

Black Box BB_03 (with controllers Z-series, ver. 5.20 and more)

Measuring recorder Black Box BB_03 is an outstanding and unique system which is priceless and irreplaceable for optimal setting of your power unit and for an overall optimal drive setting (including batteries, controller, motor and propeller).

BB_03 cooperates very closely with the **TMM xxxx-3 Z-series** controllers from which it obtains whole range of measured data. Part of the measured data is acquired using its own measuring unit. **Thanks to this cooperation BB_03 is very small, light (< 6 grams) and also cheap.**

It measures and saves all important data of your drive (batteries – controller – motor – propeller) during flight, thus real values in operation, not static values measured on a test bench. This allows the user not only to optimize the power unit but also to determine mutual dependencies such as dependence of current on propeller, efficiency of drive on propeller, efficiency of timing, real power consumption of the drive, power consumption depending on type of cells (their hardness), etc.

It is a powerful device for determining the real load of BEC during operation of the model (it is the end of absurd evaluations with 300% error leading to destruction of BEC or the model).

After the flight the saved data are transferred to PC using USBCOM module, where they can be evaluated. Data are represented in graphs, as well as in excel tables which may be further processed.

BB_03 together with TMM xxxx-3, Z-series controllers measures and saves (and display on the PC) each 100 ms these values:

- voltage of feeding battery under load (in current pulses)
- current drawn from the feeding battery
- motor input
- voltage of BEC
- current of BEC
- BEC power losses
- motor / propeller revolutions
- throttle stick position
- temperature of the controller
- temperature of batteries, motor, ...(external sensor)
- any receiver channel (or event marking), start of saving data
- external voltage (0 up to +5V) with an additional resistor 24k Ω , voltage +25V with different resistor or more (it can be used for altimeter, speedmeter, etc.)

Other features:

- accidental overwriting of saved data protection
- length of recording more than 13 minutes
- very small and light
- fed from controller
- communication with PC using USBCOM module

Measurement of the following data are carried out by the controller, the other ones are measured by BB_03 itself and all data are processed in BB_03:

- voltage of feeding battery under load (in current pulses)
- voltage of BEC
- current of BEC
- motor revolutions
- throttle stick position
- temperature of the controller

The BB_03 is connected with the controller using multicore cable CC_01 with micro connectors. The cable provides the BB-03 feeding, as well as communication between BB-03 and the controller.

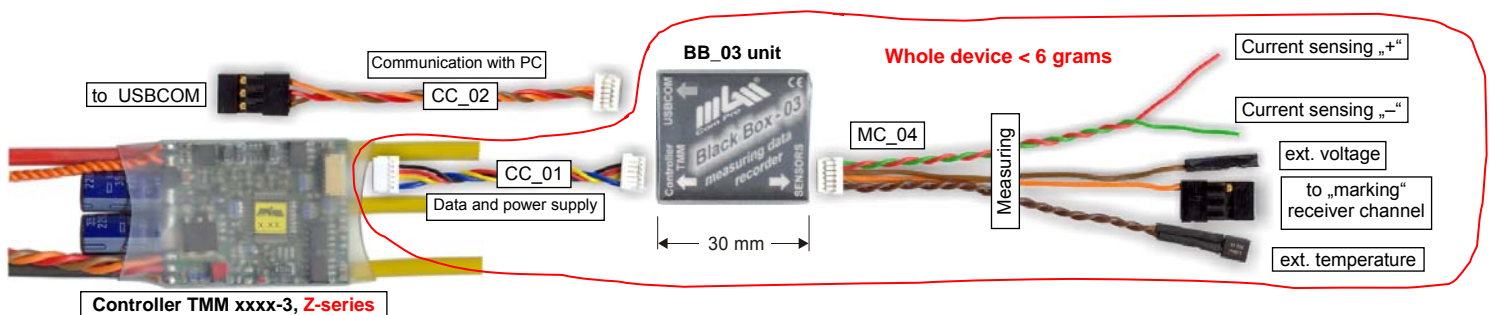
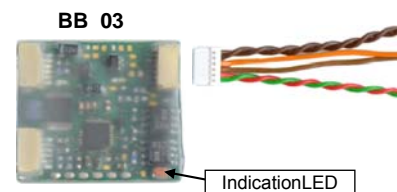
The measuring and data saving process' start when the motor starts to rotate after switch on or when marking signal > 1,65 ms. If you do not wish to use the marking feature, connect this measuring wire with ground (minus pole of the feeding cells).

It is also possible to use this wire for tracking and recording of any receiver channel.

The current of the feeding batteries is taken on the resistor of the ground wire of the controller. This measuring method, even though less accurate than the use of accurate sensing resistor, is not only cheaper, but more significantly it does not bring any additional (unwanted) resistor in the circuit. Another great advantage is that the value of the measured current is not limited (e.g. by the sensing resistor, its allowed load, ADC range, etc.) **thus it is possible to measure current of 250A or even more.**

The package of BB-03 includes:

- The measuring unit BB_03
- Connection cable controller – BB (CC_01)
- Cable for connection to USBCOM, USBCOM+ (CC_02)
- Measuring cable includes:
 - External temperature sensor
 - External voltage conductor
 - Marking conductor
 - Conductors of batteries current sense
- External resistor 24k Ω for extending the measuring range of "Ext. Voltage"
- SW for PC on CD
- Instructions for connecting and use of BB_03 on CD
- Instructions for installation and use of SW for PC on CD

