Sender: root@albatross.prod.itd.earthlink.net
Date: Mon, 17 Sep 2001 18:33:41 -0700
From: ACRE NL <rotaryeng@earthlink.net>
X-Mailer: Mozilla 4.72 [en] (X11; U; Linux 2.2.14-5.0 i586)
X-Accept-Language: en
Subject: D'oh! EC2 wire list error

> Thought this might be the quickest way to get the word out to many of the
> EC2 users out there.
>
> There is an ERROR on the EC2 wiring list. I will be sending all owners the
> corrected sheets but here's a heads up so you can correct it now. The pins
> #10 and #24 are reversed on the EC2 connector. If it is easier, you can
> reverse pins 4 and 10 at the programming panel instead. This error has the
> effect of disabling program modes 4 thru 8.
>
> Found the error while tracking down an anomoly on Charlie Airesmans' EC2.
> I fly the latest version of the EC2 BUT I'm still using my old EC1 control
> panel which is different. D'oh! What really confused me is that I do bench
> test every EC2 with the same panel that it is shipped with. I had wired
> the test rig up before making the wirelist page of the installation guide
> which is where the error got in.
>
> Tracy Crook
> tcrook@rotaryaviation.com
> www.rotaryaviation.com

The AirCraft Rotary Engine NewsLetter. Powered by Linux.
ACRE NL web site.
http://home.earthlink.net/~rotaryeng/ http://www.linux.org

REAL WORLD SOLUTIONS 13BREW *EC2 ENGINE CONTROLLER* 04-04-01
INSTALLATION AND PROGRAMMING GUIDE (Preliminary) 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
5. 5/32" vacuum line to connect EC2 MAP sensors to manifold vacuum ports
6. 2 DPDT switches rated at 10 or more amps (Switches are optional. See "Injector Failure Backup Mode" for details.)
7. 1 SPDT switch, Momentary contact. (coil test switch)

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 lifetime 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 8 countersunk Phillips head screws around the perimeter 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.

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 small aluminum plate that you can mount as a sub-panel, or you may choose to remove the module from the plate and mount it directly on your instrument panel. If you decide to do this, remove the knobs and mounting nuts from the control module and carefully slide the plate off of the module. You can use the plate as a template for drilling your panel.

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.

If you are not skilled in soldering and wiring and cannot obtain help locally for building the wiring harness, we can do this for you if you furnish all the necessary wire lengths and specifications. Cost for a typical harness will be $150 - $200. Call us for details.

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. You can also glue 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.

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.

You should begin wiring the system together only after the fuel injectors, Mazda 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 he 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 return pins (19 & 37) should be connected to ground where the negative battery terminal is connected to the airframe or to the negative battery terminal itself. These two wires from the EC2 should be as short as possible.

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.

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, CD 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%.

