



## The **PE3** Series User Manual

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- The products manufactured by Performance Electronics, Ltd. are subject to change without notification.
- Performance Electronics, Ltd. is not responsible for any property damage or bodily injury that may occur as a result of using this product.
- The user assumes all responsibility for any damage that may occur to an engine and or vehicle as a result of tuning. Performance Electronics, Ltd. will not cover any damage that may occur as a result of using this product.
- The system covered in this manual is not designed to meet any emission level regulations and does not carry a CARB E.O. identification number.

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## Updates to the Manual and Help Files

Version	Description	Date
1.0	Initial draft release of manual and help files for software versions 3.03.XX	2/14/12
1.1	Full (non-draft) release of manual and help files for software versions 3.03.XX	5/31/12

## **WARNING**

The PE3 is a sophisticated electronic product. Do not weld to any part of the vehicle with the PE3 connected to the vehicle. Large ground spikes and/or level shifts can damage the internal circuitry of the PE3.

# Introduction

The PE3 system is a fully adjustable engine control unit for single and multi-cylinder engines requiring a stand alone fuel injection and ignition Engine Control Unit (ECU). All setup and tuning parameters can be adjusted with any PC running a Windows operating system and containing an Ethernet port.

Below are some of the key features of The PE3 system:

## **General System Features**

- Completely adjustable via a PC.
- Lightweight (less than 1 pound) and compact (4.25"x 4.88" x 1.00") with a waterproof option.
- Dedicated CAN bus that allows communication with external devices.
- Standard on-board data logging for engine parameters and external inputs
- 25,000+ max RPM.
- Adjustable rev limits including primary, secondary and boost limits.
- Password protected access.
- Fast and reliable communication via Ethernet. Allows for easy tuning with wireless routers.
- Real-time tuning.
- Extensive error and diagnostic functions.
- Real-time plotting and data display.
- Save and load tuning files, or parts of tuning files, to and from disk.
- Primary/Secondary main fuel and ignition tables configurable with a switch.

## **Fuel Specific Control**

- 25x26 Main fuel table with adjustable indices and an option to reduce table size to 13x13.
- Barometric pressure, acceleration, deceleration, MAP, battery, air temp, coolant temp, and starting compensations.
- Individual cylinder trims.
- Closed loop O2 control with adaptive learning.
- Sequential, random sequential or semi-sequential injector firing.
- Adjustable injection timing control.
- Saturated or peak-and-hold injector drivers.
- Adjustable peak current and adjustable hold current for low impedance injectors.
- Staged injection.

## **Ignition Specific Control**

- Coil-on-plug, wasted spark or distributor based ignition.
- No external igniters required. 4 Inductive igniters are built in to the ECU.
- 25x26 Main Ignition table with adjustable indices and an option to reduce table size to 13x13.
- Starting, air temp, coolant temp, MAP and barometric pressure compensations.
- Individual cylinder trims.

- Adjustable dwell as a function of battery voltage.

### **System Inputs**

- MAP, TPS, barometric pressure, air temp, coolant temp, battery voltage, crank, cam and lambda.
- Up to 8 generic analog inputs that can be used to modify fuel, modify timing, cut fuel, cut timing or simply be logged.
- 2 generic thermistor inputs.
- Up to 7 user configurable digital inputs that can stop fuel, stop ignition, measure speeds, initiate secondary rev limit, start/stop data logging, etc.

### **System Outputs**

- Fuel pump driver.
- 8 peak-and-hold or saturated injector drivers.
- 4 ignition coil drivers with internal igniters.
- Dedicated tachometer driver.
- Idle air stepper motor driver.
- Up to 10 user configurable digital outputs.
- Up to 8 pulse width modulated (PWM) outputs with adjustable duty cycles based on 3-D tables.
- CAN bus.

## Abbreviations and Definitions

**Analog** - Refers to an input to the system that has an variable voltage. MAP sensors, for example, produce an analog signal. Typically they vary voltage from 0-5 volts as a function of manifold pressure.

**Alpha-N** - Type of fuel injection strategy where the main fuel and ignition tables are based on throttle position (alpha) and engine RPM (N).

**ATDC** - Abbreviation for 'After Top Dead Center'. Refers to an angular position of the crankshaft that occurs after top dead center of a particular cylinder.

**Base Open Time** - The open time of the injectors without additional compensation terms. The ECU calculates Base Open Time from the main fuel table using engine load and engine RPM.

**Batch Fire** - This defines a classification of fuel injection systems where all or a portion of the injectors fire at the same time.

**Breakpoint** - Breakpoints refer to the numbers in the axis of any table. For example, the x-axis of the main fuel table is RPM. The breakpoints for this axis are the RPM values that make up the axis.

**BTDC** - Abbreviation for 'Before Top Dead Center'. Refers to an angular position of the crankshaft that occurs before top dead center of a particular cylinder.

**Comp** - Short for compensation. Compensation terms modify the base fuel and ignition values to arrive at 'total' open time or 'total' ignition timing.

**CSV** - Stands for 'Comma Separated Variable' and refers to a type of data file. CSV files are outputs from the PE3 data acquisition system and trigger diagnostics. CSV files can be viewed in peViewer or Microsoft Excel.

**Digital** - Refers to an input or output to the system with either an 'on' or 'off' state.

**ECU** - Engine Control Unit. This is the main computer of the engine management system.

**Hall Effect Sensor** - This is a specific type of speed/position sensor used for cam/crank position sensing or wheel speed measurements. It is characterized as having a square wave output when a ferrous tooth passes in front of the sensor. Hall Effect sensors have three wires coming from them.

**IAC** - Idle Air Control. Generally refers to the act of controlling bypassed airflow to the engine at idle to regulate engine speed.

**IAT** - Intake Air Temperature. A measurement used to compensate fuel and ignition.

**kPa** - Abbreviation for kilopascal, a unit of pressure. This is usually used in the context of discussing manifold pressure. Approximately 100 kPa equals atmospheric pressure.

**LTF** - Long Term Factor. This is a fuel compensation term used in closed loop compensation.

**MAP** - Manifold Absolute Pressure or the pressure of air in the manifold. This is sometimes used to indicate engine load for electronic control.

**MAT** - Manifold Air Temperature.

**PSI** - Abbreviation for Pounds per Square Inch. This is a measure of pressure like kPa.

**PWM** - Pulse Width Modulated. Refers to a control technique used to drive some actuators and DC motors. A PWM drive signal turns the actuator on and off at a specific frequency. The amount of time that the signal remains on each cycle is called the duty cycle.

**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.

**Speed-Density** - Type of fuel injection strategy where the main fuel and ignition tables are based on manifold pressure (MAP) and engine RPM.

**STF** - Abbreviation for Short Term Factor. This is a fuel compensation term used in closed loop compensation.

**TDC** - Top dead center.

**Total Calculated Open Time** - This is the total open time of the injectors including all compensation terms except individual cylinder compensations. This is the value that is displayed under 'Fuel' in the main engine data header.

**TPS** - Throttle position sensor.

**VR Sensor** - Variable Reluctance sensor. This is a specific type of speed/position sensor usually used for cam or crank position sensing. It is characterized as having a sin wave output when a ferrous tooth passes in front of the sensor. VR sensors have two wires coming from them.

**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.

## Engine Management Overview

The PE3 is a completely adjustable engine control unit (ECU) designed to be used on single and multi-cylinder spark ignition engines. The heart of the system includes several microprocessors capable of executing millions of commands per second. Based on simple input from the user and the response from a variety of sensors, the ECU makes critical decisions concerning fuel and spark delivery as well as other outputs. Tuning the PE3 is as simple as running the peMonitor software while the ECU is connected to a PC via an Ethernet port or wireless network.

The following sections are intended to give the user some basic understanding of engine management and how the ECU is determining important values necessary for successful fuel and ignition control.

## Engine Control Hardware

A successful engine control system requires many electrical and mechanical components to work together. In addition to the PE3 engine control unit itself, there are many other parts necessary to complete a working installation. Below is a listing of some of the more common hardware components found in many modern electronic engine control systems.

### Fuel Supply Components

**Fuel Injector** - Fuel injectors are high speed solenoid valves that are either open or closed. When the injector is open, fuel is allowed to flow to the engine. When the injector is closed, fuel flow stops to the engine. The amount of fuel that the engine receives depends on the amount of time that the injector stays on during each engine cycle. This amount of time is commonly measured in 1/1000 of a second or milliseconds (ms).

**High Pressure Fuel Pump** - Fuel injected engines require a high pressure fuel pump to provide a constant flow of fuel to the injectors. Generally, the fuel pressure on the back side of the injectors for an electronic port injected electronic engine is 45-60 psi.

**Pressure Regulator** - Most fuel injection pumps require some form of regulator to maintain constant fuel pressure for the injectors. Many systems use a pressure regulator mounted directly on the fuel rail. Quite often, the pressure regulator is referenced to intake manifold pressure so that a constant pressure differential is maintained across the injector regardless of manifold pressure.

**Fuel Filter** - An important component in any fuel injection system is the fuel filter. Fuel injectors have very small orifices that need to be kept free from debris in order to function properly. Fuel filters are designed to remove potentially harmful contaminants from the fuel supply and should be selected based on the engine application and where in the system the filter is intended to be used.

### Engine Control Sensors

**Trigger Sensor (Crank)** - Many of the functions the PE3 must perform are solely or partially determined by the position of the crankshaft within the engine cycle. Appropriate hardware must be used so the position of the crankshaft can be determined by the ECU at all times. Generally, this consists of a variable reluctance (VR) or Hall effect sensor and a toothed wheel mounted on the crankshaft.

**Sync Sensor (Cam)** - A Sync Sensor works in conjunction with the Trigger Sensor and



allows the PE3 to determine the current stroke of the engine. In most 4-stroke piston engines, for example, the crankshaft rotates two times for every four engine strokes. The Sync Sensor and associated toothed wheel allow the PE3 to calculate the position of top dead center for each of the cylinders. This sensor is also either a VR or Hall effect sensor like the Trigger Sensor.

**Manifold Absolute Pressure (MAP) Sensor** - A MAP sensor measures the Manifold Absolute Pressure in the intake. MAP is commonly used as an indication of engine load. Generally, the higher the manifold pressure the more load on the engine. For naturally aspirated engines the maximum MAP is equal to barometric pressure (approximately 14.5 psi or 100 kPa).

**Barometric Pressure (Baro) Sensor** - A barometric pressure sensor measures the ambient air pressure surrounding the engine. Generally the Baro sensor is used to compensate the fuel and ignition for changes in ambient pressure.

**Throttle Position (TPS) Sensor** - Throttle position is one of the most basic measurements used on any engine. TPS can be used as an indication of engine load (like MAP) or for other fuel and ignition compensations to account for transient conditions in the engine. TPS can also be used to signal different operating conditions of the engine like idle or wide open throttle operation.

**Intake Air Temperature (IAT) Sensor** - The IAT sensor measures the temperature of the incoming air charge to the engine. This information is generally used to compensate the overall fuel and ignition terms for changing operating conditions. For example, colder air is more dense than warm air. Therefore a cold air charge will require more fuel than a warm air charge.

**Coolant Temperature (CLT) Sensor** - The CLT sensor is used to measure the coolant temperature of the engine. Like the IAT sensor this information can be used to add or remove fuel or ignition timing to the engine. Typically, colder engines require more fuel and a little more timing to idle and run well than do engines that have reached operating temperatures.

**Oxygen (Lambda) Sensor** - An oxygen, or lambda, sensor measures the oxygen ( $O_2$ ) content of the exhaust. The amount of remaining oxygen in the exhaust can be used to determine the air-fuel ratio (A/F) of the engine in real time. Generally speaking, oxygen sensors can be divided into two categories; wide band and narrow band.

**Narrow Band** = These sensors exhibit a very non-linear response around the stoichiometric mixture level ( $A/F=14.7$  for gasoline) and are only good for providing feedback right around stoichiometric levels.

**Wide Band Sensors** = Wide band sensors have a much larger usable range and can be used to measure both rich and lean mixtures in an engine. Wide band sensors are more complicated than narrow band sensors and require special conditioning to provide a usable signal for the ECU. A wide band sensor cannot be directly connected to the ECU without using a conditioner to turn the sensor's response into a 0-5 volt signal.

## **Ignition System Components**

**Ignition Coils** - The PE3 ECU can directly drive up to 4 inductive ignition coils or up to 8 coils using external igniters. The PE3 can also drive external CDI boxes.

**Spark Plug Wires** - If coil-on-plug ignition coils are not used, some kind of plug wire is required. It is recommended that only high quality plug wires with some sort of EMI (electromagnetic interference) suppression be used. Excessive EMI can lead to errant sensor signals and difficulty running the engine under a load. In addition, solid core plug wires

should NEVER be used with an electronic controller like the PE3.

## Fuel Metering

The PE3 is capable of individually controlling up to 8 saturated or peak-and-hold fuel injectors in several different modes including sequential, semi sequential and random sequential (16 injectors can be driven in certain modes). Fuel injectors are either open or closed. The length of time the injectors remain open every engine cycle determines how much fuel flows to the engine. The ECU controls when and for how long each injector remains open based on input from external sensors and the tuning parameters established by the user. The equation below describes how the ECU calculates the open time of the injector for each event. In addition to the length of time the injector is open, the angle (in crank degrees) when the injector closes can be defined in peMonitor.

$$\text{Open Time} = (\text{BOT} \times \text{AT} \times \text{CT} \times \text{ST} \times \text{AC} \times \text{BP} \times \text{MP} \times \text{STF} \times \text{LTF} \times \text{CC} \times \text{UI}) + \text{BA}$$

Where:

BOT = Base open time from the main fuel table  
 AT = Air temperature compensation  
 CT = Coolant temperature compensation  
 ST = Starting compensation  
 AC = Acceleration compensation  
 BP = Barometric pressure compensation  
 MP = MAP compensation  
 STF = Short term factor for closed loop lambda compensation  
 LTF = Long term factor for closed loop lambda compensation  
 CC = Individual cylinder compensation  
 UI = User selectable input compensation (could be several if configured)  
 BA = Battery voltage compensation

## Ignition Control

The PE3 has the capability to directly control up to 4 inductive ignition coils in sequential, wasted spark or distributor mode. The PE3 **DOES NOT** require external igniters to fire inductive coils. There are 4 igniters built into the ECU hardware. If more than 4 ignition coils are required for a particular application, the PE3 can accommodate up to 8 ignition coils using external igniters or smart coils.

Ignition control is completely configurable in the PE3. The type of ignition, coil charge time and the ignition timing itself are all adjustable. The total ignition timing is the sum of the base timing from the main table and several other compensation terms as defined below.

$$\text{Total Ignition Timing (degrees)} = \text{BIT} + \text{AT} + \text{CT} + \text{BP} + \text{MC} + \text{CC} + \text{UI}$$

Where:

BIT = Base ignition timing from the main ignition table  
 AT = Air temperature compensation  
 CT = Coolant temperature compensation  
 BP = Barometric pressure compensation  
 MC = MAP compensation  
 CC = Individual cylinder compensation  
 UI = User selectable input compensation (could be several if configured)

## **Table Interpolation**

Much of the control logic built into the PE3 involves using information from large tables that are developed by the user. For all of these tables, linear interpolation is used to look up values and calculate results. Table interpolation allows the PE3 to estimate the value from a table even if the current operating point is between several cells of the table.

## Wiring The PE3

For some applications, adapters are available that allow the PE3 to plug directly into a stock factory wire harness without additional wiring by the user. Many cases, however, require a custom harness. The next several sections are intended to provide information for building a custom harness or adding functionality to a factory installation.

The PE3 ECU contains two, waterproof, automotive style connectors. The 34-pin connector is always required for operation and is the 'Main' connector. The smaller 26-pin connector accommodates additional inputs and outputs as well as the Ethernet connection required to communicate with a PC. The 26-pin connector is called the 'Comm' connector.

Un-terminated Main and Comm harnesses from PE have the connector that mates to the ECU at one end and bare wire at the other. Connector pin numbers are printed every 8 inches of wire for easy identification. Wires in the Main harness are labeled with the prefix 'M' (e.g. M-16 is pin 16 in the Main connector) and wires in the Comm harness are labeled with 'C' (e.g. C-12). This wire labeling convention is also utilized in the wire diagram.

If additional wire must be added to the supplied harnesses, the same gage or larger wire should be used. In addition, proper wiring practices should 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. Unused wires in the harness should be removed or clipped, eliminating any bare copper that could cause an unwanted short circuit.



Waterproof PE3 Unit



'Main' Harness Pigtail



Example Factory Harness Adapter

## Connecting Power to the PE3

Power for the PE3 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 14-gage wire should be used for the ground wire on the ECU. For the +12 volt side of the power supply, 20-gage wire is sufficient.

The PE3 begins to run anytime that power is applied. It is necessary to power the ECU off when the engine is not running to avoid depleting the vehicle battery.

Power to the PE3 should be provided through a relay activated with switched +12v power. See the PE3 wiring diagram for details on connecting power to the PE3 (see 'Wiring Diagram' for details).

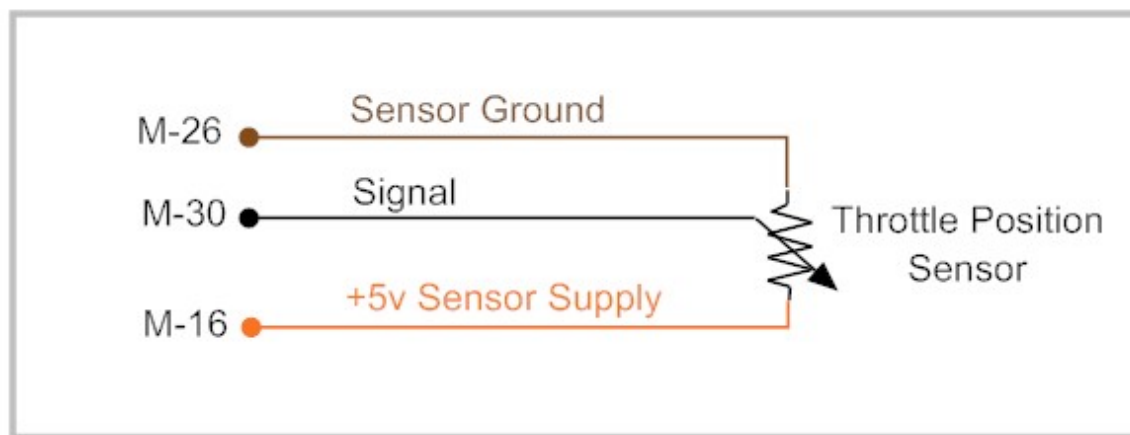
## Connecting Sensors and Analog Inputs

The PE3 is a sophisticated ECU that can take advantage of many different analog and digital signals to properly control an engine. Some sensors are not necessary for basic operation, however, and can be omitted if the particular feature or compensation is not needed. In its most basic configuration, the ECU requires only an indication of engine load and a trigger signal to function. Generally, a well-tuned engine will require many more inputs than this.

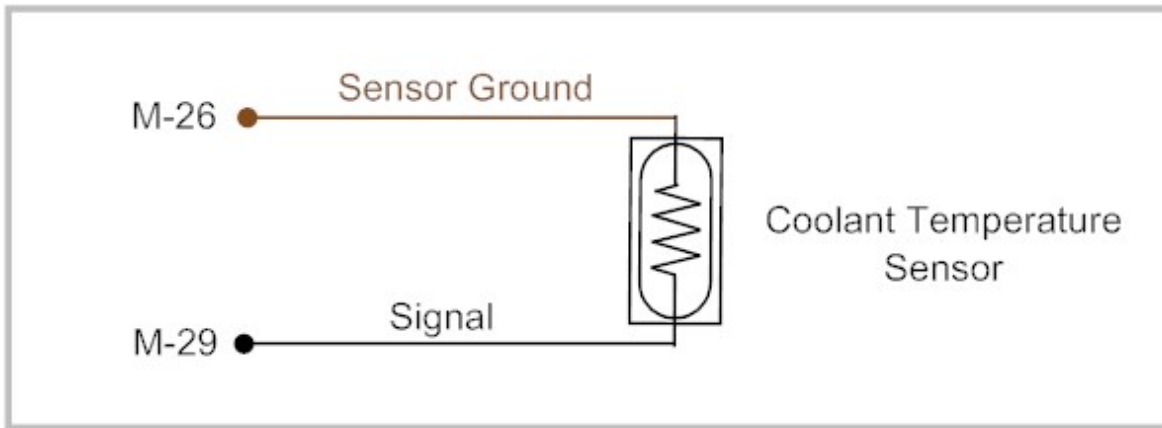
The PE3 has dedicated inputs for most common sensors including Throttle Position (TPS), Intake Air Temperature (IAT), Coolant Temperature (CLT) and Manifold Absolute Pressure (MAP). Barometer and lambda sensors can be connected to any of the extra analog inputs and configured as such in the software. Please refer to ['Setup Sensors'](#) for more information on configuring sensors.

In addition to the standard sensors mentioned above, the PE3 can also accommodate up to eight generic analog inputs that can be used to modify the fuel or ignition timing or simply for logging purposes. One of these inputs can accommodate 0-22 volts input. The remaining are 0-5 volt inputs. Two of these extra inputs can be configured to measure temperature using a resistive device like a thermistor similar to the CLT and IAT sensors. Please refer to ['Setup User Data'](#) for information on configuring the extra inputs and to the ['Wire diagram'](#) for pin locations of the individual inputs.

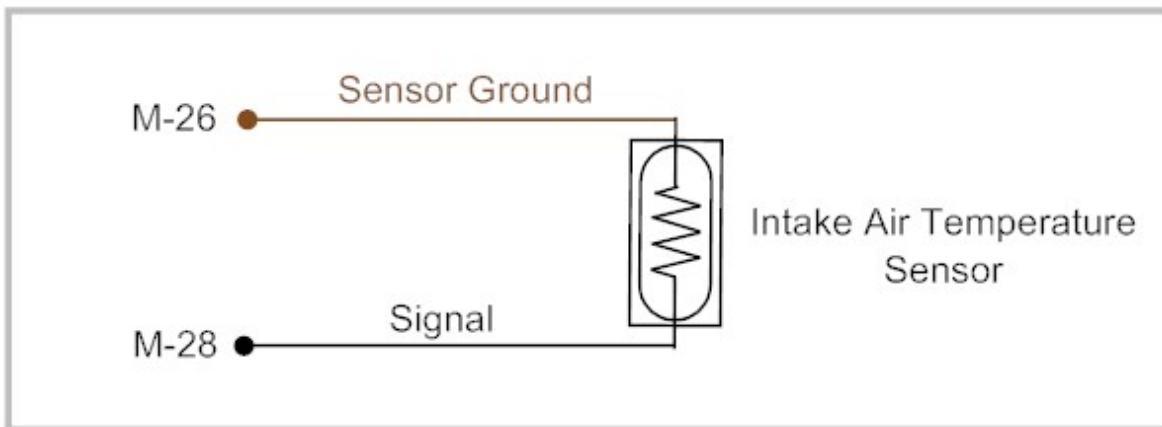
Below are several diagrams showing how to wire common sensors to the PE3. A more complete diagram can be found in the ['Wire Diagram'](#) section of the manual. Also, please refer to the PE website for application pages concerning other specific sensors.



Throttle Position Sensor Wiring



Coolant Temperature Sensor Wiring



Intake Air Temperature Sensor Wiring



Manifold Absolute Pressure Sensor Wiring

## Connecting Digital and Frequency Inputs

The PE3 has the ability to monitor up to 7 digital inputs. Five of these digital inputs are activated by switching them to +5 to +22 volts (Digital Inputs #1, #2, #3, #4 and #5). Two other inputs are activated by switching them to battery ground (Digital Inputs #6 and #7). None of the digital inputs are left floating when inactive. They are all pulled either high or low internal to the ECU.

Please refer to the [wire diagram](#) for pin locations for the individual inputs. Digital inputs can be used to activate a number of additional features in the PE3 control system. Whenever a digital input is activated, the corresponding green light in the data header lights up (see '[Engine Data Header](#)'). Please refer to the '[Digital Inputs](#)' section for additional information on possible functions.

In addition to the ability to measure a change in state on the input, Digital Inputs #1, #2, #3 and #4 can be configured to measure frequency. These can be used to measure vehicle speed or rotating shaft speeds with a square wave. In addition, some original equipment automotive pressure and flow sensors are also frequency based. The frequency inputs are available for use by other modules in the PE3 like modifying fuel and ignition timing or simply for logging to the internal data acquisition system.

## Wiring Injectors

The PE3 is capable of individually controlling up to 8 saturated or peak-and-hold fuel injectors when wired with 1 injector per driver. When 2 injectors are paired on a single driver up to 16 injectors can be controlled. The PE3 is capable of running in several different modes including sequential, semi sequential, random sequential and throttle body modes (see the '[Fuel](#)' tab for a description of each).

The length of time each injector remains open is based on the total calculated injector open time. The timing of the injector with respect to the crank position is determined from the entries in the table '[Fuel Angle](#)'.

In addition to the different modes, injectors can also be staged such that a second set of injectors begins flowing fuel at a pre-determined load and engine speed (see Staged Injection in the '[Fuel](#)' tab). This can be particularly useful for engines requiring high fuel flow under loaded conditions. When using the 'Staged Injection' option, injector drivers 1, 2, 3 and 4 are always the primary injectors and injector drivers 5, 6, 7 and 8 are the secondary injector drivers that come on at specific load and RPM values. When the secondary injectors begin firing, they open at the same instant and for the same length of time as their corresponding primary injector according to the following pairing:

- Injector #1 and Injector #5 fire together
- Injector #2 and Injector #6 fire together
- Injector #3 and Injector #7 fire together
- Injector #4 and Injector #8 fire together

Please refer to the '[Wire diagram](#)' or the PE website for application pages concerning specific installations and wiring examples.

## Wiring Ignition Coils

The PE3 has the capability to directly drive up to 4 inductive ignition coils in sequential, wasted spark or distributor mode. The PE3 **DOES NOT** require external igniters to fire inductive coils. There are 4 igniters built into the ECU hardware. If more than 4 ignition coils are required for a particular application, the PE3 can accommodate up to 8 ignition coils using external igniters or smart coils. When driving more than 4 ignition coils, digital outputs can be used as the additional coil drivers per the table below.



<b>PE3 Pin (from Wire Diagram)</b>	<b>Function</b>
Coil #1 (M-01)	Control signal for ignition coil #1
Coil #2 (M-04)	Control signal for ignition coil #2
Coil #3 (C-13)	Control signal for ignition coil #3
Coil #4 (C-26)	Control signal for ignition coil #4
Digital Output #7 (M-22)	Control signal for ignition coil #5
Digital Output #8 (M-24)	Control signal for ignition coil #6
Digital Output #9 (M-25)	Control signal for ignition coil #7
Digital Output #10 (M-06)	Control signal for ignition coil #8

Coil Wiring When Driving More Than 4 Ignition Coils

The PE3 fires each coil driver based on the total calculated ignition timing and the Top Dead Center (TDC) settings as defined in the ['Define TDC'](#) tab. The firing order of the engine is also determined by the 'Define TDC' settings.

Each coil driver is current protected. If at any time the ignition driver senses more than 10 amps of current, an over-current error will be set and the driver will be disabled until the PE3 is powered down. A common cause of over-current errors in the ignition system is charging the coil for too long based on the ['Charge Time'](#).

Information regarding how to configure the software for specific ignition systems can be found under the ['Setup Engine-Ignition'](#) tab. Please refer to the ['Wire Diagram'](#) or the PE website for application pages concerning specific installations and wiring examples.

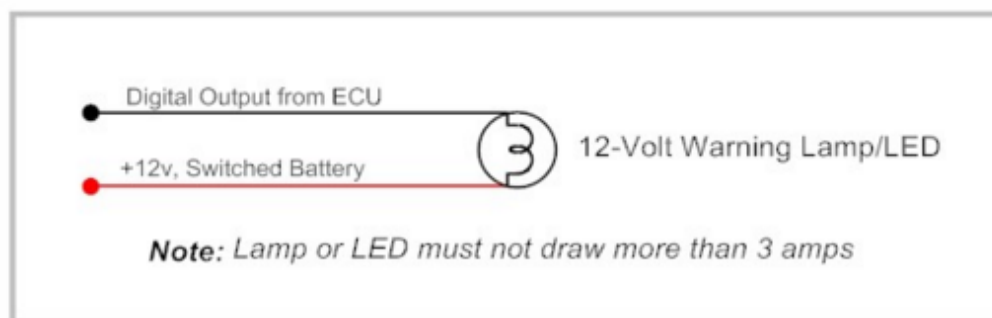
## Controlling Auxiliary Devices with Digital Outputs

The PE3 has 10 digital outputs that be used for various functions. Digital outputs can either be used to turn on and off external devices like a fuel pump or cooling fan or used to PWM (Pulse Width Modulate) external actuators like a boost control solenoid or idle speed valve. The type of control that the actuator requires depends on the design of the actuator. The digital outputs are all low-side drivers which means that when they are turned 'on' they complete the circuit to ground. Whenever a digital output is activated, the corresponding green light in the data header lights up (see ['Engine Data Header'](#)).

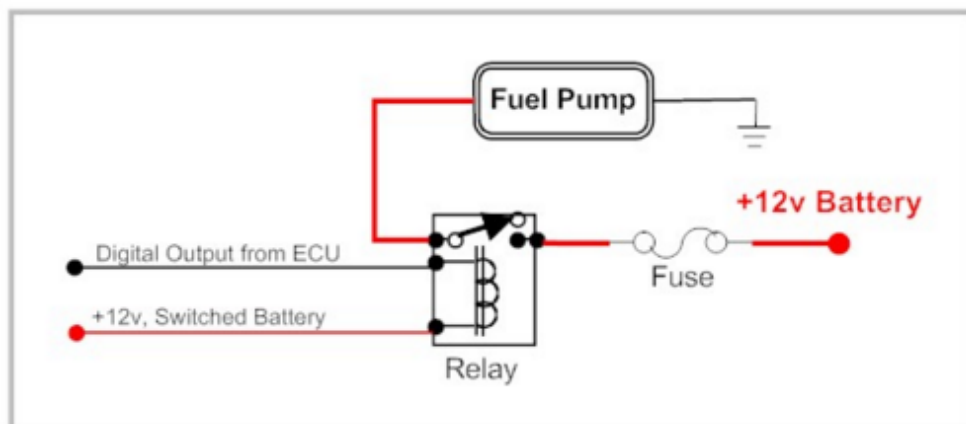
Each digital output is internally protected and cannot supply more than 3 amps of current. If more than 3 amps of current is required by the actuator, either a relay or an external high current driver must be used. If any one digital output flows more than 3 amps or all of the digital outputs combined flow more than 15 amps, an over-current error will be generated (see ['System Status'](#)). Each of the digital outputs corresponds to a particular driver or pin coming from the PE3. Please refer to the ['Wiring Diagram'](#) for the pin locations of specific digital outputs.

