

Automatic Running-in Bench

for internal combustion engines

Part 3: application software

Michel Kuenemann (France)

Our series of three articles about the running-in bench for model i/c engines begun in April concludes this month with a presentation of the automatic running-in software.



In order to take full advantage of the software (*CBRMrunning-in.hex*, [1]) we're going to be describing here, you'll need the following equipment:

- A built and tested CBRM board and a GMMI pocket terminal (described in the April 2009 issue of Elektor [2]);
- A test bench fitted with all its detectors and actuators,
- as described in the May 2009 issue of Elektor [3]. You will already have carefully checked that the bench works properly, using the *CBRMtest_sensors.hex* [3] software and an engine that's already been run-in;
- A model i/c engine that's already been run-in, fitted with a suitable twin-bladed propeller;
- An engine to be run-in with its twin-bladed prop;

- Some fuel, and a means of starting the engine.

If you have a laptop PC running under Windows 2000/XP/Vista, you can if you wish install the *CBRMmonitor* [1] software on it and connect it to the bench via a USB link. As its name indicates, this software will let you monitor all the bench parameters on your computer screen in 'real time' as they change during the running-in process.

Moving on to the nitty-gritty...

Rather than systematically describing all the menus in the application, without more ado we're going to go through a try-out operation — preferably using an already run-in engine.

Flash the *CBRMrunning-in.hex* software as per the procedure given in the April 2009 article, and check that the application runs; the pocket terminal should give three short beeps and the screen should display the welcome message (**Figure 1**). This display soon changes to the manual mode screen (**Figure 2**) which summarises seven vital parameters of the engine operation:

- Throttle (abbreviated to Thr.);
- Engine (Tmp.) and ambient (Amb.) temperatures;
- Speed (Rpm.);
- Mixture richness ('Ned.' for needle);
- Ignition battery condition and voltage (Ign.);
- Board supply voltage (Sup.)

Richness setting

The asterisk in the first column on the third line indicates that the richness adjustment is enabled. Temporarily loosen off the mechanical coupling between the stepper motor and the richness screw. Screw the richness screw all the way in lightly by hand, then retighten the coupling appropriately so that the link shaft cannot slip. By turning the encoder knob anticlockwise ('unscrewing'), you'll see that the stepper motor will slowly and carefully open the richness screw as you wish. Choose a rich setting, i.e. open by around two or three turns (this is only by way of an indication — the exact value depends on your particular installation and engine). The display will appear as in **Figure 3**.

The left-most figure on the 'richness' line indicates your set value. In the centre of the line, an animated 'propeller' turns when the engine is running. Check that the richness needle closes fully when you go back to zero turns. The mechanical coupling should be such that it rotates freely, so that the motor won't miss any steps. If it does, the indication of the needle opening will be incorrect!

The richness screw setting is retained as long as the board has not been re-booted using the reset or emergency stop button or powered down.

Starting the engine

Now press the button by the first line. An asterisk appears in the first position on the first line, indicating that the throt-



Figure 1. The bench's welcome screen.

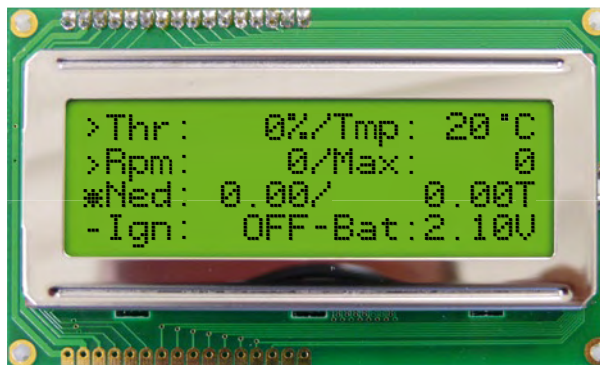


Figure 2. The manual mode screen.

