

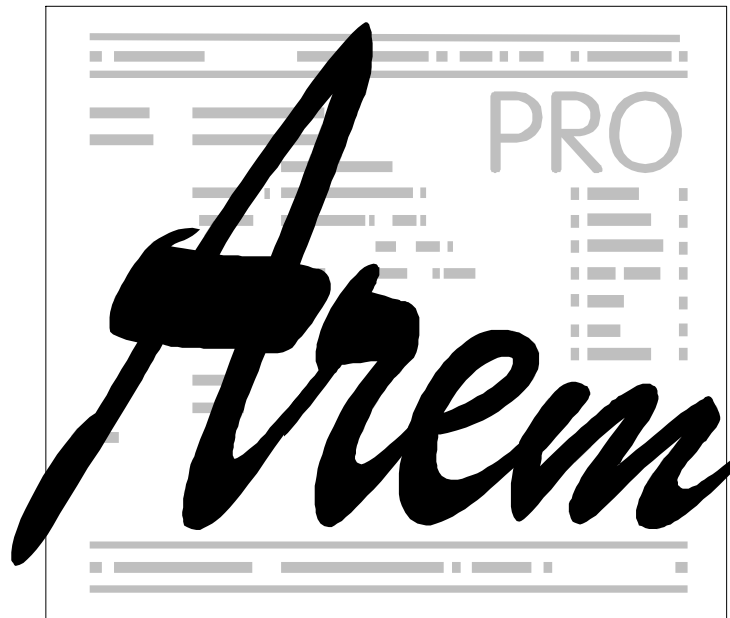


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Operation of the Cnc886/Win Control System

General Part



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2. Basic Information

Cnc886/Win Control System is industrial computer based system equipped with a supplementary CAN bus.

Cnc886/Win Control System is operated in Windows operation system, to which RTX real time upgrade, made by Ardence (former VentureCom), was installed. The philosophy of the control program, built on Windows basis, brings many advantages. One of them is possible cooperation with other programs in the control system computer, such as CAD/CAM systems, production control programs, workshop programming software etc. Another advantage is its functioning in all peripheries ensured by the operation system, functionality of all Windows system net services and last but not least a guaranteed growth of future performance of the control system as well. The Windows system further brings many interesting program technologies, which Cnc886/Win utilizes or plans to utilize for improvement of graphical user interface.

You can see a standard user interface of the Windows system after you switch the computer on. An icon, which allows you to initiate the Cnc886 program, is prepared on your desktop. After the initiation the application carries out many preparatory operations. Their course depends to a large extent on the state of the Windows system; therefore the initiation may take even several tens of seconds. First of all, after the initiation and start-up of the program the processes connected with login of the computer in the network are in progress in the Windows system. These processes disable initiation of Cnc886 and initiation of other applications as well. You just have to wait.



After the initiation of Cnc886 a window creating graphic interface of the program appears. Most of operations are being carried out in a usual manner. You just have to point to the object by the mouse and click on the left mouse button to activate it. Or click on the window with the text and you can change the text by means of the keyboard. An overwhelming majority of such operations is entirely standard and the operations are respected by

the Cnc886 system.

The graphic user interface of Cnc886 system is variable. Various types of control applications require various graphic processing and sets of functions easy accessible from the interface. At the creation of these variants we have set out the following way. The Cnc886 program has its standard interface, which is further described in this general part of the system operation description. The standard interface is in some applications supplemented with additional windows or it is completely replaced by them. The standard interface is in case of "complete replacement" minimized in the menu bar and it is prepared for use. Less frequent operations may be left out in the specialized interface, because they remain accessible within the scope of standard interface. All graphic interfaces are applicable concurrently; therefore there is no need to switch of the current interface to be able to use the other.

2.1. System Security

Except advantages the utilization of Windows operation system brings certain risks as well. Thanks to its spread the system is often the target of hackers' attacks. The system further lures to installation of new and new applications. This brings a danger of control



program collision with newly installed applications. Therefore it is strictly necessary to observe following rules:

- No programs, drivers, or program patches may be installed on the control computer without awareness and consent of the control system supplier. Failing that, it is not possible to guarantee the correct functioning of the control program.
- Programs or scripts, which are not locally installed, must not be initiated in the control computer. It means, programs on diskettes, CDs or net and other possible data medium must not be run.
- The firewall must not be switched off.

Windows system is being delivered on the assumption of your consent with the licence contract with the end user (EULA). If you do not agree with the contract, you are not entitled to use the control system. Conditions of the guarantee, given by the EULA contract (article 8), naturally feature in the guarantee conditions of the control system as the whole and thus they are equal.

2.2. Touch Screen

Cnc886/Win system may be equipped by a touch screen. The touch screen is a combination of the display and the input device. Finger touch or touch by other objects invokes the same response as pointing by the mouse on the position and pushing its left button. Holding the finger on the screen equals to holding the mouse button. It means that you do not have to use the mouse at the common operation at all. The only limitation of the touch screen is that it does not usually allow operations accessible through the right mouse button. However, you shall probably not need such operations. Before you shall get used to the touch screen, be careful when you try to explain another person something and point to the screen. One is often used to touch the display and to tap it by the finger. The touch screen shall perceive such touches as commands!

2.3. Keyboard and Mouse

It would be possible to design the entire system completely without the keyboard and the mouse and to solve everything by the touch screen. However, the practice has shown that entering of numbers, editing of files and many other operations became too much cumbersome. Therefore the keyboard and sometimes also the mouse were retained. The keyboard and the touch screen work together. The same task may be carried out either by touching the screen or by clicking the mouse.

3. Standard System User Interface

Standard system user interface is divided to three basic segments.



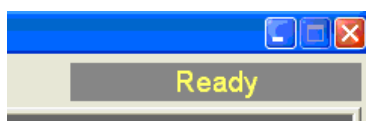
- Status window
- Cards with tabs
- Fingerboard

The status window is located in the right upper angle of the system screen. It is always visible.

Cards with tabs fill up the main part of the screen surface. They resemble filing cards ordered in blocks, from which tabs with descriptions of cards “stick out” on the top. By clicking (by the finger or the mouse) on the tab the card comes forth. Some cards contain further system of subordinate cards with tabs.

The fingerboard is in the bottom part of the screen and it is always accessible.

3.1. Status Window



The status window displays the current state of the system by yellow letters. If you want to carry out some operation and it does not work as you expected, the problem may lie in the fact that the system status does not allow it. In such case, you should pay the attention to this window. Here the sign “Error” appears in case of an error.

Possible status of the system:

| Status | Information in the window |
|---|---------------------------|
| Power supply to the power part switched off | Power OFF |
| Initiation after switch-on the power part | Initialising |
| The system is in order, some axis is not referred | Not referred |
| Referring is in process | Referencing |
| The system is ready, referred | Ready |
| Program is in process | Running |
| Program suspended by M0 function | Stopped by M0 |
| Program suspended by STOP button | Stopped |
| Manual shift of axis is in process | Manual move |
| Spindle started manually | Manual bin |
| Loading of the program is in process | Loading: xxxxxxxx |
| Error state | Error |

3.2. Fingerboard



Along the bottom edge of the screen there is a panel with five buttons. The buttons may have various functions according to activities of respective tabs. Buttons change their color according to their statuses; they behave like back-lighted buttons. They may be pressed or unpressed and lighting or unlighting at the same time.

RESET

This button serves for stopping the operation in process – program run, referencing, manual operation of spindle etc. If the light is red, it signalizes that the machine is idle. If it does not light, the machine is in one of following operation modes.

START-

This button serves for initiation of manual movements of axes to the back. The light is yellow when the axis moves.

SPEED

This button is used for reduction of fast feed speed invoked by G0 function. All fast feeds are slowed down ten times at the activation of this button. Repeated pressing the button abolishes reduction of the speed. If the reduction of speed is switched-on, the button is white back-lighted. Reduction of speed is particularly suitable at the tuning of technological programs. It provides the operating personnel with time in case of threatening collision of the machine with objects in the working area

START+

This button serves for initiation of manual movements of axes forward and for initiation of program operation and for recovery of program operation after suspension by M0 function or STOP button. The light is yellow at manual moving and at automatic operation of the program unless suspended by M0 function or STOP button

STOP

This button serves for suspension of running program. The light is red when the program was suspended (stopped) and it waits until the START+ button is pressed.

3.3. Tab Auto



The screenshot shows the 'Auto' tab of the Cnc886 software. The status bar at the top right indicates 'Ready'. The main area contains a table with the following data:

| Axis | In program | Tool 370 | Off.G53 | ProgOff | InP | Mode |
|---------|------------|----------|---------|---------|-----|----------|
| X | 85.623 | 0.000 | 0.000 | 0.000 | Yes | Normal |
| Y | 226.952 | 0.000 | 0.000 | 0.000 | Yes | |
| Z | 57.799 | 0.000 | 0.000 | 0.000 | Yes | |
| A | -50.924 | 0.000 | 0.000 | 0.000 | Yes | |
| C | 39.032 | 0.000 | 0.000 | 0.000 | Yes | |
| Radius | | 0.000 | | | | Step |
| Spindle | 0 | 0 | 1.00 | | | Duration |
| Feed | 0 | 0 | 1.00 | | | 0:00:00 |

Below the table, the current program code is displayed:

```
M5 M50 H7
%1:%1 {5X_MODEL2_T370.CNC}
%1:N5 T370 S18000. M3
%1:N10 G54
```

The control panel at the bottom features five buttons: RESET (red), START- (diamond icon), SPEED (wrench icon), START+ (diamond icon), and STOP (stop sign icon).

Axes

Tab **Auto** serves for technological program monitoring and control. Information on statuses of individual axes takes the largest space. Number and names of axes vary according to the type of the machine. In case of our sample it is a system with six axes named X, Y, Z, C, A, and V. Data on current position, number and value of tool corrections (column Tool), data on value of shifting of the system of coordinates (column Off. Gxx), and data on value of shift caused by G92 function (column Offset) are displayed in the table (see 3.3.1 Image of Position). More on the meaning of individual data you can find in the Chapter 6.1 System of Coordinates and Corrections. The last line shows the status data InP (In Position), which signalizes conformity of required position with real and tolerated deviation set by the supplier. The sign changes during the machine operation. When idle, it should be always in status Yes. If not, the system shall evaluate an error. The standard interface was designed for no more than five imagined axes. If the system has more than five axes, it is possible to call the menu, which offers names of all axes in the system by clicking the right mouse button in the field. Now you can select, which axis you want to display in the line.



The screenshot shows the Cnc886 software interface. At the top, there are tabs for 'Auto', 'Manual', 'Library', 'Param', 'Service', and 'Errors'. The status is 'Ready'. Below the tabs is a table with columns: 'Axes', 'In program', 'Tool 370', 'Off.G53', 'ProgOff', 'InP', and 'Mode'. The table contains data for X, Y, Z, A, and C axes. Below the table are 'Radius' and 'Spindle' rows, and a 'Feed' row. At the bottom, there are five control buttons: 'RESET', 'START-', 'SPEED', 'START+', and 'STOP'. A dropdown menu is open over the 'Spindle' row, showing options X, Y, Z, A, C, and V.

| Axes | In program | Tool 370 | Off.G53 | ProgOff | InP | Mode |
|---------|------------|----------|---------|---------|-----|----------|
| X | 85.623 | 0.000 | 0.000 | 0.000 | Yes | Normal |
| Y | 226.952 | 0.000 | 0.000 | 0.000 | Yes | |
| Z | 57.799 | 0.000 | 0.000 | 0.000 | Yes | |
| A | -50.924 | 0.000 | 0.000 | 0.000 | Yes | |
| C | 39.032 | 0.000 | 0.000 | 0.000 | Yes | |
| Radius | | 0.000 | | | | Step |
| Spindle | 0 | 0 | 1.00 | | | Duration |
| Feed | 0 | 0 | 1.00 | | | 0:00:00 |

M5 M50 H7

```
%1:%1 {5X_MODEL2_T370.CNC}
%1:N5 T370 S18000. M3
%1:N10 G54
```

The last line of the table is **Length**, which serves for displaying the radius correction or length correction. By clicking on the Length sign you switch between these two corrections. The sign Length changes at the displaying of radius correction to Radius.

Mode

On the right from the table of axes there is a box with sign **Mode**. Under this sign there is a roll-out menu, which allows you to select the desired mode.



The screenshot shows the Cnc886 software interface. At the top, there are tabs for 'Auto', 'Manual', 'Library', 'Param', 'Service', and 'Errors'. The 'Ready' status is shown in the top right. Below the tabs is a table with columns: 'Axes', 'In program', 'Tool 370', 'Off.G53', 'ProgOff', 'InP', and 'Mode'. The 'Mode' column has a dropdown menu open, showing options: 'Normal', 'Test', 'From', 'Time', and 'FromPos'. The 'FromPos' option is currently selected. Below the table, there are fields for 'Spindle' and 'Feed', both set to 0. There are also buttons for 'Step' and 'Duration' (0:00:00). At the bottom, there are several control buttons: 'RESET', 'START-', 'SPEED', 'START+', and 'STOP'. The main display area shows the following text: 'M5 M50 H7', '%1:%1 {5X_MODEL2_T370.CNC}', '%1:N5 T370 S18000. M3', and '%1:N10 G54'.

Normal

If Normal is active, the run of the entire program shall be started after pressing the START+ button.

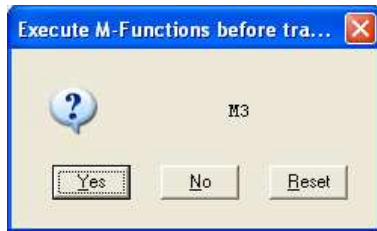
Test

If Test is active, the check of the entire program shall be started after pressing the START+ button. The system shall process the program, however without any movements of axes and without the M function. Nevertheless, all corrections, shifting of the starting point etc. shall be taken into consideration, so that if no program error occurs, no error occurs at the real operation as well. Another result is that the verification whether limits of axes are not exceeded and the dimensions of the resulting work-piece are measured so it is possible to determine the size of the necessary semi-finished product. These results are stated in the message in Errors tab.

From

In the From mode the program is tested only to the program line the number of which is entered in the field under the Mode field. The program test shall stop at this line and following lines are processed already in the normal mode, when axes are moving and

M functions are carried out. For a correct change between the test and the normal mode the system shall offer all M functions which are active according to the program. Some machines require based on their logic initiation of functions to initiate them before pre-travel, some require their initiation after pre-travel. The selection shall be made by the manufacturer and therefore the menu dialog may appear in other phase than described below.



The Dialog shall offer a list of all M functions.

There are three options of choice:

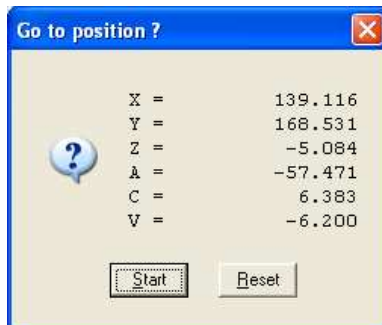
- Yes immediate realization of the offered function
- No functions shall not be realized
- Reset the program is terminated

If you answer by selection of No, there is still an option to start functions manually by means of some other method,

for example from tab 3.4.3 Tab Manual Function.

After answering to the dialog with menu of functions the system offers another action, which is the pre-travel to the initial point. The coordinates are absolute.

Selection of Reset ends the program without movement.



After pressing the Start button (or START+) the movement from the current position to the position at the beginning of the program line, from which the performance of the program was entered, is carried out. The movement is carried out in the order of axes determined by the producer. During the entire time of movement the control system is in Stopped status, in which it is allowed to carry out many operations, e.g. to start or to switch off M functions. After its end the machine stops in the status equal to the STOP button. It waits for

the START+ button for the continuation. Even in this moment, it means after completion of the pre-travel, it is possible to start and switch off M functions. After pressing the START+ button the program continues in the Normal mode.

Notes:

The track, on which the pre-travel shall be carried out, depends on the type of the machine. In case of a five-axes cutter the following process is selected: C axis and A axis are rotating first, then the pre-travel at X and Y axes is carried out and at the end at Z axis. The pre-travel is carried out by the fast feed. If you are not sure about the trajectory, on which the pre-travel is carried out, it is better to select the fast feed speed limitation by means of SPEED button.

At the program operation a precise compliance of the row number with the preset value is being tested. So, if the program does not contain the row with the number, the entire program shall operate in the Test mode.

Time

If the Time mode is active a simulated run of the entire program including acceleration and braking ramps, deceleration in dynamically problematic points etc. shall be started by pressing the START+ button. The system is measuring the consumed time. The time is running according to the processor performance approximately 30 up to 60 times faster than at the real program operation. The resulting time of the program



operation displayed in the field Duration is a very good estimation of program operation time. Not only time of realization of M functions is included in it. In case M functions do not create an essential part of the program, the incorrect estimation is in order of seconds even at programs lasting many hours. The measuring result is also recorded in the Errors tab, in which the total run track and the average speed of feed are displayed.

FromPos

This mode is very similar to the From. However, the initial position is not entered by the line number, but by the current position of the machine. The program shall be initiated in simulated mode and checks the position of simulated passage with real position. If the values conform (to the accuracy predefined by the manufacturer) the simulation stops and the transition to normal mode is prepared the same way as in the From. This mode is permitted only with several types of machines.

Step

The Step button serves for switching the standard mode of the program operation and step operation. If the step operation is selected, the button remains pressed in. Each pressing changes the mode. The mode may be changed even during the operation of the program if the program is suspended.

Duration

On the right from the table of axes is a field with the title **Duration**. In this field the time of processing in hours minutes and seconds is being displayed while the program is in operation. The information remains displayed even after termination of the program and provides the information on the time of duration of the program initiated for the last time.

Spindle

The row inscribed by the title **Spindle** serves for monitoring and adjustment of operation of the spindle. In case of machines that do not have the spindle, the row is either empty or it is used for control of some other type of equipment. Current speed in revolutions/min is displayed in the red field. The positive value of speed conforms to the M03 function – spindle forwards, the negative one conforms to M04 function – spindle backwards. The left field displays the speed prescribed by the program. The remaining part of the row serves for correction of revolutions/min. The left arrow reduced revolutions by 10% steps; the right arrow increases revolutions by 10% steps. The square 100% button cancels the correction. The current value of speed correction is displayed between arrows. The correction may have values 0.50 up to 1.50.

If the machine has more spindles, it is possible to click on the field **Spindle** and to switch cyclically between displays of individual spindles. The field with display of speed adjustment coefficient which is individual for each spindle is changing as well.

Feed

The row prescribed by the title **Feed** serves for monitoring and adjustment of movement speed. A current feed in mm/min is displayed in the green field. The field on the right displays the feed prescribed by the program. The remaining part of the row serves for feed override. The left arrow decreases the feed by 10% steps; the right arrow increases the feed by 10% steps. After the speed is reduced to the value lower than 10 % the value is decreasing or increasing by 1 %. The 100 % button cancels the correction. The current value of feed correction is displayed between arrows. The



correction may have values 0.00 up to 1.00. At the value of 0.00 the machine stops, however the program operates! Repeated setting of non-zero correction restores the feed.

Active M functions

Under the row **Feed** there is a field, in which active M functions are being displayed.

Active G functions

Another row is displayed at the program operation and active G function.

Active ECHO

Another row (empty in the sample) displays a text at the program operation written by the ECHO program command.

Program lines

Last field of the tab displays part of the program, which is just being processed. The line, which is being processed, is displayed as the first. After the stop in the Step mode the completed row is displayed as the first and the row prepared for another step is displayed as the second.

3.3.1. Axes position

The axis position is displayed based on the real value read from the servo-mechanism. Therefore it may vary even in the idle condition of the machine. The system allows selecting the way of position display.

