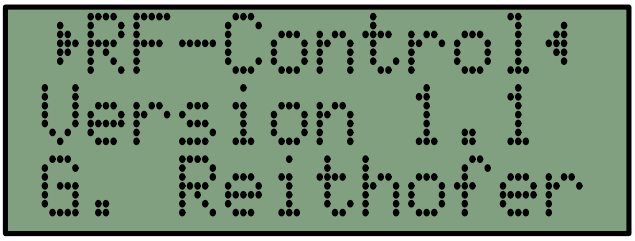
Bag rotation facility manual



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Date: **24th of June 2006**
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Contents

1 Objective

The document describes addons and integrated enhancements of the existing setup for exanmining dust cakes on bag filters at the Institute for Chemical Apparatus Design, Particle Technology and Combustion at Graz University of Technology.

I assume that the reader is familiar with the objectives of the BAG FILTER TEST FACILITY as it was before the redesign. This is described in Document [1]. The BAG ROTATION FACILITY is an extension of the BAG FILTER TEST FACILITY with the primary goal to allow examination of dust cake outside of the visible area (e. g. back side of a filter bags). The optical insitu measurement of dust cake height on the filter bags. based on optical scanning of the filter cake surface, has driven the decision to install a rotation facility to allow optical contact around the full 360 degrees of filter bags.

2 Functional requirements

The BAG ROTATION FACILITY has to follow the basic requirements of the BAG FILTER TEST FACILITY and must not limit any basic functionality which is necessary for research.

The following requirements have been defined to satisfy:

1. The exact measurement of the of injected dust defines some of the basic research criterions for exact and repeatable results.

   $\Rightarrow$ The BAG ROTATION FACILITY has to be hermetically closed without any loss of dust.

2. The actual rotation angle must be measurable, as it maybe an input parameter for the downstream evaluation software of the optical thickness measurement system.

   $\Rightarrow$ The BAG ROTATION FACILITY has to provide an angle value information with the accuracy of 1 degree.

3. The facility must include the ability to store specific angle positions which may be retrieved in measurement process.

   $\Rightarrow$ The BAG ROTATION FACILITY must be able to store at least 8 positions (all 45° steps of a full rotation).

4. The rotation angle position should be repeatable within a required accuracy. As the main goal is the measured angle and not the physical position, this feature is more like an accommodativeness for the user.

   $\Rightarrow$ The BAG ROTATION FACILITY should be able to stop near any measurable position, which is currently 0.5°.

3 Basic components

The complete facility addons may be divided into 3 categories, which are:

1. M**echanical design**
   This is implemented by a single level drive train which allows full 360° rotation of the filter bag in the center of the facility (fig.1). The gear has to be hermetically close, that no test material (dust) should be transferred outside of test circuit or should be transferred from the dust side to clean gas side with the exception of the filter material loss.

2. **Electrical installation and actuation**
   This is implemented by a DC electromotor with worm gear, a *DC motor power control unit*, a *microcontroller board* as basic control unit and an *interface card* between microcontroller and power control unit. Additionally an *angle measurement unit* is mounted on the motor directly.

3. **Control software**
   This assembler software was developed for the microcontroller to fullfill all required features and enhancements defined in section 2.

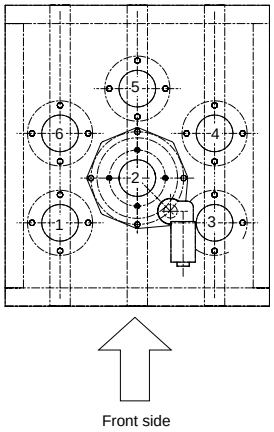


Figure 1: Top view of the facility

4 The mechanical part

The mechanical BAG ROTATION FACILITY requires special care of the mounting procedure to ensure the seal quality and the functionality of the rotation part.

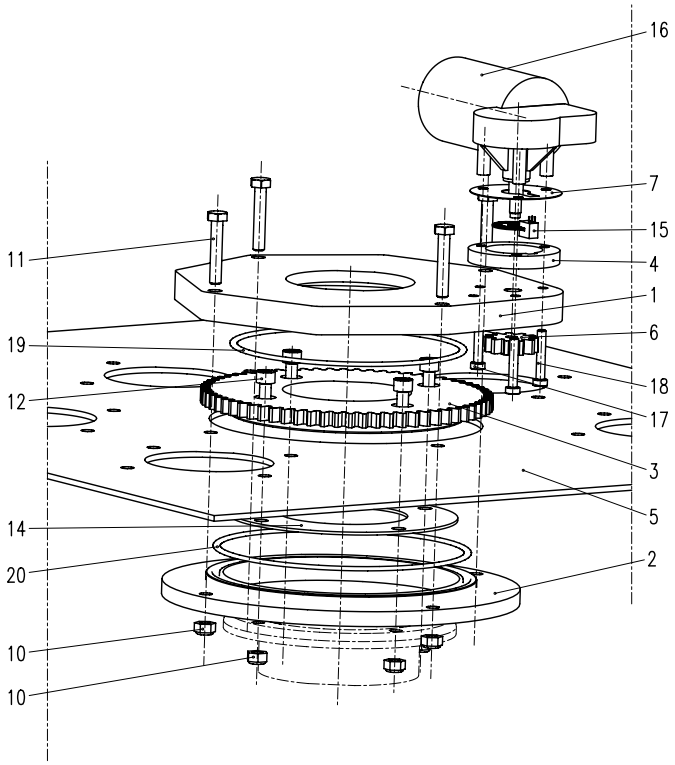


Figure 2: Mechanical assembly

It must be ensured, that the 2 sealing rings (pos. 19 and pos. 20) get enough pressure to make the facility leak-proof and on the other way it has to ensure the movability of the gears (pos. 3 and pos 6) which are guided between the top plate (pos. 1) and the holding ring (pos. 2). It is recommended to measure the current consumption of the DC motor when tightening the mounting bolts (pos. 10 and 11).

For driving the facility a DC-motor with worm gear has been used, refer to appendix B.1.

5 The electronic part

The electronic part consists of 4 modules (see fig. 3) which are mounted on 4 different boards and the power supplies for the high current part (24V) and the microcontroller (9V).

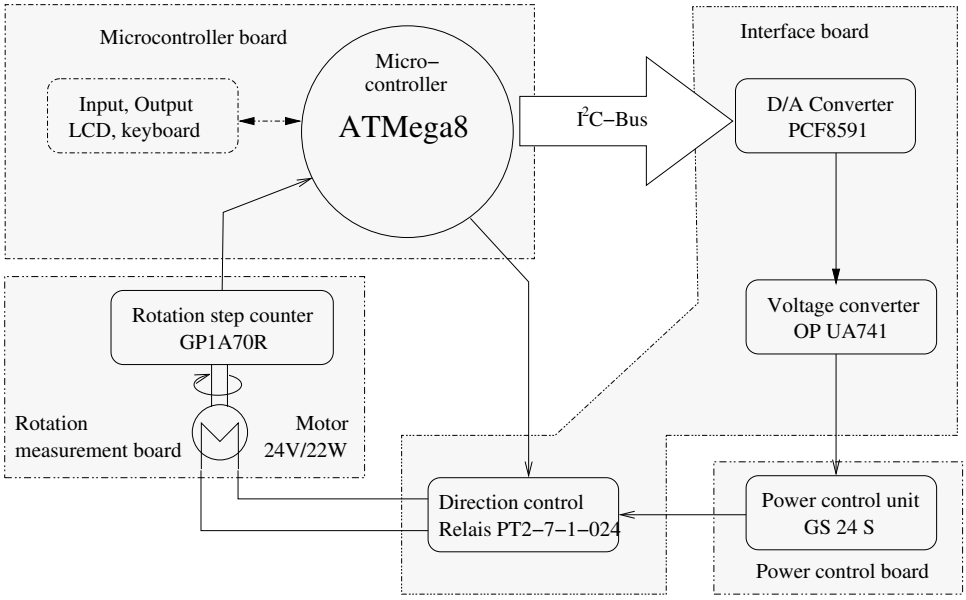


Figure 3: Electronic modules

The four boards are identified as:

1. Microcontroller board (moved out from the housing in the figure 4, the *halvedDISC*),
2. I^2C-interface board (located on the left side in figure 4),
3. Power control board (located on the right side in figure 4) and
4. Rotation measurement board (displayed in figure 5).