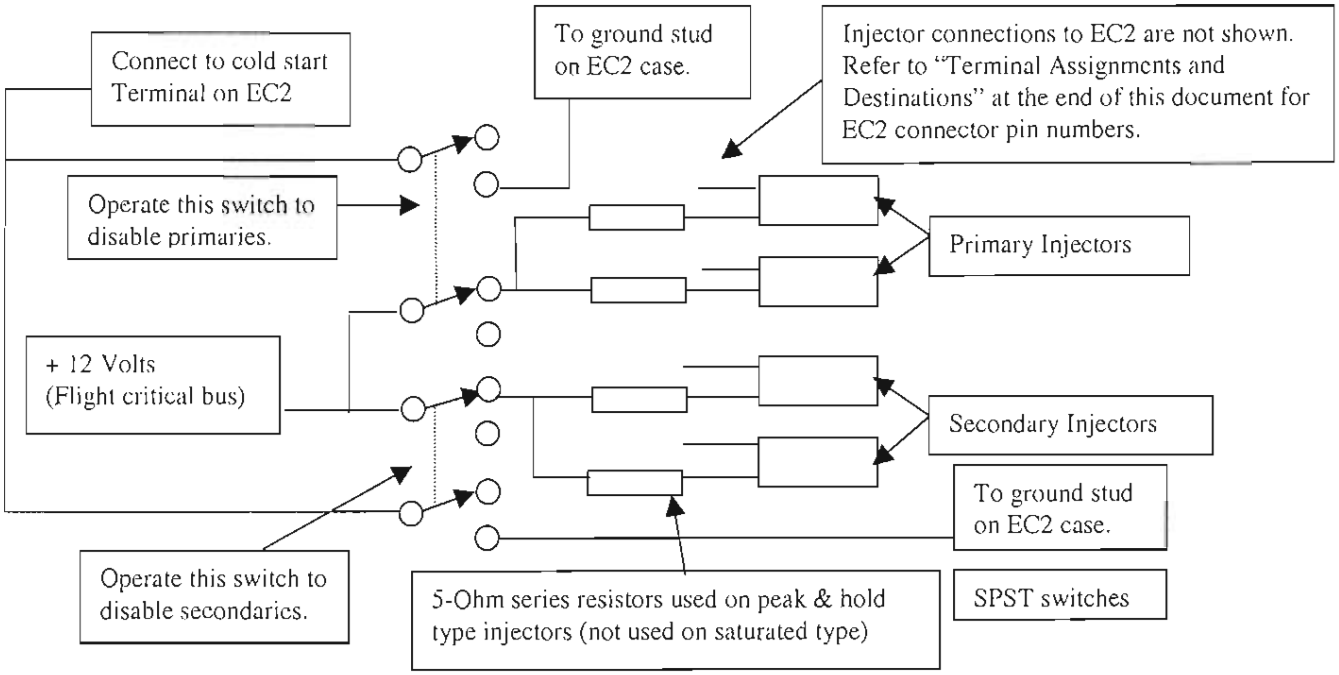


Figure 1 – Fuel Injector Wiring Diagram.

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 Sensors (CAS) are wired to the EC2 connector using 22-gauge wire. There are four wires from the two crank angle sensors but two of them are connected 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. The two wires connected together are the return lines referred to on the wiring list. Connect the shield for the CAS wires to the ground stud on the EC2 controller. Do not ground the shield end near the CAS.

