PERFORMANCE ELECTRONICS, Ltd.
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Programmable Fuel and Ignition Control Systems

User and Installation Manual

PE-ECU-1 Engine Control System

Revision I, 3/25/2005

For Software Versions 2.051

Legal Disclaimer

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Updates To This Manual

- Version G
  - Added updates page
  - Changed gap between Hall effect sensor and trigger wheel to be 0.060”-0.090”
  - Moved location of “Fused Battery +12” location on Main ECU Wiring Diagram to after main relay
  - Added “Warning” page
  - Added sensor pictures for wiring in Appendix

- Version H
  - Made specific manual version for new software 2.051
  - Modified starting compensation description to include temperature dependence and priming pulse
  - Removed injector open angle feature
  - Increased max accel compensation to 500
  - Included description of secondary rev limit
  - Added Delta RPM to Decel Fuel Cut-Off
  - Changed allowable run out of trigger wheel to be 0.005”
  - Added description for adjustable MAP in fuel and ignition tables
  - Modified data logging description based on changes to software
  - Added note concerning flexible crank trigger mounting
  - Added description of “Flood Clear” condition

- Version I
  - Added description of factory set crank pickup type
  - Added wiring diagrams for low impedance injectors
  - Added description of low impedance injectors to text

WARNING

- **The PE-ECU-1 system is not capable of directly driving low impedance injectors that have less than 10 ohms of resistance. If you are using peak and hold injectors with the PE-ECU-1 system, please contact Performance Electronics, Ltd or your distributor for the proper configuration.**

- **Do not weld to any part of the vehicle with the ECU electrically connected to the vehicle. Large ground spikes and/or level shifts can damage the internal circuitry of the ECU.**

- **The PE-ECU-1 system is designed with internal igniters capable of directly driving certain types of ignition coils. Using ignition coils that do not meet the minimum resistance requirements of the system can result in permanent damage. Please refer to the "Ignition Wiring Diagram" in the Appendix for specific requirements.**

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1 Introduction

Precise fuel and spark control is critical in realizing the full performance potential of any engine. Power production, overall efficiency and pollution levels all directly relate to the fuel and spark delivery system's performance. A simple, easily configured engine control unit capable of handling the complex responsibilities of fuel injection and spark management is an asset to anyone seeking to improve the overall performance of any powerplant.

The Performance Electronics, Ltd. system is a fully adjustable engine control unit for 1, 4, 6 and 8 cylinder engines requiring a stand alone fuel injection and ignition **e**lectronic **c**ontrol **u**nit (hereafter referred to as ECU). The system can control up to eight injectors in semi-sequential mode as well as handle all of the ignition responsibilities. All of the setup and tuning parameters can be adjusted with any personal computer running Windows® 98, 2000 and XP.

The complete ECU is enclosed in a water-resistant aluminum case incorporating positive lock, automotive style connectors. Important engine conditions are monitored using standard, readily available, GM sensors.

Additional features of the system are summarized below:

- General
  - "Semi-sequential" fire fuel injection
  - Wasted spark or distributed ignition (6 & 8 cylinders require the use of a distributor)
  - Easily installed and configured
  - Easy to use and understand Windows® based monitor program for tuning
  - Ability to load and save engine configuration files to and from PC hard drive
  - Standard inputs including: MAP, MAT, Coolant Temp, Throttle Position and Crank Position
  - 3 General purpose analog inputs to modify either fuel or ignition for use with custom sensors
  - 2 General purpose digital inputs to cut fuel, cut ignition or kill the engine for use with devices such as automatic shifting or traction control
  - 4 Digital outputs as a function of any standard input
  - Default fuel and timing table generation to get up and running in a hurry
  - Data logging to the PC
  - On-line help

- Fuel injection specific
  - 16x16 table of fuel values (actual values are interpolated from the table)
  - Load based on MAP, TPS or any other 0-5v signal
  - Acceleration and Deceleration compensation
  - Cranking compensation
  - Choke compensation
  - Battery voltage compensation
  - Individual cylinder bank fuel flow adjustment

- Ignition specific
  - 16x16 table of advance values (actual values are interpolated from the table)
  - Spark cutout for rev limit
  - User defined dwell
  - Load based on MAP, TPS or any other 0-5v signal
  - Air temperature compensation
  - Internal igniters

2 List of Abbreviations and Definitions

Base Open Time	The open time of the injectors without compensation from additional circuits. The term circuit in this context is defined as any additional amount of fuel. The ECU calculates Base Open Time as a function of the fuel table, engine load and engine RPM.
Batch Fire	This defines a classification of fuel injection systems where all of injectors fire at the same time.
ECU	Engine control unit, the main computer of the engine management system
MAP	Manifold absolute pressure
MAT	Manifold air temperature
PSI	Pounds per square inch, measure of pressure
Semi-Sequential	This is a fuel injection strategy that fires groups of injectors phased with the motion of the pistons. Semi-sequential injection is similar to full sequential except that it does not require a cam sensor.
TDC	Top dead center
TPS	Throttle position sensor
Wasted Spark	This is a type of ignition system where pairs of cylinders are fired at the same time. One cylinder fires on the compression stroke at the same time another cylinder fires on the exhaust stroke.
WOT	Wide-open throttle
Analog	Refers to an input to the system that has an infinitely variable voltage. MAP sensors, for example, produce an analog signal. Typically they vary voltage from 0-5 volts as a function of manifold pressure.
Digital	Refers to an input or output to the system with either an “on” or “off” state.

3 Overview of the Engine Management System

The Performance Electronics, Ltd. system is a completely adjustable ECU designed to be used on any 1, 4, 6 or 8 cylinder spark ignition engine. The heart of the system is a microprocessor capable of executing thousands of commands per second. Based on simple input from the user and the response from a variety of standard sensors, the ECU makes critical decisions concerning fuel and spark delivery. Tuning the ECU is as simple as running the ECU Monitor software while the control unit is connected to a PC via the serial port. The following sections are intended to give the user some basic understanding of engine management and how the ECU is determining important values necessary in successful fuel and spark delivery.

3.1 Determining the Position of the Crankshaft

Many of the functions the ECU must perform are solely or partially determined by the position of the crankshaft. Because of this, appropriate hardware must be used in conjunction with the controller so the position of the crankshaft can be monitored at all times. This system uses a steel wheel attached to the crankshaft and a crank position sensor to monitor this critical parameter. When the steel wheel and the crank position sensor are installed correctly, the moving wheel generates a signal that allows the ECU to monitor crank position. If the ECU senses a signal other than what is expected, an error state will be detected.

3.2 Fuel Metering

The ECU is capable of controlling up to 8 injectors. The injectors are either fully open or closed. The length of time the injectors remain open every engine cycle determines how much fuel flows to the engine. Every time each bank of cylinders gets to within a prescribed number of degrees before top dead center (DBTDC) the injectors for those cylinders are opened. This classifies the system as semi-sequential. The injectors remain open for a length of time determined by the ECU based on parameters specified by the user and the state of the engine.

Several times each engine cycle the ECU calculates how long the injectors should remain open based on measured parameters and the values that are stored in the controller's memory. Equation 1 describes how the ECU calculates the open time of the injectors based on the user's settings and measured values.

Open Time = (Base Open Time x AT x CT x CR x AC x CC x U1** x U2** x U3**) + BA*

Equation 1 – Total Open Time Calculation

Where:

Base Open Time = Basic open time based on engine load and RPM (2D Table)
AT = Air temperature compensation (1D table)
CT = Coolant temperature compensation (1D table)
CR = Cranking compensation (1D table)
AC = Acceleration compensation (User defined parameters)
CC = Individual cylinder bank compensation (User defined parameter)*
*U1** = User selectable analog input number 1 (1D table)*
*U2** = User selectable analog input number 2 (1D table)*
*U3** = User selectable analog input number 3 (1D table)*
BA = Battery voltage compensation (1D table)

* *Cylinder bank compensation is adjustable for injector banks 2,3 and 4. These are set as a percent of bank 1.*
** *Only included in calculation if set to modify the fuel flow*

In order for the ECU to perform as it was designed, the appropriate fuel delivery hardware must be installed and working properly. Each injector must receive a reliable supply of fuel. Most injectors are designed to work best with a constant fuel pressure differential of 40-50 psi across the injector. This means that the fuel pressure at the injector inlet must always be a constant 40-50 psi above the manifold pressure. This regulated supply of fuel is provided by a high-pressure pump and a specially designed pressure regulator. The regulator maintains the correct pressure by varying the amount of fuel allowed to return to the tank as a function of manifold pressure.

3.3 Ignition Control

The system also has the capability to control up to 2 banks of inductive coils with a primary resistance greater than 2.0 ohms. The ECU can be configured in either wasted spark or distributed mode. This determines how many times the coil drivers fire each revolution. Because 2 coil drivers are included in the controller only 4-cylinder engines can take advantage of the wasted spark option.

Total ignition timing is the sum of 5 potential factors. The calculation that the ECU makes to determine total engine timing is shown in Equation 2.

Total Ignition Timing (degrees)= Base Timing + AT + U1 + U2* + U3**

Equation 2 – Total Ignition Timing Calculation

Where:
Base Ignition Timing = Basic ignition timing based on engine load and RPM (2D Table)
AT = Air temperature compensation (1D table)
U1 = User selectable analog input number 1 (1D table)*
U2 = User selectable analog input number 2 (1D table)*
U3 = User selectable analog input number 3 (1D table)*
* *Only included in calculation if set to modify ignition*

In addition to controlling the spark timing, coil dwell can also be adjusted. The dwell is defined as the amount of time that the coil charges each cycle. This parameter can be set by the user in the Monitor program.

4 Wiring The ECU

Packaged with the ECU is a standard wire harness. The harness has the connector that mates to the ECU at one end and bare wire at the other. The pin numbers for each wire are stamped on the back of the connector. It will be necessary to know corresponding pin numbers when terminating the harness. Wiring diagrams for the ECU and related hardware are located in the Appendix.

If additional wire must be added to the supplied harness, ***add the same gage or larger than what is already included***. In addition, proper wiring practices should also be observed when making the harness. Most problems with new systems can be traced back to incorrect wiring or poor connections. All wire joints should be soldered and covered with heat shrink tubing.

4.1 Connecting Power to the Box

Power for the ECU is brought in through the main connector. Any wiring added to the power pigtails must be substantial enough to handle the potential current. A minimum of 12-gage wire should be used for the power ground wire on the ECU. For the +12 volt side of the power supply, 14-gage wire is sufficient. The wiring diagrams in the Appendix show how to correctly connect power through a relay and the fuse.

Anytime power is applied to the ECU, the computer immediately begins to run. Therefore, it is necessary to turn the ECU off when the engine is not running to avoid depleting the battery.

4.2 Connecting the Sensors to the ECU

The ECU requires several sensors in order to gather the necessary information to run. All of the approved sensors were originally designed for automotive applications and are rugged and durable. Some of the sensors are not necessary for basic operation and can be omitted if that feature is not required. Below is a list of the standard sensors and their corresponding part numbers.

Table 1 - Standard Sensors

Sensor	Function/Description	Manufacturer	Part Number
MAP, 1 bar[1]	Manifold Absolute Pressure, can be used to determine load	GM	16137039
MAP, 2 bar[1]	Manifold Absolute Pressure, can be used to determine load	GM	16009886
TPS	Throttle Position Sensor, can be used to determine load, used for acceleration and de-acceleration compensation	Any	Any that has 0v closed and 5v WOT
MAT[2]	Manifold Air Temperature, used for air temperature compensation, no threads	GM	12110320
MAT[2]	Manifold Air Temperature, used for air temperature compensation, requires 3/8" NPT threaded hole	GM	25036751
Coolant Temp	Coolant temperature, used for choke compensation, requires 3/8" NPT threaded hole	GM	12146312
Gear Tooth Sensor[3]	Crank trigger, allows ECU to determine position of crankshaft.	Honeywell	1GT101DC

[1] The 2 bar MAP sensor is for forced induction engines and the 1 bar sensor is suitable for all naturally aspirated engines. One of these sensors must be used if MAP will be used for load control.

[2] Either one of the listed sensors can be used. The major difference between the two is how they mount to the engine.

[3] Many 2 and 3-wire OEM sensors are also compatible with the PE-ECU-1 system. Contact Performance Electronics, Ltd. for compatibility.

The ECU only requires load and crank trigger signals to function in its most basic configuration. The trigger signal allows the controller to calculate the location of the crankshaft for injection and ignition events while the TPS or MAP sensor provides a measure of the engine load. The TPS, MAT and coolant temperature provides additional compensation based on throttle movement, manifold air temperature and coolant temperature. If a particular channel is not connected to a sensor, certain precautions must be taken to prevent inadvertent short circuits. Insulate all of the loose pigtails from the connectors with shrink-wrap tubing or electrical tape to provide an isolated termination.

4.3 Connecting the Fuel Pump and User Outputs

In order to control the fuel pump and any auxiliary output through a digital output, relays must be used with the ECU. Most 12-volt automotive style relays have sufficient resistance across the internal coil to avoid damaging the ECU. **It is important, however, to confirm that the resistance across the coil of any relay that will be used with the system is greater than 40 ohms. In addition, make sure the relay being used is capable of carrying the amount of current required by the load.** This feature is intended to be used for things like idle air bypass, cooling fan, shift light or nitrous oxide. See Section 6.4 for information on how to set up the User Outputs in the software.

