Flyin' Miata
tech line: 1 970 242 3800

Flyin' Miata ECU tuning instructions for 1990 through 1995 Miatas

Revision 3.1
For software revisions 416M0325, 218M0325 and later

Contents

Section 1: Required Knowledge

This manual is big. And we know that men hate reading manuals. The first six sections of this manual must be read and followed in order to get the Flyin' Miata ECU up and running in your car. As the title says above, this stuff is required, so suck it up and read the first six sections. Our technical staff will gladly clarify any aspect of the ECU for you, but they do not want to read the manual to you. Sections seven and later offer more in-depth information about the operation of the ECU. The casual user does not need to know all this information, but it can, and will, answer any questions you may have about the ECU. You information geeks, and we mean this in the kindest way possible, will love these later sections.

Important things to know about the FM ECU:

1) The ECU uses its own MAP sensor to measure airflow. When using the FM ECU on a normally aspirated car the installer will have to fabricate a replacement for the factory air flow meter.

2) The ECU uses memory locations called "zones" for all the operating parameters of the engine. A table of all the zones is on page #30. Commonly used zones are listed in the hand held keypad with a descriptive title. All zones can be accessed from the EDIT Z menu found at the end of the menu list using the keypad.

3) There are two ways to interface with the FM ECU. First is with the hand held keypad included with the ECU and the second is through a lap top computer using our Windows based interface called Data Log Lab (DLL). DLL offers the advantage of data logging from the ECU and viewing all of the operating parameters at one time.

4) The ECU includes 4 different default settings to get the car up and running quickly. Two of these defaults are for turbocharged cars and two are for normally aspirated cars.

5) The ECU features a self-learning mode called Lambda, where the ECU uses the air/fuel ratio signal from the O2 sensor to tune the fuel delivery while the car is driven.

6) The ECU uses an intake air temperature sensor to adjust the fuel delivery and ignition timing and a knock sensor to retard the ignition timing when detonation (knock) is detected.

7) The ECU measures pressure in kilo Pascals (kPa) with 100 kPa equaling atmospheric pressure at sea level. The ECU measures temperatures in degrees Centigrade.

8) When starting the car always turn the car "on" and pause until the keypad boots up before hitting the starter. This allows the program to boot up and the ECU to measure atmospheric pressure. Failure to do this will make the boost control erratic.

9) To make understanding the manual easy, memory locations displayed in the main menu on the keypad are shown in red. Memory locations not displayed in the main menu are in blue and can only be modified from the EDIT Z menu.

Section 2: Microprocessor (software) Installation

Note: When installing a new ECU for the first time, skip this step. The microprocessor has already been installed before the ECU was shipped. This procedure only applies when upgrading to new software after the ECU has been installed.

To remove the microprocessor a chip puller must be used. Using paperclips, etc. to try to remove the chip will probably damage the chip or socket. Radio Shack sells a puller for a 52-pin flat-pack IC for less than $5. Buy one.

The microprocessor can be found in the picture of the circuit board below. Insert the two prongs of the puller into the openings in the corners of the socket and squeeze the puller. The chip will pop out.

Beveled edge on software chip goes up towards the top of the circuit board.

After removing the old chip with the proper puller, install the new chip by pressing it into place firmly with your thumb. The chip must be properly oriented. If you look very closely at the edges of the chip, you will see that one edge is beveled and has a small dot in the middle of the edge. This is the top of the chip. With the multiplugs on the printed circuit board at the bottom, the top of the chip should face up.

Once the chip is in place, replace the cover on the ECU case and go to Section 3 of the manual.

Section 3: Getting Started

This section of the manual explains step by step how to get a Miata running with the Flyin' Miata ECU installed. Following these steps will get the car up and running with minimal time spent reading this manual. If further detail of one or more of the parameters mentioned below is required, then the tuner should refer to section 8 of this manual. Initial tuning of the Flyin' Miata ECU is not difficult, but having someone in the passenger seat to take some readings while the driver drives the car is a very good idea.

Before getting started, here is a primer on using the keypad

The keypad is a simple way to access all of the functions of the ECU without dragging along a laptop. The laptop has definite advantages for datalogging, analysis and multiple changes, but on a daily basis the keypad wins out. There are three pairs of keys:

The SELECT keys move through the main menu. When turning on the car, the ECU always wakes up in the RPM screen. This is considered the beginning of the main menu. Use the up and down keys to scroll through the menu choices. When holding the key down longer, it will scroll faster. When it gets to the end of the main menu (where it says "EDIT Z0 XX"), it will stop moving. Pressing the key again, it will go back to the start (RPM) screen.

Once the desired screen has been found, changes are made to the setting by using the ADJUST keys. Some screens don't have any adjustable parameters in them, in other words they are read only. The ADJUST keys are used to access additional information in some of these screens, for instance in the RPM screen, pressing the ADJUST down key access the atmospheric pressure.

The EDIT menu is a submenu of less often used parameters. It is accessed by either holding the SELECT up key until it stops or hitting the SELECT down key once. At this point, the screen will display "EDIT Z0   XX". You move through this menu by using the EDIT up and down keys. To make changes, use the ADJUST keys, just like in the main menu. As a side note, a store can be performed anywhere in the EDIT Z menu by holding down both EDIT keys at once. When in the main menu, a store can only be performed in the STORE window and holding both ADJUST keys down. Some rarely-used submenu screens are hidden and can be accessed only by pressing both SELECT keys simultaneously while in the parent screen. This may take a little practice because if you press either SELECT key before the other you'll change to a different parent screen where the hidden screen is not accessible before getting both SELECT buttons pressed.

1) **Load Default values:** The ECU contains 4 sets of default values to help speed along the tuning process. In most cases the default values will allow the car to start and run normally. Turn the car "on" but do not start the engine. Scroll to the RELOAD screen and press the combination of edit buttons that makes the desired default title display in the screen. Then, while holding down the correct combination of edit buttons, press both adjust buttons to load the default values. When the screen fills with asterisks, release the adjust buttons.

TURBO 1: Used for all turbo applications when 92 octane, or better, fuel is available. These defaults are automatically loaded when powering up the ECU for the first time.

TURBO 2: Used for turbo applications when 91 octane and lower fuel is the best available.

N/A OEM inj: Used for normally aspirated cars running stock fuel injectors.

N/A big inj: Used for normally aspirated cars running 440cc/min (1.6L) or 550cc/min (1.8L) fuel injectors.

On supercharged cars use the TURBO defaults that apply to the available fuel.

2) **Check MAP SENSOR operation:** In the RPM screen press the adjust down button on the keypad to display the atmospheric pressure. At sea level the MAP reading should be about 100kPa. Higher elevations will read lower values. The MAP sensor has an accuracy window of +/-5kPa. Refer to the table below for the atmospheric pressure at different elevations. If this reading looks good, go to step #4. If the reading is wrong, follow step #3 for possible solutions.

Elevation (ftX1000)	0	1	2	3	4	5	6	7	8	9
Pressure (kPa)	100	97	94	91	87	84	80	77	74	71

3) Two problems are usually the cause of an incorrect MAP reading. First, on 1.6L cars, double-check the Black/Green wire that was used to tap into the MAP sensor wire harness. There are two Black/Green wires in the harness and tapping into the wrong one (or using the wrong end of the correct wire) will affect the MAP sensor's readings. On 1.8L cars, double check the wire harness connector at the MAP sensor. The locking tab on the connector should point toward the engine, not the fender.

4) **Check the intake air temperature sensor operation:** Press the adjust up button, the screen should display the ambient air temperature in degrees centigrade.

5) Scroll up to the BOOST TGT screen and verify that the boost target is set to 100kPa. This should be 100kPa as the default, but it is a good idea to check. Supercharged, Aerodyne turbos, and normally aspirated users will not have to perform this step since the boost control functions will not be used.

6) **Set Throttle Position Sensor (1.8 cars only):** Use the select button and go to the TPS window. With the throttle closed, use the adjust buttons and adjust the setting to 10. Open the throttle fully and adjust TPS to 100. Each setting affects the other so repeat these steps 2 or 3 times until the two readings toggle between 10 and 100.

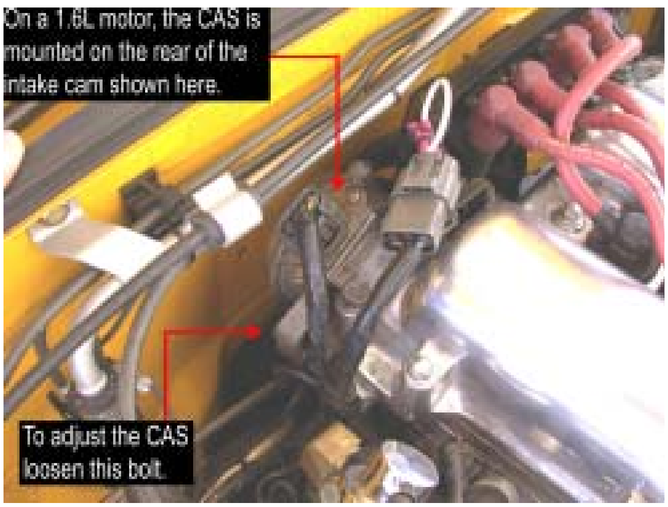
7) Start the car. If fuel injectors were installed check for fuel leaks around the junction of the fuel injectors with the fuel rail.

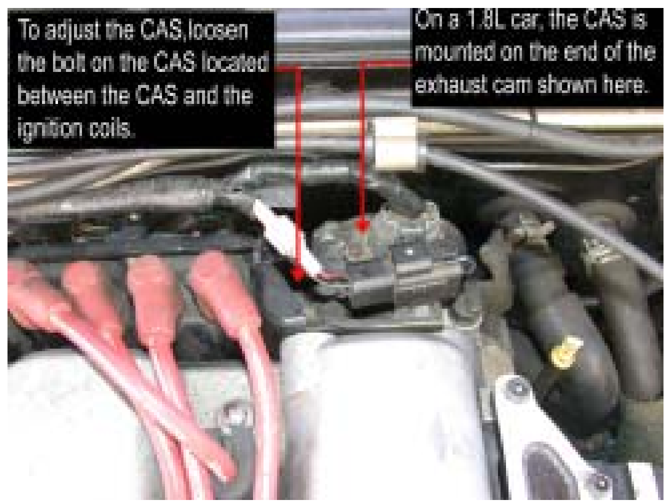
8) **Check the idle:** At this point the car should idle smoothly. The idle speed may vary, but it should be running on all four cylinders. If all four cylinders are not firing, immediately shut off the engine and solve the problem.