INITIAL TIMING ADJUSTMENT

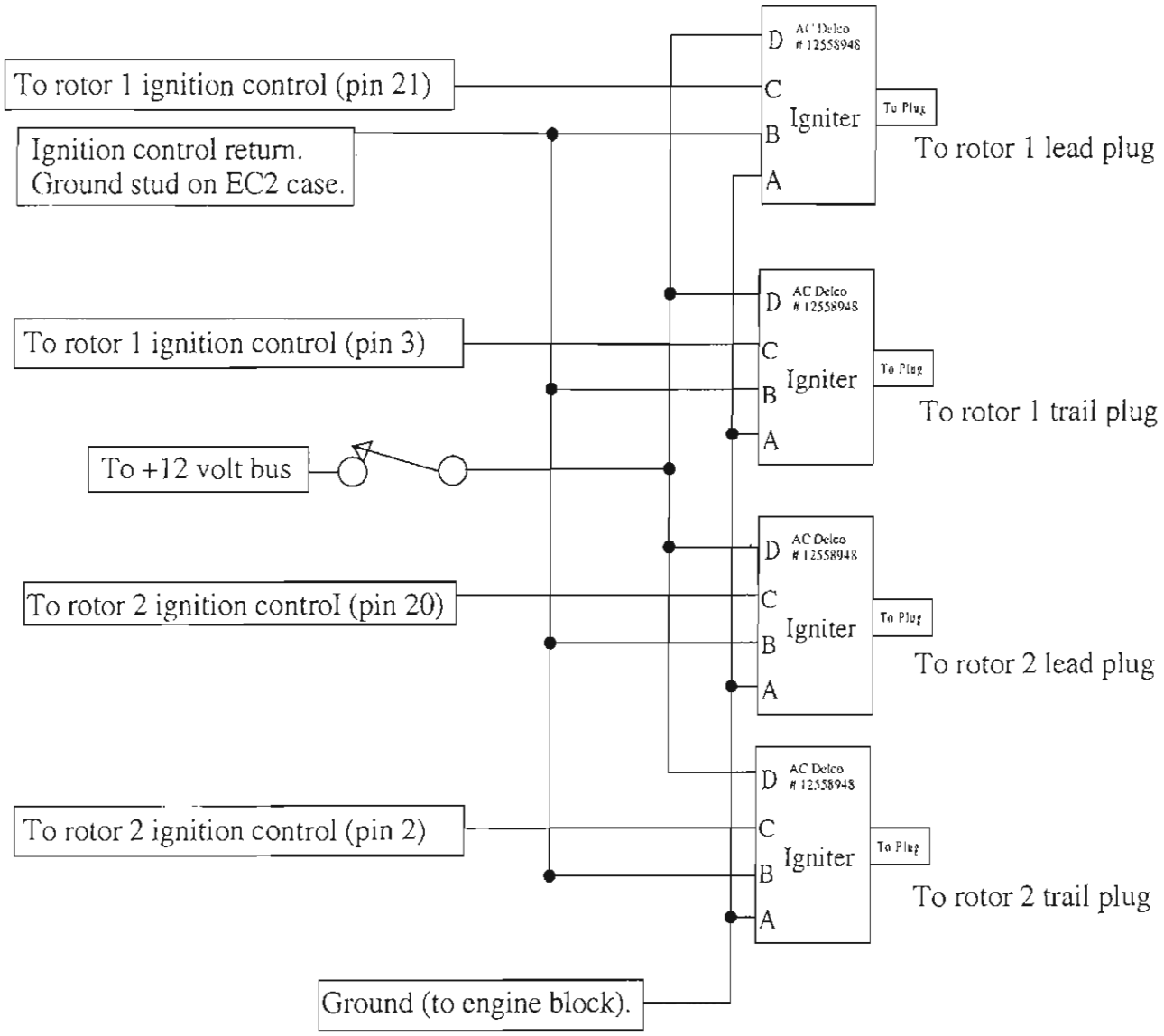
The CAS timing on the 13BREW is not adjustable so no preliminary adjustments are necessary. Final timing should be accomplished by making a new timing mark on the eccentric shaft pulley at 20 deg. Before TDC. Using a timing light, time the **leading** plugs to fire at the new timing mark (20 degrees BTDC) at 5000 RPM with a manifold pressure higher than the threshold set in mode 6. Unless you have reset it to something different, the mode 6 threshold comes programmed at 22" Hg. At manifold pressures lower than the mode 6 threshold, the ignition will advance about 5 degrees. Make any timing adjustments using Mode 8 which is the programmable timing adjustment.

AC Delco IGNITION MODULE WIRING

Wire the GM coil modules as shown on the 13B-A Ignitor 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 135°F 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.

13B-A Igniter wiring diagram. Pin numbers are for EC2 connector.



All Igniters are AC Delco PN # 12558948

TACHOMETER CONNECTION

The Tachometer terminal (pin 29) on the EC2 supplies 12 pulses for every engine revolution. This is designed for driving a high-resolution digital tachometer such as the one in the Grand Rapids EIS (Engine Information System). I like the EIS for the adjustable alarm threshold capability. This saves a lot of time when scanning the instruments. If the bright red light is not on, you know that the critical engine parameters are within limits.

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.

EC2 OPERATING INSTRUCTIONS

The following procedures are to be followed after the EC2 has been setup and optimized using the Programming Procedure. Refer to that section if your engine and the EC2 have never run before. The operating procedure is still under development and will be refined as I continue to gain experience. The following are the procedures I use at this time. If you have additional suggestions or ideas, I would like to hear them.