There are no software adjustments for the fuel pump. It will come on initially and run for approximately 6 seconds when the ECU is powered to prime the system. The pump will also run anytime the engine is spinning. If the pump has already primed and the engine is not running, the fuel pump will turn off. Wiring diagrams for the fuel pump and User Outputs are shown in the Appendix.

4.4 Connecting Custom Analog Inputs

The Performance Electronics, Ltd. system is equipped with the ability to use 3 custom analog inputs to modify either the fuel or ignition events. These inputs can be defined in the monitor program and can be used to connect user specific sensors to the ECU. The inputs have a voltage range of 0 to 5 volts (0 volts is the battery ground). Power for user specific sensors can be pulled from the *sensor +5 volt* and *sensor ground* lines (Pins 15 and 25 in the connector). Only sensors that draw less than 0.20 Amps can be directly powered by the ECU. See section 6.5 for details on how to configure the software for User Inputs. Wiring diagrams for these inputs are Included in the Appendix.

4.5 Wiring the Injectors and Coils

The PE-ECU-1 system is capable of directly driving up to 8 high impedance injectors with a resistance of 10 ohms or greater. The resistance of an injector can be determined by measuring across the two electrical pins with an ohmmeter. If low impedance injectors (4 ohms or less) are used with the system, an external resistor box is required. Please contact Performance Electronics, Ltd or your distributor for compatibility with your hardware. Wire the injectors according to the wiring diagrams included in the Appendix based on your application.

If an external resistor box is used, mount it to a metal surface so that heat can be dissipated. A good location for the installation is on the firewall or inner fender well of the vehicle away from the exhaust. Please note that the resistor box in not waterproof and should be mounted away from areas that could see moisture.

The ECU can also control up to 2 banks of inductive coils. Wasted spark or distributed ignition may be used on 4-cylinder engines. This option is configurable in the Monitor program. For engines with more than 4 cylinders, a distributor must be employed.

Regardless of ignition type, the maximum current through the primary side of the coil must not be exceeded. See the wiring diagrams in the Appendix for the minimum required ignition coil resistance.

Failure to use coils or injectors without the minimum required resistance might permanently damage the ECU or the injectors and coils. Please be sure to verify the resistance of these components before attempting to run the controller.

Wasted Spark Ignition

When wiring an engine for wasted spark ignition, connect the coil that fires the #1 cylinder to coil 1. The other cylinder on this coil should be the one that is at TDC at the same time as the #1 cylinder. The remaining two cylinders can be connected to coil 2. Accel® makes a coil particularly well suited for wasted spark ignition (Part Number 140403). Coil on plug ignition systems can also be wired to work in wasted spark mode. See the Appendix for correct wiring of both configurations.

Distributed Ignition

Only one of the coil drivers is used if a distributor is going to be part of the ignition system. For this configuration, connect the single coil to the pins labeled for coil 1. In addition, remove any excess wire in the harness from the coil 2 leads and prevent these from shorting together or to vehicle ground. For a distributed coil, Bosch® part number F00E140281 works well.

4.6 Wiring Digital Inputs

The system has the ability to monitor two 5 volt digital signals. Depending on how the ECU is configured, a high signal (5 volts) on these inputs can cut fuel, cut ignition, or kill the engine (see Section 6.5 for details). Users can wire in any 0-5 volt digital device. A typical application may include an ignition cut for automatic shifting. Because the ECU already has a clean 5v supply for the sensors, it is best to use this signal to drive the Digital Inputs. Please refer to the wiring diagrams in the Appendix for pin numbers of the 5 volt supply.

4.7 Wiring External Tachometers

The tachometer drive feature is only supported on control units with a serial number of 110301520 or greater.

The PE-ECU-1 system can drive most aftermarket and some OEM tachometers. The output from the drive circuit is a 12v rectangle wave with a 30% "on" (12v) and 70% "off" (0v) duty cycle. The number of pulses per revolution is based on the number of cylinders selected in the Monitor software as described below. See Appendix A for wiring details.

- 1, 2 or 4 Cylinders = 2 Pulses per Crank Revolution
- 6 Cylinders = 3 Pulses per Crank Revolution
- 8 Cylinders = 4 Pulses per Crank Revolution

5 Installing the Hardware

The ECU should be securely mounted away from excessive heat and vibration. Care should be taken to place the controller sufficiently away from sources of RF noise such as the spark plug wires. Also, use plug wires with some noise suppression characteristics to avoid interference with the electronics. DO NOT USE SOLID CORE WIRES, AS THESE ARE KNOWN SOURCES OF EXCESSIVE NOISE. Although the ECU is enclosed in a water-resistant container, it is advisable to mount it out of constant contact with water or any petroleum products. Doing so will extend the life of the connectors and circuit contacts located on the ECU. Inside the vehicle's passenger compartment is the best location to mount the controller.

5.1 Installing the Crank Pickup and Trigger Wheel

In order for the ECU to determine the position of the crankshaft, the steel trigger wheel and the pickup sensor must be installed correctly. The trigger wheel should be mounted to the crankshaft via a suitable adapter by using the location hole in the center of the wheel. If a smaller or larger trigger wheel is required, one can be manufactured from mild carbon steel using the same tooth pattern as the original (12 tooth pattern missing 1 tooth). Any trigger wheel not supplied by Performance Electronics, Ltd. must have magnetic properties. In other words, a magnet must be attracted to the wheel. Trigger wheels with an outside diameter as small as 2.25" with a thickness of 0.25" have successfully been used on engines with maximum speeds of 12,000 RPM.

A poorly positioned sensor or wheel may cause the engine to misfire. This will sometimes become evident with increasing speed or increasing sensor temperature. If an error is detected in the trigger wheel signal while the ECU Monitor program is running, a red box will appear in the bottom right hand corner of the program (Figure 1). The appearance of the red error box will usually coincide with the engine misfiring. The error may also appear while the engine is starting. This is normal and due to the fact that a complete signal for one revolution has not yet been observed.

If a mount for the crank position sensor must be fabricated, make sure that the final configuration is stiff enough to avoid excessive vibration during operation. If the mount can be significantly moved by hand, it is probably not rigid enough and could cause potential problems. These problems are generally observed as crank errors and engine misfires at specific and repeatable engine conditions (load and speed).

If the standard Hall effect sensor is used with a trigger wheel supplied by Performance Electronics, follow the clearance guidelines outlined in the Appendix. When mounting the sensor, make sure that the trigger wheel passes directly in front of the middle of the sensor tip.

If a variable reluctance (VR) sensor is used, the position of the sensor relative to the trigger wheel is very critical. These sensors are usually characterized as having only 2 wires. When mounting the trigger wheel and sensor it is imperative that the installation meets the following requirements:

- The peak voltage generated by the VR sensor at maximum engine speed must be less than +/-20 volts. This can be verified with a good multi-meter or oscilloscope.
- The peak voltage generated by the VR sensor during cranking must always be greater than 0.8 volts. This level is required in order for the ECU to determine a pulse has occurred.
- The total radial and axial run-out of the trigger wheel, as it spins on the shaft, must be less than 0.005”. This is required so that a consistent signal is available for the ECU.

You must provide the type of crank position sensor that will be used at the time of purchase. This input is jumper-selectable in the ECU and is set from the factory based on the application. Each ECU is labeled on the serial number tag (located under the connector) as to which way it is configured – “Hall” or “2-Wire”.

Many stock sensors are compatible with the PE-ECU-1 system. Please contact Performance Electronics or you distributor for compatibility. See the Appendix for details concerning specific trigger wheel configurations and wiring.

6 Tuning the System Using ECU MONITOR

Once all of the hardware is in place, you can begin to set up the ECU for your particular application. The first step in the tuning process is to load the required software onto an IBM compatible PC running Windows 98, 2000 or XP. Run the executable *setup.exe* to load the software. This will create a *Performance Electronics* subdirectory under the Programs menu and install the program, ECU Monitor. If an RS-232 communication cable is connected and power is applied to the ECU, the monitor program will communicate with the controller.

6.1 Starting the ECU Monitor

Starting ECU Monitor brings up the main screen shown in Figure 1. Users have the option of connecting to the ECU or working offline. Working offline allows the creation of basic tuning files without communication with the ECU. Tuning files can be saved and recalled from the hard disk once they are created with the monitor program. In addition to basic Windows features like *Save*, *Open* and *Print*, the main screen allows the user to perform other specific tasks as outlined in Figure 1. If the ECU will not communicate with ECU Monitor, change the communication port using the drop down menu *Setup.*

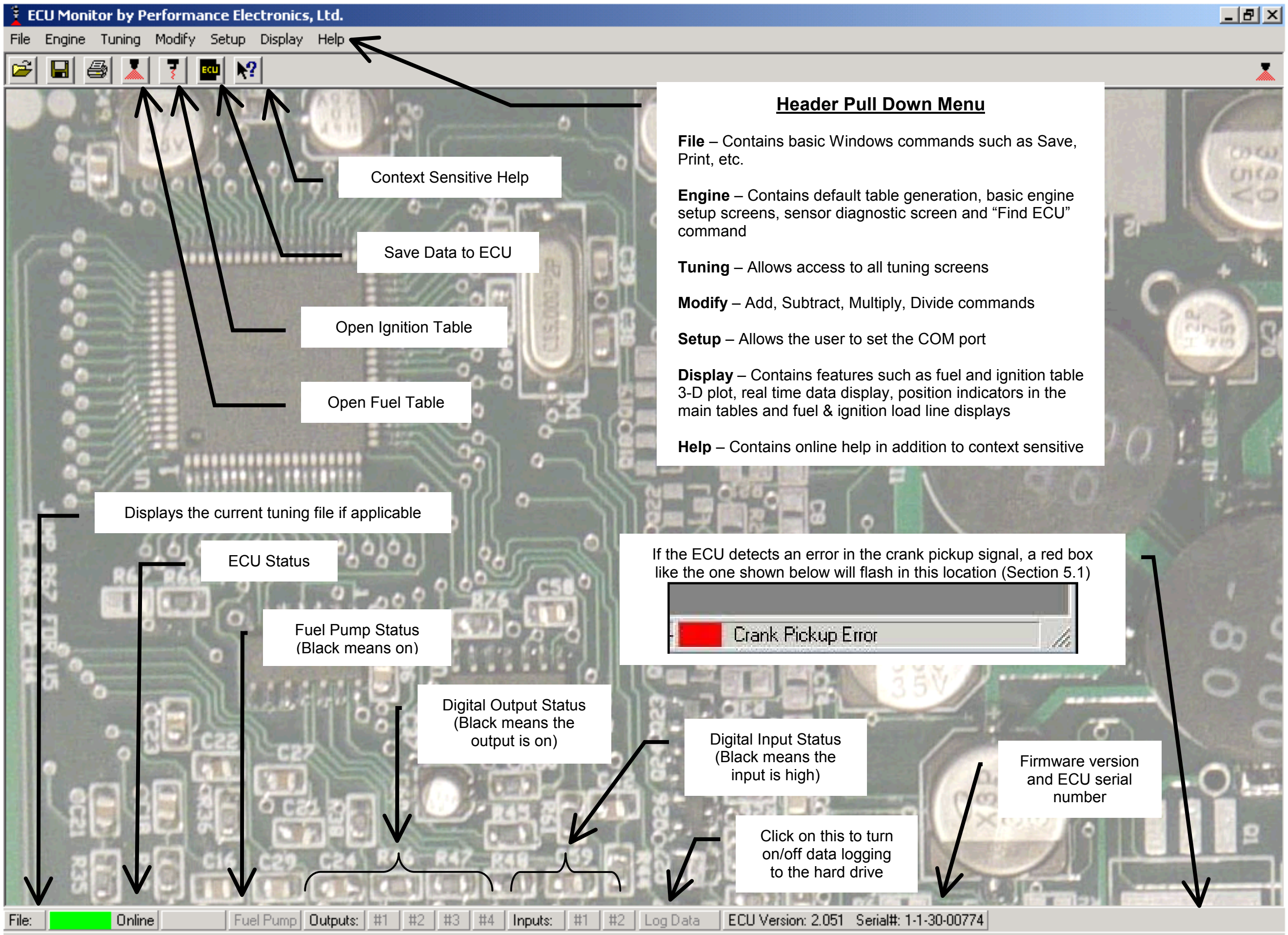


Figure 1 - Monitor Screen at Startup

6.2 Basic Engine Setup

The first step in tuning is setting up the basic engine parameters. Under the *Engine* pull down menu in the main header is the command *Setup. Setup* contains several tabs, the first of which is *Engine* (Figure 2). Descriptions of the parameters contained in *Engine* are listed below.

- **Cylinders** – Number of cylinders in the engine

- **Min On Time** – This defines the minimum allowable pulse width for injection. Typical values for saturated injectors are 1.2 ms. The allowable range is 0 - 15.94 ms.

