Flyin' Miata

Installation and setup instructions for the Hydra Nemesis 2.7 ECU

Tech line 970-464-5600

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Contents

WARNINGS!

Modifying your vehicle can be very rewarding, but it also has the potential of leading to financial and emotional distress. The Hydra Nemesis ECU is no different- standalone engine management tuning is serious business! If you are not qualified to tune your vehicle, PLEASE seek out the assistance of a professional. The tech staff at FM will be happy to help as much as we can with installation and tuning via phone and email, but there are still a number of things that have to be understood & done in person by you or a qualified professional. FM's base maps are good, but it is impossible to account for every variable there is. With that in mind, neither Flyin' Miata nor Hydra EMS will be held responsible for the results of bad tuning or bad luck on the part of the end user. Also, when street tuning, use either a co-pilot or the datalog feature in your laptop in order to make safe tuning changes. Please do not drive and tune at the same time! We of course recommend dyno tuning for the best and safest results.

The Hydra ECU will not return OBD-II codes and is not CARB legal. The end user is responsible for determining if this system is legal for use on public roads in their state. By installing the Hydra EMS in your car you acknowledge and understand the aforementioned guidelines & recommendations.

Basic Info About the Hydra Nemesis Engine Management System

Congratulations on your purchase of the Hydra Nemesis EMS! This full standalone engine management system will allow you to tune your **90-05** Mazda Miata to its maximum potential. It incorporates tuning tools that assist in developing the best engine management map for your system, and also includes safety features that protect the engine from certain adverse situations. It will allow you to datalog and store map files using a laptop computer, which can then be used for tuning. This manual is specifically for Hydra Miata installation & setup. **Please read and learn this information for maximum insight on how to operate this system. The knowledge it contains will be integral to your success and/or the success of your tuner.** We recommend spending time perusing the Hydra software while offline to become familiar with the interface & where things are. Also know that you should always download the latest 2.7 software, firmware, and tuning tips from Hydra at http://hydraems.com/software/.

Parts List. The FM Hydra EMS system comes with the ECU box, an adaptor harness to interface the unit with your factory wiring, a serial cable for connecting the Hydra to your laptop computer, a vacuum hose for sourcing the manifold absolute pressure (MAP) signal, a NTK lab-grade wideband oxygen sensor (WBO2), an air temp sensor (except MSM, optional), a mounting clip for the ECU, and a CD with the software suite and Hydra main manual (not yet available for 2.7). **90-97** cars will also come with a knock sensor (**99-05** Miatas have one from the factory). Optional items you may have or need to purchase are a Serial -> USB converter cable (FTDI chipset) for those who only have a USB port on their PC, larger fuel injectors if you are running more horsepower than your stock injectors can handle, and an electronic boost control solenoid or a manual boost controller for turbo cars. *Note- Contact FM for recommendations on spark plug heat range and gap. We recommend Magnecor wires and NGK plugs for all applications.*

Installing the Hydra Nemesis Engine Control Unit

Location. Start by disconnecting the negative battery terminal. Then, locate the stock ECU. On U.S. spec vehicles it is: under the dash by the steering column on **99-05** cars; behind the passenger seat on **94-97** cars; and under the passenger's kick panel on **90-93** cars. Unplug the factory harness connectors. For **90-97** cars the Hydra will sit in the location that the factory ECU occupied using the supplied clip, so you'll need to remove the stock ECU. For **99-05** cars take the adaptor harness and run it under the dash (above the transmission tunnel) such that the single connector end is on the driver's side and the three connector end is on the passenger's side. Then you'll mount the Hydra behind the glove box with the supplied bracket: on **99-00** cars the bracket mounts to a 6mm stud at the bottom, while on **01-05** cars it mounts to a 6mm stud at the top. To remove the glove box on the **99-05**, open it and pull the right side towards the rear of the car. Once the right side pops out the left side will slide out.

Next (for **all cars**) plug the stock harness ends into the adaptor harness plug. Attach the serial cable and run it out somewhere where it can be stashed normally but accessed for tuning. Leave the 3 plug side of the adaptor harness be for now- you'll have to pin in the WBO2 wires which will be described later. Attach the MAP sensor hose to the barb on the Hydra and run it out to an appropriate signal source (vacuum nipple) on the intake manifold plenum. **The**

source must be between the throttle body and head when looking at the direction of airflow- this way the Hydra will see both vacuum and boost. This means **no** check valves inline! In fact, we don't recommend sharing this MAP hose with anything other than a boost gauge. ***Note- This is the most important hose on the car!*** *A failure, a leak, or a pinch here can cause poor running and possibly major engine damage. Please maintain this hose accordingly!* Also, on **99-05** intake manifolds there's at least one nipple that does not see vacuum & boost, so be sure to verify that the Hydra sees both vacuum & boost when you first drive the car. (In the software "Dashboard" make sure that the Load values are appropriate for your throttle inputs.)

