



# **SYSTEM SPECIFICATION**

**CNC Series**

**PA 8000 L2**

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# 1 INTRODUCTION

## Superior Capability in Technology and Productivity

The **PA 8000 L2 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 Celeron CPU gives you leading edge CNC performance and flexibility.

The **PA 8000 L2 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 8000 L2 CNC** provides you with the performance you need at an excellent price / performance ratio.

## Modularity

To match the **PA 8000 L2 CNC** to your requirements a variety of hardware components such as a 10,4" or 12,1" TFT-display, the latter optionally with Touch screen, different I/O components allow various customized configurations.

## PC Technology

The **PA 8000 L2 CNC series** is based on standard PC-technology, integrated on an industrial level. Through the standard PC motherboard with the powerful Celeron processor running the standard **WIN 2000** operating system plus the **PA L2 Real Time Kernel**, the PA 8000 L2 is open to the PC components manufactured world wide. This way, e.g., a modern **WIN 2000** based human machine interface was readily incorporated. Moreover, there is the possibility to have 8 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 axis turning to complex milling machines the **PA 8000 L2 CNC** fulfills a wide range of application requirements. A long list of standard functionality i.e. compensations as well as high tech functions like look ahead make the **PA 8000 L2** 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 500 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 8000 L2 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 8000 L2** 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 8000 L2** easy to learn and use. By means of the window technology, the information is presented where it is needed on the screen.

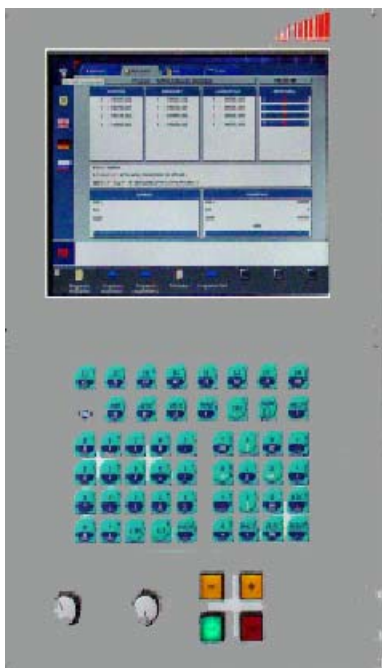
## 2 CHARACTERISTICS

	PA 8000 L2	
Blocks / sec.	250 -500	
Numbers of axes	basic	4
	max.	12
Dyn. block buffer (blocks)	basic	50
	max.	200
NC-memory (RAM KB /HD MB)	128/7000	
PLC-memory (KB)	64	
Inputs/outputs with PAMIO	basic	48/32
	max.	576/348

### 3 PA 8000 L2 Control Models

The PA 8000 L2 in its standard configuration is a compact device comprising an operator's station with display and a industrial PC-CNC.

#### PA 8000 L2 CNC



Panel with 10,4 TFT Color-Monitor



19" Panel with 12,1" TFT



PA 8000 L2



## 4 OPERATOR'S ELEMENTS

### **Operator's module with 10,4" TFT or 12,1" color flat screen display**

VGA 640 x 480, SVGA 800 x 600 (12,1")

- Membrane switch keyboard with short stroke keys
- Mode selection keys
- Soft keys
- Numeric keypad
- Optional touch screen

## 5 OPERATION

The **PA 8000 L2 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

### **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

## SYS

- 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

### 4 axes simultaneous

### analog interface

Measurement frequency after quadruplication	20 MHz
Measurement resolution	freely selectable
Output Signal	$\pm 10$ V DC 16 Bit

### 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 2 CNC channels with max. 12 axes total

### Axis Types

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

### Distance Control

- 2D distance control

### Tangential Control

- 2D tangential control of rotary axis

### **Axis Control**

- Velocity override via external analog or digital signal
- Adaptive Look Ahead 2½D
- Adaptive ART II 2½D

### **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
- NC programs up to 200
- Program number 6 digits
- NC memory on hard disk 7 GB
- Dynamic block buffer 50 - 200 blocks
- PLC program memory 64 KB
- Cycle parameters 200
- Setup data 8 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 4000 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

