REAL WORLD SOLUTIONS *EC2-A* 13B *ENGINE CONTROLLER* 08-28-05
INSTALLATION AND PROGRAMMING GUIDE (LS-1 Coils) 2000 series

Thanks for purchasing the Real World Solutions EC2 engine controller for the 13B Mazda rotary. We have endeavored to make it the most versatile and reliable controller on the market today. Needless to say, the quality of installation is just as important as the quality of the hardware itself. It is not practical to include a course on proper electrical wiring practices in these installation instructions, but it is imperative that proper wiring techniques be employed during the installation of the EC2. Good connections and proper strain relief are crucial to system reliability. If you are not comfortable with reading a wiring schematic or wiring of electrical equipment, find someone to assist you. If you are in doubt about any of the instructions that follow, please contact me before operating the controller. I want your project to succeed and your life to be a long and happy one.

MATERIALS & TOOLS REQUIRED

1. Small Soldering iron
2. 63 - 37 or 60 - 40 rosin core electrical solder
3. 16,20 & 22 gauge stranded wire (See "Fuel Injector Wiring" for details.)
4. 1/16" ID heat shrink tubing for insulating connector solder connections DigiKey PN VFP116-X-ND (X= how many feet you want)
5. 5/32" vacuum line to connect EC2 MAP sensors to manifold vacuum ports (Available at Auto Parts stores)) Do NOT use hard nylon or plastic line as this could damage the sensors due to the difficulty of removing them.
6. 2 DPDT switches rated at 10 or more amps (Switches are optional. See "Injector Failure Backup Mode" for details.)

INSTALLATION

CAUTION: Make sure the positive terminal of the battery is disconnected during installation of the EC2 or any other electrical equipment. Damage caused by failure to heed this warning or due to incorrect wiring of the EC2 will not be covered under the warranty. Any other failure resulting from normal operation of the controller will be repaired at no cost except for shipping charges.

CONTROLLER

Begin by selecting the mounting location for the EC2 controller. This location should be as close to the engine as practical but not on the engine side of the firewall. It must be on the cockpit side in order to avoid exposure to engine heat and vibration. Remove the EC2 cover, on which the circuit board and connector are mounted, by removing the 4 countersunk Phillips head screws at the four corners of the case. Set the controller aside in a safe place while mounting the case. Mount the controller case by drilling mounting holes in the back or sides. If at all possible, mount the case directly to a grounded part of the airframe. The controller may be mounted vertically or horizontally. It is critical to isolate the unit from engine heat and excessive vibration. Choose a location with enough clearance for the wiring harness and connector; four inches or better is recommended. Be sure to remove all metal chips and dust from the case before reinstalling the controller and cover. You may paint the case if you wish, but do not paint the mating surface between the cover and case. It is important there be electrical contact between the cover and the grounded case.

I would also suggest that the EC2 be installed in an easily accessible location where you can visually verify that the connections to the EC2 are properly made. In one case, we spent several weeks troubleshooting (via long distance phone and shipping the unit back several times) only to find out that the builder was installing the controller backwards so that the manifold pressure sensors were not behind the slots in the case. The vacuum lines were being pushed into the slots by feel alone since the controller was buried far underneath the instrument panel. He thought the lines were plugged onto the sensors but they were not.

All external connections to the EC2 are protected from static damage, but do not touch the components or circuit board when they are exposed to avoid any possibility of static damage. If at all possible, the controller case should be mounted to an electrically conductive part of the aircraft structure that is connected to the negative terminal of the battery. If this is not possible, the EC2 case must be grounded to a conductive part of the airframe (engine mount, instrument panel, etc.) with as short a wire as possible. There is a ground stud on the top of the EC2 case for this purpose. Connect a ground wire from this stud to the airframe, even if the case is mounted to the airframe (this should be at least a 16 gauge stranded wire).

PROGRAMMING & CONTROL MODULE (PCM)

Next choose a location for the Programming & Control Module (PCM) where it can be easily accessed in flight. The control module comes mounted on a labeled plate to be mounted on the instrument panel in an easy to reach location.

Because the placement and configuration of the controller will vary greatly depending on the aircraft being built, it is not possible to furnish a pre-made wiring harness. Connectors for building the wiring harness are included with the controller. All wiring should be done with 22 and 20 gauge wire as indicated on the "Terminal Assignments and Destinations" sheet at the end of this document. Use wire that meets specification MIL-W-22759/16 or similar high quality wire. This is available from Aircraft Spruce

& Specialties and other aircraft suppliers. Remember that the reliability of any electronic device is no better than the wiring and connections used to install it.

TEMPERATURE SENSOR MOUNTING

The temperature sensor should be mounted in such a way that it is exposed to the incoming air to the throttle body. Use any suitable means of securing the sensor, such as a non-metallic cable clamp. I would suggest gluing the sensor into a threaded fitting such as an AN816-4 if you want to use it in a location where threading it into an intake manifold bulkhead or plenum would be advantageous. J-B Weld epoxy or a non-corrosive RTV rubber adhesive may be used for this purpose, but make sure that the sensing end of the device remains exposed to the incoming air stream. Do not cover it with adhesive. Note that only controller A has a temperature sensor. The backup controller (B) has no temperature sensor in order to eliminate this as a possible failure mode. The two wires on the temperature sensor are interchangeable. Note that one of the connections for the temp sensor has been changed from earlier versions. It is now connected to pin 1 (ground) instead of pin 11 (+5) in order to eliminate a failure mode in the event that the wire shorts to ground causing the controller to stop.

WIRING HARNESS

I suggest doing all wiring and soldering of the EC2 harness connectors at a comfortable workstation with good lighting. The close spacing and small size of the connector terminals require very careful work. Trying to do this while bending over the control panel in the airplane will almost certainly result in unsatisfactory results. When wiring the connector, use 1/16" I.D. heat shrink tubing to insulate each of the soldered terminals.

For a source of pre-wired harnesses, see our Website for contact information on Bob White who does top notch electrical work and builds pre-wired harnesses for the EC2 at a very reasonable price.

You should begin wiring the system together only after the fuel injectors, coil assemblies, air temperature sensor, EC2 controller, and the Programming & Control Module are installed.
After all components of the system are in place, use the "Terminal Assignments and Destinations" sheet (at the end of this document) to determine the length and gauge of each wire to be soldered to the connectors. Pre-cut all wires and label them about 5 inches from each end with a piece of tape or by other suitable means. Take the two connectors (for the EC2 and PCM) and the precut wires to your workstation and solder all connections to the connectors. If the physical layout of your electrical wiring will allow you to mount the Coil Test switch in its final location later, you may also solder the connections to the Coil Test switch (furnished with the controller) at this time.

When wiring the EC2 and PCM connectors, refer to the drawings included on the last page of this manual to determine the pin numbers. The drawings show the back of each connector. This is the side to which you will be making the soldered connections. If you look carefully, you can see that the pin numbers are molded into the back of the connectors. CAUTION: The order of the pin numbers on the EC2 connector is different from the order of the pin numbers on the PCM connector.

FUEL INJECTORS

TYPES OF FUEL INJECTORS

There are two basic types of fuel injectors available. Mazda used both types, so you must determine which type you have in order to wire them to the controller properly. The two types are "Peak & Hold" and "Saturated". To determine which type you have, measure the electrical resistance between the two terminals on the injector. The Peak & Hold type will measure between 2 and 3 ohms. The Saturated type will measure between 11 and 16 ohms. The Peak & Hold type requires an external resistor in series with each injector to limit the current flow. You can use a resistor pack from an RX7 car, but I would recommend using Mil Spec resistors. We can supply the recommended resistors ($25 for a set of 4), or you can purchase them from an electronics supply house. You will need 4 resistors rated at 5 ohms and 25 Watts.

You can use virtually any fuel injector that has a sufficient fuel flow rating. I chose to use the stock Mazda injectors that came on the engine. The EC2 is set up to use 4 injectors (two per rotor) with staged injection. "Staged injection" means that only two of the injectors are active at low throttle settings. At higher power settings (above 15" Hg manifold pressure) all four injectors are active. I recommend that you obtain new fuel injector connectors rather than using the old ones from the car wiring harness. I purchased mine at a Nissan dealer. The Mazda injectors use the same connectors found on a Nissan 300ZX car. Be sure to take an old connector with you (or better yet, an injector) to be sure that the ones you get are the same type and are keyed the same way. Splice the wires from the EC2 connector to the injector leads and insulate the connections with heat shrink tubing.

FUEL INJECTOR WIRING

When wiring the injectors, note that the two wires from the injectors are interchangeable. Also note that rotor 1 refers to the front rotor as it is positioned in the car (this is the rotor closest to the crank angle sensor). Rotor 2 is the one closest to the flywheel end. "Primary injectors" refers to those mounted directly on the engine block, which feed the inside ports. The secondary injectors are mounted on the intake manifold and feed the outside ports. Note that the injector return lines from the EC2 connector (pins 19 &

37) and the injector control lines (17, 18, 35, and 36) should not be bundled with the other wires in the harness. These lines carry relatively high current that is switching on and off. This can induce noise into the other lines if they are bundled together. Bundle these 6 wires separately from the others.

The injector current return pins (19 & 37) should be connected to ground on a conductive part of the airframe near the EC2. <u>These two wires from the EC2 should be as short as possible.</u>

Figure 1 shows the recommended injector wiring. Installation of the two DPDT switches shown is optional (they are not included with the EC2). They should be rated at 10 amps or more. Wire the power connections on the injectors directly to a +12 V (battery) power bus if the switches are not used. Do not wire the injector power leads directly to the battery without a switch. The EC2 will power itself through the injectors and drain the battery. In other words, power to the injectors should be switched off when the engine is shut down.

On the subject of aircraft electrical systems, I use two separate power busses in my airplane. The main bus I call the "Flight Critical" bus because only the things necessary to make the engine run are hooked to it. This bus is connected to the battery through a combination switch/circuit breaker rated at 50 amps. This is the bus you should use to power fuel pumps, ignition modules, fuel injectors, and the EC2. A 40-amp switch/breaker powers the other bus, which supplies all the non-essential stuff (radios, instruments, lights, MP3 player, and other accessories).

If you elect to install the switches, wire them as shown in Figure 1 below. This allows power to be removed independently from the primary or secondary injectors. If, for instance, a primary injector were to fail, the primary injectors could be switched off. This would, of course, reduce the fuel delivered to the engine by half. To compensate for this, the Cold Start input to the EC2 is activated, which doubles the fuel delivered by the remaining two injectors. In this configuration, the engine will continue to run on the secondary injectors alone. This emergency procedure would work equally well if the secondary injectors were to fail. Disabling the secondary injectors would allow the engine to continue running on just the primaries. Engine power in this emergency mode would be limited to about 80%.

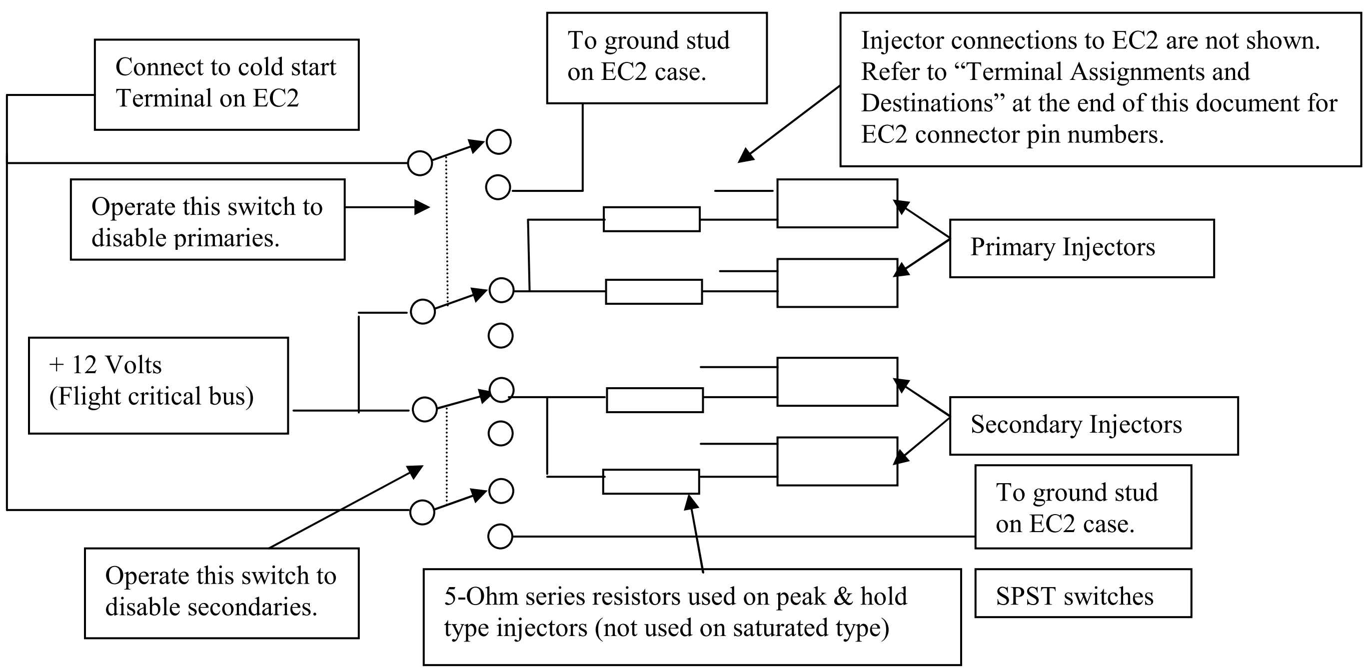


Figure 1 – Fuel Injector Wiring Diagram.