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 135°F 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. 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.

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 12 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 1750°F (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 50°F 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 1550°F. (about 100°F 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. 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. I mounted the O_2 sensor by drilling and tapping (18mm spark plug thread) a small 3/16" thick plate (about 1.25" square) and welding it to the front of my muffler. This instrument is available from several racing equipment suppliers. These suppliers sell O_2 sensors separately. You can order a kit from us at Real World Solutions consisting of the mixture monitor, an O_2 sensor and a steel sensor mounting bung for welding into your exhaust system are available for $90.00 including shipping. If you need EFI fuel pumps, we can also supply these ($95.00 each).

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.

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 40th 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 injector.

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.

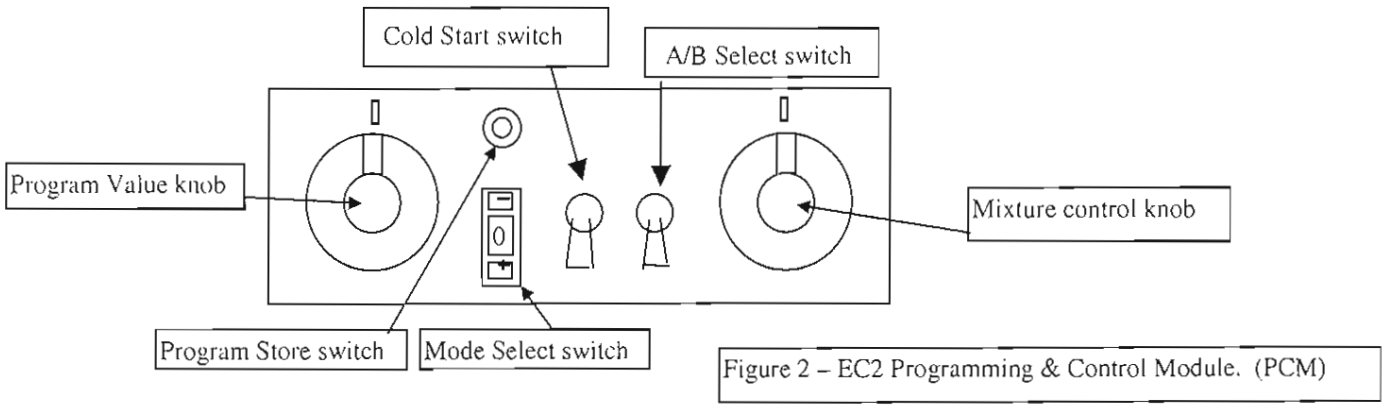


Figure 2 – EC2 Programming & Control Module. (PCM)

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. This is the position it should be set to during normal operation to avoid any "accidental programming." Also note that program modes 1 through 6 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 (three exceptions, for resetting the factory defaults, are detailed later in this section).

Program Mode 1 (programming the MAP table)

This is where you will do 99% of the controller programming. Mode 1 is the function that adjusts the MAP table. Mode 1, and occasionally mode 4 and 5, are the only ones you will likely use while in-flight. 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 adjustment.

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.

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.

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.

Note! Do not even <u>think</u> about resetting the MAP table while in-flight, as it will require you to shut down 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 three; meaning that a range of three MAP table entries will be stored. This means that unless you change the Program Store range using program mode 2, the mixture will be adjusted over 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 the default range of three is optimum for most tuning on the EC2. The following paragraphs will illustrate the procedure required in other possible situations. Use these only if you find that the default setting is not adequate to achieve the result needed.

Let's say you notice that the mixture is too lean from 20 to 23.5 inches of manifold pressure, a range of 3.5 inches. Since there is 1 table entry per ½ inch of manifold pressure, this would require a Program Store range of 7 (the maximum allowed). In program mode 2, the Program Value knob adjusts the Program Store range from 1 (knob fully CCW) to 7 (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 7 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 1.75 inches below to 1.75 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 to 23.5" 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 three. 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.