## 10.1 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 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 radians
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
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 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 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 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 230	Circle in space cw; starting point outside	
G 231	Circle in space ccw;	
G 232	Circle in space cw; + back to the starting point	
G 233	Circle in space ccw; + back to the starting point	
G 234	Circle in space cw; starting point = center point	
G 235	Circle in space ccw; starting point = center point	
G 236	Circle in space cw; starting point = center point + back to the starting point	
G 237	Circle in space ccw; starting point = center point + back to the starting point	
G 270	Turning finishing cycle	
G 271	Stock removal in turning	
G 272	Stock removal in facing	
G274	End phase peck drilling cycle	
G275	Outer diameter/internal diameter drilling cycle	
G276	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	

## 10.2 Cycle Programming

- Programming tool with 200 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

## 11 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 576 /PAMIO

### Outputs

- up to 348 /PAMIO

### PLC-memory

- 64 KB,

### Data memory

- 64 KB, non-retentive,
- 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,  
16 Outputs (0,7A/ pin 4,A/ connector) 24 VDC

**PAMIO-Modul 4AD4DA**

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

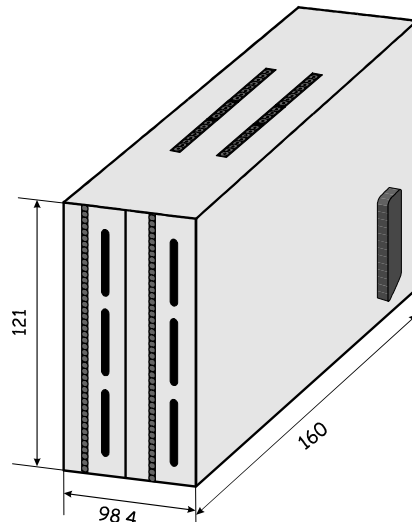
**PAMIO-Modul 4ENC4A**

- 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



## 12 INTEGRATED PC

- ATX Motherboard
- CELERON-Processor
- System-hard disk min. 10 GB including an 3 GB PA-Systempartition
- WIN 2000
- PA L2 Real time Kernel

## **13 COMMUNICATION**

### **Interfaces**

- 2 x RS 232
- 1 x Centronics for printer
- PS/2 mouse port
- USB

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

**Continuous downloading of part programs**

**LAN-network (Ethernet)**

### **Field-bus interfaces**

- Profi-Bus-DP
- CAN-Bus (CAN Open)

## **14 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

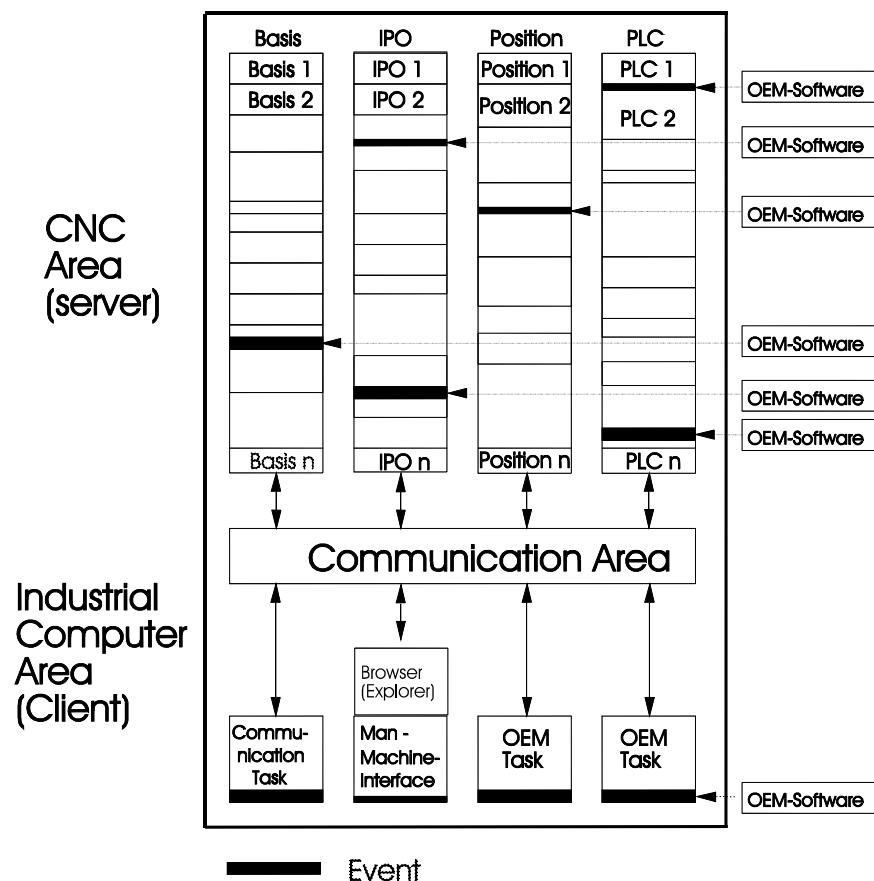
- Operator Guidance through soft keys
- Syntax check during NC program inputs
- Checksum test
- Software limit switches
- Comprehensive CNC status and machine status display via PLC
- Read , write-, and clear protection for NC-programs
- Protected programs
- Password protection (up to 10 levels)