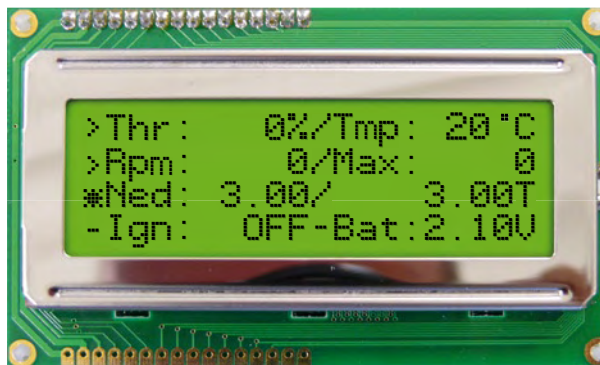


Figure 3. The asterisk indicates the parameter whose value can be adjusted using the encoder knob.

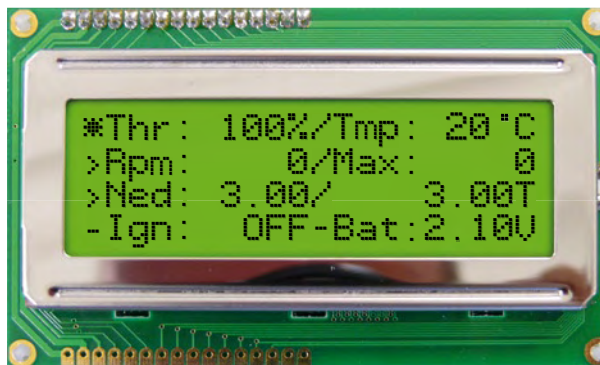


Figure 4. Full throttle!

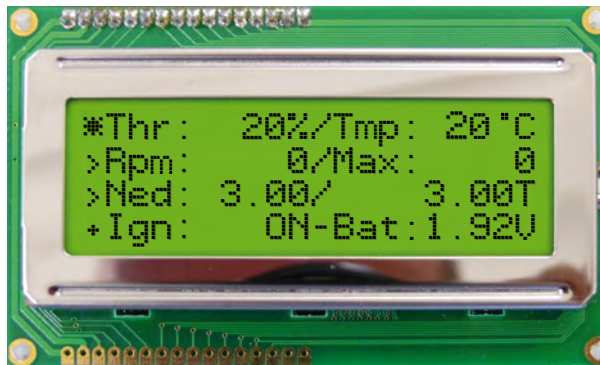


Figure 5. The ignition is on. Watch out for your fingers!

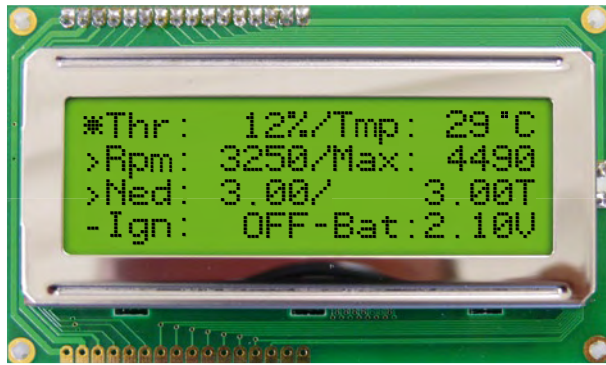


Figure 6.
The engine is running and the ignition can be turned off.

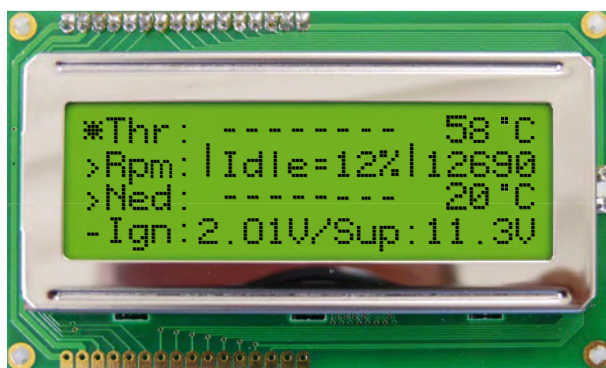


Figure 7.
Press the encoder knob to store the servo position in idle.

