zub
machine control AG

MK1/100

Mono axis compact control

Manual for installation
and hardware reference

Impress

Address zub machine control AG · Buzibachstrasse 23
CH-6023 Rothenburg

Telefon +41 41 54150-40
Telefax +41 41 54150-49

http://www.zub.ch
http://www.aposs.ch
info@zub.ch

Copyright © zub machine control AG

All rights reserved. Reproducing or disassembling the computer algorithms in this program is strictly forbidden. Subject to technical changes.

Issued June 2001

Editor Monika Droeger, www.marketingdienstleistung.de

This manual is set in ITC MixageBQ.

To improve utilization of the printed manual and the on-line help with a variety of programs, only special characters from the Symbol and Wingdings fonts were used.

Trademarks APOSS is a registered trademark of Z&B GmbH.

IBM is a registered trademark of International Business Machines, Inc.

Microsoft, MS, MS-DOS, Microsoft NT, Windows and Wingdings are either registered trademarks or trademarks of the Microsoft Corporation in the USA and other countries.

ITC MixageBQ is a registered trademark of the International Typeface Corporation.

VLT is a registered Danfoss trademark..

Table of Contents

Table of Contents

Hardware Installation

Connection and Initial Operation

For safe operation of the compact motor control MK1/100 it is necessary for the unit to be connected and set in operation according to the VDE regulations.

! ! ! Follow the steps described below and observe the warning messages.

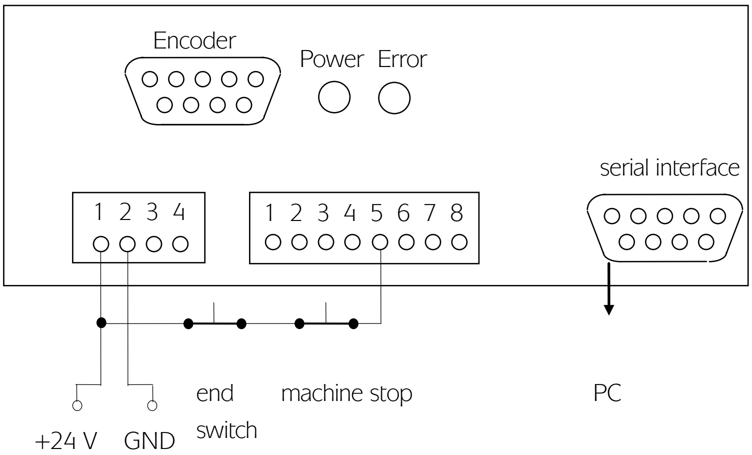
How to use the APOS Software, please see software manual, chapter I 'APOS user interface'.

Power Supplies and Communication Test

To supply the MK1/100 compact unit, you require two voltage sources which have the following properties:

power supply 1 24 V ±25 %
min. output current 3.5 mA

For the initial tests, you can connect the supply voltages and the end switch to the MK1/100, and plug the 9-pin Sub-D jack on the front panel of the MK1/100 into the serial interface of the computer.



! ! ! Carry out the test without the motor and the encoder.

After the voltage turn-on, only the green Power LED should be lit. The red Error LED must not be lit. In that case, no error is present.

In order to carry out the communication test with the computer, select the menu **Execute → Error State** in the APOS program with the **cursor** keys ← and → and the **Enter** key.

A window opens for the messages of the MK1/100. By turning the supply voltage of the MK1/100 off and on, you receive the following initialization message on the monitor:

Z&B MOC-SDT SN Zx_xIL1? xxx. 19xx

Motor controller is initialized with 1 axis

It should be noted that approx. 5 seconds are required after turn-off before the green Power LED is extinguished.

If you close the window by pressing **ESC**, an enquiry will appear, asking whether the possible failure should be deleted. Answer this with **J** (for Yes) and a corresponding command is transmitted to the MK1/100. If the command is not received, a time-out error message will be displayed.

If the communication test was not completed successfully, find out about possible causes at the end of this section.

End Switch

You can now carry out a test of the end switch. After activation of the end switch, an error must occur and the red Error LED must be lit.

In order to enquire about the error, open the error enquiry window as described above. The error message "End switch reached" must appear. Delete the error message with **ESC** and **J** (for Yes).

