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## 1. Introduction

Colinbus controller is a processor that uses HPGL file system to operate the machines. This document will describe the proper usage of HPGL commands. It only includes commands that are used for positioning the head to a specified position and the commands to control some modes of working. Every command needs to follow certain syntax rules; otherwise the file will be invalid.

Commands that are used in the controller can be divided in two groups, standard and extended. Standard commands are those that are normally used in HPGL file language, extended are the commands used to execute special features supported by the controller. At the end of this document is a text with detailed description on how these commands should be used in practical terms.

## 2. HPGL commands

### 2.1 Syntax Rules

The generic format for both standard and extended commands comprises:

- A standard or extended command string
- Optional 1, 2 or more parameters depending on the command
- Parameter separator if more than one parameter is specified
- Command terminator

Each element will now be discussed in detail.

#### 2.1.1 Command String Syntax

The command string may be made up of upper or lower case ASCII codes or a combination of both, however there may be no blanks in between the characters that make up the command string. For easy readability of the file it is recommended that upper case ASCII codes are used.

#### 2.1.2 Parameter Syntax

The parameters that go with the commands must be made up of valid ASCII codes in accordance to the listing below:

- Integers: represented by a set of ASCII characters 0...9, minus sign assumes negative value, if omitted positive value is assumed.
- Floating: represented by a set of ASCII characters 0...9, decimal separator is dot (.), minus sign assumes negative value, if omitted positive value is assumed.
- Hex: represented by a set of ASCII characters 0...9, A...F

#### 2.1.3 Parameter Separator

Some commands require 2 or more parameters. In this case the parameters must be separated by at least one space character or a comma. In the latter case additional spaces before and/or after the comma will be ignored. For easy readability of the file it is recommended that comma (,) is used.

#### 2.1.4 Command Terminator

A command string is considered finished by terminating the occurrence of either a semi-colon or a new valid command string.

#### 2.1.5 Ignored Characters

<SPACE> except when used as a parameter separator  
<CR> except in the end of file marker combination <EOF><CR>

#### 2.1.6 Command Strings Examples

Following strings are valid command sequences:

```
PA 1000,1000;PD
PA1000,-1000;PU
PA 1000 -1000;PU
PA 1000 1000 ; PD
PA 1000 1000PUPR100 100
```

Following strings are invalid command sequences:

PA 1000-1000	Missing parameter separator
PA1000:-1000;PU	Invalid parameter separator
PA 1000 1000X	Invalid command terminator
P A 1000, 1000;	No spaces allowed within the command itself

### 2.1.7 User Units

Controller is using millimeters as measure units. All speed settings are represented in mm/s.

Example:

VS 45.5;	set the XY moving speed to 45.5 mm/s.
@ZU 30.0;	set the Z up moving speed to 30 mm/s.

When representing moves of certain length all movements need to be represented as integers. Therefore using resolution of 0.025 mm as a smallest move, 1 mm will be represented as 40 user units.

Example:

PA 4000,4000;	Move XY-axes linear interpolated to 100,100 mm (4000,4000 uu)
@ZA120;	Move Z ax to position 3 mm from zero position.

All 3 axes (X, Y and Z) use the resolution of 40 user units per millimeter.

## **2.2 Standard HPGL Commands**

In this section all supported standard HPGL commands are individually described in detail... For each command following topics are listed (where applicable):

- Syntax: exact command string
- Parameters: description, type, range, format
- Action: description of what the command does

Regarding the parameters that go with some commands, following rules apply:

- Parameters within brackets are optional
- Parameters without brackets are mandatory

The reader may notice that in the command description sections the command string and the parameters are separated by a blank and multiple parameters are separated by a comma although neither is strictly necessary according to the syntax rules above. This is mainly done to improve the readability of the command strings in this manual.

**PLOT ABSOLUTE****PA**

Syntax:

PA (X<sub>1</sub>, Y<sub>1</sub> [, X<sub>2</sub>, Y<sub>2</sub> ...]);

Parameters:

X<sub>1</sub>, Y<sub>1</sub>, X<sub>2</sub>, Y<sub>2</sub> ...: Absolute X and Y co-ordinates in user units

Range: -2<sup>23</sup> ... +2<sup>23</sup> (only integers allowed!!)