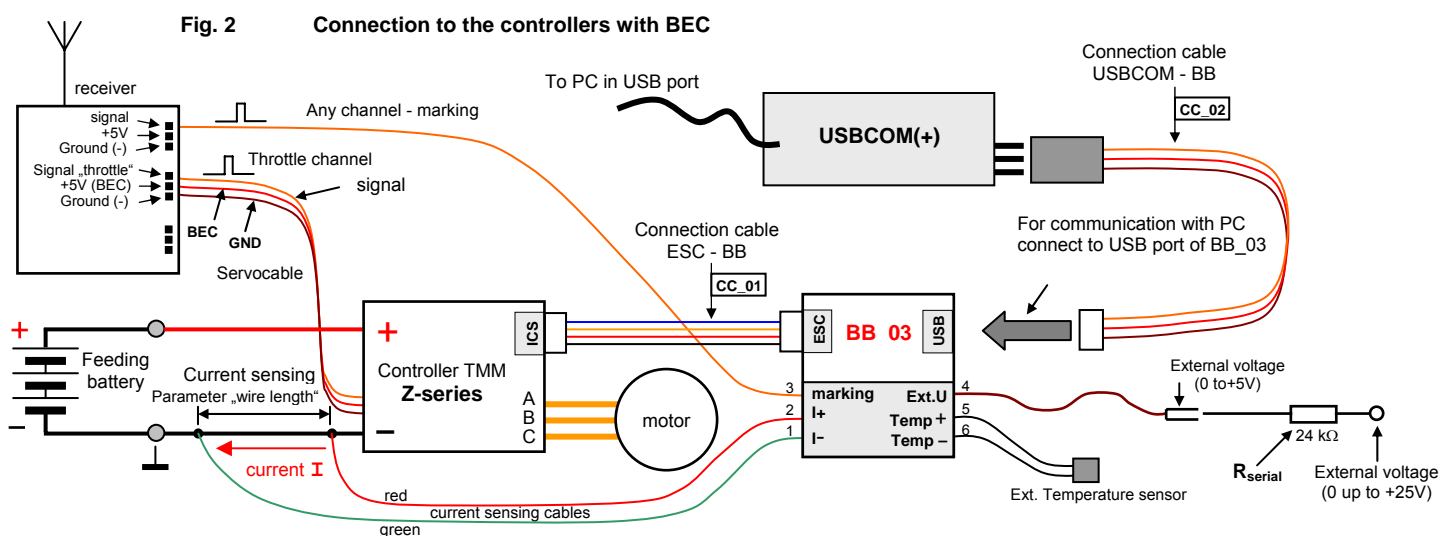


Technical data:**BB_03**

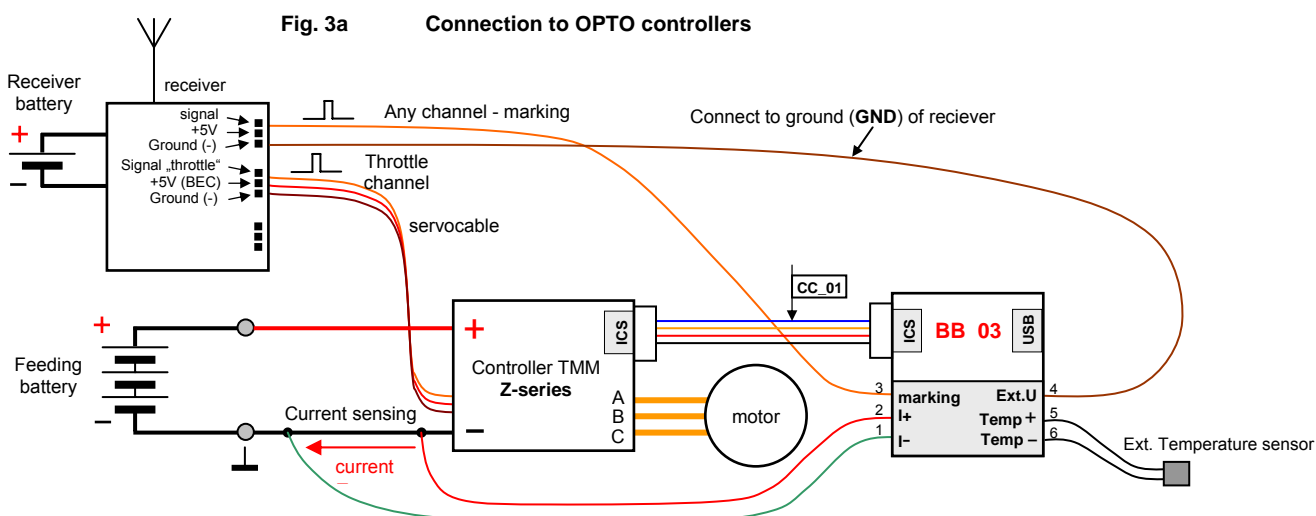
dimensions:	30 × 26 × 4 mm
weight:	3,3 grams
weight with connection cables and sensors (flying weight):	< 6 grams
current drawn during measuring and saving:	≈ 15 mA
operation temperature:	0 to 40°C
resolution:	8 up to 16 bits (depend on measured parameter)
length of recording	>13 minutes
saving period:	100 ms (10 / sec.)
measurement start:	„throttle“ > 1/3 (motor start up) or marking > 1,65 ms
fed from and cooperation with:	controllers of the range „Z-series“

Connection and operation of BB_03 (fig. 2):

- 1) connect BB_03 to the controller using CC_01
- 2) if you wish to measure the current drawn from the feeding batteries during the flight, connect the red and green conductor of the measuring connector with the ground cable of the controller (place the green wire in the area of connectors connection to batteries and in place as close to controller as possible (recommended distance from the green wire – see table on page 3) cut a part of insulation of the ground wire and solder on the red conductor – for details see fig.5
- 3) fasten the temperature sensor on the motor, battery or other object whose temperature is to be measured during flight
- 4) if you wish to measure any voltage (to the feeding battery negative terminal) use the „external voltage“ measurement wire. The basic resolution is +5V. If the measured voltage is higher, use external resistor in serial (that is for 25V range the 24 kΩ resistor - a part of the package). For a different voltage range, the serial resistor may be calculated according to: $R_{\text{serial}} = (U_{\text{requested}} - 5V) / 0.833333$.
- 5) If you wish to take advantage of event marking, place the „marking“ connector into a chosen receiver channel (preferably a free channel controlled by a switch). The best is a 3-position switch which enables to make marks by moving from neutral up (1,5 ms → 2 ms) and also by moving it down (1,5 ms → 1 ms). This will enable you to easily mark an interesting event or more events during the flight (start up of acrobatic figure, etc.) It is also possible to start the recording by marking channel by moving the switch from neutral to max. (1,5 ms → 2 ms).