INJECTOR FAILURE BACKUP MODE

Injectors are very reliable devices, but anything can fail given enough time. The two switches shown in the injector wiring diagram will allow you to work around an injector failure should the need arise. This arrangement does require some intervention from the pilot. The following procedure is suggested as a guideline for dealing with a suspected injector failure and assumes that you have already tried switching the EC2 to the backup (B) controller without success.

A failed EFI injector will probably cause the engine to run on just one rotor, so there will be a lot of vibration and engine RPM will drop drastically. There is no way to know whether a primary or secondary injector has failed, so just pick one of the two injector disable switches at random. If the engine smoothes out, you have gotten lucky and turned off the correct injector bank. If the engine starts to stall or runs worse, turn the switch back on immediately and try turning off the other one. As you would expect, disabling both banks of injectors will cause the engine to stop. Be prepared to adjust the manual Mixture Control to optimize the mixture. It is probably not necessary to say this, but as soon as you have things under control and running smoothly, land and replace the defective injector.

This procedure is neither elegant nor foolproof and requires that the pilot think quickly and clearly under very stressful circumstances. The best that can be said for it is that it is better than not having any "Plan B" at all. I have never had an actual injector failure but this procedure has been tested while in-flight and does work. You should test it on the ground first to make sure every thing is wired correctly.

CRANK ANGLE SENSOR WIRING

The Crank Angle Sensor (CAS) is wired to the EC2 connector using 22-gauge wire. There are four wires from the CAS but two of them may be tied together near the CAS so that there are only three wires to run to the EC2. These wires need to be shielded. You can either use 3-conductor shielded wire, or you can use the same non-shielded wire used for the other connections to the EC2 and shield them with tinned copper braid. Tie the two CAS return lines together at the CAS rather than at the EC2. This makes it much easier to connect the two return lines to the single pin at the EC2 connector. Connect the shield for the CAS wires to the ground stud on the EC2 controller. Do not ground the end near the CAS. The wire colors for the CAS that are shown on the Terminal Assignments and Destinations list refer to the wires coming out of the CAS body, not the wires on the Mazda wiring harness connector to which it mates. If you choose to use the stock Mazda CAS connector, carefully note that the wire color may change at the connector. This can vary depending on the model year of the car.

INITIAL TIMING ADJUSTMENT

There are two timing marks on the stock eccentric shaft pulley of the 13B engine. The first mark is yellow and is 5 deg. after TDC. The second mark is red and is 20 deg. after TDC (15 degrees between the two marks) Note! Aftermarket pulleys are marked differently! Consult the manufacturers' information if using a non-Mazda pulley. Using these marks as a guide, position the eccentric shaft at 35 deg. **before** TDC. Now check that the top sensor in the crank angle sensor is exactly in line with its trigger wheel (the one with 2 points). Either of the two points is OK. Loosen the nut at the base of the angle sensor and adjust timing if necessary. This procedure will get the timing close enough to start and run smoothly.

Final timing can be verified by making a new timing mark on the eccentric shaft pulley at 23 deg. Before TDC. Using a timing light, verify that the leading plugs fire near the new timing mark (23 degrees BTDC) at 4000 RPM (or higher) with a manifold pressure around 20 inches or more.

The timing specifications given here are appropriate for normally aspirated engines. Turbocharged engine installations may require less advance when manifold pressure is in the boost range (above 30" Hg.). The exact timing requirements will vary depending on factors such as maximum boost pressure, octane rating of fuel, compression ratio, manifold air temperature, etc. Due to the widely varying parameters involved, we cannot give exact timing requirements for turbo or supercharged installations and the builder must determine these. A ballpark figure of about 19 Degrees BTDC at manifold pressures above 30" Hg. is suggested as a starting point.

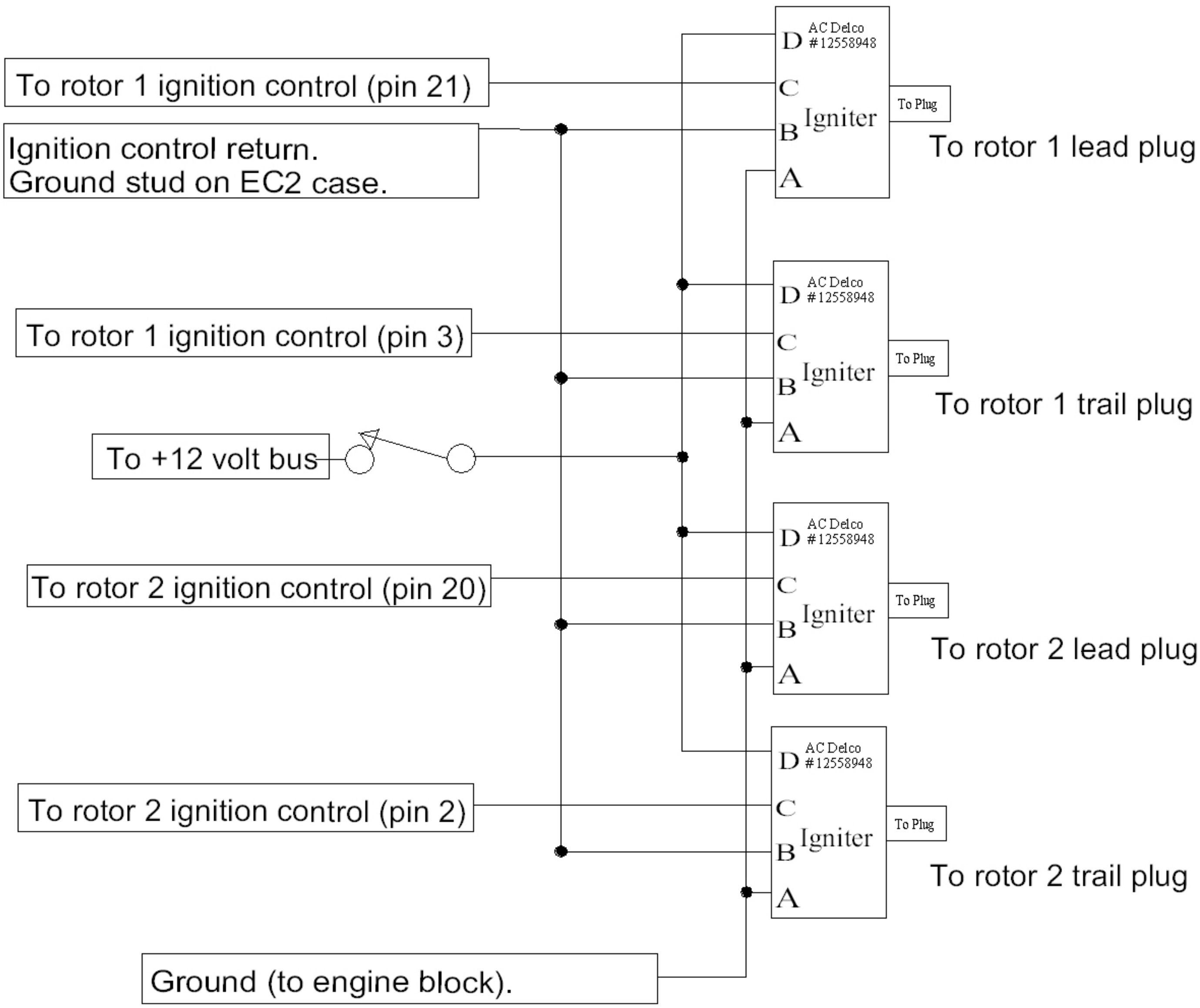
AC Delco IGNITION MODULE WIRING

Wire the GM coil modules as shown on the 13B-A Igniter wiring diagram. The +12 volt power for the igniters (pin D on the igniters) should have their own dedicated line from the flight critical battery bus. Use 16-gauge wire for this supply line. To ensure minimum noise on the EC2 power line, do not connect the EC2 and the coils to the same +12 volt power wire. The igniters may be mounted on the engine side of the firewall, but you should insure that they are not exposed to excessive heat, especially from the exhaust system. Use a remote thermometer (available from Radio Shack for under $20) to verify that the ambient temperature around the igniters does not exceed 135ºF during normal operation. Use cool air blast tubes to cool the coils if necessary.

When making the connections between the igniters and the spark plugs, use good quality automotive silicone-insulated radio suppression wires. I would recommend the spiral wound metallic suppression core type wire available at Summit and other racing equipment suppliers. DO NOT USE solid copper wires or aircraft type metal shielded-wires. Note that Rotor 1 refers to the rotor closest to the water pump. Note that the spark plug wire terminal on the LS1 coil is rather unique. Some builders have purchased a set of wires for the LS1 Corvette engine to ensure that the wire properly mates to the coil connector.

The connectors for the AC Delco coil/igniters are currently only available through GM dealers. They are sold only in a prewired harness of 4 connectors as used on the LS-1 Corvette engine. An alternative to using these connectors is to wrap and solder wires directly to the connector pins then pot the igniter cavity with epoxy glue for wire strain relief. See the photos at the end of this document for details.

13B-A Igniter wiring diagram. Pin numbers refer to EC2 connector.



All Igniters are AC Delco PN # D580 or D581

TACHOMETER CONNECTION

The EC2 sends engine information over a serial link to the EM2 engine monitor (if used) including engine speed and many other parameters. If you are not using the EM2, the coil driver signals may be used to drive a tachometer if it does not load the signal too heavily. I would suggest using pin 2 on the EC2 for this purpose. The tach selected should be capable of using a one pulse per revolution signal with an amplitude of +5 volts. If a higher amplitude pulse is required, the injector drivers will have a 12 volt pulse once per revolution and may be used to trigger a tach.

MAP (MANIFOLD ABSOLUTE PRESSURE) SENSOR CONNECTION

There are two slots in the side of the EC2 controller. The two MAP sensors sit just behind these two slots and are to be connected to ports on the manifold. Connect the two MAP sensors on the EC2 controller to vacuum connections on the intake manifold using 5/32" vacuum line. This is available at most auto parts stores. You can use a single manifold connection and "T" it off to the two sensors, but I chose to use separate lines and connections for maximum redundancy. If a proper sized line is used, no clamp is needed on normally aspirated engines but turbo or supercharged engines should have a suitable clamp on these connections to insure that they remain in place at maximum boost pressures.

EC2 OPERATING INSTRUCTIONS

The following procedure assumes that the EC2 has been programmed reasonably well. The unit is shipped with the default program developed over several years of flying in out development test mule aircraft N84TC. If this does not give satisfactory results you may want to reset it to the "Zero" option described in Mode 1 of the programming guide.

Before any attempted flight, be sure that you have verified operation of the controller at all power settings and made any mixture adjustments necessary using the programming procedure included with these instructions. Any new engine installation should have several hours of ground test time including at least one full hour at full throttle. Most installations will not cool adequately for an hour of continuous operation so this time may be accumulated in shorter engine runs after which the engine is allowed to cool down. Always monitor engine temperatures and pressures during all tests and shut down when maximum temperatures are reached.

STARTING PROCEDURE

In order to greatly simplify and increase the reliability of the EFI for aircraft applications, many of the sensors and servos typically used on EFI autos are not used on the EC2. This makes the engine starting procedure a bit more dependant on the operator.

Turn on the primary fuel pump and verify that the fuel pressure rises to about 36 PSI. Momentarily turn on the backup fuel pump and note that the fuel pressure raises a few PSI to verify its operation. Turn the backup pump off before proceeding.

When the engine is cold, the Mixture Control should be turned to full rich position (CW) and the Cold Start switch turned on prior to engaging the starter. The throttle should be opened a small amount to a "high idle" setting. Engage the starter, and when the engine starts, turn off the Cold Start switch immediately. If the engine does not start within a few seconds, turn the Cold Start switch off in order to avoid flooding the engine. In colder weather it may be necessary to leave the Cold Start switch on for a few moments until the engine warms up a bit. After a little experience, you will quickly learn the right amount of time to leave the cold start switch on. As the engine warms up, turn the Mixture Control down toward the center mark at 12 o'clock. Wait until the oil temperature has reached at least 135ºF before running the engine at full power for takeoff.

Because the rotary's spark plugs are in a shrouded recess in the combustion chamber, a flooded engine is much more troublesome and harder to flush out than typical piston engines. It is frequently necessary to remove the plugs, blow them clean and crank the engine over without the plugs (and the fuel pumps switched off) to flush the excess fuel out of the engine. Having said this, I must caution against the fear of turning on the cold start switch when starting a cold engine. In order to avoid flooding the engine, some builders avoid turning on the cold start switch, which can reduce the fuel flow to the point where the mixture will not readily fire. If the engine does not fire soon after cranking begins, the injected fuel will not ignite causing the fuel to accumulate in the spark plug recesses, causing the engine to flood and the plugs to foul. When they find that the engine is flooded, they attempt to reduce fuel delivery even more. This, of course, makes the engine even harder to start.
Update 03-17-05 An alternative to using cold start is to use the Primer function. Unless the temperature is very cold, try leaving the cold start switch off and just turning the mixture control to full rich (Clockwise). Use the Primer function as described in the Mode 0 programming section to prime the engine prior to cranking. Many users report easier and faster starting when using the primer function. This is the method we use here at RWS.

PREFLIGHT CHECKS

Before takeoff, set the Controller Select switch to the "B" (backup) position to verify that it is operational. While the engine is running on controller B, momentarily push the Coil Disable switch up to disable the leading coil and down to disable the trailing coil. Verify that the engine continues to run smoothly on either coil. When disabling the lead coil it is normal for the engine RPM to drop. Note that the Coil Disable switch works only on controller B. If you do not get a small drop in RPM when disabling the lead coil, it may indicate that Controller B is not being selected due to a wiring error, switch failure, or relay failure in the controller. If any of these preflight checks reveal a problem, do not attempt flight until the problem is resolved. Be sure to set the Controller Select switch back to “A” before takeoff.