A detailed discussion for configuring the digital outputs can be found in the tuning software section in either ['On/Off Control'](#) or ['Table Based PWM'](#) depending on the type of digital output required.

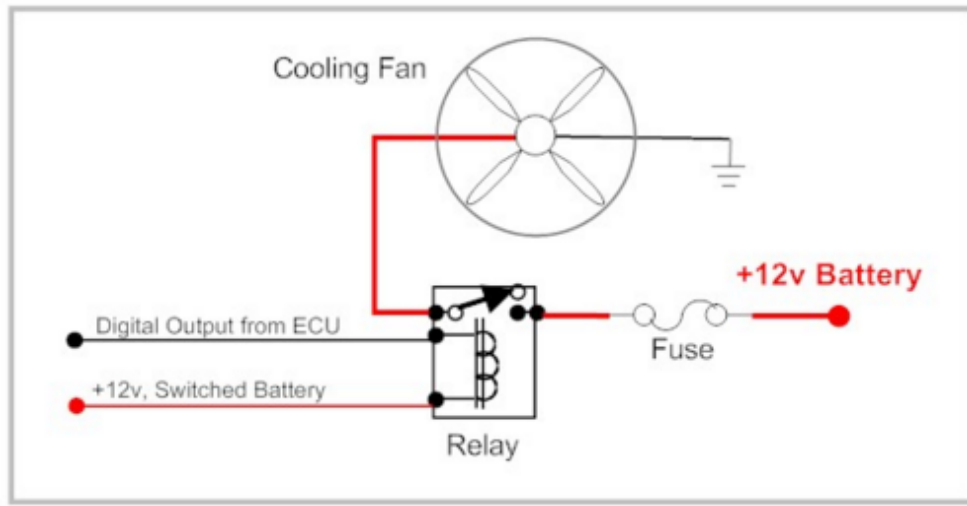
Below are several examples of wiring common actuators using digital outputs from the PE3.



Connecting a Warning Light to the PE3



Wiring a Fuel Pump with the PE3

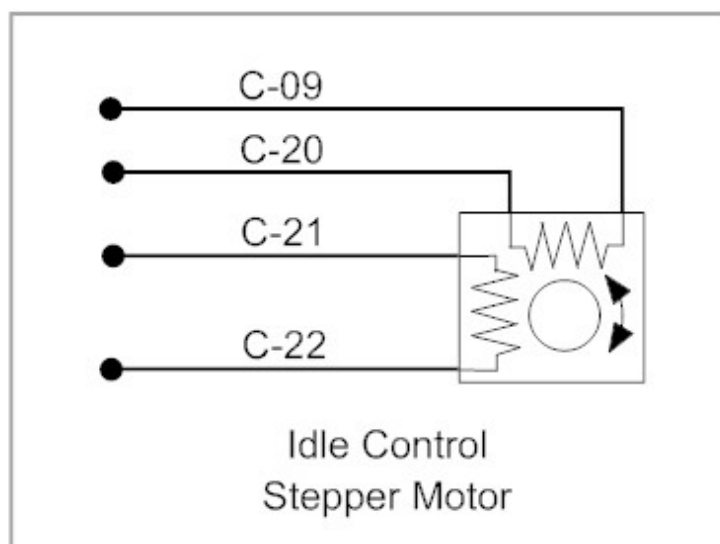


Connecting a Cooling Fan to the PE3

## Using an Idle Control Motor

The PE3 can control several types of idle control devices including bipolar stepper motors, PWM based single coil motors and unipolar (star drive) stepper motors. Below is a brief description of each type and how they are wired to the PE3. Please refer to ['Idle Air Control'](#) for notes on configuring the idle control system.

**Bipolar Stepper Motor** - An example of a bipolar stepper motor is a traditional 4-wire, GM style idle motor. Each motor pin is connected to the end of one of two coils of wire in the motor. Positive voltage and ground is connected to the different wires in a specific pattern to turn the motor one direction or the other. Below is an example of how a stepper motor is connected to the PE3. A bipolar stepper motor must use the dedicated stepper motor driver in the PE3.



Bipolar Stepper Motor Wiring

**PWM Based Motor** - A pulse width modulated (PWM) idle motor uses only one coil and a spring loaded return mechanism. Without any power applied to the motor, the valve is held closed using spring pressure. The valve moves open as a function of the amount of current that is flowing through the coil. Generally, the PWM frequency is between 100 Hz and 500 Hz depending on the design of the valve. The average current through the valve is controlled by the duty cycle of the PWM signal. The higher the duty cycle, the more current through the valve. This is typical of the type of valve Ford uses for idle control. Digital outputs #1 - #8 can be used to drive this type of motor. The other wire from the motor is connected to switched +12 volts.

**Unipolar Stepper Motor** - A unipolar stepper motor is similar to the bipolar stepper motor except for the fact that the polarity at each pin never changes. This type of motor is common with some kinds of motorcycles and other smaller engines. It is also sometimes called a 'Star Drive' because of the way that the circuit diagram for the motor looks. This type of motor uses digital outputs #5, #6, #7 and #8.

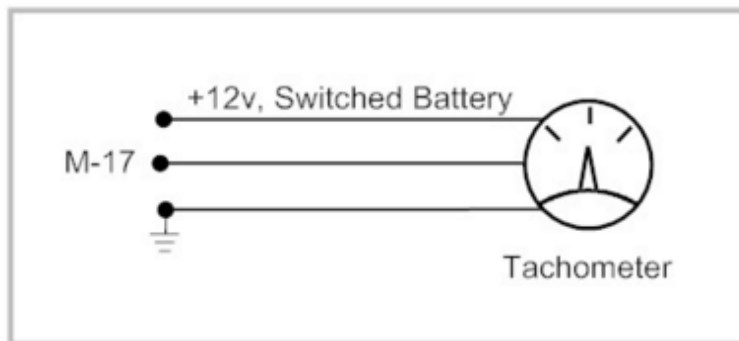
## Wiring an External Tachometer

The PE3 ECU has a built in, dedicated tachometer driver (See ['Wire Diagram'](#) for location). This

output can drive most after-market and OEM tachometers. The output from the drive circuit is a square wave with a 30% "on" (Vbat) and 70% "off" (0v) duty cycle. The number of pulses per revolution that the driver outputs is based on the parameter 'Tach Pulses per Rev' set under on the ['Engine' Tab](#).

In addition to the dedicated tachometer output, the PE3 Digital Outputs can also be configured as a tachometer drivers. If driving a traditional tachometer, a pull-up resistor may be required. Please refer to ['Digital Outputs - On/Off Control'](#) for more details.

Please refer to the tachometer manufacture documentation to ensure proper wiring. Below is an example.



Tachometer Wiring

## Wiring and Using a CAN Device

On some models, the PE3 system includes a CAN based communication bus that allows the ECU to send information to external devices including data loggers and racing dashes. Connecting to the CAN bus requires hooking up two wires to the external device, Can Bus Lo and CAN Bus Hi. Also, depending on the length of the CAN wiring and proximity to electrically noisy components, it may be necessary to use shielded, twisted wire to make the connection. The PE3 does include a 120 Ohm termination resistor internal in the ECU.

There is no configuration required to enable the CAN bus on the PE3. When powered up, the ECU is always broadcasting data on the bus. Please refer to the latest PE application page that discusses the protocol for data on the bus. Information that is broadcast is constantly being added to and updated. The PE standard protocol for broadcasting data is loosely based on the SAE J1939 standard.

## peMonitor Tuning Software

The sections below describe the different functions that can be configured in the peMonitor tuning software. Starting with the section labeled '[File Drop Down Menu](#)' below, this part of the manual is organized in the same order as the main drop down header at the top of the peMonitor screen.

## Installing peMonitor and Establishing Communication

The PE3 communicates with a computer via Ethernet using the peMonitor tuning software. The ECU can either be directly connected to the computer through a standard Ethernet port or it can be part of a wired or wireless network using a third-party router. Establishing communication with the PE3 is a little different depending on the particular configuration and operating system.

**Establishing a Direct Connection Using Windows 7** - A direct, wired connection using Windows 7 requires the least amount of setup. Follow the steps below to begin communicating with the PE3.

1. Install the tuning software, peMonitor, on a computer with an Ethernet port by running the file 'peMonitorInstaller.msi' from the disk or downloaded file. Do not start peMonitor at this time.
2. Connect the 26-pin Comm harness and the 34-pin Main harness to the PE3. Make sure that any unused pins are not shorted together or to the vehicle ground.
3. Connect the PE3 Ethernet connector from the Comm harness to the computer's Ethernet port.
4. Power up the PE3 by connecting 'Battery V+' and 'Battery GND' to the appropriate locations (see ['Wiring Diagram'](#) for pin locations).
5. Start peMonitor. When peMonitor launches for the first time, the computer's firewall program will prompt you to allow peMonitor access to the Ethernet port. You must select 'Unblock' (or equivalent depending on your firewall program) in order to establish communication.

**Note:** Sometimes the firewall software will display this window under the peMonitor screen and it will be necessary to minimize peMonitor to access it. If you do not allow peMonitor through the firewall you will not be able to communicate with the ECU. The figure below shows the notification for the Windows firewall.



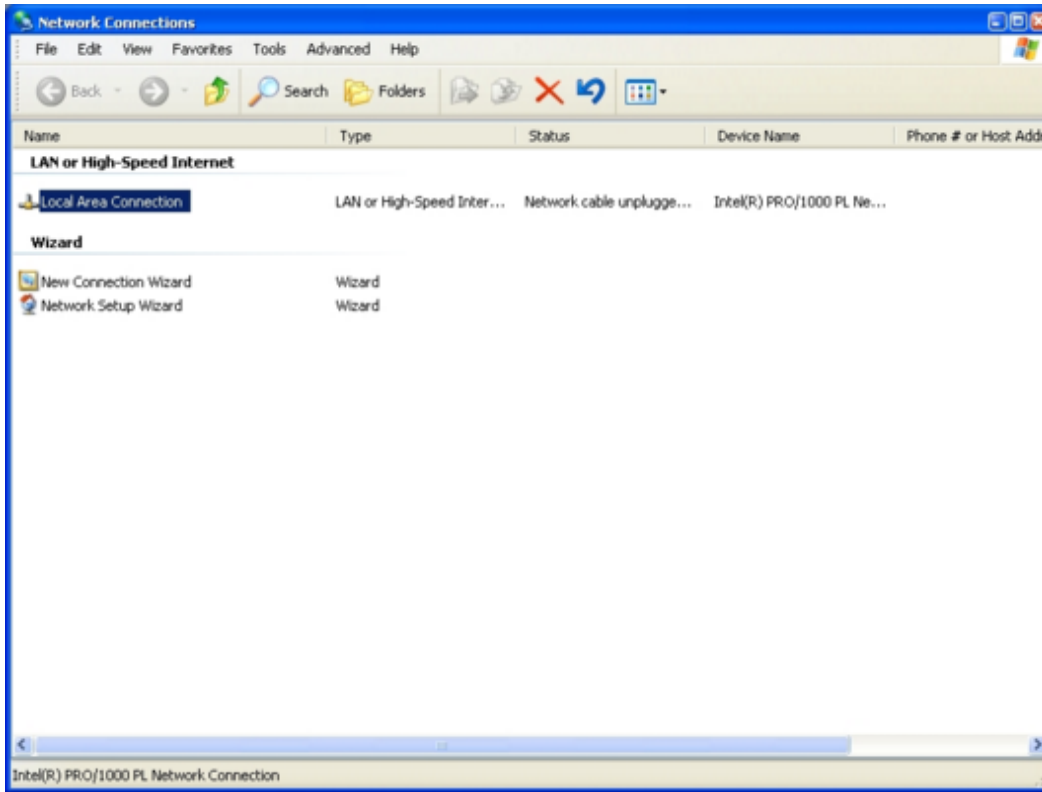
Windows Firewall Notification During First Launch of peMonitor

6. After 'Unblocking' peMonitor, a dialog box will appear asking you to search for the ECU. Select 'Direct' as the method of communication.
7. When communication is established, peMonitor will report back with 'ECU Found' and display the IP address of the PE3. While the PE3 is communicating with the computer, a green box displaying 'Online' will be visible in the bottom left corner of peMonitor as well as an animated injector squirting fuel in the upper right corner.

**Establishing a Direct Connection Using Windows XP, 2000 and Vista** - A direct, wired connection using an older version of Windows requires configuration of the computer's IP address. This will only need to be configured one time to communicate with the PE3. In order to access the internet using the Ethernet port, however, it will be necessary to change the IP address of the computer back to the default configuration of 'Obtain an IP address automatically'. Follow the steps below to begin communicating with the PE3.

1. In Windows, configure your Local Area Connection. To do this go to the 'Start' menu and click on 'Settings' and then on 'Network Connections'. This will bring up a menu that looks similar to the one below. Double click on 'Local Area Connection' (highlighted in the figure).

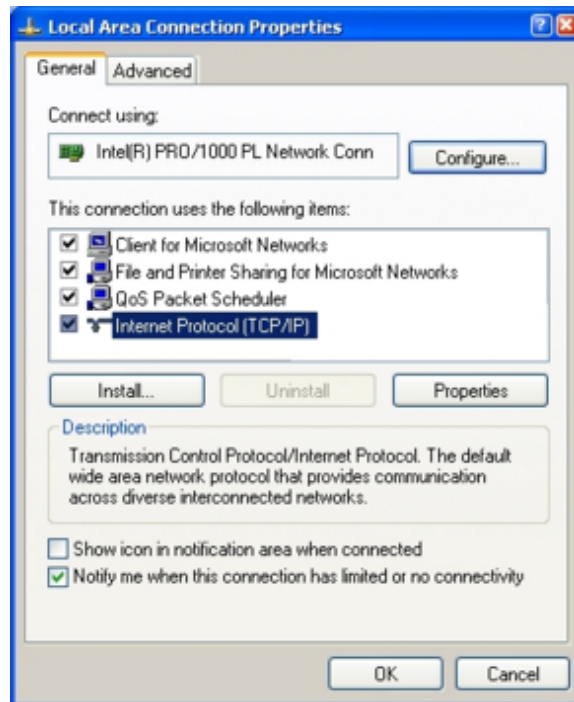
**Note:** It may be necessary to have the Ethernet cable from the PE3 plugged in to the PC and the PE3 powered on to see 'Local Area Connection' as a selection in the Window.



'Network Connections' Window

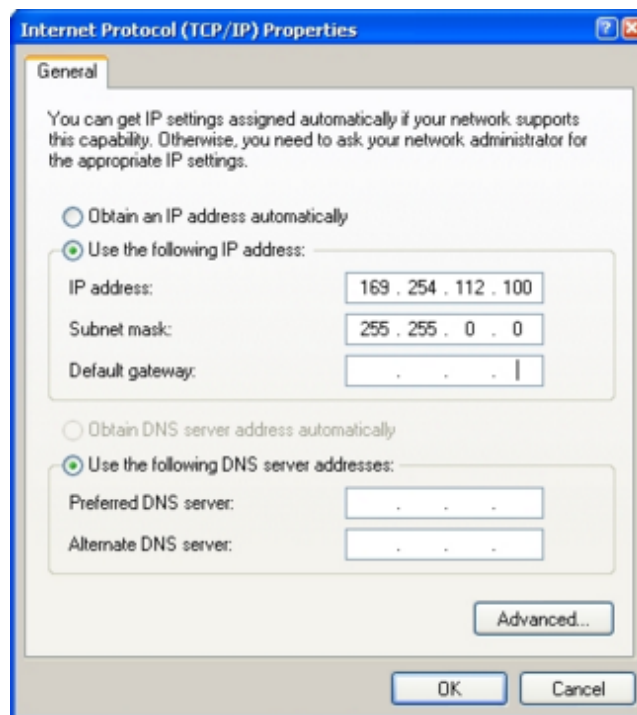
2. Highlight 'Internet Protocol (TCP/IP)' and click on the 'Properties' button to modify the Properties.





'Local Area Connection Properties' Window

3. Under 'Internet Protocol (TCP/IP) Properties' choose 'Use the following IP address:' and enter the address and Subnet Mask shown below in the figure. Click "OK" to save the changes and close the next Window.



'Internet Protocol (TCP/IP) Properties' Window

4. Once you have configured the computer for the correct static IP address, establishing communication is the same as with Windows 7. Please refer to step 1 in '**Establishing**

## **a Direct Connection Using Windows 7' above.**

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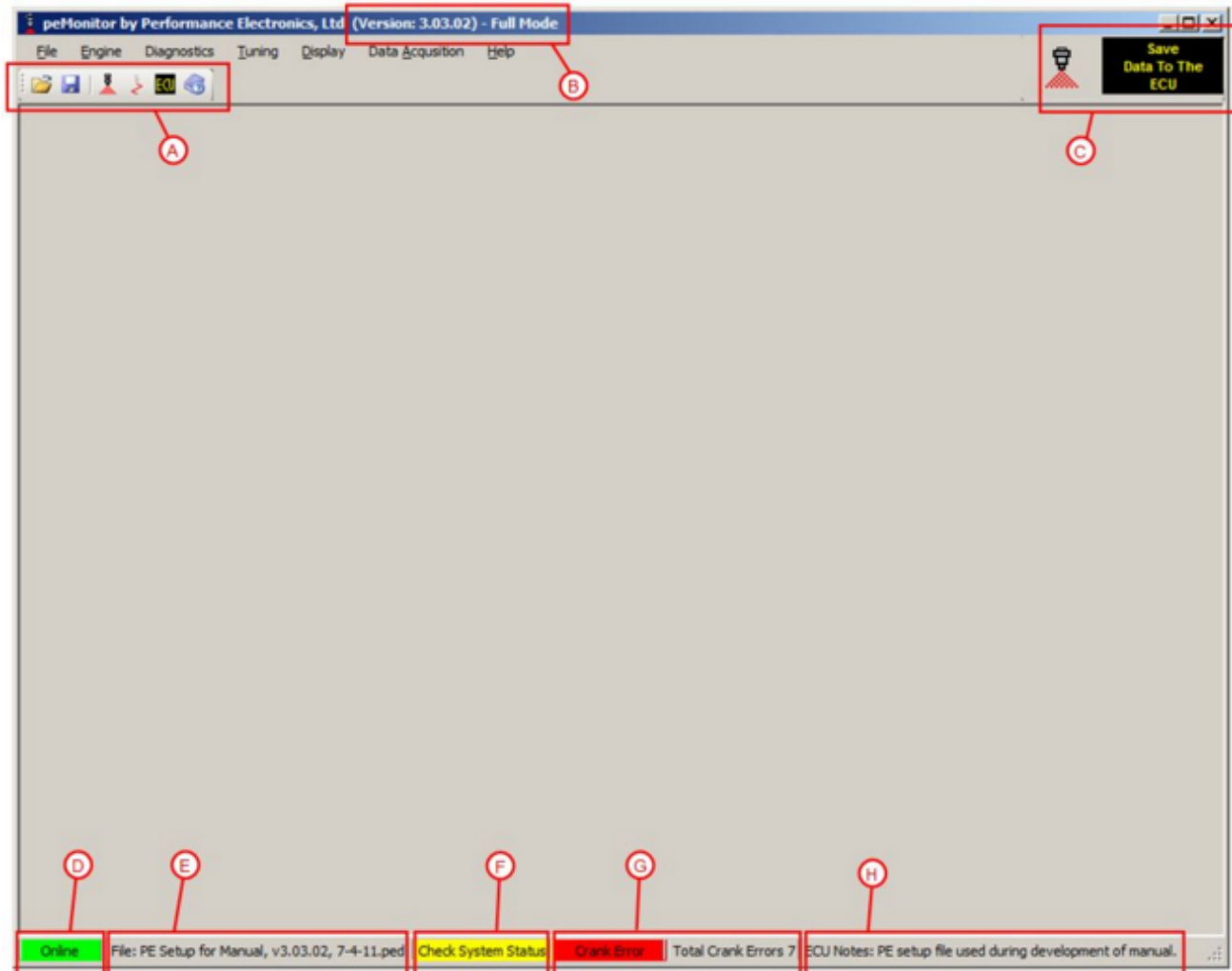
**Establishing a Wireless Network Connection Using Windows Through a Router** - To establish a wireless connection with the PE3 using a router, please follow the steps below. This procedure assumes that you are using a wireless router with the PE3 and a PC with a wireless Ethernet port. Most standard wireless routers will work fine for this application. Please refer to the PE website for an application sheet containing a list of known routers used with the PE3. Connection strength will be a function of the router and wireless Ethernet port on the PC.

1. Before attempting to communicate with the PE3 wirelessly, please make sure that you can establish communication using a direct wired connection between the PC and the ECU. See above for instructions depending on your operating system.
2. Turn the laptop wireless Ethernet port on.
3. Turn on the wireless router. Make sure to power the router before powering the ECU so that the router can provide an IP address to the PE3 when you turn the ECU on.
4. Establish a wireless link between the laptop and the router by 'finding' the wireless network.
5. Plug the PE3 Ethernet cable into a port on the wireless router. Make sure to plug it into one of the standard network ports not labeled 'Internet' or 'Modem'.
6. Power up the PE3 ECU.
7. Start peMonitor.
8. When prompted to 'Search for ECU?', click on 'Networked'
9. The ECU should now respond with 'ECU Found'. You are now wirelessly connected to the PE3.

**Note:** Many common routers can be powered directly from +12v vehicle power.

## **Main peMonitor Screen**

This section describes the components of the Main Screen in peMonitor. The sections of the screen defined by letters A through G on the figure are described below.



## A



- Open a saved tuning file from the PC.



- Save the current tuning file to the PC.



- Open main fuel table. The majority of the fuel tuning will be done in this main table.



- Open main ignition timing table. The majority of the ignition tuning will be done in this main table.



- Save the current tuning file to the ECU. Pressing this button permanently saves the tuning parameters to the ECU. Until data is saved to the PE3, modified parameters are only temporarily stored in the ECU's memory. This command can also be accessed from the button in section 'B' or by going to ['Save Settings to ECU'](#).



- Open Help window.

## **B**

This part of the header indicates the version number of peMonitor. Also, when connected this shows the hardware mode of the PE3. In the case shown in the figure, this is a Full build of hardware.

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## **C**



- This graphic indicates when the PE3 is online and communicating with the PC. If the injector is squirting fuel the ECU is talking with peMonitor.



- This button is another way to save settings to the PE3. It has the same effect as the 'ECU' button in section 'A'.

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## **D**

This area indicates the online status of peMonitor. In the case shown in the figure, the ECU is currently online and communicating with the PC. If the ECU was offline, this would be a red box displaying 'Offline'.

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## **E**

Displays the last file that was opened during the current session of peMonitor either online or offline. This shows the file that was loaded into peMonitor from the PC. Depending on recent activity, this box may not display any file at all.

---

## **F**

This yellow box indicates that there is a problem or error that requires attention such as a sensor out of range or an over-current on one of the PE3 outputs. Specific errors can be viewed by clicking on the yellow box itself or by going to '[System Status](#)'. Both of these actions will open the System Status page where errors are displayed and can be cleared.

---

## **G**

This area displays 'Crank Errors' when present and also keeps a running total of Crank Errors since the last time the PE3 was reset. Crank Errors are erased every time the ECU is powered off and then on again. These errors occur anytime the PE3 loses sync with the engine and has a problem determining the angular position of the crankshaft. Generally, with most engine configurations, several Crank Errors will be indicated during engine start-up and shutdown but should not be present continuously during starting or at all during normal operating conditions. In the case shown in the figure, the engine is just shutting down and a crank error is present. A total of 7 Crank Errors have been logged since the ECU was powered on. These errors occurred during starting and stopping the engine.

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## H

This area of the footer is a notes section that allows the user to record a short description for the tuning file. These notes are stored in the tuning file and with the ECU.

## Changing and Modifying Parameters in peMonitor

There are several ways to make changes to the tuning parameters in peMonitor. Some parameters are drop down menus, some are check boxes and still others are fields that allow the user to type in values. All parameters can be changed real time while online with the PE3 and while the engine is running. There are only a few very basic setup parameters that require cycling the power to the PE3. These include some of the trigger and sync settings. When these are changed, peMonitor will prompt the user to cycle the power.

Anytime a new value is typed into a parameter field in peMonitor (for example in a table), the user must hit the 'Enter' key or move from that parameter in order for the changes to take place.

While online, modifications made to the tuning file take immediate effect after they are entered. Changes are stored instantaneously in the PE3 controllers's internal memory as long as the ECU remains powered up. In order for changes to be permanently saved to the ECU, the ['Save Data to ECU'](#) command must be used. This command can be accessed from several locations on the ['Main peMonitor Screen'](#).

Right clicking in many of the tables brings up an additional menu of commands like add, subtract, multiply and smooth. These are provided to make tuning more efficient.

## File Drop Down Menu

The sections below describe the different elements that are located under the 'File' drop down menu at the top of the main screen in peMonitor.

### **Open (File → Open)**

This command opens a tuning file from the PC. PE3 tuning files all have a .PED file extension. All of the tuning parameters are stored in these tuning files.

### **Open Fuel Table (File → Open Fuel Table)**

This command allows the user to open the main fuel table from another tuning file stored on the PC. When this command is selected, peMonitor will prompt the user to choose a donor tuning file (\*.PED). The main fuel table will then be imported from the file that is selected into the current tuning session.

### **Open Ignition Table (File → Open Ignition Table)**

This command allows the user to open the main ignition table from another tuning file stored on the PC. When this command is selected, peMonitor will prompt the user to choose a donor tuning file (\*.PED). The main ignition table will then be imported from the file that is selected into the current tuning session.

### **Save (File → Save)**

This command saves the current session and all of the tuning parameters to the PC. Once 'Save' is selected, the user will be prompted to type in a file name with a .PED file extension. PE3 tuning files all contain this file extension. Once saved on the PC, tuning files can be later loaded into the ECU via peMonitor or manipulated offline.

### **Export (File → Export)**

'Export' allows the user to export the main fuel, ignition and target lambda (AFR) tables to a Comma Separated Variable text file (\*.CSV) on the PC. Once these tables have been exported they can be viewed and manipulated in a text editor or Excel and also imported into peMonitor using the 'Import' command.

### **Import (File → Import)**

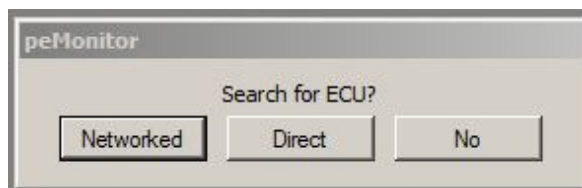
'Import' allows the user to import a main fuel, ignition or target lambda (AFR) table from a Comma Separated Variable text file (\*.CSV) on the PC.

## Engine Drop Down Menu

The sections below describe the different elements that are located under the 'Engine' drop down menu at the top of the main screen in peMonitor. These menus include most of the basic setup parameters required to run an engine.

### **Find ECU** (*Engine* → *Find ECU*)

The 'Find ECU' command forces peMonitor to attempt to establish communication with the PE3 ECU. All communication between the ECU and the PC is via Ethernet. 'Find ECU' requires the user to choose the manner in which the PE3 ECU is connected to the PC (see dialog box below).



Dialog Box for 'Find ECU'

The PE3 ECU can communicate with peMonitor in one of two ways:

**Networked** - Networked communication implies that the PE3 is connected to the PC through either a wired or wireless network. Generally this involves the use of an Ethernet hub or wireless router.

**Direct** - A Direct connection requires that the ECU is connected directly to the PC without any intermediate connections to a router. Direct connections are the most common and simplest method of communicating with the ECU.

### **Quick Find ECU** (*Engine* → *Quick Find ECU*)

'Quick Find ECU' is the same as 'Find ECU' except that it remembers the last way that communication was established with the ECU and attempts to establish this type of connection. For example, if the last communication attempt was using a 'Direct' connection, than 'Quick Find ECU' tries to establish communication using a direct connection. This command is extremely useful during tuning especially when the user takes advantage of the shortcut key 'Ctrl+Q' to invoke the quick find command.

### **Setup Engine** (*Engine* → *Setup Engine*)

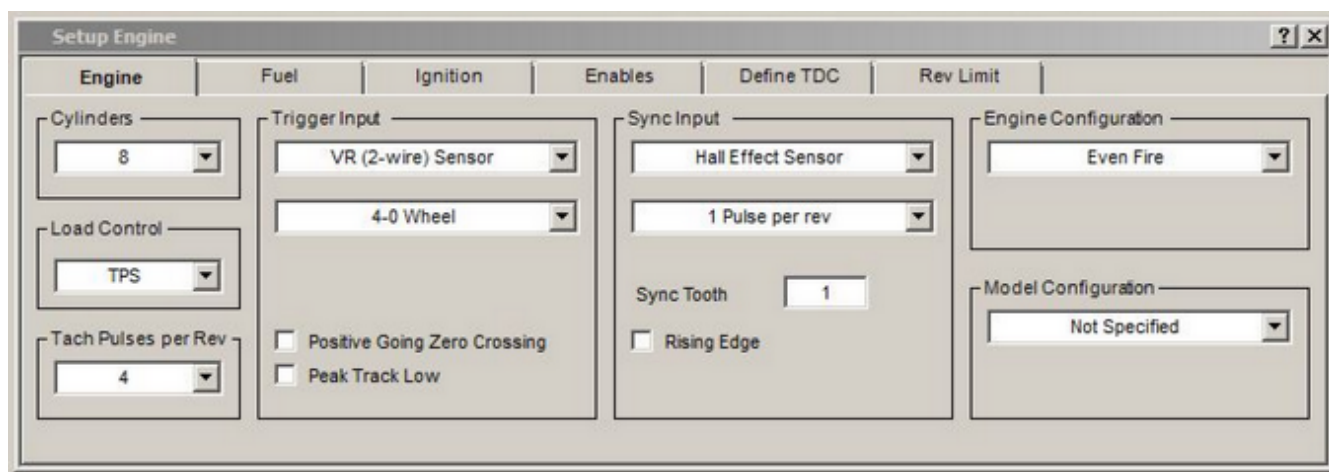
The 'Setup Engine' window contains many of the basic parameters required to effectively configure the PE3. The 'Setup Engine' window is sub-divided into several tabs and is designed such that the user can configure the first tab ('Engine') and then work from left to right to completely configure the basic engine parameters.