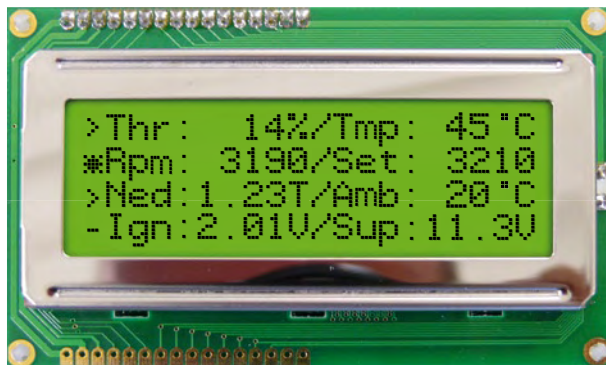


Figure 8.
This screen lets you set the engine speed.

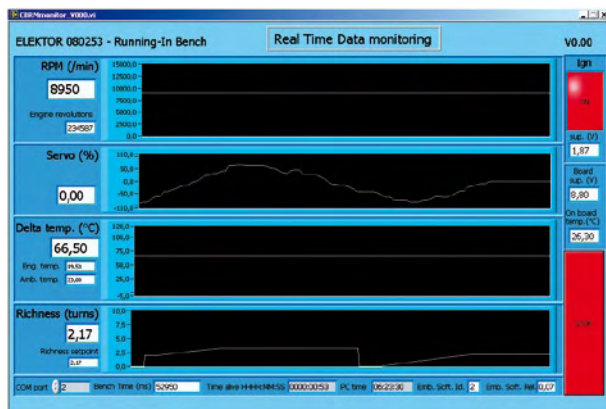


Figure 9.
The CBRMmonitor software for PC shows the key engine parameters live as they change.

tle control is enabled. To check this, turn the encoder knob anticlockwise. The servo should turn in the direction to increase the throttle – if this is not the case, you'll need to alter the bench parameters. Set it to 100%: full throttle! (**Figure 4**).

Important safety note: if the throttle control is not working satisfactorily, check and adjust the throttle control setting ('Parameters' menu — see below) before continuing.

Now prime your engine as usual, then reduce the throttle to around 10 or 20%. Turn the propeller a few more turns to finish priming the engine, then briefly press the button alongside the fourth line (**Figure 5**).

The '+' sign at the start of the fourth line indicates that the glow-plug is enabled. You should also clearly hear the beeping from the pocket terminal sounder. This indicates that the ignition is enabled and that the engine is ready to start at the next attempt. **From now on, keep your fingers well away from the propeller!**

Start the engine, then adjust the idling speed using the throttle control. Turn off the power to the glow-plug by pressing the button on the fourth line again. The sounder will stop and the display will appear as in **Figure 6**.

Now increase the throttle to 100%. Since the mixture was set to 'rich', the engine will not reach its maximum speed, the 'peak'. To adjust this, press the button on the third line and gradually close the richness screw by turning the encoder knob slowly clockwise until peak speed is reached, just as you would do if operating the mixture needle manually. Take care not to weaken the mixture too much. As the setting resolution is 1/100 of a turn, this setting can be made very accurately. Then go back to idling by pressing the first line button and turning the encoder knob clockwise.

When you are satisfied with the idling speed, you can store the corresponding servo setting (Idle) by briefly pressing the encoder knob (**Figure 7**). At this moment, a pop-up window will appear for one second, confirming that this value has been saved in non-volatile memory.

Speed setting...

... comes into operation when you press the button on the second line (**Figure 8**).

By turning the encoder knob, you can alter the engine speed set point (Set). You'll see that the engine speed will automatically adjust to this value and remain there. To avoid abrupt jumps in speed, the set point automatically adopts the speed the engine is set to at the moment the adjustment is enabled. In the same way, when returning to manual throttle control, the servo maintains the same position at the moment of leaving the 'speed control' mode.

If you have a (portable) PC, you can now connect it to the bench, run the CBRMmonitor software and see the parameters on the screen as they change (**Figure 9**).

In the event of a problem with the bench, don't panic! Quickly hit the emergency stop button to stop the engine at once.