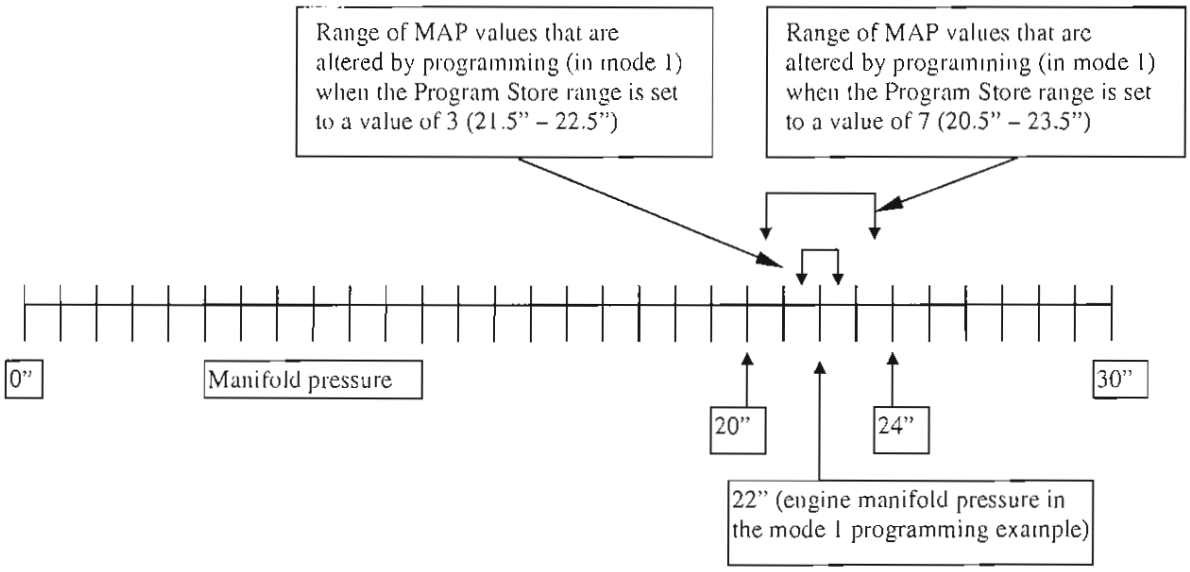


Figure 3 – Illustration of the effect that changing mode 2 (Program Store range) has on mode 1 (MAP table).

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 Mazda 13B injectors. Use the following procedure to adjust the flow rate only if you are unable to properly adjust the mixture using mode 1. For instance, if you find that you are unable to program the mixture lean enough at low throttle settings without turning the manual Mixture Control down, you might want to lower the injector flow rate using mode 3. All programming, especially in mode 3, 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. When the injector flow rate is reduced enough to get the mixture right in this example, you will have to go back and do the mode 1 mixture adjustment at high throttle again. For this reason, it is best to make a rough adjustment of mode 1 mixture corrections to determine whether a mode 3 injector flow rate adjustment is needed. If it is, do the mode 3 adjustments before fine-tuning the mode 1 adjustments.

Here are the actual 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.

Since past experience tells us that the fuel flow might be slightly high (rich) during this first engine run, turn the Program Value knob left to 9 o'clock in order to step the injector flow rate in the lean direction. At this point I assume the Mixture Control will be turned left of center (leaner) in order to get the engine running smoothly. Begin by turning the Mixture Control a little richer (toward the center position). Do not turn it so rich that the engine stumbles and quits, but just far enough to get a rich indication on the air/fuel gauge or EGT gauges. Now press the Program Store switch to decrease the injector fuel flow. You should notice a change in the lean direction on the air/fuel gauge or EGTs. Continue this same procedure until the engine is running smoothly with the Mixture Control in the center (12 o'clock position) and mixture indication on the air/fuel gauge is showing the engine running slightly on the rich side of the mid-point (6 or 7 LEDs lit). It should only take 1 to 4 steps, at most, from the factory setting to get to the correct setting if you are using stock 13B injectors. If you inadvertently step the injector flow rate too far lean and have to turn the Mixture Control on the rich side of center to keep the engine running, set the Program Value knob to 3 o'clock and step the injector flow rate richer until the mixture is correct with the Mixture Control knob set to 12 o'clock.