## 15 SYSTEM ACCESS

via PA Compile Cycles in C<sup>++</sup>

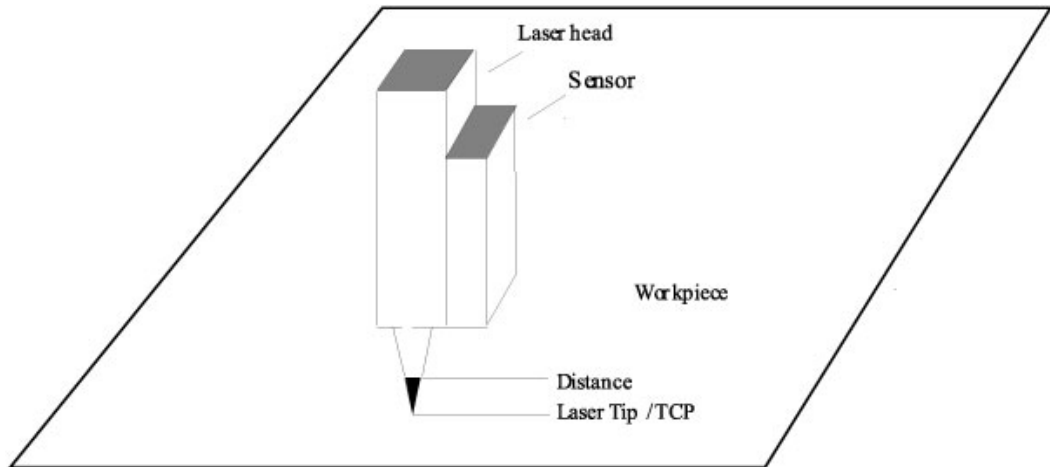
Development set

- Compile Cycle CNC Kernel library

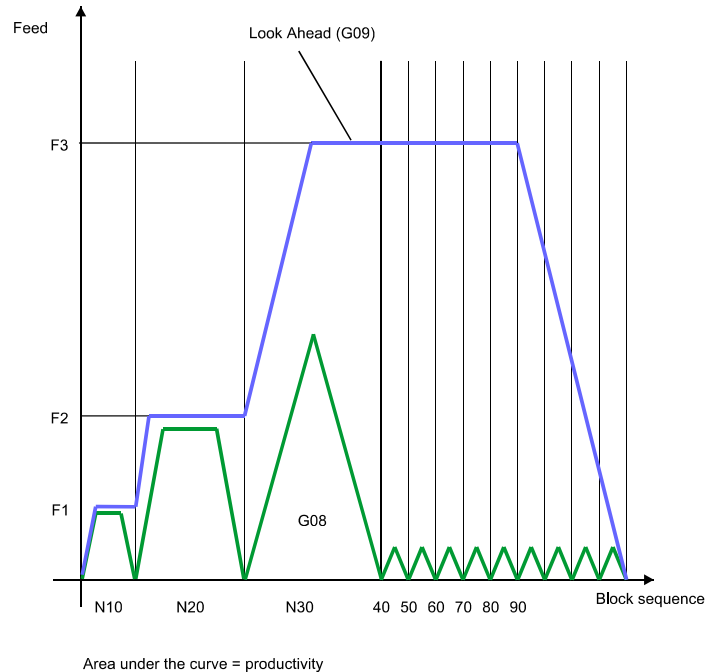




## 2D DISTANCE CONTROL



## ADAPTIVE LOOK AHEAD

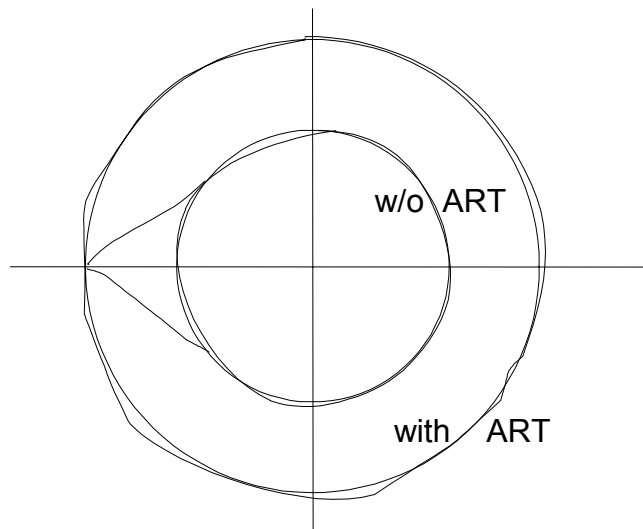


- Adaptive Look Ahead results: Error free block transitions
- Adaptive Look Ahead analyzes up to several hundred subsequent NC blocks
- Adaptive Look Ahead monitors the acceleration and deceleration values set for each axis