## Engine Tab

The 'Engine' tab contains the basic setup parameters that are not directly associated with either fuel or ignition. The 'Trigger Input' and 'Sync Input' parameters configure the PE3 for the pattern of pulses (or teeth) that a specific engine has in order for the ECU to determine the correct crank angle at any given time. On a 4-stroke piston engine, for example, the 'Trigger Input' is generally associated with the crank sensor and the 'Sync Input' is associated with an input on the camshaft.

Below is a screen shot of the adjustable parameters in the 'Engine' tab along with a description of each.



'Engine' Tab in 'Setup Engine'

**Cylinders** - This is the number of cylinders for the engine, 1-8.

**Load Control** - Load Control is the method for determining the commanded load on the engine. This can be set for either TPS (Throttle Position) or MAP (Manifold Absolute Pressure). This parameter sets the load axis in the main tables (e.g. main fuel, ignition and target lambda tables). Changing this parameter will change the vertical axis in the tables that use load.

**Tach Pulses per Rev** - This parameter sets the number of tachometer pulses that the ECU outputs per engine revolution. This setting effects the Tachometer Output (M-17) and any digital output that is configured as a 'Tach'. Tachometer pulses are 30% duty cycle signals from 0 volts to battery voltage. This output can be configured to drive original and after market tachometers.

**Trigger Input** - The 'Trigger Input' parameters configure the engine speed and position input to the ECU. Generally, the trigger input is generated by a sensor on the crankshaft. The top drop down menu configures the type of sensor (VR or Hall Effect) and the bottom defines the trigger pattern itself. Below are several examples of available trigger patterns. In addition to the standard patterns, there are also special cases listed below. Please refer to the [Define TDC](#) tab for additional discussion on configuring the Trigger. PE Application sheets are also available on the website for engine specific information.

Example Trigger Patterns (Please refer to peMonitor for a complete list of patterns)

4-0 Wheel = 4 evenly spaced teeth per engine revolution with 0 missing teeth. This is also the correct setting for 8 evenly spaced teeth on a distributor for a V-8 engine since the camshaft rotates at 1/2 speed.

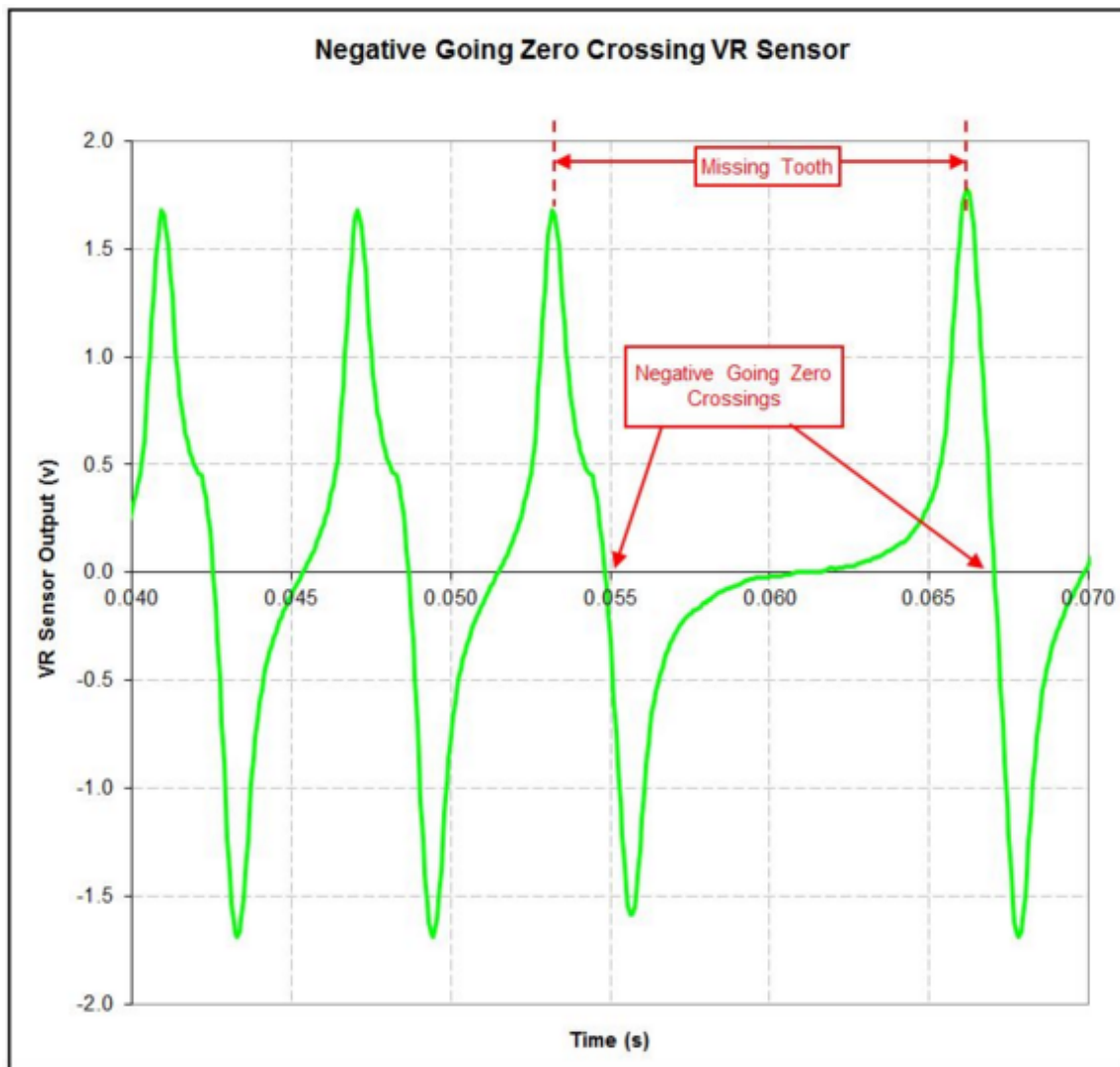
32-2 Wheel = 30 teeth per engine revolution (on a 32-tooth spacing) with 2 missing teeth directly next to each other.

18+1 Wheel = 18 total teeth per engine revolution with 1 of the teeth being longer than the other 17. This is common on some Suzuki engines.

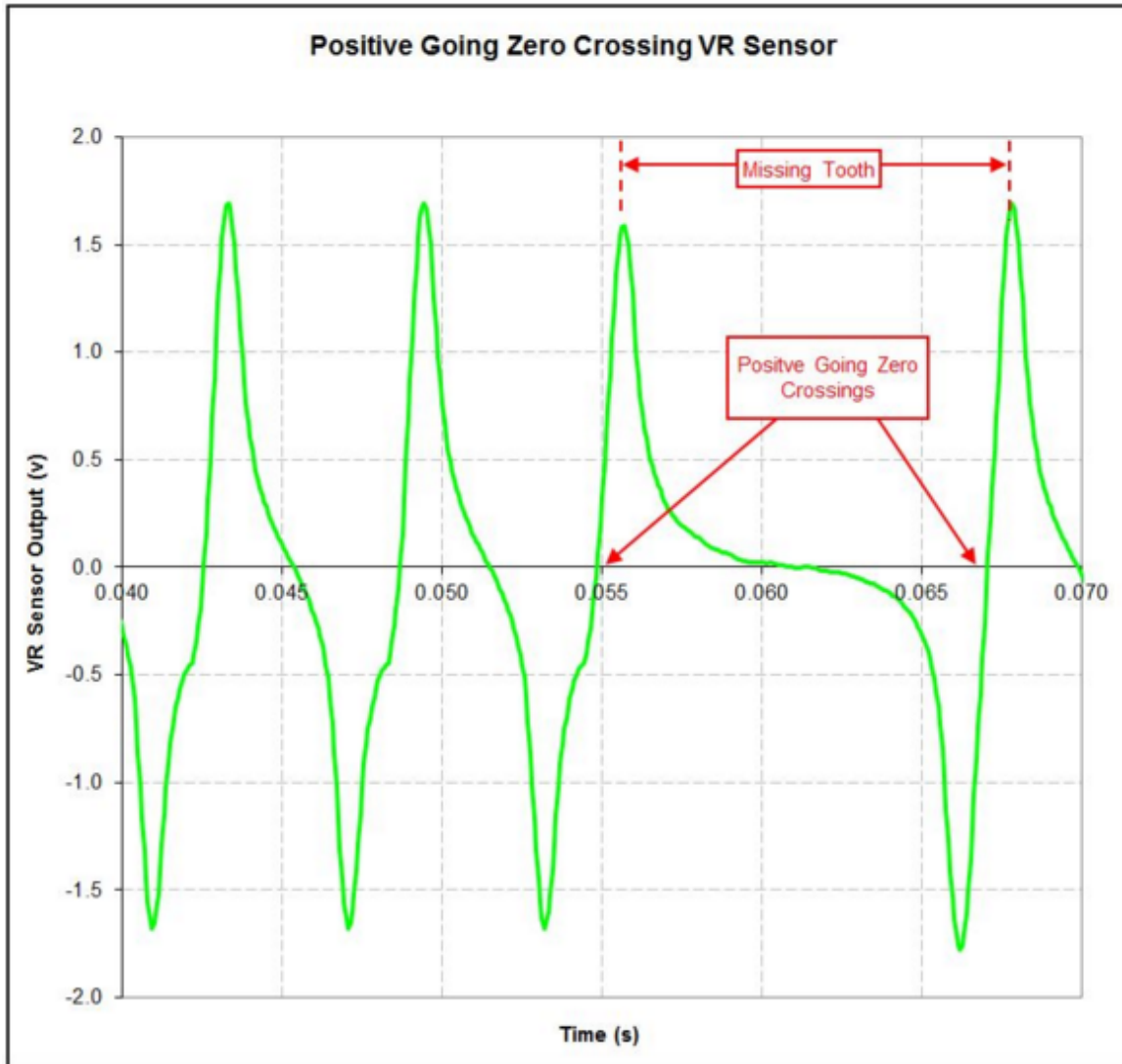
60-1(6) Wheel = 54 total teeth on a 60-tooth spacing with a total of 6 teeth missing at different locations. This pattern is common for some Mercury Marine engines.

36-2-2-2 Wheel = 30 total teeth on a 36-tooth spacing with a total of 6 teeth missing at different locations. This pattern is common for some Subaru engines.

**Positive Going Zero Crossing** - This check box provides a way to change the polarity of the signal that the PE3 recognizes as a tooth. For VR type sensors, the ECU normally looks for a Negative Going Zero Crossing to indicate the center of the tooth. If this box is checked the polarity is reversed and the ECU looks for a Positive Going Zero Crossing instead (see figure below). This option is available for VR sensors for both the Trigger and Sync Input.



Negative Going Zero Crossing VR Trace



Negative Going Zero Crossing VR Trace

**Peak Track Low** - The 'Peak Track Low' option works with VR sensors only. This parameter adjusts the required arming voltage from the trigger or sync sensor. This option is typically used with VR sensors that are generating low voltage levels at slow speeds and may only be required if the engine generates excessive crank errors.

**Sync Input** - The Sync Input parameters configure the signal that is used by the PE3 to determine the correct cycle of a multi-cycle engine. This signal generally comes from a cam sensor or something that occurs once per engine cycle. The top drop down menu configures the type of signal used for the Sync Input. This can be either a VR sensor, Hall effect sensor or the opposite tooth edge from the Trigger Input (common on some systems triggered from a distributor).

The bottom drop down menu sets up the Sync pattern itself. In addition to a standard '1 Pulse Per Rev' selection, there are also several application specific settings available. Please refer to the PE Application sheets located on the website for engine specific information for non-standard patterns.

**Sync Tooth** - The 'Sync Tooth' is the first trigger tooth after the sync occurs. The 'Sync Tooth' setting tells the PE3 what number to assign to the sync tooth. Generally this parameter

is left as '1' for most applications. However when the PE3 is using a trigger wheel with missing teeth, the Sync Tooth is used to define where the missing teeth are so that RPM can be calculated correctly. In this case (e.g. 12-1 tooth trigger wheel), the parameter 'Sync Tooth' must be set so that the first trigger tooth after the long space equals '1'.

The ECU works in the following way. Anytime the PE3 recognizes a signal on the sync input (usually from a cam sensor), it assigns the next trigger tooth the number defined in the parameter 'Sync Tooth'. This number could be anything from 1 to 120. The ECU then increments the trigger tooth count until it reaches the maximum number of teeth at which point it starts over again at '1'. When the PE3 gets to trigger tooth number '1', it assumes that the gap that just occurred is the long pulse and accounts for this accordingly (if a long pulse exists). If trigger tooth '1' is not right after the long gap, the ECU will not calculate RPM correctly for that tooth.

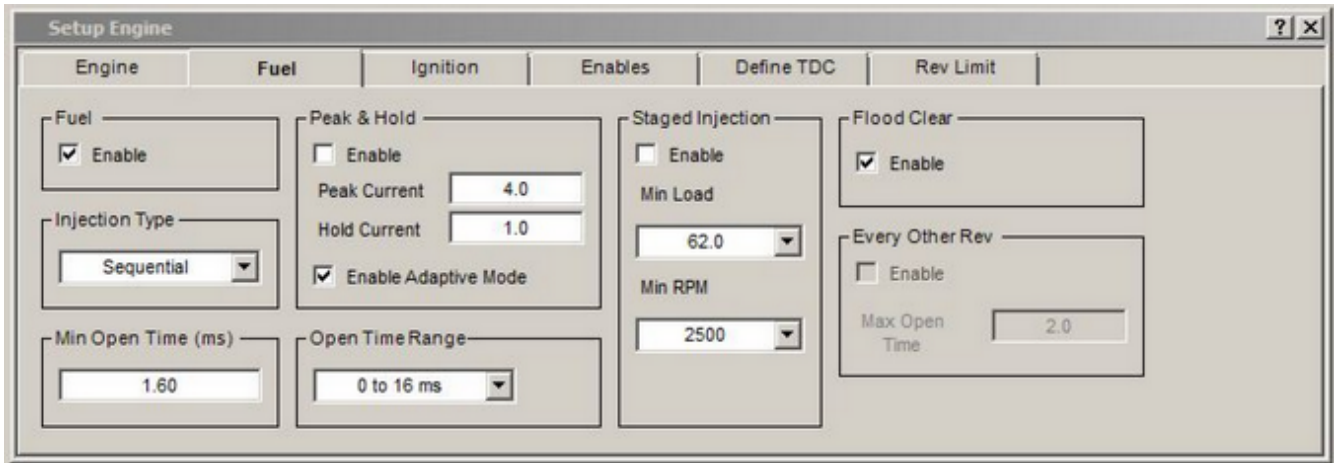
**Rising Edge** - This check box provides a way to change the polarity of the signal that the PE3 recognizes as a tooth. For Hall Effect sensors, the ECU normally looks for a falling edge in the signal to indicate a tooth. If this box is checked, the polarity is reversed and the ECU looks for a rising edge in the signal instead. This option is available for Hall Effect sensors for both the Trigger and Sync Input.

**Engine Configuration** - This allows the user to configure either an even fire or odd fire engine with the PE3. An even fire engine is defined as a engine that has combustion events evenly spaced with respect to crankshaft rotation. Most inline and 'V' engines are even fire. For example a Ford V-8 engine fires a cylinder every 90 degrees of crank rotation. Many V-twin engines like those from Harley Davidson and Aprilia are not evenly spaced and therefore considered 'Odd Fire'.

**Model Configuration** - 'Model configuration' allows the user to configure specific settings based on the make and model of a vehicle or engine. These parameter include features and settings that cannot be easily configured using the PE3 standard features.

## Fuel Tab

The 'Fuel' tab contains the basic setup parameters that are directly associated with fueling. Below is a screen shot of the adjustable parameters in the 'Fuel' tab along with a description of each.



'Fuel' Tab in 'Setup Engine'

**Fuel Enable** - The 'Enable' check box allows the fuel to be completely enabled or disabled. If the box is checked the fuel injectors will operate normally. If the 'Enable' box is not checked, the fuel injectors will not open at all. This parameter provides a convenient way to completely suspend fuel to the engine for diagnostic or testing purposes.

**Injection Type** - 'Injection Type' controls the manner in which the injectors are fired. Different types of injection schemes require different kinds of trigger and sync inputs. Below is a list of the available injection types.

- No Fuel = Injection system is turned off
- Semi Sequential = Each Injector fires one time per engine revolution at a specific crank angle. 'Semi Sequential' does not batch fire all of the injectors at the same time but rather fires them at specific locations throughout the engine revolution. This type of injection scheme does not require a 'Sync' input, just a 'Trigger' (crank) input.
- Throttle Body = This mode uses only one injector driver to fire a single throttle body injector. 'Throttle Body' injection fires the same injector one time for each combustion event. For example, for a 4-stroke V-8 engine, the throttle body injector fires 4 times each crank revolution (8 times per cycle). This type of injection scheme does not require a 'Sync' input, just a 'Trigger' (crank) input.
- Sequential = 'Sequential' injection requires that every cylinder have it's own injector and that the opening and closing of that injector be based on the timing of the combustion event for that cylinder. For this type of configuration, each injector fires once each engine cycle. This is different from 'Semi Sequential' injection which fires the injector twice each engine cycle. This type of injection requires both a 'Sync' input and a 'Trigger' input.
- Random Sequential = Like 'Sequential' injection, 'Random Sequential' generally has one injector per cylinder that each fire once per engine cycle. Unlike 'Sequential', injector events are not tied to the timing of combustion events but rather happen randomly based on the orientation of the engine when it first turns over. This type of injection scheme does not require a 'Sync' input, just a 'Trigger' input. Random

Sequential is most commonly used with single trigger distributor-based systems because it allows the fueling for individual cylinders to be trimmed without using a cam (Sync) input..

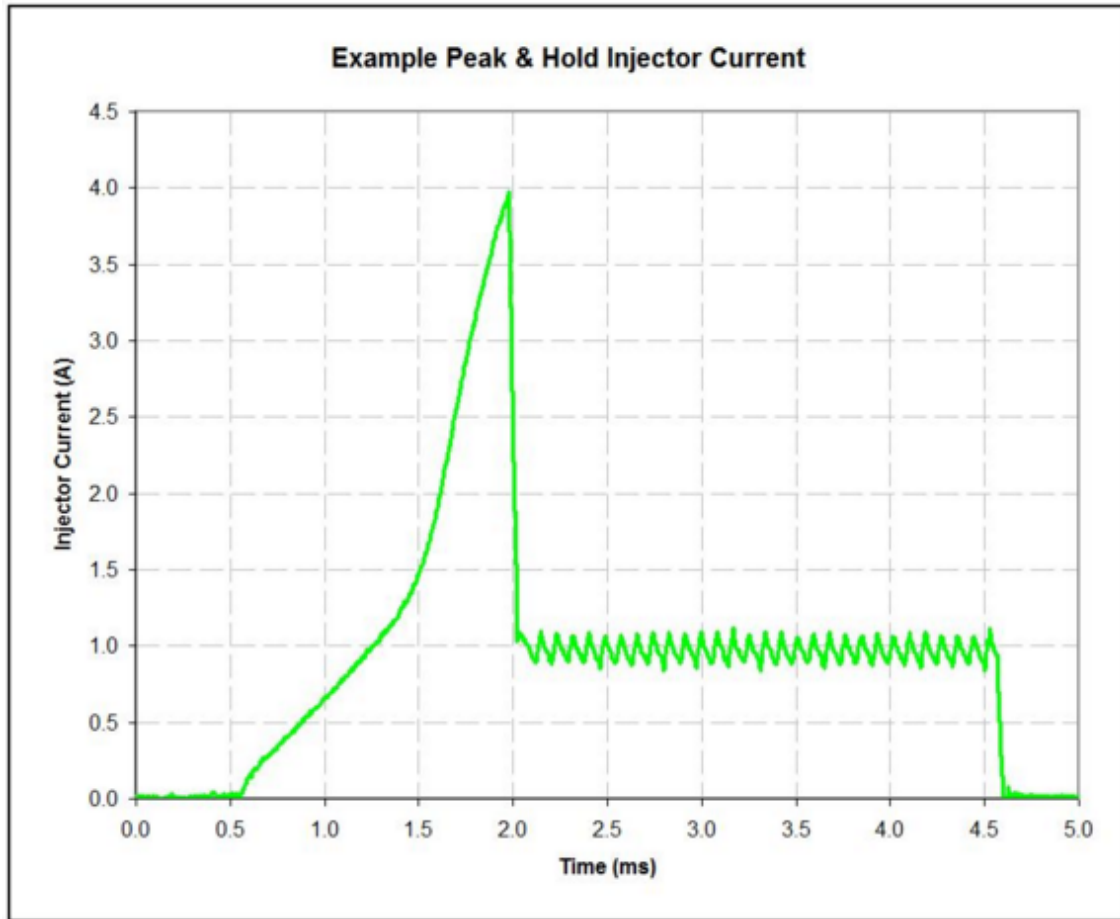
**Min Open Time (ms)** - This defines the minimum allowable pulse width for injection. Typical values for saturated injectors are 1.0 to 1.8 ms. If at any time the ECU calculates a final open time less than 'Min Open Time' based on the main fuel table and all other compensation factors, the actual open time of the injectors will be set to this value. This allows the user to set an absolute lower limit for injector pulse widths so that the injectors do not attempt to operate outside of their normal limits.

**Peak and Hold Enable** - This parameter enables the use of peak and hold injectors. Peak and hold injectors are generally low resistance and require a more complex control strategy. An initial 'peak' of current is required to open the injector and then a lower 'hold' current is necessary to keep the injector open without overheating the injector windings. Typical peak and hold values are 4 amps peak and 1 amp hold current although these values are adjustable in the PE3 for different types of injectors. The figure below shows a typical current trace from a 4/1 peak and hold injector controlled by the PE3.

**Peak Current** - This defines the maximum initial current of the injector in peak and hold mode. This value is only used by the PE3 if 'Enable Adaptive Mode' is also selected. If 'Enable Adaptive Mode' is not selected than the 'Peak Factor' defines the peak current. 'Peak Factor' can be adjusted in ['Injector Diagnostics'](#).

**Hold Current** - This defines the holding current of the injector in peak and hold mode. This value is only used by the PE3 if 'Enable Adaptive Mode' is also selected. If 'Enable Adaptive Mode' is not selected than the 'Hold Factor' defines the hold current. 'Hold Factor' can be adjusted in ['Injector Diagnostics'](#).

**Enable Adaptive Mode** - 'Enable Adaptive Mode' allows the PE3 to automatically adapt to the 'Peak Current' and 'Hold Current' that are listed in the 'Peak and Hold' section. If 'Enable Adaptive Mode' is not selected than the 'Hold Factor' and 'Peak Factor' define the peak and hold current levels. These can be adjusted in ['Injector Diagnostics'](#).



Typical current trace from a 4/1 peak and hold injector controlled by the PE3

**Open Time Range** - This defines the allowable entries in the main fuel table for open time. This parameter does NOT set the total open time range of the injector, but rather sets the limits for the main fuel table. The total open time is a combination of the main fuel table and all of the compensation factors and can exceed the range specified in this parameter. The 'Open Time Range' should be set to the lowest range that still allows the maximum required open time to be entered in the main fuel table. Allowable ranges are as follows:

- 0 to 4 ms
- 0 to 8 ms
- 0 to 12 ms
- 0 to 16 ms
- 0 to 20 ms

**Stage Injection Enable** - This enable box allows the PE3 to run in staged injection mode with multiple injectors per cylinder. The PE3 has a total of 8 built-in injector drivers. These injector drivers can be 'staged' such that some drivers control primary injectors and others control secondary injectors. Secondary injectors begin flowing fuel only at a pre-determined load and engine speed. When using the staged injection option, injector drivers 1, 2, 3 and 4 always control the primary injectors and injector drivers 5, 6, 7 and 8 are the secondary injector drivers. When the secondary injectors begin firing, they open at the same instant and for the same length of time as their corresponding primary injector according to the following pairing:

- Injector driver #1 and #5 fire together
- Injector driver #2 and #6 fire together
- Injector driver #3 and #7 fire together
- Injector driver #4 and #8 fire together

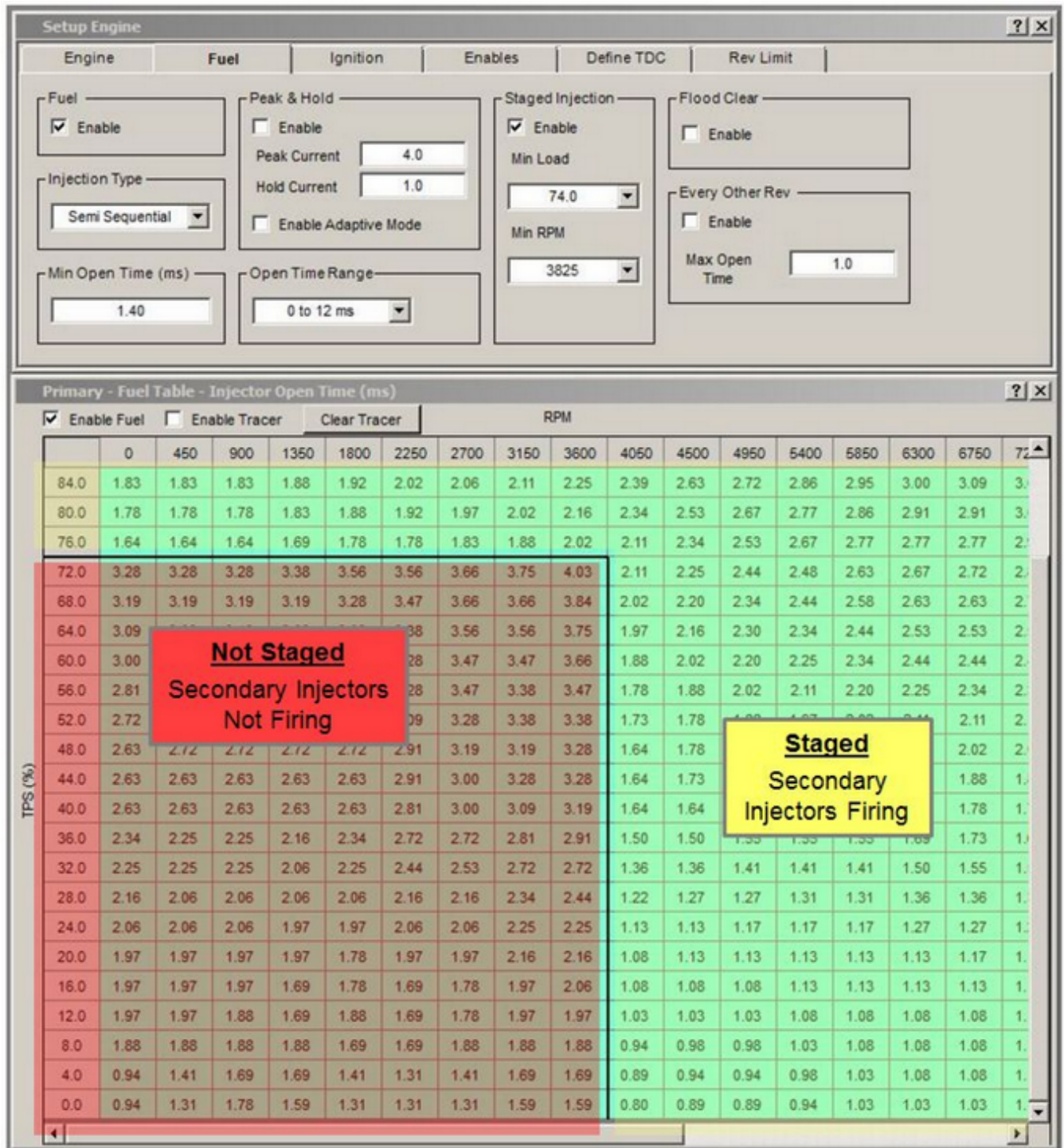
Whenever the engine is actively staged and the secondary injectors are firing, the background color of the 'Fuel' cell in the main data header will turn green (see ['Engine Data Header'](#)).

**Min Load** - When staged injection is enabled, this parameter defines the minimum load for staging the secondary injectors. The 'Min Load' has the same units as the load axis in the main fuel table. In the figure below, Min Load is set to 74% TPS. This is the yellow highlighted area at the top of the table. peMonitor draws a heavy black line at this load in order to differentiate between the staged and non-staged areas of the table.

**Min RPM** - This parameter defines the minimum RPM for staging the secondary injectors. In the figure below, the Min RPM is set to 3825 which is halfway between 3600 and 4050. This is the yellow highlighted area to the right of the table. peMonitor also draws a heavy black line at this RPM in order to differentiate between the staged and non-staged areas of the table.

Based on the 'Min Load' and 'Min RPM' parameters set in the figure below, the red highlighted portion of the table is the area where the secondary injectors are not firing and the yellow highlighted section represents the area where the secondary injectors are firing.