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 & 5 (front and rear 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 leave this adjustment as is 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.

Mode 4 adjusts rotor 1 and mode 5 adjusts rotor 2. 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 100°F 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 20°F difference between rotor EGTs it is probably not necessary to do any adjustment.

The mixtures can usually be matched by adjusting only one rotor. I usually choose the leanest rotor and adjust it richer to match the other. First select the leanest rotor with the Mode Select switch (mode 4 or 5). Turn the Program Value knob slightly richer (clockwise) and press the Program Store switch. Wait for the EGTs to stabilize. If the selected rotor 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.

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 and rotor 2 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

Mode 6 is used to adjust the vacuum advance point of the EC2 controller. In order to achieve maximum efficiency, the ignition timing is advanced by about 4 degrees when the manifold pressure is relatively low. The point at which this happens is programmable. This point comes pre-set from the factory at 22" Hg manifold pressure. This is approximately the atmospheric pressure at 8000 ft. This is close to the optimum point and I would suggest that you do not change this until you are very familiar with your engine and airplane and have been flying it for some time. If after this time you feel there may be some advantage to adjusting the vacuum advance point, perform the following steps:

1. With the engine running, select mode 6.
2. Adjust the throttle to the manifold pressure at which you want the ignition advance to take effect.
3. Press the Program Store switch.
4. The advance point will now be set to the manifold pressure that was present when you pressed the Program Store switch.
5. Below this pressure, the ignition will be advanced about 4 - 5 degrees. Above this pressure, the ignition advance will be normal.
6. Return the Mode Select switch to 0.

Turbocharged engines often require that the ignition timing be retarded at higher boost levels. Users of the turbocharged version of the EC2 can use this feature as a "turbo retard" function by setting the ignition advance point to the manifold pressure where this would be appropriate. This will usually be around 32" Hg. Manifold pressure. In this case, the ignition timing should be adjusted to about 22 degrees BTDC at 4000 rpm and 30" Hg. (or less) manifold pressure by turning the CAS with the adjusting lock nut loosened. The ignition would then be retarded by the EC2 to about 18 degrees BTDC at the Mode 6 set-point of 32" Hg. The programmable ignition timing should be set at the factory default setting (see mode 8 instructions) before setting this.

This and other turbo related comments in this guide are based on information from automotive turbo experts. I have no personal experience with turbocharging at this time.

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 injector staging. 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" Hg. Manifold pressure. I would not recommend that this adjustment be changed unless you have a specific reason to do so.

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.

Resetting Programmable ignition adjustment to factory default setting (0)

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.

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.

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.

MAP sensor mounting hardware

Some builders have been concerned about the non-locking screws & nuts used to mount the MAP sensors on the EC2. These screws must not be over-tightened to prevent cracking of the sensor. Do not tighten them or replace the nuts with stop-nuts. The plain nuts have been properly tightened and installed with Loc-tite. They are in no danger of coming loose.

More to Come

Watch for more tips on EC2 operation and programming in the Rotary Aviation Newsletter as we gain more experience.

Also watch for progress on our engine monitor instrument that will connect to the EC2 and display fuel flow (GPH), total fuel burn, miles per gallon (MPG), manifold pressure, RPM, and other engine information. You can also watch for this information on our website at www.rotaryaviation.com.

Happy flying from all (both) of us here at Real World Solutions!