MAF Removal. Because the Hydra uses an internal MAP sensor you can optionally eliminate the factory mass air flow sensor on **94-05** cars (MAF) or the air flow meter on **90-93** cars (AFM) which imposes a restriction on your intake system. This sensor is located at the outlet of the factory air cleaner assembly. Remove this sensor if you want to increase the flow potential of your intake. If the removal of this unit creates a void that needs to be filled in your intake system, you will need to fabricate or purchase a pipe to take its place. *Our FM2 turbo kits include a stainless steel delete pipe for the* **94-05** *MAF.* The section of harness that went to the MAF can be tied back out of the way- it is no longer used. You will want to tape the end up to prevent a short since at least one wire is hot.

Upgrading from a Piggyback (optional). If you are upgrading to the Hydra from some other brand of engine management, you will first need to remove everything associated with that system and return the car in effect to stock. This will make the Hydra installation much more straightforward.

Air Temp Sensor. The supplied Hydra air temp sensor will need to be mounted and wired in. *(Except for* **04-05 MSM** *cars that are using the factory turbo setup and FM MSM intake- they can reuse the stock sensor. However, the Hydra ATS is more responsive than the* **MSM** *unit so it may be worth a few more bucks to you if you can fabricate around the fact that they use a different thread pitch. the* **MSM** *unit is M10x1.25.)* FM turbo kits include a bung for the sensor; other systems will require you to fabricate a 3/8 NPT bung to mount the Hydra ATS. *Note- With* **99-05** *cars you could alternatively remove the upper intake manifold and drill / tap the hole in it.*

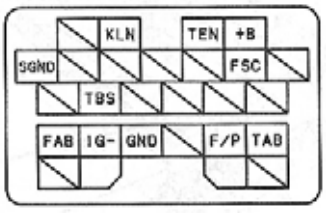
The Hydra ATS comes with a plug & pigtail that must be wired in. For wiring on the **99-05** Miata (**except MSM**) you will be using the two wires that go to the factory air temp sensor which was mounted in the stock airbox. Remove these wires and splice them into the connector that is provided with the new sensor. *Note- if you may need to revert back to stock in the future, use spade connectors here to make the swap easier. The* **99-05** *cars running on a stock ECU may not charge the battery without the factory ATS connected.* If you have a **MSM** & choose to upgrade, the ATS that is mounted in the throttle body inlet pipe is already wired through the harness to the Hydra, so you'll use these two wires for the Hydra ATS. (The other ATS in the **MSM** stock airbox needs to be secured out of the way and is not used.) **90-97** cars will require one wire from the supplied ATS run to chassis ground and the other wire to be connected to the power steering pump wire that runs across the front of the engine- it is blue

with a yellow stripe and has a female bullet connector at the end. Remove the wire from the PS pump and connect it to the ATS lead. If your car does not have this wire, you will need to run a flying lead back to BD9 in the Hydra harness (Large blue, bottom row, position 9).

Fuel Injectors (optional). The factory fuel injectors will support up to around 200 rwhp on **99-05** cars and around 160 rwhp on **90-97** cars, give or take, based on octane, induction type, and tuning. The Hydra can control both high impedance (saturated) and low impedance (peak and hold) injectors with a change to the table at 2D Engine Calibration -> Injector Response. This injector dead-time compensation is unique to different types of injector, and will affect starting, idle, and high vacuum cruising fuel values. FM will program the base map for your injectors, so it is important that we know what you are using. We will have the best calibrations for the injectors we stock. Contact us if you have questions on what injector will best suit your needs- we offer many different types. One other thing to consider is that if you plan on running E85 you'll need injectors that are 40-50% larger for the same HP level.

To install the injectors on a **99-05** Miata you will need to remove the upper portion of your intake manifold (including the throttle body) and your fuel rail. For the **90-97** Miatas, you will just need to remove the fuel rail and the hoses/ solenoids that are in the way. Some injectors are plug-in, some come with an adaptor harness. *(BTW, solenoids & injectors are non-polar.) Note- After installing fuel injectors make sure to check for fuel leaks **immediately** after starting the car for the first time!* Remember to use a light coating of oil on the upper O-ring before pushing the injector into the rail to avoid a pinch. Also, cleaning out the lower seat area can prevent vacuum leaks on a fresh install. Be careful not not drop any debris into the engine through the holes while they are exposed!