9) **Set Ignition Timing:** The ignition timing needs to be reset when installing the Flyin' Miata ECU. The software has a special mode to make setting the timing easy. Go to the IGN TRIM window and press both edit buttons. A new screen will appear that reads IGN SETUP +10deg. With this mode selected, set the CAS to 10* BTDC. DO NOT use the jumper between terminals TEN and GND in the diagnostics connector. When finished press either of the edit buttons to return to the IGN TRIM **screen**.

Press both the edit buttons to change the IGN TRIM screen to the CAS set up screen.

In this screen and only this screen, set the CAS to 10°BTDC with a timing light.





10) Scroll up to the INJ / O2 window to check the O2 sensor reading. If the O2 sensor reads between 76-80, the car is ready for a test drive. If the O2 sensor reads below 76-80, scroll down to the ZONEF screen and increase the fuel correction number on the right by a few points, using the adjust buttons. Scroll back up the INJ/O2 screen and check the O2 sensor reading. Don't spend a lot of time on idle at this point, the car needs to be driven to operating temperature before proper idle adjustment is possible. Sitting and heat soaking for twenty minutes will not yield good idle settings.

At this point the car is up and running. The fuel delivery will not be perfect, but the car can be driven. To get the most out of the Link ECU the fuel curves must be tuned to your particular car. Move onto the next section to learn how to tune the fuel curves.

Section 4: Tuning the Fuel Delivery

The Flyin' Miata ECU uses the motor's oxygen (O2) sensor to tune the fuel delivery while the car is driven. Refer to the table on page #30. In the center of this grid are the Fuel Zones. These are the correction factors the ECU uses to fine tune the fuel delivery based on engine RPM and manifold pressure. These individual zones are what the ECU alters when tuning the fuel.

On an engine using forced induction the top three rows (100, 200, 300) are used when not in boost. The last three rows (400, 500, 600) are used when in boost. The first column of this chart contains upper limit on the manifold pressure for each row. For example, the 300 row covers manifold pressures from 81kPa to 120kPa.

The O2 sensors used on Miatas (and most other cars for that matter) are designed to operate in a narrow temperature range and a narrow air/fuel ratio range close to stoichiometric combustion. Once a car using forced induction starts making boost, the exhaust temperatures and corresponding air/fuel ratios get high enough to make the reading from the O2 sensor inaccurate. Therefore, when tuning the fuel on forced induction cars we recommend tuning only the 100,200, and 300 rows in the ECU. The fuel values in the TURBO 1 and TURBO 2 defaults for the 400, 500, and 600 rows have been derived with a combination of dyno tuning and road tuning with special O2 sensors designed for wide air/fuel ratios and high temperature operation. These zones will not have to be tuned by the user when using a standard Flyin' Miata turbo kit. For modifications to these fuel values when using different systems or components, refer to the end of this section.

When tuning normally aspirated cars the inaccuracy of the O2 sensor will not be a problem. All 6 fuel rows should be tuned as described below.

There are two modes of tuning the fuel - coarse and fine. Both must be performed to make the fuel delivery as accurate as possible. In order to make the tuning go quickly and accurately, the engine should be operated as close as possible to the center of each pressure row. Below is a table of the rows and their centers. Use the keypad to determining the reading on the boost gauge that equates to the row center listed below in kPa.

ROW	RANGE TURBO	CENTER	RANGE N/A	CENTER
1	0-40	20	0-33	17
2	41-80	60	34-47	41
3	81-120	100	48-60	54
4	121-160	140	61-73	67
5	161-200	180	74-87	81
6	201-254	227	88-100	94

Manifold pressure ranges and zone centers. Units are kPa.

While tuning, the following characters will show up next to the zone number in the ZONEF screen.

When these characters are showing the ECU will not tune.

A - Acceleration, the throttle is moving down.
V - High vacuum the manifold pressure is below IDLE MAP.
T - Timer, the ECU will not tune for 90 seconds after the car is started or for 5 seconds after coming out of high vacuum. So a "V" will always be followed by a "T"
E - Engine temperature, the ECU will only tune after the engine has warmed to over 80*C.
X - Tuning has occurred but the fuel value has been changed 6%. The fuel will not change any more without doing a store. This feature keeps the ECU from tuning itself to death in the event that the engine has a sensor problem, such as a bad 02 sensor.
"?" The engine is not operating close enough to the center of the fuel zone to tune properly.

When these characters are showing the ECU is tuning.

"+" The ECU is adding fuel to the engine.
"-" The ECU is subtracting fuel from the engine.
"=" The ECU has reached its A/F target for that zone.

1) Go to the LAMBDA screen and turn lambda "on" and L3 "off". The edit buttons control LAMBDA and the adjust buttons control L3.

Link keypad in the ZONEF window for coarse fuel tuning

2) **Coarse tuning:** Drive the car with the keypad set to the ZONEF window. The ECU will automatically tune the current fuel zone the engine is operating in. The 3-digit number in the center of the ZONEF window displays the current operating zone.

Tuning can be done anywhere, but using a flat straight road with low traffic will make the process easier because more attention can be used for driving and reaching as many zones as possible. For the 200 and 300 rows, accelerate gradually in 3rd or 4th gear from 1500RPM up to redline. As the car passes through each zone, that zone will be tuned. If an equal sign does not show before passing to the next zone the throttle can be modulated to stay in that zone longer, or the car can be slowed and the acceleration run can be made again. Passing through a zone that has already been tuned is not a problem because the ECU always tries to tune to the best value. Again, on forced induction cars do not tune the 400,500, or 600 rows (i.e. do not go past zero on the boost gauge).

While the car is driven in ZONEF the ECU will display the tuning characters +,-,=,?. Have a co-pilot monitor these characters because they indicate when the computer is adding or removing fuel to meet its O2 sensor target. Try to hold the car in a particular zone until the plus or minus sign turns into an equal sign. Each zone usually tunes within 2 to 4 seconds. After driving for 15-20 minutes pull over and store the changes. Do not forget to store before you shut off the car!

3) On normally aspirated cars continue this process for the 400,500, and 600 rows.

4) Tune the 100 row. This can be tricky. However, not tuning the 100 row can make the car lurch when the throttle is opened and closed. Modulate the throttle to operate the engine at high vacuum. Driving down a slight hill makes this easier. Zones in the 100 row above 4000RPM are almost impossible to drive in so do not ruin your day by trying to tune them.

5) **Fine Tuning:** Coarse tuning changes the fuel at any point in the fuel zone. To get a more accurate fuel value, fine-tuning must be done. Drive the car for 8 to 10 minutes beyond full warm up (i.e. the coolant temperature is above 80*C) before fine tuning the fuel. Fine-tuning occurs in the STORE and RPM windows when Lambda 3 is turned off. The same symbols, +, -, = , ? are still used, but the RPM and MAP ranges in which tuning occurs are narrower. The ECU tunes only within 100RPM of the zone's centers, which is every 500RPM on the 250RPM mark (i.e. 2250,2750,3250, etc.). Perform fine tuning exactly like coarse tuning using the RPM window. Do not forget to save the new values.

Note: On cars running Vishnu fuel rails the fuel numbers in the 400 row should be lowered by 8 points. Fuel numbers in the 500 and 600 rows should be lowered by 10 points.

6) The fuel values are now tuned. Turn Lambda3 back on for day-to-day driving.

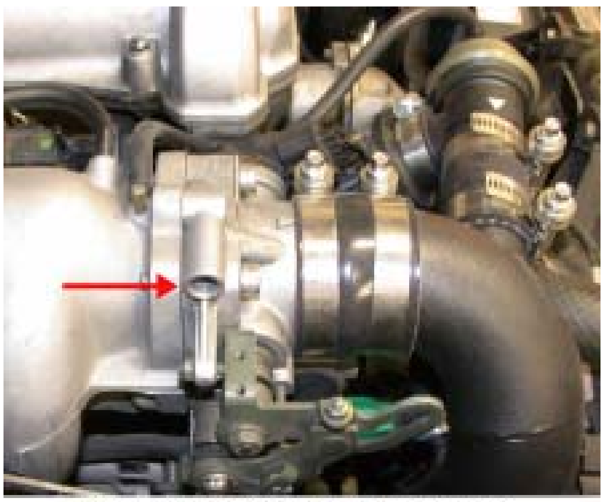
If more precise fuel tuning is desired refer to Section 11, Advanced Fuel Tuning, for information on tuning the fuel in the boosted rows. Driving the car on the default fuel values in the boosted rows will yield about 90% of the total capacity of the system. Following the steps in Section 10 will help find that final 10%.

Section 5: Setting the Idle Settings

Making the car idle properly requires setting a few parameters correctly. Always drive the car for 8 to 10 minutes beyond full warm up (i.e. the coolant temperature is above 80*C) before adjusting the idle settings.

1) Scroll to the IDLE MAP window. Set the number on the far right, using the adjust buttons, 5 points lower than the lowest number displayed in the parenthesis while the car is idling.

2) Scroll up to the IDLE screen. This screen displays the IAC valve duty cycle. Adjust the screw on the side of the throttle body so the duty cycle is in the 30% to 35% range.



Idle screw on the top of the throttle body. 1.8L

Idle screw on the side of the throttle body. 1.6L

3) On the far right of the IDLE screen are an asterisk (*) and an “n”. The asterisk denotes the throttle position. When the throttle is fully closed the asterisk should show and light pressure on the throttle should make it disappear. If the asterisk does not disappear when the throttle is opened, or does not appear at all, then the throttle position sensor must be adjusted. To adjust the TPS, locate the black box on the inboard side of the throttle body. Adjust the TPS by loosening the two screws that hold it in place. Rotate the TPS so the asterisk shows until the throttle cable pulls the throttle plate open, then it should disappear. When the throttle is closed, the asterisk should show up again.

4) The “n” denotes the neutral switch. When the clutch is depressed or the transmission is **not** in any gear the “n” will show. If the “n” is not controlled by the clutch, then the clutch switch is bad or out of adjustment. If the “n” is not controlled by the transmission, then the neutral switch is bad.

NOTE: Both the asterisk and the “n” must show in the IDLE screen when the car is in neutral and the throttle closed. If not, the car will not idle properly.

