

# User information for PCBMotor LabKit v5

Dear Customer,

April 29 2010

This document describes the installation and use of the PCBMotor LabKit v5 and the associated WindowsXP control program "LabKit v5.3". Please read the following information carefully and keep in mind that the system is a tool developed to help design and evaluate our piezo motors. Only skilled personnel should use the system and care should be taken to avoid excessive current in the output stage (>1.5A). If you are in doubt we suggest using a lab power supply with current limiter as a precaution.

## New features in v5.3

**Output voltage & currents:** Changed settings for 5.6V maximum output, but take care: **DO NOT exceed 500mA for the 30mm stator.** Typically this will happen at a supply voltage setting of approx 3V. Smaller and larger stators will handle currents scaled with the radius. When the current exceeds 1000mA a warning will appear.

**Scripts:** The Sequencer has been much improved and new functionality added to take input from a stimuli textfile with voltage in mV and negative voltages used to reverse rotation. The format in the textfile is as follows (see also StimDemo.txt):

```
; Format is: Vsupply, Timemultiplier
; "Vsupply" is in mV (negative value reverses direction) and "Timemultiplier" is multiplied with StepTime on frontpanel
; Empty lines & comment lines starting with ";" are allowed
; Setting Vsupply less than Vmin=1.35V will stop the motor in that period
; StepTime X TimeMultiplier cannot exceed 60.000mS, i.e. max 1 min per step
1300 , 1
1315 , 10
1401 , 1
-1546 , 100
```

When Tracking is turned on before the stimuli-file is executed, tracking will be suspended while the execution is ongoing but if you have asked for a number of repeats, a short period of tracking happens between repeats. This means you can use the script feature for very long periods without having to readjust the frequency of the motor, e.g. life tests for your application etc.

**Command line execution:** The LabKit-program can be called / executed from a DOS prompt, command-line or a .BAT file using the stimuli file as the optional parameter

e.g: "LabKit v5.3.exe " & FileName,

where filename is the optional stimuli file to be executed. See Runsine.bat as an example.

If the filepath/name contains spaces, it should be embedded in double quotes. It is also possible to run the program from within Visual Basic (or VBA) by the shell command.

**USB dongle for TestKit:** The LabKit SW is now able to control a simple USB dongle for the EvalKit and TestKit using RS232 status lines DTR & RTS to control STB respectively SEL on the driver. The dongle is available from our webshop. Autodetect finds out if only the USB dongle and not the complete LabKit is available and disables the the command buttons for the missing features. Script functionality and command line execution remains, but voltage setting in the stimuli file is ignored.

Numerous small improvement/corrections have been made to make the program more intuitive to use. Comments and criticism are welcome to make the program even better.

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## Driver installation

A USB driver for the FTDI chip in the box is required for proper communication. First time you connect the Development Box to your PC you should point the automatic installation to the driver supplied as part of the SW kit. Do not let the installation procedure search for drivers on the Internet, but direct the driver search to the directory.....: [CDM 2.02.04 WHQL Certified](#).

## Stand Alone Development Box without PC

(NOTE: This functionality is a precursor of a fully embedded driver and is still under development)

1. Connect the motor to the box.
2. Choose voltage level on the potentiometer on top of the box (Set to max first time)
3. Connect the Power Supply

You should observe that the motor starts turning, hesitates and then turns on properly. This behaviour is due to the initial frequency sweep and subsequent frequency tracking.

If you disconnect the power and start once more with a lower potmeter setting the motor starts turning with a lower rpm. You can turn up and down for the voltage and let the automatic tracking system find the right frequency.

With the motor turning you might hear a slightly "fluttering" sound as the tracking routine follows the change in mechanical resonance due to self-heating. However, once you operate the switch on the box the tracking will cease until next power up and the frequency will stay fixed at the current setting.

*NOTE: Running continuously at full power will make the stator very hot. Although this is not damaging for the stator it is not recommended. The stator should not be run continually without a rotor due to self-heating! Adjust Vs for a max current of 500mA (30mmØ stator).*

## USB mode with PC control (FTDI Driver should already be installed)

1. Connect the motor to the box.
2. Connect the USB cable (Not supplied)
3. Connect the Power Supply (The motor starts turning)
4. Wait approx 10 s for the PC to find the port
5. Start "USB ADC Testbox v4.2.exe"

Once the program loads the motor stops and you should see the message: "FT232R USB UART" with a handle of "A4000". If you see "COM Error: FTDI port not responding", you have either been too fast in loading the program or the driver is not working properly. Try re-starting the program and/or verify driver installation.

With the PC in control of the box the voltage setting potmeter on the box is disconnected until next power up, but the switch is still working.