- **Charge Time** – This defines the length of time that the coils will charge each cycle. As the engine speeds up, the amount of time available to charge is reduced. If the available time is less than this value, the coils will only be charged for as long as possible. Typical values are 3-5 ms. The allowable range is 3.0-10.0 ms**. Using excessive charge time can damage either the PE-ECU-1 unit or the ignition**

coils. If there is less than 2.0 ohms of resistance per ignition driver, never use more than 3.0 ms Charge Time.

- **Load Control** – This setting controls which input is used in the main fuel and ignition tables along with RPM. Allowable choices are listed below:

  - TPS: Load control based on throttle position
  - MAP: Load control based on manifold pressure

- **Max RPM** – This value defines the upper RPM limit in both the fuel and ignition tables. The engine can run faster than this upper limit, however, the last values in the fuel and ignition tables will be used.

- **Rev Limit RPM** – When engine RPM is greater than the **Rev Limit RPM,** the coil(s) will not charge. This is what is known as a "hard rev limit". Acceptable values are between 1000 and 16,500 RPM.

- **Ignition Type** – Ignition type defines the number and order in which the coils fire by defining either *Wasted Spark* or *Distributed*. Only 4-cylinder engines may be run in *Wasted Spark* mode.

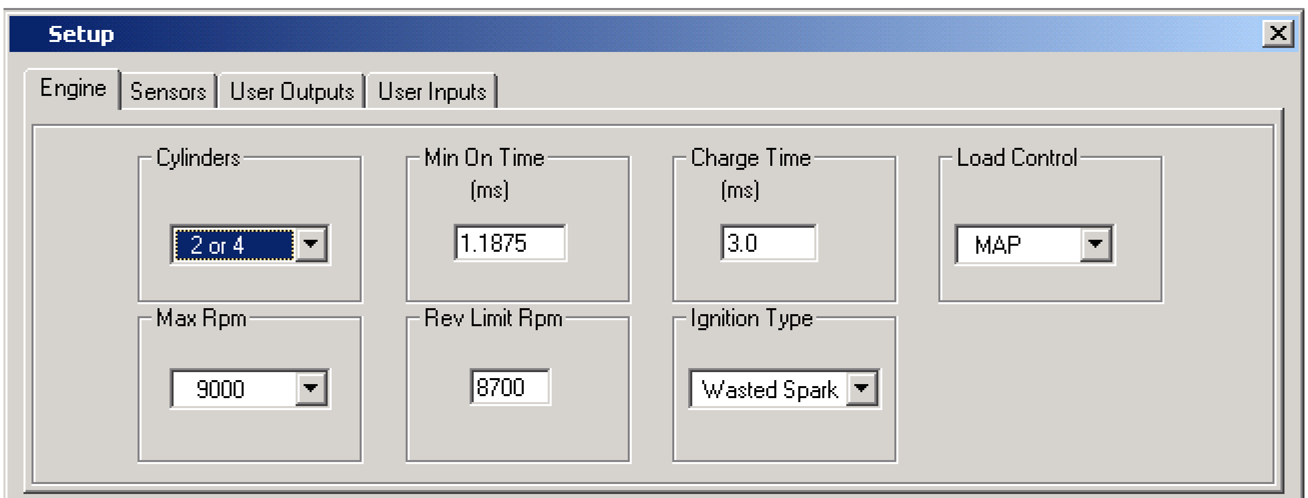


Figure 2 - Engine Setup Screen

6.3 Sensor Setup

The second tab in the *Setup* menu is the *Sensors* page (Figure 3). This page allows the user to configure all of the standard sensors for the engine. A description of each of the parameters is listed below.

- **Air Temperature Sensor** – Allows the air temperature sensor to be turned on or off. A GM air temperature sensor is the only device supported at this time.

- **MAP Sensor** – This sets the type of Manifold Absolute Pressure sensor used on the engine. A "1 Atm" sensor is for naturally aspirated engines. The other selections are for forced induction based on the expected level of boost. If your particular engine combination will make between 1 and 15 psi of boost, a 2-bar MAP sensor should be used and configured in the software. A 3-bar sensor should be used if the engine will run with 15 to 30 psi of boost.

- **Max Map (PSI), Min Map (PSI)** – These parameters allow the main fuel and ignition tables to be tailored based on the minimum and maximum MAP levels. Changing these will alter the MAP values along the load axis in the main fuel and ignition tables. When one of these parameters is changed, the Monitor program will prompt the user to rescale the current fuel and ignition tables. If the user answers "Yes", the tables will be re-scaled such that the fuel and ignition at a given MAP value remains the same. This is particularly helpful if the Min/Max Map values are modified after an engine has been tuned. If the user replies "No", the tables will not be re-scaled and the values in the table will remain the same.

Note: Because the MAP axis is equally spaced, when one of the limits is modified, the Monitor program will automatically adjust this parameter to the closest value that allows for equal spacing. In addition, only one of the values (either Min or Max) can be changed for each re-scaling of the tables. If both the **Max Map** and the **Min Map** must be adjusted, this must take place in two steps.

- **Map (PSI)** – This is a real-time display of the manifold pressure. It is used to view the PSI during the setup procedure so the values can be entered in the fields above.

- **Water Temperature Sensor** – Allows this temperature sensor to be activated. A GM water temperature sensor is the only device supported at this time.

- **Throttle Position Sensor** – This pull down configures the TPS sensor as either on or off.

- **WOT Voltage** – This parameter is the voltage when the throttle is in the full open position (WOT). This value allows a "percent open" value to be calculated for the throttle position (0-100%). The range for this setting is 0 to 5 volts. This value must be greater than the **Closed Voltage**.

- **Closed Voltage** – Closed Voltage is the TPS voltage when the throttle is in the full closed position. This is used in conjunction with WOT Voltage and the throttle position signal to calculate the percent open. The range for this setting is 0 to 5 volts. This value must be less than the **WOT Voltage**.

- **TPS Volts** – This is a real-time display of the TPS voltage. It is used to view the voltage at wide open throttle and closed throttle so the values can be entered.

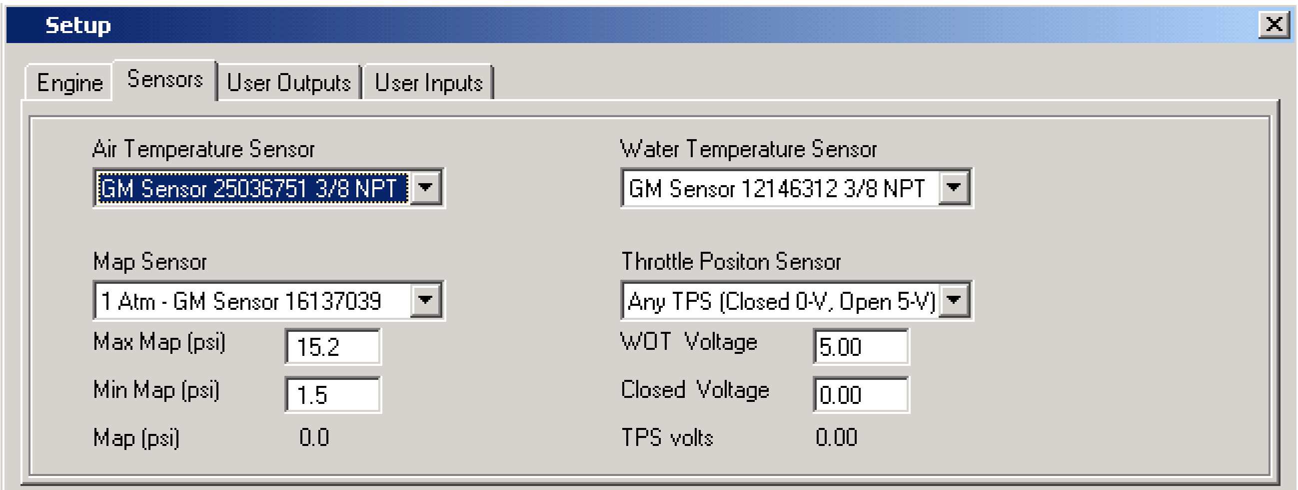


Figure 3 - Sensor Setup Page

6.4 User Output Setup

The *User Outputs* page is the third tab in the *Setup* menu (Figure 4). This page allows the user to configure the four outputs based on air temperature, coolant temperature, RPM, MAP or throttle position. The outputs are switched to ground when they are turned on and can be used to switch automotive style relays (See Section 4.3).

The drop down menu contains the sensors that the outputs can be based on. The **On Value** and the **Off Value** determine when the digital outputs are turned on. Depending on which value is larger the outputs operate differently. If the **On Value** is larger, the output will turn on as the analog input increases past the **On Value** and then turn off as the input decreases to a level less than the **Off Value**. If the **Off Value** is larger, the output will turn off as the analog input increases past the **Off Value** and the turn back on as the input decreases past the **On Value**.

A good example of using a *User Output* is for a cooling fan. If the fan should turn on at 180 degrees F, set the **On Value** to 180 and the **Off Value** to 170. This will turn the fan on at the appropriate temperature and also prevent the fan from fluttering on and off at 180 deg.

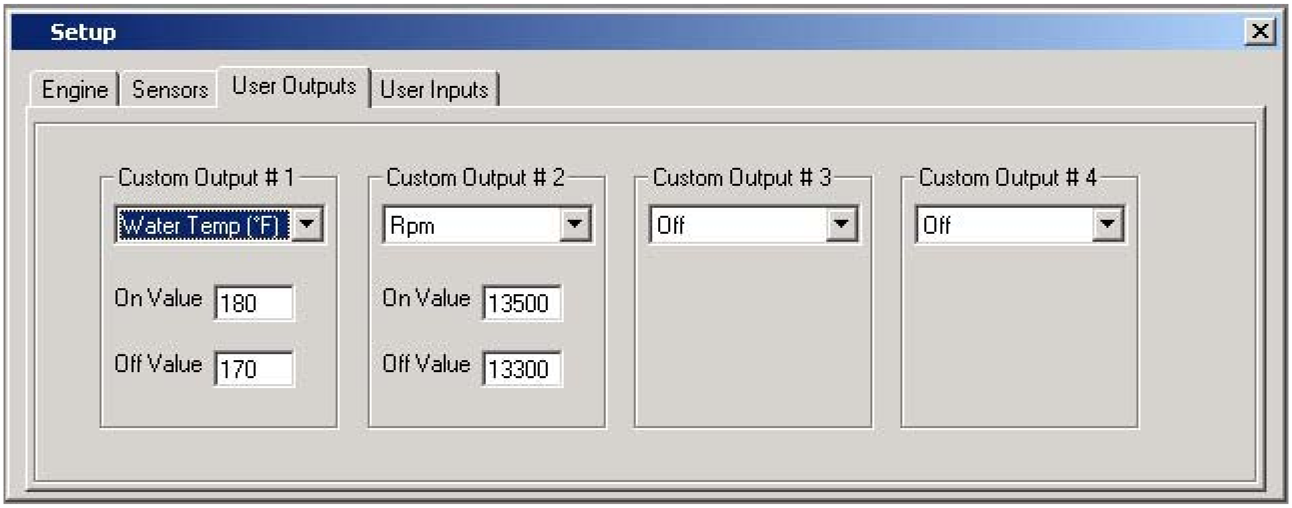


Figure 4 - User Output Page

6.5 User Input Setup

The *User Inputs* page is the final tab in the *Setup* menu. Two types of configurable input channels are available, analog and digital. The analog *User Inputs* allow the user to vary either the fuel flow or ignition timing of the engine based on some external sensor. Any analog sensor can be used as a custom input provided that voltage range does not fall outside of 0-5 volts. When the user selects either *Fuel Percent* or *Ignition Degrees* from the drop down menu, a table is created under the *Tuning* menu (located in the Main Header). This table is a 1-D modification of either the fuel or ignition as a function of the analog signal on that input line. Figure 5 shows a typical *User Inputs* setup screen and Figure 6 illustrates the corresponding tables created.