5) After the steps above have been done the fuel mixture at idle must be set. When the * and n are showing the ECU operates in Zf100. The fuel correction value in this screen controls the

mixture at idle. Use the INJ/O2 screen to check the signal from the O2 sensor. If the O2 reading is between 74 and 78 then the idle fuel is set. If the value from the O2 sensor is lower, scroll down to ZONEF and add a few points of fuel using the adjust buttons. If the value from the O2 sensor is higher, scroll to the ZONEF and subtract a few points of fuel using the adjust buttons.

Additional zones to cure idle problems
Occasionally the ECU will exhibit unusual idle behavior. Before moving onto the following steps to solve a problem, make certain that all the settings above are set correctly. These advanced settings will not solve a basic set up problem in the steps above.

Problem: The idle will oscillate between 1400 and 1600RPM in cold weather for a few seconds after start up.

Solution: When the car is first started ZONE Z19 raises the idle speed to keep the motor running. If the value of Z19 is set too high the motor will run into its idle speed limiter, at 1500RPM, that drops the idle to a lower level. Lower Z19 by one point until the oscillating stops.

Problem: The idle speed drops or the engine stalls when coming to a stop.

Solution: When the ECU registers high vacuum followed by the * and the n, ZONE Z18 is used to elevate the idle speed to keep the motor running. Raise Z18 a point or two until the idle speed hangs at 1000 RPM for a second or two, when coming to a stop.

Problem: The idle speed drops too far when the AC turns on.

Solution: The AC IDLE screen provides an increase in the IAC duty cycle to offset the load on the engine by the AC compressor. Raise this value so when the AC compressor turns on the idle varies less than 100 RPM. If the idle jumps more than 400 RPM when the AC compressor shuts off, AC IDLE is set too high.

Section 6: Setting up the Boost Controls

The turbo boost pressure is controlled by a part called a wastegate. The wastegate gets its name from the fact that it “wastes” a portion of the exhaust gas by diverting it around the turbine wheel to limit the speed of the compressor wheel, and hence the boost pressure. Wastegates can either be integral or external. All FM2 turbo systems use an integral wastegate, while the old FM3 system and the current FM4 use an external wastegate.

On the FM2 turbos, a gold colored can, called the wastegate actuator, is mounted on top of the turbo with a rod that connects to a lever on the wastegate. The wastegate actuator houses a diaphragm and a spring calibrated to give the turbo a certain amount of boost. All turbo systems have to produce a minimum level of boost. No turbo system can run zero boost pressure. This manual refers to this minimum level of boost as WG BASE. The Flyin’ Miata ECU can only increase the boost level above WG BASE. When the ECU’s boost target is set to 100kPa the ECU does not control the boost and the engine will operate at WG BASE.

Without the Flyin’ Miata ECU the wastegate actuator would have a hose connecting one side of the diaphragm to the pressurized air coming out of the compressor called the signal hose. This hose allows the wastegate actuator to “see” the level of boost developed by the turbo. The Flyin’ Miata ECU intercepts this signal with the boost control solenoid and manipulates this pressurized air signal to control boost pressure. The solenoid bleeds off some of the pressurized air so that the wastegate actuator “sees” a lower level of boost than what the turbo actually makes. The amount of bleed off is called duty cycle. The ECU controls boost pressure by altering the duty cycle of the wastegate. Understanding this concept is crucial in understanding how the ECU controls boost pressure.

When using the Flyin’ Miata ECU for boost control there two modes of control, open loop and closed loop. Open loop control means the ECU modulates the solenoid at a given duty cycle without using feed back to verify that the wastegate position produces the desired boost level. Open loop control produces a steady and repeatable boost pressure but lacks the ability to correct itself when external factors change. The user must check the operation and make the necessary changes to the settings to maintain the correct boost level.

Closed loop control means the ECU modulates the solenoid at a given duty cycle, then checks the boost pressure to see if that position produces the desired boost pressure. If the wastegate duty cycle produces the wrong boost level the ECU will alter the duty cycle to correct the boost level. This method requires more parameters to be set, but once set the boost control can be very accurate over a large variety of external factors. We recommend using closed loop boost control whenever possible.

Zones used for boost control

Boost control in the Flyin' Miata ECU uses the following Zones. Knowledge of these zones is vital for getting the boost set accurately. The descriptions are an abbreviated version of the full descriptions found in Section 8.

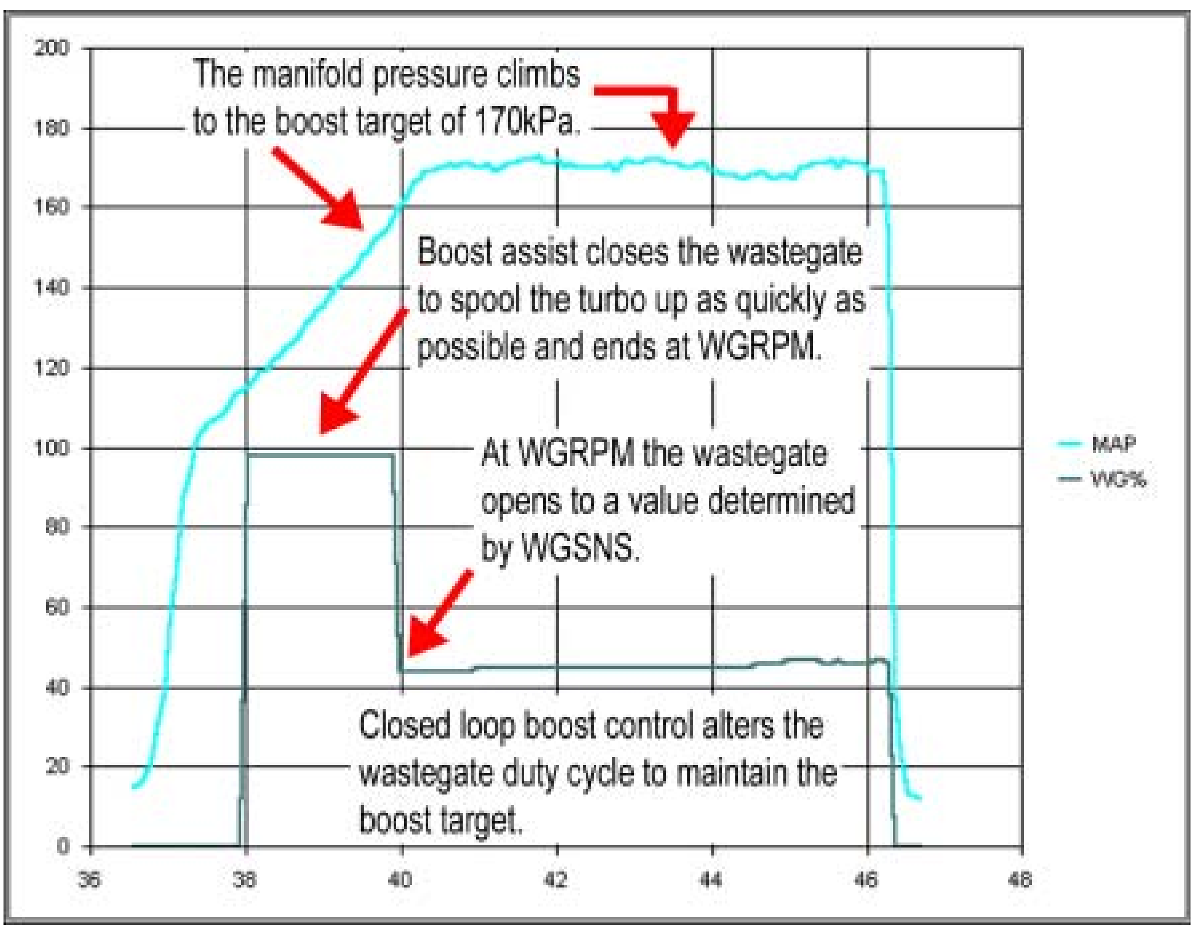
BOOST TGT 100 n: This screen sets the manifold pressure (Boost) target. Use the adjust buttons to enter in the desired boost target.

WG SNS (XX) 43: From this value, the ECU calculates the initial duty cycle used to control the boost when boost assist shuts off. If the boost is within 10kPa of the boost target, the ECU will go closed loop to maintain the boost target. The value in parenthesis is the manifold pressure. Use this screen as the boost gauge in all steps for setting up the boost controls unless directed otherwise.

WG BASE 174: The ECU needs to know how much boost the wastegate actuator on the turbo makes without any assistance from the ECU. This value is the boost measured with the ECU when BOOST TGT is set to 100.

WG RPM 3700: The RPM point at which the ECU goes into closed loop boost control, maintaining the boost target by altering the wastegate duty cycle.

The DLL graph below shows the affect of these zone settings



The next four screens help solve particular boost control problems.

WGlg up 5 dn 6: This screen, Wastegate Loop Gain, controls the rate at which the ECU reacts to changes in manifold pressure. These numbers should be run as high as possible while still maintaining smooth boost response. Our experience has proven the default values work very well with our ball bearing turbos.

WGsp O=20 D=25: This screen, Wastegate Spike Control, controls unwanted variations in boost pressure under two specific situations

> When approaching target boost from low RPM (below WG RPM) the turbo can momentarily droop below the boost target. The "D" value stops this from happening. The anti-droop functions only occurs after boost assist has shut off and before reaching WGRPM. So WGRPM may need to be raised to allow "room" for the droop control to function.
>
> When reaching target boost at a high level of RPM (above WG RPM) the turbo can momentarily over-boost; the "O" value stops this from happening.

For both O & D, higher values increase their action and zero takes their action away completely.

BOOST HYSTERESIS (Z840): This value sets the amount the boost pressure can vary before the ECU will leave closed loop control.

BOOST RISE RATE WEIGHT (Z845): This value controls how quickly the ECU will allow the boost pressure to ramp up. Lower numbers will make the boost rise slower. This setting is very helpful with ball bearing turbos. At this time a value between 20 and 50 works well with ball bearing turbos.

Closed loop boost control with one boost target
This is the most common form of boost control.

1) **Setting WG BASE** Set the BOOST TGT set to 100. In the WG SNS window the number shown in parenthesis is the manifold pressure measured by this FM ECU. Use this as your boost gauge. Take note of the value that settles out in this screen while accelerating hard in 3rd gear from 2500 RPM to 5000 RPM. This value is WG BASE.