Boost Control Solenoid (optional). If you are adding a Boost Control Solenoid it will need to be wired in and mounted. You will want to mount it on the frame of the car by the shock tower so the signal lines to the turbo will be short. On FMII cars, the air baffle is a convenient location and holes are provided. On **MSM**s, you may want to fabricate a spot on the plastic baffle behind the driver's side headlight that holds a couple relays. The boost control solenoid has two wires (which are non-polar). One wire will go to a B+ (12v) source. The best place to get this is to T tap into the power wire in the diagnostics box located right in that area. Access the wires as they come out of the bottom of the box. In **90-97** Miatas it is the white wire with the red stripe. In **99-05** Miatas it is the black wire with the white stripe. (Both should be coming from the top right slot if you are looking down at the top of the diagnostics box while standing at the front of the car.) The other wire from the BCS will go to the Hydra where it will be controlled by a switched ground at pin BA5 (Small blue, top row, #5). The Hydra adaptor harness runs this into the factory harness to make it easier to wire up- it leads to the wire that goes to the TEN terminal in the diagnostics box (right next to the B+ wire you already spliced into). Splice the ground wire from the BCS to the following wire (labeled TEN) coming out of the diagnostics connector: **90-97** light green with a yellow stripe, **99-05** brown with a yellow stripe.



***Note-** if you want to have a switched high and low boost setting, install a toggle switch inline on the signal wire so that you can switch from mechanical base boost to electronically controlled*

boost. Your mechanical base boost should be high enough to provide sufficient pre-load on the WG actuator. Your EBC pressure should be no more than around double your mechanical base boost for good control.

The following is the vacuum hose routing for hooking the internal wastegate actuator to the Ingersol Rand FM BCS: attach the post-compressor signal line to the EXH port; the nipple on the wastegate actuator to the OUT port; vent the IN port to atmosphere (or port it back in between your air filter and compressor inlet). These labels are stamped into the BCS housing. *Note- Our FM2 kits come with a Turbosmart manual boost valve that makes boosted life much easier than with EBC.*

Extra Wiring for 1990-93 Cars. On **90-93** cars there are extra wires that need to be run.

1) You can run the injectors in sequential since all **90-93** cars **except 93 California** cars run batch injection. This is optional, but recommended, and your base map comes set up for sequential injection. *(For the* **93 CA** *cars you can skip this step and ignore the following fuel injector leads since the sequential wiring is already in place within the harness.)* The flying lead from BA7 (small blue, top row, position 7) will be run through the firewall to injector 3. (Injector 1 is at the front of the engine and 4 is at the firewall.) Find the yellow wire going to injector 3 and cut it (leaving a pigtail in case you ever go back to stock). Connect the injector side of this wire to the flying lead from BA7. Next, we will be doing the same thing for injector 4. The flying lead from the Hydra for injector 4 is coming from BC16 (large blue, top row, position 16). Run it out to the yellow wire with a black stripe going to injector 4. Cut the Y/B wire and attach the injector side to the wire going to the Hydra.

2) In order to remove the AFM from the car you will also need to run the flying lead from BA6 in the Hydra harness (small blue, top row, position 6) across the transmission tunnel to the light green wire in the fuel pump relay plug that is under the dash next to the steering column. (See photo) Cut this Lg wire and splice the BA6 lead to the relay so that the Hydra powers the relay.

Note 1- The **90-93** cars have a unique fan / AC fan / AC relationship. The AC fan will not engage unless the AC is on. If you find your car overheating, or if you're doing a track day, unplug the harness from your AC clutch (under the hood) and turn on the AC button in the car- then you'll have both fans. If however your car does not have AC it's relatively easy to re-wire your fan relays so the Hydra can control them independantly, just like in 94-05 cars.

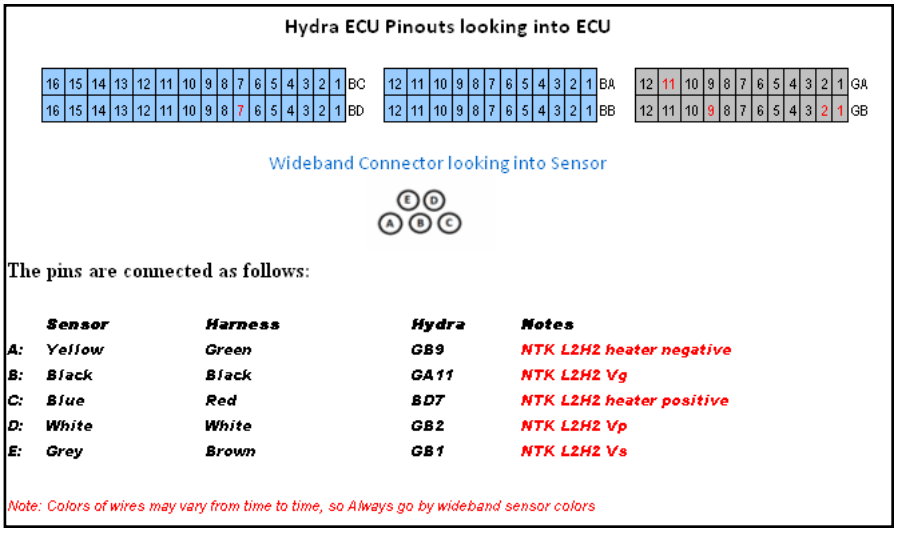
Note 2- 90-93 manual transmission Miatas come with a TPS that's an on/off switch. With the Hydra you can install an automatic linear TPS for better drivability. Contact FM for instructions.