FUEL MIXTURE CONTROL

One of the supposed advantages of EFI has been referred to as “single lever power control.” This means that no adjustment other than setting the power is required. This is theoretically possible, but I found that in the real world this is not practical without unrealistic complexity or sacrifice of versatility and economy. The EC2 controller can maintain constant mixture under almost any condition or altitude, just like a modern automotive EFI. The problem is that we don’t always want the same mixture in the aircraft environment.

It is possible to perform all phases of flight (takeoff, climb, cruise, and descent) while leaving the EC2 Mixture Control at a nominal setting (typically 12 o’clock). Due to the nature of aircraft engine operations however, it is advantageous to do some manual adjustments. Just prior to takeoff I set the Mixture Control to “best power” setting. Where this is will depend on how you setup the controller during the programming procedure. I setup my controller to be at about the 2:00 o’clock position for best power.

The EC2 controller will compensate for altitude and keep the mixture set at best power (or wherever you set it) at any altitude you care to climb to. During takeoff and initial climb, best power is what we want, but after reaching desired altitude this setting would use more fuel than necessary. After takeoff and initial climb the engine is usually throttled back to a cruise/climb setting. At this point the Mixture Control can be leaned-out to reduce fuel burn by setting it to a median mixture setting at the 10 – 11 o’clock position. The engine will drop-off in power slightly but the fuel burn will drop a lot.

After reaching the desired cruise altitude, the mixture can be leaned even more to reduce fuel burn. The best procedure for doing this is still under study, but here are some guidelines: The procedure is similar to that used with a conventional aircraft engine. Starting with the engine running at best power setting, the EGTs will read hotter as the mixture is leaned from this point. The engine will loose some power (but not much) as the mixture is leaned to the peak EGT point. This is about 1750ºF (at sea level) on my installation. The engine starts to loose power more rapidly as the mixture is leaned further and the EGT and fuel burn go down as well. The trick is to find the point at which the engine is producing the most power per pound of fuel burned. More experimentation will be required to determine this point exactly. A commonly used number for the most efficient point on conventional aircraft engines is 50ºF on the lean side of peak (LOP) EGT. The correct number on the rotary seems to be quite a bit higher than this. During my limited experience so far I have found that an EGT of around 1550ºF. (about 100ºF LOP) gives fairly good results. (These are the observed numbers at about 8000 – 12,000 ft. MSL when running at economy cruise.) At this point, the air/fuel gauge is not of any use because the reading is below the scale (no LEDs lit). EGT readings are your best indication when leaning at cruise altitude. If the mixture is leaned too far, power will start to drop off rapidly and further leaning will cause the engine to miss. Don’t worry about getting the very lowest fuel burn numbers during your early hours of testing. Later, as you become more comfortable with the airplane, you can try eking out every last drop of economy from the engine.

For local recreational and aerobatic flights where I probably won’t exceed 3500 ft. AGL, I just leave the Mixture Control set for a midpoint indication on the air /fuel gauge after takeoff and climb-out. This setting is fine for descent and landing as well.

EC2 PROGRAMMING PROCEDURE

To successfully program the EC2 you will need some means of determining whether the engine is running too lean or rich. The best instrument for doing this during initial tuning is the air/fuel gauge. This instrument is available from several racing equipment suppliers including Summit racing (PN SUM-G2986). The readout on this instrument is a bar graph made up of 10 LEDs. A lower reading on the bar graph shows a lean condition. As the mixture gets richer, higher LEDs light on the bar graph. During initial tuning on the ground, proper mixture will be indicated by a center reading (lower 5 or 6 LEDs lit on the monitor). A conventional automotive Oxygen (O_2) sensor drives this instrument. Mount the O_2 sensor by drilling and a ¾” hole in a convienient place in the exhaust system after the collector, then weld a mounting bung (available from Summit racing, PN SUM-G2990). A Bosch 11027 O2 sensor is a universal replacement part and can be obtained from most any auto parts store.

EGT gauges can also be used for EC2 tuning, but it is not as easy and takes much longer. The main advantage of the air/fuel gauge is that it responds instantly to mixture changes. There is a significant delay between the time the mixture changes and the time that the EGT gauge responds to that change. Another factor to consider is that there is never any question about which way the mixture is changing on an air/fuel gauge. As we will discuss later, when an EGT goes lower it is not immediately clear whether a leaner or richer condition caused the change.

You will also need some means of measuring manifold absolute pressure (usually referred to as simply “manifold pressure”). The best way to do this is with a manifold pressure gauge. A conventional aircraft instrument works well for this but is fairly expensive.

An automotive manifold vacuum gauge can be used and is much less expensive. It does, however, require some interpretation. To measure manifold pressure using a vacuum gauge, subtract the vacuum reading from the barometric pressure (30" Hg at sea level). The barometric pressure at higher altitudes can be closely estimated by subtracting 1" of pressure per 1000 feet of altitude above sea level. For example, if you are at 2000 feet above sea level and the manifold vacuum gauge reads 8" of vacuum, the approximate manifold pressure can be calculated as follows:

30" (approx. pressure at SL) - 2" (1" per 1000 ft. altitude) = 28" barometric pressure

Next, subtract the vacuum gauge reading from the barometric pressure to give the manifold pressure:

28" (barometric pressure) - 8" (vacuum reading) = 20" manifold pressure

A digital fuel flow and totalizer instrument designed to work with the EC2 is now in development at Real World Solutions. It will also have a digital readout of absolute manifold pressure. Availability of this instrument is expected by mid 2001.

SYSTEM BACKGROUND

Before getting into the specifics of EC2 programming, it will help to have some understanding of how the system works.

The operating software of the EC2 has been permanently programmed into the two microcomputers it contains. This program cannot be erased or changed. Programming as referred to in the title of this section means the optimizing of mixture ratios at various manifold pressures (throttle settings). In addition to the permanently programmed computers, the EC2 contains what are called EEPROMS: Electrically Erasable Programmable Read Only Memories. These memories can be rewritten with new data by the computer but the data stored in them is not lost when the power is turned off.

Keep in mind that the EC2 contains 2 separate and independent engine controllers. When you are programming one controller (the controller selected by the controller select switch), the other controller is not affected. You must select the (B) controller and repeat the same procedure used to program the (A) controller in order to program both.

An easier way to program Controller B is to first fine-tune all parameters in controller A. When you are satisfied with the tuning, use Mode 2 to copy all the programming from controller A to controller B. See instructions on Mode 2 for details on how to do this.

The main information stored in these memories is a lookup table that the EC2 uses to adjust the mixture above or below the mixture calculated by the computer. The computer does its best to figure out the proper fuel mixture based on what it knows about the engine. It knows things like how much volume there is in the rotor chambers at bottom dead center and the average air pressure in the manifold feeding the chambers. It also knows when the intake ports open, how fast the engine is turning, and how much fuel per second the fuel injectors flow when it turns them on. What it does not know are things like how the intake manifold is tuned and what kind of pressure waves are present in the manifold due to things like the dynamic chamber and ram tuning effects of intake runner length. To accurately compute factors like this in real time would require a super computer that would be too large to fit in your airplane. The lookup table is a way to get around this problem. It is simply a list of corrections that the computer can look at to compensate for factors it does not know about. It is the setting of this list of numbers that we refer to as programming the EC2.

In aircraft applications, the manifold pressure most accurately defines the engine's operating condition. If we know the manifold pressure, we also know approximately how fast it is turning. This is unlike a car where the engine could be at full throttle but only turning at low RPM (lugging up a hill in high gear for example). For this reason, the lookup table in the EC2 is a list of numbers corresponding to different manifold pressures. We will refer to it from this point on as the MAP (Manifold Absolute Pressure) lookup table or "MAP table" for short. There is one entry in the table for approximately each ½ inch of manifold pressure. To illustrate, if the engine is running at 20" of manifold pressure the EC2 calculates the theoretically correct amount of fuel to inject, but before opening the fuel injector it looks up the 40^{th} number in the MAP table (hence the name 'lookup table') and modifies the mixture according to the number it finds there. The numbers in the MAP table can range from -127 to +127. If the number is in the center of this range (zero), the processor does not modify the mixture. If the number is negative, the mixture is adjusted in the lean direction, or in the rich direction if the number is positive. The further from zero the number is, the more the mixture is adjusted.

The MAP table comes from the factory (my house) loaded with zeros. With this value, the mixture is not adjusted from the value computed by the EC2 computers. The EC2 will work right out of the box with this setup, but the mixture will probably not be optimized over the full range of throttle settings.

ADJUSTING THE INJECTOR FLOW RATE

In addition to the MAP table, there are three special values stored in the EEPROM. The computer uses these values (and others) to calculate the theoretically correct mixture. The most important value of the three is the injector flow rate. Because this value is programmable, the EC2 can be used with almost any fuel injector. The injectors must, of course, be capable of a flow rate high enough to feed the engine they are used on. The EC2 comes preset with a value that is about right when using the Mazda 13B normally aspirated fuel injectors.

GETTING TO KNOW THE PROGRAMMING & CONTROL MODULE (PCM)

Refer to the drawing of the Programming & Control Module (PCM) in Figure 2 during the following discussion. Although the Mixture Control knob is the only control you will use most of the time, it is important that you get to know this panel and commit the functions of all the controls to memory. Of course it doesn't hurt to have a little "cheat sheet" posted in the cockpit to help you remember.

The Mixture Control knob is on the right side. It is active at all times and the mixture is changed immediately when this knob is adjusted. Turning the knob counter-clockwise (CCW) causes the mixture to be leaned. Conversely, turning it clockwise (CW) makes the mixture richer. Strictly speaking, the Mixture Control is not one of the programming controls but it is used frequently during the programming procedure.

The switch immediately to the left of the Mixture Control, is the Controller (A/B) Select switch. The primary controller (A) is selected when in the down position. The backup controller (B) is selected when in the up position. Note that the following programming procedures affect only the selected controller. Also note that only controller "B" is affected by the Coil Disable switch, which is mounted elsewhere on your panel. This switch is furnished with the EC2 but you must decide where to mount it.

The next switch, to the left of A/B Select is the Cold Start switch. This switch causes the EC2 to double the fuel delivered to the engine when turned on (up position). It is used when starting a cold engine (see "Operating Instructions") and for certain emergency procedures (see "Injector Failure Backup Mode"). This switch is not used during the programming procedure.

The other three controls on the panel are for programming use only. The control at the far left, which looks identical to the Mixture Control knob, is called the Program Value knob. It determines the value to be stored in the various program modes described below. The small push-button to the upper-right of this knob is the Program Store switch. The value selected by the Program Value knob is stored only when the Program Store switch is pushed. Just below the Program Store switch is the Mode Select switch. This is a 10-position switch that determines which function is being programmed when the Program Store switch is pushed. Although there are 10 positions (0 – 9), only 0 – 6 are used. The program mode number is displayed in a small window in the center of the Mode Select switch. Pressing the small button below the window increases the number. Pressing the button above the window will cause it to decrease. We will go through each of the programming modes and explain what each does. Don't be intimidated at this point. It's not as complicated as it sounds.

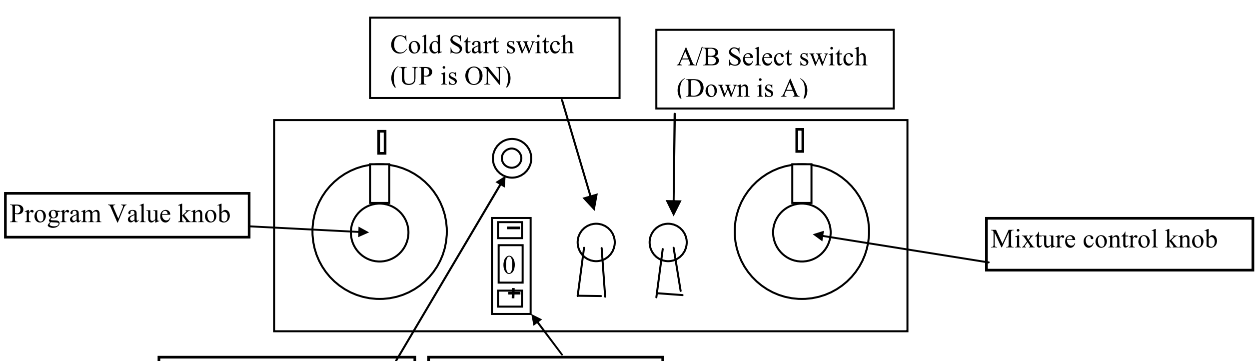


Figure 2 – EC2 Programming & Control Module. (PCM)

Program Mode 0 (programming disabled)

When the Mode Select switch is set to 0, no programming mode is active and turning the Program Value knob or pushing the Program Store switch will have no effect on any of the engine parameters. This is the position it should be set to during normal operation to avoid any "accidental programming." Also note that program modes 1 through 8 will function only when the engine is running. Adjusting the Program Value knob or pushing the Program Store switch with the engine stopped will have no effect Exceptions to this rule, (resetting the factory defaults), are detailed later in this section.

PRIMER FUNCTION

02-28-05 Update. A primer function was added to the EC2 after hearing from a builder in Canada who found that the Cold Start switch did not enrichen the mixture enough for reliable starts in very cold weather. Before the engine has started and the Mode switch is in Mode 0, pressing the STORE switch will fire all injectors for a short burst in order to prime the engine for cold weather starts. The number of priming shots required for your particular installation will vary with temperature, manifold design, position of injectors and other factors. The proper technique for your installation will have to be determined experimentally. Start with 2 or 3 primer shots then increase as necessary.