- Adaptive Look Ahead assures that the dynamic limits of the machine will never 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

2 Axis Cylindrical Grinder  
Roundness Test

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



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

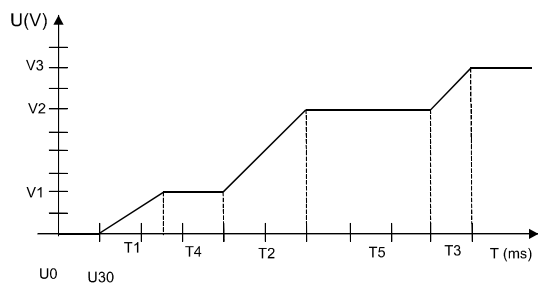
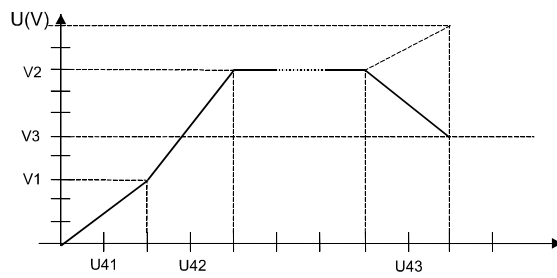
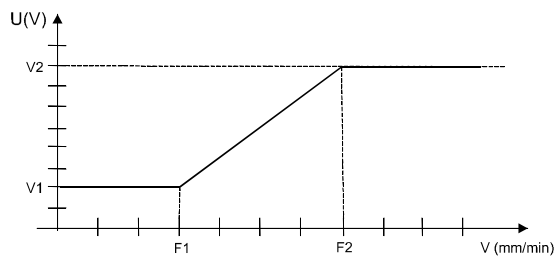
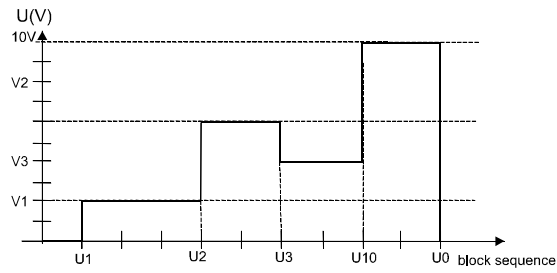
Adaptive ART uses