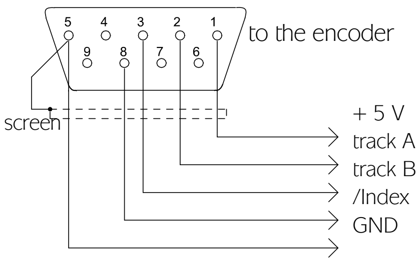
Incremental Encoder

! ! ! Switch off the power supply, before you connect the encoder to the MK1/100.

For error-free operation it is necessary for the encoder to be connected with the MK1/100 via a shielded cable. In making the connection it is important to keep the cables as short as possible and to route them as far away from power cables as possible. Encoders with TTL or open collector outputs can be used, which have a supply voltage of 5 V.

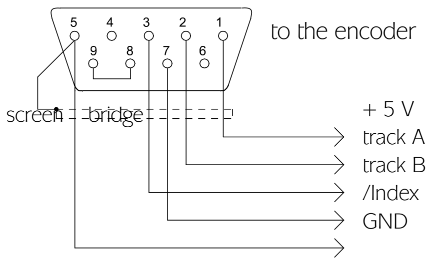
Encoder with
negative index impulse

Encoder



Encoder with
positive index impulse

Encoder



The precise allocation of the encoder jack and the significance of the signals (temporal trends and interrelationships) can also be found in the hardware reference section.

The encoder is mounted on the motor shaft. In order to test the encoder, it is necessary that the motor shaft is able to move freely.

! ! ! The motor must not be connected during this test.

In order to test the encoder in a simple way at first, carry out an APOS test program. Select the APOS menu item **File → Load.**

With the keys **Pos1** and **End,** select the document "DREHGTST.M“. You can also enter the name of the document directly. The entry must be completed with the **Enter** key.

After the APOS program has been loaded, it must be started as follows:

Leave the Editor window with the **ESC** key. Then select the menu **Execute → Start program** with the **cursor** keys and the **Enter** key. When the **Enter** key is pressed, the program is processed.

In the output window, you will now see a new position value displayed every half a second. After a full revolution of the motor shaft by hand, the position value should amount to four times the encoder count per turn. For instance, if the encoder count per turn is 500, you should receive a position value of ±2000. After a further revolution in the opposite direction, the position value should be zero.

!!! For the operation of the positioning system it is absolutely necessary that the encoder is functional. If the test described above has resulted in improper functioning of the encoder then this error must be remedied before the starting of operation can be continued.

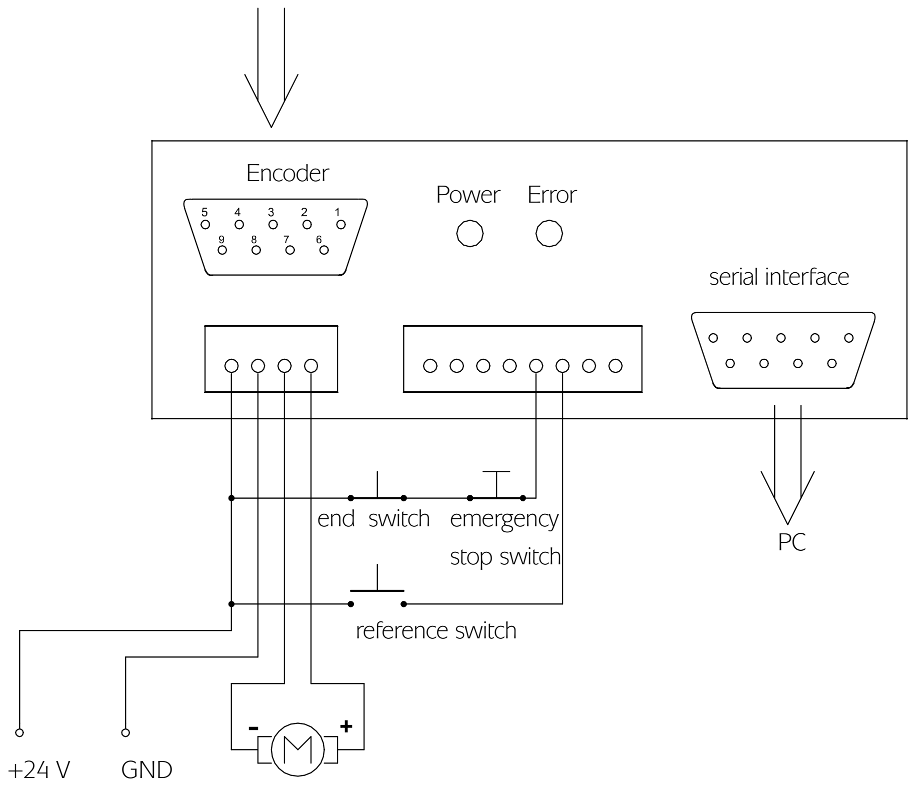
See also troubleshooting at the end of this section.