**Differences for OPTO versions (fig. 3a):**

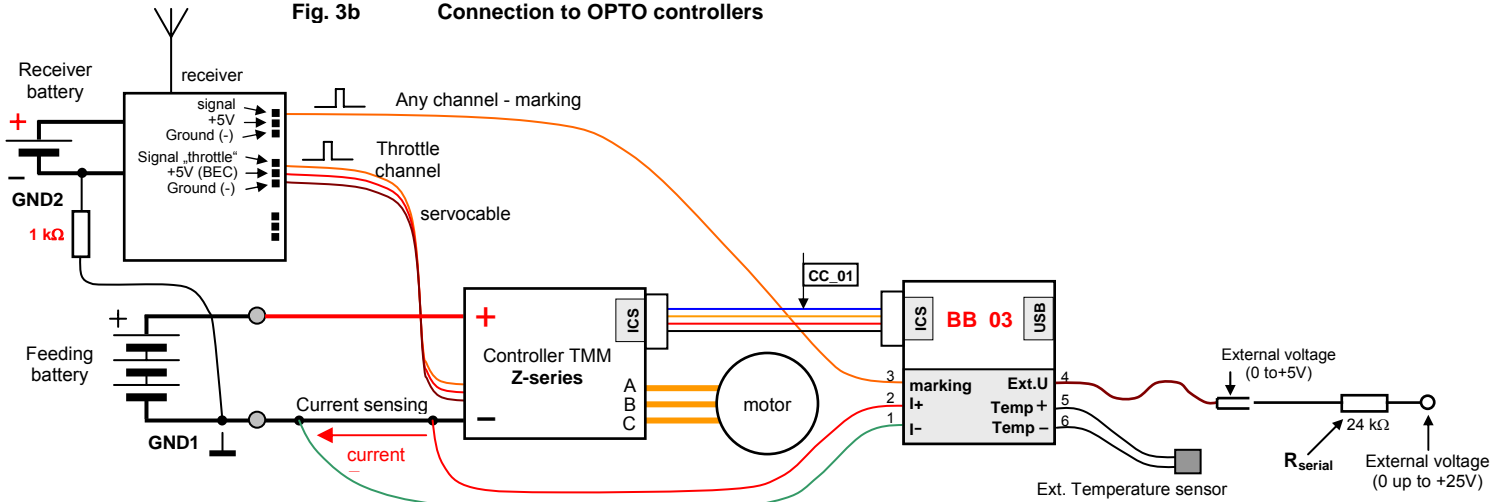
If you wish to use the marking event feature it is necessary to connect the „external voltage“ cable to connector „marking“ on position „ground“ (GND, minus). It is not possible to use the „external voltage“ cable for voltage measurement – applies to OPTO versions, when is requested use „marking“.



Differences for OPTO versions (fig. 3b):

If you wish to use the marking event feature and also measure the „external voltage” (for example for altimeter), it is necessary connect receiver's ground with controller's ground by te resistor with aprox 1 kΩ value.
 External voltage is refer to ground of feeding (main) battery – GND1.