The total number of parameters following the command MUST always be an even number!

Action:

PA instruction without parameters

The command PA without any parameters will result in activating the absolute plot mode. From this point on, all XY co-ordinates following PU or PD commands will be considered to be absolute. This mode stays in effect until a PR command is received.

PA instruction with parameters

The command PA with parameters will result in a XY-vector move towards the specified absolute co-ordinates. If more than one pair of co-ordinates is given, the associated absolute moves will be executed sequentially.

**PEN DOWN****PD**

Syntax:

PD (X<sub>1</sub>, Y<sub>1</sub> [, X<sub>2</sub>, Y<sub>2</sub> ...]);

Parameters:

X<sub>1</sub>, Y<sub>1</sub>, X<sub>2</sub>, Y<sub>2</sub> ...: X and Y co-ordinates in user units

Range: -2<sup>23</sup> ... +2<sup>23</sup> (only integers allowed!!)

The total number of parameters following the command MUST always be an even number!

Action:

PD instruction without parameters

When the instruction is given without any parameters it will result in the Z-axis moving to the PD position. The actual PD position depends on the setting specified in the user interface software. In order to have exact control over positioning the Z ax please see command @ZA.

PD instruction with parameters

First the Z-axis will be moved in the same way as described above. Subsequently, a XY-vector move towards the specified co-ordinates will be executed (after the specified PD Wait time, if any). If more than one pair of co-ordinates is given, the associated moves will be executed sequentially.

The co-ordinates will be interpreted as absolute positions or relative displacements depending on whether PA or PR was the last plot instruction preceding the current PD instruction.

**PLOT RELATIVE****PR**

Syntax:

PR ( $\Delta x_1, \Delta y_1$  (,  $\Delta x_2, \Delta y_2$  ...));

Parameters:

$\Delta x_1, \Delta y_1, \Delta x_2, \Delta y_2$  ...: X and Y displacements relative to current position, in user units  
Range:  $-2^{23}$  ...  $+2^{23}$  (only integers allowed!!)

The total number of parameters following the command MUST always be an even number!

Action:

PR instruction without parameters

The command PR without any parameters will result in activating the relative plot mode. From this point on, all XY co-ordinates following PU or PD commands will be considered to be relative. This mode stays in effect until a PA command is received.

PR instruction with parameters

The command PR without any parameters will result in a XY-vector move towards the specified relative displacements. If more than one pair of co-ordinates is given, the associated relative moves will be executed sequentially.

<b>PEN UP</b>	<b>PU</b>
---------------	-----------

Syntax:

PU (x<sub>1</sub>, y<sub>1</sub> [, x<sub>2</sub>, y<sub>2</sub> ...]);

Parameters:

x<sub>1</sub>, y<sub>1</sub>, x<sub>2</sub>, y<sub>2</sub> ...: X and Y co-ordinates in user units

Range: -2<sup>23</sup> ... +2<sup>23</sup> (only integers allowed!!)

The total number of parameters following the command MUST always be an even number!

Action:

PU instruction without parameters

When the instruction is given without any parameters it will result in the Z-axis moving to the PU position. The actual PU position depends on the setting specified in the user interface software. In order to have exact control over positioning the Z ax please see command @ZA.

PU instruction with parameters

First the Z-axis will be moved in the same way as described above. Subsequently, a XY-vector move towards the specified co-ordinates will be executed (after the specified PU Wait time, if any). If more than one pair of co-ordinates is given, the associated moves will be executed sequentially.

The co-ordinates will be interpreted as absolute positions or relative displacements depending on whether PA or PR was the last plot instruction preceding the current PD instruction.

**VELOCITY SELECT****VS**

Syntax:

VS (v);

Parameters:

v: XY plotting speed in mm/sec, resolution 0.1 mm/sec

Action:

VS without parameter

No action

VS with parameter

The specified plotting speed is set as the actual working speed for XY vector moves with either PU or PD. Any working speed settings previously set will be replaced by the new working speed value.

## **2.3 *Extended HPGL Commands***

In addition to the standard HPGL commands described in the previous section, the system also offers a number of extended commands for improved performance and flexibility.

In this section all extended commands are individually described in detail..