Motor Connection Once the encoder function properly then it is possible to proceed with the connection of the motor.

!!! Switch off the power supply, before you connect the motor!

!!! Moreover, the motor should be set in operation without any related mechanics: in case of reversed polarity, it may happen that the motor turns at full speed in a random direction.

For this reason – and for safety purposes – the motors are to be fixed in place and existing brakes are to be released.



Test the motor with the APOS program "MOTORTST.M". Inform you about **File → Load** and **→Execute** in the section "Incremental Encoder".

After the program has been started, the motor will execute two small motion command (forward and back) and then pause in a resting position.

No error should occur during the test and in the execution window the message "Program completed without problems" should appear.

If the test is not completed successfully and the message "position error" appears, this may have two causes:

1. there is no connection between the motor and the MK1/100.
2. the polarity of the motor does not coincide with signals A and B of the encoder. As a result, the motor turns uncontrolled at top speed in one direction. To solve this problem, you can reverse the poles of the motor or exchange the encoder signals A and B.

Index Impulse of the Encoder and Reference Switch

At every revolution, the encoder delivers a index impulse. Together with the reference switch, this impulse helps with the establishment of the absolute zero.

In order to detect the index impulse, it is necessary that the signals A and B and /Index are simultaneously low. This can be expressed in the following logical equation:

Detected_index impulse = /A * /B * Index

In order to enable the MK1/100 to detect the index impulse, the MK1/100 must be informed of the count per turn of the encoder.

In APOS, select the menu **Init → Axis param.**

!!! In order to set the axis parameters, the MK1/100 must be turned on.

When the **Enter** key is pressed again, a window opens, in which you can specify the encoder count per turn. You can close the window again by pressing the **Enter** key several times.

As there are certain differences between the encoders from different manufacturers, we recommend that you test the detection of the index impulse. This can be achieved with the help of the "NULLTST.M" APOS program. In the illustration "Motor connection", the wiring of the reference switch has also been displayed.

You may carry this test out without any connected mechanics, provided that the reference switch can be activated.

After the "NULLTST.M“ program has been started, the shaft of the motor must turn until the reference switch is closed. After this, it should turn in the opposite direction until the reference switch is opened and then the index impulse is detected.

If the message "Zero impulse not found" is displayed in the execution window, read about the possible causes of the error and the corresponding steps to be taken at the end of this section.

!!! In order to facilitate initial installation, the delivery parameters are set so that movement to the reference switch after switching on the unit is not absolutely programmed. The software end switch is also disconnected. Before final integration in a mechanical system it is absolutely essential that these parameters are set in order to avoid damage to the unit or the system.

Program testing

After the compact unit has been connected as described above, some of the enclosed demo programs can be started for initial testing. As far as possible, these tests should be carried out without connected mechanics (see above).

For instance, in order to establish the basic operability of the data transmission circuit, the assembly and the programming surface, load the demo program Motortst.M via **File → Load** and start it with **Execute → Start program** (entire program is run in full) or with **Execute → Trace program** (program is run line by line, after pressing the **Enter** key each time).

As a further test, the outputs 1 to 2 can be addressed (by entering APOS commands under the menu item **Online**. They are set and reset. They were set and reset. The inputs 1 to 4 can be read (direct mode) and the end switch can be checked. During a step-by-step program run, the signal level can be monitored with a suitable measuring device. However, this only functions if the open collector outputs are connected to a resistor.

First steps towards programming

The programming of the compact unit is carried out using the APOS software on the PC. The program supports the development of the user's own movement programs and on-line testing with the connected drive unit.

The programs are started in exactly the same way as in the previous example.