Fig. 3b Connection to OPTO controllers

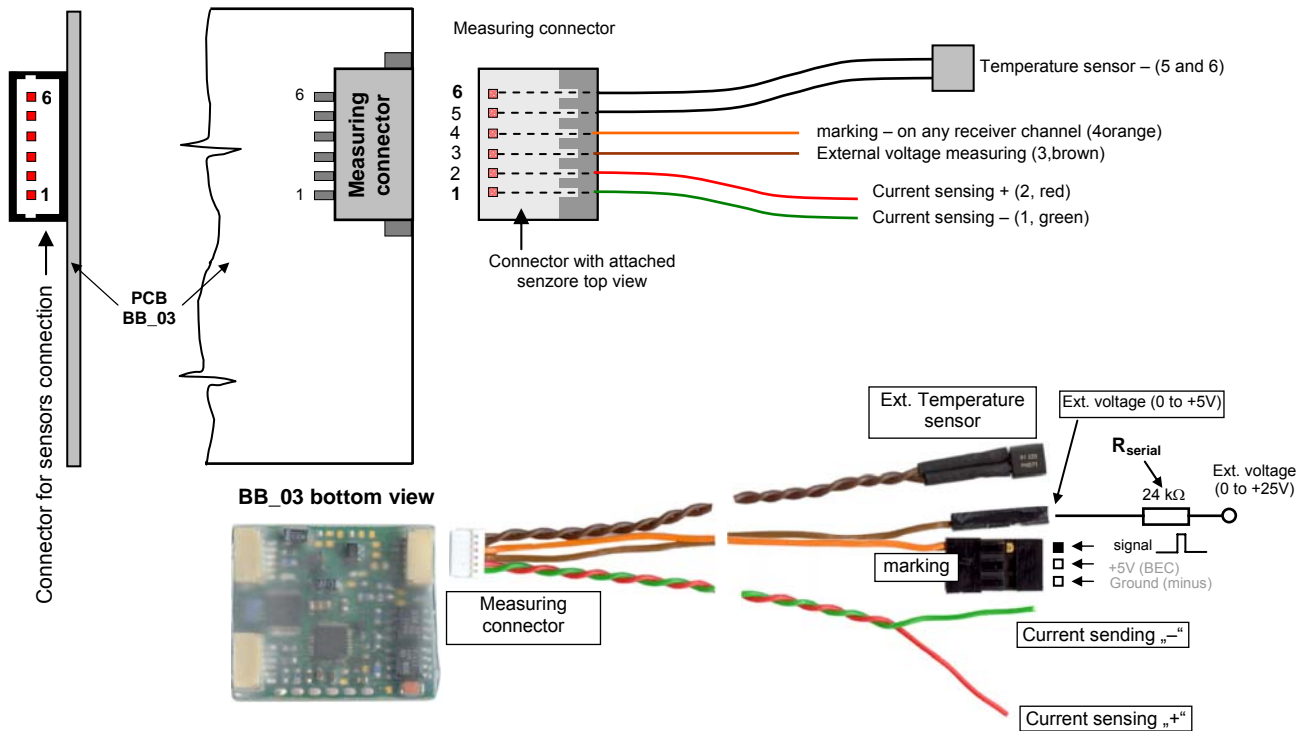


If all is correctly connected, the controller may be switched on (and thus also BB_03). To start the recording process, move the throttle above its middle position or move marking channel to value > 1,65 ms (this is above the normal range 1 to 2 ms.) . To mark any event during flight, use the channel in which the „marking” connector is placed.

After the flight and switch off the controller it is possible:

- a) fly again – in this case the older recording will be rewritten with the new one
- b) pull out the conntor CC_01 from BB_03 or from controller and fly again – now the previous recording will not be rewritten
- c) connect using CC_02 with USBCOM with the PC and download the recording to PC for evaluation

Fig. 4 Connection of sensors

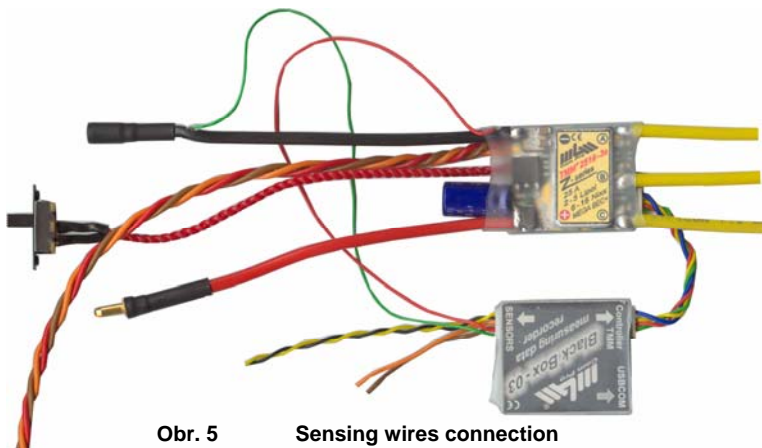


Current Measurement

The current drawn from battery is measured as a drop in voltage on the minus wire of the controller. Solder the green and red wires from the measuring connector to this wire so that the green wire is close to the connector of battery and red is as close to controller as possible – see the figures.
 The recommended mutual distances between the red and green wire (in program the parameter is called „wire length“):

controller	Wire cross section	wire length
18A	1,0 mm ²	80 mm
25A	1,5 mm ²	80 mm
40A	2,5 mm ²	80 mm
50A	2,5 mm ²	80 mm
60A	2,5 mm ²	80 mm
80A	2,5 mm ²	60 mm
90A	2,5 mm ²	50 mm
120A	4,0 mm ²	60 mm
160A	4,0 mm ²	45 mm
224A	4,0 mm ²	30 mm

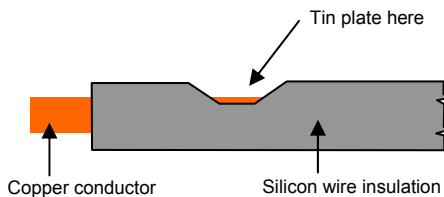
If the current in peaks is displayed as limited in the flight recording, solder the wires with shorter distance than stated in the table. It is necessary to type correct distance (measured) between the wires in the program.



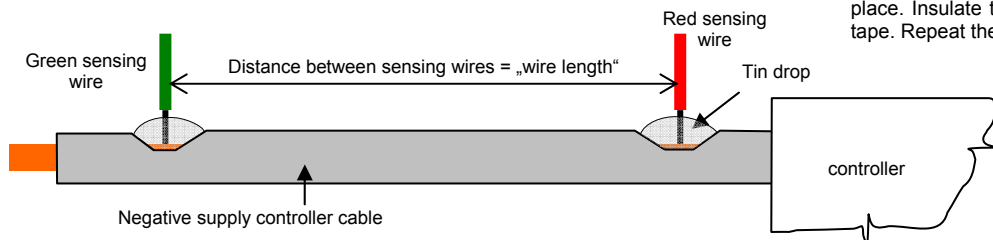
Obr. 5 Sensing wires connection

How to connect the sensing wires to the controller:

Cut the insulation of the minus wire (black) sideways towards you. Cut carefully until you reach the copper conductor. Do not cut the conductor. Create a cut in the „V“ shape in the insulation.



Tin plate the copper conductor in the cut – it is best to create a small drop of tin. Then, solder one of the sensing wires to this place. Insulate the soldered area with heat shrinking sleeve or by tape. Repeat the same with the second sensing wire.



Installation of program Controller

Run automatically after start the „Controller_v1.2.2.xx_setup.exe“ program from the enclosed CD or download it from www.mgm-compro.com to your computer. Please, reed instruction on manual „Automatic_Installation_of_Program Controller_v1.2.2.x.pdf“.