2) Scroll up to the WG BASE window and enter this value with the adjust buttons. Save this new value of WG BASE now.

3) **Set the boost target** Scroll to the BOOST TGT window and enter the desired boost level. We recommend 180kPa on a car with a stock engine.

Conversion table for PSI to kPa

PSI	4	5	6	7	8	9	10	11	12	13	14	15	16
kPa	128	134	141	148	155	162	169	176	183	190	196	203	210

4) **Setting WG SNS** Scroll to the WG RPM screen and set the value to 7200. This will keep the ECU from going into closed loop boost control and make setting WG SNS easier.

5) Scroll down to the WG SNS window. Accelerate at full throttle from 2500 RPM in 3rd gear while watching the value in parenthesis (this is the manifold pressure, remember?) A value of WG SNS needs to be found that allows the boost to rise up to the boost target without over-shooting. If the boost fails to reach the boost target, raise WG SNS. If the boost pressure goes past the boost pressure lower WG SNS.

> **Keep these notes in mind while setting WG SNS:**
> **-** Small changes in WG SNS make a large difference in boost pressure, so make changes in this screen 1-3 units at a time. The range of WG SNS is 0 to 255 with most people finding a value between 35 and 80 to control the boost properly.
>
> - If the boost will not rise above WG BASE setting regardless of how high WG SNS is adjusted, then check the air hoses on the boost control solenoid. They are probably mis-routed. Or, the electrical connections for the solenoid are not correct.
>
> **-** When setting WG SNS do not run the engine to redline. We are setting the value that the wastegate goes to when the ECU begins closed loop boost control. An FM turbo system will reach full boost by 4000RPM so the engine only needs to be revved during this test to about 4500RPM.
>
> **-** If you ever change the BOOST TGT the WG SNS will need to be re-calibrated.

6) **Setting WG RPM** To find the value for WGRPM, go to the RPM screen. Make a run in 5th gear on a level road starting at 2500RPM while holding the adjust down button. The MAP value will be displayed on the keypad. When the MAP value reaches 10kPa below the boost target release the adjust button and the screen will immediately change to display engine RPM. Round the displayed value down to the closest 100 and this will be WGRPM. Repeat this step two or three times to find the most accurate value. For most applications WG RPM falls between 3200 to 4200.

Note: If the 4 parameters above are set correctly the car should have reasonably good boost response. It may not be perfect and the following parameters will solve any problems that still exist. However, it is imperative that the settings above are as accurate as possible before moving on.

Note: for the next two settings, using data logs to see the boost response is very helpful in getting these variables set properly. On the next page, a DLL graph gives examples how these variables affect the boost response.

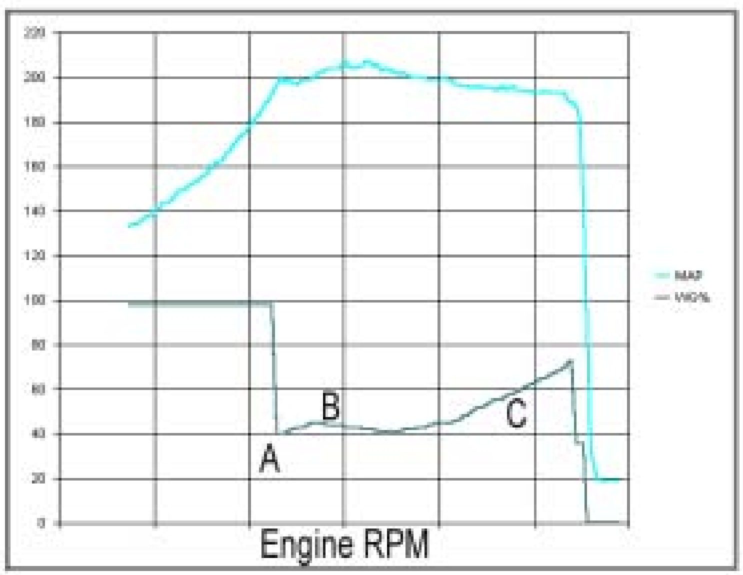
7) **Setting Loop Gain** From experience we have found the default values for loop gain are the best for our ball bearing turbos. Sleeve bearing turbos can use values 2 to 3 times higher than the defaults. These values should be set as high as possible while maintaining stable boost control.

8) **Over shoot and Droop suppression**

Anti-droop (D): On systems with a ball bearing turbo set this value to 0. On systems with sleeve bearing turbos set this value between 10 and 20.

Spike Control (O): To set the "O" value drive the car on the highway in 4th gear and cruise at 4000RPM. Start with an "O" value of 0. Snap the throttle open long enough to observe the boost rise to target on the boost gauge, then let off the throttle. If the boost momentarily goes past the boost target, then falls back down to the target, raise the "O" value by 5 and repeat the process. Keep repeating this process until the boost climbs quickly to the boost target without overshooting by more than 1psi on the boost gauge.

This DLL graph shows problems that can be solved using WGsp and WG lg



Problem #1: In the graph above the effects of WGlg and WGsp can be seen. At point "A" boost assist has brought the manifold pressure up to within 10kPa of the boost target (202kPa). After boost assist shuts off, the manifold pressure drops off because there is not enough exhaust energy to maintain the boost pressure. The ECU responds by increasing the wastegate duty cycle. This does bring the boost back up, but also causes an overshoot of the boost target, shown at point "B".

Solution #1: Raise WGRPM 200RPM or 300RPM. Then increase WGsp D to 15. Boost assist will still shut off in the same place because the ECU automatically shuts off boost assist when the manifold pressure reaches within 10kPa of the boost target. The wastegate duty cycle will then be raised a few points until WGRPM is reached eliminating the boost droop.

Problem #2: As the engine RPM builds, the ECU must raise the duty cycle of the wastegate to hold the manifold pressure. This can be seen at point "C". However, the duty cycle is not rising fast enough and the boost pressure is falling off.

Solution #2: The ECU must react faster to changes in the manifold pressure by raising the duty cycle faster. To do this WGlg up (+ve) should be raised.

9) Set MAP LIMIT to 15kPa above your target boost setting. This will protect the engine from overboost.

Closed loop boost control using multiple boost targets

Setting up the boost control with multiple targets is exactly the same as setting the boost with one target, except instead of entering a boost target in the BOOST TGT window, go to the EDIT Z menu and enter the desired boost targets in each cell of the 700 row from 725 (2500RPM) to 775 (7500RPM). When viewing the BOOST TGT window the boost target set in Z735 is displayed.

Open Loop boost control

If stable closed loop boost control is impossible to achieve, open loop control can be used. For open loop control the values in Z725 through Z775 are now wastegate duty cycles instead of manifold pressure targets. For instance, setting Z735 to 40 results in the ECU modulating the boost control solenoid at 40% between 3500 and 4000RPM. The user will have to determine, by driving the car and taking data logs, if this value of duty cycle produces the desired manifold pressure. A different duty cycle will need to be set in each boost zone to produce the desired boost response.

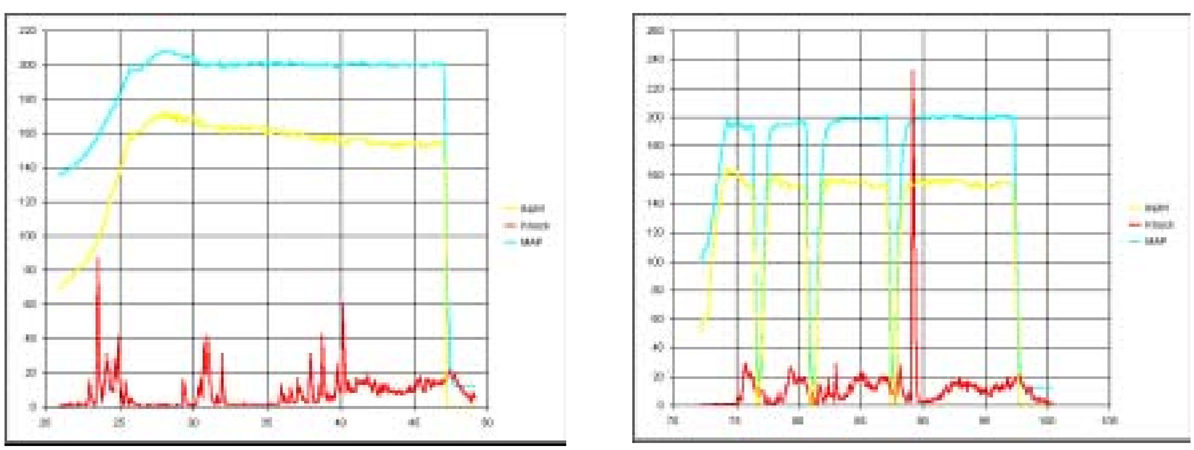
Section 7: Tuning the Ignition Timing

NOTE: When veiwing the Ignition Zone Table, (using the keypad or DLL) the values are in 1/4 degrees. Therefore, a 40 in Zi100 equates to 10* of advance.

The ignition timing numbers provided in the defaults will make good power with a minimum chance for detonation (knock). If the engine does experience knock, the ECU will automatically reduce the ignition timing in the zone where the knock occurred. The reduced value of timing will be used until the car is shut off. If a store is performed before shutting the car off, the reduced timing will be written into permanent memory and used every time the car is started. If a store is not performed before shutting the car off, the reduced timing will be lost and the original timing value will be used the next time the car is started.