The demo programs contain a commentary which explains which commands are being performed and what should happen. In general, all position specifications in the programs are given in units in multiples of four of the encoder resolution (hereinafter referred to as qc = quadcounts). For instance, if a encoder with 512 lines is being used, the command POSR 2048 (= 4 * 512) causes a relative movement of a single revolution. Similarly, a command POSA 512 means that the motor will be located at a quarter revolution from the machine's zero calibration. If a encoder with a division of 1,000 lines is being used, the same results are achieved with the commands POSR 4000 or POSA 1000 respectively. See also the explanatory notes to the parameters.

Setting the Control Parameters

This section describes the simple procedure for empirically determining the control parameters. The values determined in this matter have proven to be sufficient in most applications; in order to make setting the parameters easier we also offer the program OPAL.

In order to be able to perform the adjustment tests described here the drive must be able to run, with a normal load, a test distance that is long enough so that the majority of the distance can be run at the necessary top speed. If the motor is driven at load torque's which differ greatly (e.g. movements with and without tools), different control settings must be determined for the various loads and the parameters of the control unit are to be set accordingly in subsequent application programs.

The control algorithm of the PID filter used is described by the following formula:

$$u(n) = K_P * e(n) + K_I \sum e(n) + K_D [e(n') - e(n'-1)]$$

u (n) = Correction factor in n   e (n) = Control error in n

n = Sample cadence   n' = Sample cadence for differential factor

K_P = Proportional factor K_I = Integration factor

K_D = Differential factor K_{ILIM} = Integration limit factor

For the initial connection of the system it is advisable to set a very low value for the proportional factor, e.g. $K_P = 1$ (K_I, K_D and $K_{ILIM} = 0$); thus it is certain that the cycle of the closed loop control circuit is correct. Now K_P can be set to values ranging from 20 to 200 (typical values) in order to check the basic functions of the system. The values are set individually, with the aim that vibration-free operation is possible. Then it is possible to begin with the setting of the other filter parameters.

The setting of the filter parameters directly in the application is necessary since the mechanical systems can change sufficiently due to fluctuations in temperature, etc., to make an accurate model recording impossible. However, since it is easy to change the filter parameters, only a small amount of effort is required. Various methods can be used to empirically determine the optimal filter values. The method described in the following section is most suitable to make the settings without having any measured values on hand.

In order to logically comprehend how the settings are made, it is necessary to first understand the functions of the various filter parameters. The proportional factor K_P causes a gain, the differential factor K_D dampens, the integral factor K_I eliminates constant positioning errors.

K_D and K_I are set to zero, and K_P is increased until an overcorrection becomes visible. Reading of the speed over time can be made over the measurement of the motor voltage. By increasing K_D a reduction in the overcorrection can be observed. With ITERATION K_P and K_D

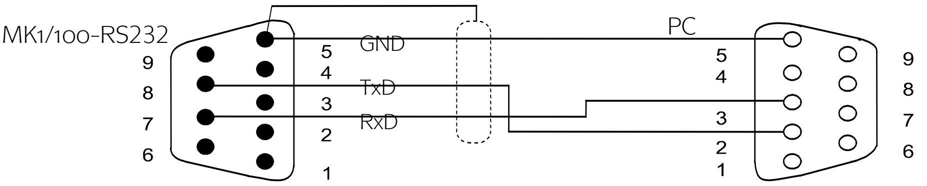
can be increased further until the desired reaction can be observed or until the stability limit is reached. Here K_I and K_{ILIM} can also be used to eliminate any constant position errors which may possibly occur.