Knock Sensor. On **90-97** cars you will need to install and wire in a knock sensor. (The **99-05** cars have one from the factory and no additional work is required, so you can skip this step.)

The knock sensor itself replaces the upper front mounting bolt on the passenger side motor mount. Remove the 10mm bolt in the upper forward corner of the motor mount. Replace this bolt with the supplied adapter bolt and tighten to 20 ft/lbs. Fasten the knock sensor to the adapter with the supplied 8mm allen bolt. Tighten this bolt to 12 ft/lbs, using Locktite on the threads. **TORQUE CAREFULLY!** Next, there is a long coaxial flying lead that comes out of the Hydra adaptor harness. Run this through the firewall at the main harness port on the passenger side. Once it is through and run down to the knock sensor, attach the 2 wire "injector" plug to it- one end goes to the main inner wire of the coaxial lead, and the other attaches to the shielding after you peel back the insulation and twist the shielding into a rope with your fingers. Finally, plug the harness onto the knock sensor- it will snap in. Use ties to secure the wiring appropriately.

Wideband Oxygen Sensor.

The wires for the Wideband O2 sensor will need to be run, plugged in, and the sensor calibrated. First, run the harness from the ECU location, through the shift boot, to the WBO2 sensor location. Next plug the 5 pinned wires into the appropriate locations in the Hydra harnes plugs. Attach the wires in the following locations by removing the retaining clip and sliding the pins into the appropriate hole until they click in:



Triple check your work here! *Replacement sensors are $240 and the heater element is delicate!* Also, when you insert the pin, make sure that its up/down orientation is the same as the pins around it.

The WBO2 sensor itself now needs to be calibrated and installed. Until that is done, run everything to where it needs to be, but leave the sensor itself in free air and unplugged from the harness. *Note- with a new purchase we will likely calibrate your WBO2 to your ECU here at the shop so you can just install your sensor. If so, we'll let you know.* If you have a FM turbo kit there will be an extra bung for the WBO2 already in place in the downpipe just before the catalytic converter. If you have something else, you will need to weld in a bung- we have them available. Make sure the sensor is as perpendicular as possible so that condensation does not pool in the sensor tip. Also, the WB needs to be after the turbo (or after the collecter on non-turbo cars) and still in front of the catalytic converter. *Note- in* **96-05** *OBD-II Miatas, the rear factory O2 sensor (post-cat) is not wired in with the Hydra. Remove it and plug the hole or it will fail. You can pull the harness plug back through the body, unplug it & stash it under the*

*carpet. You may even be able to run your new WB harness through this hole on **96-97** cars.*

99-05 Engine Swap (optional). If you are using a **99-00** intake manifold in a **90-97** chassis you will have to run the wires for VICS. Locating its solenoid, one post will go to switched 12v and the other needs to go to BA11 (small blue, top row, position 11) in the Hydra harness. If you have a **94-97** car the PRC wires already go to 12v and BA11, however the Hydra doesn't control PRC (hot restart fuel control solenoid) so just run those two wires to the VICS solenoid and you're done. Finally, while online you'll have to go to Settings -> Output Configuration -> BA11 -> Switch -> "RPM" "is less than" "5400". Click Apply & then OK. Now, your VICS will pull to ground & activate when the RPM is less than 5400. *Note- The switchover RPM can be optimized on a dyno. Do one run on, one run off, and set the RPM where the lines cross.* If you are swapping in an **01-05 VVT** head we also have instructions written for wiring this up, contact us for more information as this is much more complicated.

Trim Map Switch (optional). You can set up a trim map switch so that you can make a second map for different octanes or fuel types. Your base fuel, timing, and AFR target tables (for pump gas) are normally active. When you flip the switch, your fuel and timing trim maps will be overlaid onto your respective base maps, and your Aux AFR target map will replace your base AFR target map. *Note- Lambda = 1 is always stoichiometric regardless of fuel type.*

You will need to request a Hydra ECU pin from us, which you will attach to a wire and pin in to the Hydra harness at BC7 (large blue plug, top row, position 7). You will run this wire to a switch, which you will mount wherever works for you. You will run a wire from the other post of the switch to a chassis ground. When the ground breaks at the switch, you will be on your base maps. When the ground has continuity to the Hydra through the switch, your trim maps will be active. (You can monitor any active requests in the bottom of the Hydra PC screen.) Finally, you need to tell the software what to do. Go to Settings -> Input request types. For Auxiliary port 8 select Auxiliary low request and click OK. Now you can tune your Aux map groups as appropriate.