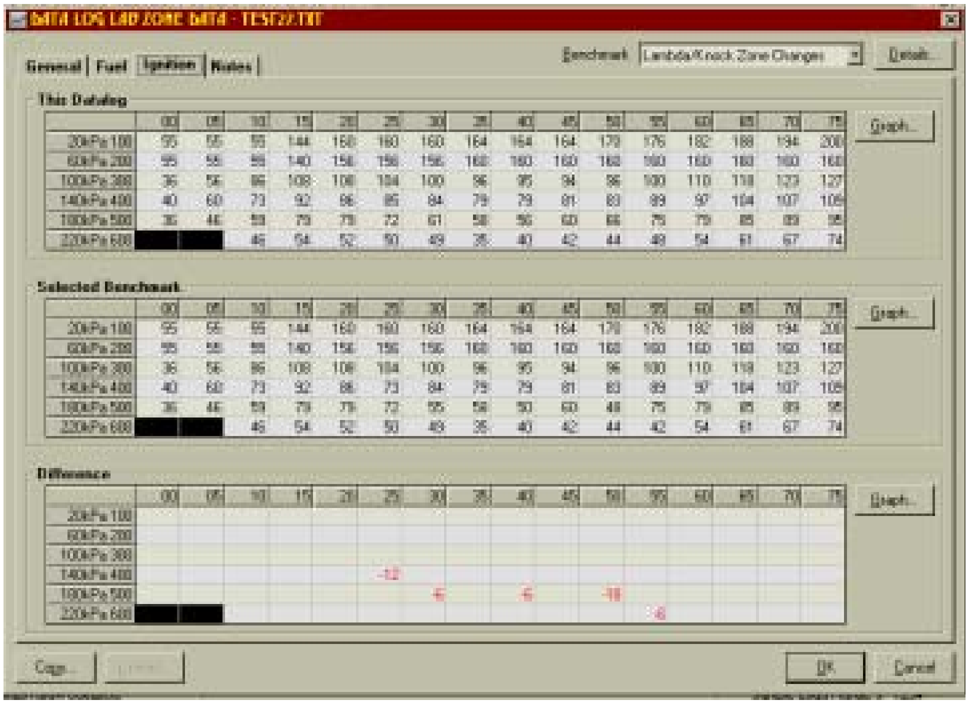
Simply letting the knock sensor reduce timing where knock occurs and storing the reductions in timing will allow the engine to operated free of knock, but power will be lost and the temperature of the exhaust gases will be elevated. More timing has to be removed to stop knock once it starts than has to be removed to keep the knock from happening in the first place. Saving all the timing reductions made by the knock sensor will result in a greater amount of ignition retard than necessary. This is not the most desirable way to set the ignition timing.

Our data logging software, Data Link Log (DLL) , is excellent for tuning the ignition timing because reductions in timing caused by knock are recorded. After taking a data log the zones that caused knock are identified with the amount of timing removed to stop the knock. Generally, 1/3 of the amount of reduction can be replaced without the knock happening again. For instance, if a zone was reduced by 12 (3 degrees) the resulting number can be increased by 4 (1 degree) without the knock re-occurring. With a little work and patience a set of timing numbers can be found that allow the car to run strong and free of knock.



DLL graphs showing knock

The two graphs above are taken from a DLL graph to show what knock looks like to the ECU. The red trace is the signal from the knock sensor. Any spike greater than 40 should be considered knock and the timing should be lowered to reduce the knock. In both graphs the fuel is tuned properly because it rises with the manifold pressure and remains fairly constant throughout the run. The knock will need to be addressed by reducing timing in the appropriate ignition zones.



Those two graphs resulted in the timing numbers above. In the very top chart are the ignition timing numbers for this car taken at the very beginning of the data log. The chart in the middle are the numbers at the end of the data log. And the chart at the bottom is the difference between the two upper charts. The red numbers showing a difference between the two charts are the amounts of timing needed to stop the knock in that zone.

This process can be duplicated without DLL. First, the user will need to write down all the timing numbers. Then, go out and run the car at full throttle from 2000RPM to redline in 3rd or 4th gear. If any knocks have occurred, perform a “store” so that the reduced timing numbers are saved in memory. Compare the original timing numbers with the new numbers in memory. Any differences will be caused by knock. Try raising the altered numbers by 1/3 of the amount of reduction and go out and do another power run. This should be repeated until the ECU does not reduce any timing numbers to stop knock. This method is more labor intensive, but equally effective.

In many cases more power can be found by advancing the ignition timing. Timing should only be added in the boosted rows (rows 400,500,600) to make more power when operating under boost. Power can not be gained by advancing the non-boosted rows (100,200,300). Advancing the timing is a trial and error process by increasing the ignition timing numbers and then checking for knocks. When advancing the timing, increase the timing numbers by 2 (1/2 degree) at a time.

Warning: Advancing ignition timing too far causes knock. Knock can break pistons and rods. Advance timing in small steps and be certain the knock sensor on the ECU is functioning.

Section 8: Definitions of Zones

Below is a detailed list of all the operating parameters of the Flyin' Miata ECU in the order in which they appear on the keypad. Zones not listed in the main menu are listed at the end of the list. The text in bold print reflects exactly how it displays on the keypad. Words in red are displayed on the keypad. Words in blue are not listed and can only be modified in the EDIT Z menu. The number in parentheses is the data location in the EDIT Z menu.

RPM XXXX T 0: Displays the engine RPM on the left, Lambda3 tuning correction factor in the center, and the amount that MASTER FUEL is being changed as a result of the intake air temperature compensation on the right. When Lambda 3 is turned off the center character shows the status of fine tuning.

More information can be shown in this window by pressing and holding the following combination of buttons.

Adjust up: coolant temperature and intake air temperature.
Adjust down: manifold pressure (MAP) and the value from the oxygen sensor (O2).
Both Adjust: security feature
Edit up: ignition advance and fuel injector pulse width.
Edit down: atmospheric pressure and the wastegate duty cycle.
Both edit: ECU type and the software release code.

SECURITY FEATURE: Press both adjust buttons together to access the security feature. Pressing the edit up button (while holding both adjust buttons) turns the security feature on and pressing the edit down button turns it off. When security is turned on the car will not start when the keypad is disconnected from the ribbon cable, but the car will start if the Serial Link is installed.

STORE: The ECU works like a PC. Any information changed in the memory while the car operates must be saved before turning the car off. Scroll to the window that says STORE and press both adjust buttons down together and hold until the screen fills with asterisks. Once the asterisks are gone all new information is saved into permanent memory. The numbers displayed next to the asterisks are the memory locations being updated. The ECU will not STORE above idle speed. A STORE can also be done anywhere in the EDIT Z menu by holding both edit buttons down until a row of asterisks fill the screen. The ECU displays the fine tuning status to the right of the STORE window. While the ECU stores information the car will idle erratically and will not accelerate if the throttle is opened. This is normal. Because of this, only STORE when the car is not in traffic.

ZONEF: **FUEL ZONES** (Zf100 to Zf675) These zones represent a grid, 6 rows by 16 columns, of fuel correction values used to fine tune the operation of the engine. See the grid on page #30. The first digit of the zone number indicates manifold pressure row. The second and third digits indicate RPM column. Example: Zf105 would mean "row 1" (high vacuum), between 500 and 1,000 RPM (05). Rows are divided by manifold pressure as follows:

ROW	RANGE TURBO	CENTER	RANGE N/A	CENTER
1	0-40	20	0-33	17
2	41-80	60	34-47	41
3	81-120	100	48-60	54
4	121-160	140	61-73	67
5	161-200	180	74-87	81
6	201-254	227	88-100	94

Manifold pressure ranges and zone centers. Units are kPa.

The columns are divided by engine RPM, 0-8000 in 500RPM steps. The RPM centers are on the 250 mark between zones. For example, 3250 and 3750.

INJ % O2: Two pieces of information are displayed in this screen, instantaneous display of the fuel injector duty cycle and the value from the oxygen (O2) sensor. The fuel injector duty cycle can be changed to fuel injector on time by pressing the Edit up button. Edit down switches back to duty cycle.

> **O2 SENSOR TYPE:** In this screen the type of O2 sensor can be chosen. When pressing both Adjust buttons together, pressing Edit up selects a wide band O2 sensor while pressing Edit down selects an OEM 4-wire O2 sensor.

ZONEIGN: **IGNITION ZONES** (Zi100 to Zi675) The same grid used for fuel values, but for ignition advance values. The timing numbers are stored in quarter degrees, so a value of “40” is actually 10 degrees BTDC. **The Cam Angle Sensor (CAS) must always be set, according to the set up instructions, when installing the ECU .**

KNK 0 (0) 35: (Z13) Knock sensor threshold. The number on the far right sets the value at which the ECU will distinguish detonation from background noise. This value will increase to twice its value between 6000RPM to 7500RPM to stop normal engine background noise from triggering a false knock indication. When knock is heard the ECU will take up to 6 degrees of timing out of the ignition zone in which the knock occurred. This amount of reduction will **not** be stored permanently. The user must perform a STORE to permanently save the ignition timing change. Pressing both edit buttons will reset the knock count to zero, but the timing changes will still be saved when performing a store.

> The number to the far left is the instantaneous level of “noise” heard by the sensor. This display verifies that the sensor is functioning. When the engine RPM is over 3000RPM and on boost, the number on the left will flash instantaneous values from the knock sensor.
>
> The center number, in parentheses, counts the number of times noise exceeded the threshold (knocks) since the last save or when the car was turned off.
>
> The knock sensor has a 2000RPM threshold. Any knocks that occur below 2000RPM will not be identified and the ECU will not take steps to stop the knock.

Setting the threshold to 255 disables the knock sensor function. This would be useful to keep a malfunctioning knock sensor from removing all the ignition timing while driving the car.

IDLE XX % 850*n: (Z8) Four pieces of information are displayed in this window. The right side of the window displays the target idle RPM value. The left side displays the duty cycle of the Idle Air Control (IAC) valve. With the engine fully warm, adjust the bypass screw on the throttle body so that the IAC value is between 30% & 35%, with the ideal reading of 32%.

When the throttle is closed, an * will appear to the right of the idle target value. When the car is in neutral or when the car is in any gear and the clutch is depressed, an "n" will appear to the right of the idle target value. If these two characters are not showing when they are supposed to, the car will not idle properly.

IDLE MAP (XX) 28: (Z0) Sets the MAP value at which the ECU shuts off fuel on idle overrun. Set the number on the far right 5 points lower than the MAP reading in parenthesis when the car is idling and the engine temperature is over 80*C.

TPS = XX AUX = XXX: On 1.8L cars only, the ECU uses the potentiometer on the throttle (TPS) to monitor throttle position. This screen is a combination of zones Z10 & Z11. With the car "on" but not running, adjust the number on the right to 10 using the adjust buttons with the throttle closed. Open the throttle fully and adjust the number on the right to 100 using the adjust buttons. Repeat this procedure a few times. Each setting affects the other so repeat these steps 2 or 3 times until the two readings toggle between 10 and 100. Sometimes the upper value can only be 99 or 101, use 99.

EGR CONTROL: In this screen the EGR can be turned off to utilize wide band O2 sensor tuning. To turn EGR on or off, press both select buttons, then press the edit down button to turn the EGR function off. Edit up turns it back on.

AC IDLE: (Z20) The amount the IAC valve opens to increase the idle speed when the air conditioner turns on. A higher number makes the car idle faster. The idle target speed is automatically raised 100 RPM when the A/C is turned on.