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EC2 Engine Controller Terminal Assignments and Destinations 01-24-00

	TERMINAL		DESTINATION
1.	Ground connection		Ground stud on EC2
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.	(NE) Crank Angle Sensor (CAS)	#	Mazda Crank Angle Sensor (12 point sensor)
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		Future connection to engine monitor.
8.	N/C		No connection
9.	N/C		No connection
10.	Mode Select switch 2		Pin 10 on PCM connector
11.	Temperature sensor power (Vcc)		Temp sensor wire (either)
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 (center port on rotor 1)
18.	Rotor 1 secondary injector	*	Rotor 1 secondary injector (outside port on rotor 1)
19.	Injector return	*	Ground on airframe near battery terminal (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) returns	#	Two common lines from G & NE crank angle sensors.
23.	(G) Crank Angle Sensor (CAS)	#	Mazda Crank Angle Sensor 1 (1 point sensor)
24.	Mode Select switch 3		Pin 4 on PCM connector
25.	Program voltage		Pin 9 on PCM connector
26.	Mixture Control voltage		Pin 15 on PCM connector
27.	N/C		No connection
28.	Future connection to fuel flow instrument (O2 sensor)		Install wire but do not connect at this time (insulate wire)
29.	Tachometer output (12 pulses / rev , 12 volt pulse)		Engine Information System (EIS)
30.	Cold Start switch		Pin 13 on PCM conneetor (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 battery terminal (See section on "Fuel Injector Wiring")

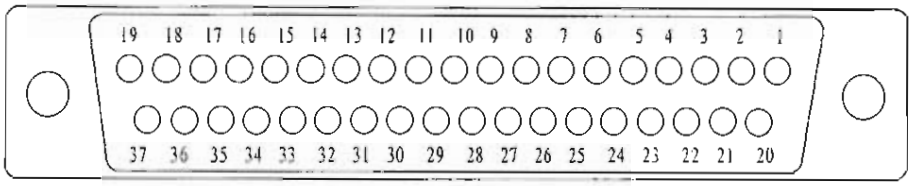
* Indicates connection to be wired with 20-gauge wire. Make all other connections using 22-gauge wire. Twenty (20) gauge wire needs to be used for these six specific connections; however, do not use 20 gauge wire for all connections or the back shell will not fit on the connector.

† 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.

\# Note that the wires between the CAS and EC2 should be shielded.

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

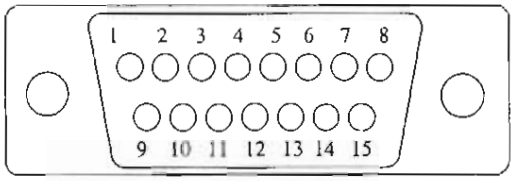
MALE PLUG (For EC2 Controller)



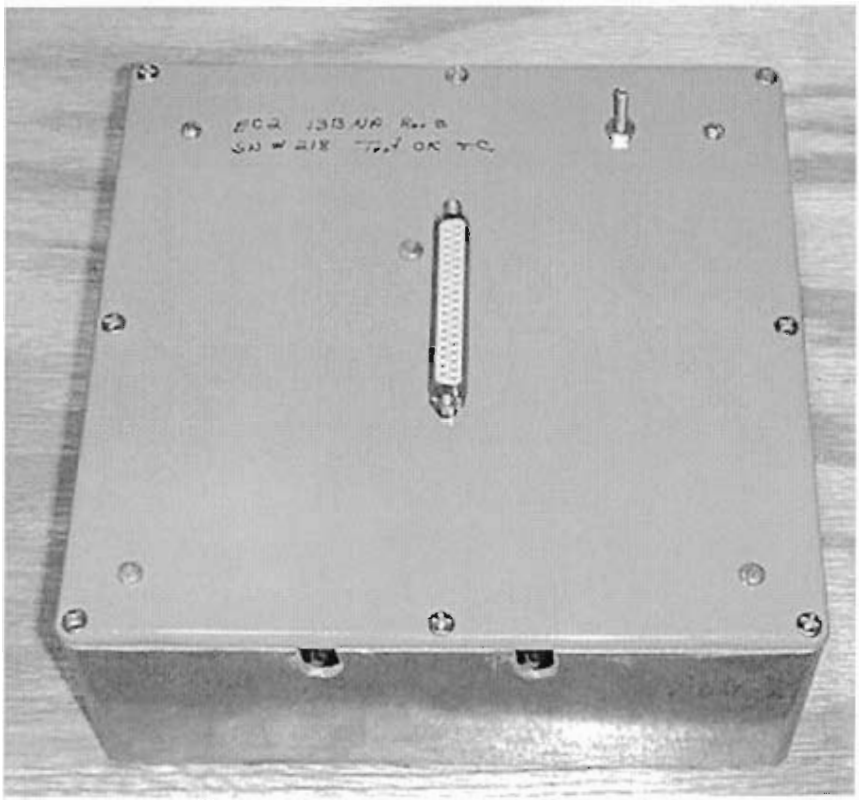
NOTE! The Male & Female connectors are numbered in opposite directions when viewed from the back side (side with solder connections).