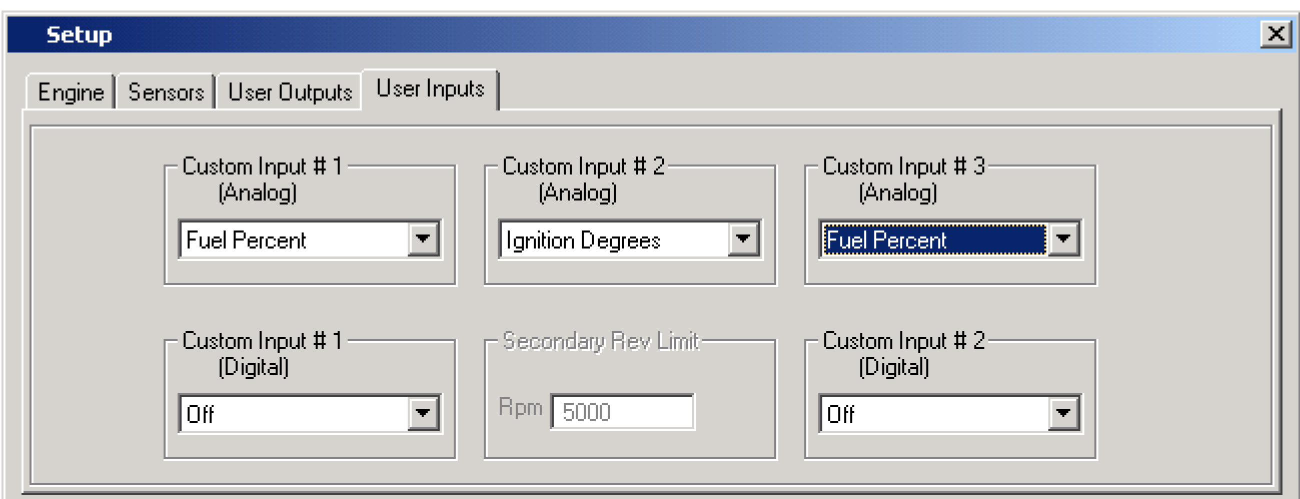


Figure 5 - User Input Setup Page

User Inputs

User Input #1 - Fuel Percent

Volt	0.0	0.3	0.6	0.9	1.3	1.6	1.9	2.2	2.5	2.8	3.1	3.4	3.8	4.1	4.4	4.7	5.0
%	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108

User Input #2 - Ignition Degrees (Positive Degrees Advances Timing)

Volt	0.0	0.3	0.6	0.9	1.3	1.6	1.9	2.2	2.5	2.8	3.1	3.4	3.8	4.1	4.4	4.7	5.0
Deg	-18	-16	-14	-12	-10	-8	-6	-4	-2	2	4	6	8	10	12	14	16

User Input #3 - Fuel Percent

Volt	0.0	0.3	0.6	0.9	1.3	1.6	1.9	2.2	2.5	2.8	3.1	3.4	3.8	4.1	4.4	4.7	5.0
%	100	100	100	100	100	100	100	100	100	100	100	102	104	106	108	110	112

Figure 6 - User Input Tables

The digital inputs can respond in several ways depending on how they are configured. If a digital input is enabled and a high state is observed (a high state is 3.1-5.0 volts), one of four actions will occur:

- **Cut Fuel** – For the time the input remains high, the injectors will be held closed.
- **Cut Ignition** – While the input remains high, no spark will occur.
- **Cut Engine** – Neither fuel nor ignition events will take place during the high state.
- **Secondary Rev Limit** – This functions just like the regular rev limiter except that it is only armed when the digital input is high. If the input is high, and this option is enabled, the ignition will be cut if the RPM is greater than the **Secondary Rev Limit RPM.**

Any digital devices, including switches or relays, can be connected to the digital inputs provided that they provide a signal between battery ground and +5 volts. A voltage of +3.1 volts is required to register a high state. The low state is defined as any voltage below +2.25 volts.

6.6 Main Fuel Injection and Ignition Setup Pages

Steady state tuning is done largely by modifying the main Fuel and Ignition tables. These main tables define the basic fuel and ignition requirements of the engine. To aid in the tuning process, the four values in the table currently being used by the ECU are highlighted in red. The red block moves around the table based on the engine speed and load. In addition to the red block, *CrossHairs*, may also be turned on through the *Display* drop down menu in the main header. The *CrossHairs* are actually small green dots that move around inside the red blocks in the main Fuel and Ignition tables. These green dots show the operating point of the engine within the red blocks.

The main fuel injection and ignition tables can be modified in several ways. Values can be directly entered in the tables by highlighting a specific cell. If more than one cell is highlighted, the entered value will fill all of the selected cells. Table values can also be changed relatively. This is accomplished by using *Add*, *Subtract*, *Multiply* and *Divide* buttons at the bottom left hand corner of the screen. Clicking on these buttons will perform the specified mathematical function with the highlighted cells and the value entered. For example, if you click on the *Multiply* button with a value of 1.2 entered in the space, all of the highlighted cells will be multiplied by 1.20. The final way that cells can be modified is by using the *Smooth* function. This feature allows the user to “smooth” the data contained within a row, column or block of data. If a row or column of data is highlighted when this button is depressed, the end points of the highlighted data are used to fill in the middle cells. The Monitor program uses a linear interpolation routine to calculate what these interior points should be. These new points are then automatically entered into the table. If a block of data is selected, the smooth function uses the four corner points and linear interpolation to fill in the interior cells.

If the *Load Line Display* option is enabled, 2-dimensional plots will be displayed at the bottom of the table. This feature plots the row of data where the cursor is currently positioned as well as the row directly above and below the cursor. The *Load Line Display* in Figure 7 is plotting the row of data associated with 7.9, 8.8, and 9.7 PSI. Moving the cursor to another row in the table would cause a different plot to appear. For computers that lack the resolution to properly display this feature, *Load Line Display* can be turned off in the *Setup* drop down menu.

Anytime the Fuel or Ignition table is opened, the Engine Data header also opens. This small window appears at the top of the screen and displays information about the engine. The list below describes the parameters that are displayed.

- **RPM** – Speed of the engine
- **Water** – Coolant temperature in degrees F
- **Tps** - Throttle position in percent open
- **Fuel B1**– Open time of the injectors in Bank #1 in milliseconds. Because the open time of the other three injector banks are a function of Bank #1, this one is displayed.
- **Duty** – Duty cycle of the Bank #1 injectors in percent of allowable open time. 100% means that the injectors are never closing. Most injectors are designed to run at a maximum duty cycle of around 80%.
- **U# Ign** – If a User Input is configured to modify the ignition timing, this value indicates the contribution from that input to total timing (Example: U2 Ign -8°)

- **U# Fuel** – If a User Input is configured to modify the fuel flow, this value indicates the contribution from that input on the total injector open time (Example: U1 Fuel 98%)

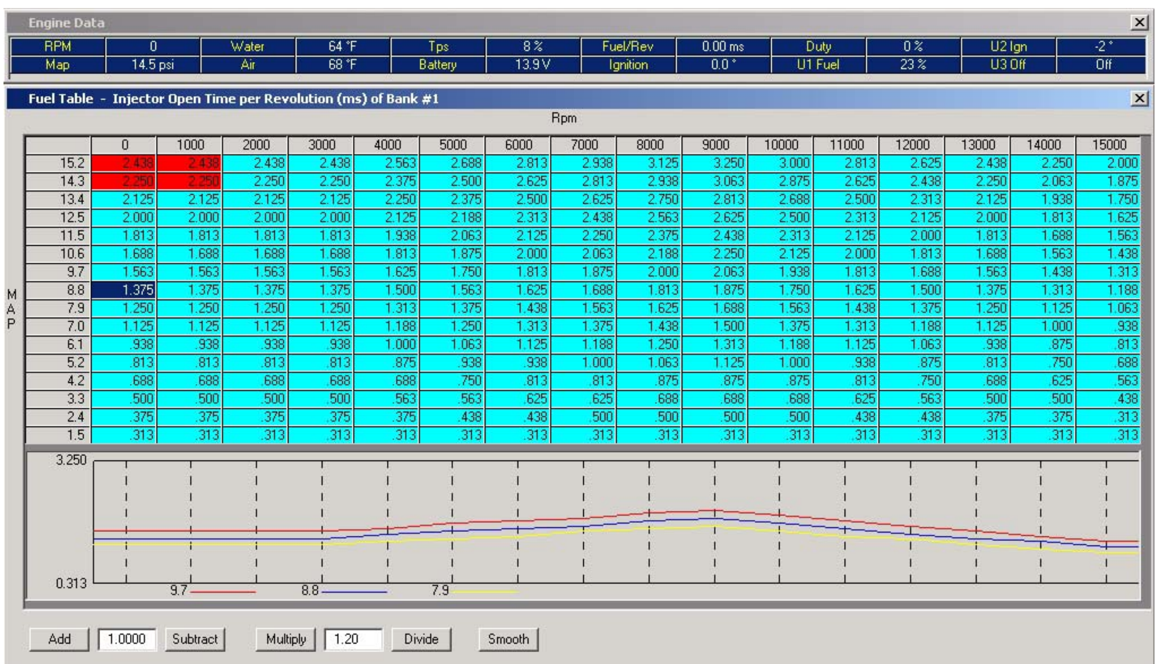
- **MAP** - Manifold Absolute Pressure in psi

- **Air** - Air Temperature in degrees F

- **Battery** – Battery voltage

- **Ignition** – Total ignition timing in degrees before top dead center

The Fuel Table (Figure 7) can be accessed from the *Tuning* pull down menu or by clicking on the small injector in the main screen . Values in the fuel table represent the open time of the injectors each revolution as a function of load and RPM. Fuel values have a resolution of 0.0625 milliseconds and a range of 0.063 -16.000 ms. The actual open time that the ECU calculates is interpolated from the table. This value is also referred to as “base open time”. The base open time is modified by all of the other fueling factors to arrive at the actual open time (Equation 1).


Engine Data

RPM	0	Water	64 °F	Tps	8 %	Fuel/Rev	0.00 ms	Duty	0 %	U2 Ign	-2 °
Map	14.5 psi	Air	68 °F	Battery	13.9 V	Ignition	0.0 °	U1 Fuel	23 %	U3 Off	Off

Fuel Table - Injector Open Time per Revolution (ms) of Bank #1

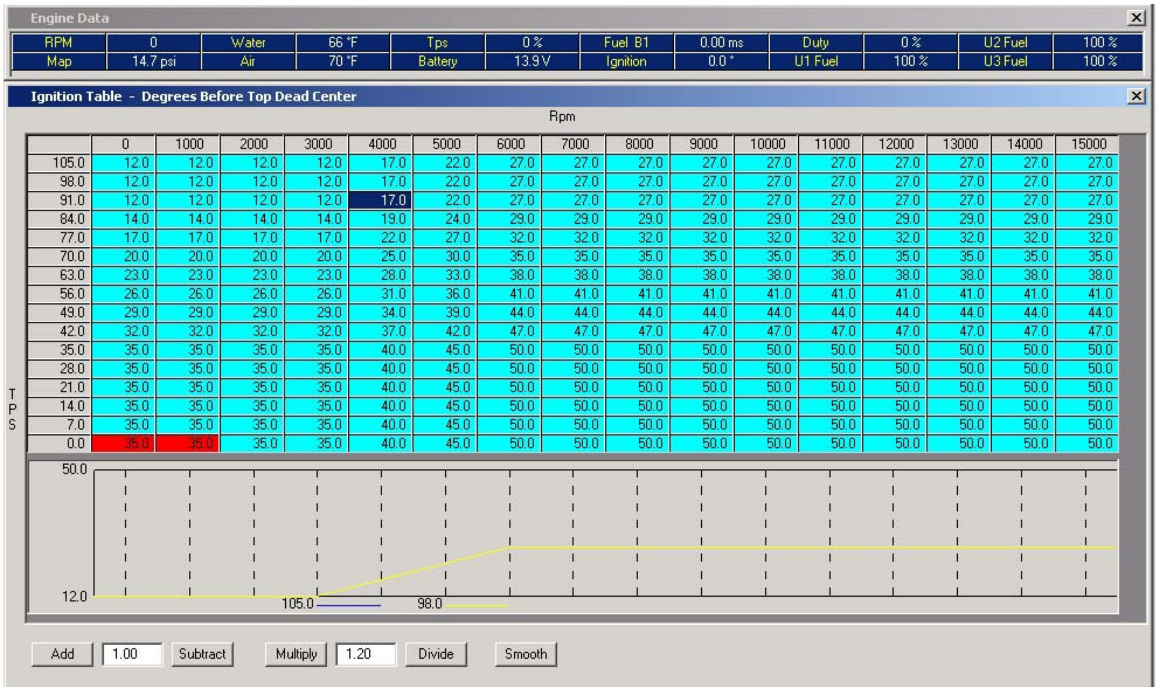
Rpm

MAP	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000
15.2	2.438	2.438	2.438	2.438	2.563	2.688	2.813	2.938	3.125	3.250	3.000	2.813	2.625	2.438	2.250	2.000
14.3	2.250	2.250	2.250	2.250	2.375	2.500	2.625	2.813	2.938	3.063	2.875	2.625	2.438	2.250	2.063	1.875
13.4	2.125	2.125	2.125	2.125	2.250	2.375	2.500	2.625	2.750	2.813	2.688	2.500	2.313	2.125	1.938	1.750
12.5	2.000	2.000	2.000	2.000	2.125	2.188	2.313	2.438	2.563	2.625	2.500	2.313	2.125	2.000	1.813	1.625
11.5	1.813	1.813	1.813	1.813	1.938	2.063	2.125	2.250	2.375	2.438	2.313	2.125	2.000	1.813	1.688	1.563
10.6	1.688	1.688	1.688	1.688	1.813	1.875	2.000	2.063	2.188	2.250	2.125	2.000	1.813	1.688	1.563	1.438
9.7	1.563	1.563	1.563	1.563	1.625	1.750	1.813	1.875	2.000	2.063	1.938	1.813	1.688	1.563	1.438	1.313
8.8	1.375	1.375	1.375	1.375	1.500	1.563	1.625	1.688	1.813	1.875	1.750	1.625	1.500	1.375	1.313	1.188
7.9	1.250	1.250	1.250	1.250	1.313	1.375	1.438	1.563	1.625	1.688	1.563	1.438	1.375	1.250	1.125	1.063
7.0	1.125	1.125	1.125	1.125	1.188	1.250	1.313	1.375	1.438	1.500	1.375	1.313	1.188	1.125	1.000	.938
6.1	.938	.938	.938	.938	1.000	1.063	1.125	1.188	1.250	1.313	1.188	1.125	1.063	.938	.875	.813
5.2	.813	.813	.813	.813	.875	.938	.938	1.000	1.063	1.125	1.000	.938	.875	.813	.750	.688
4.2	.688	.688	.688	.688	.688	.750	.813	.813	.875	.875	.875	.813	.750	.688	.625	.563
3.3	.500	.500	.500	.500	.563	.563	.625	.625	.688	.688	.688	.625	.563	.500	.500	.438
2.4	.375	.375	.375	.375	.375	.438	.438	.500	.500	.500	.500	.438	.438	.375	.375	.313
1.5	.313	.313	.313	.313	.313	.313	.313	.313	.313	.313	.313	.313	.313	.313	.313	.313

Figure 7 - Main Fuel Table

The Ignition Table (Figure 8) can be accessed from the *Tuning* pull down menu or by clicking on the small spark plug in the main screen . Values in the table represent the ignition timing as a function of load and RPM in units of degrees before top dead center.