For each command following topics are listed (where applicable):

- Syntax: exact command string
- Parameters: description, type, range, format
- Action: description of what the command does

Regarding the parameters that go with some commands, following rules apply:

- Parameters within brackets are optional
- Parameters without brackets are mandatory

The reader may notice that in the command description sections the command string and the parameters are separated by a blank and multiple parameters are separated by a comma although neither is strictly necessary according to the syntax rules above. This is mainly done to improve the readability of the command strings in this manual.

**SPINDLE SPEED****@SS**

Syntax:

@SS s;

Parameters:

s: 0, 1, 2 of 3

Action:

This instruction controls the states of the SP1 and SP0 open collector outputs. These may be used to select 1 of 4 preset speeds for the tool spindle motor. The state of these two outputs will reflect the parameter value as shown below:

s SP1 SP0

0 Off Off

1 Off On

2 On Off

3 On On

<b>WAIT</b>	<b>@WT</b>
-------------	------------

WAIT @WT

Syntax:

@WT w;

Parameters:

w: integer in the range 0 ... 32767

Action:

This command will wait w ms before executing the next instruction.

**Z-AXIS ABSOLUTE MOVE****@ZA**

Syntax:

@ZA z;

Parameter:

z: Absolute Z-axis co-ordinate in user units.

Range:  $-2^{23}$  ...  $+2^{23}$  (integers only).

Action:

Results in the Z-axis moving to position z (in user units)...

**Z-AXIS MOVE DOWN SPEED****@ZD**

Syntax:

@ZD sd;

Parameter:

sd: speed used to move the Z-axis downwards expressed in mm/sec  
Maximum resolution is 0.1 mm/sec

Action:

Sets the given speed value as the working speed for downwards movements of the Z-axis. If the speed value following the instruction is higher than the absolute maximum speed of the Z-axis specified in the configuration table, then the maximum speed will be used as working speed.

**Z-AXIS RELATIVE MOVE****@ZR**

Syntax:

@ZR  $D_z$ ;

Parameter:

$D_z$ : Relative Z-axis displacement in user units.

Range:  $-2^{23}$  ...  $+2^{23}$  (integers only).

Action:

This command will move the Z-axis over a distance  $D_z$  relative to its current position.

**Z-AXIS MOVE UP / DOWN SPEED****@ZS**

Syntax:

@ZS  $s_u$ ,  $s_d$ ;

Parameters:

$s_u$ : speed to move Z-axis upwards expressed in mm/sec

$s_d$ : speed to move Z-axis downwards expressed in mm/sec

Maximum resolution 0.1 mm/sec

Action:

Sets the given speed values as the active working speeds for moving the Z-axis upwards and downwards respectively. If the speed value following the instruction is higher than the absolute maximum speed of the Z-axis specified in the configuration table, then the maximum speed will be used as working speed.

**Z-AXIS MOVE UP SPEED****@ZU**

Syntax:

@ZU  $s_u$ ;

Parameter:

$s_u$ : speed used to move the Z-axis upwards expressed in mm/sec  
Maximum resolution is 0.1 mm/sec

Action:

Sets the given speed value as the working speed for upwards movements of the Z-axis. If the speed value following the instruction is higher than the absolute maximum speed of the Z-axis specified in the configuration table, then the maximum speed will be used as working speed.

### 3. Extra information

In this section you can find additional information on some commands and how and when to use them. This document contains only commands that are necessary to create post processor for Colinbus controller board. Section contains following parts that will be described hereafter.

- Commands that stay in affect until the new command is given
- Relative and absolute coordinates
- Z-axis positioning
- Circles and curves
- Fast moves
- Extra commands for User Interface software
- Tool information
- Example file

All settings that are used in the file remain in affect until the new command is given. This applies mainly to speed settings; this however does not apply to positions. This means that PA and PR instructions must take both axis parameters for correct file processing.

It is recommended to work with absolute coordinates, since the User Interface program is taking care of object positioning on the machine and the new home positions that need to be used.

Z-axis moves described with @ZA command are always given in reference to the Z-home position selected. This means that by example @ZA400; will move the head downwards 10 mm in reference to the home position selected. Selection of the home position is done with the User Interface program. Therefore when safe retract is used (travel height above working piece) it should be represented with negative coordinate. (@ZA-400;). Using PU and PD instructions is possible, but to avoid possible errors it is better to use @ZA instruction instead. This way there is no interference between user interface and post processor program. (PU & PD need to be set in the User Interface program).

