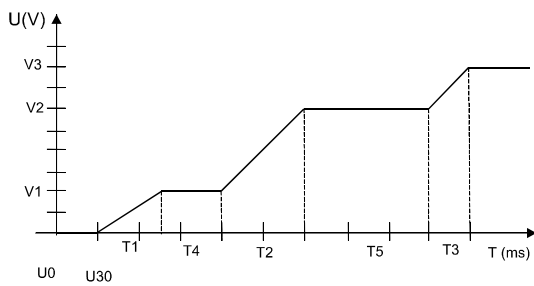
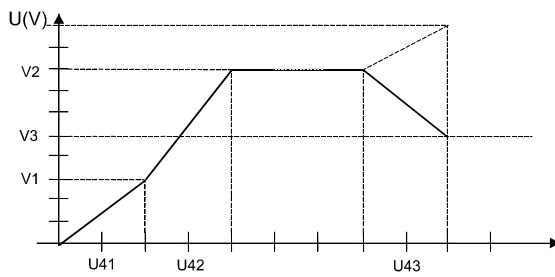
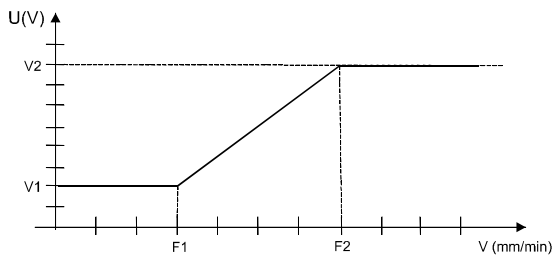
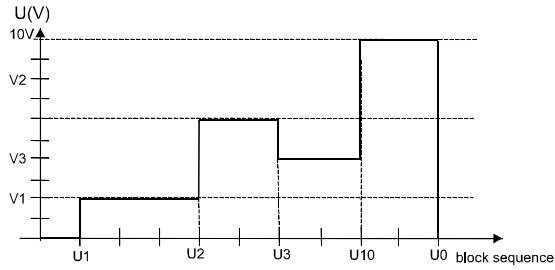
Adaptive ART uses

- feedrate
- acceleration/deceleration
- acceleration/deceleration changes (jerk)