There are five modes available:

| Mode | Method of position value calculation |
|------------|--|
| In program | The displayed value is the total of: <ul style="list-style-type: none">• positions reported by Irc servo sensor• positions of the reference point• manually preset offset of the coordinates system• tool correction• coordinates system offset G53 up to G59 set in terms of the program• coordinates system offset set by G92 |
| Corrected | The displayed value is the total of: <ul style="list-style-type: none">• positions reported by Irc servo sensor• positions of the reference point• manually preset offset of the coordinates system• tool corrections• coordinates system offset G53 up to G59 set in terms of the program |
| Absolute | The displayed value is the total of: <ul style="list-style-type: none">• position reported by Irc servo sensor• positions of reference point• manually preset offset of the coordinates system |
| Irc | The displayed value is a position reported by Irc servo sensor, |

More about the meaning of modes of display see in *6.1 System of coordinates and corrections*.

The modes are being switched by using the roll-out menu and selection of the choice.



A form for displaying one more position is available in the Auto tab. It is the **To end**. The difference between the current position of the coordinate and the end position given by the just completed line of the CNC program is displayed in this mode. This mode is not available in other tabs.

3.4. Tab Manual

Manual tab joins functions, which are being carried out manually by the operator. In this mode the system has a limited option of verification of the correctness of realized operations and the operator is responsible for their result.

3.4.1. Tab Manual Move



The tab Manual-Move has a table in its upper part for the display of the axes status and an additional button **Adjust** (it may vary at some systems).

Under the table there is a row for the manual operation of the spindle and the row with the four buttons for selection of manual movement speed.

The last row is determined for entering simple commands.

The Table of Axes

The table for display of axes status contains following columns:

- **Sel** - is the column of buttons by means of which it is possible to select the axis for movement. The inside of the small box lights up as you can see as the example in the X axis on the picture. When leaving the tab the selection automatically resets. It is a certain safety measure, which prevents moving of axes by mistake. It may sometimes cause a delay, however it minimizes the probability of damage.
- **Axis** – displays names of axes

- **Position display** – it abides by the same rules as the **Auto** tab. The exception is display in final positions within the range of axes movement. If the lower final position is reached, the **Lower Limit** is displayed; in case the upper position is reached the **Upper Limit** is displayed. Final positions are preset by the machine constants in the configuration file.
- **Offset** displays manually preset offset of the system of coordinates. Change of this preset shall be carried out by **Adjust** button. After it is pressed, the **Offset** title changes to **NewAbsP** and the **Adjust** button changes to the pair **Done** and **Clear**. Items of the column shall become editable. You can enter the position in it (in the meaning of Absolute display). After pressing the **Done** button the shifting of the system of coordinates is adjusted so that the system shall report the current position Absolutely equal to the value preset by you. The **Clear** button zeros the shifting. Change carried out by the button **Adjust** is accessible only in the idle state of the machine. The value of the offset is stored in reserved R parameters and it is kept in the computer disc. Therefore it remains preserved also after the system is switched off and switched on again.
- **Ref** is the status attribute of axis indicating whether the referencing took place.
- **InP** is the status attribute of axis indicating the state of In Position the same way as in Auto tab
- **NSt** and **PSt** are statuses of end limit sensors in axes. In the Yes condition is everything ok and the position is inside the limits.
- **Err** is the error status attribute of servo-amplifier.

| | NewAbsPos | |
|-------|-----------|---|
| 23 | 85.623 | Y |
| 52 | 226.952 | Y |
| 99 | 57.799 | Y |
| 24 | -50.924 | Y |
| 32 | 39.032 | Y |
| Done | | |
| Clear | | |

Row Speed

The row starts with the indication box. If the spindle is manually initiated the box is lighting. On the right from the **Spindle** title there is a field for current speed of the spindle and besides this there is a box for preset spindle speed. Buttons **DN** and **UP** allow the setting. **DN** reduces the speed, **UP** increases the speed with the pace determined by the machine configuration. The row ends with **FWD** button, which initiates rotation of the spindle forward and the **RWD** button, which initiates rotation of the spindle rewards. Direction of revolutions may be changed also during operation of the spindle. The spindle is stopped by **RESET** button on the fingerboard. If the machine has more spindles, it is possible to click on the **Spindle** field and to switch cyclically between displaying individual spindles. Also the fields with display of required speed, which is individual for each individual spindle, are changing. Buttons **UP**, **DN**, **FWD**, **RWD** and **RESET** relate to the currently selected spindle. If the machine has no spindle, it is empty or it is used for control of another machine.

Row Feed

The four buttons allow changing speed of the manual movement. The speed for manual movement is assigned to each axis in machine constants. This value is multiplied according to selection of button by 10x, 1.0x, 0.1x or 0.01x. The selected speed and the current speed are displayed in small windows.



Row for Command Entering

For manual pre-travel to a certain position or for machining of very simple shapes the system allows entering a one-row command in CNC language syntax. Touching the indication box of the text field activates the cursor and it is possible to edit the command. It is possible to select the row by pressing the indication box – the same way as the selection of individual axes. If the row is selected, it is possible to carry out the command by pressing the **START+** button. In this moment the system generates a three-row program the first row of which is a heading, the second row represents the command entered by you and the third one contains the M30 function for termination of the program. This program is saved on disc under the name ManualCmd.cnc and it is possible to activate it automatically and initiate it. After completion of work the system takes your program out of the memory and activates the original program. However the ManualCmd.cnc file remains on the disc.

Vector

For some machines, such as five-axes cutters, it is possible to activate the Vector menu in the configuration file. It allows manual movement in the axis of the tool and this way also moving the work-piece out when the program is interrupted etc. The item is selected the same way as the movement in the individual axis and the movement is initiated by buttons **START+** (forward in the direction of the tool) or **START-** (backwards in the direction of the tool). Calculation of the direction is tightly connected with the mechanics of the machine instruction and it is carried out by the system.

Fingerboard

When opening the **Manual Move** tab, some buttons on the panel have rather different functions:


START- If one of axes is selected (the indication box beside it is lighting), you may just press the **START-** button, which initiates the backward movement in the given axis. The movement shall be ended by releasing the button. Movement may be initiated even when the spindle is running.

START+ If one of axes is selected (the indication box beside it is lighting), you may just press the **START+** button, which initiated the forward movement in the given axis. Movement may be initiated even when the spindle is running. The **START+** button serves for initiation of the single-row command, provided it is selected. It is not possible to start operation of the program in this tab.

3.4.1.1. Position limits

If axes are referred the system does not allow manual moving behind limits set by machine constants. However, if the axis is not referred, the system is not able to supervise final positions. In this situation the operator may run up to the emergency end switches, which results in the error state. .

3.4.2. Tab Manual Referencing



| Sel | Axis | Abs position | Ref | InP | In1 | In2 | PSt | NSt | Err |
|-------------------------------------|----------|--------------|-----|-----|-----|-----|-----|-----|-----|
| <input checked="" type="checkbox"/> | X | 85.623 | Yes | Yes | No | No | Yes | Yes | No |
| <input checked="" type="checkbox"/> | Y | 226.952 | Yes | Yes | No | No | Yes | Yes | No |
| <input checked="" type="checkbox"/> | Z | 57.799 | Yes | Yes | No | No | Yes | Yes | No |
| <input checked="" type="checkbox"/> | A | -50.924 | Yes | Yes | No | No | Yes | Yes | No |
| <input checked="" type="checkbox"/> | C | 39.032 | Yes | Yes | No | No | Yes | Yes | No |
| <input checked="" type="checkbox"/> | V | -6.200 | Yes | Yes | No | No | Yes | Yes | No |
| <input type="checkbox"/> | ---- | ---- | No | No | No | No | No | No | No |
| <input type="checkbox"/> | ---- | ---- | No | No | No | No | No | No | No |
| <input type="checkbox"/> | ---- | ---- | No | No | No | No | No | No | No |
| <input checked="" type="checkbox"/> | All Axes | | | | | | | | |

Tab Manual-Referencing contains a table for display of axes status.

Table Axes

Display of axes status table contains following columns:

- **Sel** - is a column of buttons, by means of which an axis for referencing is selected. The inside of the box is lighting at the selected axis. When leaving the tab the selection automatically zeroes. It is a certain safety measure, which prevents moving of axes by mistake. Sometimes it may cause a little delay, however it minimizes the probability of damage.
- **Axis** – displays names of axes
- **Abs position** – displays position of the axis in the sense of Absolute mode. It is not possible to switch the mode in the tab.
- **Ref** - is a status sign of axis indicating, whether the referencing was carried out.
- **InP** – is a status sign of axis indicating the In Position status, the same way as in **Auto** tab.
- **In1** and **In2** – are statuses of sensors used for indication of reference positions – which of sensors is used and how it depends on setting of servo-amplifier and selection of referencing algorithm.
- **NSt** and **PSt** – are statuses of end limit sensors on axes. In yes status – everything is ok and the position is inside the limits.

- **Err** – is an error state sign of servo-amplifier.

Item All

The tab Item All is prepared for facilitation of work. Its selection and pressing of the **START+** button initiates referencing of all axes in the order preset by the manufacturer.

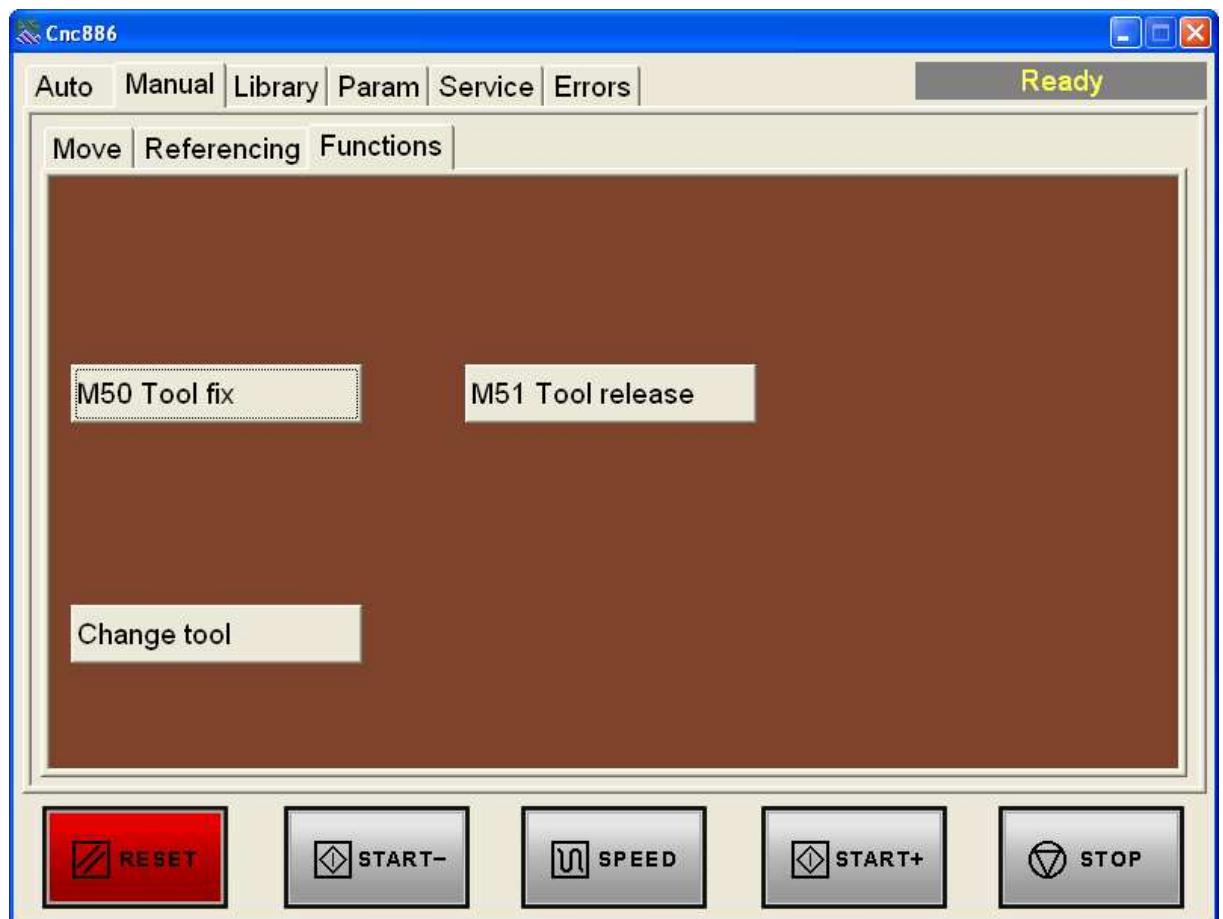
Fingerboard

When opening the **Manual-Referencing** tab, some buttons on the fingerboard have rather different functions:

START+ If some of axes is selected (the indication box is lighting), pressing the **START+** button initiates the referencing process.

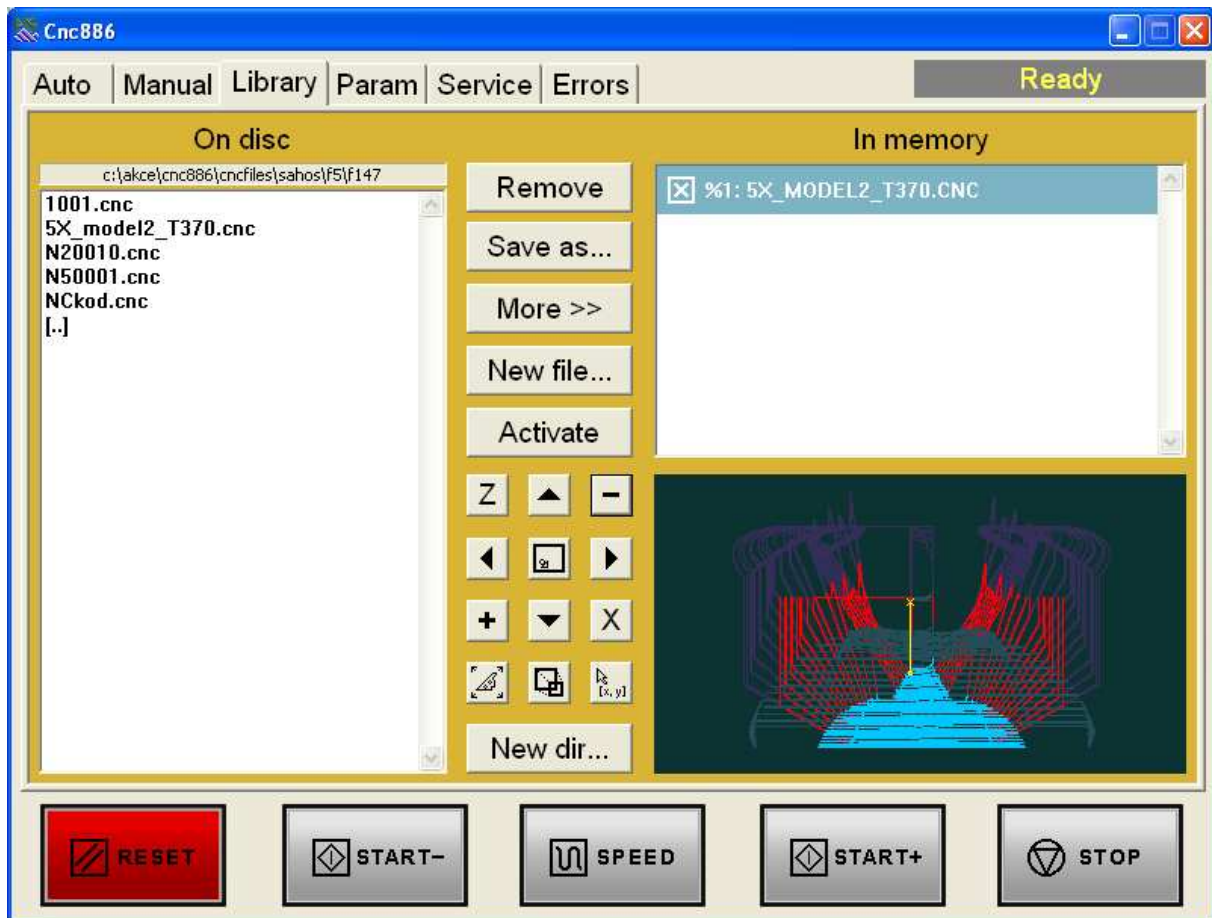
RESET This button interrupts the referencing process. When the program is in operation or the spindle is manually initiated, the operation is stopped.

3.4.3. Tab Manual Functions



Content of this tab is completely dependent on the particular machine. There are placed buttons for various functions. Their number and the related reaction of the system are changeable.

3.5. Tab Library



The **Library** tab serves for reading of programs from the disc or from the serial line to the memory, saving to the disc, erasing from the memory and the disc, selection of the program for initiation etc. The tab contains a window with list of files with programs on the disc titled **On disc**, window with list of programs in the memory titled **In memory** and window with view of the program selected for initiation (see below). Further there are following buttons: **Remove**, **Save as ...**, **RS232**, **New ...**, **Activate** and **New directory ...**. Some buttons change their function and the title depending on the fact, whether the selection of the program in memory or in the disc is active. All operations may be carried out only when the machine is in idle status.

On disc

The window contains list of files with programs on the disc in the directory titled in the headline of the window. The initial directory is determined by machine constants. It is possible to go through the directory structure; however it is possible to realize operations only in the initial directory and its subdirectories. The name of any of files or directory is selected by clicking on the file or directory (its name is displayed in white on grey background) and it is prepared for an action according to buttons.

For moving with the cursor inside the window you can easily use cursor keys of the keyboard. It is particularly advantageous when going through the directory structure. Point on the selected directory with the cursor and enter to it by means of ENTER key.

To leave the directory “one level above” you have to point to the item „[.]” (Up Dir) placed before the first subdirectory.

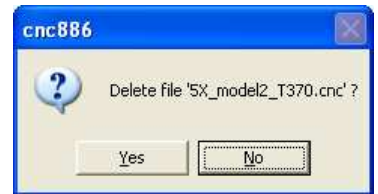
For quick searching of the file you may just press the initial letter of the file name. The cursor automatically moves to the first file with the relevant initial character.

In memory

The window contains a list of programs loaded to the memory from the disc or from the serial line. The loaded program has a number with % character included in the first row and an optional text in parenthesis. This first row of the program is displayed in the window **In memory**. The relevant item is selected by clicking on the item of the window; (it appears in white on a grey background) and it is prepared for action according to buttons.

Remove/Delete

The button allows removing the file or the directory from the disc or from the memory according to the window of the selected item. Erasing in the memory is carried out immediately, erasing in the disc has to be first confirmed to the system. The directory may be removed only if it is empty.



Save as ...

The button **Save as...** allows to save the selected program on the disc under the entered name. If the item **In Memory** is selected, the program saves from the memory, if the item **On disc** is selected, the file saves from the disc. The dialog window with notice for entering the name of the file with **.cnc** suffix appears in both cases. If you change the suffix, you can not see the file in the window **On disc**! If you enter the name of a file, which already exists, the system displays a question, whether you wish to rewrite the file. If you enter a negative answer by means of the relevant button, the file is not saved.

More>>



The **More>>** button allows loading of the program to the memory from the serial line and from other sources. After you select RS232, the system immediately starts Loading: The status window displays number of loaded characters. Now you can send the program from the connected computer. If you want to cancel the operation, you should use the **RESET** button. After successful loading the name of the program appears in the **In Memory** window and the statement appears in the lower part of the window. At the same time the program is set as active, it means it is prepared for initiation. If you want to save the loaded program in the disc, use the option **Save as....** This option used to be utilized mainly in the past and it remained in the system. We suppose it will be deleted or replaced by something more useful.