To represent curves and circles a series of PA or PR commands are to be given which are following the curve. Controller is able to interpret these vectors as a part of a curve and use circular interpolation when needed.

To make a fast move (per example, move to the first coordinate in the file) set the speed setting to 50 mm/s, make a move and reset the speed back to the speed for material processing.

All commands described within this document are handled by the controller; however, in every file a header should be entered for the correct interpretation of the file by the User Interface software. There is only one such command at this time:

OF X:f<sub>x</sub>,Y:f<sub>y</sub>,Z:f<sub>z</sub>

F<sub>x</sub>: scale factors used to represent X-ax move

F<sub>y</sub>: scale factors used to represent Y-ax move

F<sub>z</sub>: scale factors used to represent Z-ax move

(See section 2.1.7 user units)

By default this line is always the same and should look like : OF X:40,Y:40,Z:40; It should be the first line in the file.

When creating a file one or more tools are used to process this file on the machine. Every tool change action that needs to be done for proper file processing needs to be stated in the file in the following format:

T:%d N:%s H:%f D:%f

Explanation:

T:%d - %d represents the number in range 1..9 that specifies tool position in tool exchange box.

N:%s - represents name of the tool per example Flat End Mill

H:%f - %f represents height of the tool in mm

D:%f - %f represents diameter of the tool in mm

Example

T:7 N:FlatEndMill H:15 D:2

Line represents a flat end mill with height of 15 mm and diameter of 2 mm. It is located in turret nr 7 on the tool exchange box.

Example file:

Note: double forward slash is used in this document to represent comments; they are not to be used when generating the file.

```
OF X:40,Y:40,Z:40; //user interface command for user units used in the file
T:1 N:FlatEndMill H:10 D:2; // Tool information
@ZU 40.0; // Z-axis up speed
@ZD 5.0; // Z-axis down speed
@ZA -500; // Move Z-axis to position 500 user units above home position. (12,5 mm)
VS 50.0; // Set XY travel speed to 50 mm/s
PA 8966, 5440; // Move XY to position 8966, 5440
VS 15.0; // Set travel speed to 15 mm/s
@ZA 30; // Move Z-axis to position 30 user units below home position (0,75 mm)
PA 9014, 5440; // Move XY to position 9014, 5440
PA 9014, 5194; // following series of PA will result in circular interpolation to be started
PA 8412, 5199;
PA 8323, 5153;
PA 8069, 5158;
PA 8011, 5214;
PA 7922, 5166;
PA 500, 5329; // end of circular interpolation
PA 500, 5450;
PA 7932, 5494;
PA 7998, 5445;
PA 8064, 5511;
PA 8333, 5506;
PA 8432, 5445;
PA 8966, 5440;
@ZA -500;
VS 50.0
PA 9141, 5417;
VS 15.0;
@ZA 30;
PA 9093, 5417;
PA 9093, 5171;
PA 9692, 5171;
PA 9784, 5120;
PA 10038, 5120;
PA 10096, 5181;
PA 10185, 5128;
PA 17602, 5204;
PA 17602, 5329;
PA 10175, 5461;
PA 10109, 5407;
PA 10043, 5473;
PA 9774, 5473;
PA 9674, 5417;
PA 9141, 5417;
@ZA -500;
VS 50.0
PA 8938, 4686;
VS 15.0;
@ZA 30;
PA 9136, 4622;
PA 9136, 5984;
PA 9113, 6006;
PA 9088, 6023;
PA 9063, 6032;
PA 9046, 6034;
```