LS3 Coil Conversion (optional). The Miata runs its stock coils in batch (waste spark) ignition. While the factory coils are good for most applications, in high boost cars they can run out of steam. An excellent upgrade in these situations is to upgrade to full sequential ignition using the much stronger individual coils from the GM LS3 engine. FM has a complete kit including coils, brackets, harness, wires, instructions, etc.- see http://www.flyinmiata.com/ for details.

Upgrading from an earlier Hydra.

1999-05 cars, 2.1/ 2.5/ 2.6. The tachometer in the NB Miata is more sensative & we've had to use a different configuration for proper operation w/ 2.7. Without doing this you may lose your tach over ~5K RPM. You will need to follow these instructions to set it up. **1)** In the software go to Settings -> Output configuration -> Inj 6. Under the Simple tab Select "Tach". Click OK, and save your new configuration to your PC. **2)** At the Hydra harness disconnect the large blue plug that attaches to the Hydra ECU. Remove the plastic combs on both sides to access the terminal pins. **3)** Remove the tach wire that is on the top row (thumb tab side), position 12. **4)** Re-pin this wire into the same plug, bottom row, position 10. (This is the output for Inj 6.) **5)**

Procure a 1K (1000) ohm resistor. You'll use the resistor to jumper between the following two wires. This is what we call a "pull-up" resistor. **6)** Attach one end of the resistor to the wire you just moved- bottom row #10. **7)** Attach the other end of the wire to the wire also on the large blue plug, bottom row, position #1. This is B+. **8)** Cover the jumper so it doesn't short out on anything- it is hot! **9)** Re-install the combs on the plug and re-assemble everything. **10)** Start the car, your tach should work properly. *Note- if you prefer, send us your harness & we'll perform the modification for you.*

All years, 2.1/ 2.5. In your Hydra harness there is a diode beween BA2 and BA10 on the top row of the small blue plug. Remove the diode, leave the wires. 2.7 has new A/C & A/C fan functions that negate the need for this diode.

01-05 cars, except MSM. 2.7 no longer runs VVT on a RPM / Load spread map. It now has its own standard map which is covered later in this manual. Your new FM VVT base map will have the new VVT table in it, but it will need to be calibrated as covered later in this manual. It is similar to 2.6 but different from 2.1 or 2.5.

All years & ECUs. The dwell in 2.6 ran a little hotter than in 2.1 & 2.5. We had to reduce the values in the 2.6 Dwell base map ~1 mS across the board to account for this. The jury is still out on the 2.7 dwell, but the base maps are now using the 2.5 numbers successfully. So, if you get load based misfires you may want to go -1mS on your dwell curve & see if that helps. If your dwell output is too hot, you will feel misfires as you rev out to redline while staying in vacuum or boost. If your dwell was too cold, you may only get a misfire in boost.

1990-93, 2.1/ 2.5/ 2.6. Previous generations had a relay embedded in this harness to allow the TPS to function properly, keeping in mind the **90-93** manual trans TPS is an on/off switch. This is no longer needed with 2.7. If you'd like to remove the relay here's how you do it. **1)** Remove the relay. **2)** BC05 at the Hydra now goes to 1N at the factory harness. **3)** BD04 at the Hydra now goes through a 1K resistor & then on to 1N at the factory harness. (Yes, 2 wires in 1N.) **4)** Delete BB08 so it doesn't short out. *Note- if you prefer, send us your harness & we'll perform the modification for you.*

Setting up the ECU

Re-attach the negative battery terminal. After you have completed the hardware installation it is time to perform the initial setup & calibration procedures in the software.

Open Your Map. Load the software package & open it. Connect your Hydra to your PC & click the "connect" button. All Hydras shipped from FM come with your custom base map programmed into the ECU. When you use the Hydra 2.7 software to connect to the ECU it will automatically pull the map from the ECU onto the PC. Any changes in real-time to the map will automatically save to the ECU. (We do recommend saving a current copy of your map to your PC!) *Note- The 2.7 software will auto-range for the correct COM port.* Also, go to Tools -> Experience Level & click "Guru" so that you can see all of the maps. Any map that is not available

at your level will be greyed out, offering you temptation to upgrade. :)

Notes- a) *The base map programmed into your ECU prior to shipping at FM has settings as appropriate for your car. This should get your car going, and may even be really close to optimum. However as all cars are a little different, you are in charge of verifying that the fuelling & timing tables are in fact safe for the type of driving you'll be doing- this is where a professional tuner would be a worthwhile investment.* ***b)*** *When you key on* ***01-05*** *cars after installing the Hydra you will get a "blinky key" light. This is the immobilizer function in the factory ECU. It is not an operational issue- you can simply remove the light bulb from the instrument cluster.* ***c)*** *If you're using a Serial -> USB converter cable & the connetion is twitchy, try a different one with a FTDI chipset- we have them. For best results use a laptop with a Serial port.*