Staged Fuel Injection Example

**Flood Clear** - The 'Flood Clear' feature is used to help clear unnecessary fuel from the engine in the event that it becomes flooded. While enabled, if the throttle position sensor indicates a percentage greater than 98% when the engine begins to spin, the injectors will remain closed. This allows only air to be pumped through the engine and helps to evaporate the liquid fuel. Anytime the injectors are kept closed because of a flood clear condition, the background of the fuel cell in the main [Engine Data Header](#) turns red. Hovering over the cell

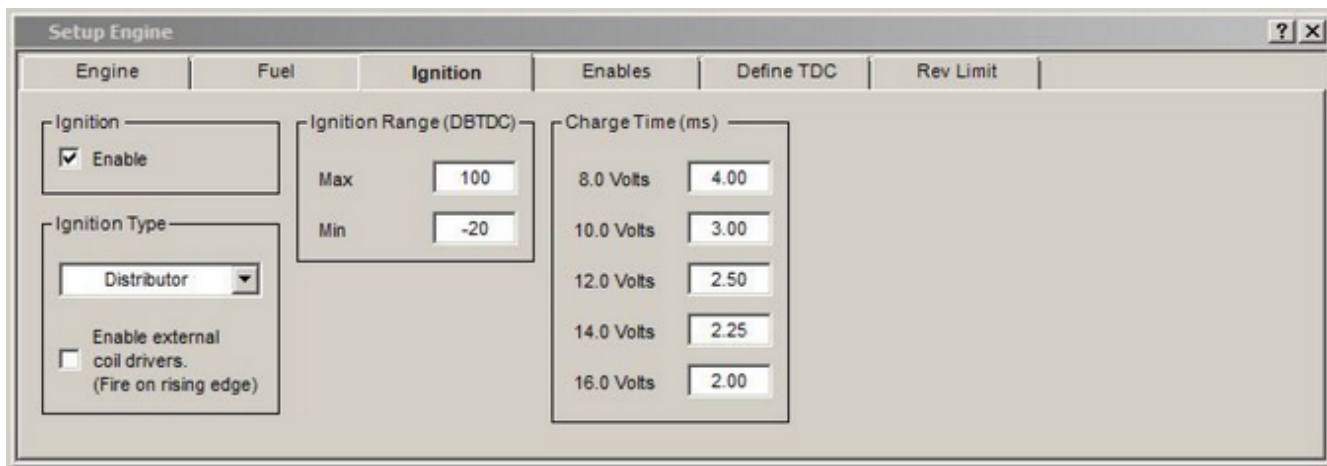
with the cursor indicates why the fuel is cut.

**Every Other Rev Enable** - 'Every Other Rev' is designed to help engines running in semi-sequential mode with large injectors idle more smoothly. When in semi-sequential mode, each of the injectors fire one time every engine revolution. It can be difficult to get large injectors to operate in a stable manner with the small open times required to provide the correct amount of fuel at idle. When 'Every Other Rev' is active, the PE3 only opens the injector one time every other revolution but for twice the calculated open time. Because the injector is open twice as long but half as often, it can operate in a more stable manner. When the fuel system is in Every Other Rev mode, the background of the fuel cell in the main ['Engine Data Header'](#) turns black. Hovering over the cell with the cursor indicates why the cell has changed color.

**Max Open Time** - This parameter sets the open time below which the 'Every Other Rev' feature will be active. If the total open time is calculated to be less than this value, and if Every Other Rev is enabled in the check box, the PE3 will begin firing the injectors every other revolution for twice the calculated open time.

## Ignition Tab

The 'Ignition' tab contains the basic setup parameters that are directly associated with the ignition system. Below is a screen shot of the adjustable parameters in the 'Ignition' tab along with a description of each.



'Ignition' Tab in 'Setup Engine'

**Ignition Enable** - The 'Enable' check box allows the ignition to be completely enabled or disabled. If the box is checked the coils will fire normally. If the 'Enable' box is not checked, the ignition coils will not charge or fire. This parameter provides a convenient way to completely suspend ignition to the engine for diagnostic or testing purposes.

**Ignition Type** - 'Ignition Type' controls the manner in which the ignition coils are fired. Different types of ignition schemes require different kinds of trigger and sync inputs. Below is a list of the available types.

- No Ignition = The ignition system is turned off.
- Distributor = Distributor ignition uses 'Coil #1' to fire a single ignition coil through a distributor. This ignition setting requires a Trigger input but not a Sync input.
- Wasted Spark = Wasted Spark ignition generally pairs two cylinders with one ignition coil. One spark is 'wasted' during the exhaust stroke and one spark occurs during the compression stroke. Wasted Spark ignition requires a Trigger Input but not a Sync Input.
- Sequential = Sequential ignition uses one driver per coil and one ignition coil per cylinder. Each coil fires one time per engine cycle. This type of ignition setup generally requires both a Trigger and Sync input.

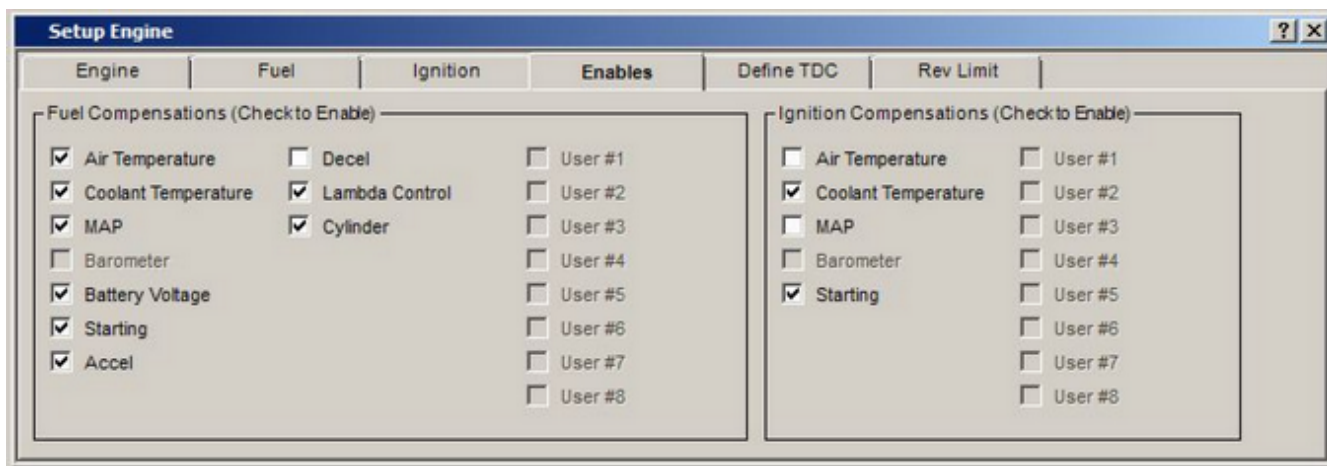
**Enable External Coil Drivers** - Checking 'Enable External Coil Drivers' causes the PE3 to fire the ignition coils on a rising signal with external igniters. When using the internal inductive ignition drivers of the PE3, this option should not be checked.

**Ignition Range (DBTDC)** - This parameter sets the total allowable ignition range of the PE3. If the ECU calculates a value outside of this range based on the main ignition table and all of the compensation factors, the ignition timing will be truncated to this range. The default values for these parameters are -20 to 100 (20 deg after top dead center to 100 deg before top dead center). Negative values are degrees after top dead center (ATDC).

**Charge Time (ms)** - The 'Charge Time' is the length of time that the inductive ignition coil will charge in milliseconds before firing. The charge time for most coils is longer at lower voltages than at higher voltages. If the engine is spinning too fast to charge the coil for the full requested 'Charge Time', the PE3 will automatically adjust the charge time for as long as possible before firing the coil.

## Enables Tab

The 'Enables' tab provides a centralized location to turn on and off different tuning parameters for both fuel and ignition. If the parameter is 'Checked', the function or compensation is enabled. If there is no check next to the parameter, it is disabled. The left side of the menu is dedicated to fuel compensation terms and the right side is for ignition terms. Below is a screen shot of the 'Enables' tab.



'Enables' Tab in 'Setup Engine'

If the parameter and check box are grayed out this is an indication that the specific function is not available to turn on. For the example, in the figure above, 'Lambda Control' is not available because an Oxygen sensor has not yet been defined in the 'Setup Sensors' section. Anytime a specific function or compensation is turned on or off in the 'Enables' tab, all other check boxes that control the on/off state of that function are updated as well.

## Define TDC Tab

The 'Define TDC' tab is used to configure the PE3 for different Trigger and Sync patterns. By entering the 'Trigger Tooth Before TDC' and 'Angle from Tooth to Sensor at TDC' the PE3 knows when top dead center occurs for each cylinder.

The peMonitor software will highlight a different number of cylinder fields for adjustment based on the number of cylinders and how the ignition and/or injection is configured. In the figures below, the PE3 was configured to run wasted spark ignition and semi sequential injection on a 4-cylinder engine. The difference between the two examples shown below is the orientation of the trigger wheel with respect to the VR sensor at the TDC locations.

Please refer to the PE Application sheets located on the website for engine specific information and for other examples defining TDC locations.

Trigger Wheel and Sensor are Shown in the Position of TDC for Cylinder #1

**Notes**

Example trigger wheel and corresponding TDC definitions for the following:

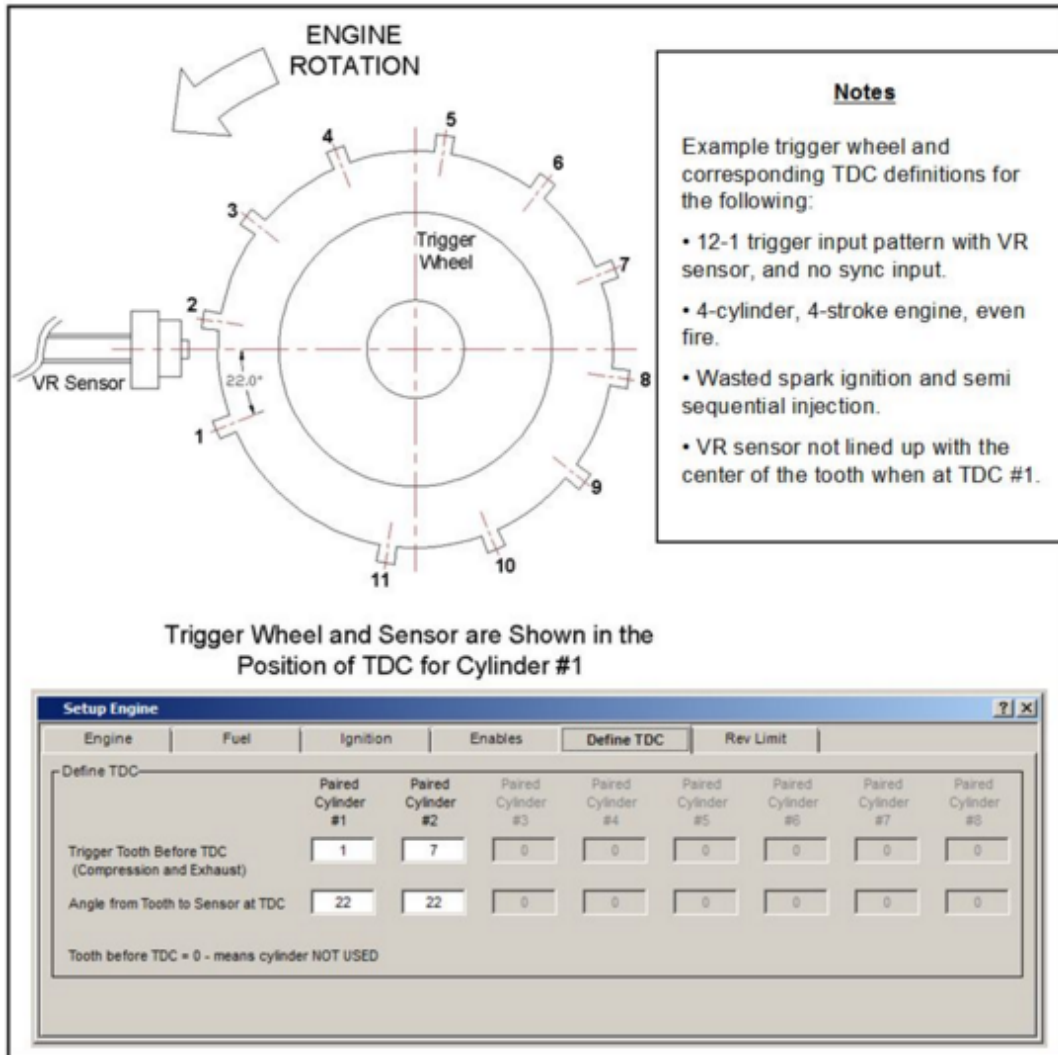
- 12-1 trigger input pattern with VR sensor, and no sync input.
- 4-cylinder, 4-stroke engine, even fire.
- Wasted spark ignition and semi sequential injection.
- VR sensor lined up exactly with the center of the tooth when at TDC #1.

Define TDC	Paired Cylinder #1	Paired Cylinder #2	Paired Cylinder #3	Paired Cylinder #4	Paired Cylinder #5	Paired Cylinder #6	Paired Cylinder #7	Paired Cylinder #8
Trigger Tooth Before TDC (Compression and Exhaust)	1	7	0	0	0	0	0	0
Angle from Tooth to Sensor at TDC	0	0	0	0	0	0	0	0

Tooth before TDC = 0 - means cylinder NOT USED

TDC Setup for Trigger Teeth Aligned with the Trigger Sensor





TDC Setup for Trigger Teeth Not Aligned with the Trigger Sensor

**Trigger Tooth Before TDC** - This row of adjustments tells the PE3 which trigger tooth occurs directly before (or at the same time) as TDC for a specific cylinder or pair of cylinders. If this parameter is set equal to zero than that cylinder is turned off and not used.

**Angle from Tooth to Sensor at TDC** - These adjustments allow the user to define TDC locations in between two teeth. Please refer to the figures above for examples on how these parameters are used.

#### Notes Regarding Trigger Teeth

- Trigger teeth always start at number '1' or whatever 'Sync Tooth' is set to, and count up to the total number of trigger teeth.
- The total number of trigger teeth in a system depends on whether or not the engine uses a 'Sync Input'. If the engine uses a sync input (e.g. cam input), the total number of trigger teeth is two times the number of teeth on the trigger wheel. If the engine does not use a sync input, the total number of trigger teeth is just the number of teeth on the trigger wheel itself.
- The definition of trigger tooth #1 depends on the configuration of the trigger and sync.
  - If the trigger input has a missing tooth profile (e.g. 12-1 or 24-2), tooth #1 is always

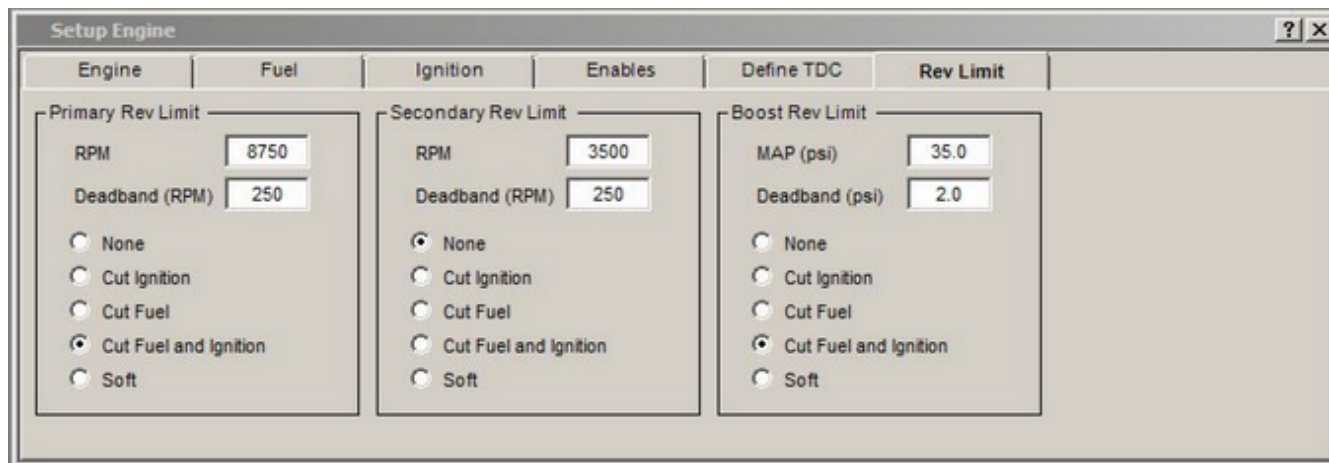
the first tooth after the large gap.

- If the trigger input is used with a single sync tooth, the first trigger tooth after the sync is assigned the tooth number defined by 'Sync Tooth' in the ['Engine'](#) tab.
- If the trigger input has equally spaced teeth with no sync input (e.g. trigger provided by a distributor), the first tooth recognized by the ECU is randomly assigned as trigger tooth #1 regardless of the crank position.
- If the trigger input and/or sync input is a custom definition (e.g. Honda F4i, Subaru, etc) trigger tooth #1 is defined in the PE3 firmware. Please refer to PE Application sheets for engine specific information.



## Rev Limit Tab

The 'Rev Limit' Tab allows the configuration of several available rev limiters in the PE3. Below is a screen shot of the adjustable parameters along with a description of each.



'Rev Limit' Tab in 'Setup Engine'

**Primary Rev Limit** - The 'Primary Rev Limit' is exactly as the name implies. This limiter is the primary mode by which safe RPM levels are maintained during operation. The 'RPM', 'Deadband (RPM)' and method of rev limit are all adjustable by the user. Please refer to the descriptions below for the different tuning parameters.

**Secondary Rev Limit** - The 'Secondary Rev Limit' (also known as a stutter box function or 2-step limiter) is generally used to help launch the vehicle from a stop. It can also be used for things like a 'valet' mode to ensure an engine is not over-revved. The secondary rev limit can only be used in conjunction with a digital input (see ['Digital Inputs'](#)). When a digital input is set to 'Secondary Rev Limit' and is activated (through a brake switch for example), the engine speed is limited to the value entered in 'RPM'. As soon as the digital input is no longer active, the secondary rev limit is eliminated and the engine is allowed to rev normally.

**Boost Rev Limit** - The 'Boost Rev Limit' provides a means to limit engine speed in the event that a forced induction system is generating unsafe levels of boost. This limiter would generally be used on vehicles with a turbocharger.

With the exception of the 'Boost Rev Limit' all limits utilize the same tuning parameters. The parameters used for the configuring the rev limiters are listed below.

**RPM** - This is the maximum target RPM. When the engine speed exceeds this value, the PE3 will attempt to slow the engine down based on the Rev Limit Method.

**Deadband (RPM)** - This parameter provides an RPM window so the limiter is not constantly turning on and off when close to the max speed. For the Primary Rev Limit in the figure above, the Deadband is set to 250 RPM. In this example, the PE3 will cut both fuel and ignition when the RPM exceeds 8750. The fuel and ignition will not start to function again until the engine speed falls below  $8750 - 250 = 8500$  RPM.

**MAP (psi)** - This parameter is used only for the Boost Rev Limit. If the manifold pressure exceeds this value, the PE3 will try to limit the speed of the engine by implementing one of

the Rev Limit Methods listed below.

**Deadband (psi)** - Like the RPM deadband, this parameter provides a window where the limiter remains active as the pressure decreases. In the example above, the MAP must fall below  $35-2 = 33$  psi before fuel and ignition are allowed to fire once the limiter is engaged.

#### **Rev Limit Method**

- None = No rev limit at all. This turns the limiter off.
- Cut Ignition = Suspends only the ignition when the limiter is active.
- Cut Fuel = Cuts only the firing of the injectors when the limiter is active.
- Cut Fuel and Ignition = Suspends both fuel and ignition when active.
- Soft = The soft limit method will sometimes be less abusive on the engine. A soft limit consists of 2 steps to keep the engine from overrunning.
  - Step 1 - If the RPM (or MAP for Boost limit) exceeds the maximum value, the PE3 first tries to limit the engine by reducing the ignition timing to 0 ° total advance.
  - Step 2 - If the RPM (or MAP) continues higher than the maximum value plus the deadband, the PE3 then cuts fuel and ignition.

For the Soft limit, both the timing and the state of the fuel and ignition systems are restored when the RPM (or MAP) drop below the (set value - deadband).

### **Setup Sensors (Engine → Setup Sensors)**

The 'Setup Sensors' page provides a way to configure the basic sensors for any engine. The window is divided into areas for several different sensors, all which can be enabled/disabled, calibrated and filtered. A screen shot of the page is shown below along with a description of the different parameters.

**Setup Sensors**

**Display Units**

Pressure - psi  
Temperature - °F

Display Air Fuel Ratio

Primary Table Stoichiometric Air-Fuel Ratio: 14.70  
Secondary Table Stoichiometric Air-Fuel Ratio: 14.70

Common Stoichiometric Air-Fuel Ratios:  
14.7 - Gasoline  
15.5 - LPG  
6.4 - Methanol  
9.0 - Ethanol  
17.2 - CNG  
14.6 - Diesel

**TPS**

voltage based TPS  
TPS Voltage 0.00

0% Throttle Voltage: 0.50  
100% Throttle Voltage: 4.44  
Low Out Of Range Limit (V): 0.40  
High Out Of Range Limit (V): 4.50  
Filter: Off

**MAP**

1 Atm - GM Sensor 16137039

Low Out Of Range Limit (psi): 1.0  
High Out Of Range Limit (psi): 17.0  
Pressure (kPa) at 0.5 (V): 19.8  
Pressure (kPa) at 4.5 (V): 95.3  
Filter: Off

**Air Temperature**

GM #1

Low Out Of Range Limit (°F): -50  
High Out Of Range Limit (°F): 250  
Resistance at 0°C (32°F): 9256  
Resistance at 20°C (68°F): 3457  
Resistance at 80°C (176°F): 329  
Filter: Off

**Lambda Sensor**

Wide Band  
Use Analog Input #1

Lambda at 0 (V): 0.68  
Lambda at 5 (V): 1.36  
Low Out Of Range Limit (V): 0.30  
High Out Of Range Limit (V): 4.70  
Filter: Off

**Barometer**

Use Analog Input #2  
1 Atm - GM Sensor 16137039

Low Out Of Range Limit (psi): 10.0  
High Out Of Range Limit (psi): 16.0  
Pressure (kPa) at 0.5 (V): 19.77  
Pressure (kPa) at 4.5 (V): 95.31  
☐ Latch at Startup  
Filter: Off

**Coolant Temperature**

GM #1

Low Out Of Range Limit (°F): -30  
High Out Of Range Limit (°F): 320  
Resistance at 0°C (32°F): 0  
Resistance at 20°C (68°F): 0  
Resistance at 80°C (176°F): 0  
Filter: Off

'Setup Sensors' Window

**Display Units** - The 'Display Units' section at the top of the window sets up how different measurements will be displayed in the tuning software.

- 'Pressure-psi' or 'Pressure-kPa' = This drop down menu configures the display units for pressure used throughout peMonitor. Available units are pounds per square inch (psi) or kilopascals (kPa).

**NOTE:** Changing from one set of units to another does **NOT** change the entered values for pressure in the tuning file. For example, if one of the Digital Outputs is set to turn 'on' at 15 psi and the pressure units are changed from psi to kPa, the Digital Output will then turn on at 15 kPa. peMonitor does **NOT** convert the settings based on the units change. The user is responsible for converting all pressure values when changing units.

- 'Temperature-°F' or 'Temperature-°C' = This drop down menu configures the display units for temperature used throughout peMonitor. Available units are Fahrenheit (F) and Celsius (C).

**NOTE:** Changing from one set of units to another does **NOT** change the entered values for temperature in the tuning file. For example, if one of the Digital Outputs is set to turn 'on' at 185 F and the temperature units are changed from F to C, the Digital Output will then turn on at 185 degrees C. peMonitor does **NOT** convert the settings based on the units change. The user is responsible for converting all temperature values when changing units.

- 'Display Air Fuel Ratio' or 'Display Lambda' = This setting allows the user to change the oxygen sensor output between 'Air Fuel Ratio (A/F)' and 'Lambda'. When lambda is selected, the user must also enter the type of fuel that is being used because air fuel ratio is lambda multiplied by the stoichiometric fuel ratio for that particular fuel. There is an entry for both the primary and secondary tables because it is possible to use different fuels for each table (e.g. gasoline and ethanol).

**TPS** - This section is used to configure the TPS (Throttle Position Sensor).

- The top drop down menu can configure the TPS as either 'voltage based TPS' or disable the sensor using 'Not Used'.
- 0% Throttle Voltage = This is the output voltage from the TPS when the throttle is closed (0%). In the upper right hand corner of the 'TPS' section is a display of the current voltage from the TPS sensor. When the throttle is closed, enter this voltage into the field '0% Throttle Voltage' to calibrate the closed position of the TPS sensor.
- 100% Throttle Voltage = This is the output voltage from the TPS when the throttle is fully open (Wide Open Throttle, 100%). In the upper right hand corner of the 'TPS' section is a display of the current voltage from the TPS sensor. When the throttle is open all of the way, enter this voltage into the field '100% Throttle Voltage' to calibrate the open position of the TPS sensor.
- 'Low Out Of Range Limit (V)' and 'High Out Of Range Limit (V)' = These parameters set the out of range limits for the sensor. If the sensor reading falls outside of this range, the ECU sets an 'Out of Range' error which can be cleared in ['System Status'](#). The error will also display a yellow background around the appropriate sensor in the Engine Data header (['Engine Data Header'](#)) and a yellow warning box at the bottom of the main peMonitor screen indicating that an error has occurred (['Main peMonitor Screen'](#)).
- Filter = The 'Filter' setting allows the user to apply a low-pass filter to the sensor. These filters remove unwanted 'noise' from the measurement. Filter levels can be set from 1 to 15. Level 1 is the smallest amount of filtering and level 15 is the highest level of filtering. Please refer to the ['Technical Specifications'](#) Section for more information on the filters.

**Lambda Sensor** - This area is for configuring the Oxygen or Lambda sensor. The PE3 ECU can be configured to work directly with a narrow band sensor or with a conditioned wide band sensor that outputs 0-5 volts.

- The top drop down menu configures the sensor as either a 'Wide Band' or 'Narrow Band' sensor.
- The second drop down menu allows the user to choose the analog input where the sensor is located. Analog inputs #1 through #7 are available.
- If configured as a 'Wide Band' sensor:
  - Lambda at 0 (V) = This is the lambda value from the oxygen sensor when the voltage is at 0 volts. Generally this value will be provided by the manufacture of the sensor and/or the lambda conditioner.
  - Lambda at 5 (V) = This is the lambda value from the sensor when the voltage is at 5 volts. Generally this value will be provided by the manufacture of the sensor and/or the lambda conditioner.
- If configured as a 'Narrow Band' sensor:
  - Voltage at (lambda=1.00) = This is the output voltage of the sensor when lambda is equal to 1.00. Any voltage greater than this indicates a rich mixture

and a voltage less than this tells the PE3 a lean mixture is present. Typically this value is around 0.50 volts for most narrow band sensors.

- 'Low Out Of Range Limit (V)' and 'High Out Of Range Limit (V)' = These parameters set the out of range limits for the sensor. If the sensor reading falls outside of this range, the ECU sets an 'Out of Range' error which can be cleared in ['System Status'](#). The error will also display a yellow background around the appropriate sensor in the Engine Data header (['Engine Data Header'](#)) and a yellow warning box at the bottom of the main peMonitor screen indicating that an error has occurred (['Main peMonitor Screen'](#)).
- Filter = The 'Filter' setting allows the user to apply a low-pass filter to the sensor. These filters remove unwanted 'noise' from the measurement. Filter levels can be set from 1 to 15. Level 1 is the smallest amount of filtering and level 15 is the highest level of filtering. Please refer to the ['Technical Specifications'](#) Section for more information on the filters.

**MAP** - The 'MAP' section is used to configure the MAP sensor (Manifold Absolute Pressure).

- The top drop down menu can configure the MAP with a standard known calibration, allow the user to enter a 'User Defined' calibration or turn the MAP off.
- 'Low Out Of Range Limit' and 'High Out Of Range Limit' = These parameters set the out of range limits for the sensor. If the sensor reading falls outside of this range, the ECU sets an 'Out of Range' error which can be cleared in ['System Status'](#). The error will also display a yellow background around the appropriate sensor in the Engine Data header (['Engine Data Header'](#)) and a yellow warning box at the bottom of the main peMonitor screen indicating that an error has occurred (['Main peMonitor Screen'](#)).
- 'Pressure (kPa) at 0.5 (V)' = This is the pressure that causes the sensor to output 0.5 volts. This information will generally come from a sensor datasheet or from calibrating the sensor using known pressures.
- 'Pressure (kPa) at 4.5 (V)' = This is the pressure that causes the sensor to output 4.5 volts. This information will generally come from a sensor datasheet or from calibrating the sensor using known pressures.
- Filter = The 'Filter' setting allows the user to apply a low-pass filter to the sensor. These filters remove unwanted 'noise' from the measurement. Filter levels can be set from 1 to 15. Level 1 is the smallest amount of filtering and level 15 is the highest level of filtering. Please refer to the ['Technical Specifications'](#) Section for more information on the filters.

**Barometer** - This section is used to configure the barometric pressure sensor.

- The top drop down menu allows the user to pick the source of the barometric pressure measurement. Options include using the MAP channel or Analog Inputs #1 through #8. If something other than 'No Barometer' is selected a second drop down menu appears.
- The second drop down menu allows the user to apply a calibration for barometer that will be applied to the source selected above. Several standard sensors are provided as well as the ability to set a 'User Defined' calibration.
- 'Low Out Of Range Limit' and 'High Out Of Range Limit' = These parameters set the out of range limits for the sensor. If the sensor reading falls outside of this range, the ECU sets an 'Out of Range' error which can be cleared in ['System Status'](#). The error will also display a yellow background around the appropriate sensor in the Engine Data header (['Engine Data Header'](#)) and a yellow warning box at the bottom of the main peMonitor screen indicating that an error has occurred (['Main peMonitor Screen'](#)).

- 'Pressure (kPa) at 0.5 (V)' = This is the pressure that causes the sensor to output 0.5 volts. This information will generally come from a sensor datasheet or from calibrating the sensor using known pressures.
- 'Pressure (kPa) at 4.5 (V)' = This is the pressure that causes the sensor to output 4.5 volts. This information will generally come from a sensor datasheet or from calibrating the sensor using known pressures.
- 'Latch at Startup' check box = This is a very unique feature to the PE3 engine control system. When enabled, this forces the PE3 to make a barometric pressure measurement using the MAP sensor before the engine turns over. This allows the PE3 to measure the barometric pressure once every time the ECU is powered up without having a dedicated barometric pressure sensor. This method works well if the vehicle does not experience large swings in atmospheric pressure while running. For example, this would not be effective for driving continuously through the mountains.
- Filter = The 'Filter' setting allows the user to apply a low-pass filter to the sensor. These filters remove unwanted 'noise' from the measurement. Filter levels can be set from 1 to 15. Level 1 is the smallest amount of filtering and level 15 is the highest level of filtering. Please refer to the [Technical Specifications](#) Section for more information on the filters.

**Air Temperature** - This area is for configuring an intake air temperature sensor. The PE3 can accept most automotive style thermistor inputs for air temperature.