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

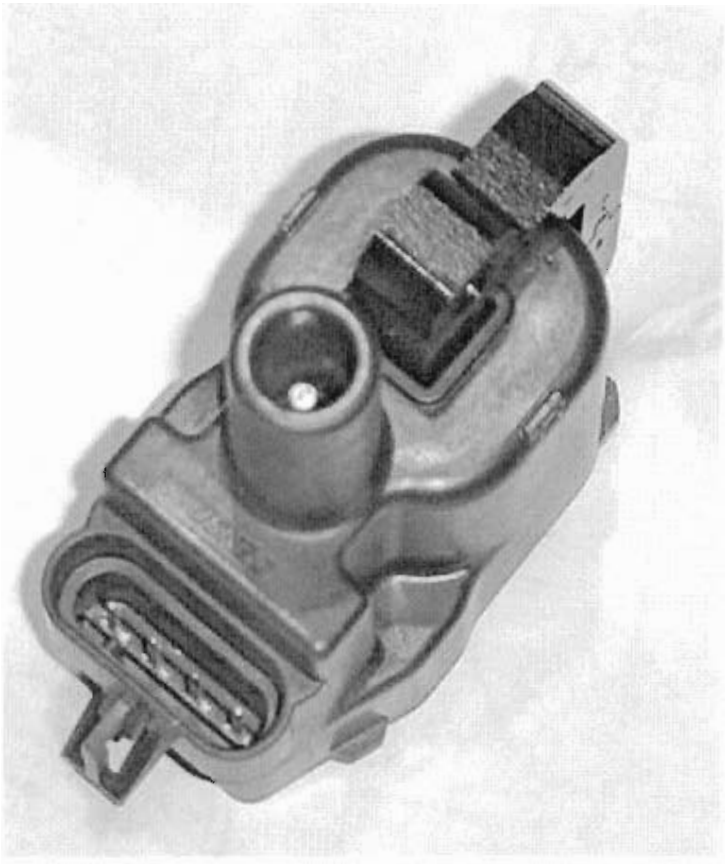
FEMALE CONNECTOR (For PCM)



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



Dimensions of the EC2 are 7 3/8" X 7 3/8" X 2 ½". The two slots at the bottom of enclosure are for the two Manifold pressure hose connections.



This is the AC Delco igniter module to be used with the 13B-A version of the EC2. The four connector pins are designated A thru D, starting at the left side as viewed in this picture.

Connectors for these igniters should be available at your local Chevrolet dealer. This igniter is used on the 1998 Corvette LS1 engine and some other GM cars.

Part # for this igniter is 12558948

These coils can be obtained at Autozone auto supply stores ($37.00) or your local Chevy dealer. The cost is lower at Autozone. So far the only source for the connectors is at Chevy dealers Be prepared for a shock when you hear the price. 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.