The *Rotation measurement board* is directly connected to the drive shaft on the motor, all other components are mounted inside of the housing where the microcontroller is located.

Note:
The main components have to be wired regarding the cabling plan on appendix C, the the *Rotation measurement board* must be mounted directly near the motor. Figure 5 determines the order of the pins for the light barrier circuit.

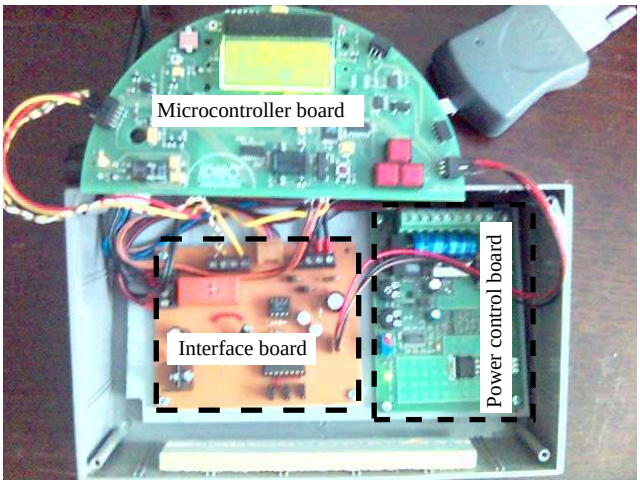


Figure 4: External mounted boards

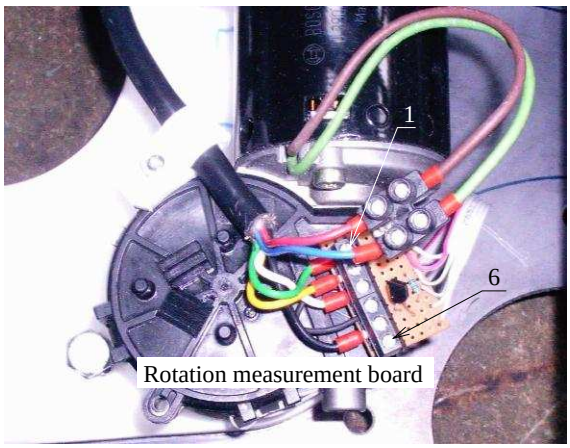


Figure 5: Rotation device/measurement board

5.1 Microcontoller board

A development board from ACMC[2] of the University of Applied Science Mittweida was chosen as main controlling unit. The board is traded under the name halvedDISC[7]. Technical data is available in appendix B.3.

5.2 I^2C-Interface board

The *I^2C-Interface board* has been developed newly for this facility to manage the communication between the *Microcontroller* and the *Power control unit* and to control the rotation direction[1].

[1] In the current software modules only single rotation direction is used. Nevertheless the hardware for using both directions is available.

5.2.1 Adjusting the interface working range

Before using the facility for measurement purposes, the the *I²C-Interface board* must be adjusted once to work in the range 0...10V.

> Hint:
> To check or set the correct working range the manual control mode (see sec. 6.2.3) can be used to measure if the correct voltage values are set or to adjust these value by using the 2 potentiometers (fig. 6).

The trim-potentiometers should be adjusted:

1. until the lowest possible voltage is reached when power control value is set to 0 and
2. a voltage of 10V is reached when the power is set to maximum value of 255.

This procedure has to be done only once before the typical measurement work will be made. Only after a long inactivation of the facility these values should be checked for correctness.

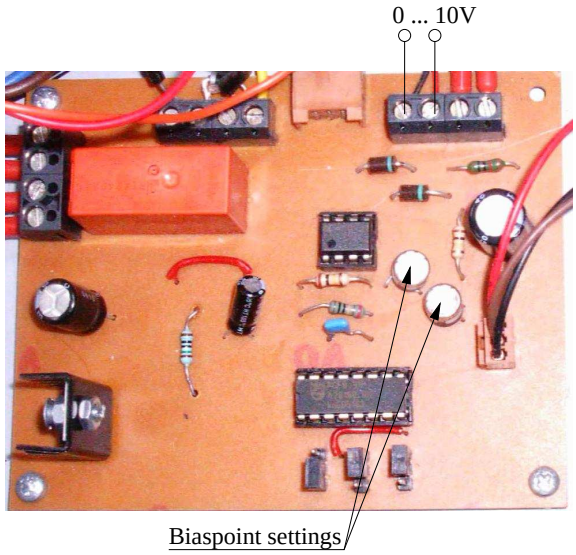


Figure 6: Interface board

More detailed technical data regarding the *I²C-Interface board* is available in appendix D.

5.3 Power Control Unit

For controlling the DC motor the 1-quadrant control unit GS24S from EPH-Elektronik[3] has been selected - see appendix B.2.

5.4 Rotation measurement unit

For measuring the rotation angle a light barrier solution from SHARP was selected, the OPIC Photointerrupter *GP1A71R* by Conrad Electronic[4]. This unit is directly coupled with the drive shaft of the electromotor (see pos. 15 in fig. 2 on page 5 and fig. 5). Technical data is available in appendix B.4.

6 Software

The main controlling task is performed by the microcontroller unit. The necessary software has been developed completely new for this facility. It is written entirely in ATMEL-assembler. For more information about ATMEL refer to [5, 6].

The software allows full control of the rotation of the filter bag in the center of the facility. Several working modes are available, either controlling the rotation “by hand” or automatically. Up to 16 positions may be preprogrammed (teach in mode) and can be addressed directly via the controller keys.

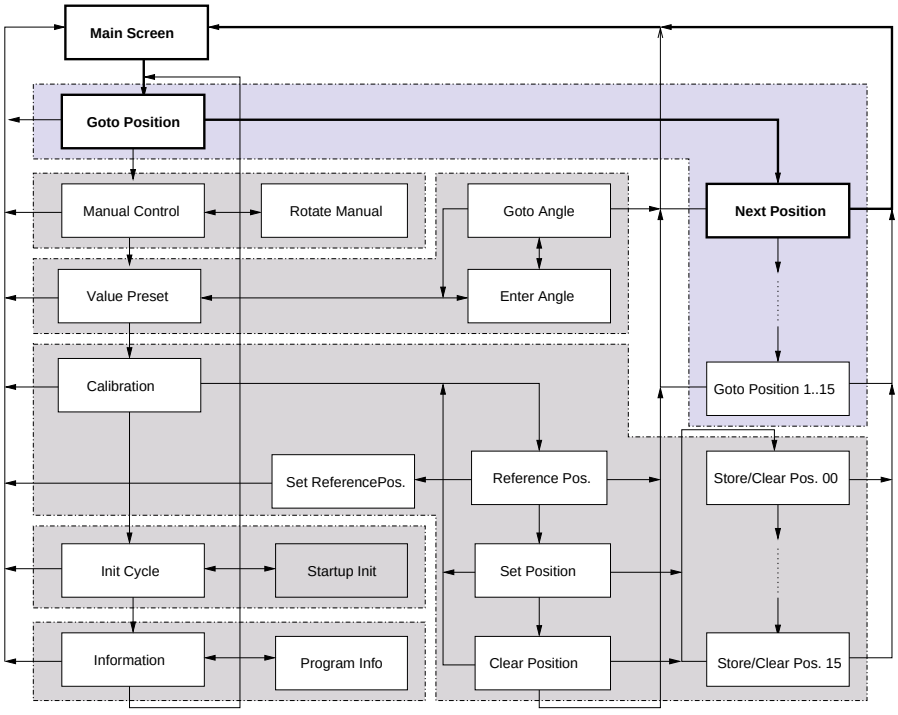
6.1 User Interface

The user interface was designed to fullfill the following requirements:

- to be informative
- to be simple and easy understandable
- to allow detailed control

To accomplish this requirements a consistent user interface has been implemented which gives the user as much as possible feedback and allows intervention in most situations. All commonly used actions are attainable by a minimum of user interaction.