New file/Edit

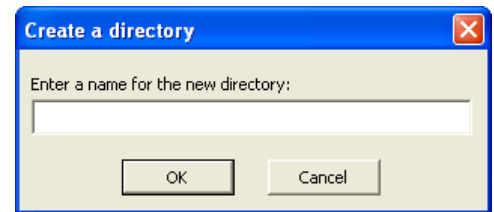
If the directory is selected or if the cursor is in the field **In memory** the button has title **New file...** and it allows creation of a new file with the CNC program. If the selection cursor is pointed on any file in the field **On Disc**, the button has title **Edit**. The button **Edit** allows editing of the program on the disc. After its pressing the editor opens. More information on the editor you can find in the independent chapter 3.9 *Editor*.

Load/Activate

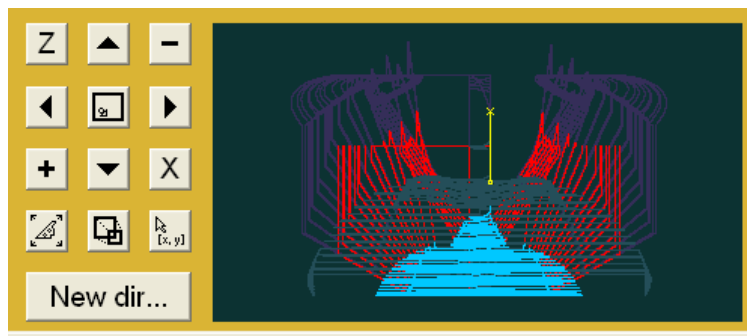
The button activates the selected program; it means that it prepares it for running. In case a file from disc is selected, the button is titled **Load**. It inputs the file to the memory; it displays its name in the window **In Memory** and indicates it as prepared for running. If a program with the same number already exists in the memory, an error is displayed. If a program was selected in the window **In Memory**, it becomes active, it means prepared for running. The active program is in the field **In Memory** marked by crossed box.

New dir ...

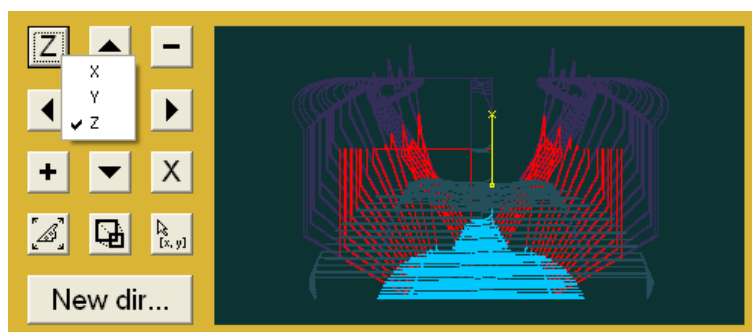
The button **New dir...** serves for creation of subdirectory. A dialog window with question about the name of the new directory appears. Further progress is intuitive and it shall not surprise any Windows user. It is ensured against cases of incorrectly entered names, attempts to create already existing directory etc.



Window with View

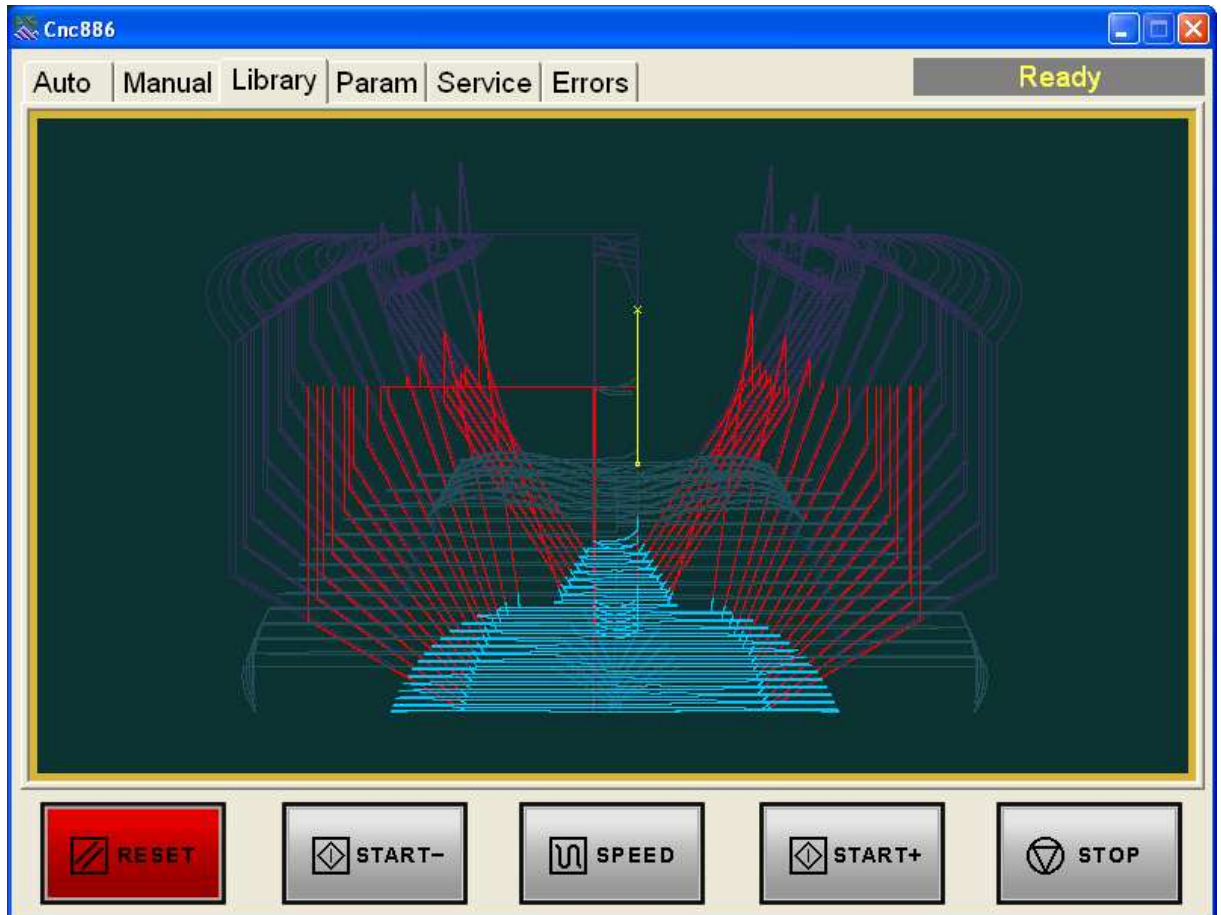


The window with view serves for display of the machine track. This function is initiated by clicking in the area of the window. A white picture appears on a black background, which in selected axes displays the machine trajectory. This function is determined first of all for orientation in technological programs. At the display the control system goes through the entire program, the same way as in the TEST mode. (However it does not carry out the check of exceeding the limit positions). The time of the program running through depends on its length and selected value of the interpolation step for the test, which is defined by the configuration file.



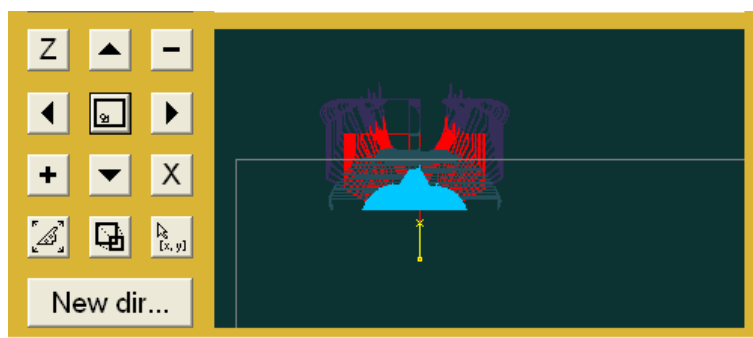
On the left from the window there is a set of buttons which serve for Zoom (+ and -), arrows for shifting of display and selection of axes (left upper arrow for vertical axis and right lower for horizontal axis). The button in the middle is for setting the initial display so that the accessible area of the machine in selected axes fits in the window. The button in the left upper corner allows selection of the vertical axis and the button in the right lower corner allows selection of the horizontal axis.

The current status of the tool position is displayed schematically even when the program is running. When the program is running, it is not possible to use the button for adjustment of display neither selection of axes.



The button “Full screen” above the button **New dir...** is available as well. It enlarges the view to the entire display. Clicking to the area of the view returns you back to the original display.

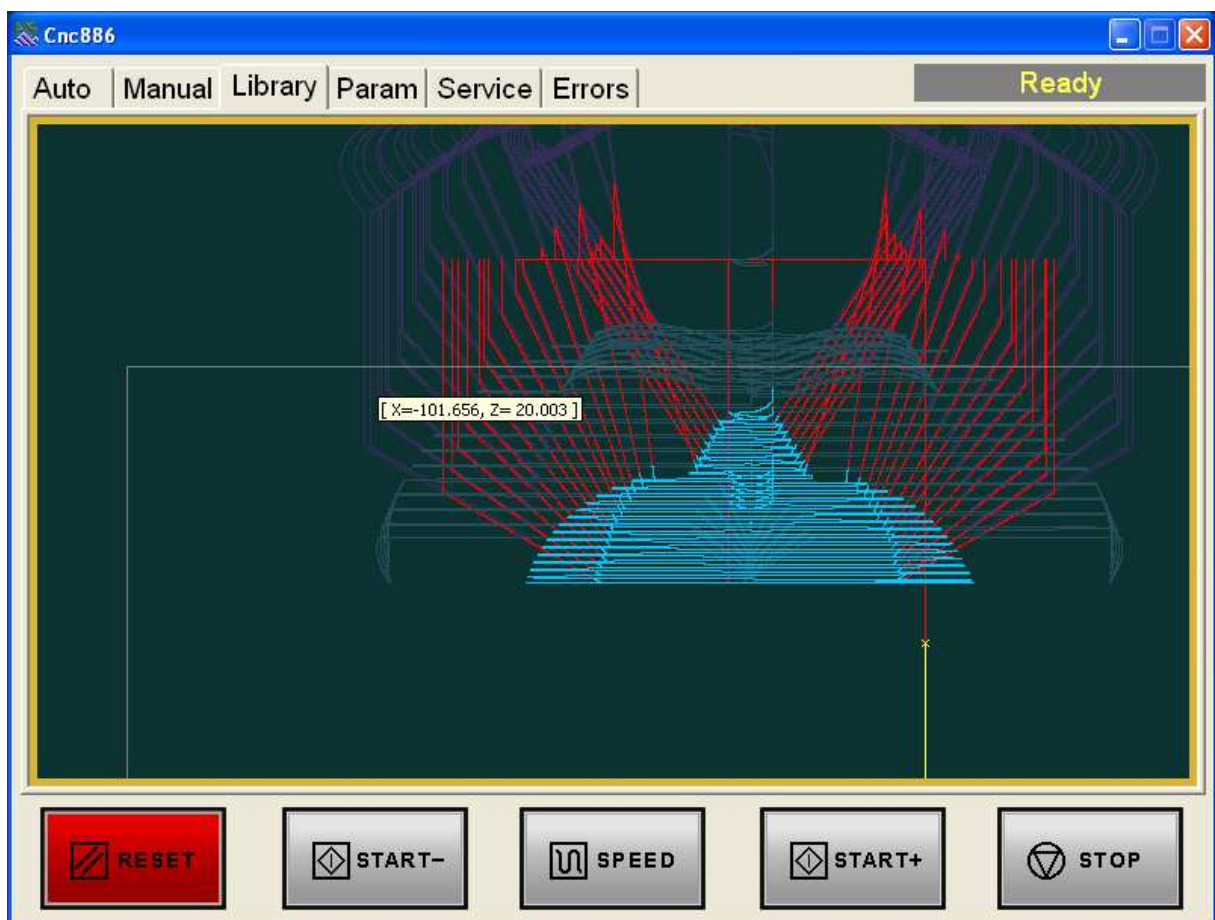
Trajectories made by the fast feed are differentiated by colors to ensure larger transparency and further trajectories of tool point and trajectory of the point determining final positions are differentiated as well. In the case shown on the picture there is a work-piece marked by white color. However, the tracks of the rotating point and machine tracks are relatively complicated, and therefore the work-piece is machined by a five-axes system with a tool of a certain length. Nevertheless, these tracks are decisive in its consequence in relation to fact whether it is possible to operate the program without exceeding the limit positions of individual



axes.

A similar situation, in which tracks of the tool point do not correspond to trajectories of the machine, is utilization of radius corrections. On the picture you can see how an unsuitable setting of the start of the system of coordinates, which leads to exceeding of final positions, proves. Besides tracks also the outlines of the accessible machine area in X and Z axes are displayed in the field of the view. The work-piece is inside the rectangle; however the machine trajectories exceed the outlines.

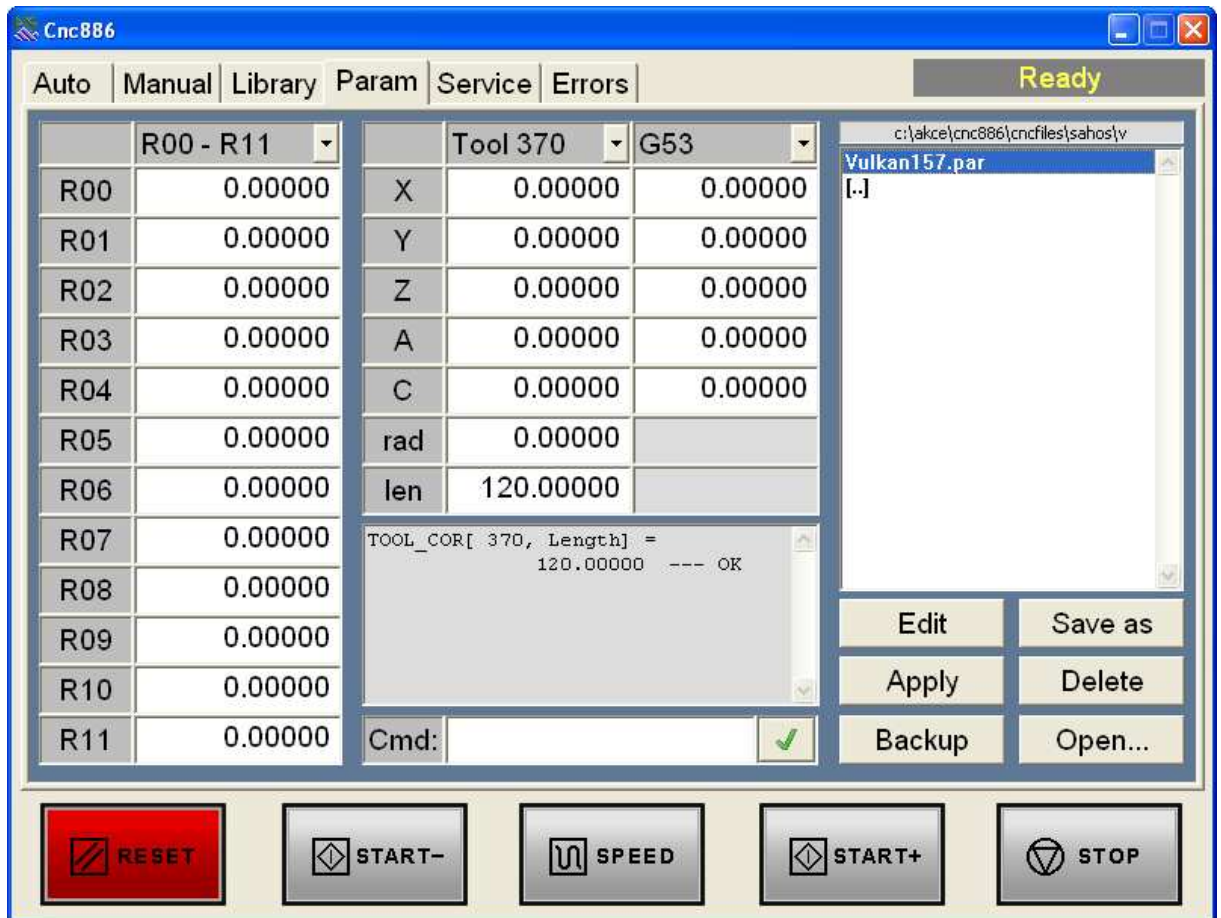
Another aid is the button on the right from the "Entire Display". It serves for switching on and off the function for display of the cursor position. If the button is pressed in, the position of the mouse cursor is displayed within the window of the display converted to machine coordinates. This way it is possible to measure distances within the displayed product.



Drag and drop

New versions of Cnc886 support drag and drop function. If you drag the file with CNC code and drop it in the Library window, you do the same like selecting the file and use **Load** button.

3.6. Tab Param



This tab serves for setting R parameters, tool corrections, and values for functions G53 up to G59. These parameters are particularly mentioned in chapter 6.2 *R Parameters*. Settings of corrections and parameters are kept in the system even after leaving this tab and saved in the hard disc and it is again loaded at the next start of the system, so the operator finds it again in the same status. It often happens that the setting for various programs significantly differs. Therefore there is an option to write setting of selected parameters to a file and then to load it. Parameters, which are not mentioned in the file, remain unchanged. Therefore it is possible to load even several files one after another and combine their effect. Files with setting have suffix **.par** and they have very simple format. It is a plain text file. Each row, which begins with the character of percent **%** is understood as a commentary. Other rows must contain commands of following type

R<parameter number> = <expression> ;

or

TOOL_COR[<tool number>,<correction name>] = < expression > ;

or they must be empty. Terminal semicolon is compulsory. The expression must be entered in a usual manner with utilization of addition, subtraction, multiplication, and division (signs **+, -, *, /**) including the option to use brackets and selected mathematical functions (more you can find in 7.2.2 *Arithmetical operations and*



commands statement). Elements of expressions are constants, or values of R parameters. (see the following example).

File example:

```
% -----Parameter file example-----  
%  
% Program parameters  
%  
R3 = 182.4 ; R4 = 15 ;  
R5 = (R4 + 3*R3)/25.4 ;  
%  
% Tool #1  
%  
TOOL_COR[ 1,X ] = 12.85 ;  
TOOL_COR[ 1,Y ] = 50.00 ;  
TOOL_COR[ 1,Z ] = 50.00 ;  
TOOL_COR[ 1,Length] = 180.00 ;  
%  
% END
```

The area of the tab is created by three roll-out menus for setting parameters, tool corrections, and offset functions G53 up to G59. In the right part there are tools for administration of files with parameters, i.e. it is a window for selection of files and buttons **Edit**, **Save as...**, **Apply**, **Delete**, **Backup**, and **Open...**. In the middle of the lower part of the tab there is a row titled **Cmd**: for setting the parameter with command and above it there is a window for log of commands.

R00-R09

Under the roll-out menu there is a list of twelve values of R parameters. Clicking on the value places the cursor in the relevant row and the value may be adjusted by the keyboard by entering the number or an expression. You can type for example **1.23**, but you can also type **R0+10*(2+SIN(65))**. You can use every line as a calculator. The value is saved in the parameter by clicking on another object of the tab or by pressing the Enter on keyboard. In the window for log of commands a record on realized change appears. If the entered value was incorrect, the record is provided with an error sign **??**. Otherwise it is provided with sign **OK**. When unrolling the roll-out menu a selection of another interval of displayed parameters is provided. Parameters in the range from R00 up to R102 may be adjusted. Further parameters may be set by means of a command in the window **Cmd**:

Tool

Under the roll-out menu there is a statement of values of tool corrections in mm for the relevant tool. In the row **rad** there is a radius correction; in the row **len** there is the length correction.