The functions offered by the manual mode let you run-in an engine in a 'controlled' way. The speed adjustment will let you ensure that the engine runs fast enough to run it in properly, whilst avoiding any risk of damaging it with excessive

speeds. The 'automatic running-in' mode lets you control the process even better; but before we get to that, we need to go back to the main menu and enter a few safety limits and other parameters.

The main menu...

...is displayed by a pressing the button on the first line twice (**Figure 10**). Press the button on the fourth line to modify the safety limits.

The safety limits...

... define three parameters that are vital for the safety of the bench in operation. These are:

- Maximum permitted engine speed;
- Maximum permitted engine temperature;
- Minimum board supply voltage (to protect your batteries from deep discharge).

The values for these parameters can be modified in the screen shown in **Figure 11**.

Select the parameter to be modified by pressing the corresponding button. Confirm the data entered by pressing the encoder knob. The parameter is then saved into non-volatile memory and will not need to be entered again next time the bench is turned on. Now go back to the main menu by pressing the first button twice, then select the Parameters menu.

The parameters...

...that can be adjusted are as follows:

- Servo travel;
- Number of propeller blades (Pro.);
- DSC (Direct Servo Control) throttle channel.

The values for these parameters can be modified in the screen shown in **Figure 12**.

The key servo travel adjustment is done in three steps:

1. Press the second line button twice to position the cursor in the neutral position (marked 'N' on the third line), then adjust the throttle servo rod mechanically so that it is perpendicular to the latter. If necessary, adjust the value slightly using the encoder knob, then confirm the data entered.

2. Put the cursor into the 'throttle closed' position (marked Closed), then adjust the throttle control linkages mechanically so that the throttle flap is closed when set to the -100% position. If the servo moves in the wrong direction, turn the encoder knob until a value of +100% is displayed. Save the data entered.

3. Set the servo to the 'full throttle' position (marked Full) and check that the throttle flap is fully open. If the servo moves the wrong way, turn the encoder knob until a value of -100% is displayed. Save the data entered.

These adjustments need to be made each time the engine is changed or if there is any modification to the servo installation.

Before proceeding, go back to Manual mode (via the main menu of Figure 10) and check that turning the encoder knob anticlockwise ('unscrewing') increases the throttle set-



Figure 10. The main menu.

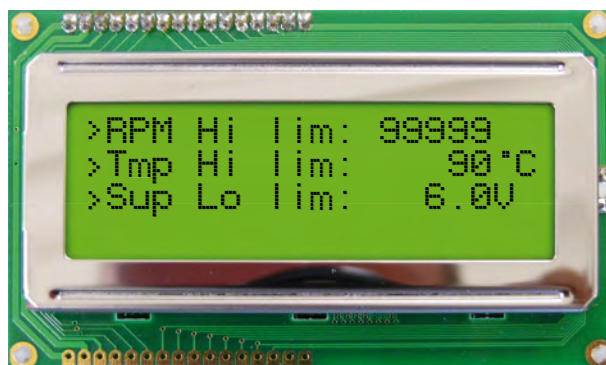


Figure 11. Don't forget to enter the limits for these three parameters that are vital for safe operation of the bench.

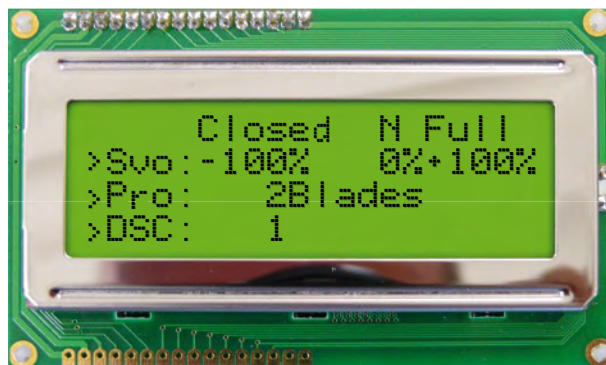


Figure 12. The adjustments to be made each time the engine is changed or if there is any modification to the servo installation.