The primer function also makes a good preliminary test after you have first installed the EC2. You should be able to hear the injectors click when you press the store switch if everything is wired correctly.

Pressing the store switch in Mode 0 with the engine running will have no effect.

Program Mode 1 (programming the MAP table)

This is where you will do most of the initial controller programming. Mode 9 will be most useful during the fine tuning stages. Mode 1 and 9 are the functions that adjust the MAP table. Note: All EC2 programming should be done with a propeller load on the engine. Without a load, the engine will be at relatively low manifold pressure at any RPM you set, which will make programming the controller difficult or impossible. The only adjustment you can make without a load is at idle and even this will not be an accurate without a prop load.

Background

To properly setup the EC2, it is important to understand the basic principles behind its operation so pay careful attention to this background information.

If the amount of air drawn into the combustion chamber were directly proportional to the manifold pressure, the computer could easily calculate the exact amount of fuel to inject each time the intake port opened. Unfortunately, there are many other factors that affect the actual volume of air taken in. Among these are various tuning effects in the intake system that change how the engine breathes at different throttle settings and engine speeds. It is the MAP table that allows the EC2 controller to work with a variety of different intake manifold designs, engine porting, etc.

The MAP table is a list of 64 values. Each value represents the mixture correction value for a particular manifold pressure. Since manifold pressure can vary between 0 and 30" Hg, this means that each value determines the mixture correction over a range of about ½" Hg of manifold pressure. So how do you select the manifold pressure you want to program? The answer is that the controller does this for you. Let's go through an example to clarify this.

Let's say that you are running the engine at a manifold pressure of 20" Hg. You have looked at the EGT or air/fuel gauge and determined that the engine is running slightly too rich at this throttle setting. You can verify this by adjusting the Mixture Control counterclockwise and seeing the effect on the EGT gauge. The procedure for making this correction is as follows: Note how far you had to turn the Mixture Control counterclockwise from the 12 o'clock position to get the desired mixture and then return it to 12 o'clock. Make sure the Mode Select switch is set to 1. Then turn the Program Value knob to about the same position that the Mixture Control was set at when you obtained the correct mixture. Now push the Program Store switch to save this correction. The EC2 should respond to this change by adjusting the mixture. If the mixture is still too rich, turn the Program Value knob a little further counterclockwise and push the Program Store switch again. Repeat this procedure until the mixture is what you want at this throttle setting. It is best to do this in small steps in order to avoid over-correcting. If you do over-shoot the proper setting and go too lean, turn the Program Value knob back clockwise a bit and push the Program Store switch. After a bit of practice this procedure becomes automatic. Note that the mixture correction you just made at 20" of manifold pressure does not affect the mixture at other throttle settings. Programming the mixture table only effects the mixture over a small range of manifold pressures close to the value at which the engine is currently running. For this reason, you should not vary the throttle setting while adjusting one particular point in the mixture MAP table. Again, remember that the "A" and "B" controllers are completely separate. Adjusting controller "A" has no effect on "B". You must repeat the procedure on the other controller to have them programmed the same way.

<u>After you have gotten the engine running smoothly after the first start, follow this general guideline when setting up the MAP table in Mode 1</u>. Start with the engine running at low idle speed and adjust the mixture in mode 1 until the mixture monitor indicates mid-range with the manual mixture control at 12:00. Open the throttle to increase manifold pressure in 1" Hg. steps and adjust Mode 1 for the mid-range mixture reading at each step until you have set the entire range of throttle settings.

If during your first attempts at EC2 programming you get confused and end up with the adjustments so far out of whack that the engine will not run well, don't panic. There is an easy way to reset the table back to the factory default settings. This is described below. Feel free to call us here at Real World Solutions for help with programming if needed.

8-19-03 - Dual MAP TABLE
As of this date, the EC2 now has a dual rpm range MAP table. Simply put, this means that two separate tables are used at low and high RPM. The dividing line between these ranges is 2400 rpm. The main reason for implementing this feature is to allow more accurate mapping of the mixture under all operating conditions.

It is possible for the engine to see a low manifold pressure under two very different conditions. The first is when idling. At idle, the manifold pressure is in the range of 12 – 13" Hg. (18 – 17" if read on a vacuum gauge) When on the ground with a propeller load, the manifold pressure will always be considerably higher when the engine is running at a higher rpm than idle (typically 1300 – 1700 RPM) The low RPM MAP table will cover this operating condition and is easily adjusted during ground operation with the propeller mounted to the engine..

When in-flight, the engine can see a very different condition. If the aircraft is cruising at high altitude or is descending at low throttle, the engine will now be able to run well above 2400 rpm even at a low manifold pressures. The mixture correction for this condition may be significantly different than what was called for at low rpm. This is the reason for implementing the dual MAP table feature. The selection of which MAP table the EC2 uses is automatic and requires no action from the pilot.

There is usually very little fine tuning of the high rpm MAP table necessary but the only practical way to do it is while in-flight. This should be done only when you are fully familiar with and comfortable with flying your plane and with the programming procedures described in this guide. Until you achieve this level of comfort, don't worry about fine tuning of this sort. Use the manual mixture control and your mixture monitor to keep it in range. This is a perfectly acceptable way to operate the engine and thousands of pilots flying conventional aircraft engines have used this as their only method of fine tuning the mixture.

When you are ready, climb to a safe altitude at or above 5000 ft. AGL so that the aircraft can be held in descending flight long enough to accomplish the adjustments without worrying about colliding with the earth. If possible, a co-pilot on board to help with piloting duties is also recommended. Establish a shallow descent (about 300 fpm) at a manifold pressure of about 17" Hg. Different aircraft will require adjustments to the suggested figures in order to keep the airspeed in a safe range so use your judgment as a pilot here.
Adjust the mixture as previously described using MODE 9. Reduce the manifold pressure in increments of ½" Hg. and program the MAP table for proper mixture at each step all the way down to around 12" Hg.

Auto-Program If you are using the EM2 engine monitor, you can use the EM2 Auto-Program mode to make most of the MAP table adjustments for you. See the comments on this mode in the EM2 engine monitor description at the end of this document.

Resetting the MAP table to factory default settings
To reset all MAP table entries to the factory default settings (zero), perform the following steps:

1. Turn the EC2 power off (engine stopped).
2. Select mode 1 with the Mode Select switch.
3. Press and hold the Program Store switch.
4. While holding down the Program Store switch, turn on the power switch to the EC2.
5. Keep holding the Program Store switch for about 2 seconds, and then release it.
6. All MAP table entries will now be restored to the factory setting of 0 and you can begin programming after re-starting the engine.

Program Mode 2 (setting the Program Store range)
As mentioned in the description of mode 1, each value in the MAP table only controls the mixture correction over a range of about ½" manifold pressure, which is a pretty narrow range. In actual practice, it would be rare to find that the mixture needed adjusting over such a small range and it would be tedious and time consuming to program every entry this way. A more likely scenario would be to find a range of perhaps 1 to 4 inches of manifold pressure where the mixture is not quite right. Mode 2 allows you to set the range over which the mixture is adjusted while using mode 1.

The default value for Program Store range is one; meaning that a range of one MAP table entry will be modified. This means that unless you change the Program Store range using program mode 2, the mixture will be adjusted over a range of about .5" Hg. If mode 2 is used to set the Program store range to 3 (mid point of Mode 2 range) a range of .75" above and .75" below the current manifold pressure setting when you press the Program Store switch in mode 1. If the range of manifold pressures that you want to change is larger or smaller than this, use mode 2 to change it using the following procedure. I have found that a range of three is optimum for initial tuning on the EC2. Later, when you want to fine tune the EC2, use the default range of 1. The following paragraphs will illustrate the procedure required in other possible situations. Use these only if you find that the suggested setting is not adequate to achieve the result needed.

Let’s say you notice that the mixture is too lean from 20.5 to 23. inches of manifold pressure, a range of 2.5 inches. Since there is 1 table entry per ½ inch of manifold pressure, this would require a Program Store range of 5 (the maximum allowed). In program mode 2, the Program Value knob adjusts the Program Store range from 1 (knob fully CCW) to 5 (knob fully CW). The Program Store range is changed when you press the Program Store switch. For example, to set a Program Store range of 5 you would select program mode 2 with the Mode Select switch, turn the Program Value knob fully clockwise, and press the Program Store switch. Then you would switch back to program mode 1 and all settings made, by adjusting the Program Value knob and pressing the Program Store switch, would alter the MAP table from about 1.25 inches below to 1.25 inches above the current manifold pressure. In mode 1 the Program Value knob selects mixture adjustment values from -127 (fully CCW) to +127 (fully CW). When the Program Value knob is set in the center (12 o’clock) position it is at the zero point (no mixture adjustment). You don’t really need to remember these numbers, just remember that counterclockwise from center is leaner and clockwise from center is richer.

To correct the mixture problem described above (too lean from 20.5 to 23.0” MAP), we would adjust the throttle to the center of the problem area (about 22 inches MAP), and then select mode 1 with the Mode Select switch to initiate MAP table programming. Since the mixture was too lean, the Program Value knob would be turned a little clockwise from the center position and then the Program Store switch pressed. Observe the result on either the air/fuel gauge or your EGT gauges. Continue adjusting the Program Value knob in small increments and pressing the Program Store switch until you are happy with the mixture. Remember that the object of MAP table programming is to have the mixture remain constant over the full range of throttle settings with the manual Mixture Control set at 12 o’clock.

Figure 3 illustrates the effect of different Program Store range values when programming the MAP table in mode 1.
Note that the EC2 remains set to the last Program Store range setting made in mode 2 as long as the power is on. If the EC2 is turned off the Program Store range is reset to the default value of one. Note - at any given program store range setting, the range of affected values is slightly wider on the turbo version because of the wider range of possible manifold pressures. The turbo EC2 can be used with manifold pressures up to 50” Hg. The non turbo EC2 is limited to 34” Hg.

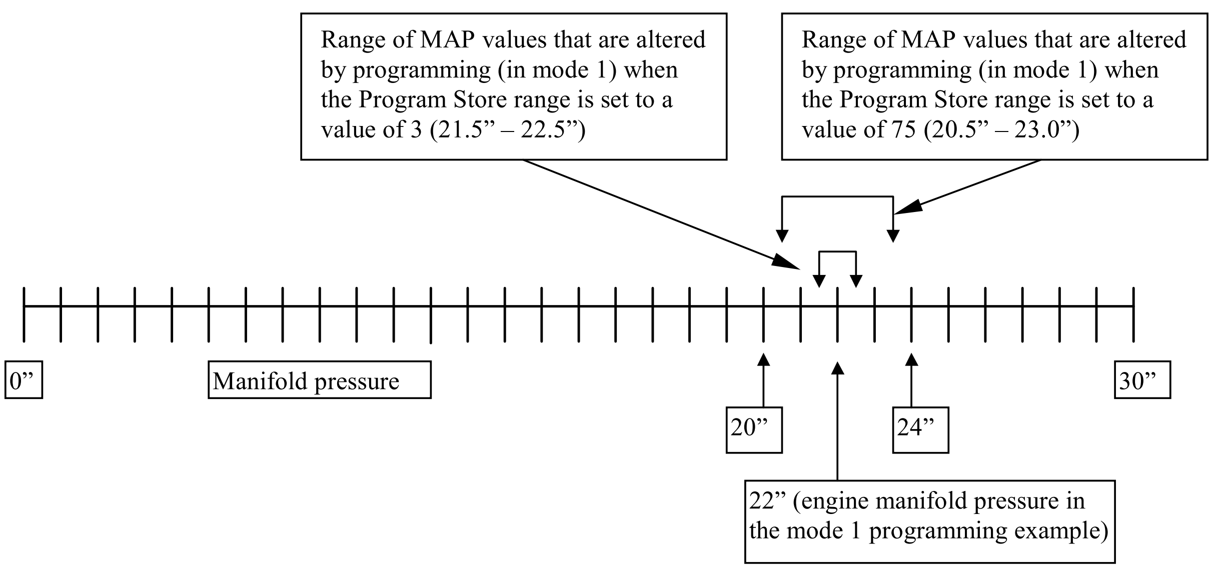


Figure 3 – Illustration of the effect that changing mode 2 (Program Store range) has on mode 1 (MAP table).

Copying all programmed parameters from A to B (Only on Rev B version of EC2, Small 7.5” X 4” case)
Mode 2 is also used to copy all the programming that you have done on controller A to backup controller B.
Doing this is similar to resetting to factory defaults in some of the other modes. To invoke the Copy A to B function, perform the following steps:

1. Turn the EC2 power off (engine stopped).

2. Select controller A using the controller A/B switch on the PCM
2. Select mode 2 with the Mode Select switch.
3. Press and hold the Program Store switch.
4. While holding down the Program Store switch, turn on the power switch to the EC2.
5. Keep holding the Program Store switch for about 2 seconds, and then release it.
6. All programming entries which you have performed on controller A will now be copied to Controller B.

Program Mode 3 (fuel injector flow rate)

Program mode 3 adjusts the fuel injector flow rate. As mentioned before, this value comes preset to the correct setting for stock injectors. Use the following procedure to adjust the flow rate only if the mixture is not at around mid-scale on the mixture monitor at around 22” Hg manifold pressure with the mixture control set at 12:00. All programming should be done with the engine warmed up to normal operating temperature. Note that adjusting the injector flow rate will affect the mixture at all throttle settings. If you change the setting of Mode 3 after you have done any programming in Mode 1, you may have to go back and do the mode 1 programming again. For this reason, it is best to check the mixture at about 22” Hg MAP (a mid range throttle setting) before doing any Mode 1 programming.