ATLIM (XX) 40: (Z4) Maximum temperature for which the air/fuel ratio will be made leaner with the increasing intake air temperature. We have had good experience with 40. The number in parenthesis is the current intake air temperature.

AT-FUEL COMP = 64: (Z865) Fuel enleanment slope from +25*C to Z4. Increasing this value will provide less fuel as the intake temperature increases.

This number has been determined through testing. We do not recommend changing it unless data gathered from your specific car dictates otherwise.

AT-IGN T 32 S 32: (Z870 & Z875) Two pieces of information are shown here. The "T" value is the intake air temperature at which the ECU will start to reduce the ignition timing.

The “S” value is the amount of ignition retard, in units of 1/256th of a degree, taken out above the “T” value. For example, the default value of 32 equates to .125 or 1/8th degree removed for every 1*C above 32*C. (1/256)x32=0.125

We have had success with the “T” value at 40 and the “S” value at 32.

COLD 12: (Z16) Amount of additional fuel added to the engine during cranking and warm up. This amount of fuel decays to zero as the engine warms to 80*C. The current engine temperature is shown in parentheses.

CSTART 39f 27t: This window displays the cold start enrichment, similar to the choke on a carburetor. The choke fuel (Z6) is shown before the “f” and is adjustable using the adjust buttons. The choke decay time (Z710) is shown before the “t” and is adjustable by using the edit buttons.

HOT RESTART: (Z17) Amount of additional fuel added to the engine during hot restart. This additional fuel decays to zero over ninety seconds. On 1.6L cars a value of zero adds no additional fuel. We have had good operation with a value between 0 and 10.

In 1.8L a value of 70 in the HOT RESTART window indicates no additional fuel added by the ECU. The PRC valve cuts vacuum to the fuel pressure regulator on a hot restart, giving additional fuel. A value below 70 will deduct hot start fuel. If value of 70 does not provide enough fuel, raise it.

MASTER FUEL: (Z1) Sets the overall fuel delivery to the engine. Unless you are using a unique injector size, the default value should be used.

TEMP SWITCH 94: (Z9)

On 1.8L cars this screen sets the temperature, in *C at which the primary engine cooling fan will energize.

On1.6L cars this screen is not in the menu, but Z9 sends a ground signal out on terminal 1L when the coolant temperature exceeds this setting. Refer to the 1.6L ECU installation manual for details on using this feature.

TEMPERATURE LIMIT 112: (Z705) If the engine exceeds this setting, the ECU will impose a rev limit to 3,000 RPM, to alert the driver to look at the engine temp gauge. The temperature can be adjusted, but not the engine RPM.

IGN TRIM: (Z21) Provides an overall ignition timing adjustment for all the ignition zones. If the car is filled with low octane fuel, ignition timing can be removed using this screen to prevent detonation and having the knock sensor take timing out of the ignition zones. When the fuel is used up, the retard can be removed restoring all the previous zone ignition settings. The value in IGN TRIM will not take any ignition zones below 0. It is also handy for making overall timing changes when dyno-tuning.

IGN SETUP +10* is a sub-screen in the IGN TRIM screen and can be accessed by pressing both edit buttons together when in the IGN TRIM screen. **This screen must be used when setting the Cam Angle Sensor (CAS). In this mode the CAS will be set to 10* BTDC.**

RPM LIMIT 7400: (Z2) Sets the rev limit for the engine. Hard limit, fuel cut off, occurs at set point. Soft limit occurs at 300RPM before set point by reducing boost. For normally aspirated cars the setting can be as high as 9000RPM with no soft limit.

MAP LIMIT 220: (Z3) Overboost protection. This sets the manifold maximum pressure anywhere from 0 to 254kPa. When the manifold pressure reaches the MAP limit, the wastegate sensitivity goes to 0, to reduce boost pressure, for one second, then the ECU shuts off the fuel delivery. MAP LIMIT should be set 15kPa above the target boost pressure. Setting MAP limit to 255 eliminates the manifold pressure limit. We do not recommend doing this.

BOOST TGT 100 n: (Z725 to Z775) Manifold pressure targets. Zones are separated in 500RPM increments from 2500 to 7500RPM. When a value is entered in the BOOST TGT window all zones from 725 to 775 are filled with the same value. If a boost curve is desired, different target values can be entered into each zone using the edit Z menu. Making adjustments in the BOOST TGT window in the main menu will over-ride all individual targets in Z725 through Z775.

In the BOOST TGT window the type of boost control can be selected. When the "n" shows in the BOOST TGT window, boost control is normal meaning the boost target is always the values in Z725 to Z775. When the "t" shows, the boost target varies depending on the position of the throttle. On 1.6L cars the boost target is WG BASE until the throttle is wide open. At that point the boost target goes to BOOST TGT. On 1.8L cars, as the throttle opens, the boost target increases from WG BASE to BOOST TGT as the TPS goes from 63% to 95%.

Press Edit up for throttle controlled boost and press Edit down for normal boost.

WG SNS (XXX) 43: (Z12) From this value, the ECU calculates the initial duty cycle used to control the boost when boost assist shuts off. If the boost is within 10kPa of the boost target, the ECU will go closed loop to maintain the boost target.

WGlg up 5 dn 6: (Zf600 & Zf605) Controls the rate at which the ECU reacts to changes in manifold pressure. When these two values are set too high the manifold pressure will oscillate around the boost target. Slowing down the response solves this problem. The default values are what we have determined to work well for ball bearing turbos. Sleeve bearing turbos can run 2 to 3 times these values. These numbers should be run as high as possible without boost oscillation.

WG BASE 174: (Z14) Wastegate base is the amount of boost made by the mechanical wastegate controller mounted on the turbo. The ECU has to know this value. Z14 is the wastegate spring pressure, which is WG BASE minus ambient atmospheric pressure. WG BASE and Z14 are not the same value but they are closely related. After setting WG BASE as described in section #9, the ECU will calculate Z14. Each time the car starts the ECU measures atmospheric pressure and adjusts WG BASE accordingly, so do not be concerned when it changes. Also, this requires the driver to pause for 3 seconds, or until the keypad display comes up, or when the data log begins receiving data, after turning the car “on” before hitting the starter.

WG RPM 3700: (Z15) The RPM point at which the ECU goes into closed loop boost control, maintaining the boost target by altering the wastegate duty cycle. WG RPM should be set to the minimum RPM value the car can physically produce the target boost. In some cases, especially on 1.6L cars, WGRPM can be set 200RPM to 300RPM below the minimum RPM for full boost to prevent boost over shoot when approaching the boost target from below WGRPM.

WGsp O=20 D=25: This screen, Wastegate Spike Control, controls unwanted variations in boost pressure under two specific situations

> When approaching target boost from low RPM (below WG RPM) the turbo can momentarily droop below the boost target. The “D” value stops this from happening. The anti-droop function only occurs after boost assist has shut off and before reaching WGRPM. So WGRPM may need to be raised to allow “room” for the droop control to function.
>
> When reaching target boost at a high level of RPM (above WG RPM) the turbo can momentarily over-boost, the “O” value stops this from happening.

For both O & D, higher values increase their action and 0 takes their action away completely.

LAMBDA L3 ON: The ECU uses 3 different kinds of auto-tuning schemes to alter the fuel delivery curve to ensure the car operates at the proper air/fuel ratio at all times. All three types are described below.

> **COARSE TUNING:** occurs when the ZONEF window is selected on the keypad and LAMBDA is turned on. During coarse tuning the ECU samples the O2 sensor voltage very rapidly and adjusts the fuel correction numbers accordingly. The samples are taken anywhere in the operating zone in order to make tuning go quickly at the expense of accuracy. This is the first step in tuning the fuel.
>
> **FINE TUNING:** occurs in the STORE window, and in the RPM window when L3 tuning is turned off. During fine tuning the ECU samples the O2 sensor less rapidly and averages the readings together giving more accurate values. Here the adjustments are small and occur within 100RPM and within 10kPa of the zone center to adjust the fuel zones as accurately as possible. This is the second step in tuning the ECU. Tuning only the exact zone centers ensures excellent interpolation.
>
> The two types of tuning above get performed only in rows 1, 2, & 3 once after installing a new chip. These values are saved and then they do not have to be performed again.

L3 TUNING: This third type of tuning is used strictly for day-to-day driving. L3 tuning occurs in all windows on the keypad except STORE and ZONEF and alters the MASTER FUEL delivery to the engine, based upon readings from the O2 and intake air temperature sensors, to compensate for temperature and/or humidity differences from day-to-day. The function of this feature can be seen in the RPM window. The number in the center indicates the amount of compensation. The range goes from 1-9 with 5 being no compensation. Lower numbers indicate less fuel; higher numbers indicate more fuel.

At high engine loads (row 4 and higher) L3 switches to open loop. The average fuel correction factor recorded over the previous two minutes of closed-loop operation is applied along with air temperature compensation during the open-loop period. This mode eliminates the effects of O2 sensor signal changes caused by variations in EGT under boost, and is the mode of operation used in most OEM turbo cars.

Here is another way to describe L3 mode. After performing fine and coarse tuning, the fueling numbers now mirror the volumetric efficiency requirements of the engine. The shape of this curve stays constant, so if one of the fuel zones needs more or less fuel under given conditions, then all of the fuel zones would need about the same correction. L3 shifts MASTER FUEL (the overall fuel delivery to the engine) up or down to satisfy the requirements of the O2 sensor. L3 does your daily housekeeping type tuning.

When in the LAMBDA screen, to turn L3 on press adjust up. To turn L3 off press adjust down. To turn on coarse and fine tuning press edit up. To turn off coarse and fine tuning press edit down. We recommend leaving all three tuning modes on all the time after finishing the fine tuning process.

QINJ ON/OFF AUX = XXX: On 1.6L cars only. Normally, 1.6L cars fire their injectors in pairs with the exception of 1993 California cars. When this screen is turned off the injectors fire in pairs just like a stock ECU. When this is turned on the fuel injectors will fire sequentially up to 22% duty cycle where they switch to batch firing. California cars need this feature turned on to run properly. On all other cars the stock wire harness will need to be modified to allow sequential injection. This does require rewiring of the injector harness in all 1.6L cars outside California. Details for this installation are outlined in the 1.6L installation manual.