Unrolling the roll-out menu you can choose other tools. In total there are 1000 tools (T0 up to T999).

G5X

Under the roll-out menu there is a statement of values of coordinates shifts for relevant G function. Unrolling the menu you can choose from following functions G53, G54, G55, G56, G57, G58 a G59.



Files.par

The window contains a list of files and directories in the disc in the directory titled in the headline of the window. The initial directory is determined by machine constants. You can make the choice by clicking on the name of any file or any directory (its name displays in white on a grey background) and it is prepared for action according to buttons under the window.

Edit

The button **Edit** allows editing a file on the disc. If the file is selected in the window, the editor opens. More about the editor you can find in the chapter 3.9 *Editor*.

Save as ...

The button **Save as...** allows saving the selected file with parameters on disc under the entered name. A dialog window with notice inviting to enter the file name with suffix **.par** appears. If you change the suffix, you can not see the file in the window! If you enter a file name, which already exists, the system displays a question, whether you wish to rewrite the file. If you enter a negative answer by means of **No** button, the saving will be aborted.

Delete

The **Delete** button allows deleting of a file or a directory from the disc. The system requires confirmation for deletion from the disc. The directory may be removed only if it is empty.

Apply

The **Apply** button loads the file with parameters, if the file was selected in the window with files. The record on realized operation appears in the window above the **Cmd:** row. The file name is written in the.

Cmd:

By clicking in the white row **Cmd:** you are allowed to enter the command in the same format as in the file **.par**. This allows access to parameters, which are not within the range R0 up to R102. However, such need appears in praxis only rarely. The command is applied by pressing the ENTER on the keyboard.

Open...

The **Open...** button serves loading file from other source then the system disc.

Backup

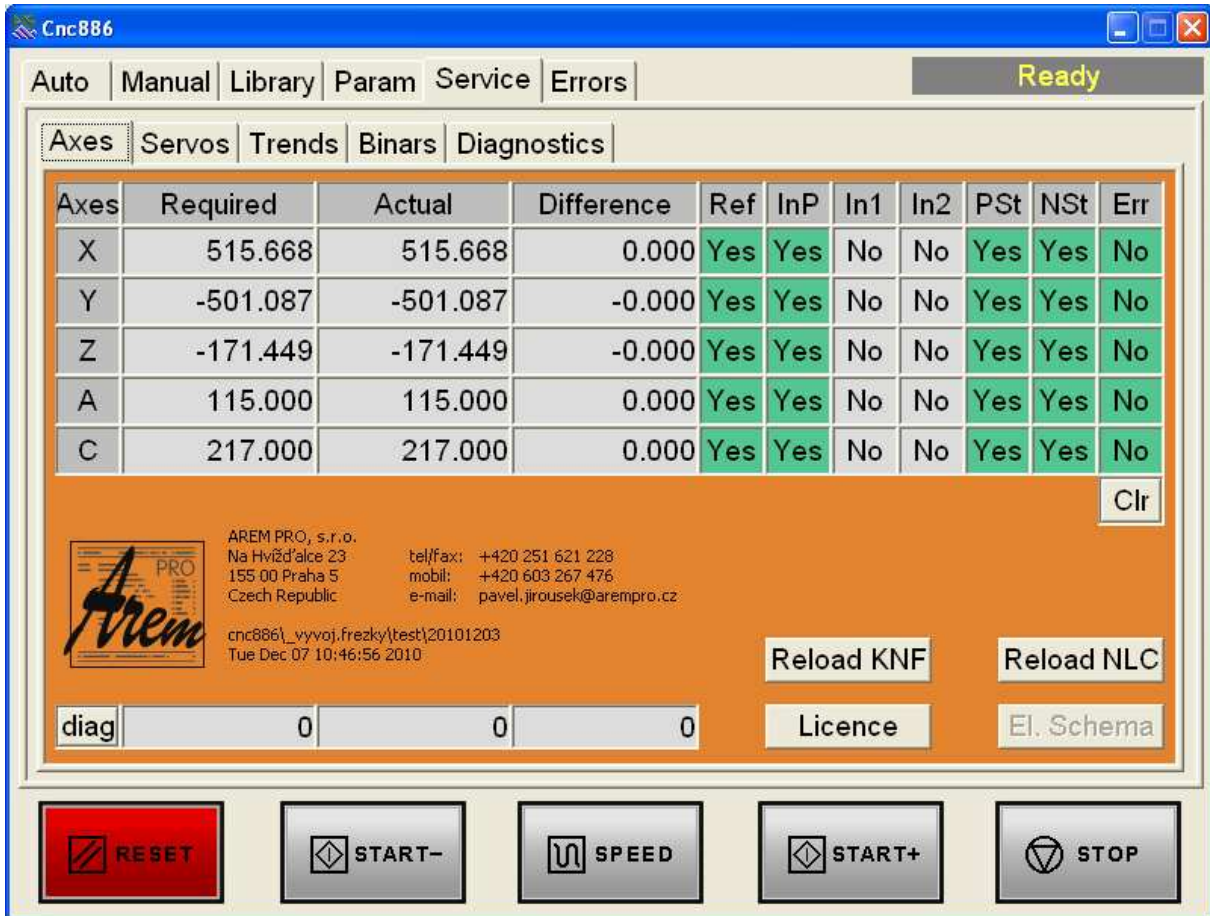
The **Backup** button serves for creation of a file containing current state of all R parameters. The file has a text format in the form applicable by **Apply** command. A file created this way may be used as a backup of machine settings, for example for tuning of tool corrections etc.

After pressing **Backup** the same dialog, as for the **Save as ...** button displays.

3.7. Tab Service

The Service tab is determined for machine diagnostics and for solution of special situations. Particularly the **Service-Binary** tab, which allows the operator to access to individual bites of outputs, it allows manipulations which have to be carried out with caution and forethought.

3.7.1. Tab Service Axes



| Axes | Required | Actual | Difference | Ref | InP | In1 | In2 | PSt | NSt | Err |
|------|----------|----------|------------|-----|-----|-----|-----|-----|-----|-----|
| X | 515.668 | 515.668 | 0.000 | Yes | Yes | No | No | Yes | Yes | No |
| Y | -501.087 | -501.087 | -0.000 | Yes | Yes | No | No | Yes | Yes | No |
| Z | -171.449 | -171.449 | -0.000 | Yes | Yes | No | No | Yes | Yes | No |
| A | 115.000 | 115.000 | 0.000 | Yes | Yes | No | No | Yes | Yes | No |
| C | 217.000 | 217.000 | 0.000 | Yes | Yes | No | No | Yes | Yes | No |

diag 0 0 0

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cnc886__vyvoj.frezky{test}20101203
 Tue Dec 07 10:46:56 2010

Reload KNF Reload NLC
 Licence El. Schema

RESET START- SPEED START+ STOP

Service-Axes tab contains in the upper part a table for display of the position of axes and an additional button **Clr**.

Under the table there is a row of diagnostics **diag** and a three buttons: **Licence**, **Reload KNF** and **Reload NLC**.

Table Axes

The table displaying the status of axes contains following columns:

- **Axes** – displays names of axes;
- **Required** – displays required position of axis in the mode of Irc display;
- **Actual** – displays the real position of axis in the mode of Irc display;
- **Difference** – displays the difference between the required position of axis and a real position of axis. This difference is calculated by the system. However the value of the position is loaded in another moment than the moment when the required value is loaded, therefore the displayed value is considerably higher than the real value depending on the speed.
- **Ref** – is status attribute of axis indicating whether the referencing was carried out;
- **InP** – is status attribute of axis indicating status of In position the same way as in **Auto** tab;



- **In1** and **In2** – are statuses of sensors used for indication of reference position - which of sensors is used and how it depends on setting of servo-amplifiers.
- **NSt** and **PSt** – are statuses of end emergency sensors on axes. In the Yes status everything is all right and the position is outside reach of these sensors.
- **Err** – is an error status attribute of servo-amplifier.

Clr

The button serves for zeroing of error status of servo drivers.

Diag

The row serves only for the purpose of service of the control program. The last window displays total length of the track run in the given program. The track is evaluated in the Test mode.

Licence

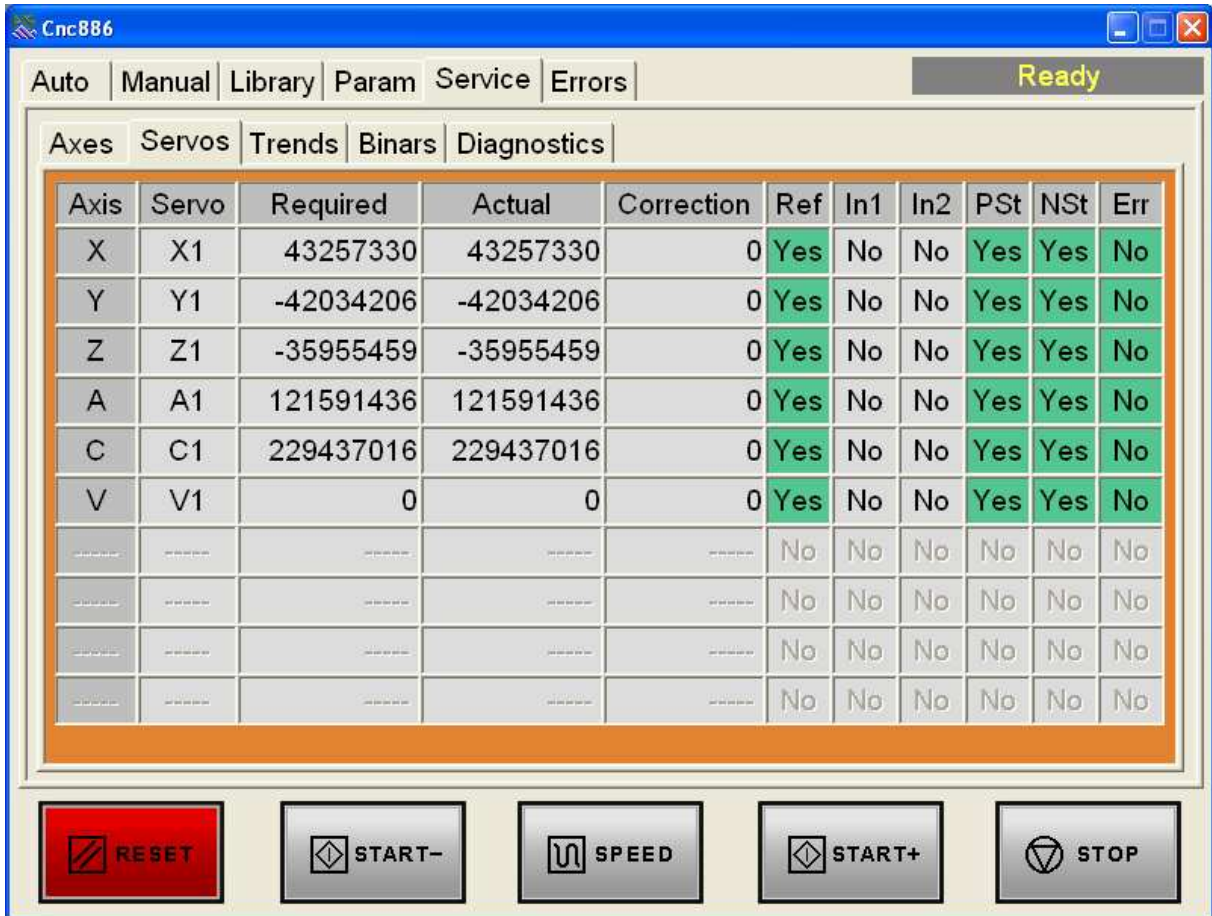
After pressing this button information on the term of control system licence validity appears. It serves also for entering the code by means of which it is possible to adjust the licence.

Reload KNF

Reload NLC

These two buttons are used only by service technicians. Non authorized use can cause unpredictable problems.

3.7.2. Tab Service Servos



| Axis | Servo | Required | Actual | Correction | Ref | In1 | In2 | PSt | NSt | Err |
|------|-------|-----------|-----------|------------|-----|-----|-----|-----|-----|-----|
| X | X1 | 43257330 | 43257330 | 0 | Yes | No | No | Yes | Yes | No |
| Y | Y1 | -42034206 | -42034206 | 0 | Yes | No | No | Yes | Yes | No |
| Z | Z1 | -35955459 | -35955459 | 0 | Yes | No | No | Yes | Yes | No |
| A | A1 | 121591436 | 121591436 | 0 | Yes | No | No | Yes | Yes | No |
| C | C1 | 229437016 | 229437016 | 0 | Yes | No | No | Yes | Yes | No |
| V | V1 | 0 | 0 | 0 | Yes | No | No | Yes | Yes | No |
| ---- | ---- | ---- | ---- | ---- | No | No | No | No | No | No |
| ---- | ---- | ---- | ---- | ---- | No | No | No | No | No | No |
| ---- | ---- | ---- | ---- | ---- | No | No | No | No | No | No |
| ---- | ---- | ---- | ---- | ---- | No | No | No | No | No | No |

The tab displays information on position of servos. The axes mentioned till now were virtual axes, which do not have to be realized by the same number and the same geometry of servos = physical axes. A frequent case is for example driving of portal by synchronous interaction of two servos. For better diagnostics it is allowed to monitor not only behaving of virtual axes, but the status of servos as well.

In the column **Axis** there is a name of virtual axis, which belongs to the given servo.

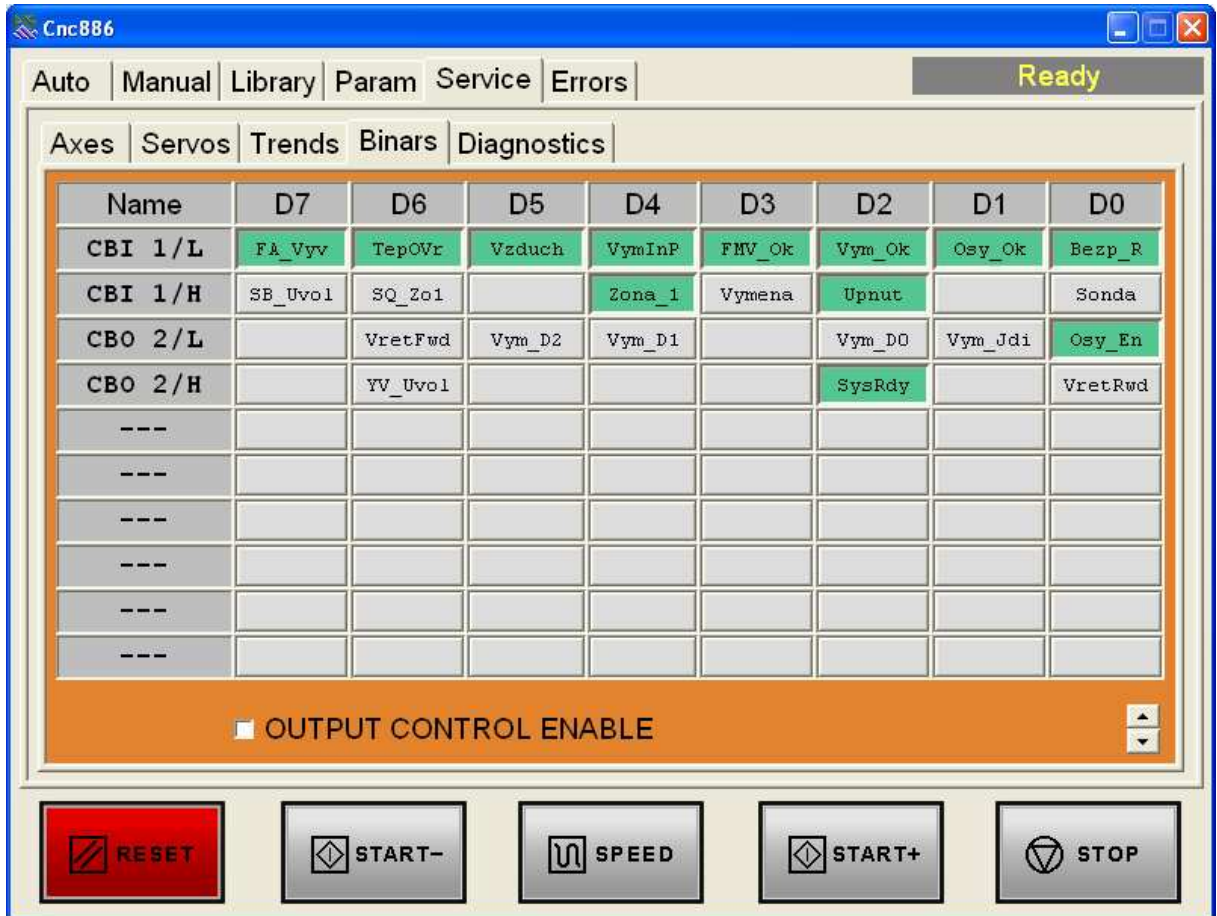
Servo column is a list of names of servos.

Required displays required position of servo in its units.

Actual displays current position of servo in its units.

Correction displays correction calculated and applied by the control system, linearizing the relation between virtual and physical axes. This correction is applied for compensations of nonlinearity of rising of ball screws, racks etc. to achieve the highest accuracy of the system as possible. At the calculation of corrections the system uses values measured for example by interferometer method.

3.7.3. Tab Service Binars



| Name | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|---------|---------|---------|--------|--------|--------|--------|---------|---------|
| CBI 1/L | FA_Vyv | TepOVr | Vzduch | VymInP | FMV_Ok | Vym_Ok | Osy_Ok | Bezp_R |
| CBI 1/H | SB_Uvol | SQ_Zo1 | | Zona_1 | Vymena | Upnut | | Sonda |
| CBO 2/L | | VretFwd | Vym_D2 | Vym_D1 | | Vym_D0 | Vym_Jdi | Osy_En |
| CBO 2/H | | YV_Uvol | | | | SysRdy | | VretRwd |
| --- | | | | | | | | |
| --- | | | | | | | | |
| --- | | | | | | | | |
| --- | | | | | | | | |
| --- | | | | | | | | |
| --- | | | | | | | | |

OUTPUT CONTROL ENABLE

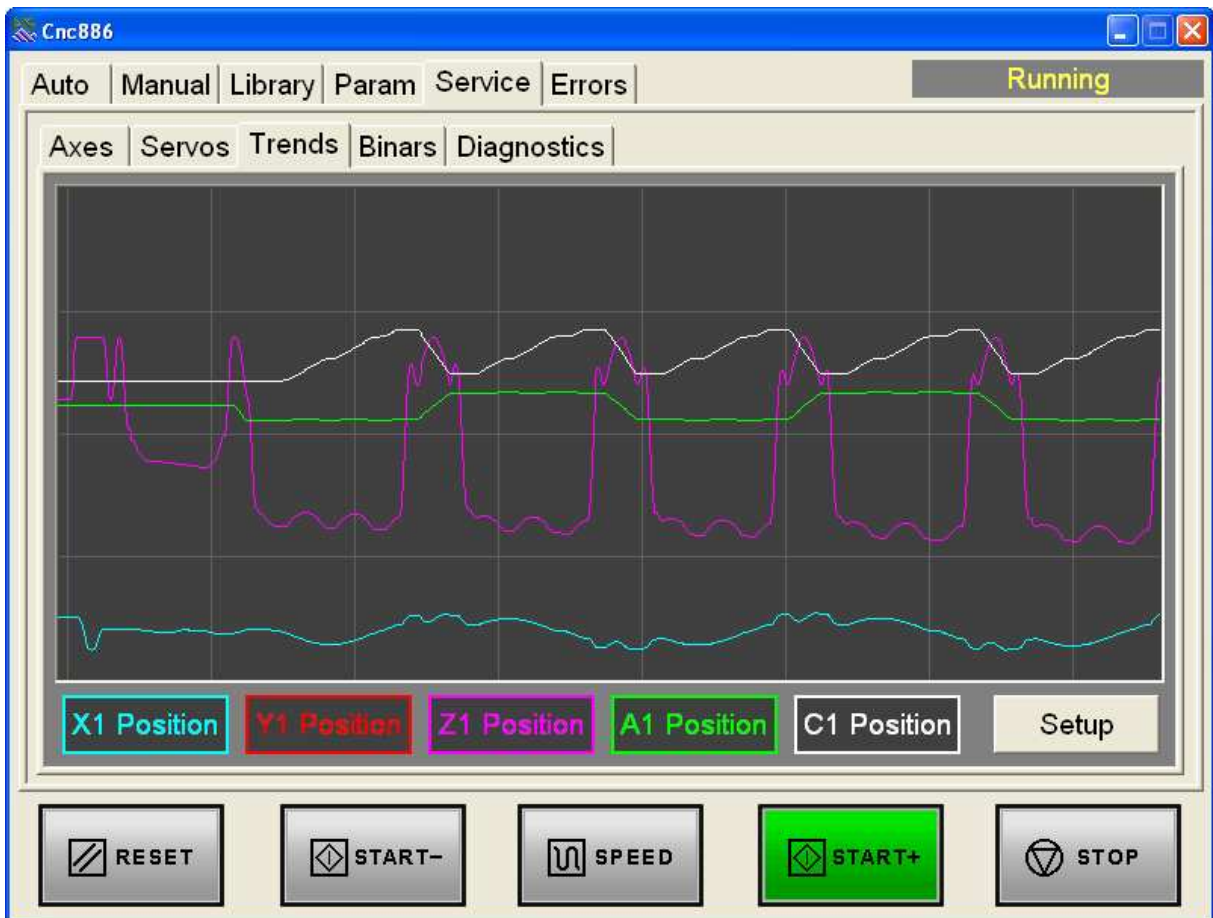
RESET START- SPEED START+ STOP

The **Service-Binars** tab contains table of binary inputs and outputs of the system. They are organized in 8 bit bytes. Meaning of individual bits and this way also notices in individual fields are quite dependent on concrete version of the machine.