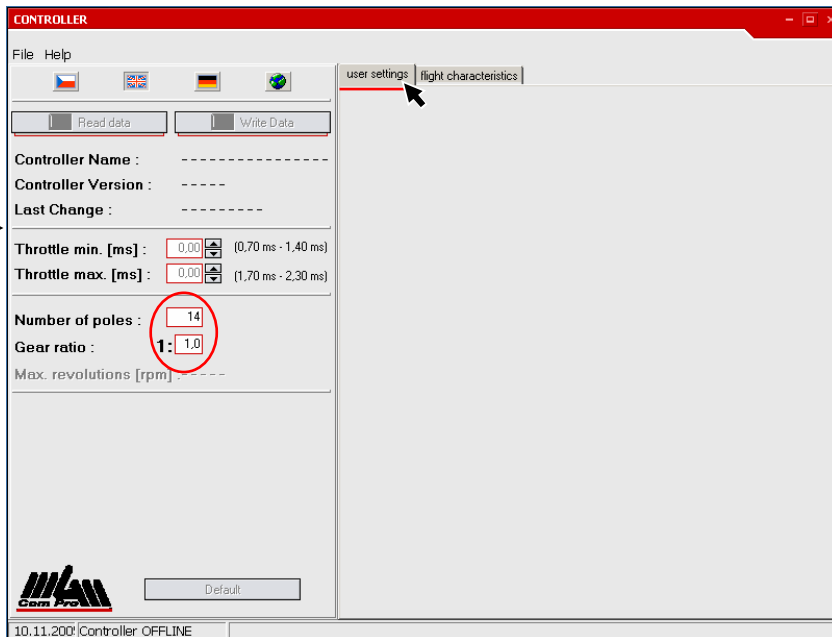
Start of program Controller

Connect USBCOM / USBCOM+ module to USB port of your PC. After click on Controller icon (shortcut), program Controller is started.



Click to „Controller + BB“ and the following window will open

! Buton „Controller“ is choice for single controllers Expert and Z-series (without connection Black Box).



Choose the „User settings“ fold (if not already opened). Correct number of poles of the motor must be entered for correct revolutions display (motor instructions) and the gearbox ration (if it is used).

Controller parameters Setting / Reading

Connect Black Box BB_03 to the USB COM(+) module using CC_02 cable. (BB_03 must be connected with „Z-series“ controller using CC_01 cable!). The type of the controller, its version and currently set parameters will be read-out when the controller is switched on (by switch or by connecting the battery).

Now it is possible to choose the following:

- new controller parameters setting – see below
- read-out data recorded on BB_03 – see page 6

To change any parameter simply click on the desired option is that parameter. If you wish to write the changed settings to the controller – click on „write data“. In this case, the data measured by the controller and displayed in the left part of the window are erased (data in BB_03 will stay saved).

Type and version of controller are recognized automatically

Min. a max. throttle position – read out/ change of value

Setting of number of motor poles and gear ratio

Measured values area

Fast setting of default parameters

Parameters read out from controller are displayed here + changes of parameters can be done here using mouse

Shift to other parameters

In this window, the name of the controller together with its SW version and all the programmable parameters and their actual values (same parameters as in the table in controller manual) will be displayed. If some of the parameters are displayed in gray, they are not available for that particular version of controller (or SW version). Possibly, they are not available in the chosen mode of controller (for example in basic mode it is not possible to change acceleration, timing, etc) – after switching to aircraft mode, these parameters will be available. All the settings may be saved in a file under any name, their number is not limited.

If instead of measured values only dashes („-----“) are shown, the controller has not run for at least 2 seconds in full throttle and the value is not available (this does not influence the recording of values in BB_03).

Any programmable parameter can be changed using mouse. Then, all the changed settings as well as the read-out data can be saved in a file for later use (file → save as). To write data to controller simply press the „write data“ button. The default settings can be restored by the „Default“ button and then „write data“. Data in BB_03 will not be erased – those are erased by new flight recording.

The possibility to find out the min and max throttle position can sometimes be very advantageous. These values can be set if needed using the appropriate buttons (arrows ▲▼).

Important Notice: If the controller was never programmed using transmitter and then read-out in the program, the real values **min. throttle** and **max. throttle** are not known to you. If values that do not correspond with the real min and max throttle positions are set, it is possible that after the controller is switched on, it might not start as it is waiting for the minimal throttle position (in the aircraft mode) which is probably set lower than the real value.

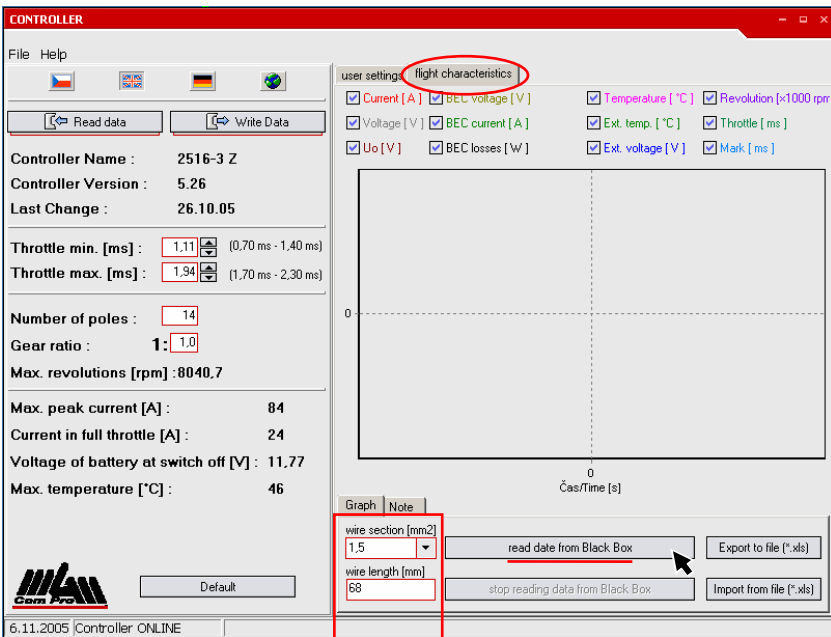
Recommendation: Program the controller using transmitter for the first time – it is enough to go thru the beginning – only entering the programming mode (full throttle, switch on controller, wait 10 seconds for 3 beeps, throttle down, 1 beep) and now you can turn the controller off – the correct min and max throttle positions are saved and you do not have to program any other parameters. Now when connected to PC, the correct min and max positions of the set will be read-out.

When the programmable parameters are written to controller the data measured during the last flight are deleted. If now the read-out data button is pressed – data from the last flight will be empty („---“) and will be filled only after the next flight with the new parameters.