Here are the steps I used when starting my engine with the EC2 for the first time: Adjust the idle stop on the throttle body so it is barely cracked open. Set the throttle to slightly above the idle stop. Set the Mixture Control to full rich (CW). Turn the Cold Start switch on. Engage the starter. As soon as the engine starts, turn the Cold Start switch off and adjust the throttle for an engine speed of about 2500 RPM. If the engine does not start in the first 5 – 10 seconds, turn off the Cold Start switch to avoid flooding the engine. Adjust the Mixture Control to obtain smooth running if necessary. As the engine warms up, it will probably be necessary to turn the Mixture Control down. The air/fuel mixture monitor will start working 10 – 20 seconds after the engine starts, when the O_2 sensor warms up. Use this instrument as your primary guide in making mixture adjustments. You should aim for a middle to upper-middle indication (6 – 7 LEDs lit) at low throttle settings. The engine will probably be running quite rich, so turn the Mixture Control to the left (CCW) until the engine is running smoothly. If you lean the mixture too much, the engine will stall. Turn the Mixture Control rich and restart if this happens. When the engine is running reasonably smoothly, increase the engine speed to about 2000 – 2200 RPM and adjust the Mixture Control again for smoothest running.

If this is the first time you have started the engine you will, of course, want to quickly check for proper oil pressure. If the oil pressure does not come up soon after starting the engine, turn it off and find out why. Always keep the engine revs under 3000 until the oil pressure comes up.

During my initial run, after the engine warmed up I found that the mixture was almost perfect at mid to upper throttle settings, but was rich at low and idle settings. This was with the Mixture Control at the 12 o’clock position. Use mode 1 to adjust the mixture at the low end, starting with the engine at about 2500 RPM. Slowly reduce throttle and adjust the mixture in mode 1 whenever necessary. Remember that simply adjusting the Program Value knob does not change anything. Only when the Program Store switch is pressed does a change take effect.

As mentioned, this was my experience with my particular engine and manifold when using the stock Mazda injectors. If you are running something significantly different, you should first verify that the mixture is roughly correct over the full range of throttle settings. If the mixture cannot be brought into proper range using just the mixture control, you should probably start by adjusting the injector flow rate (Mode 3) until it can be.

The goal we are aiming at with mode 1 programming is to have the mixture remain constant over the entire range of throttle positions without having to adjust the manual Mixture Control knob. Only if you find that you can’t get the mixture lean enough, even with the program knob set at fully CCW position, should you proceed to adjusting the flow rate in mode 3. If necessary, proceed as follows: Let the engine warm up and then select program mode 3 on the Mode Select switch. Because the adjustment of the injector fuel rate is quite sensitive, programming is a little different than in mode 1 or 2. Instead of selecting the value to be stored with the Program Value knob, this knob functions as a step-direction control in mode three. When the knob is turned to the left of the center position, pressing the Program Store switch causes the fuel flow constant to be reduced by one (stepped down). When it is turned to the right of center, the injector fuel flow is increased by one (stepped up). The injector flow rate is stepped up or down by one value every time the store button is pressed, depending on the position of the Program Value knob. It does not matter how far the Program Value knob is turned past center in mode 3, but you can use 9 o’clock and 3 o’clock for left and right settings respectively.

If you inadvertently step the injector flow rate too far, turn the Program Value knob to the other side and step the injector flow rate in the opposite direction.

Note that this adjustment is a very fine adjustment and very little change is done for each push of the program store switch. For instance, it takes about 24 pushes of the button to run the injector flow rate from its default setting to its maximum rate. If one or

two pushes don't get you the result you want, keep pushing! However, most builders find that it only takes 1 – 4 pushes to get the desired results.
You should only have to do this adjustment once unless you make significant changes to your fuel system (different injectors, for instance).

Resetting injector flow rate to factory default settings
To reset flow rate to original settings, perform the following steps:

1. Turn the EC2 power off.
2. Select mode 3 with the Mode Select switch
3. Press and hold the Program Store switch.
4. While holding down the Program Store switch, turn on the power switch to the EC2.
5. Keep holding the Program Store switch for about 1 second, and then release it.
6. The injector flow rate will now be restored to the factory setting and you can begin programming after re-starting the engine, if desired.
7. Return the Mode Select switch to 0.

Note! Adjusting the injector flow rate while in-flight is not recommended! Do this only on the ground!

Program Modes 4 (front rotor mixture adjustments)
There are several reasons why there may be slight differences in the mixture between the two rotors. These include slight differences in the system fuel pressure and small differences in the flow rates of the injectors. By making the mixture on the two rotors individually adjustable, the balance can be made near perfect. This allows the mixture to be run at the optimum point rather that at a "compromise" setting made necessary by mismatched rotors or cylinders. I recommend that you do not make any adjustment to mode 4 until you have the engine running perfectly in all other respects. If you find that there is a large imbalance in rotor mixtures, you should suspect that there is something wrong with the fuel system (a dirty fuel injector for instance). Also be aware that bad EGT sensors (or connections) and bad spark plugs can cause a false indication of rotor mixture imbalance. Use a throttle setting of about 20 – 24" MAP (about cruise throttle setting) to make rotor mixture balance adjustments. Do not attempt to make this adjustment at low throttle or idle speed. Also be aware that the mixture can usually be perfectly balanced at only one power setting. The most logical place to do this is at your normal in-flight cruise setting.

Mode 4 adjusts rotor 1. Remember that rotor 1 is the rotor closest to the front cover and crank angle sensor. The procedure is very similar that of mode 1 except that we are trying to match the readings of the two rotors. You can accomplish this by monitoring the EGTs of the two rotors and getting them to match as closely as possible. A digital EGT gauge is almost a necessity to read small differences. Unless you have separate O_2 sensors in the header pipes of the rotors, the air/fuel gauge will be of no use for this adjustment.

Even before matching the rotor mixtures, there should not be a large difference between EGTs. If there is more than a 100ºF difference, this may indicate a dirty or defective fuel injector. Investigate this possibility before proceeding with engine tuning. Swapping the injectors can help determine which one is causing the mismatch. If there is less than a 20ºF difference between rotor EGTs it is probably not necessary to do any adjustment.

Match the front and rear mixtures by adjusting rotor 1 EGT to match rotor 2 EGT. Turn the Program Value knob slightly richer (clockwise) and press the Program Store switch. Wait for the EGTs to stabilize. If rotor 1 is still leaner, turn the Program Value knob a bit further and try again. Continue this until the EGTs are matched. If the EGTs are closer but still not matched with the Program Value knob set at the fully CW position, it probably indicates a dirty or defective injector or some other problem. When making these adjustments, remember that a lower EGT can mean either a richer or leaner condition on the rotary engine. On piston engines, the EGT almost always goes up when adjusting the mixture leaner and begins to miss if the mixture is leaned much further than the peak. The rotary engine will run smoothly even when the mixture is far leaner than the peak EGT point; so don't assume that the highest EGT indicates the leanest rotor. In fact, at economy cruise condition the opposite is usually the case. If making the mixture richer moves the EGT in the wrong direction, try leaning instead.
01-07-06 update.
Because the rotary has two injectors per rotor and they are staged (see Mode 7 for details on staging), it is possible that the mixture might be miss-matched differently when staged or not staged. You may have to match the EGTs once when the engine is staged (low power) and again when not staged (high power).

Resetting rotor mixtures to factory default settings
1. Turn the EC2 power off.
2. Select mode 4 on the Mode Select switch.
3. Press and hold the Program Store switch.
4. While holding down the Program Store switch, turn on the power switch to the EC2.
5. Keep holding the Program Store switch for about 1 second and then release it.

6. Rotor 1 will now be restored to factory settings and you can begin programming after starting the engine.
7. Return the Mode Select switch to 0.

Program Mode 6 (Secondary injector differential adjustment)

Some of the Mazda rotary engines produced after 1989 (especially the 2004 and later Renesis engines) had larger injectors for the secondaries. This will result in an overly rich mixture above the staging point since the EC2 assumes that all the injectors are the same size (flow rate). If your engine is equipped with larger secondaries, Mode 6 can be used to balance the mixture above the staging point. It is also suggested that the staging point be set higher when using large secondaries. A setting of about 19" Hg MAP is a good starting point.

If you need to adjust for larger secondaries, follow these instructions. This should be performed immediately after you have checked the Mode 3 setting and adjusted it if necessary (see Mode 3 instructions)
1. With the engine running below the staging point, (I would suggest about 14 – 15" Hg manifold pressure) and the mixture monitor indicating mid scale, select mode 6 and turn the program knob slightly to the left of 12:00 position and press the program store switch. Now advance the throttle to above the staging point (~ 20" Hg) and observe the mixture.
2. If the mixture goes richer, turn the program knob a little further to the left and push program store again. Keep the throttle setting at this point (above staging point) and repeat this step until the mixture monitor indicates a mid-scale reading. If you go too far and the mixture goes lean, turn the program knob a little to the right and hit program store again. Keep making small adjustments until you get a mid-scale mixture reading.

Program Mode 7

Mode 7 is used to set the manifold pressure where the EC2 switches from using just the two primary injectors to using all four. This is called the injector staging point. The 2 primary injectors are used when the manifold pressure is below the set point. The EC2 comes preset with the staging set-point at 15.5 " Hg. manifold pressure. I would not recommend that this adjustment be changed unless you have a specific reason to do so. See comments above in Mode 6 about when setting the staging point with large secondary injectors if your engine is so equipped.

The only reason you might want to change this setting is if staging happens to occur at a throttle setting that you want to cruise at. If the engine is running at exactly where the staging set point is, the engine could fluctuate between using 2 and 4 injectors. This may cause the mixture to vary slightly and you might notice a slight surging as the engine switches between the two modes. This in itself is not a problem for the engine but any time the engine changes its hum, even if the change is very slight, it can make the pilot nervous.

Normally, 15" of manifold pressure is well below the point where cruise flight would take place. A possible exception is when cruising at low throttle settings at high altitude. If during this flight condition you encounter this phenomenon, select mode 7 and reduce throttle to get the manifold pressure below where you want to cruise. Press the program store switch and the set-point will be set to the current manifold pressure. Reset the mode switch to 0, return to the desired cruise throttle setting and continue normal flight. The staging set-point will remain at the new setting even after the EC2 is turned off so this should only have to be done once.

Program Mode 8

Mode 8 is used to adjust the nominal ignition timing. You should not make any adjustments in mode 8 until you have timed the engine statically as described on page 4 in INITIAL TIMING ADJUSTMENT. Using Mode 8 you can vary the entire range of ignition timing at all engine speeds up or down (advance or retard) by up to 9.375 degrees. This has exactly the same effect as loosening the locking bolt on the crank angle sensor and turning it. This can be a powerful tool that gives you the ability to try different ignition timing under actual flight conditions. Obviously you should use great caution when doing this. Too much ignition advance can damage an engine so use it sparingly and immediately retard the timing if the engine reacts adversely to an advance adjustment. I would suggest only trying the adjustment on one controller (A or B) until you are certain the adjustment is an improvement. You can immediately go back to known safe ignition timing by selecting the other controller.

The controller comes preset to 0 (no change to timing). If you want to advance the timing you would select mode 8 on the program mode switch, turn the program knob clockwise past 12 o-clock and press the program store switch. The ignition timing will be advanced 1.875 degrees every time you push the store switch up to a limit of 9.375 degrees (5 presses of the switch when starting at 0). Pressing the switch after the advance limit of 9.375 degrees will have no effect. To retard the timing, turn the program knob counterclockwise past 12:00 and press the program store switch. The ignition timing will be retarded 1.875 degrees every time you push the store switch up to a limit of 9.375 degrees (5 presses of the switch when starting at 0). Pressing the switch after the retard limit of 9.375 degrees will have no effect. Note that the engine will occasionally skip an ignition cycle when programming ignition advance, especially when running at high rpm. This is normal and the engine should continue to run properly afterward.

If you want to reset the Mode 8 ignition adjustment to 0, this can be done in two ways. While the engine is running, turn the program knob counterclockwise past 12:00 (retard position) and press the program store switch 10 times. This will insure that it is in the maximum retarded setting. Then turn the program knob clockwise past 12:00 (advance position) and press the program store switch 5 times which will set it at 0. The other method is similar to resetting the default condition in some of the other program modes and requires that the engine and controller be turned off first.

Mode 8 adjusts the nominal or overall timing of the ignition but there are many other factors involved what the actual ignition timing is under various conditions. In addition to an RPM dependant advance curve, the EC2 has a built in manifold pressure advance – retard curve developed over years of testing. It advances the timing at lower manifold pressures (< 24” Hg) and on turbocharged engines it retards the ignition timing at manifold pressures above 32” Hg. When Mode 8 is at it’s default setting and static timing is set as described in Initial Timing instructions, timing is retarded to 14 deg BTDC by the time manifold pressure reaches 62” Hg.

Resetting Programmable ignition adjustment to factory default setting (0 - Center of adjustment range)

1. Turn the EC2 power off.
2. Select mode 8 on the Mode Select switch.
3. Press and hold the Program Store switch.
4. While holding down the Program Store switch, turn on the power switch to the EC2.
5. Keep holding the Program Store switch for about 1 second and then release it.
6. Programmable ignition adjustment will now be restored to factory setting of 0.
7. Return the Mode Select switch to 0.

Program Mode 9 Adjust MAP table entry

Program Mode 9 is similar to Mode 1 but is used to make finer adjustments. Mode 1 should be used to make the initial MAP table corrections on the ground but you will no doubt find that later in actual use, there will be minor corrections necessary.