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

Adaptive ART is active during

- acceleration
- constant speed
- deceleration

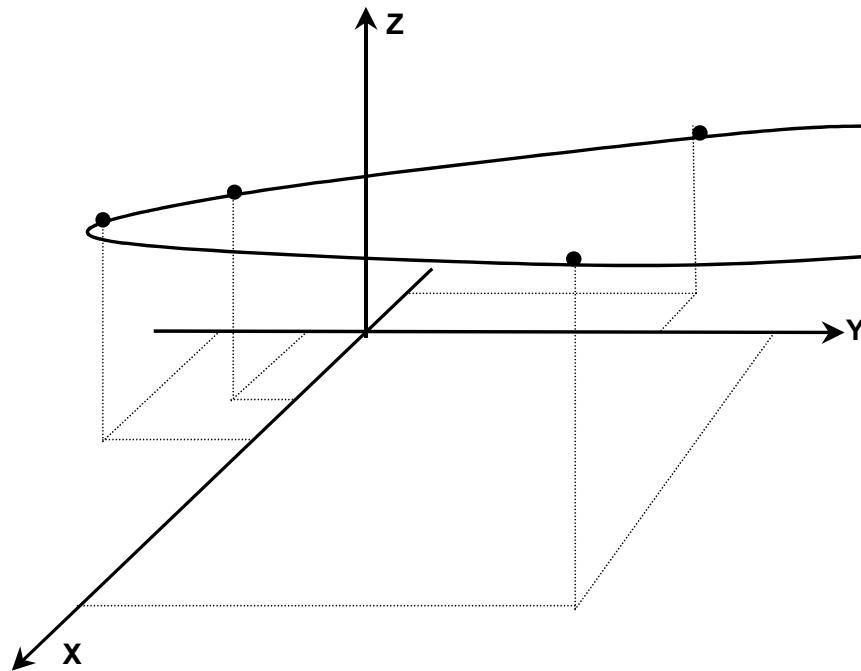
## LASER POWER CONTROL



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

System spezifikation PA 8000 L2

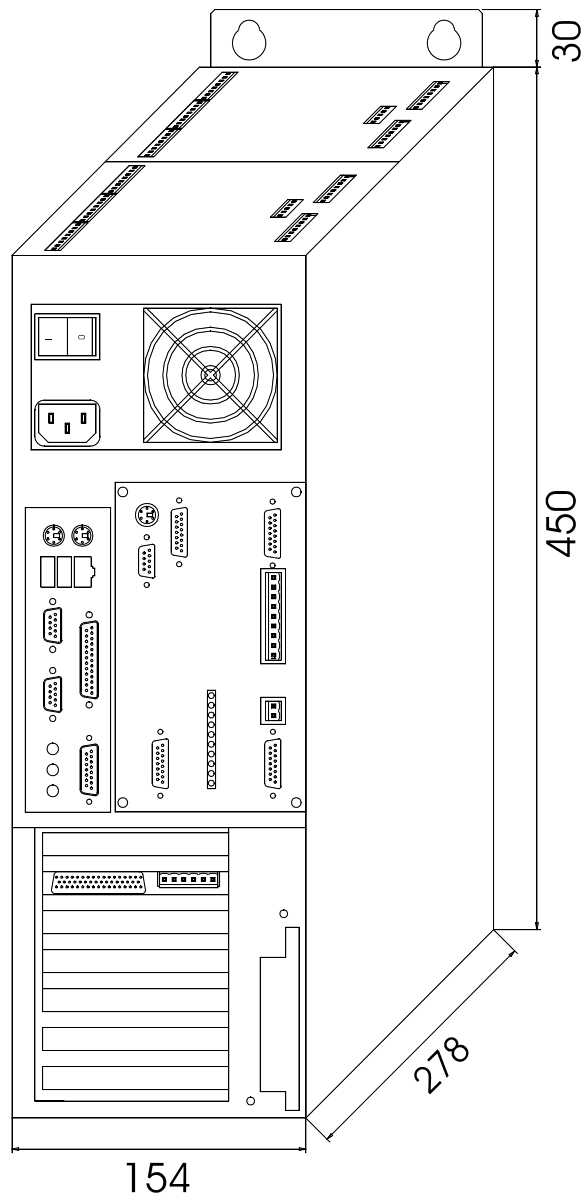
## 2D SPLINE INTERPOLATION



- Real time spline interpolation
- NC data reduction by factor 3 .. 10
- Tangential
- Smooth transitions