Adaptive ART is active during

- acceleration
- constant speed
- deceleration

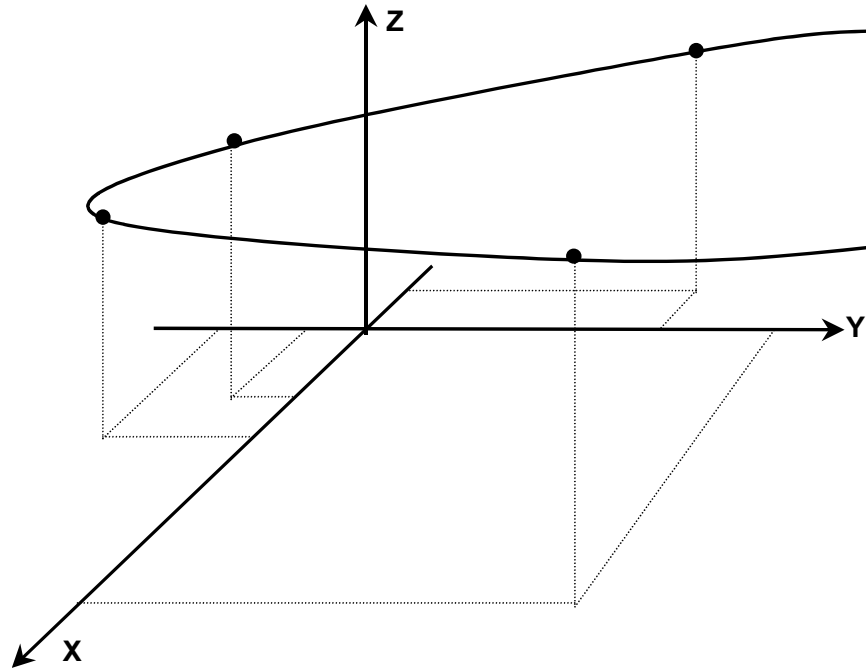
## Laser Power Control



**Parameters = f (constant, velocity, position, time)**

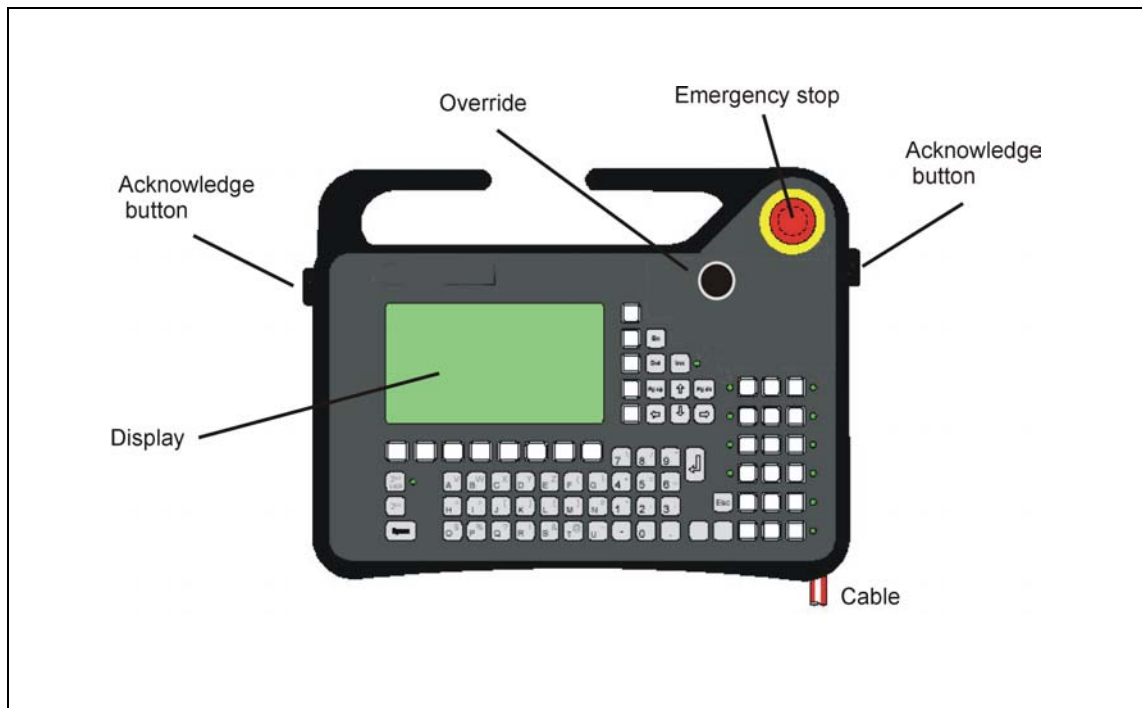


### 3D Spline Interpolation



- Real time spline interpolation
- NC data reduction by factor 3 .. 10
- Tangential transitions
- Smooth transitions
- in combination with 5-axes-transformation
- in combination with 5-axes-cuttercompensation

## Teach-In-Panel



With the PA 8000e Teach-In-Panel any teach task can be solved simply and comfortable. The user must keep solely an eye on the path to be taught independently if the machine has two or 5 axes. All other tasks are taken over automatically by the controller. Independently whether a new part taken is in or an already available part should be changed, the service is conceivable simple. By moving backward and forward again an already available path is examined and corrected if necessary. This process can be repeated until the path corresponds to the desired requirements. Very helpful is also the manual moving off of the teach contour when teaching. The production process is automatically reset and the processing continues subsequently exactly at the right point. Also, inserting of NC-blocks at arbitrary locations in a parts program is possible at any time. The changes are indicated immediately on the display of the Teach-In-Panel. All functions necessary for teaching can be called up by the user simply by pressing a button.