This requirements led to the following user interface menu structure:



Note:
A larger flyout is available in appendix A.

6.1.1 User interface and menu semantic

The menu entries have been mapped to the keyboard of the microcontroller and work in 3 modes whereas the keyboard is used in 2 differnet ways in modes 1 and 2:

The 3 modes are:

1. Menu selection mode (see notes above the leader lines in fig. 7)
2. Value control mode (see notes below the leader lines in fig. 7)
3. Information or feedback mode (this mode does not allow any user interaction).

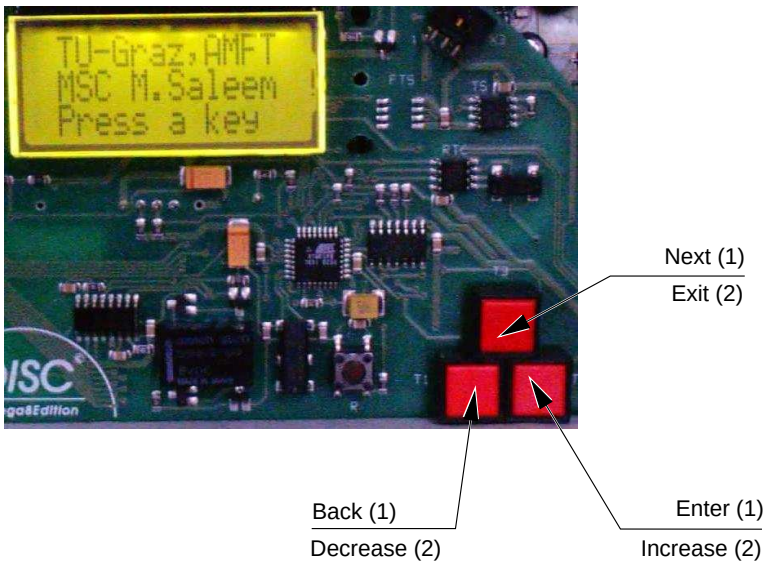


Figure 7: Keyboard usage in mode 1 and mode 2

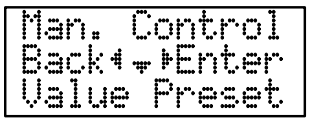
6.1.2 Menu selection mode (mode 1)

In the menu selection mode the screen layout is always:

Display line	Contents	Key semantics
Top line	current menu mode action	
Center line	menu selection keys	Back - Next - Enter
Bottom line	next possible menu selection	

Example:

The main menu entry of the “Manual Control Mode” looks like this:



This screen means, that with the *Back* key (left key) this menu mode can be left, by pressing the *Enter* key (right key) the menu mode “Manual Control” will be entered and the middle key (*Next* key) will advance to the next menu entry “Value Preset”.

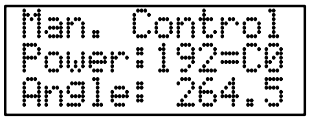
6.1.3 Value control mode (mode 2)

In this mode a numerical input value can be defined or controlled by the 3 keys.

In the value control mode the screen layout is always:

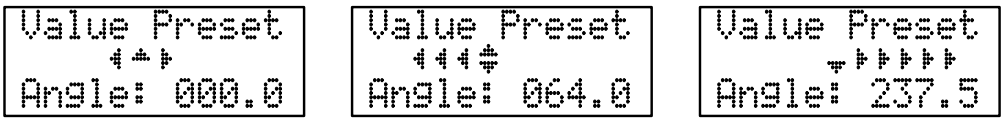
Display line	Contents	Key semantics
Top line	current control mode	
Center line	speed cursor or control value	Decrease - Exit - Increase
Bottom line	current preset or active value	

Examples: The “Manual control mode” looks like this:



In this dialog the Power value is changed according to the *Increase* (right key) or *Decrease* button (left key), the current measured “Angle” value is updated frequently to show the effect of the control action.

As another example, the “Value preset” mode for angles may look this way:



This dialog demonstrates the ability of a keyboard numerical value input.

The *Increase* (right key) or *Decrease* button (left key) change the value displayed in the bottom line, the “speed cursor” reflects the “value change speed” of the preset value by displaying a varying number of arrows, whereas the speed increases with the key-hold time to a maximum of 5 arrows.

- If the *Increase* key is pressed, right-arrows inform the user about the increase speed of the preset value. When releasing the key, the speed value is reset to the lowest value (displayed as single arrow right or left) an the value does not change anymore.
- If the *Decrease* key is pressed, left-arrows inform the user about the decrease speed of the preset value analogous as described before.
- The “Value control modes” will be left when pressing the middle button (called *Exit* button in these modes). In some cases the 1st *Exit* button press may be used as “stop” action. In this situation it may be necessary to press *Exit* a 2nd time or to hold this key down for 1 second.

Additional information according the value control range is visualized in the center of the “speed cursor” in the middle line:

- When no key is pressed, only the “up-only arrow” is displayed between the 2 “increase/decrease arrows” as no speed reduction is possible in this case - see left figure of “Value Preset” example above.
- In most cases the “up/down cursor” is displayed in the middle of the speed cursor to indicate that increasing an decreasing of the speed is possible in this situation - see middle figure of “Value Preset” example.
- When reaching the maximum increase or decrease speed value, the “up/down cursor” in the middle of the cursor line changes to a “down-only arrow” to inform the user about the fact that additional increasing is not available - see right figure of “Value Preset” example.

6.1.4 Information or feedback mode (mode 3)

Except the 2 interactive user modes several informational feedback and display contents are defined, which provide the most important data regarding the active program action.

Some feedback examples contents:

Idle mode: software title, current room temperature and the last result angle

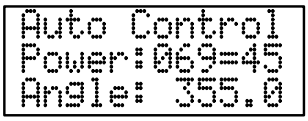
Information mode: the software build date, program author and other information

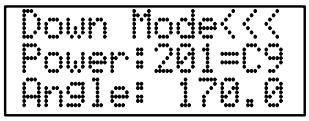
Rotation control mode: control phase, power value and current angle

All these screens are summarized under the term “Information mode” or “Feedback mode” and will be described detailed in the following sections.

Note:
In these modes any keyboard user interaction is disabled.

E. g. the automatic positioning from the “Goto Position” mode will display the following screens depending on the phase of the control cycle:





For more information regarding these screens refer to section 6.2.2.

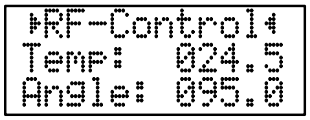
6.2 User functions and program modes

In this section each specific function will be worked on with example screens, the functionality and semantics of each function is described.