- The top drop down menu can configure the sensor with a standard known calibration, allow the user to enter a 'User Defined' calibration or turn this input off.
- 'Low Out Of Range Limit' and 'High Out Of Range Limit' = These parameters set the out of range limits for the sensor. If the sensor reading falls outside of this range, the ECU sets an 'Out of Range' error which can be cleared in [System Status](#). The error will also display a yellow background around the appropriate sensor in the Engine Data header ([Engine Data Header](#)) and a yellow warning box at the bottom of the main peMonitor screen indicating that an error has occurred ([Main peMonitor Screen](#)).
- 'Resistance at 0°C (32°F)' = This is the resistance of the sensor at 0 deg C (32 deg F).
- 'Resistance at 20°C (68°F)' = This is the resistance of the sensor at 20 deg C (68 deg F).
- 'Resistance at 80°C (176°F)' = This is the resistance of the sensor at 80 deg C (176 deg F).
- Filter = The 'Filter' setting allows the user to apply low-pass filter to the sensor. These filters remove unwanted 'noise' from the measurement. Filter levels can be set from 1 to 15. Level 1 is the smallest amount of filtering and level 15 is the highest level of filtering. Please refer to the [Technical Specifications](#) Section for more information on the filters.

**Coolant Temperature** - The 'Coolant Temperature' section is for configuring a coolant or water temperature sensor. The PE3 can accept most automotive style thermistor inputs for this measurement.

- The top drop down menu can configure the sensor with a standard known calibration, allow the user to enter a 'User Defined' calibration or turn this input off.
- 'Low Out Of Range Limit' and 'High Out Of Range Limit' = These parameters set the out of range limits for the sensor. If the sensor reading falls outside of this range, the ECU sets an 'Out of Range' error which can be cleared in [System Status](#). The error will also display a yellow background around the appropriate sensor in the Engine Data



header ('[Engine Data Header](#)') and a yellow warning box at the bottom of the main peMonitor screen indicating that an error has occurred ('[Main peMonitor Screen](#)').

- 'Resistance at 0°C (32°F)' = This is the resistance of the sensor at 0 deg C (32 deg F).
- 'Resistance at 20°C (68°F)' = This is the resistance of the sensor at 20 deg C (68 deg F).
- 'Resistance at 80°C (176°F)' = This is the resistance of the sensor at 80 deg C (176 deg F).
- Filter = The 'Filter' setting allows the user to apply low-pass filter to the sensor. These filters remove unwanted 'noise' from the measurement. Filter levels can be set from 1 to 15. Level 1 is the smallest amount of filtering and level 15 is the highest level of filtering. Please refer to the '[Technical Specifications](#)' Section for more information on the filters.

## **Setup User Data (Engine → Setup User Data)**

'Setup User Data' allows analog and digital inputs to be configured for data logging. There are a total of 8 analog inputs and 4 digital inputs available. The analog inputs are used with sensors that output a voltage proportional to a measurement (e.g. a linear potentiometer used to measure shock displacement). Each analog and digital input corresponds to a physical wire in the PE3 harness. Below is a description of the parameters for the Analog and Digital Inputs.

The 'Setup User Data' window is a configuration interface for data logging. It features a title bar with a question mark icon. Below the title bar, there is a checkbox labeled 'Enable Thermistor Inputs on Analog Input #5 and Analog Input #7'. The main area is divided into two sections: Analog Inputs and Digital Inputs.

**Analog Inputs:** There are eight panels, each for an analog input (Anlg #1 through Anlg #8). Each panel contains the following fields:

- Name: A text box with the input name (e.g., 'Anlg #1').
- Scale (Units/V): A text box with a value (e.g., '1.000').
- Offset (V): A text box with a value (e.g., '0.000').
- Filter: A dropdown menu with 'Off' selected.
- Voltage (V): A text box with a value (e.g., '0.00').
- Calibrated Value: A text box with a value (e.g., '0.00').

**Digital Inputs:** There are four panels, each for a digital input (Freq #1 through Freq #4). Each panel contains the following fields:

- Enable: A checkbox. For Freq #1 and Freq #3, it is checked. For Freq #2 and Freq #4, it is unchecked.
- Name: A text box with the input name (e.g., 'Freq #1').
- Scale (Units/Hz): A text box with a value (e.g., '1.000').
- Filter: A dropdown menu with 'Off' selected.
- Frequency (Hz): A text box with a value (e.g., '0.0').
- Calibrated Value: A text box with a value (e.g., '0.0').

'Setup User Data' Window

**'Enable Thermistor Inputs on Analog Input #5 and Analog Input #7'** - When this box is checked 'Analog Input #5' and 'Analog Input #7' can be used as thermistor inputs. When activated, this option provides a drop down menu similar to the ones in ['Setup Sensors'](#) for 'Air Temperature' and 'Coolant Temperature'. Please refer to this section for descriptions of these parameters.

### Analog Inputs

- Name = The 'Name' defines the label that is used for the channel. This label is used in various locations in peMonitor to describe the channel as well as in logged data. Channel names can be up to 8 characters long.
- Scale (Units/V) = The 'Scale' parameter defines the sensitivity and allows the PE3 to calculate actual engineering units for the channel. The measured voltage is multiplied by the 'Scale' and offset by the parameter 'Offset' to convert from voltage to actual physical units.
- Offset (V) = 'Offset' is the offset of the calibration for the channel in volts. The combination of 'Scale' and 'Offset' completely define the calibration for any analog input channel.
- Filter = This parameter allows the user to configure a first order digital filter with varying cut-off frequencies (['Setup Sensors'](#) and ['Technical Specifications'](#) contain additional information on filters).
- Voltage (V) = This is the current measured voltage for the channel when peMonitor is communicating with the PE3.
- Calibrated Value = This is the calculated value after the PE3 applies the 'Scale' and 'Offset' to the voltage measurement. 'Calibrated Value' can be used to check the calibration and measurement itself.

### Digital Inputs

Digital Inputs #1 - #4 can be configured to measure the frequency of a square wave. When 'Enabled', these digital inputs do not function as normal 'on/off' inputs but rather measure the frequency of the incoming digital signal. These frequencies can be calibrated to represent physical parameters like speeds (e.g. wheel speed, RPM, airflow, etc).

- Enable = This check box enables the input to measure frequency.
- Name = 'Name' defines the label that is used for the channel. This label is used in various locations throughout peMonitor to describe the channel as well as in any logged data. Channel names can be up to 8 characters long.
- Scale (Units/Hz) = The 'Scale' parameter defines the sensitivity and allows the PE3 to calculate actual engineering units for the channel. The measured frequency is multiplied by the 'Scale' to convert from Hz (frequency) to actual physical units.
- Filter = This parameter allows the user to configure a first order digital filter with varying cut-off frequencies (['Setup Sensors'](#) and ['Technical Specifications'](#) contain additional information on filters).
- Frequency (Hz) = This is the current measured frequency for the channel when peMonitor is communicating with the PE3.
- Calibrated Value = This is the calculated value after the PE3 applies the 'Scale' to the frequency measurement. 'Calibrated Value' can be used to check the measurement while connected to a computer.



## **Setup Digital Names (Engine → Setup Digital Names)**

The 'Setup Digital Names' menu can be used to assign names to the Digital Inputs and Digital Outputs in the PE3. The names assigned here will be used throughout peMonitor to identify various functions. For example, if Digital Output #10 is used to drive a fuel pump relay, assigning this output the name 'Fuel' might be appropriate. Digital channels do not need to be named in order to function. Each name can have up to 8 characters.

Setup Digital Input/Output Names (8 character max)			
Digital Input #1 Name: Neut_Sw	Digital Input #2 Name: Baro	Digital Input #3 Name: AC_Sw	Digital Input #4 Name: ---
Digital Input #5 Name: ---	Digital Input #6 Name: ---	Digital Input #7 Name: ---	
Digital Output #1 Name: Fan	Digital Output #2 Name: Info	Digital Output #3 Name: WOT_AC	Digital Output #4 Name: Clt_Lg
Digital Output #5 Name: Shft_Lg1	Digital Output #6 Name: Shft_Lg2	Digital Output #7 Name: Shft_Lg3	Digital Output #8 Name: Bst_Sol
Digital Output #9 Name: Alw_On	Digital Output #10 Name: Fuel		

'Setup Digital Names' Window

## **Setup Tables (Engine → Setup Tables)**

The 'Setup Tables' window allows the user to configure the main fuel and ignition tables. Both the Load and RPM breakpoints can be adjusted based on the required spacing in the tables. The user can enter values directly in the array (cells with the light green background) to set the breakpoints or can use the 'Auto Fill' functions. The only requirement for setting up the tables is that the numbers must be increasing in value from left to right. Once the breakpoints are set in the this window, the Load and RPM indices will be modified in the main fuel and ignition tables. See below the figure for a description of the adjustable parameters.

The 'Setup Tables' window displays two tables for configuring engine parameters. The 'Load Index' table has 26 columns (Index 1-26) and 2 rows (% and RPM). The 'RPM Index' table has 26 columns (Index 1-26) and 2 rows (RPM and Load). Below the tables are two 'Auto Fill' sections: 'Auto Fill RPM Array' and 'Auto Fill Load Array'. Each section has input fields for 'Min' and 'Max' values and a 'Go' button. There is also a checkbox for 'Enable Small Tables (13x13)'.

Load Index																										
Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
%	0.0	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0	64.0	68.0	72.0	76.0	80.0	84.0	88.0	92.0	96.0	100.0

RPM Index																										
Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
RPM	0	325	650	975	1300	1625	1950	2275	2600	2925	3250	3575	3900	4225	4550	4875	5200	5525	5850	6175	6500	6825	7150	7475	7800	

'Setup Tables' Window

**Auto Fill RPM Array** - The 'Auto Fill RPM' function can be used to automatically fill in evenly spaced RPM breakpoints into the index.

- Min RPM = The minimum desired RPM in the RPM Index.
- Max RPM = The maximum desired RPM in the RPM Index.
- Go = Uses 'Min RPM' and 'Max RPM' to fill in the RPM Index

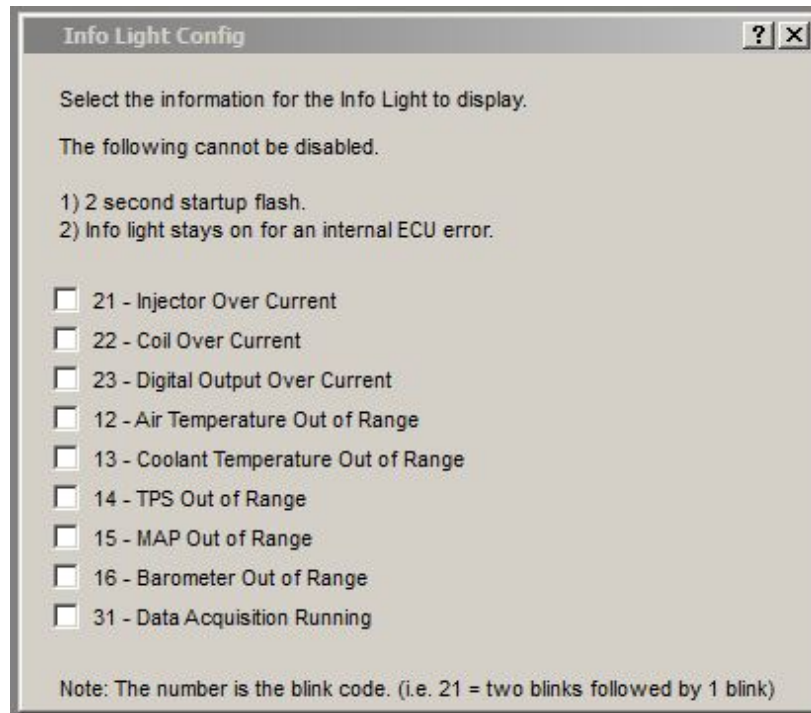
**Auto Fill Load Array** - The 'Auto Fill Load' function can be used to automatically fill in evenly spaced load breakpoints into the index. The units of the Load Index are based on the type of Load Control selected ([Setup Engine](#)) and the type of units selected ([Setup Sensors](#)). The breakpoints are represented in either percent for TPS load control or pressure if MAP load control is used.

- Min Load = The minimum desired Load in the Load Index.
- Max Load = The maximum desired Load in the Load index.
- Go = Uses the 'Min Load' and 'Max Load' to fill in the 'Load Index'

**NOTE:** Changing the breakpoints in the 'Load Index', 'RPM Index' or enabling 'Small Tables' **DOES NOT** automatically rescale the values in the main fuel and ignition tables. Changing the breakpoints does not effect the values in the tables in any way. When enabling small tables, approximately half of each table will be eliminated. If a known good tuning file is reduced from normal size tables to 'small' tables, values in the main fuel and ignition tables will not be scaled and new values will need to be entered by hand.

## **Info Light Config (Engine → Info Light Config)**

'Info Light Config' configures the blink patterns for the information light. In order for the information light to be active, it must be enabled on one of the digital outputs (see [Digital Outputs](#)) and configured in this menu. The digital output can be wired to drive a small LED or warning lamp.



'Info Light Config' Window

When configured, the info light will automatically turn on for 2 seconds when the PE3 is powered up in order to verify that the lamp is working. Depending on how the info light is configured, it will display unique blink patterns for different error states. If more than one error state exists at any given time, the unique blink patterns will be separated by approximately 1.2 seconds. Below is a description of the available blink patterns and their meaning. Error codes can be cleared in the ['System Status'](#) window.

Blink Pattern	Code Meaning
2 blinks followed by 1 blink	One of the injectors experienced an over-current situation. See <a href="#">'Technical Specifications'</a> for maximum allowable values.
2 blinks followed by 2 blinks	One of the ignition coils experienced an over-current situation. See <a href="#">'Technical Specifications'</a> for maximum allowable values. Reduce the dwell time of the coils to eliminate this error from occurring.
2 blinks followed by 3 blinks	An over-current has occurred on one or a combination of Digital Outputs. See <a href="#">'Technical Specifications'</a> for maximum allowable values.
1 blink followed by 2 blinks	The air temperature measurement is or has gone out of range in the past. Sensor ranges can be adjusted in <a href="#">'Setup Sensors'</a> .
1 blink followed by 3 blinks	The coolant temperature measurement is or has gone out of range in the past. Sensor ranges can be adjusted in <a href="#">'Setup Sensors'</a> .
1 blink followed by 4 blinks	The throttle position sensor measurement is or has gone out of range in the past. Sensor ranges can be adjusted in <a href="#">'Setup Sensors'</a> .
1 blink followed by 5 blinks	The MAP sensor measurement is or has gone out of range in the past. Sensor ranges can be adjusted in <a href="#">'Setup Sensors'</a> .
1 blink followed by 6 blinks	The barometer sensor measurement is or has gone out of range in the past. Sensor ranges can be adjusted in <a href="#">'Setup Sensors'</a> .
3 blinks followed by 1 blink	The data acquisition system is on and currently collecting data.

## **Stop Engine (Engine → Stop Engine)**

Using the 'Stop Engine' command (ctrl+K) on a running engine stops the engine by momentarily suspending fueling and ignition events. This can be helpful when the user wants to stop the engine but still maintain communication with the ECU. After approximately 5 seconds, the engine can be started again.

## Diagnostics Drop Down Menu

The sections below describe the different elements that are located under the 'Diagnostics' drop down menu at the top of the main screen. These menus include the diagnostic functions of the PE3 ECU.

### **Output** (*Diagnostics* → *Output*)

The 'Output Diagnostics' menu provides a convenient way to test the injectors, ignition coils and digital outputs.

This menu functions differently depending on whether the engine is running or not. When the engine is not running, the 'Fire' buttons are available to test fire the 'Injectors' and 'Coils'. If the engine is running, the 'Disable' buttons become available. These buttons temporarily suspend the operation of the respective ignition coil or injector in order to test their effect on the running engine.

**Output Diagnostics**

☐ Repeat last command once a second  
- Current command: Fire Digital 1

**Injectors**

Fire #1	Disable #1
Fire #2	Disable #2
Fire #3	Disable #3
Fire #4	Disable #4
Fire #5	Disable #5
Fire #6	Disable #6
Fire #7	Disable #7
Fire #8	Disable #8

**Coils**

☐ Enable fixed ignition timing (DBTDC)

Fire #1	Disable #1
Fire #2	Disable #2
Fire #3	Disable #3
Fire #4	Disable #4
Fire #5	Disable #5
Fire #6	Disable #6
Fire #7	Disable #7
Fire #8	Disable #8

**Digital Outputs**

On Time (seconds)

Fire #1 (DO # 1)
Fire #2 (DO # 2)
Fire #3 (DO # 3)
Fire #4 (DO # 4)
Fire #5 (DO # 5)
Fire #6 (DO # 6)
Fire #7 (DO # 7)
Fire #8 (DO # 8)
Fire #9 (DO # 9)
Fire #10 (DO # 10)

Yellow button means that the output is locked out due to overcurrent  
Reduce the amount of current in the circuit.  
Clear the error in:  
Diagnostics  
- System Status

'Output Diagnostics' Window

The different areas of the menu are described below.

**Repeat last command once a second** - This check box repeats whatever the last command was at a rate of once per second. In the figure above, the command that would be repeated is to fire Digital Output #1. This feature is especially helpful when troubleshooting wiring with only one person.

**Injectors** - This area of the menu provides both 'Fire' buttons (when the engine is not running) and 'Disable' buttons (when the engine is running). The 'Fire' button fires the injector one time unless the 'Repeat Last Command' box is checked. The 'Disable' button forces the injector to remain closed while the engine is running.

**Coils** - The coils can also be test fired (when the engine is not running) or disabled (when the engine is running). The 'Fire' button fires the coil once unless the 'Repeat Last Command' box is checked. Each time the coil fires, it is charged based on the settings in 'Charge Time (ms)' under ['Ignition'](#).

The 'Coils' section of the menu also has a check box for fixed ignition timing. When enabled, this feature allows the user to set fixed timing equal to the value entered, regardless of any of the other ignition timing tables in the PE3. Fixed ignition timing is only active while the user is in this diagnostic menu. Once the menu or peMonitor is closed, fixed ignition timing is no longer active. This function is helpful for checking ignition timing with a light on a running engine.

**Digital Outputs** - The digital outputs can also be test fired in this menu. The length of time the digital output stays on each test fire is adjustable by changing the 'On Time' drop down menu at the top.

## **Input (*Diagnostics* → *Input*)**

The 'Input Diagnostics' menu provides a single location where the user can view all of the analog and digital inputs at one time. In addition to the calibrated values (psi, degrees, %, etc), this menu also provides raw voltage and bit information for each channel. Below is an example of an Input Diagnostics screen.

Input Diagnostics					
Parameter	Bits	Voltage/Frequency	Calibrated	User Data Name	User Data
TPS	247	1.21 (V)	0.0 (%)		
MAP	995	4.86 (V)	14.78 (psi)		
Air Temp	570	2.78 (V)	84 (°F)		
Water Temp	288	1.41 (V)	138 (°F)		
Analog Input #1	993	4.85 (V)		Anlg #1	4.85
Analog Input #2	2	0.01 (V)		Anlg #2	0.01
Analog Input #3	309	1.51 (V)		EGT	302.00
Analog Input #4	2	0.01 (V)		Anlg #4	0.01
Analog Input #5	352	1.72 (V)		L_O2	1.72
Analog Input #6	937	4.58 (V)		Anlg #6	4.58
Analog Input #7	1	0.01 (V)		MAFv	0.01
Analog Input #8	314	6.74 (V)		Anlg #8	6.74
Battery	482	2.35 (V)	13.80 (V)		
Digital Input #1 (DI #1)	0				
Digital Input #2 (Baro)	0				
Digital Input #3 (AC_Sw)	0				
Digital Input #4 (---	0				
Digital Input #5 (---	0				
Digital Input #6 (---	0				
Digital Input #7 (---	0				

'Input Diagnostics' Window

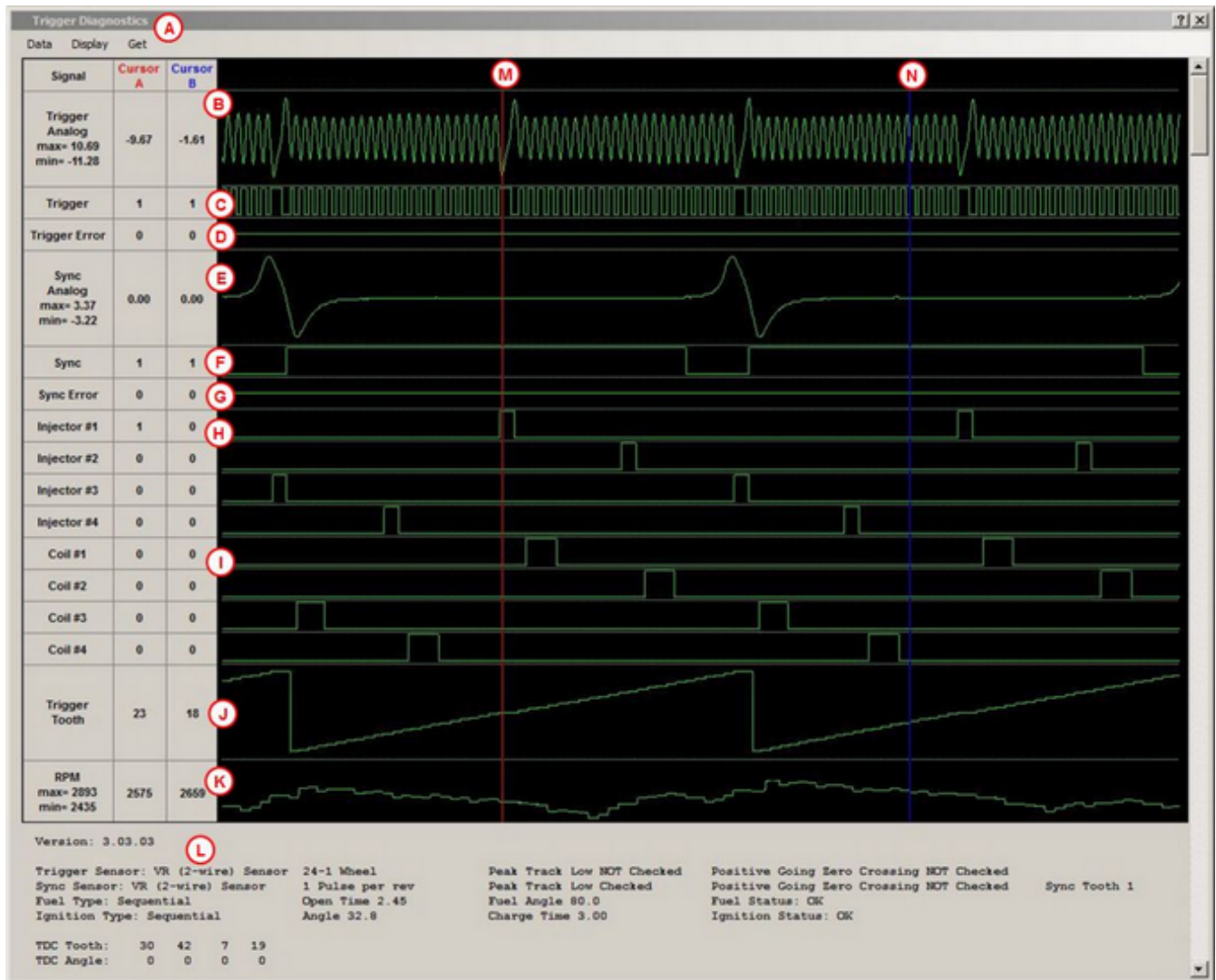
## **Trigger/Sync (*Diagnostics* → *Trigger/Sync*)**

The 'Trigger/Sync' function adds a very powerful diagnostic tool to the PE3 engine control system. Trigger diagnostics provide an oscilloscope function that allows the user to see the trigger and sync analog signals as well as the response from the injectors and coils. The top part of the screen is a plotted representation of the inputs and outputs while the bottom part of the screen provides numerical information on the current running condition of the engine. In addition to being able to view the trigger diagnostics results while tuning an engine, the diagnostic information can also be saved to a file to review later or send to Performance Electronics for support.

The left part of the data plot has three columns titled 'Signal', 'Cursor A' and 'Cursor B'. The 'Signal' column lists what data is presented in the plot to the right. Minimum and maximum values for some parameters are also listed in this column. The 'Cursor A' column lists the value of the signal where the red cursor is located. Likewise, the 'Cursor B' column lists the value of the signal at the blue cursor.

The figure below shows the diagnostic results from a 4-cylinder motorcycle engine with a 24-1 trigger and a single cam sync pulse. Below the figure are descriptions of the different parts of the diagnostic window as well as options for using the system.





'Trigger Diagnostics' Window

## A

The drop down header contains options for getting, saving and viewing data. See below for a description of each command.

**Data** - This contains commands for collecting, loading and saving data from trigger diagnostics.

- Get = 'Get' forces the PE3 to collect data based on the current configuration settings regardless of an RPM signal being detected. While the ECU is collecting data, peMonitor will pause for a moment to gather the data.
- Auto Trigger = This arms the trigger diagnostics such that data will be collected as soon as an RPM signal is detected. In order for RPM to be calculated by the PE3, the ECU must be receiving trigger and sync signals consistent with the way the ECU is configured. If a 'Crank Error' is present, RPM will not be calculated.
- Save to a file = This command saves the currently displayed trigger diagnostic data to a .peDiag file that can be loaded and viewed at a later date.
- Read from a file = 'Read from a file' allows the user to load previously stored .peDiag data from disk.



- Extract analog data = This function extracts the raw Trigger and Sync voltage data from the window and allows the user to save it in a comma separated variable (CSV) file.
- Zero RPM Sample Rate = This parameter sets the trigger diagnostic sample rate when a valid RPM is not present (RPM=0). This determines how quickly the PE3 collects data. The sample rate can be set to high, medium or low. A low sample rate provides a longer data trace (more revolutions) but sacrifices resolution. A high sample rate provides a shorter window of data in time but at higher resolution.
- Valid RPM Sample Rate = This parameter sets the trigger diagnostic sample rate when a valid RPM is present (not zero). This determines how quickly the PE3 collects data. The sample rate can be set to high, medium or low. A low sample rate provides a longer data trace (more revolutions) but sacrifices resolution. A high sample rate provides a shorter window of data in time but at higher resolution.

**Display** -This includes commands and settings for displaying trigger diagnostic data.

- Redraw = This redraws the plotted data in the graph.
- Zoom In = 'Zoom In' zooms in to the data between the cursors.
- Zoom Out = This command expands the plot out.
- Hide Injectors = 'Hide Injectors' hides the injector traces on the data plot. This shortens the overall window height to make it easier to display on small monitors.
- Hide Coils = 'Hide Coils' hides the coil traces on the data plot. This shortens the overall window height to make it easier to display on small monitors.
- Move Cursor A = Cursor 'A' (the red cursor) can be moved by dragging it with the mouse or by using the right and left arrow keys.
- Move Cursor B = Cursor 'B' (the blue cursor) can be moved by dragging it with the mouse or by holding the Shift key and using the right and left arrow keys.

**Get** - 'Get' forces the PE3 to collect data based on the current configuration settings regardless of an RPM signal being detected. While the ECU is collecting data, peMonitor will pause for a moment to gather the data. This is the same as 'Get' under the drop down menu 'Data' above.

---

## **B**

This portion of the plot is the analog signal for the trigger input. In the case above in the figure this is a 24-1 tooth crank wheel using a 2-wire, variable reluctance sensor.

---

## **C**

This is the digital equivalent of the trigger analog signal after it has passed through the signal conditioning in the PE3. This signal is what the processor sees in the ECU. A rising edge on this signal (0 to 1) is what is used by the processor.

---

## **D**

'Trigger Error' shows when a error condition occurs on the trigger signal. Anytime an error occurs, this signal will show 1 instead of 0. Either a trigger error, sync error or both will correspond with the global 'Crank Error' that is displayed on the main peMonitor screen.

---

## **E**

This part of the plot is the analog signal for the sync input. In the case shown in the figure, this is a single tooth that occurs once per engine cycle using a 2-wire variable reluctance sensor.

---

## **F**

This is the digital equivalent of the sync analog signal after it passes through the signal conditioning in the PE3. This signal is what the processor sees in the ECU. A rising edge (0 to 1) on this signal is what is used by the processor.

---

## **G**

'Sync Error' shows when a error condition occurs on the sync signal. Anytime an error occurs, this signal will show 1 instead of 0. Either a trigger error, sync error or both will correspond with the global 'Crank Error' that is displayed on the main peMonitor screen.

---

## **H**

This row in the plot shows the injectors opening and closing. In the case above there are 4 injector drivers used, one for each cylinder. When this signal transitions from 0 to 1 , the injector has opened.

---

## **I**

This area of the plot shows the ignition coils charging and firing. In the case above there are 4 ignition drivers used, one for each cylinder. When this signal transitions from 0 to 1 , the coil is charging. The coil fires when the signal goes from 1 to 0.

---

## **J**

The 'Trigger Tooth' plot tracks the current trigger tooth in the data. In the case shown above, the trigger tooth goes from 1 to 46. This is because the engine is running a 24-1 tooth profile trigger wheel (23 teeth). Because the engine has a sync signal and is running with a 'cycle-based' reference frame, the trigger tooth increments over 2 crank revolutions from 1 to 46.

---

## **K**

This row in the plot shows the instantaneous engine RPM for every trigger tooth in the data.

---

## **L**

The area below the plot displays additional information about the engine and how it was configured when the trigger diagnostic plot was generated. This data is also stored in the peDiag file if the data is saved to disk.

---

## **M**

This is 'Cursor A'. It can be moved through the data by clicking and dragging with the mouse or by using the left and right arrow keys.