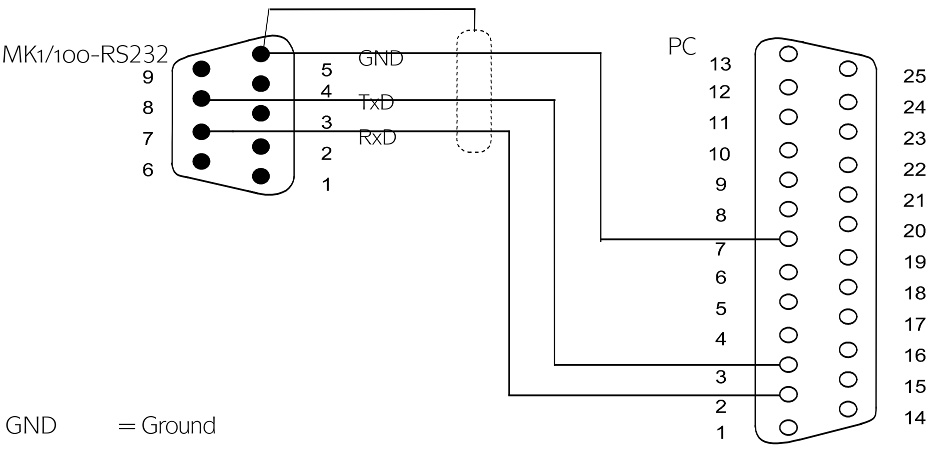
Troubleshooting

Error	Reason	Solution
After switching on the voltage the green network LED does not light up.	The voltage supply is not in order.	Check the connection of the connecting cables. Measure the voltage. It should be 24V ±25%.
After switching on the power supply the red error LED is lit.	The end switch is not connected.	Connect the end switch to the MK1/100.
No communication between the PC and the MK1/100..	Wrong interface Wrong cable assignment	Set the correct interface on the PC with the APOS program. Use the original cable or check the cable assignment.
The encoder does not function.	Wrong cable assignment. Encoder needs higher supply voltage than 5V	Check the connections. Use an encoder with 5V supply voltage. Connect external supply voltage to the encoder (only for encoders with open collector outputs)
Display of the wrong position.	The signals A and B of the encoder are not displaced by 90°.	Adjust the encoder (if possible).
The index impulse can not be detected.	The requirement that the A, B and /index signals are simultaneously low has not been fulfilled.	Connect the /A- and /B-signals of the encoder to the MK1/100, provided they exist (instead of A and B).
The motor is running uncontrolled at the highest speed.	The polarity of the motor does not correspond to the A and B signals of the encoder.	Reverse the polarity of the motor or exchange the A and B signals of the encoder with one another.

Hardware Reference

Power Supply	Control circuit (Control voltage U_{BS})	+24 V DC ±25 %, 35 mA
CPU	Micro processor	80C32, 8 bit, 24 MHz
	Operating system memory	64 kB EPROM
	Program memory	128 kB RAM = ca. 20.000 positioning commands;
	Application program memory	128 kB EEPROM
COM Interface	Signal transfer	to RS232 standard
	Baud rate	9600 bit/s
	Data format	8 bit
	Stop bit	1
	Parity	none
	Signals	RxD, TxD, GND
	Hardware handshake signal	none
	Software handshaking	XON/XOFF
	Type	9-contact D-SUB
	Pin allocation	5: GND 7: RxD 8: TxD





GND = Ground
RxD = Received Data
TxD = Transmitted Data

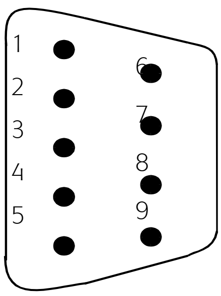
Axis Controller

Number of axis processors	1
Control algorithm	$u(n) = k_p * e(n) + k_i * \sum e(n) + k_d * [e(n') - e(n'-1)]$
	$u(n)$ = Output size
	$e(n)$ = Control error in n
	n' = Sample cadence differential factor
	K_P = Proportional factor
	K_D = Differential factor
	K_I = Integration factor
Maximum positioning path	±1 billion quadcounts (500-series Encoder ca. 536000 revolutions 1000-series Encoder ca. 268000 revolutions)

Encoder Inputs

Number	3 (A, B, Index)
Input frequency	max. 180 kHz (per channel) (500-series Encoder max. 21600 rpm 1000.series Encoder max. 10800 rpm
Input voltage low U_{EL}	0 … 0.8 V
Input voltage high U_{EH}	2.6 V … 6 V
Input current I_{ELow}	0 mA
Input current I_{EHigh}	2.5 mA … 9 mA
Pull-up-Widerstand R_{up}	1 k internal

Pin allocation of the connector for the encoder



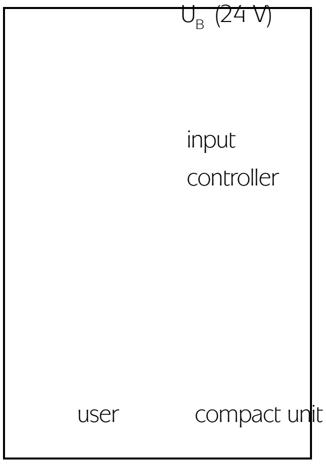
Pin	allocation
01	+5 V (supply encoder)
02	signal A
03	signal B
04	
05	GND (supply encoder)
06	
07	Index input for encoder with positive index pulse
08	signal /Index
09	/Index output (for 8) for encoder with positive index pulse