6.2.1 Main screen or “Idle mode”

This is the function which is active after system startup and may also be selected by the *Back* button (left key) in the main menu level (see also section 6.1) or after execution some other functions.

Program title, the current room temperature and the last angle stop position is displayed in this mode.

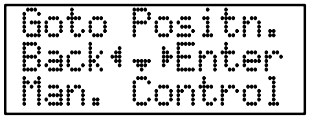


Note:
The angle position control is persistent, i. e. that the last angle is pursued even after switching off the facility and deactivating any electrical power, as it is stored in an internal EEPROM area of the microcontroller.

The “Idle mode” is left at any keyboard interaction, i. e. pressing any of the 3 keys initiates the 1st main menu entry described in the next subsection.

6.2.2 Goto Position mode

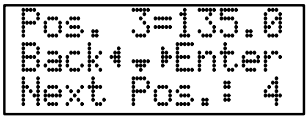
This is the function that will be used in most cases. It’s the “normal work mode” and designed to do measurement cycles in a convenient way. The main menu entry is:



Internally a list of max. 16 angle positions may be stored which are numbered from 0...15. The value of position 0 is displayed as “Reference Position” and is usually stored as angle value 0.0°, all other angles are displayed as “Pos. 1”, “Pos. 2”, etc. Any of these 15 position may also be omitted if no value is stored on that position, in that case this index will be skipped in this mode.

As an example also the following positions may occur in sequence: 0 (Ref.), 1, 3, 7, 8, 15.

When pressing the *Enter* button one of the following menu entries will appear, depending if the reference position or any other numbered position has been selected:



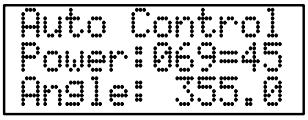
In this display the top line displays the position index of the **next** chosen angle (this angle will become the next “current” angle position on selection), in the middle menu line the “menu select cursor” is displayed and in the bottom line the index of the angle position following the chosen “next” angle.

Important note:
It is not fixed that the reference position (pos. 0) is stored as angle value 0.0°!
Use the function “Calibrate” (see 6.2.5) or the “Boot up information keys” (see 6.2.8) to verify which angle is stored definitely at position 0.
This feature makes it possible to use a “reference point offset” as fix value to be added to the reference position 0.0° (see also section 6.2.5 on page 18).

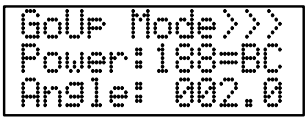
When selecting a specific location by pressing the *Enter* key, the automatic positioning control cycle begins.

5 Phases of the control cycle: There are 5 phases of the control, whereas some phases may be omitted if the control logic does not allow this (e.g. if the rotation angle is too low to reach the maximum speed phase, it will be skipped).

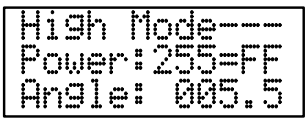
The top line always displays the control phase, in the middle line the current power value is shown and the bottom line is updated according to the current angle value:



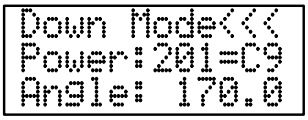
1. the “initialization and pre-movement” phase:
   This phase is defined as beginning the rotation control where no movement occurs (before reaching a power value which overrides the rest friction of the facility).



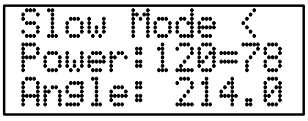
2. The “rotation speed up” phase:
   In this phase the rotation speed is increased continuously until the maximum power value of 255 (Hex 0xFF) is reached or until the “rotation speed down” phase begins.



3. The “high speed movement” phase:
   If the highest speed value is reached, the rotation speed is kept on the constant maximum value until the “rotation speed down” position is reached.



4. The “rotation speed down” phase:
   To stop at an exact predefined location, the last rotation steps must be made using a very slow speed to enabling the “power off” at the target position. This phase decreases the speed constantly until the “slow speed” power value is reached.



5. The “slow speed” phase:
   This is the exact position control phase. At a minimum speed the rotation is continued until the preselected target position is reached and the power is switched off at the correct moment.

Important remark:

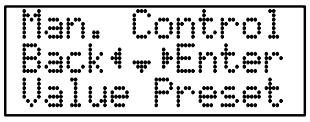
Due to the control logic and the hardware design of the rotation facility it is not secured, that the final position is exactly identical to the predefined angle value. Inertia, friction and other influences may lead to situations where the end location may differ to the preselected within 1 measurement step. This does not mean that the angle measurement is inaccurate, rather the measured angle is a main input parameter for the optical measurement software which will consider this fact in the program algorithms to come to a non-ambiguous solution for the measurement purposes.

Correcting the positions by changing the rotation directions would lead to other negative influences to the measurement results (e.g. the tooth backlash of the gears) which would impair the values in a higher degree than the mathematical approach.

The deviation of the preselected and measured angles is corrected in the calculations to fit the requirements of the scientific goal of the rotation facility.

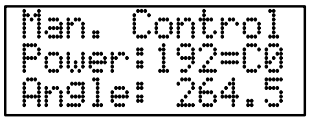
6.2.3 Manual Control mode

This mode can be used to controll the rotions speed and position “manually”. The main menu entry is:



When entering this mode by pressing the *Enter* key the “Manual Control” Menu appears.

The “Power value” the middle line displays the motor control power which is in range 0…255 maximum. At the begin of this mode the “Power value” is set to the value 000, i. e. no movement is possible. This value is displayed in decimal and hexadecimal representation:



With the *Increase* key (right) and the *Decrease* key (left) this value is increased and decreased accordingly and is directly transformed to a motor control voltage value to control the speed of the motor rotation (see also 6.1.1).

In this mode the speed of the value increment will be increased with the key hold time up to a max. value of 32x the basic speed.

When pressing the *Exit* key the power control value is reset to the value 0 immediately. In this situation the value can be increased again by pressing the *Increase* key or the ”Manual Control mode” will be left by pressing the *Exit* key once more.

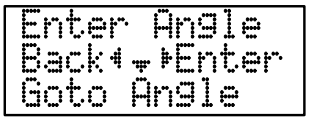
> Note:
> As there is much rest friction in the mechanic part the rotation will begin at a power value far away from the start value 0, depending on mounting conditions, material friction values, etc[2]. This function may also be used to control the necessity of maintenance cycles or to check long time behavior of the facility. For that topic refer also to maintenance section 7.4.

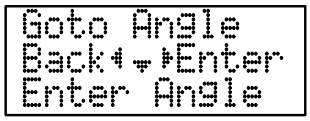
[2] In the development phase working in an experimental environment the value for rotation begin was in the range of ca. 120…140 (near the hex value 0x80), which is ca. 50% of the maximum value.

6.2.4 Value Preset mode

The Value Preset mode is designed for entering a specific angle position interactiveley via keyboard, which can also be triggered instantly. The main menu entry is:

After entering this mode by pressing the *Enter* key the "Value Preset" selection menus appear:

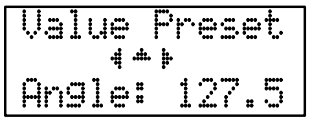




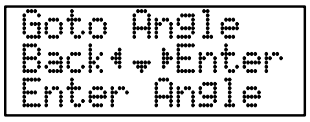
This menu loop can be used to switch between the 2 control modes:

1. Enter a requested angle
2. Start rotation to stop at this angle

If choosing the "Enter Angle" mode, the user may define a specific angle. The input screen for entering a specific angle looks as described in the section 6.1.3 on page 11 and allows the definition of any value besides the preprogrammed values as described at the "Goto Position" mode in section 6.2.2.