PA 9028, 6034;  
PA 9009, 6029;  
PA 8990, 6022;  
PA 8972, 6012;  
PA 8955, 6000;  
PA 8938, 5984;  
PA 8938, 4686;  
@ZA -500;  
VS 50.0  
PA 5814, 2982;  
VS 15.0;  
@ZA 30;  
PA 4351, 2745;  
PA 4348, 2780;  
PA 4339, 2829;  
PA 4323, 2886;  
PA 4302, 2946;  
PA 4276, 3008;  
PA 4257, 3048;  
PA 4343, 3155;  
PA 4434, 3258;  
PA 4525, 3349;  
PA 4621, 3435;  
PA 4682, 3484;  
PA 4746, 3531;  
PA 4812, 3575;  
PA 4874, 3612;  
PA 4939, 3647;  
PA 5005, 3678;  
PA 5068, 3703;  
PA 5132, 3724;  
PA 5197, 3741;  
PA 5256, 3752;  
PA 5316, 3759;  
PA 5376, 3762;  
PA 5428, 3759;  
PA 5469, 3711;  
PA 5510, 3656;  
PA 5550, 3594;  
PA 5590, 3525;  
PA 5628, 3454;  
PA 5666, 3374;  
PA 5701, 3293;  
PA 5738, 3202;  
PA 5771, 3111;  
PA 5814, 2982;  
@ZA -500;  
VS 50.0  
PA 7836, 3924;  
VS 15.0;  
@ZA 30;  
PA 7625, 3335;  
PA 7606, 3297;  
PA 7584, 3260;  
PA 7563, 3228;  
PA 7540, 3197;  
PA 7517, 3171;  
PA 7493, 3147;  
PA 7469, 3128;  
PA 7445, 3112;  
PA 7421, 3099;

PA 7395, 3089;  
PA 7372, 3083;  
PA 7348, 3080;  
PA 7335, 3081;  
PA 5994, 3002;  
PA 5917, 3200;  
PA 5836, 3386;  
PA 5785, 3494;  
PA 5732, 3600;  
PA 5692, 3674;  
PA 5651, 3748;  
PA 5631, 3782;  
PA 7836, 3924;  
@ZA -500;  
VS 50.0  
PA 7411, 764;  
VS 15.0;  
@ZA 30;  
PA 7411, 642;  
PA 9329, 622;  
PA 9329, 744;  
PA 8418, 754;  
PA 7413, 764;  
PA 7412, 764;  
PA 7411, 764;  
@ZA -500;  
VS 50.0  
PA 9537, 1351;  
VS 15.0;  
@ZA 30;  
PA 9537, 1376;  
PA 9329, 1376;  
PA 9329, 858;  
PA 7521, 868;  
PA 7521, 1422;  
PA 7231, 1422;  
PA 7231, 873;  
PA 6345, 886;  
PA 6296, 883;  
PA 6247, 888;  
PA 6200, 900;  
PA 6161, 916;  
PA 6124, 936;  
PA 6085, 961;  
PA 6049, 990;  
PA 6013, 1024;  
PA 5980, 1061;  
PA 5943, 1110;  
PA 5829, 1033;  
PA 5854, 999;  
PA 5881, 967;  
PA 5909, 937;  
PA 5940, 909;  
PA 5971, 884;  
PA 6004, 861;  
PA 6046, 836;  
PA 6090, 816;  
PA 6136, 799;  
PA 6183, 786;  
PA 6231, 778;  
PA 6278, 774;

PA 6319, 774;  
PA 7231, 774;  
PA 7231, 650;  
PA 6032, 650;  
PA 5985, 665;  
PA 5938, 687;  
PA 5892, 714;  
PA 5857, 739;  
PA 5824, 767;  
PA 5791, 798;  
PA 5760, 832;  
PA 5730, 868;  
PA 5702, 907;  
PA 5674, 952;  
PA 5539, 863;  
PA 5575, 810;  
PA 5612, 759;  
PA 5650, 714;  
PA 5690, 671;  
PA 5729, 634;  
PA 5771, 600;  
PA 5811, 573;  
PA 5852, 548;  
PA 5892, 529;  
PA 5934, 514;  
PA 5972, 505;  
PA 6011, 500;  
PA 6032, 500;  
PA 9921, 500;  
PA 9921, 622;  
PA 9481, 622;  
PA 9481, 744;  
PA 9850, 744;  
PA 9850, 853;  
PA 9537, 853;  
PA 9537, 1351;  
@ZA -500;  
VS 50.0  
PA 5148, 1221;  
VS 15.0;  
@ZA 30;  
PA 4445, 1242;  
PA 4434, 1242;  
PA 4425, 1243;  
PA 4400, 1249;  
PA 4377, 1258;  
PA 4355, 1271;  
PA 4331, 1289;  
PA 4310, 1310;  
PA 4291, 1334;  
PA 4266, 1375;  
PA 4246, 1419;  
PA 4232, 1466;  
PA 4222, 1514;  
PA 4214, 1572;  
PA 4210, 1629;  
PA 4209, 1696;  
PA 4210, 1762;  
PA 4216, 1836;  
PA 4224, 1910;  
PA 4224, 1924;