We recommend making this modification to non-California cars. The car will get better fuel mileage on the highway and have crisper throttle response at low engine loads. If the fuel has been tuned for paired injection it will need to be retuned after switching to sequential injection.

The auxiliary input is displayed on the right side of this screen.

RELOAD: Used during the initial setup to transfer the default data table into the ECU's permanent memory. RELOAD fills the ECU memory with the default settings from one of the following tables.

Turbo 1	Turbo defaults
Turbo 2	Turbo defaults with lower ignition timing values
N/A OEM INJ	Defaults for N/A stock injectors
N/A Big INJ	Defaults for N/A 440 or 550 injectors (1.6 or 1.8)

The different defaults are selected by pressing and holding a combination of the edit buttons that displays the desired title in the window. While holding the edit button(s) down, press and hold both adjust buttons until the window fills with asterisks. The new defaults are now loaded in the ECU. Any changes made before the reload will be lost.

EDIT: Enables the zone editor menu, which allows access to all zones for viewing and editing. The EDIT function may be used at any time, with or without the engine running. Use the edit buttons to select the appropriate zones and the adjust buttons to change the selected zone. The zones are identified by a number, which may be correlated to its function by consulting the zone sheet. ZONE FUEL and ZONE IGN are identified by an “f” or “i” respectively to discriminate between fuel and ignition values.

> Storing edited values may be done by pressing both edit buttons together until display shows a row of asterisks and then releasing. This method of storing works only when in the Edit menu. Alternatively, STORE may be selected and used as normal.

MODE: (Z5) This number corresponds to 8 different bit flag settings. They have no user functions. **Do not change this setting**.

CHOKE SCALE: (Z6) Cold start fuel enrichment after starting. A higher number delivers more fuel. This value appears in the CSTART window next to the “f”.

VOLTS: (Z7) Battery voltage correction factor used to compensate for heavy electrical loads. As the battery voltage drops, injector duty cycle drops, leaning out the mixture. The default value works well, do not change it.

RUN IAC: (Z18) Duty cycle of the IAC valve after the car has been running for 10 seconds. Z18 will change as necessary, between Z19 and Z18, to keep the idle steady. Z18 should always be set 4 to 6 points lower then Z19.

START IAC: (Z19) Default duty cycle of the IAC valve for the first 10 seconds after start up. Set Z19 to run the engine at a higher idle speed during warm up. Z19 should always be set 4 to 6 points higher than Z18.

ACCEL FUEL: (Z22-Z25) Simulates the accelerator pump on a carburetor by increasing the amount of fuel upon sudden throttle opening. The zones affect the following RPM ranges:

Z22 0 to 2000 RPM	Z23 2001 to 4000 RPM
Z24 4001 to 6000 RPM	Z25 6001 to 8000 RPM

LAMBDA TARGETS: (Z26-31) Target O2 sensor output used during closed loop, LAMBDA ON, operation. The ECU adjusts the fuel delivery in each fuel zone to reach these values of O2 sensor richness. The ECU shares both Z26 and Z27 for the O2 target depending on engine RPM.

Z26 row 1&2 O2 sensor target = 76	Z29 row 4 O2 sensor target = 88
Z27 row 1&2 O2 sensor target = 77	Z30 row 5 O2 sensor target = 90
Z28 row 3 O2 sensor target = 80	Z31 row 6 O2 sensor target = 91

MAP HYSTERESIS: (Z700) Dead band of MAP signal to ensure a smooth transition between acceleration and deceleration. The default value of 3 works well for most applications.

CHOKE DECAY TIME: (Z710) The amount of time, in engine revolutions, the additional fuel added in the CSTART window will take to decay one point. The rate of decay will be faster if the O2 sensor reads over 114.

PRIME FACTOR: (Z715) All 4 fuel injectors will squirt fuel when the key is turned on. If the car is hard to start in cold weather increase this value to 65.

LAST ATMOSPHERIC PRESSURE: (Z720) The ECU uses the current atmospheric pressure to control the wastegate and it measures this value every time the car is started. If the ECU does not get the chance to measure the ambient atmospheric pressure (the car is started too quickly) the ECU uses the value in Z720 which is the last good measurement.

PRIME DELAY: (Z835) On 1.8L cars, controls the time delay between key on and the shot of prime fuel injected in to the engine from all four cylinders.

BOOST HYSTERESIS: (Z840) The value of change in manifold pressure that will trigger a one half WG SNS spike to lower the manifold pressure. For example, with a boost target of 180kPa, and Z840 set to 15, the manifold pressure would need to spike to 195kPa before the ECU would halve the wastegate duty cycle to lower the boost.

BOOST RISE RATE WEIGHT: (Z845) Controls the influence the boost rise rate has on the wastegate control compared to the current boost level. Lower numbers will make the boost rise slower. This setting is very helpful with ball bearing turbos.

IAC INTEGRATION FACTOR: (Z855) Controls the reaction speed of the Idle Air Control valve. Lower values make the valve respond faster and higher values make it respond slower. As the IAC valve ages the reaction time needs to be altered to maintain a steady idle speed. The default value of 25 works well for most cars. Supercharged cars may benefit from increasing this value to the 35 to 50 range.

IDLE MAP	MASTER FUEL	REV LIMIT	MAP LIMIT	AIR TEMP LIMIT	MODE	CHOKE FUEL	VOLTAGE COMP	IDLE SET POINT	FAN ON	TPS		Wastegate			
										LOW	HIGH	WG SNS	KNOCK	WG BASE	WG RPM
Z0	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9	Z10	Z11	Z12	Z13	Z14	Z15

COLD ENRICH	HOT RESTART	RUNNING IAC	START IAC	AC IDLE IAC	IGNITION OFFSET	Acceleration				Lambda Targets					
						0-2K	2K-4K	4K-6K	6K-8K	ROW1	ROW2	POW3	ROW4	ROW5	ROW6
Z16	Z17	Z18	Z19	Z20	Z21	Z22	Z23	Z24	Z25	Z26	Z27	Z28	Z29	Z30	Z31

Fuel Zones

kPa	**0**	**500**	**1000**	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**5500**	**6000**	**6500**	**7000**	**7500**
40	Zf100	Zf105	Zf110	Zf115	Zf120	Zf125	Zf130	Zf135	Zf140	Zf145	Zf150	Zf155	Zf160	Zf165	Zf170	Zf175
80	Zf200	Zf205	Zf210	Zf215	Zf220	Zf225	Zf230	Zf235	Zf240	Zf245	Zf250	Zf255	Zf260	Zf265	Zf270	Zf275
120	Zf300	Zf305	Zf310	Zf315	Zf320	Zf325	Zf330	Zf335	Zf340	Zf345	Zf350	Zf355	Zf360	Zf365	Zf370	Zf375
160	Zf400	Zf405	Zf410	Zf415	Zf420	Zf425	Zf430	Zf435	Zf440	Zf445	Zf450	Zf455	Zf460	Zf465	Zf470	Zf475
200	Zf500	Zf505	Zf510	Zf515	Zf520	Zf525	Zf530	Zf535	Zf540	Zf545	Zf550	Zf555	Zf560	Zf565	Zf570	Zf575
254	WGLG UP	WGLG DN	Zf610	Zf615	Zf620	Zf625	Zf630	Zf635	Zf640	Zf645	Zf650	Zf655	Zf660	Zf665	Zf670	Zf675

Ignition Zones (values shown in 1/4 degrees)

kPa	**0**	**500**	**1000**	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500**	**5000**	**5500**	**6000**	**6500**	**7000**	**7500**
40	Zi100	Zi105	Zi110	Zi115	Zi120	Zi125	Zi130	Zi135	Zi140	Zi145	Zi150	Zi155	Zi160	Zi165	Zi170	Zi175
80	Zi200	Zi205	Zi210	Zi215	Zi220	Zi225	Zi230	Zi235	Zi240	Zi245	Zi250	Zi255	Zi260	Zi265	Zi270	Zi275
120	Zi300	Zi305	Zi310	Zi315	Zi320	Zi325	Zi330	Zi335	Zi340	Zi345	Zi350	Zi355	Zi360	Zi365	Zi370	Zi375
160	Zi400	Zi405	Zi410	Zi415	Zi420	Zi425	Zi430	Zi435	Zi440	Zi445	Zi450	Zi455	Zi460	Zi465	Zi470	Zi475
200	Zi500	Zi505	Zi510	Zi515	Zi520	Zi525	Zi530	Zi535	Zi540	Zi545	Zi550	Zi555	Zi560	Zi565	Zi570	Zi575
254	WGSP O	WGSP D	Zi610	Zi615	Zi620	Zi625	Zi630	Zi635	Zi640	Zi645	Zi650	Zi655	Zi660	Zi665	Zi670	Zi675

MAP HYSTER.	RPM LIMIT	CHOKE DECAY	PRIME FACTOR	MIN. AIR PRES	Boost Targets										
					2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500
Z700	Z705	Z710	Z715	Z720	Z725	Z730	Z735	Z740	Z745	Z750	Z755	Z760	Z765	Z770	Z775

							PRIME DELAY	BOOST HYSTER	BOOST RRW	DECEL FUEL	IAC INTEG	FUEL SLOPE		IG RETARD	
												RICH	LEAN	TEMP	RATE
Z800	Z805	Z810	Z815	Z820	Z825	Z830	Z835	Z840	Z845	Z850	Z855	Z860	Z865	Z870	Z875