Figure 13. On this screen, you can define just how the automatic running-in is performed.

ting. Check too that the throttle flap moves over its full travel between 0% and 100%. Tweak the setting until you get the proper travel for the servo.

Important safety note: it is absolutely vital that the throttle adjustment operates in the correct sense. If not, going into 'speed control' mode will make the engine race! What's more, pressing the emergency stop will not stop it — quite the reverse, the engine will be set to full throttle!

It's also very important to enter the number of propeller blades correctly, as this factor is used for measuring the speed. Confirm and save the value by pressing the encoder knob.

Lastly, the DSC parameter allows you to define the channel number associated with the throttle control. Once the parameter has been entered and saved, go back to manual mode, connect your transmitter to the DSC socket and check that the throttle control drives the servo correctly. The servo also needs to be adjusted in the transmitter (direction and travel).

Now go back to the main menu and select the 'Automatic Running-In' mode.

Automatic running-in...

...consists of carrying out successive acceleration/deceleration cycles with a fuel-rich mixture. Running-in takes place during the high-speed phase, but the engine temperature can have a tendency to rise dangerously. So it is necessary to lower the speed every now and then to allow the engine to cool down. This cycle needs to be repeated, gradually increasing the periods of high-speed running and reducing the richness of the mixture. All these parameters depend on the type of engine, the manufacturer's recommendations, and your own habits.

The second line of the automatic mode parameters (**Figure 13**) lets you define the high-speed settings. The first parameter on this line is the speed for this phase, and the second parameter is its duration in seconds. At the end of the line, you'll find the maximum temperature reached during the current cycle. The third line lets you define the low-speed settings. The first parameter on this line is the speed for this phase, and the second parameter is its duration in seconds. At the end of the line, the software indicates the minimum temperature reached during the current cycle. Move between the different fields on the line using the relevant button, and store the parameters using the encoder knob. The fourth line lets you adjust the richness, specify the number of cycles to be performed, and choose the way the bench behaves at the end of the cycle. If you select the number of cycles as zero, the bench won't stop of its own accord. At the end of the cycle, you can choose between stopping the engine (St.), running it at idling speed (Id.), or leaving it running at low speed (Lo.) Lastly, the first line indicates, from left to right, the current phase ('h' or 'l'), the current engine speed, the number of seconds left in this phase, and the number of cycles remaining to be performed.

By way of a conclusion...

So now here you are the proud owner of an original, comprehensive automatic running-in bench. We hope you have great fun using it safely.

(090250-1)

References and weblinks

- [1] www.elektor.com/090250
- [2] www.elektor.com/080253, Elektor April 2009
- [3] www.elektor.com/081187, Elektor May 2009
- [4] breakinbench.free.fr
- [5] author's e-mail address: breakinbench@free.fr

Corrections

The first part of this series was published two months ago [2] and since then, we have found a few small points that deserve special attention:

- The speed detection circuit uses a 'stabistor' diode (D4) — it's like a zener diode, but for voltages under 3 V. Unlike the zener diode marked on the 080253-1 PCB, a stabistor diode is mounted like an ordinary diode. So D4 must be fitted 'backwards', i.e. with its cathode to ground. The 080253-71 kit contains the stabistor diode, so take care!
- If you can't find the stabistor diode for D4, you can replace it by a 3 mm red LED. Fit the LED with its cathode to ground, it should light up when the board is powered;
- The speed detector may be lacking in sensitivity. If this is the case, you can increase the value of R40 up to 22 k Ω ;
- There are some minor typos in the pocket terminal components list and circuit: T1 should be a ZXM61P02F;
- The value of D10 in Figure 3 (April 2009, page 45) should be 3V3 instead of 5V6. The component list gives the correct value;
- At the start of the paragraph 'Testing the pocket terminal' (April 2009, page 49) you are told to fit jumper JP8. This is wrong, it is JP6 that needs to be fitted, otherwise the pocket terminal won't be powered;
- Those who have taken a close look at the circuit will have already realised: use a non-crossed (straight through) cable for connecting the pocket terminal to the controller board, as shown in the figure here.