After predefining an angle value and leaving the "Enter Angle" mode by pressing the *Exit* button (middle key) the user comes back to the "Value Preset" selection with the second option as default (the "Goto Angle" mode in this situation). By using the *Next* key he can switch back to the "Enter angle" mode, etc.

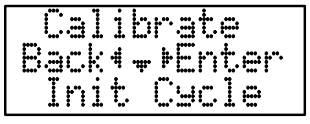


Usually the "Goto Angle" will be selected to go to the predefined angle position, where the user can continue his measurement work or change to the "Calibrate" mode (see 6.2.5) to store this specific angle in one of the 16 memory locations for later usage in the "Goto Position" mode (see 6.2.2).

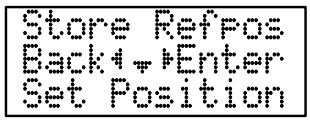
When leaving the "Value Preset" mode by pressing the *Back* button, the user falls back into the "Idle mode" of the Main Screen (described in 6.2.1).

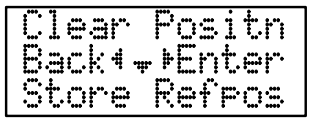
6.2.5 Calibrate mode

The Calibrate mode provides the functionality to define the base angle position (called "Reference position") and all stored angle positions in a teach-in manner. The main menu entry is:



After selecting the "Calibrate mode" by pressing the *Enter* key, the main menus of the calibration mode are displayed in order:



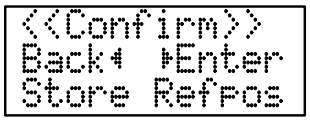


The *Next* key has to be used to rotate through the 3 menu screens.
The 3 possible functions are:

1. Store the current angle as new reference position
2. Store the current angle in any of the numbered positions (0…15).
3. Clear any of the numbered position angle values.

Note:
These first two actions have totally different semantics. Whereas the “Store Refpos” command defines a new absolute rotation reference angle (by resetting the actual angle to 0.0° and storing this position immediately to the persistent EEPROM memory), are the “Set Position” actions all corelated relative to that reference position. The last action is used to “clear” already stored positions.

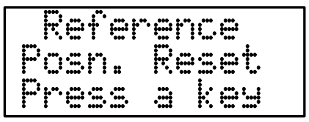
Setting a new reference position: When selecting *Enter* to store the current position as reference for all other measurement angles, the following confirmation dialog appears:

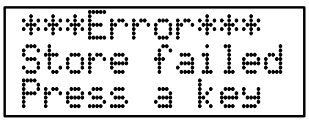


Once again the *Enter* key must be pressed to confirm that the current angle position will become the new reference position with the following effects:

1. The current angle becomes reset to 0.0°
2. This value will be stored in the persistent EEPROM memory as “last value”

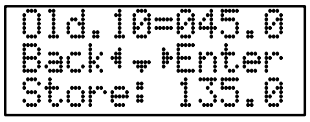
After storing the reference position, a success message (or an error message on failure) informs the user about the result this requested action:



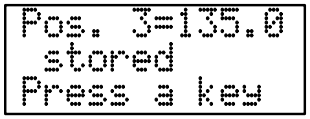


Storing a numbered position: When selecting “Set Position”, the “position store” menu becomes activated. This menu can be used to step through all possible storage positions by using the *Next* key (even if there is currently no value stored at a specific position). In each position the current angle can be stored by pressing the *Enter* key, the positions are numbered from 0[3] to 15.

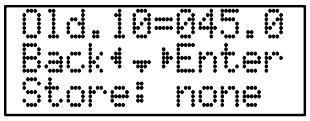
In the display in the top line the old value is displayed prefixed by “Old.”, in the bottom line the current angle is shown prefixed by “Store:”:



When pressing the *Next* key, the display is advanced to the next value. After position 15 the cycle becomes continued with position 0. The *Enter* key stores the current angle position as value for the current displayed numbered position and as feedback a screen message is displayed:



Clearing a numbered position: When selecting “Clear Position”, the “position store” menu becomes activated, as described in the previous section. The only difference to the “Set Position” function is, that the value to store is called “none”. The handling is identical to the previous described function and the confirmation display will confirm, that the value “none” has been stored in the selected position.



Programming a reference position offset: In general the reference position is preset to the value 0.0°.

But it is also possible to store another angle at position 0, which is defined as reference position. If that is intended the reference position may be defined at another absolute angle value than 0.0°.

> Remark:
> Nevertheless in any of the other positions the angle 0.0° may be stored to use this position in a measurement cycle.

An unusual reference position may lead to misunderstandings, therefore we recommend to use this feature carefully and restore the “standard” behavior when it is not used anymore.

> **Note:**
> If the reference position is set to another value as 0.0°, the user must pay attention that the facility is set up that way. In the user interface still the symbolic word “Reference Position” will be used but the facility will not match to the default behavior.

If the user is unsure about this situation he has 4 options to make this situation non-ambiguous:

1. Use the “Calibrate” mode to check which angle is stored in position 0 (see 6.2.5).
2. Use the “Goto position” mode and select the “Reference Pos.”. After reaching this position, the reference angle is displayed as “current” angle (see 6.2.2).

[3]The position 0 is dedicated to the reference position and should always have the value 000.0, except when a reference position offset has been be programmed.

3. Use the “Setting new reference position” as described above in this section, to set the reference position value to the standard value 0.0°.

4. Use the boot up information keys to display the stored positions or achieve the automatic basic setup program to reset the facility to the default behavior (see 6.2.8).

6.2.6 Init Cycle mode

When not using the rotation facility for a long time, it may be possible, that the facility bogs down. This means, that there is no way to start up the rotation in a “normal” was as described in the methods above.

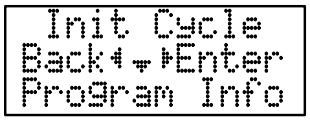
In that situation the following screen will appear and inform the user about this situation:

Important remark:
The “Init Cycle” mode is thought to implement a software solution to unsnap the frozen position. But as there may be many reasons and hardware and software solutions for dealing with this situation, no algorithm has been implemented yet, only the user interface is currently available.

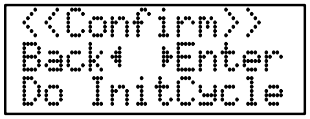
If this situation appears, the facility should be powered off immediately to prevent damage of the hardware and the reason for this situation has to be examined and eliminated before continuing the work.

Nevertheless the user interface is described in this document to show the situation if the software program would have been implemented.

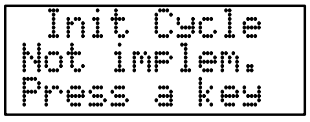
The main menu entry is:



After selecting the “Init Cycle” mode by pressing the *Enter* key, the following screen must be confirmed with the *Enter* key to execute the “Init Cycle” program:



Until the implementation of the algorithms in this situation the following message will appear to document the situation:

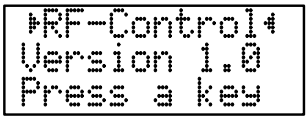


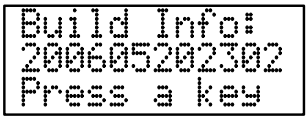
6.2.7 Information mode

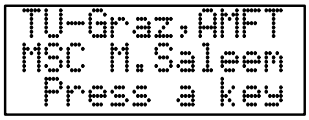
The “Information” mode informs about software release, programmers name, facility maintainer and software built time. The main menu entry is:

The different screens are displayed in a rotating manner for ca. 1 second for each line and 2 seconds after writing the last display line of each screen.