Reference Switch, Central Stop

Number	1
Logic	central stop low active reference high = reference point high active
U_B	24 V DC ±25 %
Input voltage low, U_{EL}	−3 V … +5 V DC
Input voltage high, U_{EH}	+13 V DC … U_B
Input current low, I_{EH}	−0.1 mA … +0.1 mA
Input current high, I_{EH}	< 1 mA

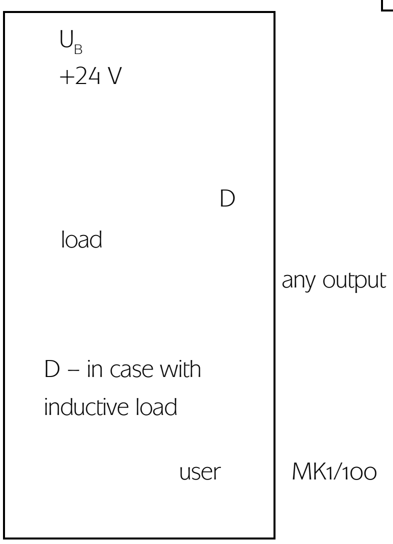
Control Inputs (Freely programmable)

Number	4
Logic	positive (high active)
U_B	24 V DC ±25 %
Input voltage low, U_{EL}	–3 V … +5 V DC
Input voltage high, U_{EH}	+13 V DC … U_B
Input current low, I_{EH}	–0.1 mA … +0.1 mA
Input current high, I_{EH}	< 1 mA



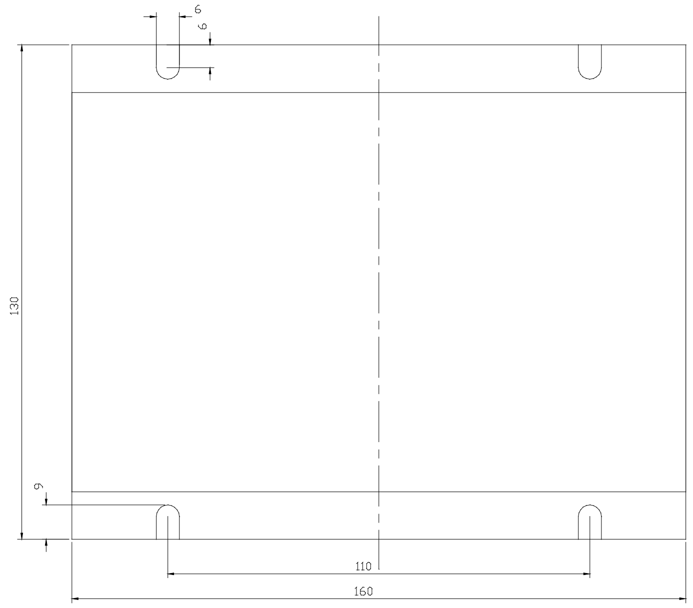
Control Outputs (Freely programmable)

Number	2 short-circuit proof
Logic	positive connecting to GND
	APOS program sample: OUT 1 1 means output 1 after GND switched by U_B
Maximum load current I_{AN}	100 mA
Voltage drop	1.8 V for I_{AN}
Switching frequency	maximum 200 Hz for ohmic load
Defined output condition	200 ms after connecting the power supply
Zero current	= 0,5 mA (not connecting)



Display Elements

Display Elements	Number	2
	LED 1 (green)	Power internal logic supply connected
	LED 2 (red)	Error has occurred
Operating Conditions	Operating temperature	0° C … 50° C
	Storage temperature	–20° C … +70° C
	Relative humidity	< 75 % without dew
Mechanical Dimensions	Design	housing with brackets for easy assembly enclosers for 19" systems (option)
	Width	105 mm; with brackets 130 mm for 19" systems 3 HE
	Height	54 mm inclusive cooling facility for 19" systems 11 TE
	Depth	160 mm
	Weight	ca. 775 g



Index