Throttle Position Sensor Calibration. Next, you need to calibrate your Throttle Position Sensor for closed throttle and WOT. Key on but do not start the engine. While connected go to Tools -> Calibrations & follow the prompts. *Note- If you notice your closed throttle values floating after initial calibration you may need to replace your TPS.*

WBO2 Calibration. While in the Tools -> Calibrations screen you'll also calibrate the wideband O2 sensor. If your battery is not between 12.5-14.5v with the key on you may want to hook a charger up while doing this- Miata batteries are weak, and the WB heater circuit needs a lot of juice to make full temp. However, if the voltage goes over 14.8 the heater circuit will shut down & it also won't calibrate properly. *Note- new Hydra kits from FM now have your WBO2 calibrated to your ECU before we ship the kit to you. So, if we indicate that this has been done at the shop, you can skip this step & install your WBO2 sensor.*

For the UEGO Zero cal you'll leave the WBO2 unplugged. For the UEGO Gradient cal you'll plug the sensor in but leave it hanging in free-air. *Note- a) When setting Zero cal, the relationship is actually inverse. b) During gradient calibration the sensor will get very hot- so be careful!* When these steps are complete you can save your calibrated base map & then remove the key from the ignition. Install the WBO2 sensor in the exhaust pipe once it has cooled down. *Note- as the sensor ages it is a good idea to repeat the free air calibration procedure. You can easily check to see if it is off- your AFR (WBO2) should read around 14.7 when your O2 (NBO2) left bank is dithering between 0-1 (assuming the front NBO2 is still in the car).*

Hint- as you make alterations it is a good idea to save the files to your PC so you have a running log of changes. This way, if a map error occurs you always have a place to go back to. If an * appears at the end of your file name at the top of your screen, there are changes in the ECU that have not been saved to your PC map file.

Switching from WBO2 to NBO2. The base map comes set up for the Wideband O2 sensor. (linear 0-5v, 5 wire) We do recommend leaving your factory primary narrowband O2 sensor (non-linear, 0-1v, 1 or 4 wire) installed so you can **a)** reality check the WBO2 calibration since the NB will only effectively tell you stoichiometric (14.7 for gasoline) or **b)** switch back to the NB if the WB dies. (NBO2s are technically better for stoich & emissions testing.) The sensor type can be changed by going to Tuning maps -> AFR target table -> Settings. The Miata application only uses the left module.

Note- *the only times you would run Open Loop (no O2 sensor feedback at all) are* ***a)*** *if you had a failed O2 sensor causing the car to run poorly,* ***b)*** *if you are dyno tuning and want to see your A/F ratios and injector pulsewidth straight as they are in the map without any O2 closed loop trim applied, or* ***c)*** *if you have a well tuned track-only race car.*

Initial ECU Tuning

Fuel. Start the car and let it idle. Once it is warmed up, if it is obviously rich (spitting) or obviously lean (hunting or stalling) you'll want to make an initial adjustment to the idle fuel areas (Tuning maps -> Base Fuel Table) to get it smoothed out so that you can set the idle speed & base timing. The base map that you were provided is based on cars tuned at FM with similar setups to yours, so it should get you going. You will need to determine if your fuelling is in the ballpark with good drivability so that the autotuning (Long Term Trim) can start working. If it is not close enough you will need to manually set up your fuel values such that the car is safely drivable before letting closed loop autotuning do its thing. If you have a custom setup, your mapping should be pretty close assuming that we knew about it before we shipped you the ECU. FWIW, if you're using a fuel injector that we sell you will have a lot less work to do here than if you're using some other injector that we don't have a tuned map for. *Note- you can select multiple cells by holding down the Shift key while arrowing around, and you can apply math to selected cells by hitting the / key. Standard Windows keystrokes such as Ctrl A, X, C, V also work in your 2D & 3D maps. We've requested from Hydra a primer on their shortcut keys to be included in their "2.7 Tuning Tips" webpage.*

Idle Speed. Once the car is warned up & idling smoothly you may need to adjust your idle speed. You'll find the controls under Tuning maps -> Base idle speed target -> & settings, and also more advanced mapping under Tuning maps -> Idle speed control. The only mechanical control you have here is the idle air bypass screw in the sheath on the side of your throttle body. For troubleshooting, if rotating that bypass screw in does not reduce a high idle, and your ISC % is bottoming out, the car most likely has a vacuum leak that you'll need to fix before proceeding. (You can also test your ISC motor to see if it's working by unplugging it & seeing if the idle speed changes.) **Hydra has written a technical primer on 2.7 ISC which can be found on their website under 2.7 Tuning Tips.** http://hydraems.com/nemesis27page/software/ Realistically, the map settings are pretty close. We recommend starting out by warming up the car, turning electrical loads off, and rotating the mechanical bypass screw on the side of the throttle body until your ISC% as seen in the Hydra real-time display is in the ~30% range. Make sure to do this to calibrate your ISC before thinking about making adjustments to the ISC mapping in the Hydra.