Now you may fly and BB-03 will save data that may be read-out after the flight – as in b).

Data read-out and processing from BB_03

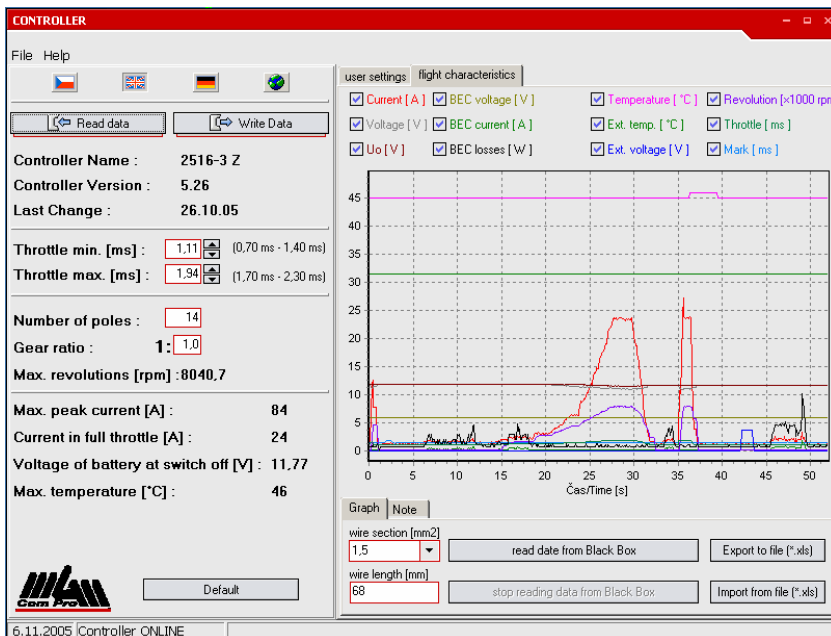
Switch to „Flight Characteristics“ fold. Now the „Wire cross section“ and „Wire length“ must be set according to the real values, that means the wire cross-section according to the used wire for current measurement, usually ground (black minus) wire connected to the minus of battery, see fig.2 or 5.



The value „Wire cross section“ may be chosen from the predefined values [▼] or maybe typed in.

The value of „Wire length“ must be typed.

When „Read data from Black Box“ button is pressed, data recorded in BB are being drawn as curves into graph.

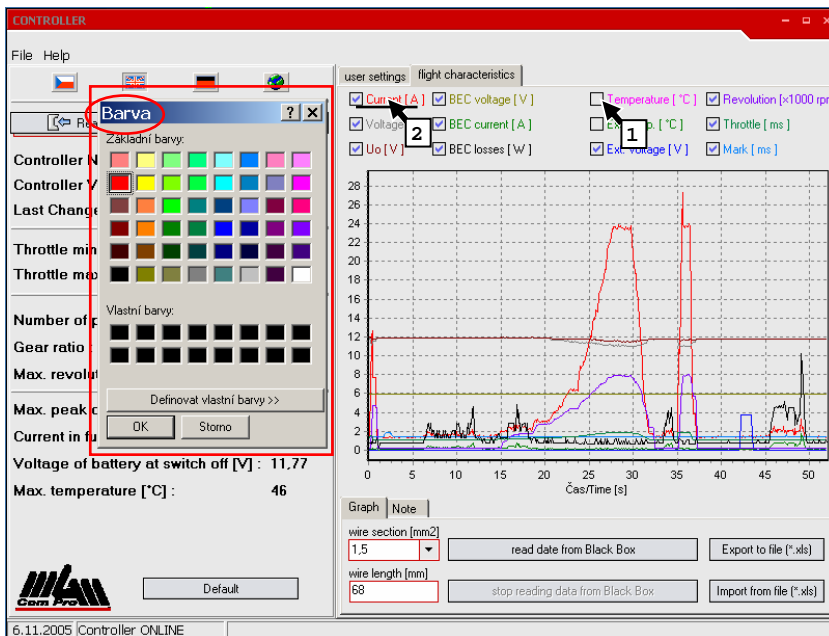


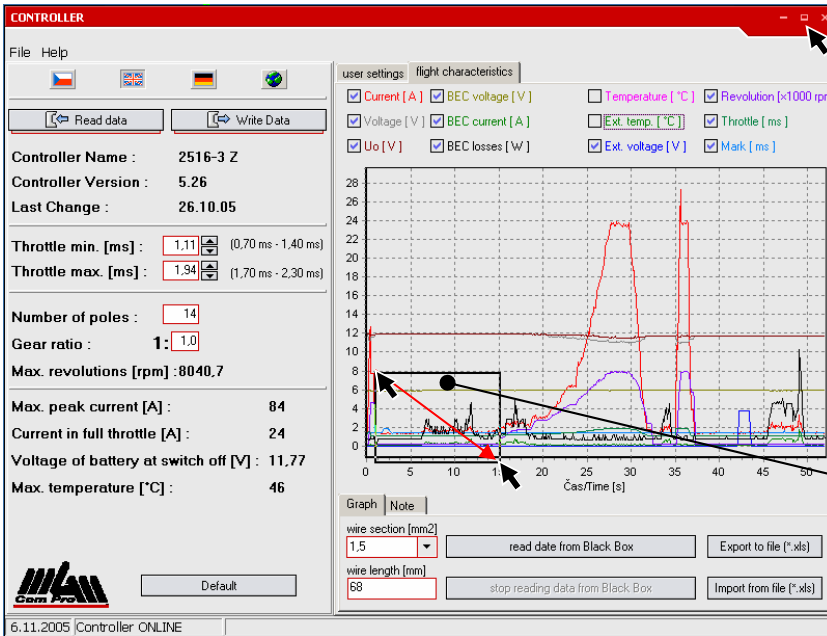
When the whole recording is read-out (here 52.5seconds) - all data are displayed on screen. The scale is set automatically according to the biggest displayed value.