Ignition values have a resolution of 0.5 degrees and a range of 5.0 to 50.0 degrees. The actual timing that the ECU calculates is interpolated from the table. This value is also referred to as “base timing”. The base timing is modified by all of the other ignition factors to arrive at the total timing (See Equation 2).



TPS \ Rpm	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000
105.0	12.0	12.0	12.0	12.0	17.0	22.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
98.0	12.0	12.0	12.0	12.0	17.0	22.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
91.0	12.0	12.0	12.0	12.0	17.0	22.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
84.0	14.0	14.0	14.0	14.0	19.0	24.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0
77.0	17.0	17.0	17.0	17.0	22.0	27.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
70.0	20.0	20.0	20.0	20.0	25.0	30.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
63.0	23.0	23.0	23.0	23.0	28.0	33.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0
56.0	26.0	26.0	26.0	26.0	31.0	36.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0
49.0	29.0	29.0	29.0	29.0	34.0	39.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0
42.0	32.0	32.0	32.0	32.0	37.0	42.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0
35.0	35.0	35.0	35.0	35.0	40.0	45.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
28.0	35.0	35.0	35.0	35.0	40.0	45.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
21.0	35.0	35.0	35.0	35.0	40.0	45.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
14.0	35.0	35.0	35.0	35.0	40.0	45.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
7.0	35.0	35.0	35.0	35.0	40.0	45.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
0.0	35.0	35.0	35.0	35.0	40.0	45.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0

Figure 8 - Main Ignition Table

6.7 Default Fuel and Ignition Table Generation

In order to aid in the tuning process, Performance Electronics, Ltd has included some routines that generate default ignition and fuel tables. These routines can be accessed from the *Engine* pull down located in the main header.

The fuel table generation routine uses information from the *Setup* screen along with volumetric efficiency estimates to create a table of open times (Figure 9). If information is not available regarding the volumetric efficiency, the default values are generally adequate to get the engine started. Clicking on the *Create Fuel Table* button replaces the current fuel table with the new one.

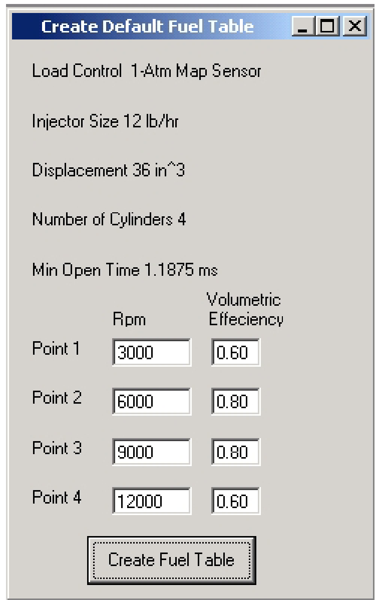


Figure 9 - Default Fuel Table Setup

In addition to default fuel table generation, a generic ignition table can also easily be created. The default ignition table routine can also be accessed from the *Engine* pull down menu located in the main header. A default ignition table is created by the user defining the required advance at several locations in the operating environment of the engine (Figure 10). The advance required as a result of increasing speed and changing load are both included in the table generation. Next to the *Default Ignition Table* window, in Figure 10, are graphical representations of the required points.

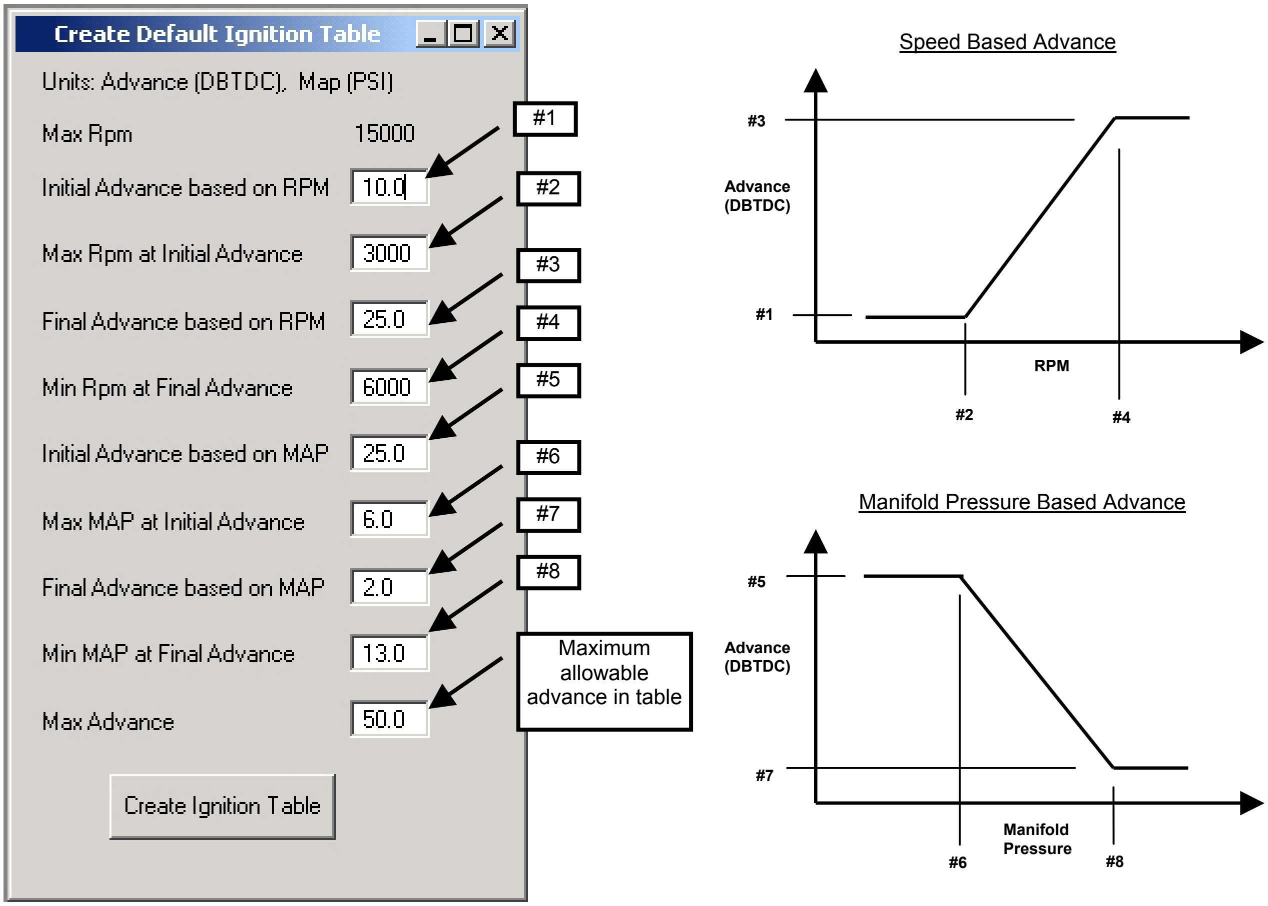


Figure 10 - Default Ignition Table Setup

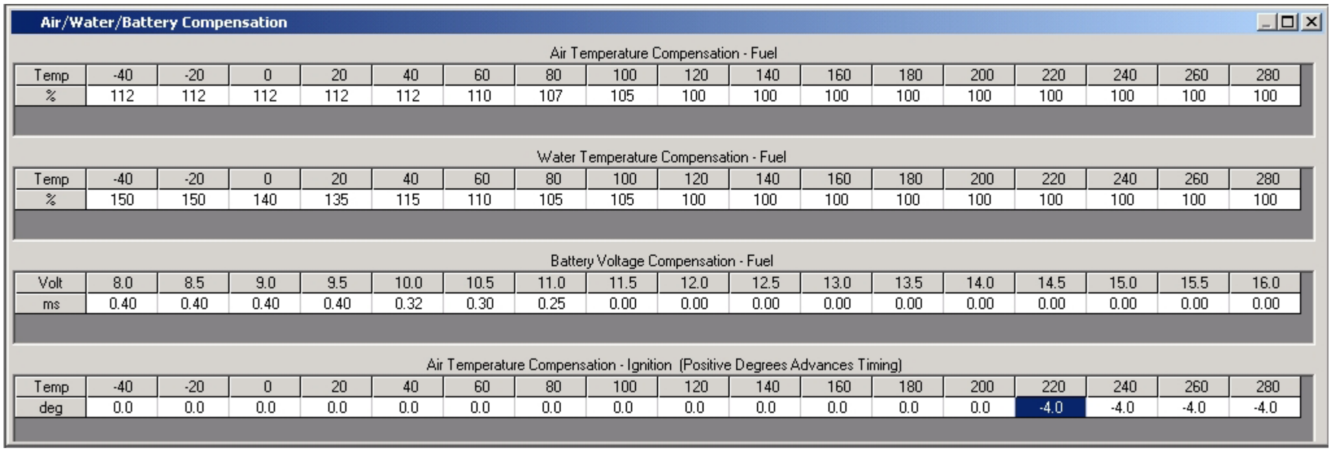
6.8 Air, Water and Battery Compensation

The air, water and battery compensation tables modify the fuel and ignition based on measured inputs (Figure 11). Tables can be accessed by clicking on the *Air/Water/Battery Compensation* command in the *Tuning* pull down. All of the values used to modify fuel or ignition are interpolated from the tables.

Entries in the air and water fuel compensation tables can range from 0% to 200%. These values modify the base open time by multiplication as a function of temperature (Equation 1).

Battery dependent adjustments in fuel flow are required in order to compensate for decreased injector response time at low system voltages. Consequently, values from this table are added to the overall open time of the injectors (Equation 1).

The air temperature can also be used to modify the total ignition timing. Entries in this table have a range of –50° to +50° of crank revolution. These values will either add or subtract timing from the total ignition. The *Smooth* function can also be used in these tables. Section 6.6 describes how this feature works.



Air/Water/Battery Compensation

Air Temperature Compensation - Fuel

Temp	-40	-20	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280
%	112	112	112	112	112	110	107	105	100	100	100	100	100	100	100	100	100

Water Temperature Compensation - Fuel

Temp	-40	-20	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280
%	150	150	140	135	115	110	105	105	100	100	100	100	100	100	100	100	100

Battery Voltage Compensation - Fuel

Volt	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0
ms	0.40	0.40	0.40	0.40	0.32	0.30	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Air Temperature Compensation - Ignition (Positive Degrees Advances Timing)

Temp	-40	-20	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280
deg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-4.0	-4.0	-4.0	-4.0

Figure 11 - Air, Water (Coolant) and Battery Compensation

6.9 Starting, Acceleration, Deceleration and Cylinder Compensation

The system includes fuel compensation algorithms to account for engine starting and transient conditions (Figure 12). The starting compensation circuit adds extra fuel to the engine while it tries to start. If the engine speed is below the Starting **RPM**, the ECU assumes that the engine is attempting to start. In this case, the injector open time is modified by a certain percentage. This percentage is based on the coolant temperature and the values entered at 0°, 80°, 160° and 240° F. If the coolant temperature is above 240°, the value at 240° is used. Likewise, if the coolant temperature is below 0° the value at 0° is used. For any other conditions, the starting compensation is interpolated based on temperature. Once the RPM increases above Starting **RPM** (when the engine starts), the compensation linearly decreases over several revolutions as defined by the setting **Duration**.

In addition to the compensation already described, the PE-ECU-1 also has the ability to provide an initial priming pulse to help the engine get fuel to start. If this parameter is set to anything other than 0.0 ms, all of the injectors will be opened for the amount of time specified for the first engine revolution.

Starting Compensation Parameters

- **0°F, 80°F, 160°F, 240°F** – These are the compensation factors at the respective coolant temperature values. Entries of 100-500 are allowed. This factor is applied to the base open time as long as the engine is trying to start.

- **Duration** – The number of revolutions that the compensation decays over once the engine is running.

- **RPM** – This is the speed value that is used by the ECU to indicate a starting condition. If the engine speed is above this value, the ECU assumes the engine is running. If the speed is below this, the ECU thinks the engine is trying to start and adds extra compensation.