The loop is ended if the user presses any key. Typical screens may look like this:

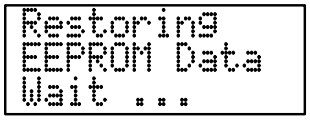






6.2.8 Boot up information keys

When booting the microcontroller before working with the rotation facility, some information will be displayed for a short time. One of these screens will display the following message for ca. 2 seconds:

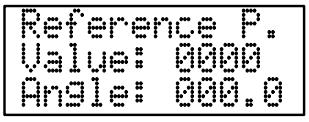


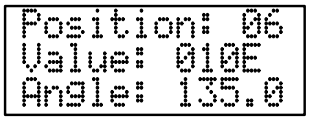
Within these 2 seconds some initialization and diagnostic programs can be activated by pressing a key, currently 3 “magic key” programs are implemented:

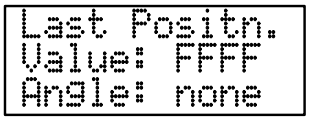
1. Angle Display Information program (left key)
2. Automatic Basic Setup program (middle key)
3. Activation of manual Dual Direction Mode (right key)

Angle display information: This programs is supposed to display all 16 stored angle positions and is activated by pressing the left key. After pressing this key each stored position is displayed for a short time.

Examples:

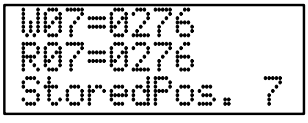






Unused angles are displayed as “none” angle value, the internal representation in hexadecimal format for each angle is displayed at line 2 of the screen.

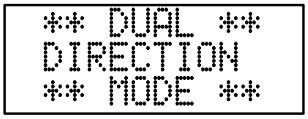
Automatic Basic Setup: This program may be used to initialize the microcontroller with typical standard values (as described in section 7). This may be used for easy preprogramming of defined standard angle position values. The stored angles are displayed in the startup phase in hexadecimal format.



The values are written to the non-volatile EEPROM memory (W07=...) and afterwards read in again (R07=...) to ensure the correct functioning of the hardware. In line 3 the stored position as decimal number is displayed.

Important note:
After writing these values any previous stored information is destroyed. Only the first 8 angle values are predefined, all upper positions are set to "none".
The current position is treated as reference position and is set to 0.0°.

Dual Direction Mode: Even as the hardware is able to rotate the bags in 2 directions, a descision was made to use only single direction rotation in measurement relevant rotation processes to ensure a maximum of preciscion (see also remark on page 14). Nevertheless in some situations it may be quite convenient to use both directions for manual positioning control (see also 6.2.3), even if the angle is not calculated in the correct way. For these situations the Dual Direction Mode may be activated by pressing the right key (*Enter*) when booting up the controller. The confirmation message:



is displayed to inform the user about this special test mode.

After activating this mode, at any selection of the Manual Control Mode a screen with the following contents is displayed and one of the 3 cursor keys must be used to select the corresponding direction or to leave the manual control mode:

When pressing the the right key (*Enter*) the "normal" rotation direction is acivated, as it is selected in any other automatic control mode, when pressing the left key (*Back*) the direction of rotation is reversed (back rotation) for this single Manual Control cycle and when pressing the middle key (*Next*) the Manual Control mode is left and the main menu is entered again.

Important remark:
The Dual Direction Mode cannot be used to do positioning using the angle value display, as the display does not honour the rotation direction. I. e. that when positioning the facility in the reverse direction mode, the angle value change is calculated with the wrong direction (means always positive rotation direction) as it is used in "normal" mode and the reference angle position is lost. The user must use the Calibration Mode (see 6.2.5) again to set the correct reference angle.

7 Quick startup guide

Mainly the rotation facility will be used to measure dust cake thickness with the FILTER CAKE TEST FACILITY. The new features are implemented to rotate the center bag to make it possible to do optical measuring not just on the front side of the filter bags, as the rotation facility extends the functionality to make measurements possible on all sides the the filter bags.

A typical experimental session may be described in this chapter and will cover the “normal” (means mostly used) steps for using the rotation capability. This document also presumes, that the operator of the facility is familiar with the handling of the test system which is not covered by this document.

7.1 Rotation Facility run up

1. The facility has to be powered up as it has been done before the rotation capability has been implemented.

2. As next step the power supply which drives the motor of the of the rotation facility must be activated (24V power supply, 10 A max. current) by plugging it to 220V.

3. After this, the controller unit power must be powered up, by plugging the the 9V supply of the microcontroller into a 220V connector.

   Notes:
   When powering up the controller before providing power to the motor and interface card, the microcontroller will not boot up.
   When the controller should be used without the interface card and the motor unit, the I^2C-connector must be unplugged. The connector is marked with “X2” on the controller board and is located to the right of the keyboard (see figure in section 4 on page 7).

7.2 Measurement process

Typically 8 images within one rotation are used to measure the dust cake thickness on the complete circumference. These are the 45° steps from 0° to 315°.

The main menu will be activated by pressing one of the 3 keys on the keyboard of the microcontroller when in “Idle mode” (Main Screen - see section 6.2.1).

1. If the current position is not the reference position (means 0.0°), the reference position has to be triggered, if the current position is already the reference position, continue to step 3.

2. Locate the reference position as start position:
   Main menu: Goto Position →Reference Position →Enter
   If the 1st menu entry is not the “reference position“, use the *Next* key (middle button) to advance to position 0 (reference position) and press *Enter* (right button)→ - (see also 6.1.2 on page 10).

3. Complete the optical measurement cycle for this angle position.

4. Advance to next angle position:
   Main menu: Goto Position →Next Position →Enter
   After the reference position, this should be the angle 45° otherwise the next 45°-step after the current angle.

5. Repeat step 3. and 4. until all 8 cycles have been finished.

7.3 Rotation Facility shutdown

After completing the experimental work it is recommended to power off the rotation control hardware.

1. Unplug the 9V supply of the microcontroller
2. Unplug the 24V power supply
3. Power off all other components of the facility as usual.

This ensures to save energy when the facility is not needed and increases the lifetime of the electrical and electronic parts.