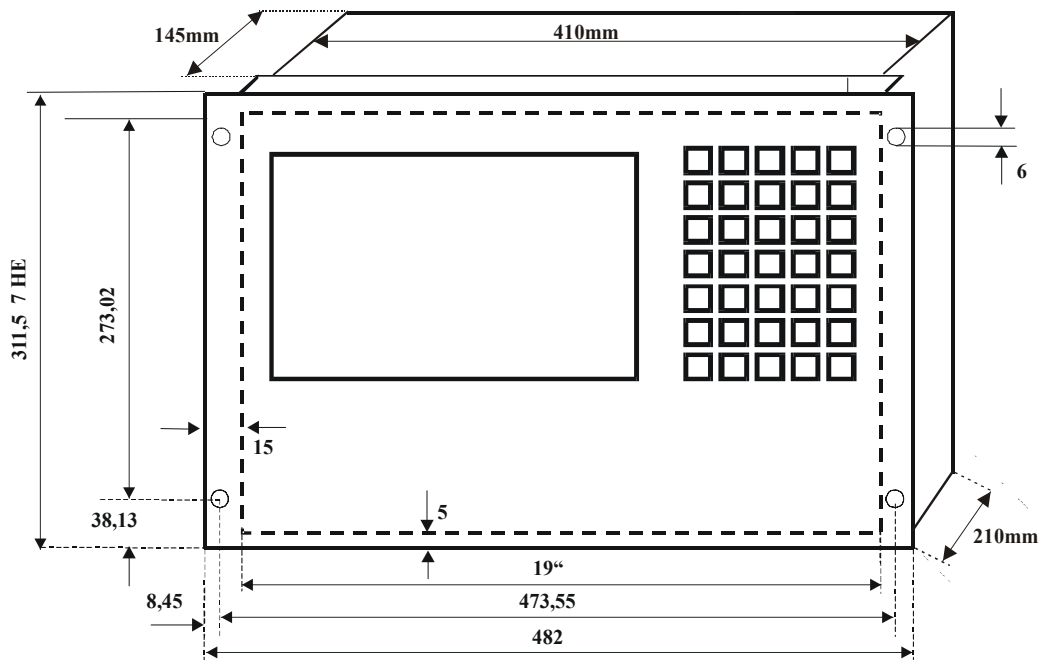


Among others these are:

- display of the renewed NC program during the teach procedure
- display of the position of the axes
- selection of the NC programs
- input and modification of NC blocks during the teach procedure
- test run with moving forward and backward
- aborting of the teach procedure and automatic reset
- setting of the axes position to zero
- zero point offset
- activate transformation

# 15 MECHANICAL OUTLINE

## CNC with Operator Station

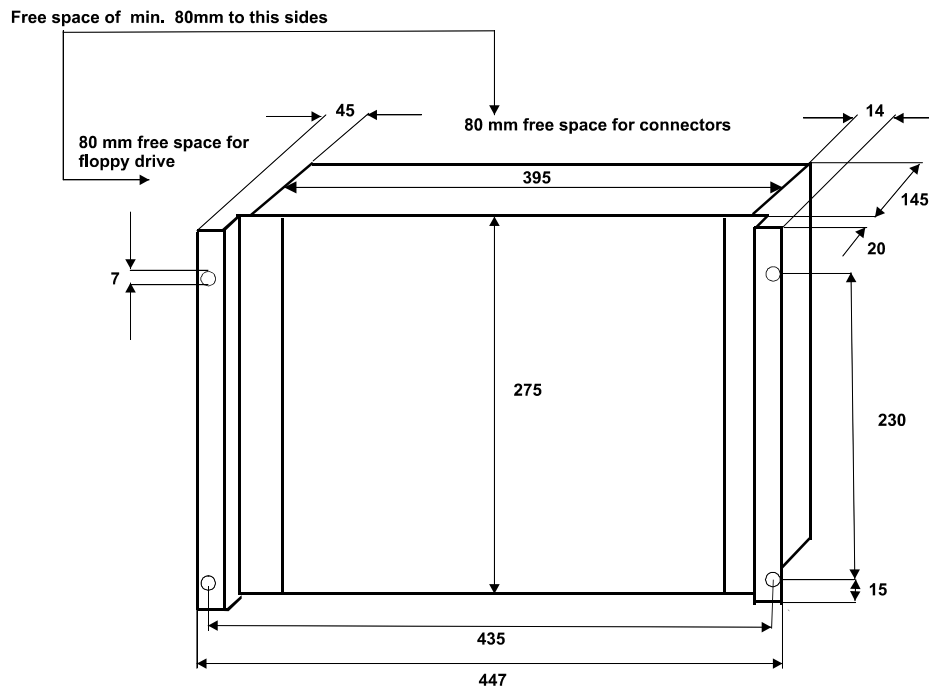




## PA 8000e logic (without Operator Station)



### Dimensions of PA 8000e



All dimensions in mm



## 16 OPERATING CONDITIONS

### Space Requirements

- For installation mind a free space left (80 mm), right (30 mm), at the top (80 mm)

### Power requirement

- 115 - 240 VAC +10% / -15 % 50/60 Hz

### Maximum power required

- 300 VA

### Temperature

- Storage temperature - 20°C to +60° C
- Environment temperature +10°C to +45° C

### Test conditions

- All controllers are subject to a run-in test of 48 hours in cycles +10 to +45°C.

### Protection

- Operator's panel IP 65