---

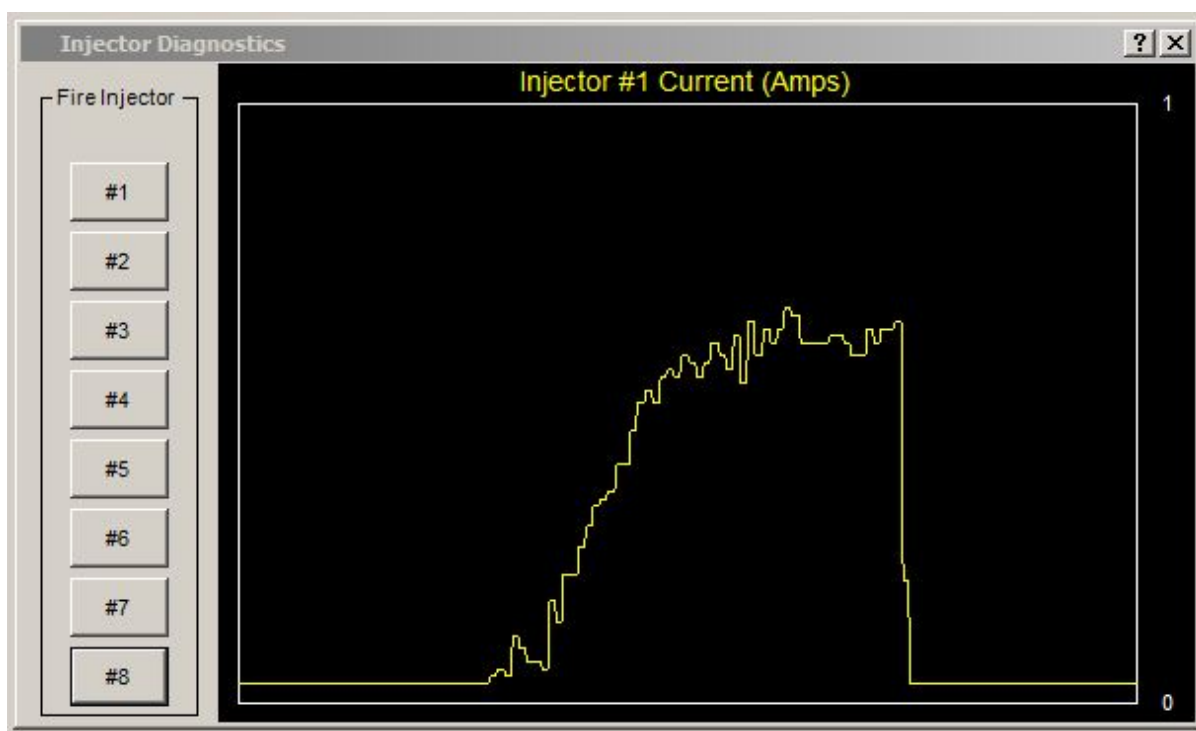
## **N**

This is the blue cursor, 'Cursor B'. It can be moved through the data by clicking and dragging with the mouse or by holding the shift key while using the left and right arrow keys.

## **Injector (*Diagnostics* → *Injector*)**

The injector diagnostics window is an extension of the simple fire/disable functions possible in ['Output'](#) diagnostics. Injector diagnostics provides the ability to fire all of the injectors and also view the current as a graphical plot. This is very helpful for troubleshooting as well as configuring peak and hold injectors.

The figure below shows an injector diagnostics window when saturated (high impedance) injectors are used. The 'Fire Injector' buttons on the left side of the window causes the injector to fire for a duration of 4 milliseconds when pressed. The current through the injector is then plotted as a function of time on the graph.

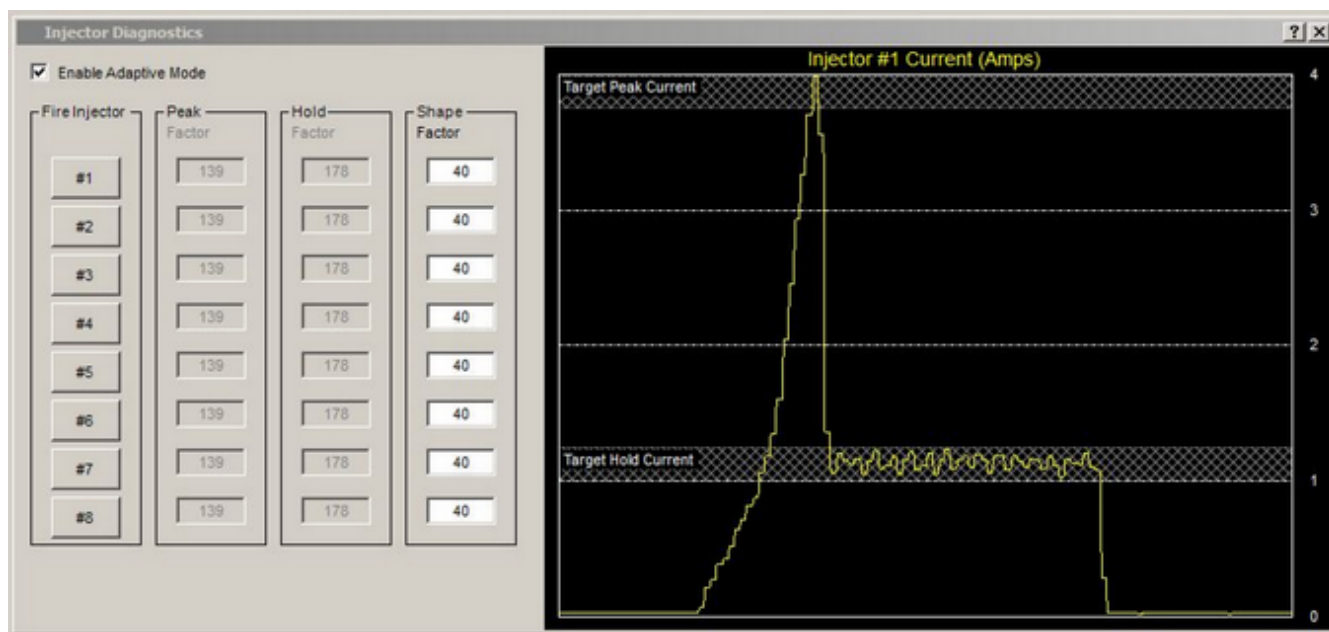


'Injector Diagnostics' Window after Firing a Saturated Injector

The look of the injector diagnostics window is slightly different when 'Peak & Hold' injectors are used (see Figure below). Peak & Hold injectors can be enabled in the ['Fuel'](#) tab under 'Setup Engine'. In addition to viewing the injector current during the test fire, peak and hold parameters can also be fine tuned in this window. Pressing the fire injector button fires the respective injector for 4 milliseconds.

The 'Enable Adaptive Mode' check box in the upper left corner of the window puts the peak & hold system into adaptive mode. Adaptive mode allows the PE3 to automatically adapt to the peak current and hold current entered in the 'Peak & Hold' section of the ['Fuel'](#) tab. If adaptive mode is not used, then the 'Hold Factor' and 'Peak Factor' in the figure define the peak and hold current levels.

Setting the 'Peak Factor', 'Hold Factor' and 'Shape Factor' is best done iteratively while reviewing the shape of the injector current plot. The shape of the current in the figure below would be acceptable for a 4 amp peak, 1 amp hold injector. The effect each factor has on the injector current is described below the figure.

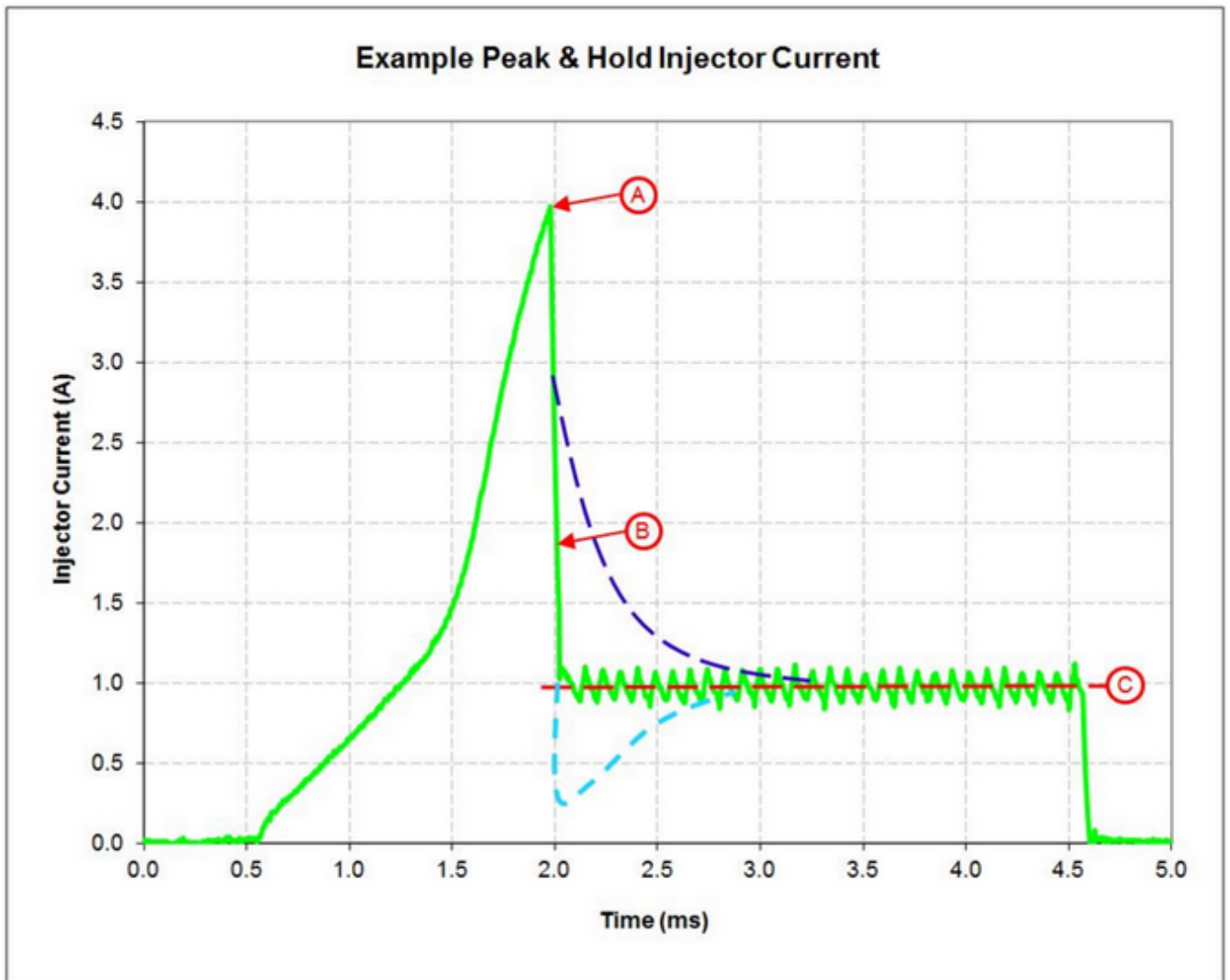


'Injector Diagnostics' Window after Firing a Peak & Hold Injector

**Peak Factor** - The 'Peak Factor' determines how high the injector current will initially peak when fired ('A' on the figure below). A **higher** entered number results in a **higher** peak value and a **lower** number results in a **lower** peak current.

**Hold Factor** - This factor sets the average current level at which the injector will be held after the initial peak. This level is shown as the red dashed line 'C' in the figure below. A **higher** value **decreases** the hold current and a **lower** value **increases** the current.

**Shape Factor** - The 'Shape Factor' must be configured regardless of whether the PE3 is in adaptive mode or not. This parameter configures the shape of the transition between the peak and hold currents (area 'B' on the figure below). Ideally, the current plot should have the shape of the green trace, with a very quick transition from peak to hold. The dark blue dashed line is indicative of a shape factor that is too low. The light blue dashed line indicates a shape factor that is too high.



Example Peak &amp; Hold Injector Trace and the Effect of Tuning Factors

## **System Status (*Diagnostics* → *System Status*)**

The 'System Status' screen provides feedback on the general health of the system. In addition to basic statistical information like number of power-on events and two hour meters, system status also provides extensive error tracking functions.

The figure below is an example System Status page containing no errors or warnings. If a warning or error does occur, the background color of the effected parameter turns from light blue to yellow. Errors can be reset by pressing the 'Reset Error Counters' button at the top of the page.

System Status				
Reset Error Counters		Reset User Hour Meter		
Parameter	Value	Parameter	Status	Error Count
Power On Events	509	Injector # 1	Current OK	0
Hour Meter HH:MM:SS	72:33:58	Injector # 2	Current OK	0
User Hour Meter HH:MM:SS	31:25:19	Injector # 3	Current OK	0
Board Temperature	93 °F	Injector # 4	Current OK	0
Total Digital Output Current	less than 0.5 Amp	Injector # 5	Current OK	0
System Status	OK	Injector # 6	Current OK	0
Crank Status	OK	Injector # 7	Current OK	0
		Injector # 8	Current OK	0
Fuel Status	OK	Open Time Clipped	No Clip	0
Injector Force Close Count	0			
		Coil # 1	Current OK	0
Ignition Status	OK	Coil # 2	Current OK	0
		Coil # 3	Current OK	0
		Coil # 4	Current OK	0
		Coil # 5	Current OK	0
		Coil # 6	Current OK	0
		Coil # 7	Current OK	0
		Coil # 8	Current OK	0
		Charge Time Clipped	No Clip	0

'System Status' Window

The 'System Status' page logs and displays the conditions listed below. For parameters that display both a 'Status' and an 'Error Count', 'Status' is the current condition and 'Error Count' indicates the number of times the error has occurred in the past. If an error occurs, 'Error Count' values are only incremented by 1 per ECU power-on event. Error counts can be reset by pressing the 'Reset Error Counters' button at the top of the page.

- **Power On Events** = Number of times the PE3 has been powered on/off.
- **Hour Meter** = Total accumulated time that the PE3 has been powered on and controlling a running engine. An RPM must be present for this timer to increment.
- **User Hour Meter** = Total accumulated time that the PE3 has been powered on and controlling a running engine since the last user reset. An RPM must also be present for this to increment. The user hour meter can be reset by pressing the 'Reset User Hour Meter' button at the top of the page.
- **Board Temperature** = Internal temperature of the PE3 printed circuit board.
- **Total Digital Output Current** = This is the total current flow for all 10 of the digital outputs. If the total current is greater than 15.0 amps, the PE3 will flag an error and turn the outputs off.
- **System Status** = The System Status refers to the internal status of the different microprocessors in the PE3. Under normal operation, this should always be 'OK'.



- **Crank Status** = Indicates a problem with the Trigger and/or Sync signals based on how the PE3 is configured. Something other than 'OK' generally means the ECU cannot determine the crank position.
- **Fuel Status** = This indicates the status of the fuel system. If the fuel is being 'cut' for some reason it will be displayed in this cell.
- **Injector Force Close Count** = This indicates that the injectors were forced to close due to an abnormal event like the crank signal abruptly being removed. Generally in normal operation, this count will not increment except during engine shutdown.
- **Ignition Status** = Indicates the status of the ignition system. Like the fuel system, if the ignition is 'cut' for some reason it will be displayed here.
- **Injector #1 - Injector #8** = These cells indicate the status of the individual injector drivers. If an injector driver flows more than 10 amps, an error will be logged. Resetting the ECU will clear the status so the injector can function (if the over-current condition is gone) but will not clear the error count. In the figure below, Inj #7 had an over-current in the past and Inj #8 is currently turned off because of an over-current condition.
- **Open Time Clipped** = This indicates that the open time for the injectors was clipped at the max duty cycle of 80%.
- **Coil #1 - Coil #8** = These cells indicate the status of the individual coil drivers. If a coil driver circuit flows more than 10 amps, an error will be logged. Resetting the ECU will clear the status so the ignition coil can function (if the over-current condition is gone) but will not clear the error count. Error counts can be cleared by pressing the 'Reset Error Counters' button.
- **Charge Time Clipped** = Indicates that one or more ignition coils was not able to charge for the full amount as set in the ['Ignition'](#) tab of the 'Setup Engine' menu. Under many circumstances this is completely normal due to the fact that the engine is turning at a high RPM and there is not enough time to charge fully.
- **Air Temp, Coolant Temp, TPS, MAP and Barometer** = Both 'High' and 'Low' out of range errors can be logged for these sensor inputs. If the sensor value is outside the range as defined in the ['Setup Sensors'](#) page, an error will be displayed and logged in the ECU. Error counts can be cleared by pressing the 'Reset Error Counters' button. These are not visible in the figure below.

System Status				
Reset Error Counters		Reset User Hour Meter		
Parameter	Value	Parameter	Status	Error Count
Power On Events	568	Injector # 1	Current OK	0
Hour Meter HH:MM:SS	73:25:51	Injector # 2	Current OK	0
User Hour Meter HH:MM:SS	32:17:12	Injector # 3	Current OK	0
Board Temperature	97 °F	Injector # 4	Current OK	0
Total Digital Output Current	less than 0.5 Amp	Injector # 5	Current OK	0
System Status	OK	Injector # 6	Current OK	0
Crank Status	OK	Injector # 7	Current OK	1
		Injector # 8	Over Current	2
Fuel Status	OK	Open Time Clipped	No Clip	0
Injector Force Close Count	0			

'System Status' Window with Injector Errors

Inj #7 had an over-current in the past, Inj #8 is currently turned off because of an over-current condition





## Tuning Drop Down Menu

The sections below describe the different elements that are located under the 'Tuning' drop down menu at the top of the main screen in peMonitor. These menus include all of the tuning parameters required to properly tune an engine.

### **Fuel Table** (*Tuning* → *Fuel Table*)

The 'Fuel Table' provides the base open time for the fuel injectors. All other fuel compensation terms modify the base open time to calculate the total open time (see ['Fuel Metering'](#) for this calculation). The main fuel table contains the injector open times in milliseconds (ms) based on the engine load and RPM. Engine load is configurable by the user under the ['Engine'](#) tab in 'Setup Engine'. In the figure shown below, the engine load is configured as throttle position (TPS %).

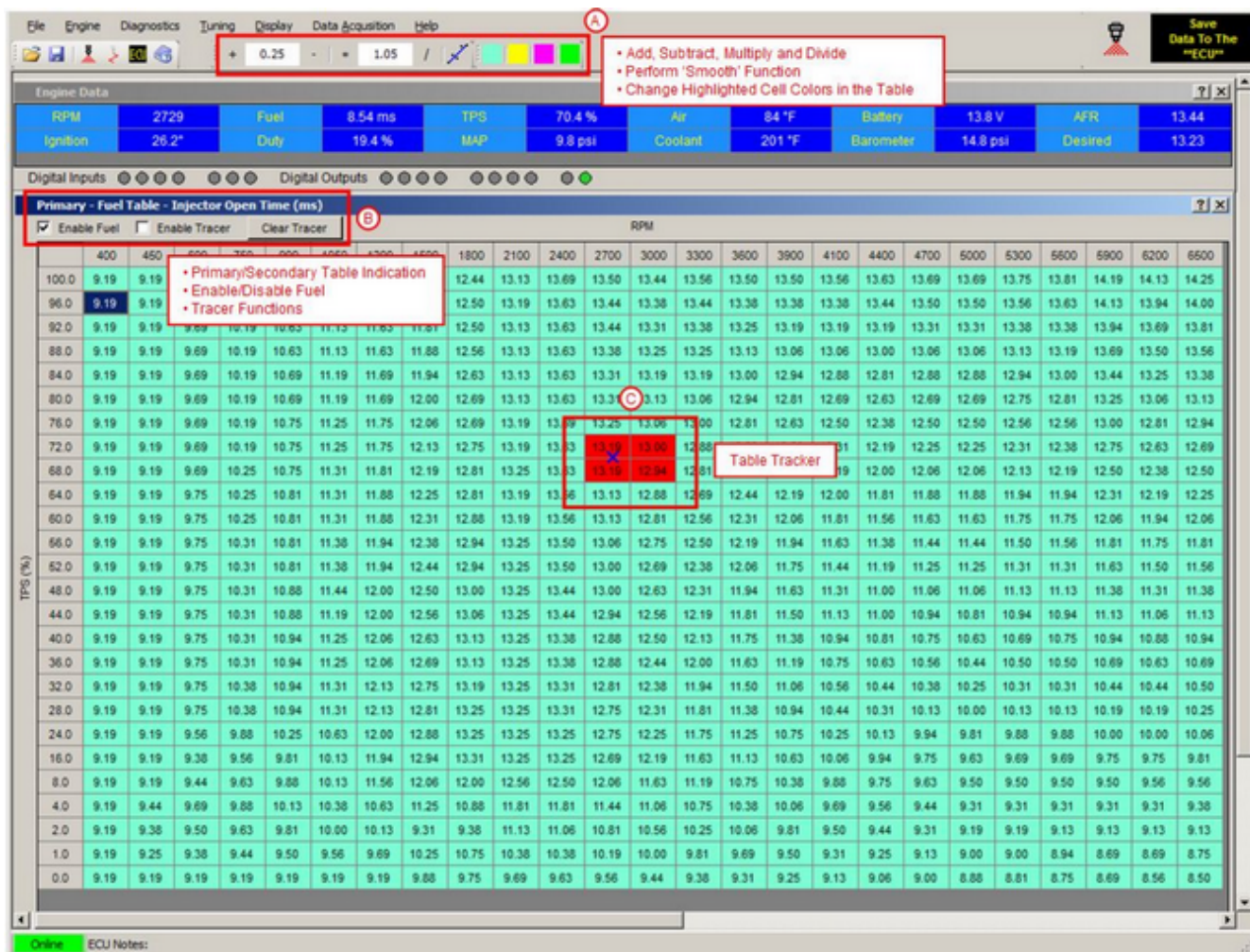
The open times in the table represent the base length of time that the injector will stay 'on' each time that the injector opens. If the injectors are configured to open once per engine cycle (i.e. sequential injection), the times in table represent open time per cycle. If the injectors are configured to fire once per engine revolution (i.e. semi-sequential), the table values represent open time per revolution.

Both axes of the table (load and RPM) are completely adjustable by the user. The Load and RPM breakpoints can be adjusted in ['Setup Tables'](#) based on the required spacing.

The fuel table has a maximum allowable open time that can be entered. This maximum value is determined by the 'Open Time Range' setting in the ['Fuel'](#) tab in 'Setup Engine'. If the fuel table will not allow large enough values to be entered during tuning, the 'Open Time Range' setting must be increased. In order to maintain the best resolution, the 'Open Time Range' should be set to the lowest setting that still allows the required values to be entered in the table. In other words, if the maximum open time in the table is 3.00 ms, 'Open Time Range' should be set to '0 to 4 ms' not '0 to 20 ms'.

If the engine operates outside of the limits of the table in any direction, the base open time values that are used by the PE3 are the last entries in that direction. In the figure below, if the TPS was at 100% and the RPM was 6600 RPM (extreme upper right corner of the table), the measured engine speed would be outside the limit of the table (the last value in the table is 6500 RPM). In this case, the base open time would be 14.25 ms because that is the last value in the table at 100% TPS.

The figure below shows a typical fuel table for an 8-cylinder engine running with MAP compensation. Sections of the table are highlighted with red boxes and labeled. These areas, along with other functions of the fuel table are described below the figure.




Example Main Fuel Table Shown with the Engine Data Header

**Enable Fuel (B)** - The 'Enable Fuel' check box is a quick and easy way to enable and disable global fuel delivery. Clearing this check box stops all injectors from opening.

**Table Tracker (C)** - The Table Tracker provides a convenient way to determine what cells in the table are being used at any given time. A red box highlights the four cells used to calculate the base open time. Inside the red box is a blue 'X'. The blue 'X' tells the user where the engine is currently operating within the red cells. This gives an indication of which cells are most influencing the base open time fuel calculation.

**Table Manipulation** - There are several ways to change values in the main table.

- **Direct Entry** = Cell values can be modified by direct entry. Simply highlight one or several cells and type in a new number. All highlighted cells will change to this value when the 'Enter' button is pressed.
- **Add, Subtract, Multiply and Divide (A)** = Cells in the table can be highlighted for simple arithmetic. The buttons +, -, \*, / located in area 'A' will add, subtract multiply or divide constants to the highlighted cells in the table. In the example above, hitting the + button would add 0.25 ms to the highlighted cells and - would subtract 0.25 ms. The \* button multiplies the cells by 1.05 and the / button divides them by 1.05. The constants (0.25 and 1.05) can also be edited by the user by highlighting the space and typing in a new constant.

- Smooth (A) = The 'Smooth' button ,  , is located next to the arithmetic functions in the figure . To use Smooth, cells must be highlighted in the table. The highlighted cells can either be a row, column or combination of rows and columns. Smooth uses the end points of whatever cells are highlighted and linear interpolates to recalculate the interior cells.
- Right Click and Shortcut Keys = Right clicking the mouse in the main table brings up some additional functions for manipulating the table. All of these functions can also be accessed using the shortcut keys. A complete listing of these keys is contained in the ['Monitor Shortcuts'](#) section.
  - Add Selected = Adds the constant value to the highlighted cells in the table
  - Subtract Selected = Subtracts the constant value from the highlighted cells in the table
  - Multiply Selected = Multiplies the highlighted cells in the table by the constant factor
  - Divide Selected = Divides the highlighted cells in the table by the constant factor
  - Smooth = Smooths the highlighted cells
  - Add Red Block = Adds the constant value to the red cells in the Table Tracker
  - Subtract Red Block = Subtracts the constant value from the red cells in the Table Tracker
  - Multiply Red Block = Multiplies the red cells in the Table Tracker by the constant factor
  - Divide Red Block = Divides the red cells in the Table Tracker by the constant factor
  - Copy = Copies the highlighted cells to the clipboard as text. Cells can be copied to and from text and spreadsheet programs like Excel.
  - Paste = Pastes the cells from the clipboard to the table. Cells can be pasted to and from text and spreadsheet programs like Excel.
  - Undo = Undo the last operation in the table. Up to 10 'Undo' operations can be performed.

**Table Colors (A)** - Individual cells or groups of cells can be re-colored by the user in order to differentiate them during the tuning process. The colored squares in 'A' above can be used to change cell colors or 'Mark' them. The available 'Mark' colors can also be changed in the ['System Colors'](#) window. This capability can very useful during tuning to indicate parts of the table that are well tuned or areas that need more work.

**Table Tracer (B)** - The 'Tracer' function can be enabled via a check box located in the upper left hand corner of the table. When enabled, the Tracer marks the used cells by changing their color. As the red tracker box moves through the table, the background cell color is changed. The Tracer provides the user with a quick indication of what part of the table has recently been used. The 'Clear Tracer' button removes the colored tracer cells. Tracer colors can be modified in ['System Colors'](#). The figure below shows the tracer cells highlighted in purple after an acceleration run.



### Fuel Angle (*Tuning* → *Fuel Angle*)

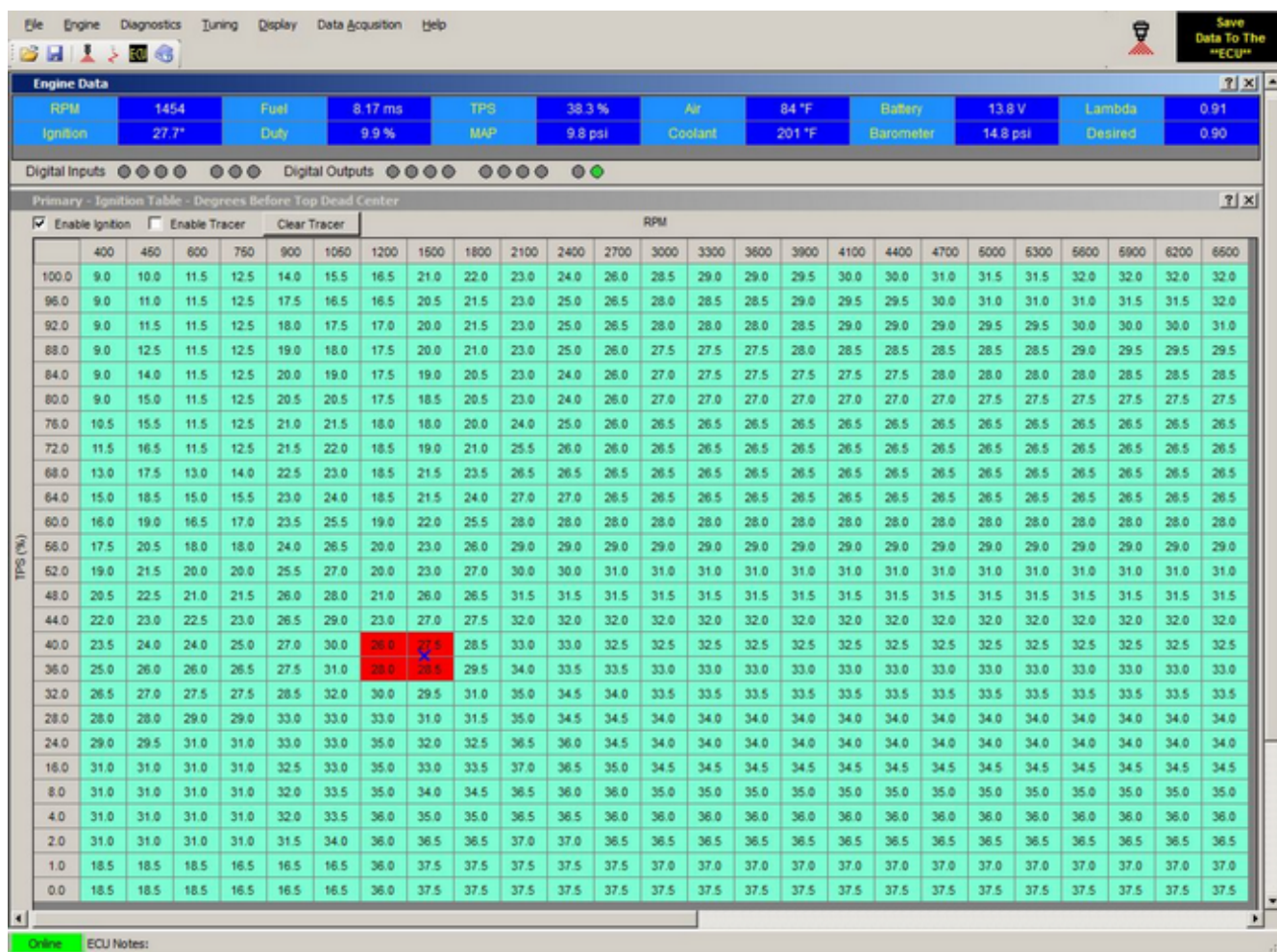
## Ignition Table (*Tuning* → *Ignition Table*)

If the engine operates outside of the limits of the table in any direction, the base timing values

that are used by the PE3 are the last entries in the table in that direction. For example, in the figure below, if the TPS was at 100% and the RPM was 6600 RPM (extreme upper right corner of the table), the measured engine speed would be outside the limit of the table (the last value in the table is 6500 RPM). In this case, the base timing would be 32 DBTDC because that is the last value in the table at 100% TPS.