Base Timing. Once the car is idling smoothly with a reasonable AFR you'll need to set the base timing- that way what the ECU says for timing advance and what the car is actually doing are the same thing. We have seen some base timing variance when just strapping the Hydra onto a stock car, so this step must be done on **90-97** cars & should be done on **99-05** cars. Setting the base timing will require a timing light. With the car running and at a smooth idle, look at the top of the real-time number display on the right of the home screen. The box la-

beled "Advance" is your ignition advance output in degrees, according to the ECU. This value is determined by taking the value from the ignition map and applying to it any ignition trims. (see Tools -> Ignition advance trims) Next, under the hood of the car hook a timing light up to the #1 plug wire and flash the light at the timing marker (around 1-2 o'clock) on the main (crank) pulley. What we want to see is the following: the timing marker on the pulley lines up with the value on the backing plate that corresponds to the displayed ADV reading, in real-time. If it does not you will need to adjust your base timing.

For example- if the value in ADV is 10, it makes the procedure easy. If your main pulley has one timing notch (**90-93**), we want this notch to line up with the "10" on the backing plate. If your main pulley has two timing notches (**94-05**), you want the "driver's right" side notch to line up with the "10" on the backing plate. (Always ignore the "driver's left" side notch.) If the value in ADV is more or less than 10 you will use the idea behind the procedure in the last sentence while making sure the backing plate marker value that you line the correct timing notch up with is the same as the value you see in the ADV screen. *Note- each notch on the backing plate is 2 degrees!* Therefore, if the real-time ADV value says 12, line the appropriate timing notch up to the notch on the backing plate one "driver's right" of the 10 marker. If it says 9, line it up in-between the 10 and the next notch to the "driver's left". The following explains how to do this in the software. *Note- If you have an ATI damper you'll use the timing marker that's farthest to the driver's right side. It's slightly removed from the grouping of other notches.*

Adjustments to your base timing will be made in the Timing Reference Angle box under Settings -> Ignition Triggers. Lowering this number will advance the base timing and raising the number will retard it. Alter this number as necessary and re-check it with the timing light until the ADV value matches the pulley value in real-time. Once it matches, the base timing is calibrated & all future timing changes will be made in the Hydra's base ignition table.

For **90-97** cars you may run out of adjustment in Timing Reference Angle (There is a floor and a ceiling) and will have to rotate your Cam Angle Sensor to get it back in range. To do this, loosen the 12mm bolt that locks the cam angle sensor (CAS) in place and rotate the sensor until the timing marker on the pulley lines up with the appropriate marker on the backing plate. Remember to re-tighten when finished. The CAS is at the back of the head: behind the intake cam for 1.6L engines and behind the exhaust cam for 1.8L engines.

Fuel "Auto" Tuning

Hydra 2.7s purchased as a kit from FM come with a WBO2 that runs short term trim (STT) and a self-learning long term trim (LTT). This is part of your ECU, so you can use any compatible PC to tune the ECU (no more passwords required). The Hydra will automatically "Autotune" while you're driving by saving consistent trim changes to the LTT table. This will occur with or without a laptop hooked up, so the more you drive the better your fuel table will be. You can access these parameters through Tuning maps -> AFR target table -> Settings, and you can see your LTT table at Tuning maps -> Closed loop -> Left bank long term trim. Before you begin LTT tuning you'll want to go to Tools -> Zero long-term trims so that any trim in the base map gets reset to 0. *Note- We still recommend tuning your full throttle zones on a dyno to optimize power & safety! At the very least you should take & review some datalogs of full throttle run-*

ning to make sure the tune is safe & appropriate.

Tech note- The maximum number of milliseconds that can be injected into the engine at any given engine speed is defined in the equation [120 / thousand RPM]. Therefore, for a 7500 RPM redline the time available is 120 / 7.5, or 16 milliseconds. If the base fuel plus any added trims exceed this amount at that RPM, the additional fuel will not richen the AFR & you should consider a larger injector / bigger fuel system.

Tuning Your Timing

The timing table that came with your base map was developed using cars tuned at FM on 91 octane gas. The off-boost spark timing is pretty good- there is no real reason to change it unless you have an exhaust gas analyzer and wish to dial it in for emissions. The on-boost timing can be tuned using datalogging, or preferably on a Dyno for optimum power & safety.