Section 9: Datalogging

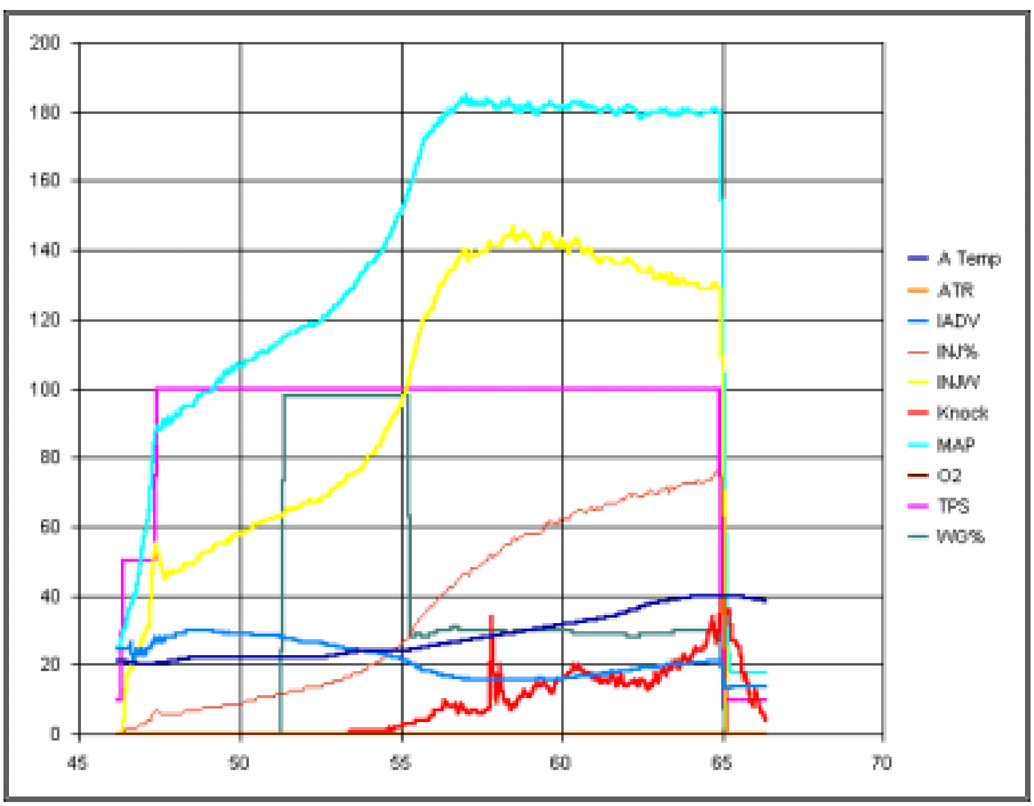
One of the best features of the Flyin' Miata ECU is the ability to data log almost all of its operating parameters from the ECU into a laptop computer, using the Serial Link interface. The Serial Link plugs into the ribbon cable in place of the keypad, then connects to the serial port of a laptop using a straight 9-pin serial cable.

Our data logging software, Data Link Lab, runs on any Pentium PC running Windows 95 or higher. The software is available for free download from the DLL web site www.dataloglab.com.   The program can be used for 30 days, then a licence needs to be purchased from Flyin' Miata to continue using DLL.

All the graphs in this manual were generated with DLL. It is a very powerful tool for recording data from the vehicle while it is driven. After the data is analyzed, changes can be made to the settings and they can be uploaded into the ECU. DLL is not a replacement for the keypad, but it offers the ability to view many different data points simultaneously. We highly recommend it for the serious tuner.

Note: We at FM are happy to assist with tuning. Simply e-mail the .txt file from a data log to tech@flyinmiata.com and we will help you make improvements to your settings.

All information about installing, setting up and using DLL can be found at the DLL web site. www.dataloglab.com



Typical DLL graph on a turbocharged Miata

Section 10: Advanced Fuel Tuning

As stated in section 4, the default fuel values for the boosted rows (400,500,600) are good for making power and are safe from knock for most users. However, there are plenty of variables that could allow a particular car, or set up, to make more power with fuel tuning beyond the defaults. In all cases (except the note below) Data Log Lab (DLL) should be used to properly analyze fueling data.

> **Note:** On cars running Vishnu fuel rails the fuel numbers in the 400 row should be lowered by 8 points. Fuel numbers in the 500 and 600 rows should be lowered by 10 points.

Tuning with a wide band O2 sensor

Ideally, fuel tuning should be performed with a wide band O2 (WBO2) sensor because of its greater accuracy over wider Air/Fuel (A/F) ratios and Exhaust Gas Temperatures (EGT). One way of tuning the fuel is to use a chassis dyno with a WBO2 sensor. The Dyno will record the A/F during a full throttle run. After the run, the fuel numbers in the Zf table can be altered to address any rich or lean spots. Because the fuel zones interpolate between each other, fuel tuning is best performed at the pressure center of each row. Below is a table showing the centers of each row and the desired A/F ratio.

Row	400	500	600
Center	140kPA	180kPa	220kPa
Desired A/F	12.5:1	12.0:1	11.5:1

> **Note:** WBO2 sensors must be located in the downpipe before the catalytic converter. Current downpipes used in Flyin' Miata turbo kits have a second O2 sensor fitting welded into the pipe before the catalytic converter just for mounting a WBO2 sensor. You are welcome. Do not try to tune a car with a WBO2 sensor after the catalytic converter because the cat removes the gasses we are trying to measure.

In the past, WBO2 sensors cost several thousand dollars and required electronic packages to run them properly. In the last few years their proliferation into OEM applications has lowered their prices to a few hundred dollars. A WBO2 sensor still requires its own stand-alone electronics package to function, but the installation of a WBO2 sensor is now within the ability for the average enthusiast to install in a car.

Data logging with a wide band O2 sensor

The FM ECU has the ability to accept the analog output signal from a wide band O2 sensor. This means a car can be tuned under boost on the road using the ECU's closed loop tuning ability to fine tune the fuel delivery in the boosted rows (400, 500, 600). Here is how it is done.

> 1) On 1.8L cars, the EGR function will need to be turned off. This is done in the TPS screen. While pressing both Select buttons, press the Edit down button to turn off the EGR. Pressing the Edit up button turns EGR back on.

2) In the INJ/O2 screen choose either the OEM O2 sensor or the WBO2 sensor. While pressing both Adjust buttons press the Edit up button for the WBO2 sensor or Edit down for the OEM (4-wire) sensor.

3) The reading on the far right in the INJ/O2 screen will now be the voltage from the WBO2 sensor multiplied by 25.6 then subtracted from 128. Here is the equation: WBO2 = 128 - (WBvoltage * 25.6)

4) All the O2 sensor targets will need to be changed to reflect the desired A/F from the WBO2 sensor. For each row the new target will be calculated with the same equation as above. See page 30 for the location of the O2 targets

5) On 1.6L ECUs the WBO2 signal input is on terminal 2P. The Red/Green wire in 2P is the ground for the fuel pump, move it over to 2R. Cut the jumper on the circuit board connecting 2P to 2R. Run a new wire from the analog output on the control box for the WBO2 sensor to the input on the FM ECU in termianl 2P.

6) On 1.8L ECUs the WBO signal input is on terminal 2J. This is the EGR position signal, that is why the EGR function must be turned off in order to use the WBO2 input. Cut this Green/Red wire and connect it to the analog output of the WBO2 sensor control box.

Tuning without a WBO2 sensor

While using a WBO2 sensor is the best for fuel tuning it is not the only way to do it. Fuel delivery can be tuned using fuel injector pulse width and the knock sensor. Experimentation has shown that most cars running 180kPa of boost will need the fuel injector on time to be between 120ms and 140ms, higher times for lower octane fuel to keep knock away. By making repeated runs on the same stretch of road with similar atmospheric conditions, the fuel delivery can be raised and lowered while monitoring the knock sensor. The goal is to run as little fuel as possible while advancing the ignition timing as much as possible without having the engine knock. DLL’s power graph function can be used to measure the results of fuel and ignition timing changes.

There are limits to these settings. Ignition timing should not be advanced past 20* between 3500RPM and 6000RPM in rows 500 and 600. The minimum fuel injector on time should be 110ms when operating at 180kPa or higher.

Section 11: Miscellaneous

Check engine light

In some areas, emissions testing requires that the Check Engine Light (CEL) illuminates when the key is turned on. The Link ECU does not do this, but a simple modification can be made to the wire harness to illuminate the CEL.

Remove the glove compartment. In the cavity for the glove compartment there is a white electrical connector off the right. In this connector is a Yellow/Black wire and a White/Black wire. Connect these two wires together. The easy way to do this is to use a modified Quick splice connector to jump the two wires together. Now the CEL will illuminate when the ignition key is turned to the on position.

O2 sensor voltages

The table below shows the linearized O2 sensor output from the FM ECU. The first column is the tens digit of the O2 sensor voltage. The top row is the hundreds digit of the O2 sensor voltage. The value in the corresponding cell is the FM ECUs value for the O2 sensor voltage, i.e. .76 = 80.

	0.00	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**
0.0	0	30	60	70	72	73	74	75	75	76
0.1	76	76	76	76	76	76	76	76	76	76
0.2	76	76	76	76	76	76	76	76	76	76
0.3	76	76	76	76	76	76	76	77	77	77
0.4	77	77	77	77	77	77	77	77	77	77
0.5	77	77	77	77	77	77	77	77	77	77
0.6	77	77	77	77	77	77	77	77	77	78
0.7	78	78	78	78	79	79	80	80	81	82
0.8	83	84	85	86	87	88	89	91	93	96
0.9	99	102	106	110	114	121	126	133	140	147

Shift light or VICS control

The output from the ECU to control the boost solenoid can be used to trigger a shift light or control the VICS flappers in a ‘99 to ‘00 engine. On a turbo installation, the ECU’s boost control functions will be lost.

Disable the boost controls by setting **BOOST TGT** to 255. The signal on the Green/Yellow wire in the diagnostics connector will go to ground when the engine RPM exceed Z15 **WGRPM.**

Section 12: Solutions to Typical Problems

1) The motor stumbles and mis-fires under boost.

Engine mis-fires under boost can be caused by a few different things. Check these items in the following order.

a) Check the condition of the spark plugs and wires. Mis-fires are most often caused by an ignition system deficit. Spark plug gap can be run as high as .040” on the current software. The gap can be reduced to .030” to reduce mis-fires.

b) Lean out the fuel delivery in the corresponding fuel row. Too much fuel can cause a misfire. The default fuel values are on the rich side. Cars running 93 octane or higher fuel can run with lower fuel values under boost. Make small changes 4-6 points of fuel at a time and check for knock.

c) Swap in a different set of known working ignition coils. In some cases the ignition coils weaken and can no longer ignite the air/fuel mixture.

2) After setting up the boost controls the system begins to over or under boost.

Look for a mechanical problem like:

a) The air hoses going to and from the boost control solenoid are either disconnected or have a crack or hole in them. If the air hoses are damaged and leak the ECU will not be able to control the boost properly.

b) Check the intercooler pipe hose clamps for tightness. A clamp could look and feel tight, but under boost it could leak out enough air to keep the system from making full boost.

3) The car lurches when the throttle is opened and closed.

The IDLE MAP setting also controls the manifold pressure value when the fuel injectors are cut off. If IDLE MAP is set too high the car will get this lurching feeling. Lower IDLE MAP one point at a time until the feeling goes away.