Fields for individual bits signalize status **0** by grey color, status **1** by green color.

Output bits of the system may be changed manually by touching (clicking) in the field. Every touch means change of value. To prevent making changes by mistake it is first necessary to activate the button **OUTPUT CONTROL ENABLE**. After leaving the tab the button is automatically deactivated.

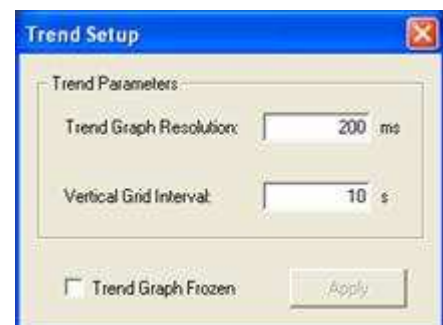
3.7.4. Tab Service Trends



This tab allows monitoring of servos parameters graphically. At each axis it is possible to monitor current of the engine, track deviation, and total load in percentage. Further it is possible to monitor the position, speed, and acceleration. First three pieces of information are calculated directly from servo-amplifiers. Display of current is basic. Change to another

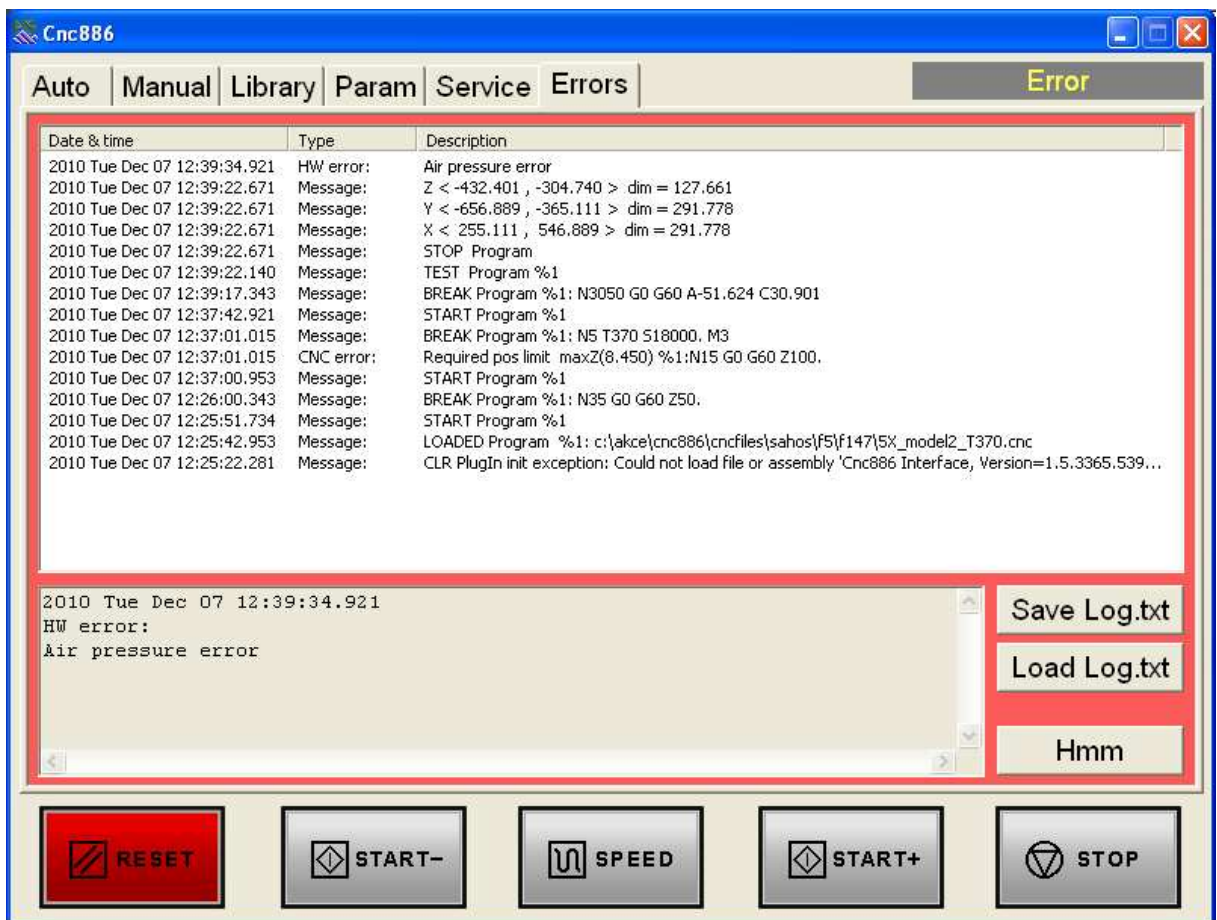


offered quantities or adjustment of content may be carried out by clicking on the button with the name of servo under the graph. A dialogue, the example of which follows, appears. A new method of displaying the trend may be selected here. Another servo may be also selected for the given color.



The **Setting** tab allows changing the scale on the horizontal axis of the graph and density of grid. If something interesting is visible in the graph and you want prevent disappearing it before you examine the picture, you may click in the graph and to fix the picture. It stops moving. Another click returns you back to the real time. Freezing and reactivation of the graph may be operated also by the checking character in the setting dialogue.

3.8. Tab Errors



The tab **Errors** displays a record on error states and other events. The window in the upper part of the tab allows view in the history of records from the last switch-on of the system. The data are provided with date and time of origin of the record, type, and specification of the record. Beside error states we can find there records on loading of the file in the memory, initiation of program, completion of the program or its stopping caused by an error or **RESET** button. At such event there is also a record on the row in which the program was interrupted. This allows us to continue by means of the **From** mode from the place in which the program was interrupted.

In case some error is active and the system is in the Error status, the error message appears in the lower window.

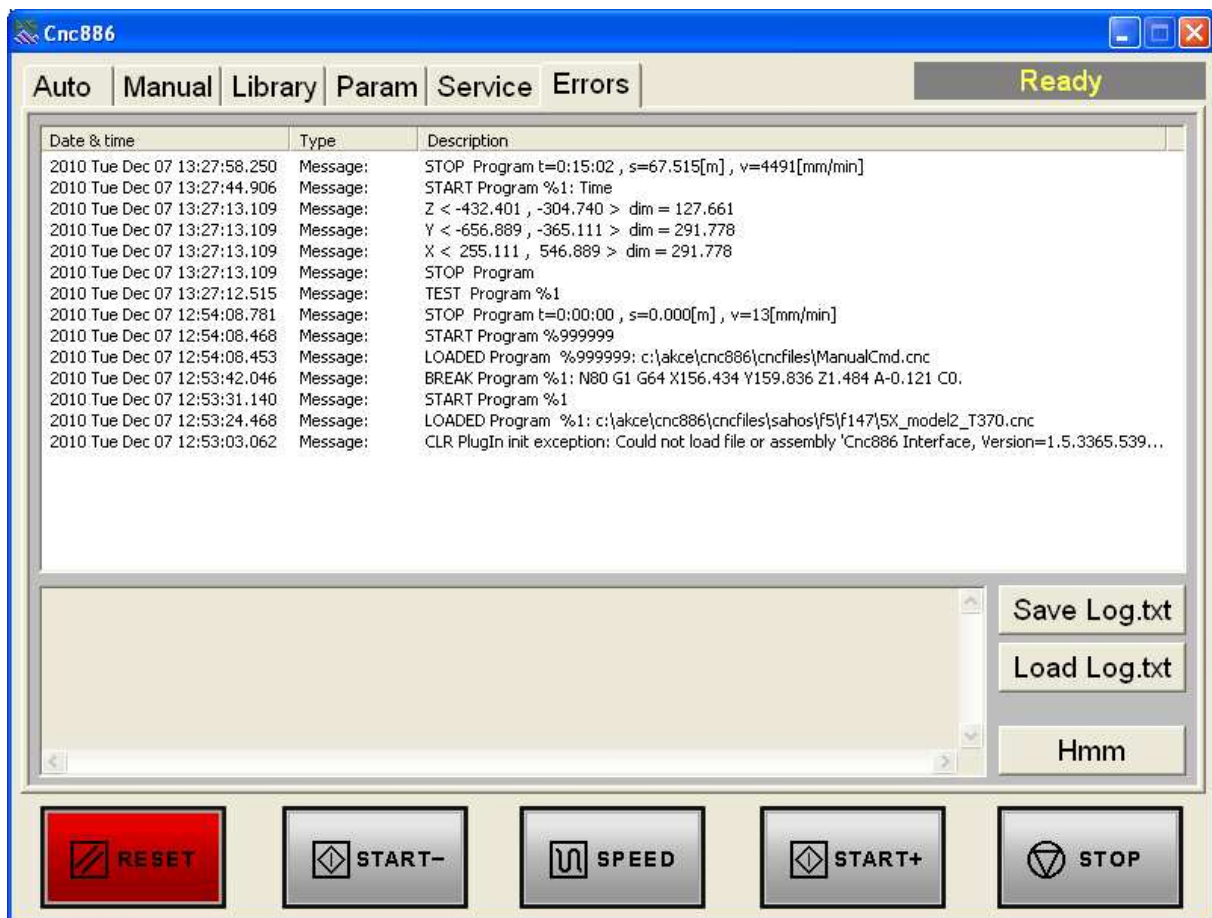
The Error status shall be confirmed by **Hmm** button. However, if the error lasts, the confirmation “aborts”. First it is necessary to remove the cause. But this relates to errors

such as “circuit breaker fallen out” etc. Program errors appear newly in the operation of the program only.

Error messages and other messages displayed in this window are or are not depending on the setting in the configuration file saved in the disc as well for service purposes. For the purpose of operation there are two buttons available: **Save Log.txt** and **Load Log.txt**. As the names suggest, they allow saving content of list of messages in the disc and loading them again. The saving is carried out in a special file Log.txt, which does not relate to earlier described file for service purposes. Saving and loading may be useful in cases when the operator wants to record information, for example on the program initiated last time, on the row in which the program was interrupted etc.

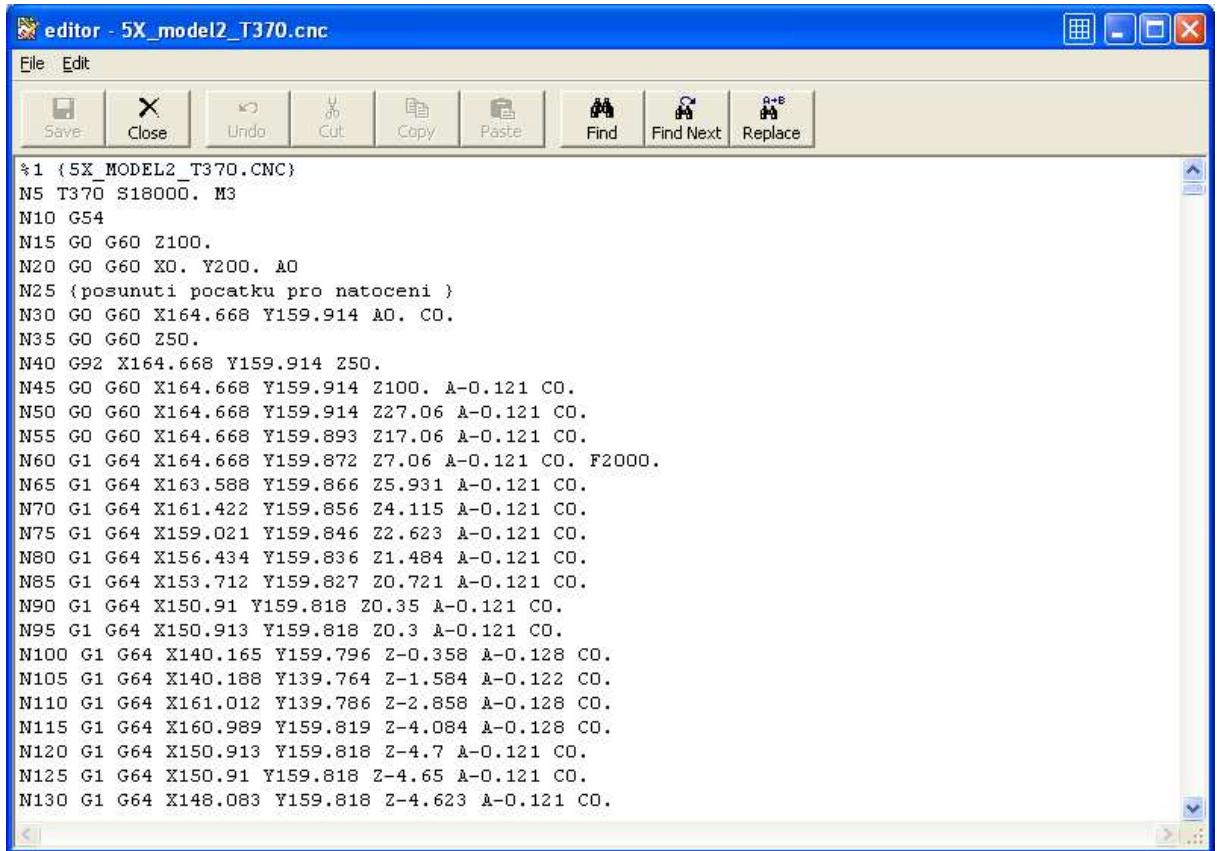
3.8.1. Other Information in Tab Errors

Also other useful information is saved in the record. For example in the mode **Test** the minimum and the maximum values of selected axes are monitored and at the end dimensions of the semi-finished product, to which the planned product fits, are written. On the picture you can see a statement which informs you that dimensions of the product shall be as follows: X=291.778 Y=291.778 Z=114.824.



Further the program was initiated in the Time mode and the result is the time 15 minutes 02 seconds, total track 67.515m with average speed 4491 mm/min.

3.9. Editor



The picture is a sample of display while editing the CNC file. Working with editor is intuitive and it perhaps does not need any comments. Considering the fact, that Cnc886 is integrated in Windows environment, the operator may use for editing of programs and other files other editors which is part of the operating system.

4. Manual Wheel AHW886

4.1. Basic Description



A manual wheel AHW886 is delivered with the Cnc886 system. It allows comfortable operation at manual pre-travels of the machine tool and smooth change of feed in automatic mode. Thanks to flexible cable with maximum length 6m it spans the entire working area of the machine.

The manual wheel is designed as an intelligent periphery of the control computer. Besides the circuit of the Central stop, which is solved separately by the separate pair of conductors, all information is being transmitted by the serial line. The transmission is controlled on the side of the wheel an inbuilt microcomputer, on the side of the control system it is the Cnc886 program. For communication with the operator the wheel contains:

- Two-row alphanumeric backlit display 2x16 characters
- Button with 100 locked positions for one rotation, equipped with incremental sensor of position
- Six control buttons

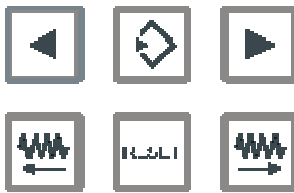
The display serves for display of information sent by the control system to the wheel. Beside the initial message,

HandWheel CNC886

AREM PRO ver-2.1

generated by the wheel, all others are sent by the control system and they reflect the Cnc886 program status, however not the status of the wheel. So, if the wheel display reports an error, it must not be an error of the wheel, but it may be an error detected by the control system.

The button under the display serves in manual modes for control of position of the selected axis, in the mode of the automatic program run for feed control.



Control buttons have various functions in various situations. In principle, it is possible to say that the upper three buttons serve as selection buttons (selection of mode, function, axis etc.); the lower buttons are operational (start/stop of shifting, program etc.).

4.2. Display of Cnc886 Situation

Display wheels reflect the status of Cnc886 program. For statuses, which do not permit control by wheel, there is a list of messages on the display summarized in the following table:

| Status | Wheel Display |
|------------------|-------------------------------------|
| Off | Switched off Wheel - ver. 2.0 |
| Initialization | Initialising Wheel - ver. 2.0 |
| Nor referred | Not referred Wheel - ver. 2.0 |
| Referring | Referencing Wheel - ver. 2.0 |
| Loading: xxxxxxx | Loading program Wheel - ver. 2.0 |
| Error | Error !! Wheel - ver. 2.0 |

4.3. Display and Control while the Program is Running

If the technological program is started, the wheel display shows current status, value of feed coefficient and text of the currently entered line (or its part).



Auto: F= 50%
N1203 G1 X150 Y1

While the program is running the Cnc886 may be still in the status of suspension and suspension with M0 function. In this situation the display shows:

Stop: F= 50%
N1203 G1 X150 Y1

M0: F= 50%
N1203 G1 X150 Y1

The display also shows the status of **SPEED** button of the control system. If it is pressed, the letter **F** at the percentage of shift is replaced by small letter **f**.

Auto: f= 50%
N1203 G1 X150 Y1

You can control the program operation by the wheel as follows:

You can change the feed coefficient by the button with the 1% step in the range from 0% up to 100%. Setting of the value to 0 completely stops moving of axes.



decreases coefficient by 10 %



increases coefficient by 10 %



changes status of the SPEED button of the control system



the same as the START+ button on the panel of Cnc886



program reset



stops the program the same way as the Stop button on the panel of Cnc886

4.4. Display and Control while the Program is Ready

If the Cnc886 program is in the Ready status, it is possible to use the wheel for initiation of the program and to control individual axes manually. There is a dialog prepared for selection of the required operation; the dialog is controlled by buttons of the wheel. The basic level of the dialog is a status, in which the following option is shown on the display:

Ready
Auto< >Manually



Selects automatic mode



Selects manual mode of the wheel

4.4.1. Control of Automatic Mode

The display shows:

```
Ready:      F=100%
%1 {Program XYZ}
```

The first row shows the status and the value of the feed coefficient and status of the SPEED button, the lower one shows the first row of the active program. In this status it is possible to set the feed coefficient by means of the wheel and to initiate the program by the wheel button, which has START+ function.