The 'Enable Ignition' check box in the upper left hand corner of the table is a quick and easy way to enable and disable the ignition system. Clearing this check box stops all ignition coils from charging and firing.

The figure below shows a typical ignition table for an 8-cylinder naturally aspirated engine. Please refer to the section describing the main fuel table ([Fuel Table](#)) for more information regarding table manipulation, table tracker, table colors and the table tracer as these functions are common for all of the main tables.



Example Main Ignition Table Shown with the Engine Data Header

## Target Lambda Table (*Tuning* → *Target Lambda Table*)

The 'Target Lambda Table' is used by the closed loop fuel control code (see [Closed Loop Lambda/AFR Control](#)). When in closed loop mode, the PE3 looks up the target value in this table and increases or decreases the injector open time in order to meet the target mixture. This table is only used for closed loop fuel control. If the PE3 is not in closed loop mode, this table is not used.

The values in this table are displayed in either lambda or AFR and are based on engine load and RPM. The units can be changed between lambda and AFR in the ['Setup Sensors'](#) section of peMonitor. Engine load is configurable by the user under the ['Engine'](#) tab in 'Setup Engine'. In the case shown below, the engine load is throttle position (TPS %) and the table units are in lambda. Typing a 0 (zero) in the Target Lambda Table disables closed loop fuel control locally at that specific load/RPM site.

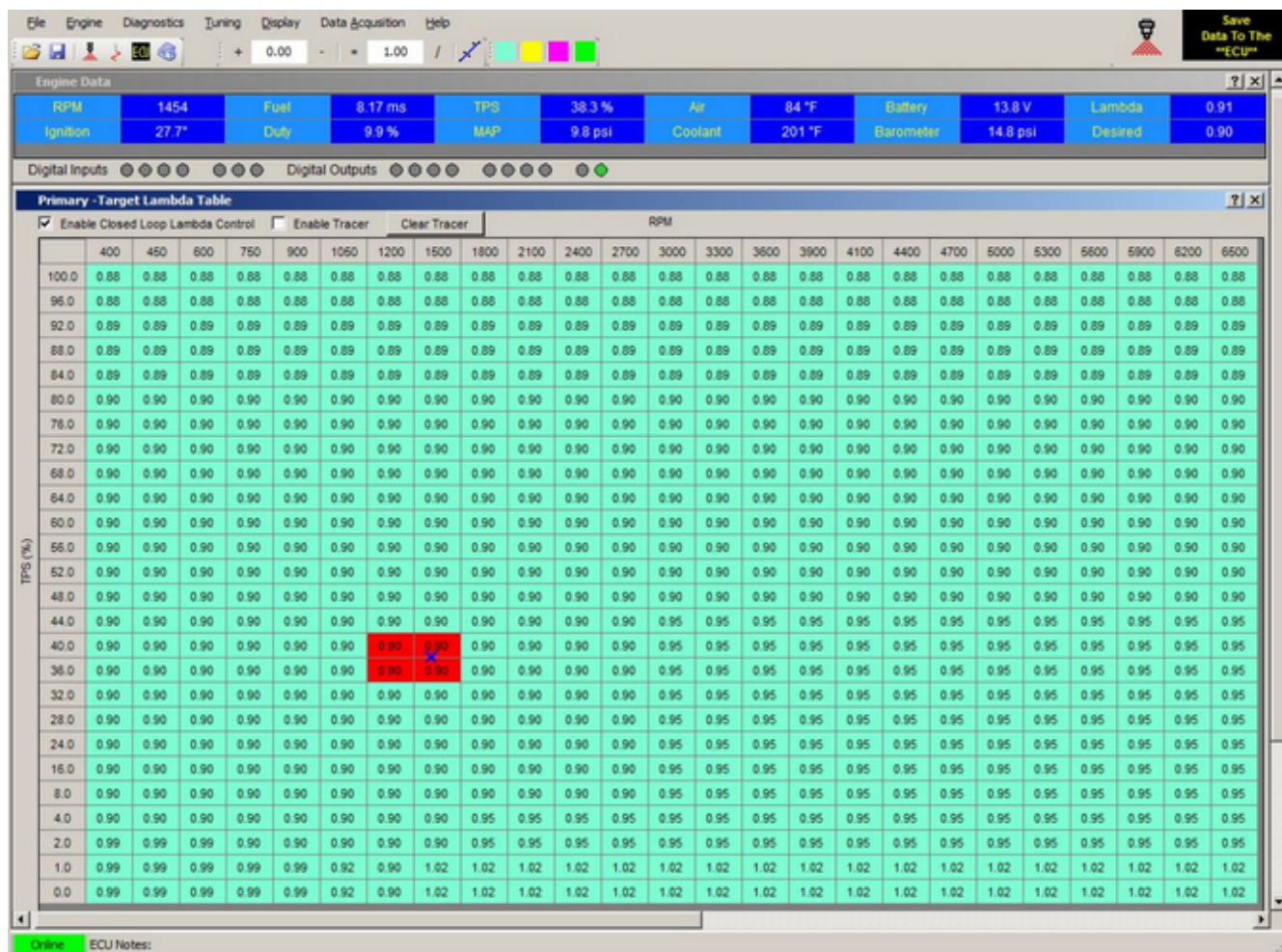
Both axes of the table (load and RPM) are completely adjustable by the user. The Load and RPM breakpoints can be adjusted in ['Setup Tables'](#) based on the required spacing.

If the engine operates outside of the limits of the table in any direction, the target values that are used by the PE3 are the last entries in the table in that direction. For example, in the figure below, if the TPS was at 100% and the RPM was 6600 RPM (extreme upper right corner of the table), the measured engine speed would be outside the limit of the table (the last value in the table is 6500 RPM). In this case, the target value would be 0.88 because that is the last value in the table at 100% TPS.

The 'Enable Closed Loop Control' check box in the upper left hand corner of the table is a quick and easy way to enable and disable the fuel closed loop control system. Clearing this check disables closed loop fuel control.

The figure below shows a typical target table for an 8-cylinder naturally aspirated engine. Please refer to the section describing the main fuel table (['Fuel Table'](#)) for more information regarding table manipulation, table tracker, table colors and the table tracer as these functions are common for all of the main tables including the target lambda table.





Example Target Lambda Table Shown with the Engine Data Header

## **Long Term Factor Table (Tuning → Long Term Factor Table)**

When in closed loop mode, the PE3 calculates and stores fuel compensation terms in the 'Long Term Factor Table'. The entries in this table are the result of the PE3 system 'learning' what is necessary to achieve the target fuel mixture as defined in the [Target Lambda Table](#). Entries in this table are in units of percent (%). A value of 100 does not modify the fueling at all. Values greater than 100 increase the fuel and values less than 100 reduce the fuel for that particular load and speed setting. For a detailed description of how this table interacts with the rest of the closed loop fuel control, please refer to the section [Closed Loop Lambda/AFR Control](#).

This table is only used for closed loop fuel control. If Closed Loop Lambda/AFR Control is not enabled, this table is not relevant.

Both axes of the table (load and RPM) are adjustable by the user, however they are the same as the main fuel table and ignition table.

There is no user adjustment allowed in this table. This table is modified, over time, by the PE3 unit itself. The extent to which changes are made to this table depend on the other closed loop fuel settings as well the initial quality of the main fuel table. When setting up a new engine, the long term factor table should all be at 100.

Although adjustments to the table itself are not possible, the user does have the ability to manipulate the table in several ways. The descriptions below refer to the buttons in the bottom

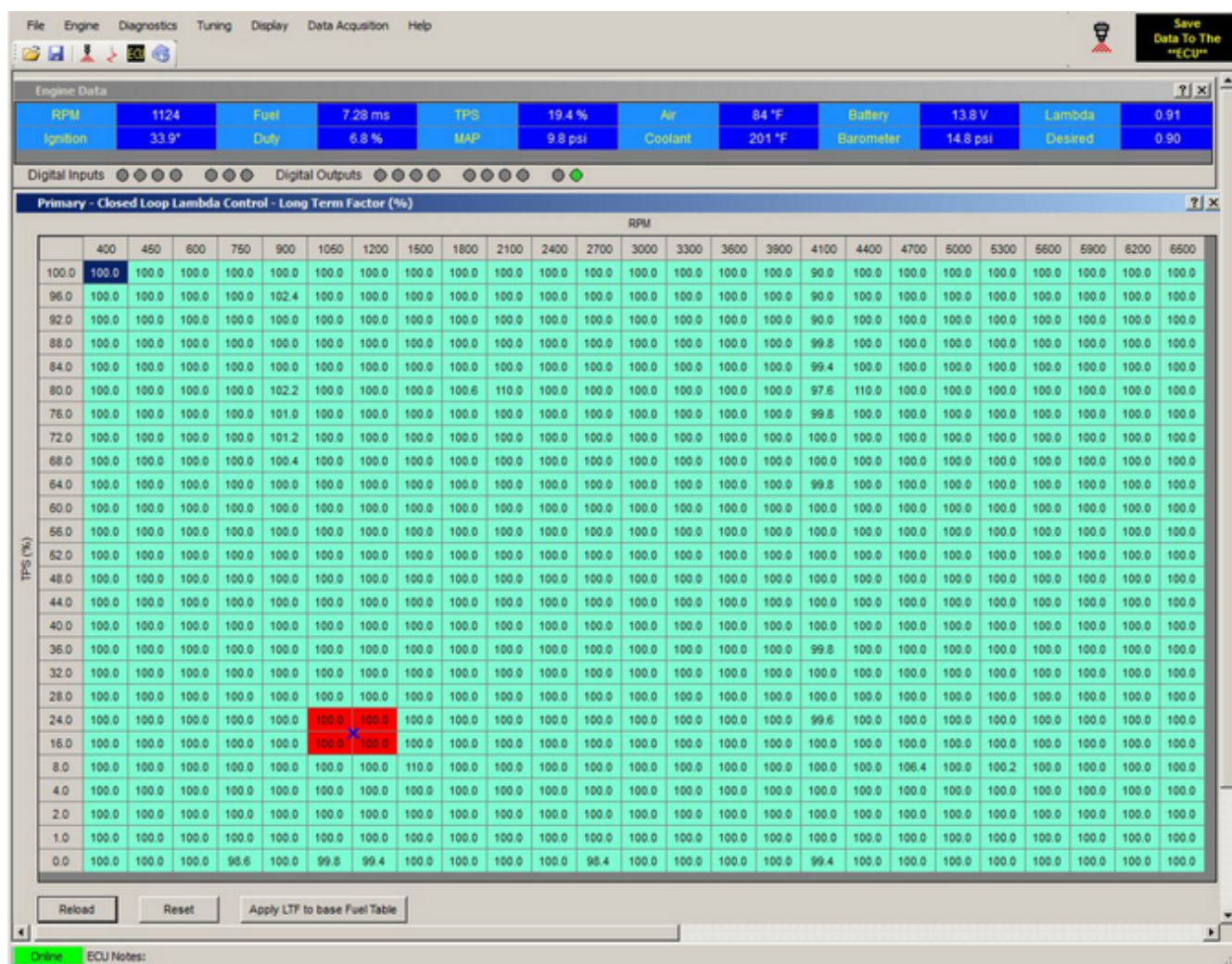


left corner of the table (see figure below).

**Reload** - This button forces the peMonitor software to reload the most recent long term factor table to the screen. As the PE3 is adapting and modifying the table, it does not automatically adjust the values displayed on the screen.

**Reset** - Reset sets the entire table to 100, essentially eliminating the long term factor compensations.

**Apply LTF to Base Fuel Table** - This button takes the entire long term factor table and applies it to the base fuel table by multiplying the two tables together. After the main fuel table has been modified, the long term factor table is reset everywhere to 100.



## **Closed Loop Lambda/AFR Control (*Tuning → Closed Loop Lambda Control*)**

The PE3 features a very sophisticated closed loop lambda fuel control system. The system can use either a wide band lambda sensor and conditioner or a narrow band sensor as input. If a wide

band lambda sensor is used, the output of the sensor must be conditioned such that it provides a 0-5 volt analog signal to the PE3. Before configuring the lambda control, a sensor must be defined in '[Setup Sensors](#)'. The main lambda control parameters can be configured in the 'Closed Loop Lambda/AFR Control' menu shown below.

STF Event	
Response Time (ms)	100
Transport Delay (rev)	10
STF Step Size per Event (%)	1.0
Max STF (%)	25.0
Lambda Deadband (lambda)	0.05

LTF Event	
STF Deadband (%)	5.0
Max LTF (%)	25.0
STF Events per LTF Event	10
LTF Step Size per Event (%)	1.0
RPM Deadband Percent	100.0
Load Deadband Percent	100.0

Closed Loop Enables	
Max TPS Rate (%/sec)	50.0
Min Coolant Temperature (°F)	5
Startup Time (sec)	10
Min Load (%)	10.0
Max Load (%)	90.0
Min RPM	1000
Max RPM	10000

'Closed Loop Lambda/AFR Control' Configuration Window

If the Lambda/AFR Control is enabled (via the check box in the upper left corner), fuel delivery has the opportunity to be in closed loop mode. In closed loop mode, the ECU makes decisions about the fuel mixture based on the response from the lambda sensor and adjusts the amount of fuel the engine receives accordingly. In order for the system to enter and stay in closed loop mode, all of the Closed Loop Enables must be met. This allows the user to setup bounds on the closed loop system such that the PE3 is not adjusting the fuel when not required. In addition to the user adjustable Closed Loop Enables shown in the figure above, the PE3 also has some built in enables that cannot be configured. The following are examples of these internal enables. Each condition below will force the ECU out of closed loop mode.

- If the Starting Compensation for fuel is greater than 100% (e.g. the engine is trying to start)
- If fuel is disabled for any reason (e.g. Decel Cutoff, Rev Limit, Flood Clear, etc)
- If the lambda sensor signal is out of range (e.g. sensor voltage is too high or too low)
- If a Digital Input is configured to disable closed loop mode and is active
- If a 0 is entered in the Target Lambda Table and the engine is operating at that load point. This allows closed loop to be locally turned off at specific load/RPM sites.

While in closed loop mode, the ECU modifies the injector open time by continuously updating the Short Term Factor (STF) and Long Term Factor (LTF) fuel modifiers. The total injector open time is multiplied by these two factors just like many of the other fuel compensation terms. The STF is not stored or remembered by the ECU. When the ECU is powered off the STF returns back to 100%. The STF can be thought of as an immediate fuel modifier. It adjusts the injector open time right now based on the reading from the Lambda sensor.

The Long Term Factor (LTF) is adjusted based on the STF. A table of LTF values is constantly being updated and saved in the ECU (see ['Long Term Factor Table'](#)). These values remain even after the ECU is powered down. The LTF table is how the PE3 'learns' the correct open times under different engine conditions. The LTF is updated in the same direction as the STF (rich or lean) after an adjustable number of STF events have taken place. The amount the LTF is updated is based on the 'LTF Step Size per Event (%)' parameter. It is important to note that the LTF modifies the total open time whenever the Lambda/AFR Control is enabled regardless of whether or not the system is currently in closed loop mode.

The user has the ability to define a ['Target Lambda Table'](#) for the engine. The Target Lambda Table defines the lambda or AFR values that the ECU is trying to achieve. This table is only used for closed loop fuel control. If the PE3 is not in closed loop mode, this table is not used.

The user can also view the Long ['Term Factor Table'](#). These values **CANNOT** be edited by the user. They are calculated by the ECU while the engine is running with closed loop control enabled. The user can, however, apply the Long Term Factor Table to the main fuel table by clicking on the button titled "Apply LTF to base Fuel Table". Essentially, this multiplies the main fuel table by the elements in the LTF table.

Below are descriptions of the different parameters that can be adjusted in Lambda Control.

## **STF Event**

**Response Time (ms)** - This is the total response time of the lambda sensor and conditioner being used in 1/1000 of a second (milliseconds). This information is usually published by the manufacturer of the sensor. The Response Time and the Transport Delay define when a STF Event takes place. A typical value is 100 ms.

**Transport Delay (rev)** - Transport Delay (rev) is the delay in engine revolutions between when the exhaust exits the exhaust port of the engine and when it reaches the lambda sensor. This can be estimated by using the displacement of the cylinder and the volume of air in the exhaust system between the sensor and the engine. The Response Time and the Transport Delay define when an STF Event takes place. A typical value is 10 revolutions.

**STF Step Size per Event (%)** - This parameter sets the amount by which the short term factor will be modified if all of the Closed Loop Enables are met and the ECU determines the fuel mixture requires modification. The larger this number, the more sensitive the Lambda Control will be to variations between actual and target lambda values. A large value will allow the system to respond quickly but may also cause large swings in lambda. A small number will result in a slower responding system that has less tendency to overshoot. A typical value is 1.0%.

**Max STF (%)** - Max STF (%) is the limit for the STF compensation. This is the maximum compensation in percent that the STF is authorized to provide to the overall injector open time. A typical value is 25%.

**Lambda (AFR) Deadband** - This parameter sets the deadband around the target lambda

value. If the difference between the measured lambda value and the target lambda value is less than this parameter, the ECU does not adjust the STF compensation. Typical values are 0.05 for lambda and 0.74 for AFR.

## **LTF Event**

**STF Deadband (%)** - If the current STF is less than +/- this amount, the LTF does not update. A lower value will allow the LTF to adjust more quickly and more closely follow the STF but may result in overshooting the target lambda. Typical values are 2% to 5%.

**Max LTF (%)** - Max LTF (%) is the limit for the LTF compensation. This is the maximum change in percent that the LTF is authorized to provide to the overall injector open time. A typical value is 25%.

**STF Events per LTF Event** - If the ECU determines that this number of consecutive STF events has occurred at a given operating condition, the LTF is either increased or decreased based on the direction (rich or lean) of the STF event. For example, if the STF is continuously adding fuel to move toward the target lambda, the LTF will also begin adding fuel as the LTF "learns" what the engine needs. Typical values are 2-10.

**LTF Step Size per Event (%)** - This is the amount in percent by which the LTF will adjust anytime it is eligible to change. The larger this value the quicker the LTF compensation will change and the more sensitive the LTF will be to deviations from the target lambda. Large values also have the tendency to increase the potential of overshooting the target value. Setting this value to 0% turns off the long term closed loop adaptive ability while still allowing the short term compensation to function. Typical values are 0.2%-5.0%.

**RPM Deadband Percent** - This parameter defines how close to an RPM breakpoint (in the main fuel table) the engine must be operating in order to update the corresponding values in the LTF table. A value of 100% means that even if the engine is operating exactly between two breakpoints, the LTF will be updated. **For most applications this value should be set at 100%.**

**Load Deadband Percent** - This parameter defines how close to a load breakpoint (in the main fuel table) the engine must be operating in order to update the corresponding values in the LTF table. **For most applications this value should be set at 100%.**

## **Closed Loop Enables**

**Max TPS Rate (%/sec)** - This is the maximum throttle rate in percent per second in order to remain in closed loop. If the throttle rate is greater than this value, the ECU falls out of closed loop during the fast transition. Typical Value: 20-50 %/sec.

**Min Coolant Temperature** - Until the engine reaches this coolant temperature, the ECU will not enter into closed loop mode. Typically, this value is set slightly lower than the fully warmed engine and to a temperature at which the coolant temperature compensation is 100%.

**Startup Time (sec)** - This is the warm-up time for the lambda sensor. Closed loop will not be enabled until the Startup Time has expired. The Startup Time starts counting from 0 every time the ECU registers RPM regardless of the coolant temperature. Typical Values: 5 to 10 sec depending on the sensor.

**Min Load** - This is the minimum load (in either TPS % or MAP psi) that the ECU must measure for closed loop to be active. Any time the measured load is less than this value the

PE3 will fall out of closed loop.

**Max Load** - This is the maximum load (in either TPS % or MAP psi) for closed loop. Any time the measured load is greater than this value the PE3 will fall out of closed loop.

**Min RPM** - This is the minimum engine speed for closed loop operation. Any time the measured RPM is less than this value the PE3 will fall out of closed loop.

**Max RPM** - This is the maximum engine speed for closed loop. Any time the measured RPM is greater than this value the PE3 will fall out of closed loop.

## **Air Temp Compensation (Fuel) (Tuning → Air Temp Compensation (Fuel))**

The 'Air Temp Compensation (Fuel)' table provides a means to compensate the fuel flow based on the intake air temperature. As the temperature of the air changes, so does its density. Cooler air is more dense than warmer air and therefore requires more fuel. In addition to temperature, the user can also include a dependence on engine load as seen on the vertical axis of the table below. The 'Load' axis is automatically set to whatever 'Load Control' is configured for in the ['Engine'](#) tab.

Values in the table can be set from 0% (fuel off) to 500% (5x the calculated amount of fuel). The Load and Temperature axes are also user adjustable by clicking on the cells and typing in new values. The Load and Temperature axes of the table must always be ascending in value from bottom to top and left to right as shown in the figure below. peMonitor will not allow the user to enter in values that do not conform to this structure.

The 'Smooth' function is available in the table as well as in the Load and Temperature axes. Right clicking on the mouse while highlighting table entries will bring up the prompt for the smooth function. The shortcut key for smooth can also be used (see [Monitor Shortcuts](#)).

Generally, the standard values for air temperature compensation provided by PE shown below are a pretty good place to start for tuning this table.

**Air Temp Compensation - Fuel**

Load - TPS (%)

80.0
60.0
40.0
20.0

Compensation Factor - Percent

125.0	116.0	108.0	100.0	93.1	86.8	81.0	77.0
125.0	116.0	108.0	100.0	93.1	86.8	81.0	77.0
125.0	116.0	108.0	100.0	93.1	86.8	81.0	77.0
125.0	116.0	108.0	100.0	93.1	86.8	81.0	77.0

Temperature (°F)

-40.0	0.0	40.0	80.0	120.0	160.0	200.0	240.0
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☒ Enable

'Air Temperature C Compensation (Fuel)' Window

## **Coolant Temp Compensation (Fuel) (Tuning → Coolant Temp Compensation (Fuel))**



The 'Coolant Temp Compensation (Fuel)' table provides a means to add fuel to the engine when it is below operating temperature. When the engine is cold, liquid fuel in the intake ports and manifold do not evaporate as well as with a fully warmed engine. For most engines more fuel is required when cold to get acceptable performance and driveability. In addition to temperature, the user can also include a dependence on engine load as seen on the vertical axis of the table below. The 'Load' axis is automatically set to whatever 'Load Control' is configured as in the ['Engine'](#) tab.

Values in the table can be set from 0% (fuel off) to 500% (5x the calculated amount of fuel). The Load and Temperature axes are also user adjustable by clicking on the cells and typing in new values. The Load and Temperature axes of the table must always be ascending in value from bottom to top and left to right as shown in the figure below. peMonitor will not allow the user to enter in values that do not conform to this structure.

The 'Smooth' function is available in the table as well as in the Load and Temperature axes. Right clicking with the mouse while highlighting table entries will bring up the prompt for the smooth function. The shortcut key for smooth can also be used (see [Monitor Shortcut](#)).

Generally, the standard values for air temperature compensation provided by PE shown below are a pretty good place to start for tuning this table.

**Coolant Temp Compensation - Fuel**

Load - TPS (%)

80.0
60.0
40.0
20.0

Compensation Factor - Percent

160.0	150.0	140.0	130.0	120.0	110.0	100.0	100.0
160.0	150.0	140.0	130.0	120.0	110.0	100.0	100.0
160.0	150.0	140.0	130.0	120.0	110.0	100.0	100.0
160.0	150.0	140.0	130.0	120.0	110.0	100.0	100.0

☒ Enable

Temperature (°F)

-40.0	0.0	40.0	80.0	120.0	160.0	200.0	240.0
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'Coolant Temperature Compensation (Fuel)' Window

## **Cylinder Compensation (Fuel) (Tuning → Cylinder Compensation (Fuel))**

The fuel cylinder compensation window provides a means to individually adjust the open times of specific cylinders compared to the total calculated open time. The cylinder compensation term that is determined from the table below is directly applied to the appropriate injector driver. Table entries can vary from 70% to 130% in order to provide more or less fuel per cylinder. A value of 100% means that the injector open time is equal to the total calculated open time.

As seen below, cylinder compensation terms are not single static values. Compensation can vary as a function of several parameters including TPS, MAP or RPM. This feature is very useful in several applications including 2-stroke engines and larger displacement 8 cylinders with individual runner throttle bodies. As with most tables in the PE3, the TPS, MAP and RPM set points can be adjusted. Values entered for this axis must always be ascending in magnitude from left to right.

The 'Smooth' function is also available in the table as well as in the 'Input Parameter' axis. Right clicking with the mouse while highlighting table entries will bring up the prompt for the smooth function. The shortcut key for smooth can also be used (see [Monitor Shortcuts](#)).

Input Parameter	0.0	25.0	50.0	100.0
Injector #1	100.0	100.0	100.0	100.0
Injector #2	100.0	100.4	100.8	101.2
Injector #3	100.0	100.3	100.7	101.0
Injector #4	100.0	100.0	100.0	100.0
Injector #5	100.0	100.0	100.0	100.0
Injector #6	100.0	100.0	100.0	100.0
Injector #7	100.0	100.0	100.0	100.0
Injector #8	100.0	100.0	100.0	100.0

'Cylinder Compensation (Fuel)' Window

## ***Air Temp Compensation (Ignition) (Tuning → Air Temp Compensation (Ignition))***

The 'Air Temp Compensation (Ignition)' table provides a means to adjust the ignition timing based on the intake air temperature. This is sometimes helpful to tune cold starting and also to avoid damage to forced induction engines when intake air temperatures are very hot. In addition to temperature, the user can also include a dependence on engine load as seen on the vertical axis of the table below. The 'Load' axis is automatically set to whatever 'Load Control' is configured for in the ['Engine'](#) tab.

Values in the table can be set from -20 (20 degrees of retard) to +20 (20 degrees of advance). The Load and Temperature axes are also user adjustable by clicking on the cells and typing in new values. The Load and Temperature axes of the table must always be ascending in value from bottom to top and from left to right as show in the figure below. peMonitor will not allow the user to enter in values that do not conform to this structure.

The 'Smooth' function is available in the table as well as in the Load and Temperature axes. Right clicking on the mouse while highlighting table entries will bring up the prompt for the smooth function. The shortcut key for smooth can also be used (see [Monitor Shortcut](#)).

**Air Temp Compensation - Ignition**

Load - TPS (%)

80.0
60.0
40.0
20.0

☒ Enable

Compensation Factor - Degrees (Positive Degrees Advance Timing)

5.0	4.0	2.0	0.0	0.0	0.0	-2.0	-4.0
7.0	5.0	3.0	0.0	0.0	0.0	-1.7	-3.0
7.0	5.0	3.0	0.0	0.0	0.0	-1.3	-2.0
7.0	5.0	3.0	0.0	0.0	0.0	-1.0	-1.0

Temperature (°F)

-40.0	0.0	40.0	80.0	120.0	160.0	200.0	240.0
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'Air Temperature Compensation (Ignition)' Window

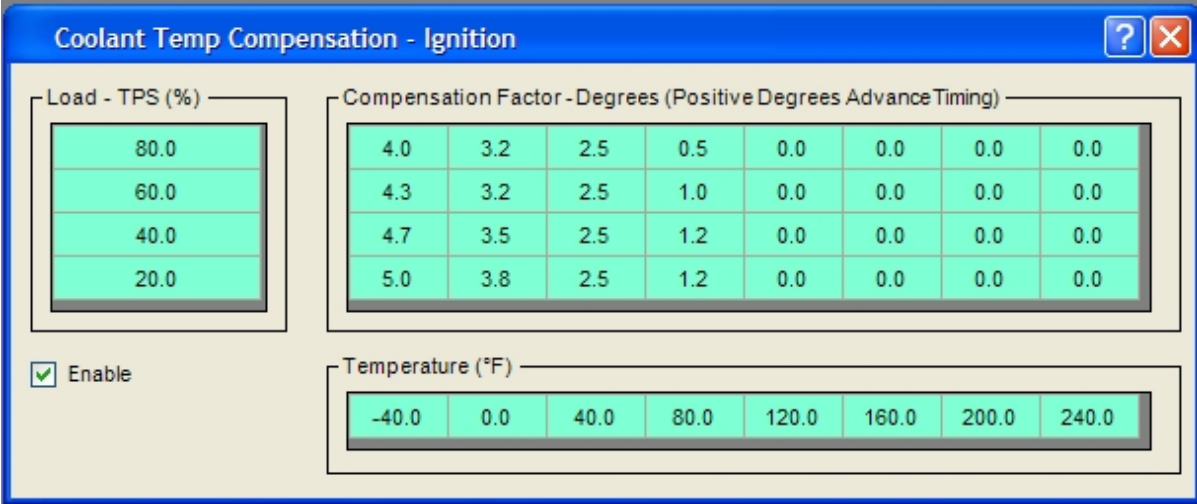
## **Coolant Temp Compensation (Ignition) (Tuning → Coolant Temp Compensation (Ignition))**

The 'Coolant Temp Compensation (Ignition)' table provides a means to adjust the ignition timing based on the coolant temperature. This is sometimes helpful to tune cold starting conditions. In addition to temperature, the user can also include a dependence on engine load as seen on the vertical axis of the table below. The 'Load' axis is automatically set to whatever 'Load Control' is configured for in the ['Engine'](#) tab.

Values in the table can be set from -20 (20 degrees of retard) to +20 (20 degrees of advance). The Load and Temperature axes are also user adjustable by clicking on the cells and typing in new values. The Load and Temperature axes of the table must always be ascending in value from bottom to top and from left to right as show in the figure below. peMonitor will not allow the user to enter in values that do not follow this structure.

The 'Smooth' function is available in the table as well as in the Load and Temperature axes. Right clicking on the mouse while highlighting table entries will bring up the prompt for the smooth function. The shortcut key for smooth can also be used (see [Monitor Shortcut](#)).