- **Injector Prime Pulse** – This defines the length of time the injectors are opened for the priming pulse on the first revolution. Valid entries are 1.0 – 50.0 ms. If this parameter is set to 0.0, a priming pulse will not be used and the injector open time will be calculated from the base open time and the other compensation terms.

“Flood Clear” Feature

The PE-ECU-1 has an integral feature that can be helpful if the engine becomes flooded while trying to start. If the throttle position sensor indicates an “open” percentage greater than 98% and if the RPM is less than the starting **RPM**, the injectors will remain closed. This allows only air to be pumped through the engine and helps to evaporate the liquid fuel.

Acceleration/Deceleration Compensation

Acceleration compensation (Accel) temporarily increases the fuel flow when the throttle is opened abruptly. Additional fuel that enters the engine as a result of a transient event tends to initially wet the walls of the intake manifold rather than evaporate. If acceleration compensation is not addressed, the engine may run lean until it reaches a steady state.

The Accel circuit adds additional fuel as soon as the rate of throttle opening exceeds the **Min TPS Rate**. The amount of additional fuel is dictated by how quickly the throttle opens and by the parameter **Max Percent**. **Max Percent** is the theoretical maximum increase of fuel flow (in %) if the throttle were opened instantaneously. Once the compensation starts, it degrades back to nothing over the time period set in **Duration**. Additionally, the Accel compensation circuit is turned off if the RPM is above **Max RPM** or the throttle is below **Min TPS**. The list below describes all of the parameters in detail.

- **Min TPS Rate** – Determines the Accel circuit's sensitivity to throttle changes. This parameter is expressed in percent per second. The larger that this number is, the less sensitive the circuit is. For instance, if **Min TPS Rate** were 500, the throttle would have to open at a rate greater than what's required to go from fully closed to fully open in 0.2 seconds before any compensation was added (100%/0.2 sec = 500). The range of acceptable values for this parameter is 50-2000.

- **Accel Min TPS** – This is the minimum required throttle position before the Accel compensation is allowed to take affect. No compensation will occur when the throttle opening is less than this value. This parameter is expressed in percent and can be 0-100.

- **Max Percent** – This value is the maximum percentage that the injector open time would be modified by if the throttle could be opened instantly. This parameter is a theoretical maximum because opening the throttle always takes some amount of time. The actual percent is linearly interpolated based on this theoretical maximum and how quickly the throttle actually opened. Making this number larger adds more fuel for a given throttle rate. Making it smaller adds less. **Max Percent** is represented in units of percent. For example, a calculated value of 150, multiplies the injector open time by 1.5. Setting this value to 100 turns the Accel circuit off. The range of acceptable values for this parameter is 100-500.

- **Duration** – This is the amount of time that the Accel compensation degrades over. When the throttle moves faster than **Min TPS Rate**, an initial factor is calculated and is used to modify the injector open time. Over the time period defined by **Duration,** this factor degrades to 100. Acceptable values are between 0 and 2.5 seconds.

- **Max RPM** – This is the maximum RPM allowed for Accel compensation. If the engine speed is above this RPM, no compensation will be added regardless of throttle rate. The range for this parameter is 0-21,000 RPM.

The **Decel Fuel Cut-Off** circuit cuts the fuel based on throttle position and RPM. If the throttle position is less than **Min TPS** and the RPM is greater than **Max RPM** the ECU assumes that the engine is being motored (e.g. the vehicle is coasting). In this case, the injectors remain closed to conserve fuel until either the TPS increases (to greater than the **Min TPS** value) or the RPM slows down (to below **Max RPM** – **Delta RPM)**. To turn this feature off, set **Min TPS** to 0 and the **Max RPM** to a high number (15,000 for example).

<u>Cylinder Compensation</u>

The cylinder compensation allows the user to adjust the fuel flow between banks of cylinders. The injectors wired in cylinder banks #2, #3 and #4 can all be adjusted as a function of the open time for bank #1. The open time for the injectors in bank #1 is what is displayed in the main fuel table and in the Engine Data Header at the top of the Monitor Program. Individual banks of cylinders can be adjusted from 75% to 125% of bank #1.

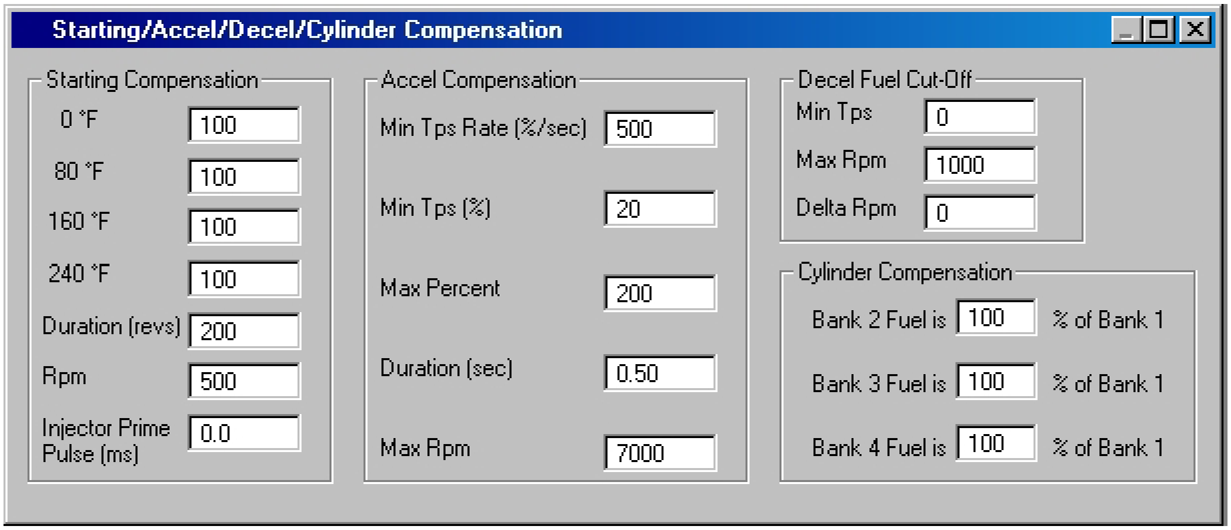


Figure 12 - Starting, Acceleration, Deceleration and Cylinder Compensation

6.10 Saving Data to the ECU

Data can be changed through the ECU Monitor while the engine is running. Anytime data is modified, updated variables immediately take effect. Unless the data is permanently stored, however, it will be lost once power is removed. Therefore, the user must save data by either clicking on  in the *Main Header* or by using the *Save Settings to ECU* command available under the *Tuning* pull down menu. This function permanently saves all variables. Depending on the number of changes since the last save, doing so may cause the engine to briefly hiccup. Once data has been saved to the ECU, it will remain there even after power down.

6.11 ECU Monitor Plotting Capabilities and Real Time Display

Both the main fuel and ignition tables can be plotted in 3-dimensions in order to better visualize the shape of the tables. These plots can be turned "on" by checking the feature in the *Display* pull-down menu (Figure 13). As a tuning aid, the plots indicate the state of the engine with a green dot. In addition, a blue dot on the plots marks the current cursor position in the table.

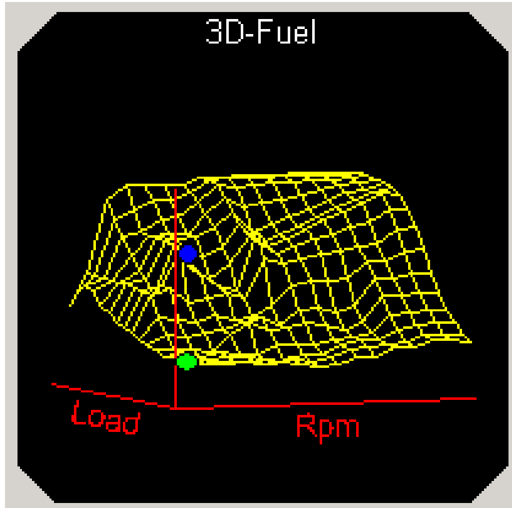


Figure 13 - Example 3-D Plot

In addition to the 3-D plotting functions, the ECU Monitor also has the ability to perform pseudo real time plotting of input signals and calculated values from the ECU. This feature is especially helpful during the tuning process in order to observe subtle changes in the engine's operation. The *Time History* command invokes the real time plotting module (Figure 14). Within the module, the user has the ability to start and stop the real time plot, change the value that is plotted, set the time axis and adjust the plot's upper and lower limits.

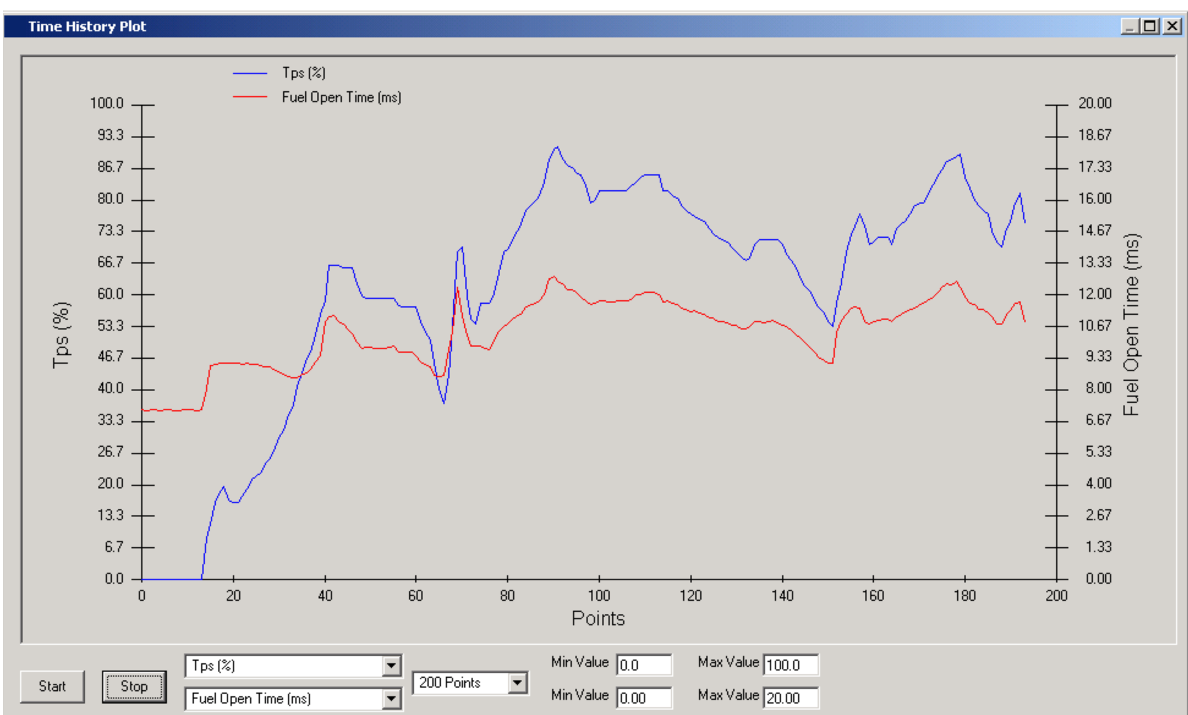


Figure 14 - Real Time Plotting Capabilities

6.12 Logging Data

The PE-ECU-1 system has the ability to record both measured and calculated data to a PC while online. This feature can be invoked by clicking on the *Log Data* command in the *Tuning* pull down menu or by clicking on the option in the footer of the Main Screen (See Figure 1). Each time that a log session is started, the Monitor will prompt the user to pick or create a data file. If an existing file is selected, data will be appended to the end of that file.

The parameters that are recorded depend on which windows are active in ECU Monitor. If the *Engine Data* header (the blue window at the top of the main fuel and ignition screen) is active without the *Time History Plot* window open, the data in the header will be logged to file. Anytime the *Time History Plot* window is open, however, the parameter that is displayed on the plot is logged along with the RPM, Load (MAP or TPS) and time. This allows faster data throughput rates when logging *Time History Plot* data.

Logged data is stored in a text file with both a date and time stamp. Once captured, the data can be viewed directly with any text editor or imported into excel for graphing.

6.13 Diagnostics and *Stop Engine* Feature

The PE-ECU-1 system has several diagnostic features available to the user. As described earlier (Section 5.1), if the ECU determines a discrepancy in the crank signal pulse train, a red error box will flash on the main screen footer (See Figure 1). This is very useful in determining an improperly aligned crank trigger wheel.

The *Diagnostics* window in the *Engine* pull down menu also contains several additional features (Figure 15). This window displays all of the system inputs in engineering units, raw voltage and binary representation. Also included is the ability to individually fire banks of injectors and coils when the engine is not running. If one of the *Fire Coil #* buttons is pressed, the associated ignition coil will charge for approximately 5 milliseconds and the fire. Pressing a *Fire Injector Bank #* button forces the ECU to open the injector for 10 milliseconds. This is enough time to produce an audible “click” in a quiet environment.