The following is a common scenario when trying to make these future corrections with Mode 1.

You notice a certain throttle setting where the mixture goes too rich or too lean and decide to correct it. The problem is that you can’t remember what position the program knob was in when this throttle position was initially programmed. If your first guess is wrong and the program knob is far away from the initial position, the mixture will change radically which could cause the engine to stumble or miss. When this happens, the engine rpm will drop which in turn changes the manifold pressure. When the manifold pressure changes, the current MAP table address in use will also change. Since the new MAP table entry was not the one you just fouled up, the engine will again run smoothly and pickup rpm. As it does, the manifold pressure will return to the point where it was when you made the bad adjustment. And of course the engine will again begin to stumble or miss, the rpm will fall, etc, etc... This cycle will continue until the throttle position is changed to a point where the MAP table has not been fouled up. This can be very disconcerting if it occurs while in-flight

Mode 9 was designed to eliminate this problem. Rather than setting the MAP table entry to the absolute setting of the program variable knob as in Mode 1, Mode 9 makes small adjustments to the MAP table entry by an amount proportional to the position of the program knob. If the pointer is close to 12:00, a small adjustment is made. If the position is all the way left or right of 12:00, a larger adjustment is made. Left of 12:00 is for leaning and right of 12:00 is for richening. If the knob is in the exact center position at 12:00, no adjustment would be made.

Let’s say that at some throttle setting the engine is leaner than you want. While in mode 9, you would turn the program knob clockwise (Right) from the 12:00 position and press the Program Store switch. The mixture will be adjusted richer by an amount proportional to how far clockwise from 12:00 the program knob is set. If the change is not enough, press the Program Store switch again and the mixture will be richened a similar amount. Keep doing this until the desired mixture adjustment is achieved. If you over correct and make the mixture too rich, turn the Program Knob counter-clockwise past 12:00 and press the Program Store switch until the mixture is proper. To make finer adjustments, move the program variable knob closer to the 12:00 position. A little practice will have you making precise adjustments in no time.

For the reasons mentioned above, I recommend using Mode 9 to make all in-flight MAP Table adjustment. Setting up the EC2 to the best possible state is an iterative process that often takes many flights to accomplish. During this time, you may want to leave the mode selector in Mode 9 during flight. Any time you notice a particular throttle setting where the mixture runs leaner or richer than desired, hold that throttle setting and set the Program knob to a fairly small change setting (10 – 11 o-clock to lean or 1 – 2 o-clock to richen). Then hit the program store switch button until the mixture is corrected to where you want it. If you over correct, just turn the program knob to the other side of 12:00 and hit program store again.

Also note that the range of MAP table entries affected is the same as in Mode 1. Mode 2 can be used to adjust the range of adjustment in Mode 1 and Mode 9.

Programming Tip

Any time you are operating the EC2 and suspect a rich or lean condition or some other anomaly, your first instinct should be to adjust the manual Mixture Control to confirm or eliminate mixture as the cause of the condition. By adjusting the Mixture Control, you learn exactly how the engine reacts to various mixture changes under different operating conditions. This enables you to make better and more accurate programming changes and set the EC2 for best possible fuel economy and power.

First Engine Start

Before running the engine it is best to do a couple of tests to make sure the controller is hooked up and working properly. Remove one or two sparkplugs from the engine (or use a couple of spares) and lay them on the engine so the metal body of the plug is in contact with the engine. Connect them to the ignition coils with a plug wire. With the fuel pumps turned off, engage the starter and watch the spark plugs for sparks. If you are not getting any sparks there is no use in attempting to start the engine. To eliminate the possibility that the problem is the EC2 itself, select the B (backup) controller by setting the controller select switch on the PCM to the up position (B) and test for spark again. If you still have no spark, follow the instructions in the section on Troubleshooting.

On your first engine start you will, of course, want to quickly check for proper oil pressure. If the oil pressure does not come up soon (10 – 20 seconds) after starting the engine, turn it off and find out why. Always keep the engine revs under 3000 until the oil pressure comes up.

During my initial run, after the engine warmed up I found that the mixture was almost perfect at mid to upper throttle settings, but was rich at low and idle settings. This was with the Mixture Control at the 12 o'clock position. If your mixture is way off at full throttle, see the instructions for Mode 3.

Use mode 1 to adjust the mixture at the low end, starting with the engine at about 2500 RPM. Slowly reduce throttle and adjust the mixture in mode 1 whenever necessary. Remember that simply adjusting the Program Value knob does not change anything. Only when the Program Store switch is pressed does a change take effect.

The goal we are aiming at with mode 1 programming is to have the mixture remain constant over the entire range of throttle positions without having to adjust the manual Mixture Control knob. Only if you find that the mixture is way off at full throttle should you proceed to adjusting the flow rate in mode 3.

Troubleshooting :

A complete course on engine trouble shooting would be too long to include in these instructions but if your engine fails to run, here are a few easy things to check in order to verify that the EC2 is functioning properly. This will NOT verify that you don't have other various installation errors such as wiring errors, fuel system plumbing or component problems, bad crank sensor, etc.

1. Try the other controller. The EC2 contains two independent engine controllers. To eliminate the EC2 itself as the cause of the problem, try the other controller by moving the A / B selector switch on the PCM panel to the other position. It is very unlikely that two controllers will fail at the exact same time and in the same way.
2. With the Mode switch in Mode 0, press the Store switch (Primer function) and listen for the click of the injectors. If they click, you at least know that the EC2 is getting power and is waiting for the crank sensor signal to start operating.
3. If you didn't hear the injector click in step 2 above, it may be that the click of the Store switch covered up the sound of the injectors clicking. Now turn off your fuel pump. Put the Mode switch in Mode 1 and press the Store switch. This puts the EC2 in injector diagnostic mode. All the injectors should now be continuously firing as if the engine were running at around 3000 RPM and should be easily heard. The fuel pump should be off to avoid flooding the engine. A long screwdriver with the handle lightly pressed against your ear and the tip against each injector makes a good make-shift stethoscope for verifying each injector operation. To end this diagnostic mode, change the Mode switch selection or cycle the power off on the EC2.
4. If all was normal up to this point, the problem may be ignition rather than fuel delivery. Remove all the spark plugs from the engine (or connect the plug wires to spare plugs) and lay them on the engine where you can see the spark gaps. Make sure the body of the plug is in contact with something grounded to the engine. Now put the Mode switch in Mode 8 and press the Store switch. This puts the EC2 in ignition diagnostic mode and fires all the coils as if the engine were running at about 3000 RPM. You should see all plugs firing. To end this diagnostic mode, change the Mode switch selection or cycle the power off on the EC2.
5. If all tests up to this point were normal, and you don't have any fuel system problems, the problem is most likely in the crank sensor circuit. Check the wiring in this area carefully for errors.

A WORD OF CAUTION!

Having the ability to program the EFI controller under actual flight conditions is an extremely powerful and necessary tool. In my opinion, an EFI intended for flight could never be optimally programmed while on the ground. This is one reason that I did not choose to program the EC2 using a laptop computer like many other EFI controllers on the market. The cockpit is no place to be fumbling around with a computer keyboard, especially while in-flight.

But, like any powerful tool, the EC2 programming panel can hurt you if used improperly. Although it is not likely, it is possible to miss-program the EC2 in such a way that the engine will stop. For this reason, it is suggested that the backup "B" controller be left in a known good state of tune whenever making changes to the primary "A" controller. Be prepared to immediately switch to the backup controller if you should inadvertently miss-program the "A" controller. You should avoid using program mode 3 (injector flow rate) during flight. This mode should be programmed on the ground because it is more likely to cause the engine to stop if adjusted too far.

In your early flight tests, I would suggest that you program the EC2 as well as possible on the ground and leave it alone until you are comfortable with the operation of your airplane and the EC2. The engine should run smoothly throughout the throttle range before flight is attempted. During your early flights, if the mixture is far enough off under certain conditions that you must correct it, make the adjustment with the manual Mixture Control and leave the programming for later. Do your fine-tuning of the MAP table AFTER you are fully comfortable flying your airplane. Your life is far more important than getting maximum fuel economy.

An air/fuel monitor is especially useful during the initial hours of operation. A brief glance will tell you if the mixture is too rich or lean and you can correct it immediately with a quick adjustment of the Mixture Control. If the monitor is in the green or yellow range (in the center), you don't need to worry about it.

Installing Update chip instructions

If you received these instructions with updated controller chips, read the following instructions carefully.
Remove the two socketed chips on the circuit board using a PLCC chip remover. If you do not have this tool, the chips may be removed by forming a small hook in the end of a paper clip wire using needle nosed pliers.

Orient the board so that the MAP sensor hose connections are pointing up. Insert the PLCC removal tool or hook under the upper left and/or the lower right corner of the chip and pull straight up.

Now locate the small dimple in one of the beveled edges of the new update chips. A magnifying glass is helpful here. The side with the dimpled edge must go on the right side of the socket when the board is oriented as described above. Position the chip exactly in the center of the socket and then press down evenly to seat the chip in the socket.

Replace both chips as described above.
Note that after performing this update the setup and MAP table programming will have to be done again due to the new features incorporated into the latest version of the EC2 software. See the updated instructions for details.
If you are not comfortable performing this operation, send the EC2 with return shipping costs and insurance ($15.00 in most areas) and we will update the EC2 and test it.

More to Come

Check our website at www.rotaryaviation.com for information and details on our engine monitor instrument (EM2) that will connect to the EC2 and display fuel flow (GPH), total fuel burn, miles per gallon (MPG), manifold pressure, RPM, temperatures and other engine information.
Happy flying from all (three) of us here at Real World Solutions.

Tracy Crook, Real World Solutions Inc.
5500 N.W. 72nd Way, Bell FL, 32619 386 935-2973

EC2 Engine Controller Terminal Assignments and Destinations

EC2 CONNECTOR PIN		DESTINATION
1. Ground connection for air temp sensor		One lead of air temp sensor (leads are interchangeable)
2. Rotor 2 trailing coil ignition control		Pin C on rotor 2 trailing igniter coil module.
3. Rotor 1 trailing coil ignition control		Pin C on rotor 1 trailing igniter coil module.
4. Crank Angle Sensor (CAS) 2		Red wire on Mazda Crank Angle Sensor (CAS)
5. Mode Select switch 0		Pin 11 on the Programming & Control Module (PCM) connector
6. Mode Select switch 1		Pin 3 on PCM connector
7. Serial Data out		Data link to engine monitor P2-11 (if used) (early EM2 P4-6)
8. N/C		No connection
9. N/C		No connection
10. Mode Select switch 3		Pin 4 on PCM connector
11. (Vcc)		No Connection
12. Disable leading coil	=	Top pole on Coil Test switch
13. Disable trailing coil	=	Bottom pole on Coil Test switch
14. Control panel power (Vcc3)		Pin 7 on PCM connector
15. A/B (Controller) Select switch		Pin 5 on PCM connector
16. Ground		Pin 1 on PCM connector
17. Rotor 1 primary injector	*	Rotor 1 primary injector (Note! Also wired to EM2 P3-6 if used.)
18. Rotor 1 secondary injector	*	Rotor 1 secondary injector (outside port on rotor 1)
19. Injector return	*	Ground on airframe near EC2 (See section on "Fuel Injector Wiring")
20. Rotor 2 Leading coil ignition control		Pin C on rotor 2 leading igniter coil module.
21. Rotor 1 Leading coil ignition control		Pin C on rotor 1leading igniter coil module.
22. Crank Angle Sensor (CAS) return	#	White wire **and** white with black stripe wire on CAS
23. Crank Angle Sensor (CAS) sensor 1		Green wire on Mazda Crank Angle Sensor
24. Mode Select switch 2		Pin 10 on PCM connector
25. Program voltage		Pin 9 on PCM connector
26. Mixture Control voltage		Pin 15 on PCM connector
27. Serial data in		Data link to engine monitor (if used) P2-24 (Early EM2 P4-5)
28. Future connection to fuel flow instrument (O2 sensor)		Install wire but do not connect at this time (insulate wire)
29. N/C Former tach connection, now obsolete		No Connection
30. Cold Start switch		Pin 13 on PCM connector (And injector disable switches if used)
31. Inlet air temperature sensor		Air temperature sensor (either wire)
32. Program Store switch		Pin 2 on PCM connector
33. Controller power (+12 volts)		To controller power switch
34. Controller power (+12 volts)		To controller power switch
35. Rotor 2 secondary injector	*	Rotor 2 secondary injector (outside port on rotor 2)
36. Rotor 2 primary injector	*	Rotor 2 primary injector (inside port on rotor 2)
37. Injector return	*	Ground on airframe near EC2 (See section on "Fuel Injector Wiring)

* Indicates connection to be wired with 20-gauge wire. Make all other connections using 22-gauge wire. Twenty (20) gauge wire needs to be used for these six specific connections; however, <u>do not use 20 gauge wire for all connections or the back shell will not fit on the connector.</u>

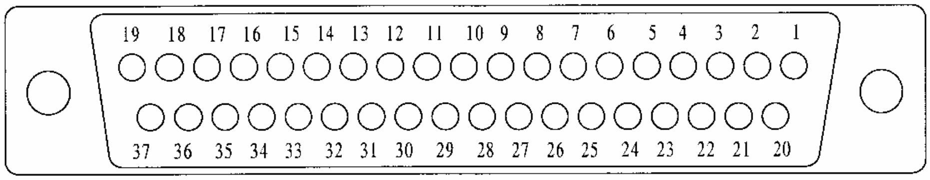
= The center (common) connection of the SPDT Coil Test switch is a ground connection. Connect it to a 22-gauge wire and terminate it with a circle lug connected to the grounding stud on the EC2 case. The shield for the crank angle sensor (CAS) wires should also be grounded here.