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## Control program features

1. Start & Stop
2. Change rotation CCW/CW
3. Set frequency (Textbox or arrow buttons)

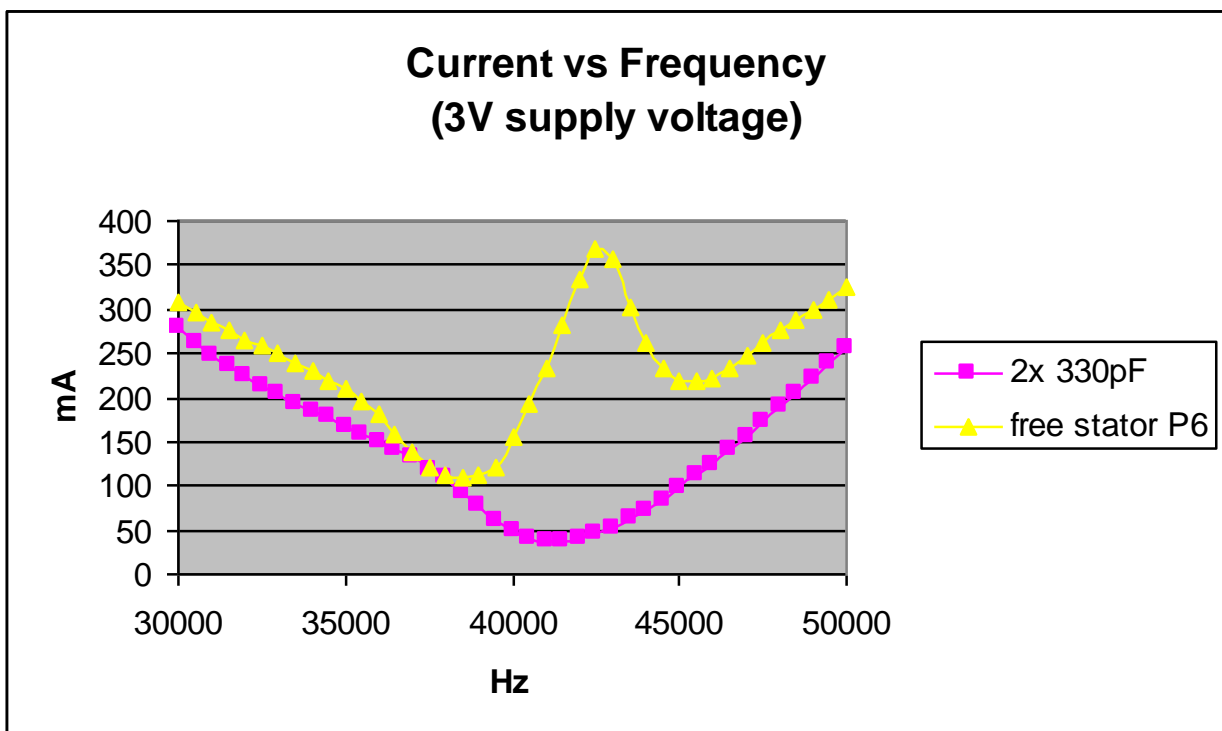
*The sweep start/stop setting also determines the frequency tuning range. If you change either of these values, watch out for the current to the motor which could go dangerously high (>1.5A) and watch also out for power dissipation.*

4. Set phase angle between the two phases
5. Set supply voltage for the output stage (replaces potmeter setting)
6. Sweep from "start" to "stop" with variable steps and time
7. "Track" resonance frequency with variable step (replaces embedded routines in box)
8. Repeating sequences

The default sequence lasts 10 s: 2s CW, 3s OFF, 2s CCW and 3s wait. The duty cycle is therefore 40% and can run continuously without severe self heating. The basic time unit can be changed as well as individual periods and rotation directions, making this feature handy for testing purposes e.g. endurance testing in several applications with more than 20.000 repeated sequences. The progress of the testing is logged for each 100 cycles in C:\Cyclecnt.txt in case a long test is stopped prematurely; just remember to rename the file before resuming the test.