The RESET button of the wheel returns you back to the basic level of the dialog.

4.4.2. Manual Mode of Wheel – Axis Selection

In the manual mode of the wheel the display shows for example:

```
<- ax->    s=0.100
<->      X= 134.000
```

In the upper row the current step of the wheel is displayed. The title <- ax -> should indicate that the axis for movement shall be selected by arrows. The lower row shows the name of the selected axis and its current position.

In this status you may change position of the axis with the preset step by slow turning the button. "Fast feeds" are available as well. Functions of buttons are as follows:



Selection of the previous axis



Access to the mode of step selection



Selection of the following axis



The same as the START+ button in the tab Manual Move. The speed of the movement is according to the setting of the step 10x, 1x, 0.1x and 0.01x multiple of the speed, set for the relevant axis in the configuration file.



Access to the basic menu



The same as the START- button in the tab Manual Move. The speed of movement is according to the setting of the step 10x, 1x, 0.1x and 0.01x multiple of speed, set for the relevant axis in the configuration file.

At the manual shifting of the axis invoked by the wheel or from the panel of Cnc886 the display shows course and direction of move of shifting axis:

```
<- ax->    s=0.100
>>>      X= 134.000
```

4.4.3. Step Selection mode

In the mode of step selection the display shows for example:

```
<- s ->  s=0.100
<->  x= 134.000
```

The upper row shows current step of the wheel. The title <- s -> should indicate that the step should be selected by arrows. The lower row shows the name of the currently selected axis and its current position.

In this status it is possible to change the axis position with preset step by slow turning of the button. "Fast feeds" are available as well. Functions of buttons are as follows:



Selection of previous step



Access to another axes rose mode



Selection of the following step



The same as the START+ button in the tab Manual Move. The speed of the movement is according to the setting of the step 10x, 1x, 0.1x and 0.01x multiple of the speed, set for the relevant axis in the configuration file.



Access to the axis selection mode





The same as the START- button in the tab Manual Move. The speed of movement is according to the setting of the step 10x, 1x, 0.1x and 0.01x multiple of speed, set for the relevant axis in the configuration file.

4.4.4. Axes rose mode

```
  A      Z      B
  X*    Exit    Y
```



This level provides you with quick access to any axis. Selected axis is marked with *. Now you can move it with the wheel. Step was selected in the „Step selection level“.

The axes names are placed on the display in the same pattern, like buttons on the



AHW886. That means, that the  button will select Z axis, the  selects the Y axis etc.





RESET button moves you back to the „Step selection level“.

Pressing  and  simultaneously means „insert point“ in the case, that the system is equipped wit TeachIn option.. The display will respond







```
<<<  Point  >>>
<<<  inserted >>>
```

Pressing  and  simultaneously invokes continuous movement in the „tool direction“ away from the material.





Pressing  and  simultaneously invokes continuous movement in the „tool direction“ towards the material.

4.4.5. Wheel in Mode from Line and from Position

By means of the manual wheel it is possible to control also dialogs in the **From** mode and in the FromPos mode. After initiation of the program, which may be carried out again by the manual wheel, and after finding the initial point, you will be asked about initiation of M functions and about the pre-travel. In this moment wheel buttons function as follows:

-  reduces the fast feed coefficient by 10 %
-  increases the fast feed coefficient by 10 %
-  changes state of the SPEED button of the control system
-  the same as START+ button on the Cnc886 panel and **Yes** answer
-  program reset
-  answer **No**

The most frequent procedure is as follows:

1.  Start the program in the selected mode
2.  Answer **Yes** to the question on function initiation
3.  Answer **Yes** to the question on the pre-travel
4.  Initiate continuation of the program

4.5. Safety at Work with Wheel

Following conditions for occupational safety were created on the side of the control system:

- Manual movement invoked by the wheel may be stopped by pressing the RESET button in the Cnc886.
- Manual movement invoked from the panel may be stopped by pressing the RESET button on the wheel.



- After completion of the automatic program operation the wheel always ends in the basic menu.
- After two minutes without operator's activity on the wheel the system returns to the basic menu.
- Interruption of communication by means of the wheel stops the manual movement.

Machine control carried out by the wheel and the Cnc886 panel by more persons at the same time is in praxis a life endangering machine operation.

Considering the fact, that the wheel cable allows the machine operator to initiate movement from any place of the workplace, the operator must particularly observe basic safety rules stated in machine operating conditions.



5. Basic Activities

The goal of this part of the user manual is to provide an easy orientation in the moment, when you need to carry out a certain operation and to lead you to some of previous chapters of the text.

5.1. Statuses of System

Recapitulation of system statuses:

| Status | Message in the window |
|--|-----------------------|
| Power supply is switched off | Power OFF |
| Initialization after switching the power is in process | Initialising |
| System is in powered, some axis is not referred | Not referred |
| Referencing is in process | Referencing |
| System is prepared and referred | Ready |
| Program is in process | Running |
| Program suspended by M0 function | Stopped by M0 |
| Program suspended by STOP button | Stopped |
| Manual movement of axis is in process | Manual move |
| Spindle initiated manually | Manually bin |
| Loading of program is in process | Loading: xxxxxxxx |
| Error status | Error |

See also: *3.1 Status window*

5.2. Switch-on of Power

After the initiation the program Cnc886 reports in the status window the **Power OFF** status. In this status it waits for pressing the **START** button on the electrical cabinet. After it is pressed the system changes into the **Initialising** status and then to the **Not referred** status. In case something is wrong, it may also show **Error** status.

The **Power OFF** status is reported also after pressing the **Central Stop** button. Even in this case it is necessary to press the **START** button to renew the supply to the power part. But pay attention to the fact that the **Central Stop** is a button with detent. Therefore it is necessary to release it beforehand.

5.3. Referencing of Axes

Referencing is initiated in the **Manually Referencing** tab – see *3.4.2 Manually Referencing tab*. Touch (or click by the mouse) the tab **Manual**, then the tab **Referencing**. Touching the box in the column **Sel** select the axis for referencing. Touching the **START+** button on the screen you will initiate the process of referencing the selected axis. You can interrupt the process by pressing the **RESET** button. Referencing may be initiated only from the status **Non referred** and **Ready**.



5.4. Manual Control of Axes and Spindle

Manual movement of axes is initiated in the tab **Manual Move** – see 3.4.1 *Tab Manual Move*. Touch (or click by the mouse) first the tab **Manual**, then the tab **Move**. Touching the box in the column **Sel** you select the axis. Pressing the button **START+** you will initiate movement of the axis in the positive direction. The movement is carried out so long as you keep the button pressed. The axis stops with its release. The Reverse direction of movement shall be initiated by pressing the **START-** button.

The speed of the movement may be selected in multiples of the value determined by the constant for each axis. The multiples are 10x, 1x, 0.1x and 0.01x. They shall be selected by means of buttons on the screen.

If the axis was referred, the system shall not allow you outside limits preset by machine constants in the configuration file. If the axis is not referred, the check is not carried out and the operator must pay particular attention. The pre-travel to the emergency end sensor may bring useless complication. The manual movement may be initiated only in statuses **Not referred, Ready** and **Manual bin**.

Moving of the spindle shall be initiated by buttons **Fwd** and **Rwd** (direction forward or direction backwards). The system changes to the status **Manual bin**. The spindle starts spinning and it continues even after releasing the press. It is possible to adjust the revolutions/min by buttons **Up** and **Dn**. You can stop the spindle by pressing the **RESET**.

It is possible to initiate the spindle also in the mode **Stopped** and **Stopped by M0**. You can stop the spindle without switching out the running program by means of the **STOP** button.

5.5. Manual Control of Functions

Other functions of the machine shall be initiated in the **Manual Functions** tab – see 3.4.3 *Tab Manual Functions*. Touch (or click by the mouse) first the tab **Manual**, then the tab **Functions**. A tab with set of buttons appears on the display. Individual buttons initiate individual functions. Their number and meaning is given by concrete version of the machine.

5.6. Loading of Technological Programs and their Administration

Loading of technological programs and their administration shall be carried out in the tab **Library** - see 3.5. *Tab Library*. Touch (or click by the mouse) the tab **Library**.

Loading and administration may be carried out in statuses **Power OFF, Not Referred** and **Ready**.

Loading from serial line

shall be carried out by pressing the **RS232** button. The system switches to the **Loading** status. Now you can send the program from the computer, where you have created it. After loading and display the system switches again to the original status. The only exception is error status, which occurs if the program is loaded with the same number. Loading may be interrupted by pressing the **RESET** button. If the loading was carried out perfectly, the program is ready for initiation.



Loading from the disc

First select the program for loading in the window **On disc**. Then touch it by finger or click by the mouse. Then press the button **Load**. After it is loaded and displayed the system switches again to the original status. If a program with the same number is already loaded, an error occurs. If loading was carried out perfectly, the program is ready for initiation.

Selection of the program for initiation

If you want to start other program than the last loaded one, you can select it in the window **In memory** and press **Activate**.

Program deletion

First select the program for deletion in the window **On disc** or **In memory** and then press **Delete/Remove** button. More you can find in 3.5. *Tab Library*.

Saving the program in the disc

First select the program for saving in the window **On disc** or **In memory** and then press **Save as....** More you can find in 3.5. *Tab Library*.

Creation of new directory

Click first in the window **On the disc** and then press the **New directory...** tab. More you can find in 3.5 *Tab Library*.

5.7. Setting of Corrections and Parameters

Setting of corrections and parameters and administration of files with corrections and parameters shall be carried out in the tab **Param**. Touch (or click by the mouse) the tab **Param**.

Setting and administration may be carried out in statuses **Power OFF**, **Not referred** and **Ready**.

5.8. Confirmation of Error Message

If an error state occurs in the system, the running program is cancelled and a notice Error occurs in the error window. Touch (or click by the mouse) the tab **Errors**. In the lower part of the screen you can find window with red frame and notice with description of the respective error. If it is an error, which requires your intervention (for example circuit breaker fallen out, transformer error etc.) remove the cause. Then press the button **Hmm** and confirm the error. If your intervention was not successful, error appears again. If it was successful, the system confirms all errors and switches to the idle status.

5.9. Resetting of Error of Servo-amplifiers

If the cause of the error status was an error in any of servo-amplifiers, you have to carry out zeroing. For this purpose there is **Clr** button in the tab **Service Axes** – see 3.7.1. *Tab Service*. Enter this tab. In the **Err** column there are transformers in error marked in red. After you press the **Clr** button, the process of zeroing servos starts and it takes



approximately 5 seconds. Then the red marks in the **Err** column should change to grey. Only then it is possible to confirm errors in the tab **Errors**.

5.10. Initiation of Technological Program

To be able to initiate the technological problem, it must be first loaded in the memory of the serial line or from the disc and the so-called activation must be carried out – see 3.5. *Tab Library* and 5.6. *Loading of technological programs and their administration*.

If any of programs is activated, it is possible to start it by means of the **START+** button. However, the system must be in **Ready** status. The **START+** button allows initiation of the program from all tabs except **Manual Move** and **Manually Referencing**.

5.10.1. Test of Program - Test

It is possible to initiate the program also in the mode, in which no machine action is carried out - only interpretation of the entire program and its testing in the syntactic correctness and correctness of system of coordinates setting are carried out. All required corrections and tests of limit positions of axes are active during the test. If the test is carried out without errors, a program error can not arise at the normal mode and at the same setting. At the same time, after the test you can find dimensions of the product in the tab **Errors** see 3.8.1. *Other information in tab Errors*. You can set the program test by selection the **Test** mode in the tab **Auto** – see 3.3. *Tab Auto*.

5.10.2. Measuring of Time of Program duration

If you set the mode **Time** in the tab **Auto** (see 3.3. *Tab Auto*) and initiate the program, you can acquire very good estimation of the time necessary for realization of the program. Statement of information after completion of the operation you can find in the tab **Errors** – see 3.8.1. *Other information in the tab Errors*.

5.10.3. Initiation From Line or From Position

The program may be initiated also from the selected line of the program. The program is running from the beginning of the mode **Test**, in which no action of the machine is carried out. When the system finds the set line, it offers processing of M functions, which are active according to the program and only then it offers the pre-travel in the initial position. It is a position, which would be achieved by the system at the end of the previous program line. After realization of the pre-travel the program is in the status **Stopped**, i.e. the same way as after pressing the **STOP** button. It is possible to continue after pressing the **START+** button. The program then continues in a standard way.

Initiation from the line you can set by selection of the **From** mode and the field for the number of the row in the tab **Auto** – see 3.3 *Tab Auto*.

It is often necessary to initiate the program from the selected line after it was interrupted by an error, the working zone was disturbed by a careless operator, or the **RESET** button was pressed for various reasons. Then you have to know the row in which the program stopped. This information you can find in the records of events in the tab **Errors**.



Similarly like from row, in some machines it is possible to carry out the initiation from the current position of the machine. The program then finds the first position in the program near the current position. See 3.3 *Tab Auto*

5.10.4. Single-step Operation Mode - Step

The Step mode allows realization of the program in the line by line mode. In this mode the program stops after realization of each row and the **STOP** button on the fingerboard lights up. The system is in the status **Stopped**. Another row is processed after pressing **START+**.

The Step mode is switched on, if the **Step** button in the **Auto** tab is pressed in. This button also switches on and off the step mode. – see 3.3. *Tab Auto*. It is possible to enter the Step mode anytime; however it is suitable to enter it from the **Ready** mode or from **Stopped** mode.

5.10.5. Suspension of Program

Suspension of the program is realized by pressing the **STOP** button on the fingerboard. The system is in position **Stopped**. The program operation is renewed after pressing the **START+** button. The **STOP** button allows suspension of the program from all tabs. Suspension causes stopping movement of axes. The spindle and M functions remain in operation.

5.10.6. Modification of Feed

Speed of tool movement at the program operation is given by the requirement from the program multiplied by the coefficient, which may be set in the tab **Auto** – see 3.3. *Tab Auto*. The value may be set in the range from 0 up to 1.0. It is possible to change it before initiation and during the program operation as well. The adjustment may be carried out by buttons in the tab **Auto** – see 3.3. *Tab Auto*.

5.10.7. Modification of Spindle Speed

Revs of the spindle at the program operation are given by the requirement from the program multiplied by the coefficient, which may be set in the tab **Auto** – see 3.3. *Tab Auto*. The value may be set in the range from 0.5 up to 1.5. It may be changed before initiation even during program operation. Adjustments may be carried out by buttons in the tab **Auto** – see 3.3. *Tab Auto*.

5.11. Stop of Technological Program

Stopping of the technological program shall be carried out by pressing the button **RESET** on the fingerboard. The **RESET** button allows stopping the program from all tabs. All movements are stopped, the spindle is switched off, and all functions, as at the termination of the program, are carried out. It is not possible to continue with the program. It may only be initiated from the beginning.



5.12. Working in Service Mode

The tab **Service Binars** allows working in the service mode. Touch (or click by the mouse) first the tab **Service**, then the tab **Binars**. The description of working with the tab is stated in the Chapter 3.7.3. *Tab Service Binary*. Don't forget that it is not possible to check the meaningfulness and safety of your intervention at the manipulation in the system tab!

5.13. Check and Setting of Licence

Check and setting of the licence relates only to users, who were limited in using of the system for a certain period for business reasons. In the **Service-Axes** tab you can display the dialog, which shows the validity time of the licence, by means of the **Licence** button. It also offers access to another dialog, which allows entering code, which shall adjust the licence.

5.14. System Switch-off

Switching out the system shall be carried in several steps. First it is necessary to terminate actions of the Cnc886 program. It means to complete or to cancel realization of the technological program, editing etc. Then it is possible to terminate the program Cnc886 by clicking on the cross in the right upper corner of the window. Consequently it is possible to terminate the work of the Windows operating system. At the end it is possible to switch the distributor off by the main switch.



6. More Information about the System

6.1. System of coordinates and corrections

The goal of this chapter is to provide you with information on the processing of positional information by the system. It shall be a guide for you in case of doubts on correctness of setting of corrections.

Servo-amplifier units

- Servo-amplifiers work in units representing fragments of motor spindle rotations. Currently the unit represents 2^{-20} of the revolution, it is approximately one micro. This unit must not be necessarily equal with the resolution of the transducer. Transducer may work with grosser resolution. However information is delivered in the above mentioned units.
- Based on data from the configuration file on transmissions the system recounts units of the servo-amplifier in physical units, i.e. millimetres or degrees. The information received this way is identified in the system as **Irc**.

Physical and virtual axes

In the system user's view the axes identified as virtual are essential. Most frequently they are axes X, Y, Z and further even rotary axes A, B, C. By means of them coordinates of machining, machine position etc. are expressed. However, shifting in each of these virtual axes may be realized by interaction of more servo-mechanisms = physical axes. At some kinematics, operation of servo-mechanisms may project itself to more virtual axes. However, because sometimes you need to know also status of these physical axes for the purpose of service, physical axes are mentioned in the Cnc886 on the level of service.

In further text all axes have already meaning of **virtual axes**.

Machine system of coordinates

Reference position of the transducer and hence the beginning of coordinates in units of the transducer usually do not accord with the beginning of the machine system of coordinate. Therefore the machine constant in the configuration file assigns position in the machine system of coordinates to the position of the reference point.

The system of machine coordinates is determined by the manufacturer of the machine. The G11 function works in these units as well. This function is used for example for pre-travel to positions for tool change in the machining centre. Incorrect setting of position of the reference point in the configuration file then may cause collision and damage of the machine!

User's system of coordinates

The machine user is allowed to shift the beginning of the system of coordinates against the machine system of coordinates. It may be useful for example in case of using special fixtures of the work-piece. The user's system of coordinates is set in the tab **Manual Move**.

The machine system of coordinates and the user's system of coordinates coincide in the basic setting; the zero shifting is preset.

The position in the users system of coordinates is called **Absolute**.



Tool corrections with shifting by functions G53 up to G59

According to the selection of the tool by the program and according to the active function in the range from G53 to G59 the length of shifting of the tool point in the given axis is deducted from the position **Absolute**. According to the selection of function G53 up to G59 the program shift is deducted from the beginning of coordinates.

The position received this way is called by the system **Corrected**.

Program shifting of functions G92

The last shifting, which influences the position, is the program shifting by function G92. Its value is figured in the tab **Auto**. You can set this shifting by function G92 as follows: the current position is "marked" as other position. The G92 function is usually used in program cycles.

The value Corrected, from which shifting by G92 function shall be deducted, is called in the system **In program**.

Conversion relations

The display of the position is based on the real position in units of the transducer and the displayed value is calculated. During the program operation it is based on the required value and the value is calculated in units of the transducer. For completeness, there are figures for both cases:

$$\text{InProg} = \text{Irc} + \text{RefPoint} + \text{UserOff} - \text{Tool} - \text{G5X} - \text{G92}$$

$$\text{Irc} = \text{InProg} - \text{RefPoint} - \text{UserOff} + \text{Tool} + \text{G5X} + \text{G92}$$

in which:

| | |
|----------|--|
| Irc | Units of the transducer recalculated to physical units |
| InProg | The value in the mode of display In program or the value required by the program |
| RefPoint | Position of the reference point in the machine system of coordinates |
| UserOff | Shifting defined by user's system of coordinates |
| Tool | Tool correction in the given axis according to selection of the tool T0 up to T999 |
| G5X | Program shifting of the beginning defined in accordance with the selected function G53 up to G59 |
| G92 | Shifting defined by function G92 |

Length correction

The system is able to work with length correction of the tool. It is applied particularly at more complicated tools, for example five-axis cutters. The tool at the machining directs in various moments to various directions and therefore it is not possible to manage with ordinary correction in individual axes. When using the length correction the system recounts the required position for machining to the position of the machine based on knowledge of geometric settlement of the machine and the length of the tool. However, this correction is not significant at all machines.