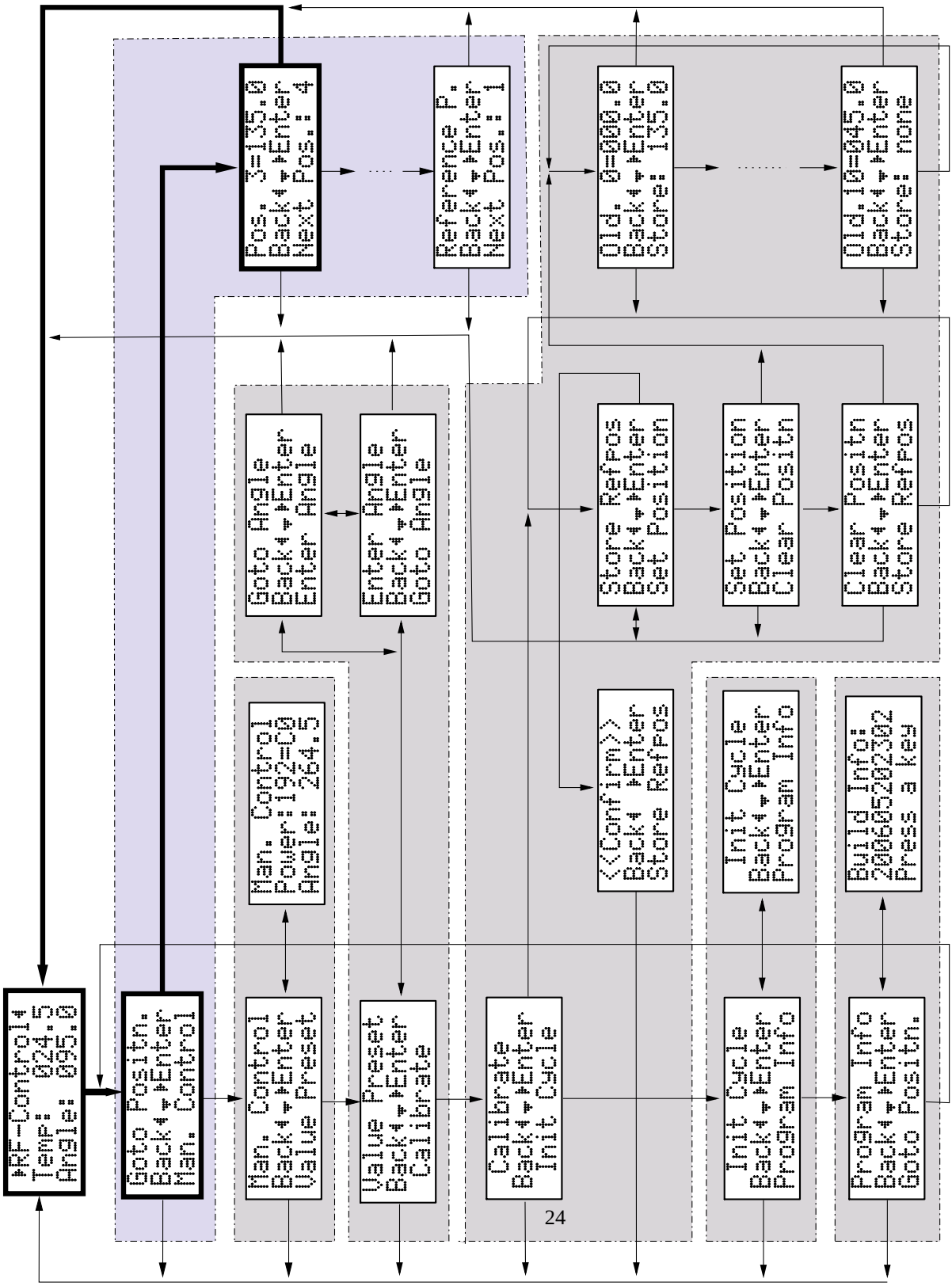
7.4 Service and maintenance

The rotation facility has no dissipating parts, so no regular maintenance work has to be achieved.

But to avoid the facility to be stuck, it should be moved periodically. Activation cycles of one week should be taken as clue. If no higher “rest friction” is noticeable, this period my be increased, if still problems occur when starting up the facility, the service period may be decreased.

As a simple test case the “Manual Control” mode can be used (see section 6.2.3). The startup value when the rotation begins should be taken as reference for further tests how the rest friction will behave over the time. Observe this value for determining clean up cycles for trouble-free work.

A User interface structure



B Technical components

B.1 DC-Motor (Actuator)

Vendor:
Wolfgang Graf - Elektromotoren[8]
Albertgasse 11, A - 1080 Wien
Telefon: +43 1 406 1400, Hotline: +43 664 38 28 119 , Telefax: +43 1 406 0990

Manufacturer: Fa. Bosch, Germany

Order No.: 0 390 257 689

Technical	Data	
Operating voltage	24	V
Nom. power	22	W
Nom. current	2.5	A
Max. current	11	A
Nom. rot. speed	29	rmp
Nom. torque	22	Nm
Transmission. ratio	1:55	

B.2 DC-Motor control unit

Vendor:
Wolfgang Graf - Elektromotoren - see appendix B.1

Manufacturer: EPH-Elektronik [3]

Order No.: 1107-GS24S/03-360B

Technical	Data	
Operating voltage	12-48	V
Max. current	6	A
Control voltage	0-10	V
Impulse frequ.	18	kHz
overcurrent relay	yes	

B.3 Microcontroller (halvedDISC)

Vendor:
IMM Elektronik GmbH, Mittweida [2]

Development: ACMC Application Center Microcontroller [2]

Technical	Data
Microcontroller	ATmega8
ISP Flash RAM/SRAM/ISP-EEPROM	8 kByte/1 kByte/512 Byte
Timer	2x8-bit/1x16-bit
Osc. frequ./Voltage supply/Current	4MHz/7.5V/>=30mA
LCD Display, Background light	EA7123-I2C
RT-Clock/Temp. Sensor/Photo resistor	DS1307/LM75/FW300
Relais output/Optocoupler input	OMRON G6H/Connector X1
I2C InOut/ISP input	Connector X2/X3
8-bit OnChip ADC	Connector X4
Input devices	3 function keys/1 reset button

B.4 Rotation measurement unit

OPIC Photointerrupter with encoder functions.
Remark: the used device did not fullfill the TTL specification.

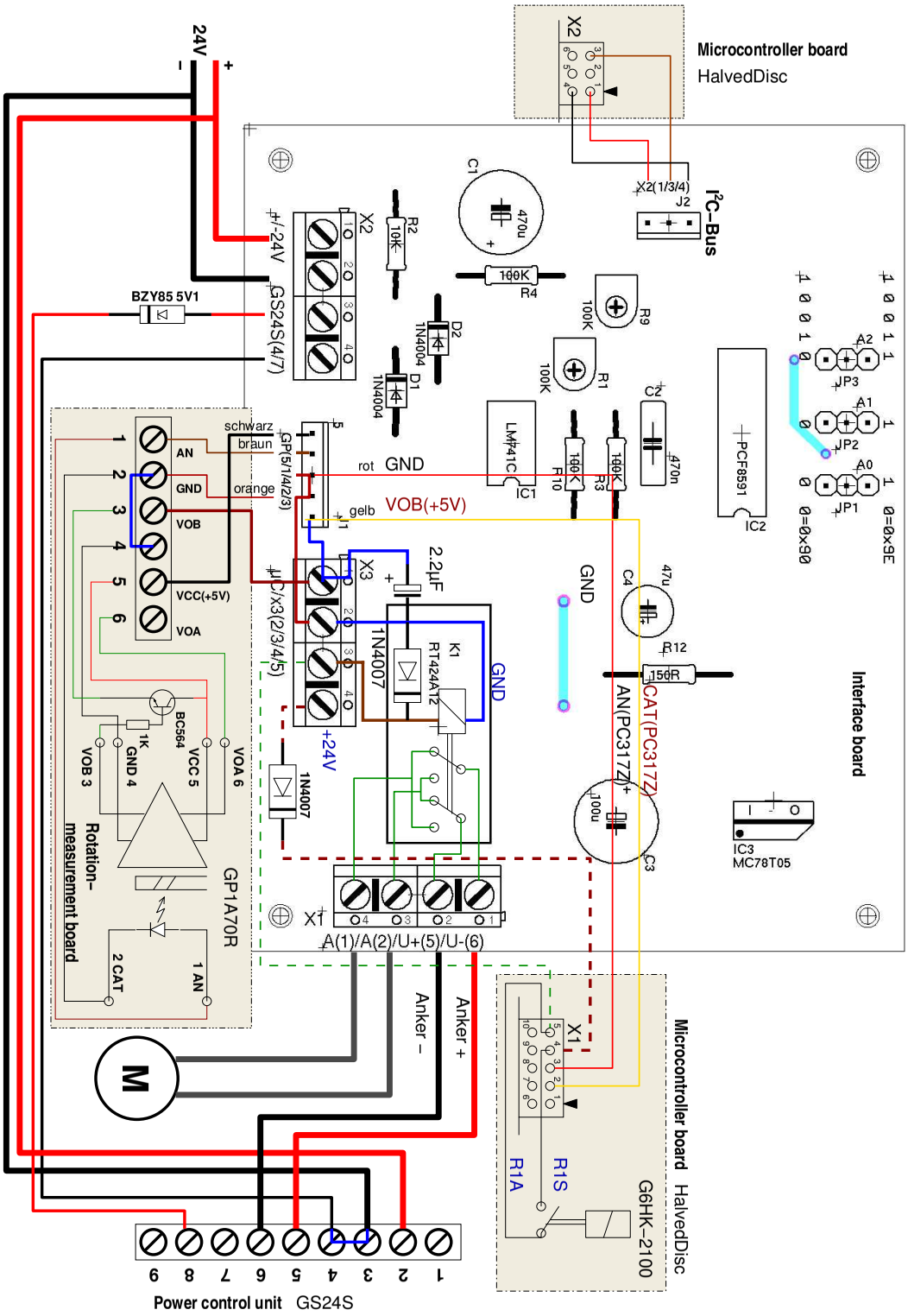
Vendor:
Conrad Elektronik[4]
Kärntner Straße 228, A-8053 Graz
Tel.: 0316/286464-0, Fax: 0316/286464-10