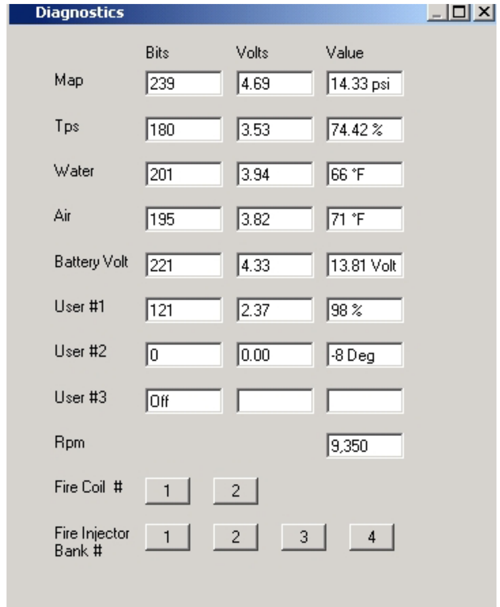


Figure 15 - Diagnostics Screen

Also included in the *Engine* pull down menu is the *Stop Engine* command. Clicking on *Stop Engine* while running stops the engine by momentarily suspending fueling and ignition events. This can be helpful when the user wants to kill the engine but still maintain communication with the ECU. After 5 seconds, the engine can be started again.

6.14 ECU Monitor Online Help

The ECU Monitor contains online assistance to provide help during the tuning process. Like most Windows™ software, the Monitor contains a *Help* menu in the header of the main window. Information is organized into specific topics that can be viewed in outline format or searched through using the help database.

Context sensitive help can also be used to identify objects and commands on the screen. Pressing the  button in the main window or selecting *What's This?* from the help menu initializes this feature. Once initialized, the user can select a parameter on the screen (for example the Main Fuel Table) and a description will appear.

7 Tuning Procedure and Starting for the First Time

The steps listed below are intended to provide a road map of how to get the engine up and running in the most efficient manner possible. Once all of the hardware is installed and operational, getting the engine to fire for the first time is very easy to do.

1. **READ THIS MANUAL IN ITS ENTIRETY!**

2. Wire the ECU and supporting hardware according to the diagrams in the Appendix.

3. Establish communications with the system using *ECU Monitor* (Section 6.1).

4. Setup all of the basic engine and sensor parameters (Section 6)

5. Check the operation of all the sensors, coils and injectors (using *Diagnostics,* Section 6.13). Do all of the sensors appear to be reading correctly and are the coils and injectors firing?

6. Disconnect the injectors and ignition coils from the ECU to keep the engine from flooding or trying to start. Turn the engine over and verify that the RPM is reading correctly. Look in the bottom right hand corner of the Monitor program for the red "Crank Error" box (Figure 1) as the engine turns over (for about 5 seconds). The error may appear just as the engine begins to spin and then again as it stops but it should go away while cranking. Reconnect the injectors and coils.

7. Evaluate the condition of all other required hardware such as the fuel pump, regulator, injectors, coils and plugs. If possible install a pressure gage somewhere in the system to ensure adequate fuel delivery.

8. If you are starting from scratch and have no prior knowledge of the fuel or spark requirements of the engine it is best to start by creating default fuel and ignition tables (See Section 6.7 for details). This will generate generic ignition and fuel tables to start the tuning process.

9. Establish a reasonable ignition curve a little on the retarded side. Concentrate on using the Main Fuel table to get the engine to run at all load states and speeds. Most misfiring can be attributed to incorrect fuel mixtures.

10. Get the engine to idle reasonably well first. Once this is done, adjust the fuel and ignition tables such that the engine will rev up, unloaded without missing.

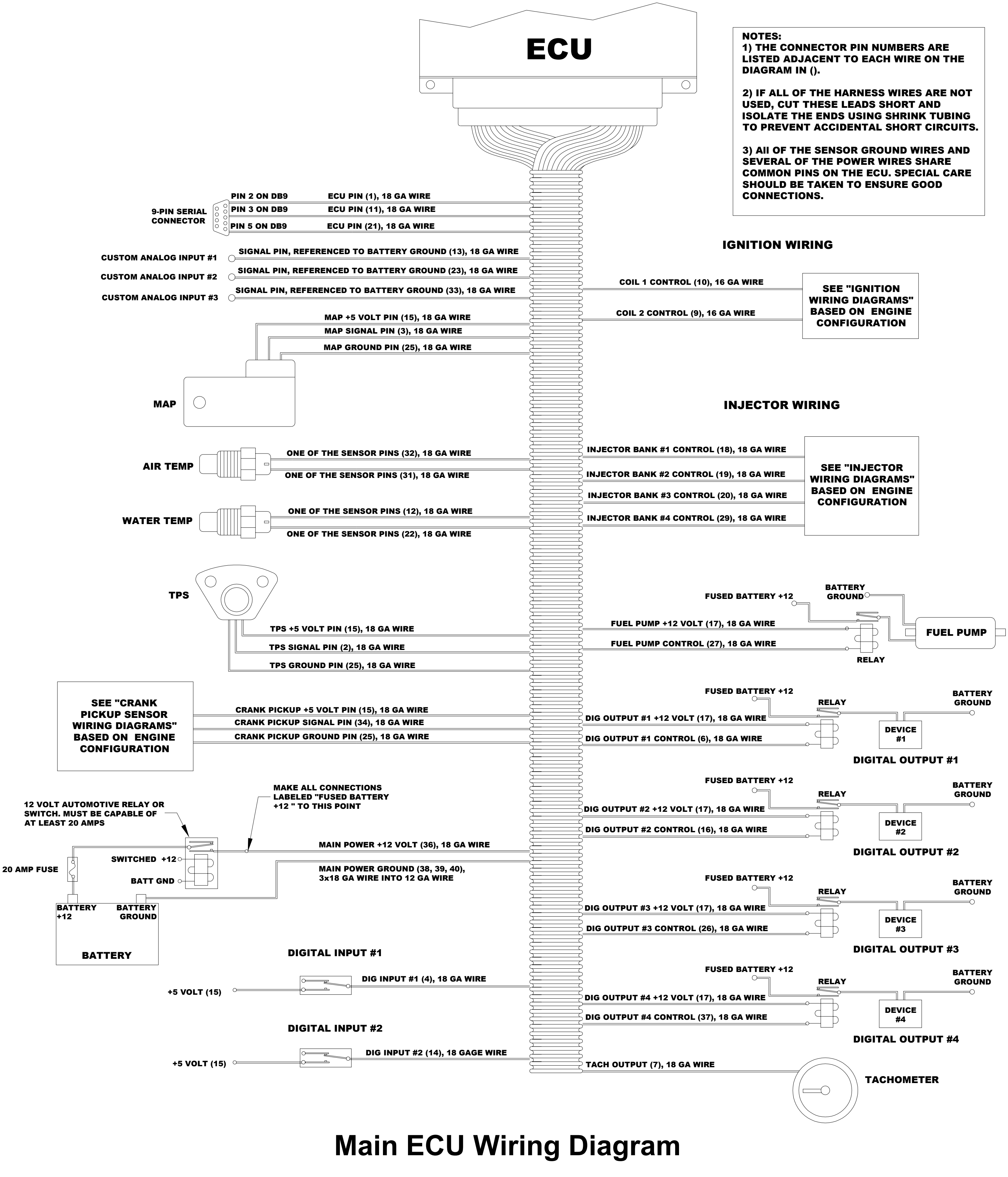
11. As soon as you get the engine to stabilize at idle, check the ignition timing with a timing light. The total timing indicated with the light should be equal to the timing displayed in the header of the Monitor program. Any difference between the two indicates that the crank position wheel is offset slightly.

12. It is sometimes very helpful to temporarily install potentiometers in two of the Analog User Inputs. Configuring one for fuel and the other for ignition timing gives the user a quick method to change the fuel flow and ignition on a real time basis.

13. Make only one change at a time before testing the effects on the engine.

14. Save the engine configuration to the ECU often. Also, if a particular set of adjustments seems to work well, save the setup file to the hard-drive of the PC.

APPENDIX – WIRING AND HARDWARE DIAGRAMS



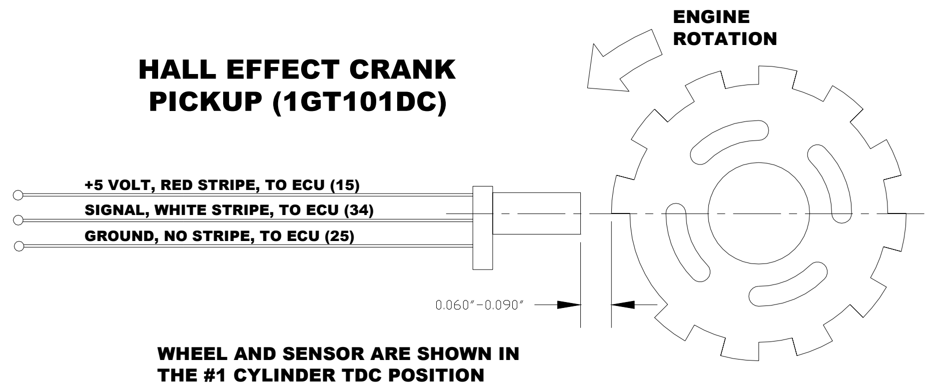
Main ECU Wiring Diagram

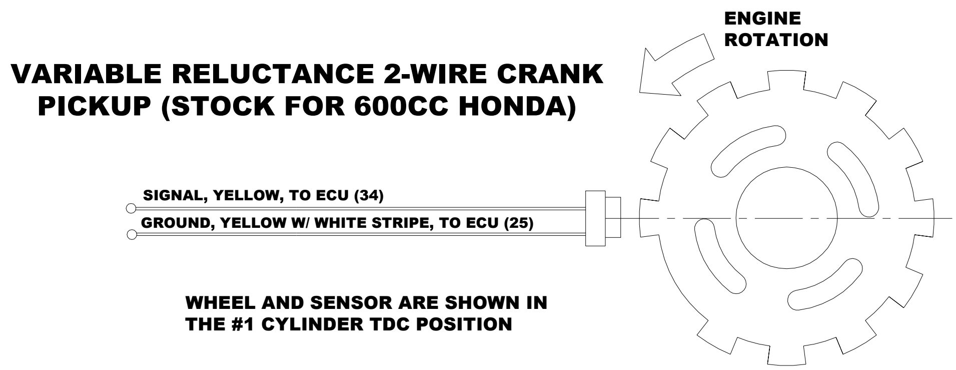
NOTES:
1) THE CONNECTOR PIN NUMBERS ARE LISTED ADJACENT TO EACH WIRE ON THE DIAGRAM IN ().

2) IF ALL OF THE HARNESS WIRES ARE NOT USED, CUT THESE LEADS SHORT AND ISOLATE THE ENDS USING SHRINK TUBING TO PREVENT ACCIDENTAL SHORT CIRCUITS.

3) BOTH TRIGGER WHEEL CONFIGURATIONS USE PERFORMANCE ELECTRONICS, LTD. SUPPLIED WHEELS.

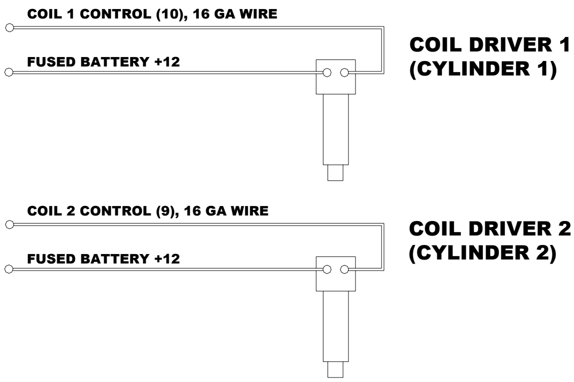
4) THE 2-WIRE VARIABLE RELUCTANCE SETUP IS SHOWN WITH A HONDA SENSOR.