## Finding the optimum frequency

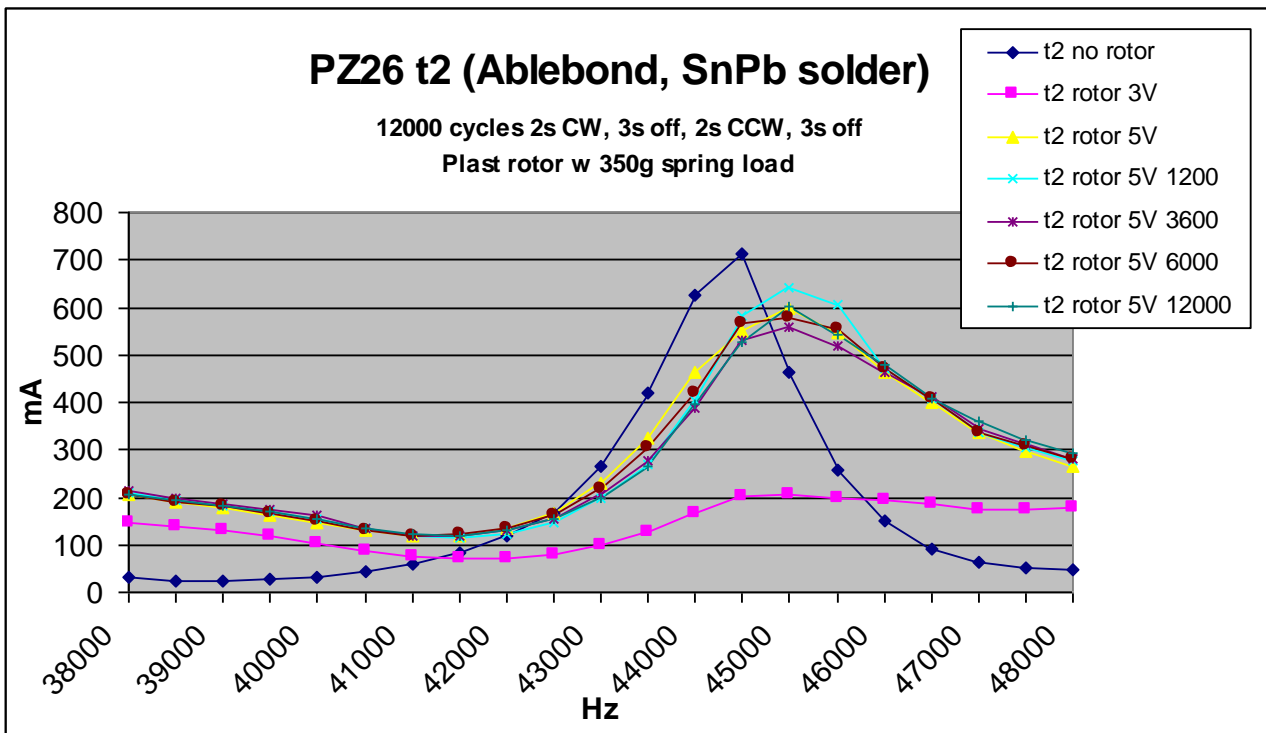
The performance of the motor, i.e. speed & stall momentum, is closely related to the total DC current supplied to the output stage transformers so the optimum frequency can be determined by measuring the current as a function of frequency. The Sweep Function has been designed for this purpose.



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The chart compares the current measurement for two ordinary 330pF capacitors (one for each phase) with a free stator (also approx 330pF). The current measured for the two capacitors shows the expected minimum at the electrical resonance of the output stage, while the stator with the piezo elements has a peak at the same frequency. This behaviour is due to the *mechanical* resonance of the stator with piezo elements, so the peaking represents the quality of the mechanical resonance. Looking at the curves you will see a power efficiency of approx 85%, as the purely electrical current is the loss involved in driving the stator. Since the mechanical resonance is slightly dependent of temperature while the electrical is stable, the efficiency will be lower at the ends of the temperature range.

When the rotor assembly is spring loaded on the stator, the frequency and the quality of the resonance will change, depending on the spring force and the supply voltage. In the extreme case with very high force, the mechanical resonance is suppressed and the piezo elements will approach ordinary capacitors. With very light spring load the available stall momentum is small, so in between the two extremes you will find an optimum spring loading force (typically 300g for a 31mm stator with double rotors).



The chart above show the results of different measurements on the same stator without and with rotor (3V and 5V supply voltage) and after endurance testing with up to 12000cycles. In order to limit the current the measurement without rotor was made @3V supply voltage, but scaling to 5V the max current would have been approx 1A (for a free stator it is relatively linear). With a rotor the resonance increases 500Hz and the current decreases to 600mA. The endurance testing has only minor impact on the current and resonance and the motor passes the test. The resonance peak with 3V is nearly suppressed indicating that the spring force is too high for this supply voltage.

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## Using the sweep feature

When the program is started the supply voltage defaults to 2V and we recommend that you chose a setting in the 3V range in order to stay below approx 500mA for the 30mm stator.

Then click "Sweep Start" and you will see a readout like this: "Max 372mA @42500Hz and 3V" after the sweep is done. The results are logged in the text file you specify, making it convenient to copy the data into a spreadsheet to create charts like shown above.

*Beware: You can change the start/stop settings for the sweep range, but far away from the resonance the current will become high and at some point you could damage the output stage (>1.5A) especially if you let the motor run for a long period at this frequencies.*

So, if you fail to find the resonance in the default range, 35-45kHz, change to a lower supply voltage setting and try 30-50kHz. If you still cannot find the resonance something might be wrong with the cabling or the stator.

## Using the tracking feature

When you click the "Track Freq" button, the program will make a sweep, so please take care and read the precautions above.

After the sweep the frequency is set to the resonance and the motor is automatically started and will run until "Track Freq" is clicked once more, then you can stop the motor.

Tracking is made by continuously measuring the current and optimizing the frequency for max current (default steps 50Hz). The flow is as follows:

- 1 Measure current (1)
- 2 Make small frequency step and measure current (2)
- 3 Step back and measure again (3)
- 4 If  $(1+3) > 2 \times (2)$  then change step direction
- 5 repeat

Although simple this procedure is adequate unless you make big changes in the supply voltage. If this happens and the procedure "hangs", a new sweep will be made,

## Bugs and unexpected features

Please note that although the Development Box and software has been in use for some years, it is basically our internal tool we are placing at your disposal. We would expect to see bugs and unexpected behaviour each time new users are starting to use the system and we welcome your comments and critique and we will do our best to help you getting the system to work.

In case you want to implement new features, the source code is available.

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