Radius correction

The system is able to work also with radius correction of the tool.

6.2. R-parameters

The system provides the user with 11000 parameters in total called R parameters and identified as R0 up to R10999. These parameters serve for saving program variables, it is possible to carry out simple calculations with them, test their value for null etc. They also include parameters, which have preset function. Values of tool corrections and shifting of the beginning by functions G53 up to G59 are saved in R parameters. On one hand it uncovers various program options, but on the other hand it brings certain danger in case they are handled carelessly.

At the initiation of the program the system is able to copy the whole set of parameters in the memory and during the entire operation of the program it works with copies. That is to say, if it would work always with the same set, the values of R parameters would be changed by the program operation and new initiation of the program would carry out other activity. When the **Param** tab is left and changes were made, the system saves the entire set in the file on the disc. It proceeds the same way at the initiation of the program in the **Param** tab. This file is loaded at the installation of the system, so values of R parameters do not change after switching the system off and on.

Assigning R parameters with special functions is as follows. The goal is not an explanation of the precise meaning of all parameters; it is only their enumeration and position is mentioned there.

| Parameter | Significance |
|-----------|--|
| R700 | Reserved for control of track filter |
| R701 | Reserved for control of track filter |
| R702 | Reserved for control of track filter |
| R703 | Minimum length of the section; otherwise ignore |
| | |
| R710 | Selection of type of ramp (0 = linear, 1 = parabolic) |
| R711 | Maximum angle for G64 |
| R712 | Interval for acceleration averaging |
| R713 | Maximum radial acceleration |
| R714 | Dead time for acceleration and deceleration |
| R715 | Minimum time for duration of the track section |
| R716 | Parameter for nonlinear speed correction |
| R717 | Parameter for nonlinear speed correction |
| | |
| R810 | Maximum acceleration in G60 for parabolic ramps |
| R811 | Maximum acceleration standard for y |
| R812 | Time for achieving the maximum acceleration for |



| Parameter | Significance |
|-----------|---|
| | parabolic ramps |
| | |
| R900 | Shifting of beginning in axis 0 |
| R901 | Shifting of beginning in axis 1 |
| R902 | Shifting of beginning in axis 2 |
| R903 | Shifting of beginning in axis 3 |
| R904 | Shifting of beginning in axis 4 |
| | |
| R910 | Total moved track in axis 0 |
| R911 | Total moved track in axis 1 |
| R912 | Total moved track in axis 2 |
| R913 | Total moved track in axis 3 |
| R914 | Total moved track in axis 4 |
| | |
| R920 | Moved track in axis 0 from the last lubrication |
| R921 | Moved track in axis 1 from the last lubrication |
| R922 | Moved track in axis 2 from the last lubrication |
| R923 | Moved track in axis 3 from the last lubrication |
| R924 | Moved track in axis 4 from the last lubrication |
| | |
| R930 | Shift of coordinates of functions G53 in axis 0 |
| R931 | Shift of coordinates of functions G53 in axis 1 |
| R932 | Shift of coordinates of functions G53 in axis 2 |
| R933 | Shift of coordinates of functions G53 in axis 3 |
| R934 | Shift of coordinates of functions G53 in axis 4 |
| R940 | Shift of coordinates of functions G54 in axis 0 |
| R941 | Shift of coordinates of functions G54 in axis 1 |
| R942 | Shift of coordinates of functions G54 in axis 2 |
| R943 | Shift of coordinates of functions G54 in axis 3 |
| R944 | Shift of coordinates of functions G54 in axis 4 |
| R950 | Shift of coordinates of functions G55 in axis 0 |
| R951 | Shift of coordinates of functions G55 in axis 1 |
| R952 | Shift of coordinates of functions G55 in axis 2 |
| R953 | Shift of coordinates of functions G55 in axis 3 |
| R954 | Shift of coordinates of functions G55 in axis 4 |
| R960 | Shift of coordinates of functions G56 in axis 0 |



| Parameter | Significance |
|-----------|---|
| R961 | Shift of coordinates of functions G56 in axis 1 |
| R962 | Shift of coordinates of functions G56 in axis 2 |
| R963 | Shift of coordinates of functions G56 in axis 3 |
| R964 | Shift of coordinates of functions G56 in axis 4 |
| R970 | Shift of coordinates of functions G57 in axis 0 |
| R971 | Shift of coordinates of functions G57 in axis 1 |
| R972 | Shift of coordinates of functions G57 in axis 2 |
| R973 | Shift of coordinates of functions G57 in axis 3 |
| R974 | Shift of coordinates of functions G57 in axis 4 |
| R980 | Shift of coordinates of functions G58 in axis 0 |
| R981 | Shift of coordinates of functions G58 in axis 1 |
| R982 | Shift of coordinates of functions G58 in axis 2 |
| R983 | Shift of coordinates of functions G58 in axis 3 |
| R984 | Shift of coordinates of functions G58 in axis 4 |
| R990 | Shift of coordinates of functions G59 in axis 0 |
| R991 | Shift of coordinates of functions G59 in axis 1 |
| R992 | Shift of coordinates of functions G59 in axis 2 |
| R993 | Shift of coordinates of functions G59 in axis 3 |
| R994 | Shift of coordinates of functions G59 in axis 4 |
| R1000 | Tool correction Tool 00 in axis 0 |
| R1001 | Tool correction Tool 00 in axis 1 |
| R1002 | Tool correction Tool 00 in axis 2 |
| R1003 | Tool correction Tool 00 in axis 3 |
| R1004 | Tool correction Tool 00 in axis 4 |
| R1008 | Radial correction Tool 00 |
| R1009 | Length correction Tool 00 |
| R1010 | Tool correction Tool 01 in axis 0 |
| R1011 | Tool correction Tool 01 in axis 1 |
| R1012 | Tool correction Tool 01 in axis 2 |
| R1013 | Tool correction Tool 01 in axis 3 |
| R1014 | Tool correction Tool 01 in axis 4 |
| R1018 | Radial correction Tool 01 |
| R1019 | Length correction Tool 01 |
| R1020 | Tool correction Tool 02 in axis 0 |
| R1021 | Tool correction Tool 02 in axis 1 |
| R1022 | Tool correction Tool 02 in axis 2 |



| Parameter | Significance |
|------------|------------------------------------|
| R1023 | Tool correction Tool 02 in axis 3 |
| R1024 | Tool correction Tool 02 in axis 4 |
| R1028 | Radial correction Tool 02 |
| R1029 | Length correction Tool 02 |
| | |
| etc. up to | ... |
| R10990 | Tool correction Tool 999 in axis 0 |
| R10991 | Tool correction Tool 999 in axis 1 |
| R10992 | Tool correction Tool 999 in axis 2 |
| R10993 | Tool correction Tool 999 in axis 3 |
| R10994 | Tool correction Tool 999 in axis 4 |
| R10998 | Radial correction Tool 999 |
| R10999 | Length correction Tool 999 |

The system is gradually preparing itself for situations with more than ten virtual axes. Placing of tool corrections in R parameters soon faces historically selected scheme of their placing. Therefore, please, do not rely on placing of parameters according indexes. Other methods of approach are available, for example:

```
TOOL_COR[001,X      ]  
TOOL_COR[001,Radius]  
TOOL_COR[001,Length]
```

6.3. Programs in Memory

The program for realization has to be first loaded from the disc or serial line to the computer memory. The reason is speed of program processing. The memory for programs is limited by space reserved for this purpose. It may differ according to concrete setting; however it is not smaller than 2MB. More programs may be loaded in the memory in the given moment. Its reason is particularly the option to access one program by means of another as a subprogram. In this case, do not forget to load really all necessary programs in the memory and to set the one, which plays the role of the main program, as the active one.



7. Programming Language Description

CNC program is an order of commands for the control system. The program contains necessary information for moving and other machine activities. Commands of the language allow also branching in the program, cycles and accessing subprograms.

7.1. Program Structure

The program is organized in lines. The first line is reserved for the number of the program.

The program ends on a line, in which the function for the program end is stated – M30. It needs not to be necessarily the last line.

Lines (with exception of the first one) are numbered. The line number is stated on its beginning after the character **N**.

Usual structure of the program is displayed in the following diagram:

Example:

```
%15      {beginning of the program}  
N1       .....  
N16     .....  
N156    .....  
N945 M30  {end program}
```

7.1.1. First Line – Number and Name of Program

The character % is the feature for the beginning of the program. Then the number of the program, which consists of characters of 1 up to 8, follows. The program number must be in the range from 1 up to 99999999.

Selection of the number of the main program and subprograms depends on the user and the system shall not rewrite it. We recommend a suitable division of the range value between main programs and subprograms for better understanding.

The number of the program may be extended by the name of the program {commentary}.

The number and the head are decoded during activation of the program or the subprogram.

Example:

```
%12 {product 124}
```

7.1.2. Command Prompts

Each command line of the CNC program starts with the number of the row preceded by letter N. Number of the row must be in the range from 1 up to 99999999. Further it contains succession of commands. Most of commands consist of the written abbreviation and natural number or real value. Marking of individual functions is deduced from the standard ISO code. Commands consist of one letter and numerical value. The number may be also the number of the line or number of the subprogram.

In the process the basic set of functions was extended by further options. However, naming by letter and number was already abandoned and functions are created in form of key words, such as IF, THEN, GOTO etc.



Real numerical values are parameters of functions and they determine e.g. speed, revs, value of coordinate etc. Values may be stated in form of mathematical expression. The term may contain numerical constants or indirect references to the so called **R** parameters and **MP** parameters. Parameters are in point of fact registers, or if you want variables, of your program. Some have special purpose; others are full-available for the program. (More about expressions you can find in a separate chapter.)

At the branching of the program it is possible to use logic expressions. They may contain values of binary inputs and outputs of the system, numerical comparisons, and all usual logic operations.

Part of the command line may contain also the command for assignment allowing performance of simple calculations with constants and values of parameters.

Special command may be also a commentary. It is a succession of figures closed by symbols { and }.

Individual commands and their syntax we will go through later. There is only their brief summary.

| | |
|---|---|
| Word for row number | N |
| Preparatory function | G |
| Determination of axis name | A, B, C, L, O, P, U, V, W, X, Y, Z, chain |
| Radius of circular interpolation | RC |
| Word for feed | F |
| Word for spindle speed | S |
| Selection of tool correction | T |
| Word for time delay | TI |
| Word for M function | M,H,D |
| Word for program GOTO | BN, B% |
| Word for conditioned command | IF THEN |
| Commentary for CNC program | {.....} |
| Identification of R parameter | R |
| Identification of MP parameter | MP |
| Identification of binary I/O variable | BIN |
| Modifier of M function | \$ |
| Operators of numerical expressions | + , - , * , / |
| Operators of logic expressions | ! , , && |
| Command for Go To | GOTO |
| Commands for calling subprograms | CALL, CALL% |
| Display of text constant | ECHO, WARNING |
| Induction of error state | ERROR |
| Prefix of mode of M functions realization | NOWAIT |



| | |
|--|---------------|
| Command for manipulation with R parameters | LOAD_RPARS |
| Prefix for manipulation with R parameters | SAVED |
| Special setting | MIRROR, SCALE |

Example :

N10 G1 X100 Y5.4 F1000 S500 M3 {commentary}

N10 {row number}

G1 { G-words are preparative functions}

X100 {naming of axes and target coordinates}

F1000 {feed speed in mm/min.}

S500 {speed of spindle 1/min for main spindle}

M3 {M-functions are logic functions – some with predefined functions and some with free functions – their processing is programmed in PLC}

{.....} {commentary is stated in brackets "{...}". In the commentary it is possible to use only viewable 7-bit ASCII characters. It is not allowed to use brackets {} in the commentary.}

End of the program

Word M30 {end of program} ends the CNC program. The control system switches to the control mode RESET.

Function M17 ends the CNC subprogram and returns back to the superior program.

7.2. R parameters and MP parameters

The system provides the user with 11000 parameters in total. They are called R parameters and identified R0 up to R10999.

These parameters serve for saving variable programs, it is possible to realize simple calculations with them, test their value for null etc. Most of them are parameters, which have a function assigned in advance. For example values of tool corrections and shifting of the beginning by functions G53 up to G59 are saved in R parameters. On one hand it uncovers various program options; on the other hand it brings certain danger, if they are not used carefully.

At the initiation of the program the system copies the entire set of parameters (basic set) in the memory and works with copies during the entire operation of the program. If it would work always with the same set, values of R parameters would be changed by the program operation, and new initiation of the program would carry out other activity. But due to the fact that this option may be sometimes desirable, special functions and prefixes are prepared; they allow working with both sets of parameters. They are prefix SAVED and function LOAD_RPARS; (see further).

The basic set of R parameters is at the completion of the program (by RESET, by error, or in a standard way M30) saved on the disc. These R parameters values, which were modified by the program by means of SAVED prefix, are therefore modified - copy and



the basic value as well, are saved in the changed form. This way it is possible to count pieces etc.

Command `LOAD_RPARS(number1,number2)` causes rewriting of parameters with indexes from number 1 to number 2 from the basic set to set of copies.

R parameters are saved in 64-bit real format. The R-parameter is determined by letter **R** and index (formula). However, this index (formula) may be dependent on other R parameter. This way the R parameter is determined directly or indirectly. Let us explain determination of R parameters in examples.

| | |
|---------|---|
| R8 | Direct determination of parameter. The eighth parameter is used. |
| RR8 | Indirect determination. The content of R8 parameter is read. The value is adjusted to an integer by cutting off the decimal part and the result is used as the index of parameter. |
| RRR8 | Indirect determination of the second order. The content of R8 parameter is read. The value should be adjusted to the integer by cutting off the decimal part and the result should be used as parameter index. Its content is read. The value is adjusted to the integer by cutting off the decimal part and the result is used as parameter index. |
| R(R1+3) | Index of R parameter is given by sum of content of R1 parameter and number 3. |

Indirectness of determination may be randomly deepened. However, the indirect addressing of higher order does not have large importance in praxis.

MP parameters are determined above all by keeping variables serving as input parameters of M functions, provided some are used. Therefore it is not recommended to use them as variables of the program. File of MP parameters contains currently 2000 items. Unlike R parameters the work is carried out only with one set.

7.2.1. Value

The word **value** in the subsequent text shall be understood as a number determined by the expression. The expression is written in a usual manner. It may contain numbers, references to R parameters and MP parameters, operations + , - , * , / and selected mathematical functions. It is possible to use brackets, practically in unlimited depth, in formulas.

7.2.2. Arithmetic Operations and Assignment Command

Part of the command line may be created by one or more commands for assigning. They are carried out in the order, in which they are stated in the row.

The form of the command is as follows:

<R parameter> = <expression>

or

SAVED *<R parameter> = < expression >*

Place of character = it is possible to use as well: =



The command calculates the expression on the right side and saves the result in R parameter. The expression may be a value, calling of standard function, addition +, subtraction -, multiplication * or division / of values.

Calling of standard function includes:

SIN(expression) sinus of the value of expression stated in brackets. The value is in degrees.

COS(expression) cosine of the value of expression stated in brackets. The value is in degrees.

TAN(expression) tangent of the value of expression stated in brackets. The value is in degrees.

CTG(expression) cotangent of the value of expression stated in brackets. The value is in degrees.

SQRT(expression) root of the value of expression stated in brackets.

As indicated in the description, the argument of the function may be again an expression!

Examples of arithmetic operation:

R0:=5

R0:=R1+3 addition

R0:=R1-R2 subtraction

R0 =R1*R2 multiplication

R0 =R1/R2 division

Following examples show some options for using R parameters and commands.

Example 1: N10 R8=6.25 {R8 acquires value 6.25}

Example 2: N10 R8=R6 {R8 acquires value of the parameter R6}

Example 3: N1 R6=4

N2 R4=10

N10 R8=RR6 {R8 acquires value 10 - indirect determination}

Example 4: N20 R1=2.5*(R2+R3) R1= R1/R5

Example 5: N20 R16=2.5*R6 R8=R145+R16

N30 XR8 YR16

Example 6: N10 G1 XR2 YRR3 FR3

As already said, the prefix SAVED causes that the value of the expression is saved in the set of copies and in the basic set as well. The prefix relates only to one command for assignment.

Example 7: N10 SAVED R1=R1+1



Examples of use of standard functions:

```
R0:=45
R2:=R1*SIN(R0)
R3:=R1*COS(R0)
R2 =R1*SIN( 180 + R0 )
R5 =SQRT( R6*R6 + R7*R7 )
```

7.3. Control of Program flow

Commands GOTO, CALL, CALL%, BN, B% and the structure IF THEN are determined for program operation control.

7.4. Unconditional Branch

7.5. GOTO statement

Example: (go to line number 10)
N157 G1 X50 Y20 F1000
N158 GOTO 10
N159 G0 X50

N158 Order number of the row
GOTO Word for go to
10 Number of the row, to which the GOTO should be carried out

It is possible to achieve the same effect even with older version by means of command BN10.

The row number may be stated also by a expression. The real value of the expression is converted to integer and it is used as the row number. If there is no line with the given number, an error occurs.

If the GOTO command is stated in the line, no other commands may be stated in the same line.

7.5.1. Calling of Subprogram CALL and CALL%

Two variants are available. The command CALL carries out calling within the scope of the relevant program. The parameter of the command is the line number. Variant CALL% - as the subprogram - calls other program and the parameter is number of the program (identified by symbol % on the first line).

In both cases the return from subprogram calls function M17 or M30.

Example: (calling of subprogram on row 1000)
N157 G1 X50 Y20 F1000
N158 CALL 1000
N159 G0 X50

N158 Order number of row
CALL,CALL% Word for calling
10 Number of row or program to which the calling should be carried out.



If the command CALL or CALL % is on the row, no other command may be in the row.

7.6. Conditional Branch

7.6.1. Conditional Go to in Program BN<line> R-Parameter

In previous versions of the program it was only one variant of branching. It was determined particularly for realization of cycles.

Conditional go to is carried out when the stated R parameter is different from zero (R12 in following cases). After every test number 1 is automatically subtracted from parameter.

Conditional branching is used generally for realization of program cycles. However, the initial setting of R parameter must not be part of the cycle; otherwise an endless loop is created.

Example: (go to row number 25)

```
N10 R12:=8
N25 G0 Z8
N150 G1 Z0 F500
N157 G1 X50 Y20 F1000
N158 BN25 R12
N159 G0 X50
```

| | |
|------|--|
| N158 | Order number of row |
| BN | Word for go to |
| 25 | Number of row to which the go is carried out |
| R12 | Number of cycles |

7.6.2. Structure IF THEN

Structure IF THEN represents conditional command. If it is used in the line, no other commands may be stated in the line in front of the word IF.

The form of the command is as follows:

IF <logic expression> THEN <commands>

Logic expression is created in a usual manner from operands, which are logic variable or numerical relation and by means of logic operators. It is possible to use brackets in expressions.

Logic operators:

| | |
|----|--|
| ! | logic negation; relates to operands placed behind the operator |
| && | logic product between two operands |
| | logic sum of two operands |

Operands may be as follows:

BIN<number> Indicates logic value of binary variable. For this purpose the binary inputs and outputs of the system are numbered from zero to variable limit. List of binary variables is in the tab Service Binary of the control system and they are numbered in a manner that the variable in the upper right corner conforms to number 0 (bit D0). The numbering continues to the left up to the order number 7, then to the right on the second row etc.