PA 4221, 1936;  
PA 4216, 1947;  
PA 4206, 1956;  
PA 4191, 1963;  
PA 4172, 1967;  
PA 4152, 1968;  
PA 4132, 1966;  
PA 3185, 2204;  
PA 3835, 2895;  
PA 4193, 3048;  
PA 4268, 3150;  
PA 4348, 3248;  
PA 4431, 3338;  
PA 4519, 3423;  
PA 4608, 3499;  
PA 4702, 3568;  
PA 4774, 3615;  
PA 4848, 3659;  
PA 4924, 3698;  
PA 5000, 3732;  
PA 5077, 3762;  
PA 5156, 3787;  
PA 5232, 3806;  
PA 5309, 3821;  
PA 5387, 3831;  
PA 5425, 3834;  
PA 5473, 3835;  
PA 7869, 4000;  
PA 8328, 4622;  
PA 8625, 4622;  
PA 8625, 4719;  
PA 9382, 4719;  
PA 9382, 4556;  
PA 10784, 4490;  
PA 10817, 4391;  
PA 10685, 4325;  
PA 11214, 3769;  
PA 11673, 3736;  
PA 11773, 3637;  
PA 12131, 3670;  
PA 12164, 2982;  
PA 11900, 2982;  
PA 11999, 2789;  
PA 17645, 2689;  
PA 19974, 4556;  
PA 20723, 4523;  
PA 18986, 2293;  
PA 18953, 2257;  
PA 18919, 2222;  
PA 18886, 2192;  
PA 18851, 2163;  
PA 18818, 2139;  
PA 18783, 2117;  
PA 18736, 2093;  
PA 18690, 2076;  
PA 18646, 2066;  
PA 18606, 2063;  
PA 18592, 2065;  
PA 11148, 1313;  
PA 5740, 1343;  
PA 5148, 1221;

```
@ZA -500;
VS 50.0
PA 9537, 1376;
VS 15.0;
@ZA 30;
PA 9329, 1376;
PA 9329, 858;
PA 7521, 868;
PA 7521, 1422;
PA 7231, 1422;
PA 7231, 873;
PA 6345, 886;
PA 6296, 883;
PA 6247, 888;
PA 6200, 900;
PA 6161, 916;
PA 6124, 936;
PA 6085, 961;
PA 6049, 990;
PA 6013, 1024;
PA 5980, 1061;
PA 5943, 1110;
PA 5829, 1033;
PA 5854, 999;
PA 5881, 967;
PA 5909, 937;
PA 5940, 909;
PA 5971, 884;
PA 6004, 861;
PA 6046, 836;
PA 6090, 816;
PA 6136, 799;
PA 6183, 786;
PA 6231, 778;
PA 6278, 774;
PA 6319, 774;
PA 7231, 774;
PA 7231, 650;
PA 6032, 650;
PA 5985, 665;
PA 5938, 687;
PA 5892, 714;
PA 5857, 739;
PA 5824, 767;
PA 5791, 798;
PA 5760, 832;
PA 5730, 868;
PA 5702, 907;
PA 5674, 952;
PA 5539, 863;
PA 5575, 810;
PA 5612, 759;
PA 5650, 714;
PA 5690, 671;
PA 5729, 634;
PA 5771, 600;
PA 5811, 573;
PA 5852, 548;
PA 5892, 529;
PA 5934, 514;
PA 5972, 505;
```

```
PA 6011, 500;  
PA 6032, 500;  
PA 9921, 500;  
PA 9921, 622;  
PA 9481, 622;  
PA 9481, 744;  
PA 9850, 744;  
PA 9850, 853;  
PA 9537, 853;  
PA 9537, 1351;  
@ZA -500;  
VS 50.0;  
PA 0, 0; // end of file so home the head to 0, 0
```