How to work with graphs

It is possible to choose which curves (data) will be shown by clicking on the box next to its name [1].

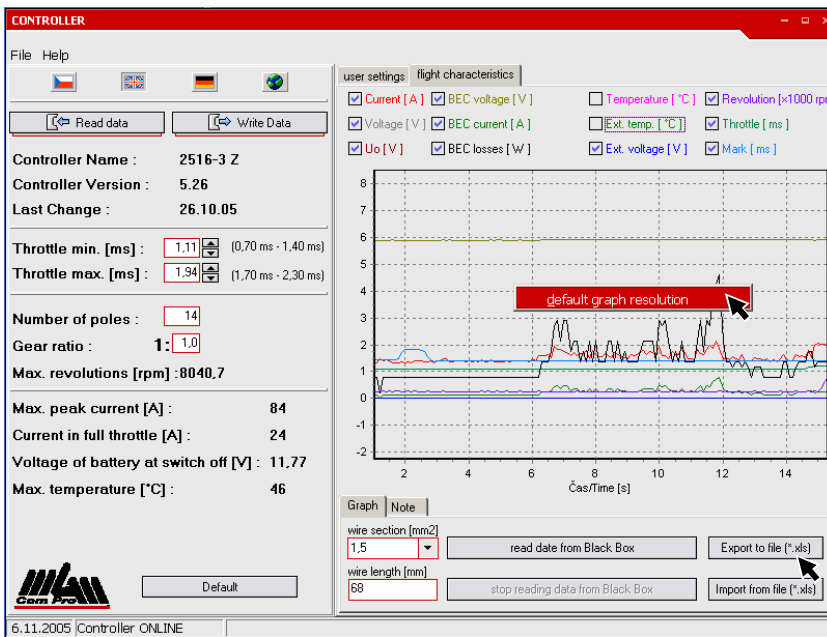
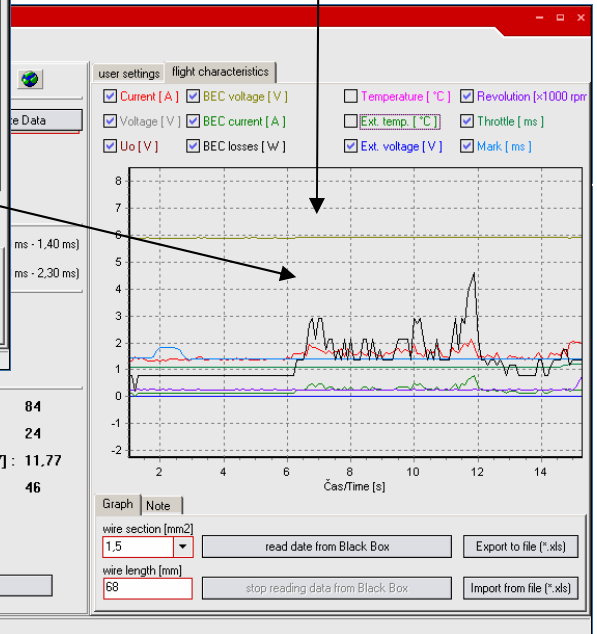
Also the color of any curve may be changed – move the cursor to the colored name of the curve [2], then right click and color toolbar will pop up. Now you may change the color.



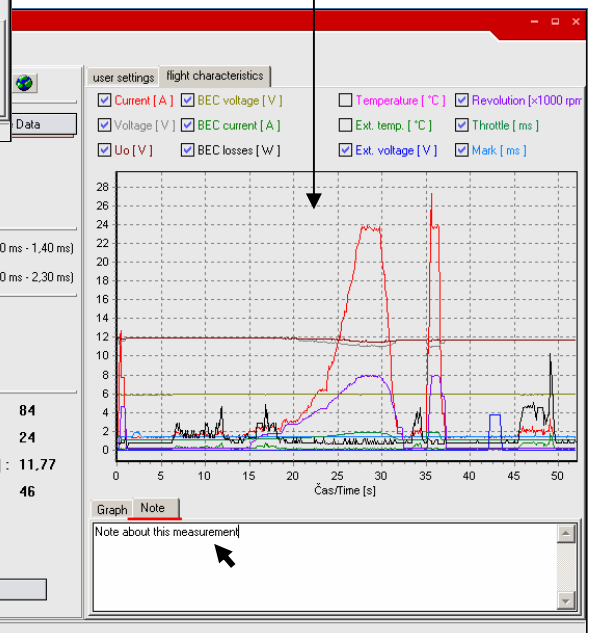


The „CONTROLLER“ window may be open in the full screen as is usual with in Windows (click on ).

To zoom in, left click on the mouse and choose the area to zoom in by moving the mouse from the areas left upper corner to its right bottom corner. To move with the zoomed area hold the right mouse button.



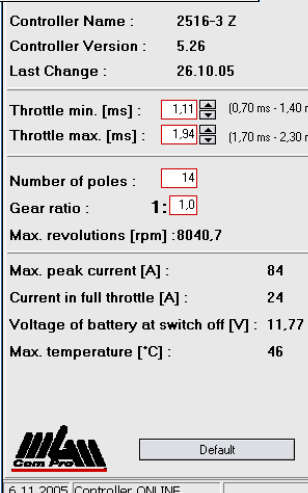
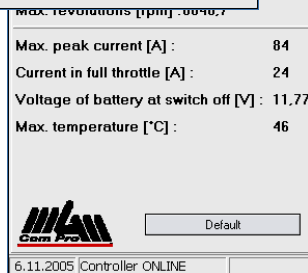
To get to the default graph scale, right click and choose „Default graph scale“. The scale depends on the currently shown curves.



The button „Export data (*.xls)“ is used to export the data under any name **together with note** which may include important data of this recording (such as model, motor, throttle, ...) for easier orientation in measurement comparison.

Data may be shown any time later using „Import data (*.xls)“ and choosing requested flight recording from the PC memory.