Numerical relation

Numerical relation is comparison of values of two numerical expressions.

Following operators are available:

- == For equality
- != For inequality
- < Less
- > Greater
- <= Smaller or equal
- >= Greater or equal

Assessment of logic expressions needs one commentary. Interpreter of CNC program is processing lines in advance before their real performance. Within the scope of this conversion also other questions related to "look ahead" functions, such as planning of speed, track modification by radial correction etc., are solved. At the assessment of logic expressions, in which there is at least one value of binary variable, the interpreter must stop the conversion and wait for processing of all previous commands, because they may change the value of the binary variable. Therefore the movement always stops in this place of the program.

<Commands> behind the key word THEN represent list of commands, the same way as they may be stated in the command line with exception of another structure IF THEN.

Examples:

```
N10 IF (R12==8) THEN GOTO 1200
N25 IF BIN36 THEN CALL 128
N50 IF (R1>10) && (R1<20) THEN M3 S12000 F7000
```

7.7. ECHO Function

Function serves for writing of texts in a special row in the tab **Auto** of the control system. It allows displaying of phase of the program, instruction to the operator at the suspension of functions M0 etc.

Chain of figures in quotation marks shall be stated behind the key word ECHO.

Example:

```
N10 ECHO "Roughing"
```

7.8. WARNING Function

Function WARNING displays text, which follows. It is displayed in a special window overlapping cnc886. The text is at the same time written in a record in the Error tab.

Example:

```
N10 WARNING "You certainly must be tired and need a rest!!"
```

7.9. ERROR Function

ERROR function calls program error and displays a text, which follows. The text is written at the same time in the record in the Error tab.



Example:

N10 ERROR "Position of tool changer is occupied!"

7.10. Special Function of System of Coordinates Transformation

A pair of functions for mirroring and change of scale is experimentally established in the new version. For the time being they are designed in a very simple way, which does not reflect concrete geometry of the machine. It may be used well at two-axes or three-axes systems; the situation is more complicated at multi-axes systems. Therefore we recommend paying particular attention at the application of these functions.

7.11. Mirroring

The command has a following form:

MIRROR = < *expression* >

Value of the *expression* in the command MIRROR shows order number of the axis, the required coordinates of which have to be multiplied by -1.

For this purpose axes are numbered from zero. It means that in case of a system with three axes in row X, Y, Z, then 0 indicates X, 1 indicates Y and 2 indicates Z. If the value of the formula is -1, mirroring is not applied.

Mirroring is applied in all other processed rows of the program, until the value of the MIRROR changes.

At the calculation of coordinates the control system first determines the required position given by CNC program. Only then possible tool corrections and shifts given by G5X functions and change of the beginning of the system of coordinates in the manual setting shall be carried out.

Mirroring can not be applied in programs, in which circle interpolations and radial corrections appear.

The control system does not solve possible senseless values of the formula.

After completion of the program MIRROR = -1 is automatically set, it means without mirroring.

7.11.1. Change of Scale

The command has a following form:

SCALE = < *expression* >

Value of the *expression* in command SCALE determines a number, by which all required coordinates of CNC plan and also diameter of RC circle shall be multiplied. Multiplication of coordinates precedes the mirroring application. Theoretically it is possible to use also negative values of *expression*; however they shall not function well, if a circle interpolation or radial corrections appear. After completion of the program the SCALE = 1 is set automatically, it means without change of the scale.

7.12. M-function

M-functions are predefined instructions for control of various functions of machine. M-functions in CNC row proceed always when axes are in idle status. (It does not relate to M17 function).



This character may be suppressed by prefix NOWAIT at the beginning of the line. M functions or D and H functions with this prefix are processed simultaneously with moving on the stated row.

Transition to the following line comes only after completion of functions and movements. Prefix NOWAIT is valid only for the given line.

7.12.1. Pre-defined M-functions

- M0 CNC program stops after processing of CNC line. The program may continue after pressing START+ button.
- M3 Activation of spindle rotation clockwise. It starts CNC axes, which are declared as the main spindle at the beginning of processing CNC row.
- M4 Activation of spindle rotation counterclockwise. It starts CNC axes, which are declared as the main spindle at the beginning of processing of CNC row.
- M5 Stopping of spindle. It stops CNC axes, which are declared as the main spindle at the end of processing of CNC row. At positioned axes the spindle automatically stops in zero position.

```
Example: {Operation of spindle}
N10 M3 S500 {start of spindle}
N20 X... Y...
N30 M5 {stop of spindle}
N50 C45 F300 {positioning of spindle as C-axis}
```

- M17 End of subprogram. This function induces return in the subprogram back to the calling CNC program.
- M30 End of program. This function induces interruption of CNC program operation. The system automatically switches to RESET status.

User M-functions

User M-functions require PLC program. List of functions and their operation must create an annex of this document. M-functions may be modified by prefix \$<number>. Meaning of prefix is given by implementation of M-function and it depends on a concrete machine.

7.13. H-functions

H-functions are predefined instructions for control of various functions of the machine. All are freely programmable from PLC. H-functions as well as M-functions are processed in idle status of axes.

7.13.1. Pre-defined H-functions

The system has no predefined H-functions.

7.13.2. User H-functions

User H-functions require PLC program. List of functions and their operation must be included in the annex of this manual.



7.14. D-functions

D-functions are predefined instructions for control of various functions of the machine. All are freely programmable from PLC. D-functions as well as M-functions are processed in idle status of axes.

7.14.1. Pre-defined D-functions

The system has no D-functions predefined.

7.14.2. User D-function

User D-functions require PLC program. List of functions and their operation must create annex of this manual.

7.15. T-word for Selection of Tool Correction

In the CNC program it is possible to place tool corrections with T-word. T-word contains number of tool correction. T-word is active until new tool is selected. No more than 1000 tool corrections may be saved in the system.

Mechanical dimensions of the tool are inserted in system R-parameters.

Following form may be used for access to R-parameters containing tool corrections:

```
TOOL_COR[ machine number, axis name ]
```

Example:

```
TOOL_COR[001,X      ] {correction of tool no.1, axis X}  
TOOL_COR[001,Radius] {correction of tool no.1, radius}  
TOOL_COR[001,Length] {correction of tool no.1, length}
```

The parameter determined this way may be used in formulas as a target of assignment.

Example:

```
N10 G1 X100 Y50 T1      {placing of correction T1}  
N20 ..  
N130 G1 X450 T56 {placing of corrections T56}  
N240 ..  
N450 G1 Y18 T1        {placing of correction T1}  
N490 M30              {cancellation of correction}
```

Tool correction is switched off by function M30 or by interruption of the program by means of RESET.

7.16. Speeds

7.16.1. Feed F

Speed of the tool movement is programmed by F-word and it is stated in mm/min.

7.16.2. Linear Axes

Speed of movement depend on the selected type of interpolation {e.g. G0/G1/G2 etc.} and setting of system parameters. Standard setting is in mm/min.



G1/G2/G3

All axes programmed in CNC line are interpolated in a manner by means of which the resulted speed of the tool corresponds to the programmed feed F in mm/min.

Example:

```
N10 G1 X100 Y50 Z20 F5000
```

G0

The track of the tool is calculated in a manner by means of which the resulted track is linear. Speed F is in this case used from machine constant. The maximum speed of movement of the tool track is determined by the slower axis.

Example:

```
N10 G0 X100 Y50
```

7.16.3. Rotating Axes

Independent rotary axis moves by speed F in degrees/min.

Example:

```
N10 G1 X100 Y100 C180 F500 {C - rotary axis}
```

7.17. Speed of Rotation S

Speed of the spindle is programmed in revs per minute. The speed of rotation is limited to the maximum speed set in the machine constant.

Example:

```
N10 G1 X100 Y50 F10 S1500 M3
```

7.18. G-function

Depending upon DIN66025 part 2 the standard preparative functions are CNC functions, which describe interpolation connection of CNC axes.

Standard preparatory functions are in functional groups, by means of which only one function from each group may be activated at a time.

Some functions are active already before start of the program (the so called preparatory functions). Some functions are retaining, other must repeat on each CNC line.

- Group 1 Interpolation
- Group 2 Waiting
- Group 3 Selection of plain
- Group 4 Compensation
- Group 5 Shifting of beginning
- Group 6 G92 and G93 - new position
- Group 7 Speed characteristics G60 G64
- Group 8 Absolute position G11
- Group 9 Measuring of distance – absolute/incremental



7.18.1. Group 1: Interpolation

All commands for interpolation consist of a word indicating type of interpolation and list of interpolated coordinates with entered end point. The end point may be entered absolutely or incrementally according to the active function G90/G91. The end point further influences G11 function, which sets absolute system of coordinates of the machine. The manner of connection of individual track sections influences functions G60/G64. In case the G64 is active the system carries out connection of individual lines of the CNC program without loss of speed, eventually it adjusts the speed in accordance with the dynamics of the entire system. In case of G60 the shifting stops at the end of each section.

7.18.1.1. G0 Shift by Fast Feed

All axes reach to the programmed position at once. Acceleration ramps for fast feed are applied at the movement.

Programmed F speed is not effective. As soon as the G0 selection is cancelled, the F speed is activated again.

The fast feed speed is given by machine configuration and in case of need it is reduced so that no axis could exceed its speed limit.

Example:

```
N10 G0 X100 Y50
```

7.18.1.2. Linear Interpolation G1

The fast feed speed of the tool track is programmed under the F address for linear interpolation. Linear interpolation is permitted in all axes at once. The maximum speed of tool track feed is determined by the slowest axis. G1 is active by default in preparatory functions.

Example:

```
N10 G1 X100 Y500 Z250 C100 A20 F1000
```

7.18.1.3. Circular Interpolations G2 and G3

Speed of feed is programmed by F function. Circle interpolation may be carried out in one plain. Circle plain is determined by functions for selection of plain {G17/G18/G19}.

G2 Circle interpolation – clockwise

G3 Circle interpolation – counterclockwise

Axes, which are programmed additionally to circle axes, are included in the interpolation context so that they reach the end coordinate in the same time as the circle axes.

End position, coordinate of centre or curve radius must be with accuracy 0.001 mm, otherwise an error message is displayed.



Circle interpolation by radial programming RC

Circle radius may be programmed in the row G2/G3 with RC The entire circle may be programmed with two half circles. Negative value of the radius indicates curve with angle larger than 180 degrees.

Example:

```
N10 G1 X100 Y0 F1000
```

```
N20 G2 X110 Y0 RC10 {Radius of the curve is programmed by  
RC10.}
```

Circle interpolation with determination of centre

Circle interpolation may be determined also by the end point and the centre of the circle.

Following words serve for determination of the circle centre:

I coordinates of centre in axis X (first axis of the system)

J coordinates of centre in axis Y (second axis of the system)

K coordinates of centre in axis Z (third axis of the system)

Coordinates of the centre are always relative with regard to the initial point of interpolation.

7.18.2. Group 2: Waiting

7.18.2.1. Delay Period (TI)

Time delays are programmed in the CNC program in seconds.

Example:

```
N10 TI2.5 {time delay in constant}
```

```
N10 TIR2 {time delay in R parameter}
```

Time delay is generated before initiation of shifting stated in the same row.

Time of delay is effective only for one row.

7.18.3. Group 3: Selection of Level G17 and G18 and G19

Interpolation plain must be set for circle interpolation and for radius correction. G17 is placed implicitly. All functions of plain selection are self-keeping.

The plain is selected by means of coordinates X, Y, Z.

- G17 = selection of plain X-Y (first and second axis of the system)
- G18 = selection of plain X-Z (first and third axis of the system)
- G19 = selection of plain Y-Z (second and third axis of the system)

7.18.4. Group 4: Compensation

Following instructions are used for compensation of the track depending on the tool radius correction. Compensation of the tool track is carried out for radius of the tool point or cutter radius. All functions are self-keeping.

- Cancellation of selection of tool radius compensation G40



- Compensation of tool radius G41, tool for left profile
- Compensation of tool radius G42, tool for right profile

Machined plains for compensation of tool radius are selected with instructions G17/G18/G19.

Machined plain must not be changed if compensation of tool radius is selected.

The number of the current tool must not be changed.

Cancellation of compensation of tool radius is after G40 or after M30.

Example 1: Placing and cancellation of radial correction

```
N10 G1 G41 X100 F500
```

```
N20 G1 G40 X150 F500
```

At the passing of internal edges the tool goes closer to the end of the section so that it does not interrupt the following section. However, if on the subsequent section there is no point, by means of which it would be able to continue with machining, message notice appears. At the passing of outside edges linear and circle section is entered by the system in dependence of the track shape. This section is not recorded in the CNC program, but only saved in temporary memory.

7.18.5. Group 5: Shifting of the starting point

Calling functions for shifting of the beginning is G53 – G59. G 53 is up to date in possible functions. All functions are self-keeping. Shifting of the beginning is cancelled by M30. List of R-parameters for shifting the beginning is stated in the following table:

| | axis0 | axis1 | axis2 |
|-----|-------|-------|-------|
| G53 | R930 | R931 | R932 |
| G54 | R940 | R941 | R942 |
| G55 | R950 | R951 | R... |
| G56 | R... | R... | R... |
| G57 | R... | R... | R... |
| G58 | R... | R... | R... |
| G59 | R... | R... | R... |

Functions G53 up to G59 are self-keeping. Stating the new one cancels the previous one. R-parameters may be read/written by the CNC program.

Example of use of shifting of beginning:

```
N10 G54 G0 X0
```

```
N20 B%4711 {processing of part 1}
```

```
N30 G55 G0 X0
```

```
N40 B%4711 {processing of part 2}
```

```
N50 G53 G0 X0
```

7.18.6. Group 6: G92 and G93 New Position

Function G92 sets program shifting of coordinates during processing of the program so that the real position becomes the required position. In doing so no shifting is realized.



G93 function shall cancel shifting, which was programmed by function G92 and for all axes.

Example:

```
N10 G0 X100 Y50 {pre-travel to position}
N20 G92 X0 Y0   {setting of new required position}
N30 G0 X100 Y50 {pre-travel to position}
N40 G92 X0 Y0   {setting of new required position}
N50 G0 X100 Y50 {pre-travel to position}
N60 G93         {cancels shifting}
```

It is not possible to combine on the same line functions G92 and G93 with functions of the group 1, it means with interpolations. That is to say, it was not clear to which function belong required positions of axes.

7.18.7. Group 7: Speed Characteristics G60 G64

For change of speed characteristic functions G60 and G64 are reserved. Functions G60 and G64 are self-keeping.

G60 places at the beginning and at the end of the line the starting or brake ramp

G64 goes through two rows without loss of speed

G60

At the beginning of the row the system places starting ramp and before end of the row a brake ram. Change of the row is carried out when the deviation from the end position in all programmed axes is smaller than the value set by the machine constant.

G64

This function may have several variants of behaving depending on setting of machine constants.

1. The system goes through two rows by programmed speed F without loss of speed. In this case the operator must anticipate behaving from the point of view of dynamics of the entire system. In principle it is possible to say that it is possible within 10 degrees of the angle deviation of trajectories.
2. The system may evaluate based on machine constants the difference of angle deviation of trajectories and based on this it automatically places a temporary row with function G60, which causes placing of start and brake ramp, in the program.
3. The system may calculate based on machine constants the real dynamic straining of the entire system and according this it adapts the speed F between two rows so that the mechanics of the set is exposed to reasonable straining. This option is applied at the passing through circle interpolation.
4. Combination of points 2 and 3.



Example:

```
N10 G1 X50 Y20 F2000
N20 G1 G64 X80 Y40
N30 G1 X100 Y60
N40 G60
N50 G1 X0 Y20
```

Function G64 functions also in connection linear section and curve, two curves etc. In the following example – passing of curved edge corner without loss of speed is programmed.

Example:

```
N5 G64
N10 G1 X80 Y80 F2000
N20 G2 X100 Y100 RC20
N30 G1 Y150
N40 G60
N50 G1 X0 Y20 F1000
```

Linear interpolation without tangent transitions {angle of two straight sections > 10°} may lead to jerky movements of axis.

7.18.8. Group 8: Absolute Position G11

Function G11 is not self-keeping. The function causes that the system stops to add shifting of beginning, tool corrections, new position G92 and shifting of beginning programmed directly on the control system panel to programmed coordinates. It is advantageous particularly in situations, when the operator needs to travel to a position, which does not shift in relation to reference point, e.g. exchanger of tools, feeder of semi-finished products etc.

Example:

```
N5 G0 X50 Y50
N10 G55
N15 G92 X120 Y15 T45
N20 G0 G11 X1000 Y100 {absolute pre-travel to position related
to reference point of the machine}
N25 G0 X120 Y15 {return to original position}
```

7.18.9. Group 9: Measuring of Distance - Absolute/Incremental

Function G90 and G91 are self-keeping.

G90 Absolute programming

All differences relate to the reference point, to which shifting of beginning, tool corrections, new position G92 and shifting of the beginning programmed directly on the control system panel are added.



Example: Absolute programming

```
N10 G0 G90 X10 Y10  
N20 G1 X30 Y30 F1000  
N30 X45 Y15  
N40 X10 Y10
```

G91 Incremental programming

At the incremental programming the machine makes a distance, which is programmed in the CNC line from a position, in which it is currently situated.

Secondary coordinates {I, J, K} for circle programming are not influenced by G90/G91.

Example: Incremental programming of coordinates

```
N10 G0 G90 X10 Y10  
N20 G1 G91 X20 Y20 F1000  
N30 X15 Y-15  
N40 X-35 Y-5
```

7.19. Summary of G - words

Legend:

- ! in preparatory functions
- & function is effective only for one row
- § self-keeping

| Group | G | Definition |
|--------------|----------|---------------------------------------|
| 1 | & 0 | linear interpolation by preset speed |
| 1 | ! 1 | linear interpolation |
| 1 | & 2 | circle interpolation clockwise |
| 1 | & 3 | circle interpolation counterclockwise |
| 3 | !§ 17 | selection of plane X-Y |
| 3 | § 18 | selection of plane X-Z |
| 3 | § 19 | selection of plane Y-Z |
| 4 | !§ 40 | cancellation of tool compensation |
| 4 | § 41 | left tool compensation |
| 4 | § 42 | right tool compensation |
| 5 | !§ 53 | shifting of beginning |
| 5 | § 54 | shifting of beginning |
| 5 | § 55 | shifting of beginning |
| 5 | § 56 | shifting of beginning |
| 5 | § 57 | shifting of beginning |



| | | | |
|---|----|----|---|
| 5 | § | 58 | shifting of beginning |
| 5 | § | 59 | shifting of beginning |
| 6 | § | 92 | setting of the required position |
| 6 | !§ | 93 | cancellation of G92 |
| 7 | !§ | 60 | passing with placing brake ramps |
| 7 | § | 64 | passing without loss of speed |
| 8 | & | 11 | absolute position (cancellation of all compensations) |
| 9 | !§ | 90 | absolute programming |
| 9 | § | 91 | incremental programming |

Only one G-function may be selected from the group at a time. All self-keeping functions remain effective until a new function for the same group is programmed.

7.20. Summary of M - words

| M | Definition |
|--------------------------|--------------------------------------|
| 0 | programmed stop |
| 3 | rotation of spindle clockwise |
| 4 | rotation of spindle counterclockwise |
| 5 | stopping the spindle |
| 17 | end of subprogram |
| 30 | End of program / reset |
| 1, 2, 6-16, 18-29, 31-99 | user M functions |

7.21. Summary of H - words

| H | Definition |
|----------|-------------------|
| 1 - 99 | user H functions |

7.22. Summary of D - words

| D | Definition |
|----------|-------------------|
| 1 - 99 | user D functions |