Do not attempt to solder two wires directly to the connector. Splice the two return lines of the CAS together near the CAS and connect them to the EC2 with a single wire. Note that the wires between the CAS and EC2 should be shielded.

The early EM2 refers to the version made in 2 separate modules. The current version is a single module.

Rear View of EC2 mating connector (solder terminal end).

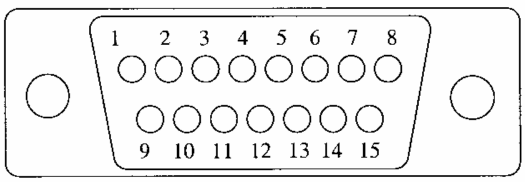
MALE PLUG (For EC2 Controller)



NOTE! The Male & Female connectors are numbered in opposite directions when viewed from the back side (side with solder connections).

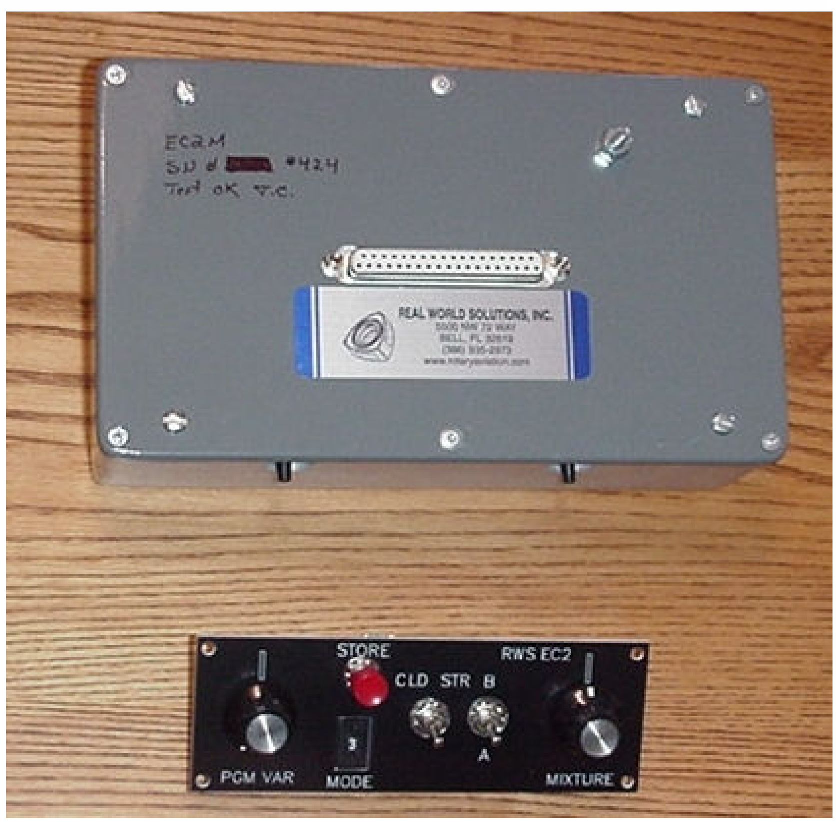
Rear View of EC2 program & control module (PCM) connector (solder terminal end).

FEMALE CONNECTOR (For PCM)

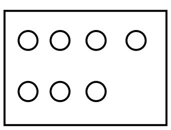


Refer to the wiring list in the instructions when wiring these connectors.

Dimensions of the EC2 are .625 X 4.5 X 2.3. The two slots at the bottom of the case are for the two manifold pressure hose connections. Make SURE the sensors line up with these slots when reinstalling the controller. We suggest that the hoses be installed and secured with small tie wraps before putting the controller and top on the case.



AC Delco D580 igniter
Wiring instructions for the 7 pin GM harness connector (if used).



View looking into 7 pin male connector on harness
Top Row, Left to Right:
1. Pink wire To +12V power for coils.
2. Purple wire To Rotor 1 Lead coil control Pin 21 on EC2
3. Blue wire To Rotor 1 Trail coil control Pin 3 on EC2
4. Brown wire To Ground stud on EC2 (B terminals of coils)

Bottom Row, Left to Right:
1. Black wire To ground on engine block (A terminals of coils)
2. Red wire To Rotor 2 Trail coil control, Pin 2 on EC2
3. Green wire To Rotor 2 Lead coil control, Pin 20 on EC2

This is the AC Delco igniter module used with the 13B-A version of the EC2. It is the coil used on the 1998 & later LS-1 Corvette engine.

The four connector pins are designated A thru D, starting at the left side as viewed in this picture.

AC Delco part number for this igniter is #D580
GM PN is 12558948

GM also makes a harness with four connectors for these coils. It terminates in a 7 pin connector that can be used for connecting them to the EC2. The GM part number for the harness is 12569111.

The GM part number for the mating 7 pin connector is 12102754
AC Delco PN is PT381

One builder reported the following source for the harness & 7 pin connector:
Bob Roybal
Parts Manager
Jim Fresard Auto Dealerships
1-800-373-7273 ext 56
www.gm-car-parts.com

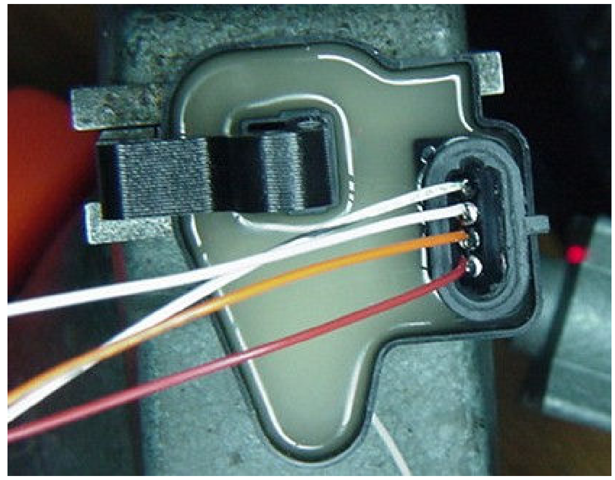
We recently started using the D581 which is electrically the same as the D580 but the connector is different and is on the opposite side from the spark plug connector. This is desirable in some installations. See the photo on the following page for position of pin A on the D581 coil.

These coils can be obtained at Autozone auto supply stores or your local GM dealer. A good on-line source is www.rockauto.com The coil connectors are available in a harness of 4 intended for use on the 2001 GM Silverado truck with 4.8L V8. GM Part number for the harness is 12558693. Price is about $60.00 at GM dealers but they usually have to be ordered as it is not a normally stocked item.

An alternative to using connectors is to wrap stranded wires around the terminal pins and solder them. Use different colored wire or some other method to identify the terminals. Bundle the wires in heat shrink tubing for strain relief then fill the recessed cavity with epoxy.

The connector for the coil spark plug wire is a bit different than most so you may want to buy a sparkplug wire set to go with them. The part number is not known but they are the plug wires for the 1998 Corvette LS-1 engine. Any GM dealer should have them. Some builders have gotten wires from MSD that fit the LS-1 coils so this may be another source for them. Other builders have simply used a universal ignition wire kit and squeezed down a standard plug wire connector so that it snapped onto the male connector contact. in the coil wire socket.

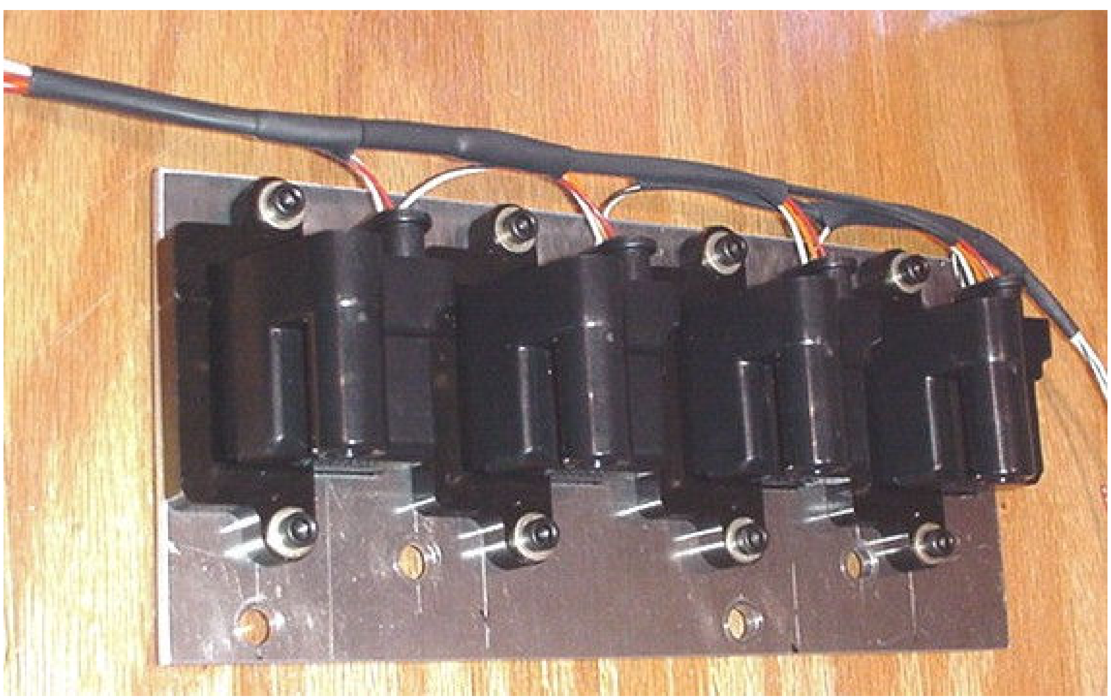
AC Delco D581 igniter



D581 igniter with soldered wires. Terminal A is at top.

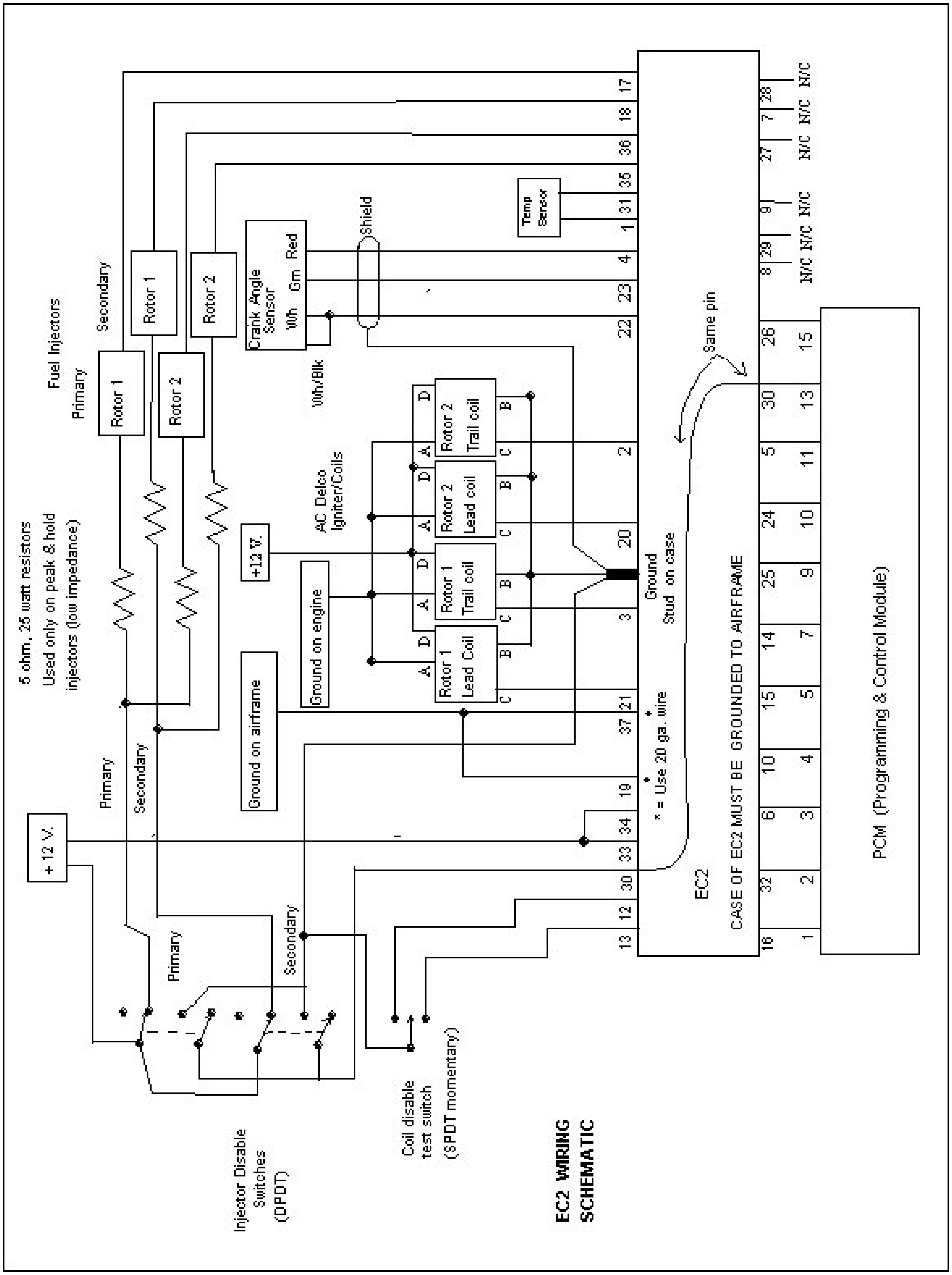
This is the alternate AC Delco coil. It was used on GMC pickup trucks equipped with the LS1 engine. It is electrically equivalent to the D580 Corvette coil except that the sparkplug wire connector points in the opposite direction from the ECU connector. The ECU connector body has already been sawed off about ¼" shorter in these photos in order to make it easier to solder wires to the terminals. We chose to do this in order to simplify the wiring harness (fewer connectors) and to eliminate the high cost of the factory connectors. The connector cavity will be filled with epoxy to relieve stress on the soldered wires.