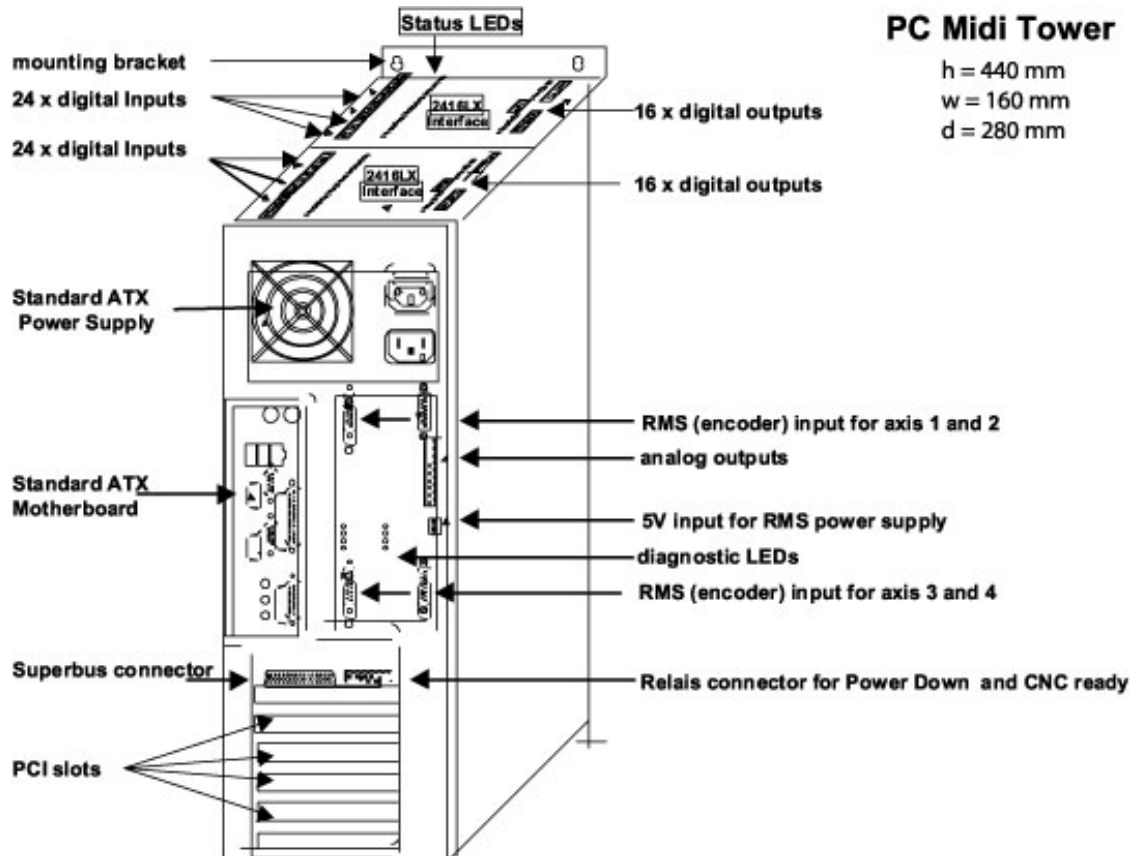
## 16 MECHANICAL OUTLINE

CNC-Box



## 17 SYSTEM OVERVIEW

### CNC Box



## 18 OPERATING CONDITIONS

### Space Requirements

- For installation mind a free space front (100 mm), right (50mm) and at the top (100 mm)

### Voltage requirement

- 115 - 240 V AC +10% / -15 % 50/60 Hz

### Maximum power required

- 300 VA

### Temperature

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