Note:
If brake is set on, then in the short time in which the motor is breaking until it stops no data are measured by the controller – it is shown as a straight line in the graph.



Further possibilities of Black Box data processing

The exported data (in excel format) may be processed in Excel, draw graphs, work with recordings, etc. For inspiration see below:

Flying characteristics from memory module

[Flying characteristics from memory module, 07.11.2005 v 21:25:23]

Controller name:

2516-3 Z

Controller version :

5.26

uLast Change :

26.10.05

Throttle min. [ms] :

1,08

Throttle max. [ms] :

1,91

Number of poles:

14

Gear ratio:

1:1

Max. revolutions [rpm]:

7936,5

Max. current peak [A]:

66

Current in full throttle [A] :

Voltage of batterz at switch off [V] :

11,22

Max. temperature [°C] :

48

Note:

Time [s]	Current [A]	Ext. temp. [°C]	Mark [ms]	Ext. voltage [V]	Voltage [V]	Uo [V]	Current [A]	BEC voltage [V]	Revolution [×1000rpm]	Temperature [°C]	Throttle [ms]	BEC losses [W]
0,1	3,365	30,25	1,216	0	11,126	11,457	0,125	5,846	3,921	45	1,344	0,663
0,2	3,432	30,25	1,216	0	11,126	11,430	0,125	5,889	3,900	45	1,344	0,657
0,3	3,507	30,25	1,216	0	11,154	11,457	0,125	5,889	3,900	45	1,344	0,661
0,4	2,818	30,25	1,216	0	11,126	11,457	0,220	5,889	3,891	45	1,232	1,150
0,5	1,169	30,25	1,216	0	11,430	11,457	0,220	5,889	3,543	45	1,232	1,217
0,6	1,315	30,25	1,216	0	11,457	11,457	0,188	5,889	3,387	45	1,232	1,048
0,7	1,440	30,25	1,216	0	11,457	11,457	0,220	5,889	3,017	45	1,232	1,223
0,8	1,386	30,25	1,216	0	11,457	11,457	0,345	5,889	2,840	45	1,232	1,922
0,9	1,378	30,25	1,216	0	11,457	11,457	0,220	5,889	2,694	45	1,248	1,223
1	1,457	30,25	1,216	0	11,457	11,457	0,220	5,889	2,617	45	1,232	1,223
1,1	1,624	30,25	1,216	0	11,457	11,457	0,282	5,889	2,567	45	1,248	1,572
1,2	1,616	30,25	1,216	0	11,457	11,457	0,345	5,889	2,540	45	1,248	1,922
1,3	1,682	30,25	1,216	0	11,457	11,457	0,345	5,889	2,514	45	1,248	1,922
1,4	1,507	30,25	1,216	0	11,430	11,457	0,471	5,889	2,495	45	1,248	2,607
1,5	1,461	30,25	1,216	0	11,457	11,457	0,439	5,889	2,486	45	1,248	2,446
1,6	1,557	30,25	1,216	0	11,457	11,430	0,282	5,889	2,477	45	1,248	1,572
1,7	1,657	30,25	1,216	0	11,457	11,457	0,471	5,889	2,476	45	1,232	2,620
1,8	1,386	30,25	1,216	0	11,430	11,430	0,471	5,889	2,474	45	1,248	2,607
1,9	1,444	30,25	1,216	0	11,457	11,457	0,471	5,889	2,469	45	1,232	2,620
2	1,348	30,25	1,216	0	11,457	11,457	0,220	5,889	2,465	45	1,232	1,223
2,1	1,653	30,25	1,216	0	11,430	11,430	0,282	5,889	2,457	45	1,248	1,564
2,2	1,703	30,25	1,216	0	11,457	11,457	0,471	5,889	2,450	45	1,248	2,620
2,3	1,482	30,25	1,216	0	11,457	11,457	0,345	5,889	2,447	45	1,232	1,922
2,4	1,841	30,25	1,216	0	11,430	11,457	0,471	5,889	2,442	45	1,248	2,607
2,5	1,428	30,25	1,216	0	11,430	11,430	0,345	5,889	2,438	45	1,248	1,912
2,6	1,536	30,25	1,216	0	11,430	11,457	0,471	5,889	2,425	45	1,232	2,607
2,7	1,616	30,25	1,216	0	11,457	11,457	0,345	5,889	2,412	45	1,232	1,922
2,8	1,561	30,25	1,216	0	11,457	11,430	0,471	5,889	2,404	45	1,232	2,620
2,9	1,407	30,25	1,216	0	11,457	11,457	0,471	5,889	2,402	45	1,248	2,620
3	1,428	30,25	1,216	0	11,457	11,457	0,345	5,889	2,398	45	1,248	1,922
3,1	1,465	30,25	1,216	0	11,457	11,457	0,345	5,889	2,397	45	1,248	1,922
3,2	1,424	30,25	1,216	0	11,430	11,457	0,345	5,889	2,398	45	1,152	1,912
3,3	1,424	30,25	1,216	0	11,430	11,457	0,345	5,889	2,398	45	1,152	1,912
3,4	1,202	30,25	1,216	0	11,430	11,430	0,627	5,889	2,371	45	1,168	3,476
3,5	1,202	30,25	1,216	0	11,430	11,430	0,627	5,889	2,371	45	1,168	3,476
3,6	1,202	30,25	1,216	0	11,430	11,430	0,627	5,889	2,371	45	1,168	3,476

WARNING :

You risk destroying the Black Box and warranty lose for:

- Feeding from any other source than controller TMM xxxx-3 Z-series
- connecting connectors differently than specified in the manual
- connecting other device to BB-03 than specified in the manual
- forcing the connectors to connect other way than designed to or by connecting different types of connectors together
- mechanical damages, cutting the shrinking sleeve
- dropping into water, or water getting inside, snow, etc..
- by metal object under the sleeve
- any other alteration to BB-03 (soldering, components change, etc)