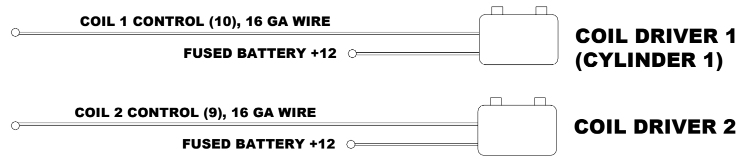


Crank Pickup Sensor Diagrams and Trigger Wheel orientation

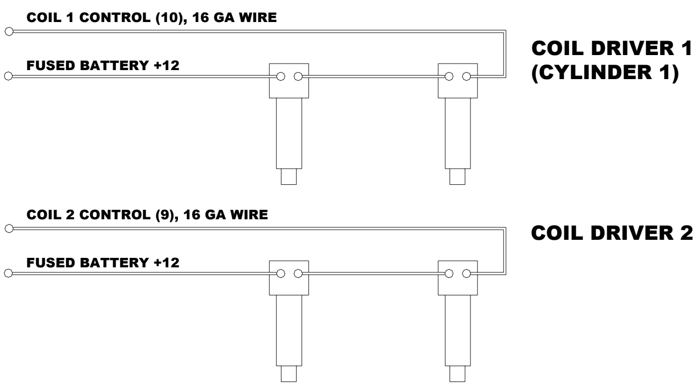
1 OR 2 CYLINDER COIL ON PLUG
MINIMUM INDIVIDUAL COIL RESISTANCE 1.5 OHM



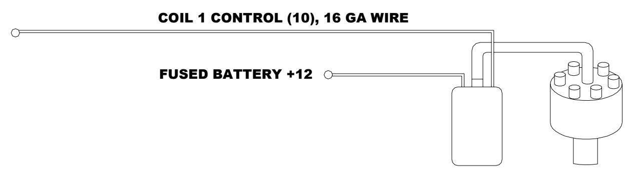
WASTED SPARK IGNITION, 4-CYL
MINIMUM INDIVIDUAL COIL RESISTANCE 2.0 OHMS



4 CYLINDER COIL ON PLUG
MINIMUM INDIVIDUAL COIL RESISTANCE 1.0 OHM



DISTRIBUTED IGNITION 4, 6 AND 8 CYLINDER
MINIMUM COIL RESISTANCE 2.O OHMS



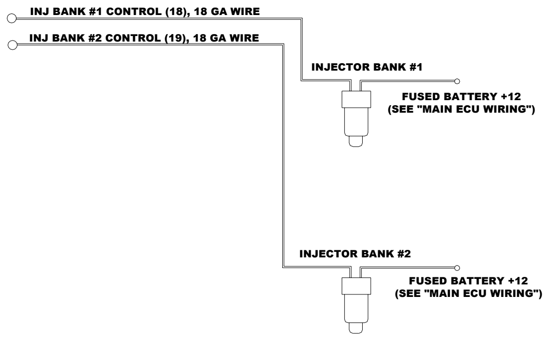
NOTES:

1) THE ECU CONNECTOR PIN NUMBERS ARE LISTED ADJACENT TO EACH WIRE ON THE DIAGRAM IN ().

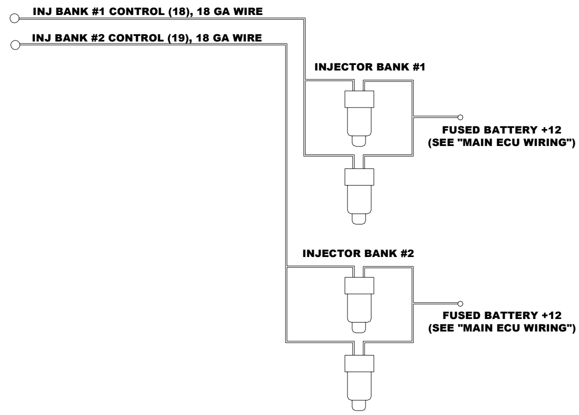
2) IF ALL OF THE HARNESS WIRES ARE NOT USED, CUT THESE LEADS SHORT AND ISOLATE THE ENDS USING SHRINK TUBING TO PREVENT ACCIDENTAL SHORT CIRCUITS.

Ignition Wiring Diagrams

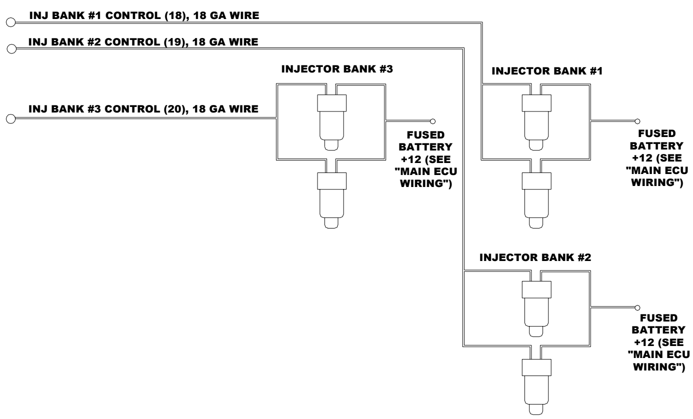
1 OR 2-CYLINDER WIRING



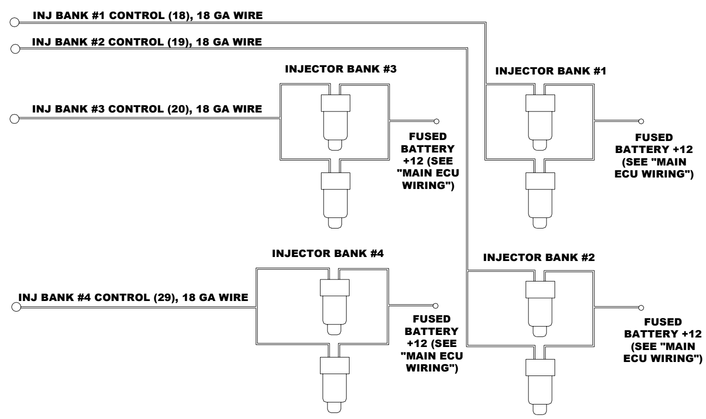
4-CYLINDER WIRING



6-CYLINDER WIRING



8-CYLINDER WIRING



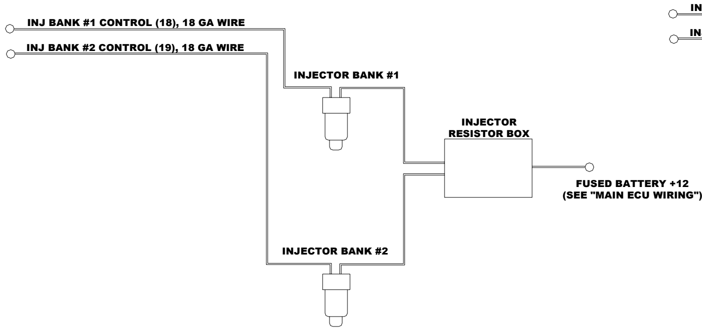
NOTES:
1) THE ECU CONNECTOR PIN NUMBERS ARE LISTED ADJACENT TO EACH WIRE ON THE DIAGRAM IN ().

2) IF ALL OF THE HARNESS WIRES ARE NOT USED, CUT THESE LEADS SHORT AND ISOLATE THE ENDS USING SHRINK TUBING TO PREVENT ACCIDENTAL SHORT CIRCUITS.

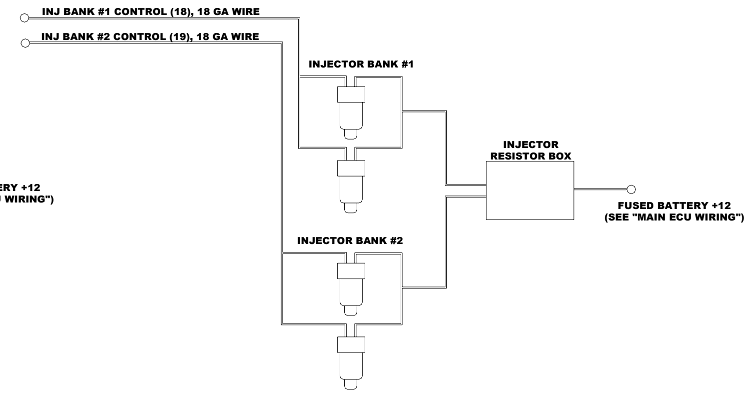
CAUTION: INJECTORS MUST HAVE A MINIMUM OF 10 OHMS RESISTANCE FOR THE CONFIGURATIONS DISPLAYED ABOVE. LOW RESISTANCE, PEAK AND HOLD INJECTORS MUST BE USED WITH A RESISTOR PACK. CONTACT PERFORMANCE ELECTRONICS FOR OPTIONS.

Injector Wiring Diagrams – Saturated (High Impedance) Injectors

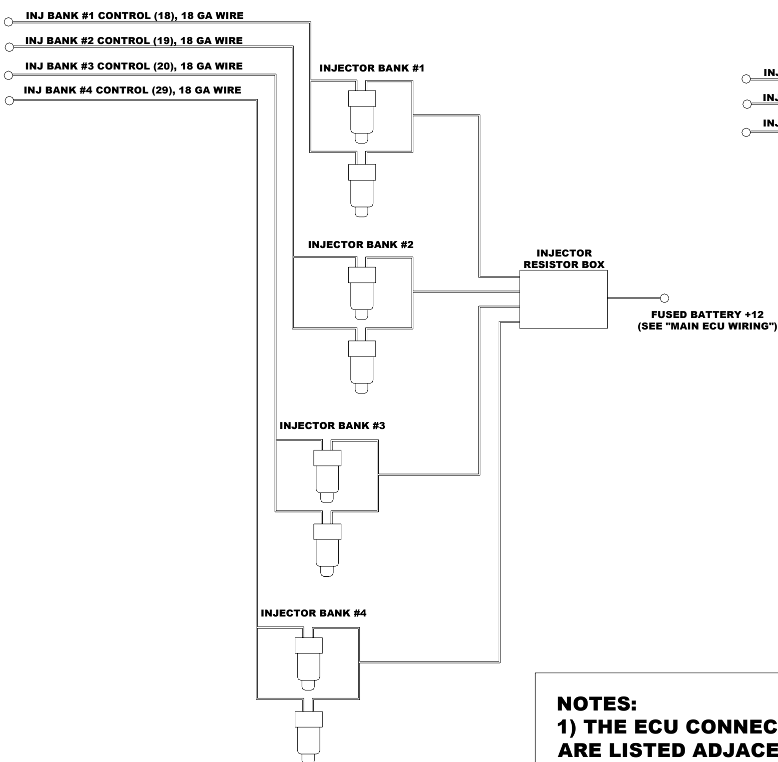
1 OR 2-CYLINDER WIRING WITH LOW IMPEDANCE INJECTORS



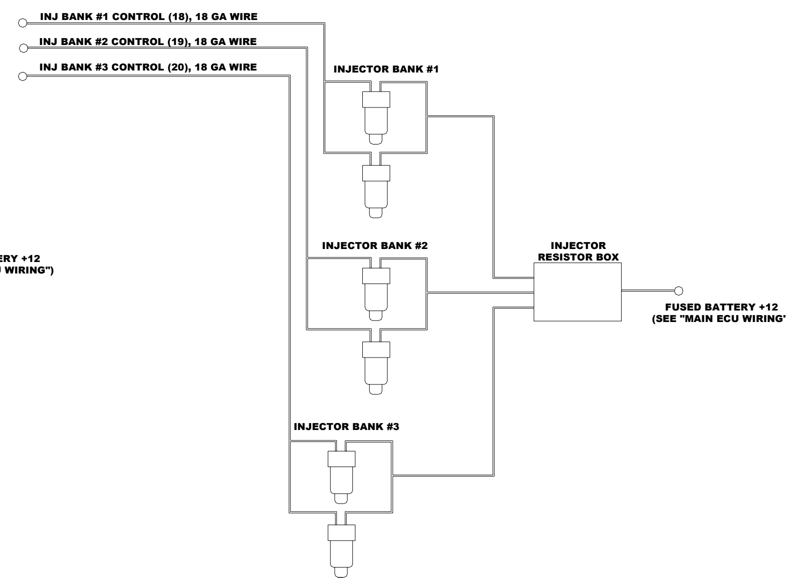
4-CYLINDER WIRING WITH LOW IMPEDANCE INJECTORS



8-CYLINDER WIRING WITH LOW IMPEDANCE INJECTORS



6-CYLINDER WIRING WITH LOW IMPEDANCE INJECTORS

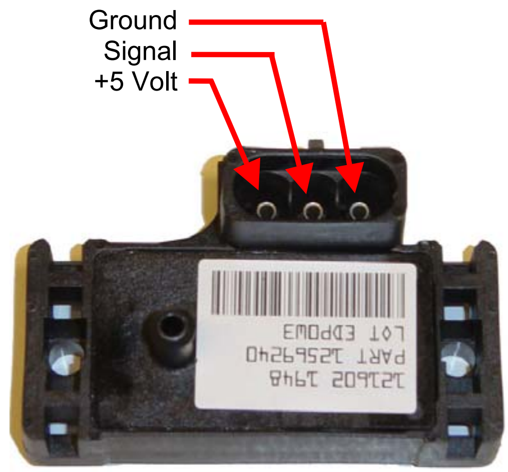


NOTES:

1) THE ECU CONNECTOR PIN NUMBERS ARE LISTED ADJACENT TO EACH WIRE ON THE DIAGRAM IN ().

2) IF ALL OF THE HARNESS WIRES ARE NOT USED, CUT THESE LEADS SHORT AND ISOLATE THE ENDS USING SHRINK TUBING TO PREVENT ACCIDENTAL SHORT CIRCUITS.

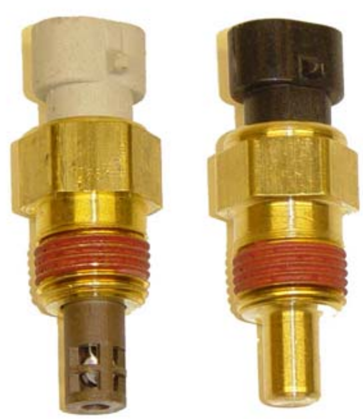
Injector Wiring Diagrams –Low Impedance Injectors



1, 2 and 3 Bar MAP Sensor Connections

Ground – Black
Signal – Green
+5 Volt - Orange

Throttle Position Sensor



Note: Because these devices are resistive, either wire can be connected to either sensor pin

Air and Coolant Temperature Sensors