When soldering wires to the terminals, strip about ½ inch of insulation then lightly pre-tin the stranded wire core. Wrap the tined wire tightly around a 1/16" hex-key (Allen) wrench then slide the wrapped end off the wrench. It will be just the right size for sliding over the coil terminals. To insure proper spacing between the soldered joints, position the first wire low on the pin and the next wire high on the pin, etc. Use 22 ga. wire.

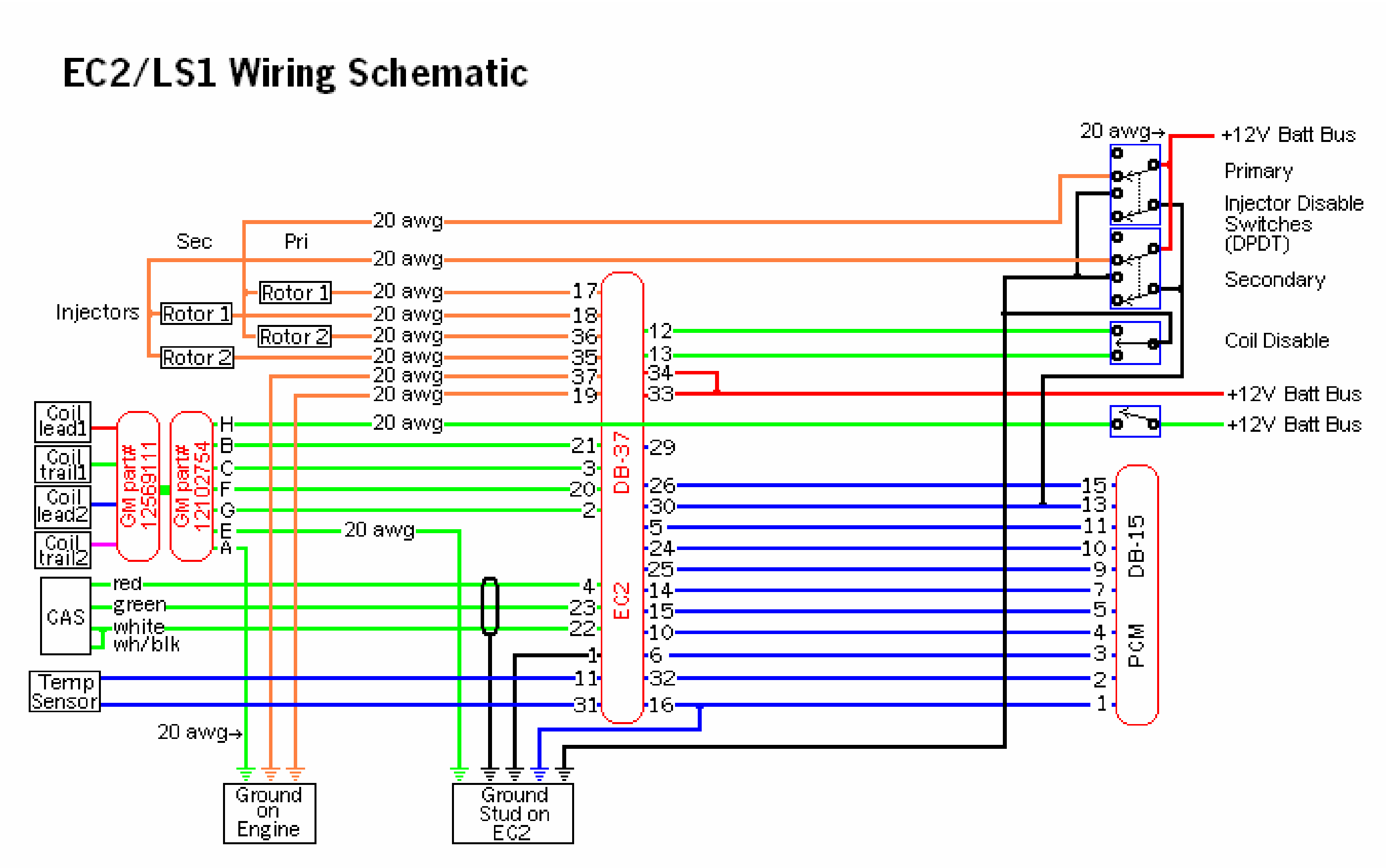


Here is the completed coil assembly we made for our Renesis engine installation. Note that the four 'A' terminal lines are routed separately (right side) and will be grounded to the engine block using a ring terminal. The other leads (left) were wired to an in-line connector. We used a 15 pin subminiature D but any suitable connector can be used.

The four holes seen in the 3/16" aluminum plate match up with the 4 threaded holes in the top of the rotor housings. This makes for a neat and compact installation but requires the use of an intake manifold that does not wrap over the top of the engine.

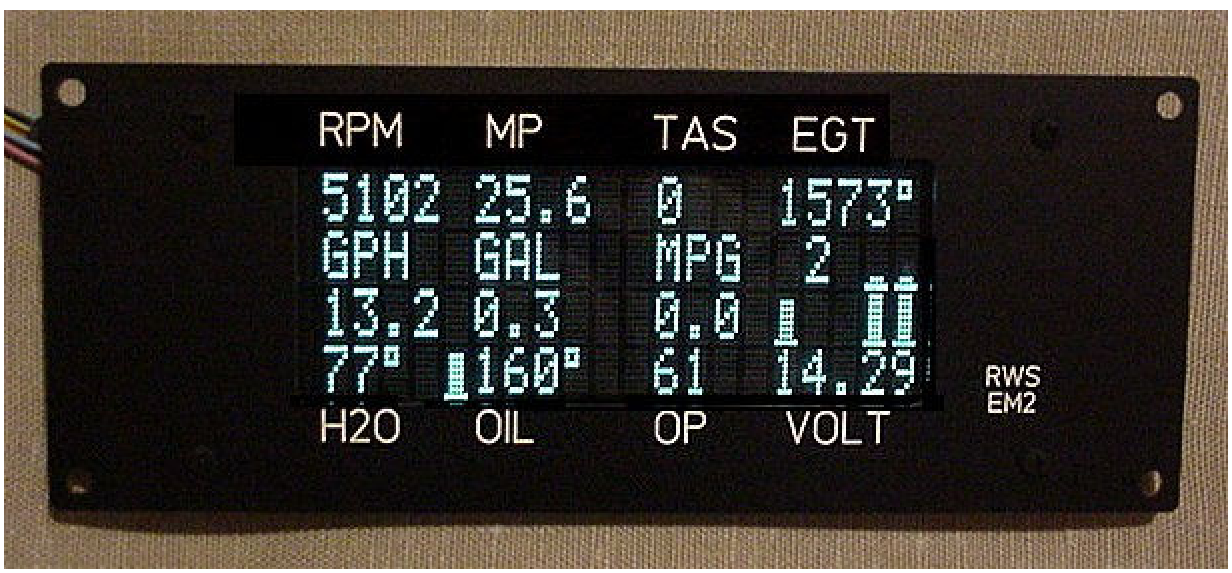


5 ohm, 25 watt resistors
Used only on peak & hold
injectors (low impedance)
Fuel Injectors
Primary
Secondary
Rotor 1
Rotor 2
Rotor 1
Rotor 2
Crank Angle Sensor
Wh Grn Red
Wh/Blk
Shield
Temp Sensor
AC Delco Igniter/Coils
+12 V.
Ground on engine
Ground on airframe
Rotor 1 Lead Coil
Rotor 1 Trail coil
Rotor 2 Lead coil
Rotor 2 Trail coil
A
B
C
D
Ground Stud on case
Same pin
* = Use 20 ga. wire
+ 12 V.
Primary
Secondary
Primary
Secondary
Injector Disable Switches (DPDT)
Coil disable test switch (SPDT momentary)
EC2
CASE OF EC2 MUST BE GROUNDED TO AIRFRAME
PCM (Programming & Control Module)
17 18 36 35 31 1 4 23 22 2 20 3 21 37 19 34 33 30 12 13
28 7 27 9 29 8 26 30 5 24 25 14 15 10 6 32 16
15 13 11 10 9 7 5 4 3 2 1
N/C
EC2 WIRING SCHEMATIC

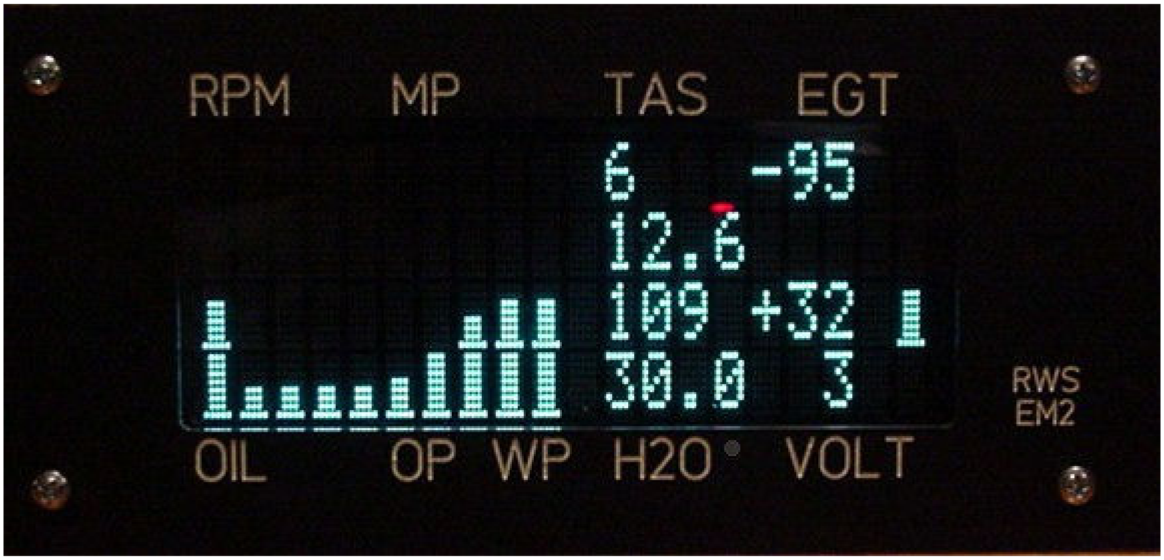


Another version of the wiring schematic showing the use of GM coil wiring harnesses. (courtesy of Richard Martin)) Note that the crank angle sensor wiring shown here is for the 2nd Gen sensor.

If you are in need of an engine monitor we would recommend our EM2 which is designed for use with the EC2 engine controller



. Not only is it a very comprehensive monitor but it makes adjusting the EC2 MAP table a snap by giving a visual representation of the MAP table in the EC2 MAP table mode shown below.



The following is an excerpt of the EM2 Instruction manual explaining this screen.

Understanding the MAP table screen
The display will now show 10 vertical bar graphs on the left and 6 numeric values on the right. The bar graphs represent 10 of the 128 values stored in the EC2 MAP tables.

The Editing area
The top two lines on the right show the selected MAP table information. The upper left number is the MAP table address that is selected for editing by the EM2. Note that the MAP table address starts at 0, not 1. Computers always start counting at 0. To the right of the address is the data contained in that address. Just below the address is the manifold pressure in inches Hg that corresponds to the MAP table address. Although not shown in this photo, to the right of the manifold pressure on line 2, the current static ignition timing adjustment for the EC2 is displayed. This value can be adjusted from the EC2 in mode 8. See Mode 8 in the EC2 setup guide for details.

Note on the left side of the screen that one of the bar graph columns is blinking. This corresponds to the MAP table entry selected for editing. We'll get back to how to edit the MAP table data in a moment but first let's complete our tour of the data presented on the right side of the display

The EC2 data area
The lower two lines on the right side of the display show a MAP table address and data in exactly the same format as described in the editing area. The big difference is that these values are the ones currently being used by the EC2 to control the engine. This is real time data so if the engine is running, you will see the MAP table address and manifold pressure change when the throttle is changed. You can't edit the data displayed here but you can use it to identify where you need to set the editing address on the upper two lines in order to correct a mixture problem.

To the right of the manifold pressure on line 4 the current staging status of the EC2 is displayed. If the EC2 is staging (only 2 primary injectors being used) an asterisk (*) will be displayed. It will be blank if not staging. This can be useful when tuning the EC2 near the staging point to determine where the staging point is and which side of the staging point needs to be adjusted.

Mixture Display
The final item on the screen is a single bar graph on the far right side of the display. This is a real time display of the mixture. It is the same as the mixture bar shown on the main instrument display. This allows you to see whether the mixture is too rich or too lean in a problem spot. The mixture display is valid only when the engine is running because it depends on the gases sensed by the O2 sensor in the exhaust system. O2 sensors only work when heated to around 700 deg. F or higher.

Auto-Program Mode A new feature of the EM2 on units built after 3-20-05 is the auto-program mode. This feature enables the EM2 to automatically optimize the MAP table by monitoring the mixture and making the appropriate adjustments to the EC2 MAP table. In order to work, it requires that an O2 sensor be installed and connected to the EM2's mixture monitor input.