Manufacturer: SHARP Electronics

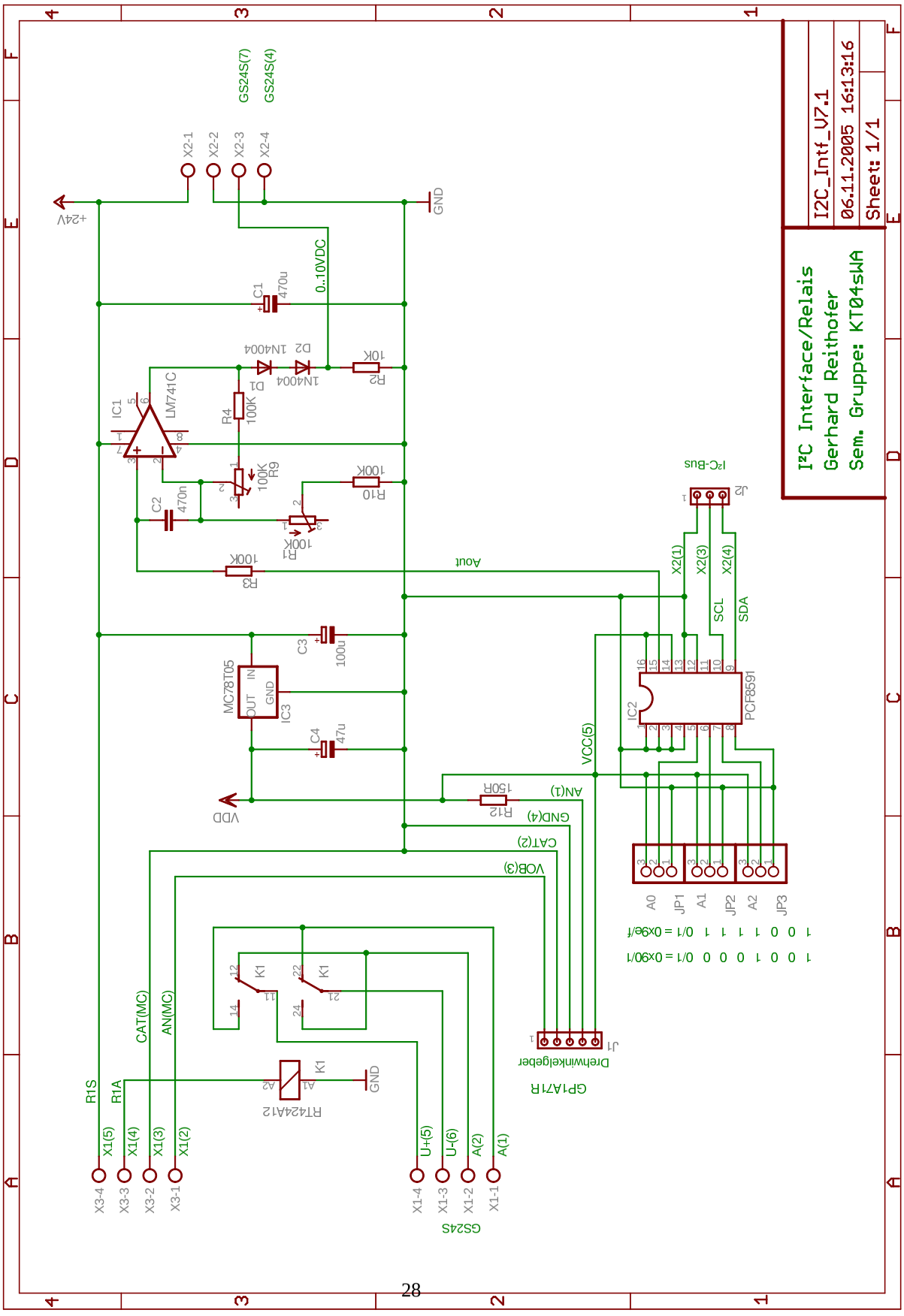
Order No.: 181714-62

Technical	Data		Remarks
Forward voltage	1.2	V	
Supply voltage	5	V	
Supply current	5	mA	max. 0.5mA on used devices
2-phase digital output			only 1 phase used in facility
max. frequncy	10	kHz	
Interrupter disc	120	impulses	

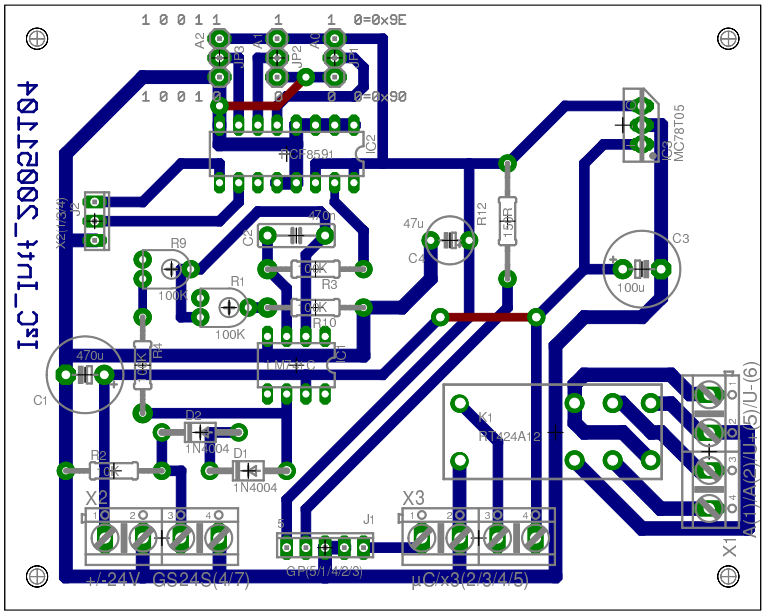
C Cabling plan



D Interface PCB data (Schema)



E Interface PCB data (Layout)



References

[1] Hand book of bag filter test facility, TU Graz, Document AMFT-27-2004

[2] Application Center Microcontroller - http://www.htwm.de/acmc/

[2] IMM Elektronik GmbH, Mittweida - http://www.imm-gruppe.de

[3] EPH-Elektronik - http://www.eph-elektronik.de/

[4] Conrad Elektronik - http://www.conrad.at/

[5] 8-bit AVR instruction set, Rev. 0856D-AVR-08/02, ATMEL

[6] 8-bit AVR witk 8K Bytes In-System Programmable Flash, ATMega8(L), Rev. 2486-AVR-09/02, ATMEL

[7] halvedDISC homepage - http://halveddisc.htwm.de/

[8] Elektromotoren Graf - http://www.elektromotor.at/