Knock Threshold. When you are ready to boost go to Tuning maps -> Knock Threshold. Here you will see a stream of "x"s that represent the real-time voltage output from your knock sensor, as well as your threshold line. The threshold level is user adjustable & should be calibrated for your car. The way to set it up is to monitor the "x"s while you rev the engine out to redline **while staying deep in vacuum** (less than 10" on your boost gauge). Without load there won't be knock. Therefore, any "x" activity is engine noise. Set your threshold at a small height above this noise level that occured during this test. Then, it is reasonable to assume that any "x" outlying from the group while driving under load will be knock. Also, test noise by performing some snap-decelerations at varying RPM to see if the sensor is picking up decel noise as knock. Make sure the threshold is contoured above any noise.

Datalogging. The best way to tune your timing (and everything else, really) is by running a datalog of the car being driven and then analyze the data after the fact. While it is best to do this on a dyno, it is possible to run a datalog on the street if it can be done in a safe, legal manner with a passenger running the laptop. Hydra 2.7 has an internal datalogger that you can export to your PC. Towards the top of your Hydra software there's a box that says "Internal Data Logging". Open it and up will come the screen where you can define what channels to log, run the logs, and also upload them to your PC for viewing. If you'd like to save a log you can save it in the native format which is great in 2.7. When sending us a datalog please also send your current map file for a more complete review.

We recommend that if you are not experienced with tuning standalone ECUs that you hire a qualified professional to do it for you. Optimization in many aspects is key to a good experience and a safe, reliable car. The tech department at FM can assist you remotely to a certain degree- feel free to call or email us if you have any questions.

Closed Loop Alternator Control (99-05)

While the **90-97** cars have voltage control built into the alternator, the **99-05** cars have ECU regulated voltage control. This means that the Hydra is responsible for maintaining a set voltage range within the system. If in your **99-05** car your system exceeds 15v, your Brake & ABS lights on the dash will come on and the radio will cut out. *Note- the Hydra software will not read over 15v! This means that your system voltage could be dangerously more!* Your controls for this parameter can be found in Tuning maps -> Closed loop -> Alternator voltage target -> & Setting. The default charging target is 14.4v- if the voltage goes below 11.3v or over 14.8v the WBO2 heater will shut down. Keep in mind that a **94-97** internally regulated Miata alternator will bolt on to a **99-05** car and work with a couple wiring changes, negating the need for ECU alternator control. Contact FM for instructions on how to set it up if you'd like to do this.

Variable Intake Valve Timing (01-05, except MSM)

On **2001-2005** Miatas (except **MSM**) there is a hydraulic assembly on the intake cam that allows for real-time adjustable cam timing between two end points based on a 3D map. Having control of your valve overlap is an excellent tool- it allows for the user to realize optimal flow rates for both cruise, full throttle, and all points in-between. Without this there is always some compromise involved in cam timing. ***Warning-*** *improper cam timing can cause increased EGTs, detonation, and also bent valves in interference engines. This variable is not for the amateur tuner!* This is a powerful tuning tool that can potentially have an even greater effect than fuel & timing fine tuning.

To access the cam timing map, go to Tuning maps -> Engine trimming -> VCT Intake Target. In this map you set the amount of intake cam advance in relation to the "off" position of full cam retard. ***Note-*** *stock Miata engines are non-interference. If you have a head shave, aftermarket pistons, high lift cams, or oversized valves you need to determine if your engine has become an interference one. If so, incorrect tuning of this map (too much advance) could put a piston into a valve!* **If you have an interference engine, or are not sure, unplug your VVT from the harness so the cam is locked at full retard. Wait to activate the VVT & tune the map until the car is in the hands of a qualified tuner.**

Fortunately there is an easy way to test the total cam advance range in *your* car & calibrate the FM base VVT map. Go to Tools -> VCT target vs. actual where you can monitor the target advance vs. what's actually happening. Not only can you verify that the VVT advance is working (free-rev & make sure the lines track each other), you can also calibrate our base table to your car by determining the maximum cam retard value for your engine. For the test you'll drop your idle VVT number 5 points at a time, and then go into the target vs. actual screen & see where the actual bottoms out. Then, put the map back to how it was, and offset the entire map by the amount which would make the idle target the same as where your cam bottomed out.

For idle and low RPM, there is not enough oil pressure in the system to reliably hold advance in the cam gear, and therefore you should leave the value in the chart at full retard so that it does not even try to advance the cam. Trying to advance it can result in a bad idle or jerky drivability. This poor behavior can come from a few different things including the VVT or the AFR

being lean, so if you experience it, you can rule VVT in our out by simply unplugging the connector from the solenoid (front / top of intake cam on the valve cover) and see if the problem goes away. If it does, try holding the fully retarded limit to higher in the rev range before you allow any cam advance. (If not, your idle may be lean.) Remember, when you're done tuning this map make sure that the transitions points are smooth- large, fast changes to the cam advance under load can damage the valvetrain in the long run and cause poor drivability.

Note- You can retrofit a VVT head or engine to a non-VVT 1.8. It is a lot of work, but it may be worthwhile for your project. Contact FM for the VVT wiring & Hydra settings info you'll need.