**Coolant Temp Compensation - Ignition**

Load - TPS (%)

80.0
60.0
40.0
20.0

Compensation Factor - Degrees (Positive Degrees Advance Timing)

4.0	3.2	2.5	0.5	0.0	0.0	0.0	0.0
4.3	3.2	2.5	1.0	0.0	0.0	0.0	0.0
4.7	3.5	2.5	1.2	0.0	0.0	0.0	0.0
5.0	3.8	2.5	1.2	0.0	0.0	0.0	0.0

☒ Enable

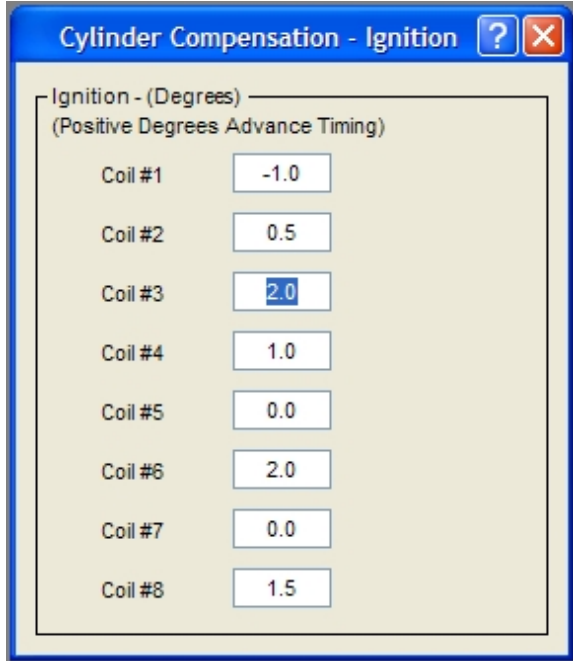
Temperature (°F)

-40.0	0.0	40.0	80.0	120.0	160.0	200.0	240.0
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'Coolant Temperature Compensation (Ignition)' Window

## **Cylinder Compensation (Ignition) (Tuning → Cylinder Compensation (Ignition))**

The ignition cylinder compensation provides a means to individually adjust the timing of specific cylinders compared to the total calculated timing. The cylinder compensation terms that are entered in the window, are directly applied to the appropriate ignition event by adding or subtracting the timing offset. Cylinder compensation values can be set from -20 (20 degrees of retard) to +20 (20 degrees of advance).



**Cylinder Compensation - Ignition**

Ignition - (Degrees)  
(Positive Degrees Advance Timing)

Coil #1	-1.0
Coil #2	0.5
Coil #3	2.0
Coil #4	1.0
Coil #5	0.0
Coil #6	2.0
Coil #7	0.0
Coil #8	1.5

'Cylinder Compensation (Ignition)' Window

## **MAP Compensation (Tuning → MAP Compensation)**

The 'MAP Compensation' feature is a useful tool for applications using a MAP sensor and running in Alpha-N mode (TPS based load control). MAP compensation allows the user to vary both fuel and ignition timing based on the MAP signal. This feature is very effective for both naturally

aspirated and forced induction engines.

'MAP Compensation' is just like other compensation terms in that the fuel term multiplies the total injector open time and the ignition term either adds or subtracts from the total timing. When enabled, the PE3 measures the MAP signal, calculates the fuel and ignition compensation terms from the table, and applies these to the total calculation of open time and ignition timing.

All values in the 'MAP Compensation' window are adjustable. The user can enter values directly to set the breakpoints or can use the 'Auto Fill' functions. The only requirement is that the numbers must be increasing in value from left to right. See below the figure for a description of the adjustable parameters. In addition, both the fuel and ignition MAP compensations can be individually enabled and disabled.

**MAP Compensation**

MAP Values (psi)

2.0	2.9	3.8	4.6	5.5	6.4	7.3	8.1	9.0	9.9	10.8	11.6	12.5	13.4	14.3	15.1	16.0
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	------	------	------	------	------	------

☒ Enable

MAP Compensation - Fuel (%)

13.8	19.9	25.9	31.9	37.9	44.0	50.0	56.0	62.1	68.1	74.1	80.1	86.2	92.3	98.3	104.2	110.3
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	-------	-------

☒ Enable

MAP Compensation - Ignition (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	0.0	0.0	0.0	0.0
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Auto Fill

min MAP

max MAP

'MAP Compensation' Window

**MAP Values** - This table sets the breakpoints of MAP for the fuel and ignition compensation terms. The units used here are determined by the units of MAP as configured in '[Setup Sensors](#)'. The user can either enter values in by hand or use the 'Auto Fill' functions at the bottom of the window to populate this table.

**MAP Compensation - Fuel (%)** - This table sets the fuel compensation values based on MAP. Generally, the default values as calculated by peMonitor using 'Auto Fill' will not require modification. The basic rule-of-thumb for MAP compensation is that the compensation amount should change the same as the manifold pressure changes, on a percentage basis. In other

words, if the MAP doubles, the fuel amount should also double to maintain the correct air/fuel ratio. Conversely, if the MAP is cut in half, the fuel amount should also be cut in half. Common practice is to define atmospheric pressure (14.5 psi or 101.3 kPa) as 100% and then fill in the rest of the values based on the change in pressure (see the Figure above).

**MAP Compensation - Ignition (deg)** - This table configures the ignition timing compensation values based on MAP. This adjustment is especially important for forced induction engines where it is advisable to retard the timing at high boost levels.

**Auto Fill** - The 'Auto Fill' functions provide an easy way to fill in the MAP Compensation tables. See below for a description of each field.

- Min MAP = The minimum desired pressure value in the 'MAP Values' table
- Max RPM = The maximum desired pressure value in the 'MAP Values' table
- MAP Values = This button evenly fills in the 'MAP Values' table based on the 'Min MAP' and 'Max MAP' parameters
- Calculate Fuel based on MAP Values = This button automatically calculates the fuel compensation values based on the 'MAP Values' table assuming 100% compensation at atmospheric pressure.

## **Battery/Barometer Compensation (Tuning → Battery/Barometer Compensation)**

The 'Battery/Barometer' compensation tables allow the user to modify fuel and ignition based on battery voltage and the ambient pressure (barometer). As the barometer changes, the fuel and ignition requirements of the engine change. The Barometer compensation tables allow the user to accommodate for those changes.

Battery voltage compensation is required for two main reasons. The first reason is to account for changes in electrical load on the battery and charging system. If the voltage available to open the injector changes, so does the length of time that the injector takes to fully open from a closed position. An injector operating at two different voltages will flow differently for the same open times without the correct compensation.

The second reason for including battery voltage compensation is to adjust for the inherent nonlinearities of the injector itself. During tuning, it is beneficial for the injector open time and fuel flow to be linearly related. For example, a 10% increase in injector open time should provide a 10% increase in the mass flow of fuel. Correct battery compensation allows this linear relationship to exist.

Both barometer compensations and the battery compensation can be individually enabled and disabled.

**Battery/Barometer Compensation**

☒ Enable

**Battery Voltage Compensation - Fuel**

Volts	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	1.66	1.50	1.34	1.24	1.14	1.06	0.97	0.91	0.85	0.80	0.74	0.68	0.61	0.56	0.52	0.52	0.52

☒ Enable

**Barometer Compensation - Fuel**

psi	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
%	0.0	6.8	13.6	20.4	27.2	34.0	40.8	47.6	54.4	61.2	68.0	74.8	81.6	88.4	95.2	102.0	108.8

☒ Enable

**Barometer Compensation - Ignition (Positive Degrees Advance Timing)**

psi	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
deg	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.5	-2.2	-1.9	-1.6	-1.2	-0.9	-0.6	-0.3	0.0	0.0	0.0

'Battery/Barometer Compensation' Window

**Battery Voltage Compensation - Fuel** - This table allows the user to set the battery voltage compensation for the injectors. Battery voltage compensation must be determined on an injector flow bench or provided by the injector manufacturer. The 'Volts' axis is based on a standard 12v charging system and cannot be modified by the user.

**Barometer Compensation - Fuel** - This table contains the fuel compensation terms. The 'psi' axis cannot be modified by the user.

**Barometer Compensation - Ignition** - This table contains the ignition compensation terms. The 'psi' axis cannot be modified by the user.

## **Starting/Accel/Decel Compensation (*Tuning* → *Starting/Accel/Decel Compensation*)**

The PE3 includes compensation algorithms to account for engine starting and transient operating conditions. Please see below for descriptions of these different functions.

**Starting/Accel/Decel Compensation**

**Starting - Fuel**

☒ Enable

0 °F (%) 300.0

\* 80 °F (%) 250.0

160 °F (%) 150.0

240 °F (%) 105.0

Duration (revs) 20

Fuel Starting RPM 400

Initial Fuel Pulse (ms) 5.0

\* value used if no sensor defined

**Starting - Ignition**

☒ Enable

Timing (deg) 10.0

Ignition Starting RPM 400

**Accel**

☒ Enable

Type TPS

min TPS rate (%/sec) 20.0

min TPS (%) 2.0

Max Factor (%) 170.0

Duration (sec) 0.5

Max RPM 7000

**Decel**

☒ Enable

min TPS (%) 1.0

max RPM 5000

RPM Delta 250

'Starting/Accel/Decel Compensation' Window

**Starting-Fuel** - Most engines require a little extra fuel to start and stay running. Anytime the PE3 recognizes an RPM and the engine speed is below 'Fuel Starting RPM', the ECU assumes that the engine is trying to start. During this time, the PE3 uses the coolant temperature sensor to determine the starting compensation and applies this to the injector open time. Once the engine starts and the RPM increases above 'Fuel Starting RPM', the starting compensation decreases over the number of engine revolutions defined in 'Duration (revs)'.

- **Enable** = The 'Starting-Fuel' compensation can be enabled or disabled using this check box. When disabled, the starting compensation is set to 100% (no compensation).
- **0 °F, 80 °F, 160 °F, 240 °F** = These are the compensation factors at the respective coolant temperature values. Typical settings are shown in the figure above. This factor is applied to injector open time anytime the engine is trying to start (e.g. anytime the engine RPM is less than 'Fuel Starting RPM'). If there is no coolant temperature sensor defined, the factor for '80 °F' is used when starting.
- **Duration** = The number of revolutions that the compensation decays over once the engine is running.
- **Fuel Starting 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 fuel.
- **Initial Fuel Pulse** = This defines the length of time the injectors are opened for the priming pulse on the first revolution. Valid entries are 1.0 – 30.0 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.

**NOTE:** The PE3 has a 'Flood Clear' feature that overrides the starting compensation when

activated (see ['Fuel Tab'](#) for a description). When enabled, if the throttle position sensor indicates a percentage greater than 98% when the engine begins to turn over, the injectors are kept closed. This allows only air to be pumped through the engine and helps to evaporate the liquid fuel.

**Starting-Ignition** - This section allows the user to set a specific ignition timing value that is used only during starting. Sometimes it can be beneficial to run retarded timing in order to get an engine started. Once the engine is running faster than the 'Starting RPM' the starting timing is not used.

- Enable = The starting timing feature can be enabled or disabled using this check box.
- Timing (deg) = This value sets the ignition timing that will be used when the engine RPM is less than 'Ignition Starting RPM'. If enabled, no other timing compensations are used during starting. Positive values are degrees before top dead center (BTDC) and negative values are Degrees After Top Dead Center (ATDC)

**Accel** - Acceleration compensation (Accel) temporarily increases the fuel flow when the throttle is opened rapidly. 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 (%/sec)'. The amount of additional fuel is dictated by how quickly the throttle opens and by the parameter 'Max Factor'. 'Max Factor' is the theoretical maximum increase of fuel flow if the throttle were opened instantaneously. Once the compensation starts, it degrades back to nothing over the time period set in 'Duration (sec)'. Additionally, the Accel compensation circuit is turned off if the RPM is above 'Max RPM' or the throttle is below 'Min TPS'. All of the individual parameters are described in detail below.

- Enable = This check box enables or disables the accel compensation. When disabled, the accel compensation is set to 100% (no compensation).
- Min TPS Rate (%/sec) = This parameter determines the Accel circuit's sensitivity to throttle changes. 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 is required to go from fully closed to fully open in 0.2 seconds before any compensation was added ( $100\%/0.2 \text{ sec} = 500$ ).
- 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 Factor (%) = 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 effectively turns the accel compensation off.
- Duration (sec) = 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. A higher value means that the accel compensation is present for a longer time after the initial throttle opening.

- **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.

**Decel** - 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 gear). 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' - 'RPM Delta').

- **Enable** = This check box enables or disables the Decel cut-off.
- **Min TPS (%)** = This is the minimum throttle position before the decel fuel cut-off is activated. If the TPS is less than this value and the RPM is above 'Max RPM' the injectors will be shut off.
- **Max RPM** = This is the maximum engine speed before the decel fuel cut-off is activated. If the RPM is above this value and the TPS is less than 'Min TPS' the injectors will remain closed.
- **RPM Delta** = 'RPM Delta' is a dead-band keeps the fuel from very quickly turning on and off right around the 'Max RPM' value. Once fuel has been suspended due to decel cut-off, the RPM must fall below ('Max RPM' - 'RPM Delta') before the injectors are allowed to operate.

## **Digital Outputs (Tuning → Digital Outputs)**

The PE3 has 10 digital outputs that be used for various functions. Digital outputs 1-8 can be used to turn on and off external devices like a fuel pump or cooling fan or used to PWM (Pulse Width Modulate) external actuators like a boost control solenoid or idle speed valve. Digital outputs 9 and 10 cannot be PWM controlled and can only be turned on and off.

The digital outputs are all low-side drivers which means that when they are turned 'on' (or activated) they complete the circuit to ground. Whenever a digital output is activated, the corresponding green light in the data header lights up (see '[Engine Data Header](#)'). Each digital output corresponds directly to a physical pin on the PE3. Please refer to the [Wire Diagram](#) for pin locations for each of the outputs.

Digital outputs are internally protected and cannot supply more than 3 amps of current. If more than 3 amps of current is required by the actuator, either a relay or a PE external high current driver must be used. If any one digital output flows more than 3 amps or all of the digital outputs combined flow more than 15 amps, an over-current error will be generated (see '[System Status](#)').

In addition to being able to configure each of the digital outputs, the PE3 gives the user the ability to name each output for easy tracking. This is visible in the configuration figure below, next to the digital output label for each channel. The text in the parentheses ('Fan' for Digital Output #1) is the user assigned label for that output. Labels can be entered in the '[Setup Digital Names](#)' window.

## **On/Off Control**



'On/Off Control' allows an external device to be turned on and off based on a parameter that is measured or calculated by the PE3. For each digital output there is a drop down box that allows the user to select different types of control. The figure below shows several examples of digital outputs configured for different functions.

The screenshot shows a window titled "Digital Outputs for On/Off Control" with 10 configuration panels arranged in a 3x4 grid (the last row has only 2 panels). Each panel has a title, a dropdown menu, and two input fields labeled "Point 1" and "Point 2".

- Digital Output #1 (Fan):** Dropdown: Coolant Temp; Point 1: 175; Point 2: 170.
- Digital Output #2 (Info):** Dropdown: Info Light; "Configure In:" section with "- Engine" and "- Info Light Config".
- Digital Output #3 (WOT\_AC):** Dropdown: TPS; Point 1: 96.0; Point 2: 98.0.
- Digital Output #4 (Clt\_Lg):** Dropdown: Coolant Temp; Point 1: 210; Point 2: 205.
- Digital Output #5 (Shft\_Lg1):** Dropdown: RPM; Point 1: 4500; Point 2: 4400.
- Digital Output #6 (Shft\_Lg2):** Dropdown: RPM; Point 1: 5000; Point 2: 4400.
- Digital Output #7 (IAC):** Dropdown: PWM Idle Control.
- Digital Output #8 (Bst\_Sol):** Dropdown: Table based PWM.
- PWM Frequency A:** Dropdown: 189.5 Hz; "For Digital Outputs 1,2,5,6".
- Digital Output #9 (Alw\_On):** Dropdown: Always On; "This output is on when the ECU is on".
- Digital Output #10 (Fuel):** Dropdown: Fuel Pump.
- PWM Frequency B:** Dropdown: 189.5 Hz; "For Digital Outputs 3,4,7,8".

'Digital Outputs - On/Off Control' Window

Below is a description of the different types of configurations available for the digital outputs. In addition to those listed below, digital outputs can also be used by other functions in the PE3 that are not configurable in this screen. This includes functions like driving an idle air control motor, setting up table based pulse width modulated output or using digital outputs as ignition triggers. All of these functions are enabled and configured in other areas of peMonitor but will still be visible in this window when enabled. See in the figure above where 'Digital Output #7 (IAC)' is configured for an idle air motor and 'Digital Output #8 (Bst\_Sol)' is configured to PWM a boost control solenoid.

### Available Functions for Digital Outputs

- Off = With this selection, the digital output takes no action and remains 'off'.
- Always On = Selecting an output to be 'Always On' means that anytime the ECU is powered up, the output will on and flowing current to GND.
- Air Temp, Coolant Temp, RPM, MAP, TPS, Analog Input = These settings turn the digital output on and off based on the level of the selected parameter. When one of these is selected, two additional settings appear. 'Point 1' and 'Point 2' are both set points that determine when the output will turn on and off. The design of this feature is extremely versatile in that the outputs can be programmed to turn on or off when the value is high or low based on which entered point is greater. Values that are entered for 'Point 1' and 'Point 2' are in the same units as the measured parameter.

**If 'Point 1' is greater than 'Point 2'** - The digital output will be on when the selected parameter is greater than or equal to 'Point 1' and will turn off when the selected parameter is less than or equal to 'Point 2'. A good example of this type of output is an electric cooling fan. In the example in the figure above, Digital Output #1



is configured to operate a cooling fan. For this particular tuning file the temperature is set for degrees F. Because 'Point 1' is greater than 'Point 2' the output will turn on when the coolant temperature is equal to or above 175 deg F and turn off when the temperature falls below 170 deg.

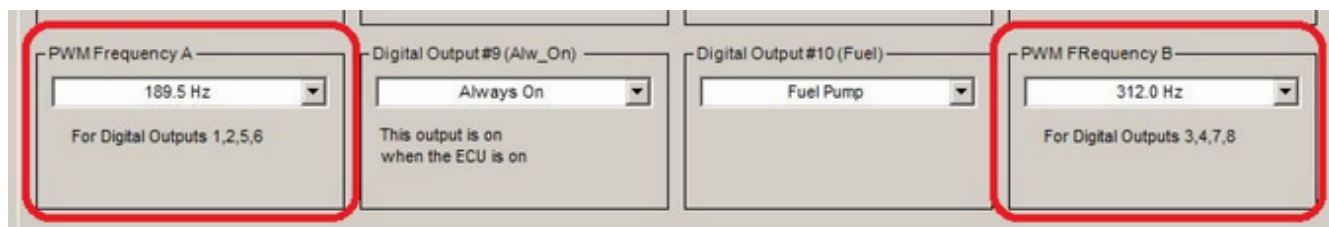
**If 'Point 1' is less than 'Point 2'** - The digital output will be on when the selected parameter is less than or equal to 'Point 1' and will turn off when the parameter is greater than or equal to 'Point 2'. Digital Output #3 is an example of this type of output. It is set up for air conditioning clutch switch which turns the A/C clutch off when the throttle is all the way open in order to reduce accessory power consumption on the engine. In the example shown, Digital Output #3 will turn off at 98% and then back on again after the TPS falls below 96%.

- Tach = When the 'Tach' option is selected, the digital output turns on and off according to the 'Tach Pulses per Rev' setting in the 'Engine' tab (see ['Engine'](#) tab). This function is provided in addition to the dedicated 'Tachometer Output' signal on pin M-17 of the PE3. As a digital output, the tachometer signal is pull to ground rather than a square wave like on pin M-17. A pull-up resistor may be necessary to use this output with some tachometers. Please visit the PE website for application pages concerning specific installations.
- Info Light = 'Info Light' configures the particular digital output as the information or 'check engine' light. Only one digital output can be selected as the information light. Please refer to ['Info Light Config'](#) for information on using this output.
- Fuel Pump = The 'Fuel Pump' function is designed to control a fuel pump through a relay or high current external driver. Anytime the PE3 is powered up, this output will turn on for approximately 6 seconds to prime the fuel pump. If no trigger signal is received after 6 seconds the driver will turn off. Also, anytime the PE3 receives a trigger signifying the engine is spinning, this output remains on to power the pump.
- Digital Input = This function allows the user to control a digital output based on a digital input. When the selected digital input is active, the digital output will also turn on.
- PWM Idle Control, External Coil Driver, Table Based PWM = These settings are not configurable in the 'Digital Outputs for On/Off Control' window. All of these selections are configured elsewhere in peMonitor and use the digital output to do a specific function.

## **Table Based PWM**

'Table Based PWM' allows an external device to be pulse width modulated based on a 3D table of values. If a digital output is already being used for 'On/Off Control', it cannot be setup as a PWM output. Only digital outputs #1-#8 can be pulse width modulated. Digital outputs #9 and #10 can **ONLY** be used for on/off control.

The frequency of the pulse width modulation is set in the 'On/Off Control' page for digital outputs (see figure below). There are 2 PWM frequencies, A and B. Frequency A applies to digital outputs 1,2,5 and 6 and Frequency B applies to digital outputs 3,4,7 and 8. Frequency A and B can be the same or different. The required frequency for a given actuator depends on the design of the device itself.

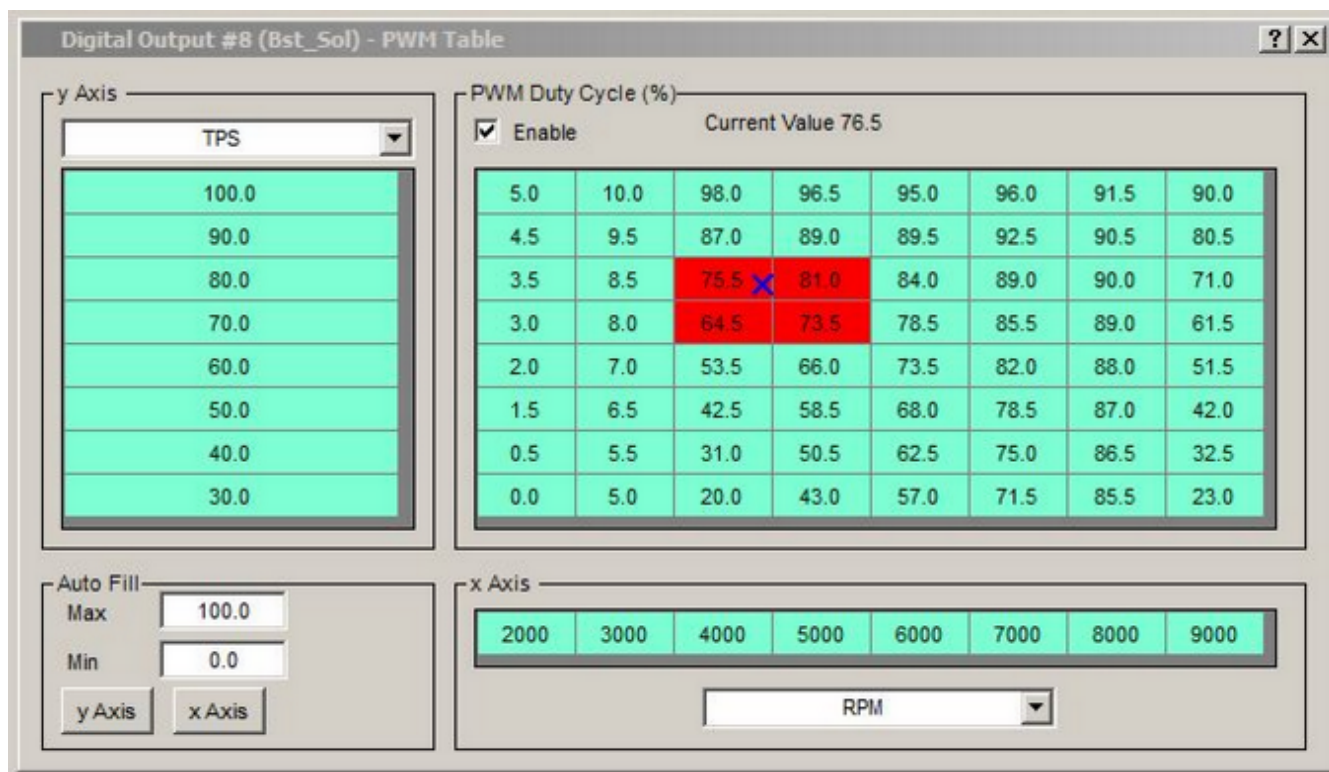


PWM Frequency Settings in the 'Digital Outputs - On/Off Control' Window

The duty cycle of the digital output is determined from the PWM table for that particular output. Below is an example of a PWM table setup for Digital Output #8. The values in the table represent duty cycle in percent. 0% is equal to the output being 'off' and 100% is equal to the output being entirely 'on'.

All values in the PWM table below are adjustable by the user, including the axes. Changing the settings in the drop down box for the x and y axes changes the parameter used to calculate the duty cycle. In the example below, duty cycle is based on TPS and RPM but these can easily be set to something else. The user can also enter values directly in each axis to set the breakpoints or can use the 'Auto Fill' functions in the bottom left corner. The only requirement is that the numbers must be increasing in value from left to right (x axis) and from bottom to top (y Axis). Right clicking the mouse in the table or the axes brings up the smooth command.

Much like the main fuel and ignition tables, the duty cycle tables also provide feedback to the user while the engine is running. There is a red box that is drawn in the table to show the four values that are being used to determine the overall duty cycle. The blue 'X' in the red box shows the user the exact operating condition within the four red cells. The current calculated value for duty cycle is also shown at the top of the window and labeled as 'Current Value'.



'Table Based PWM' Window

**PWM Duty Cycle (%)** - This table contains the duty cycle in percent for the pulse width modulated digital output. The actual percent duty cycle at any given time is interpolated from this table based on the parameters in the x and y axes.

**Enable** - The enable box allows the digital output to be enabled or disabled from this window. When a digital output is disabled, it turns off (0% duty cycle).

**y Axis** - These values define the y axis of the PWM table.

**x Axis** - These values define the x axis of the PWM table.

**Auto Fill** - The 'Auto Fill' functions provide an easy way to fill in the axes of the table. See below for a description of each field.

- Max = The maximum value in the axis.
- Min = The minimum value in the axis.
- y Axis = This button evenly fills in the 'y axis' based on the 'Min' and 'Max' parameters.
- x Axis = This button evenly fills in the 'x axis' based on the 'Min' and 'Max' parameters.

## **Idle Air Control (*Tuning* → *Idle Air Control*)**

The PE3 has the ability to drive several types of idle air motors in order to actively control the RPM to a target idle speed (see ['Using an Idle Air Control Motor'](#) for a description of the hardware). The position of the idle control motor is defined as either 'steps' if a stepper motor is used or percent (%) if a pulse width modulated idle motor is used.

The figure below shows the 'Idle Air Control' tuning menu in peMonitor. Descriptions for each of the tuning parameters that pertain to idle control are listed below the figure.

**Idle Air Control**

☒ Enable

Mode: Auto

Output: Stepper Motor

Increase in Position Decreases Idle Speed

Event Update Rate (sec)	<span>0.25</span>	Idle RPM at 32 °F	<span>950</span>
Change in Position per Event	<span>1</span>	Idle RPM at 150 °F	<span>825</span>
Position Start (steps)	<span>160</span>	Starting RPM	<span>250</span>
Position Start Time (sec)	<span>0.00</span>	Max TPS (%)	<span>1.0</span>
Position Park (steps)	<span>167</span>	RPM DeadBand	<span>30</span>
Position Min (steps)	<span>150</span>	RPM Filter	<span>level 13</span>
Position Max (steps)	<span>187</span>	Manual Position (steps)	<span>180</span>

Current Position (steps): 160  
 Current RPM: 854  
 Desired RPM: 825

'Idle Air Control' Tuning Window

**Enable** - This enables or disables the idle air control.

**Mode** - The idle control mode defines whether or not the control is automatic or manual.

- Auto = Auto mode means that the PE3 will actively try to control the idle speed to the target RPM. The target RPM is defined by the two parameters 'Idle RPM at 32° F' and 'Idle RPM at 150° F'. The actual target speed is interpolated based on the coolant temperature and these two settings.
- Manual = In manual mode, the 'Manual Position' field in the bottom right corner of the window is active and the user can manually enter the position of the motor. Position is entered in either steps or percent depending on the type of idle motor used.

**Output** - The output drop down menu defines the physical drivers (and PE3 connector pins) that are used to drive the idle air control motor.

- Digital Output #1-#8 = Any of the Digital Outputs #1 thru #8 can be used to drive a pulse width modulated idle control motor like those used on Ford vehicles. Choosing one of these as an output requires that the user connect the negative side of the motor to the associated digital output pin (see [Using an Idle Air Control Motor](#) and the [Wiring Diagram](#) for wiring details).
- Stepper Motor = The 'Stepper Motor' selection is used with a standard 4-wire stepper motor for idle control (see [Using an Idle Air Control Motor](#) and the [Wiring Diagram](#) for wiring details).

- **Star Drive** = This should be used when driving a unipolar stepper motor like those found on some motorcycle and other small engines. It is also sometimes called a 'Star Drive' because of the way that the circuit diagram for the motor looks. This type of motor uses digital outputs #5, #6, #7 and #8.

**Increase in Position** - This setting defines what happens when the idle motor increases in position. This setting is determined by the physical design of the idle motor as well as how it is wired to the PE3. For example, a GM style stepper motor normally decreases idle speed with an increase in position. Increasing the position of the stepper motor normally pushes the pintle closed thereby reducing the idle air flow. This setting can be determined by manually increasing the position of the idle motor while the engine is running and noting what happens to the speed.

- **Decreases Idle Speed** = Use this setting if an increase in idle motor position decreases idle speed.
- **Increases Idle Speed** = Use this setting if an increase in idle motor position increases idle speed.

**Event Update Rate (sec)** - The 'Event Update Rate' sets how often the position of the idle motor will be updated. When this time period elapses, the PE3 compares the target idle speed to the actual idle speed and makes a decision about the idle motor position. Setting this value too high will cause the idle speed to be slow to respond. Setting this value too low may cause the idle speed to hunt and surge.

**Change in Position Per Event** - This parameter sets the change in position (in percent or steps) that takes place every time the position of the idle motor is modified. Setting this value too large will cause the engine to have large speed fluctuations at idle and a low value will cause a slow response. Generally, the user should start with a low value and slowly increase while evaluating performance.

**Position Start** - This is the position of the idle motor (in percent or steps) when the engine has an RPM less than 'Starting RPM'. It controls the amount of air the engine receives while cranking the engine.

**Position Start Time (sec)** - 'Position Start Time' sets the amount of time that the PE3 holds the idle control motor at the 'Position Start' after the engine starts and increases in speed above 'Starting RPM'.

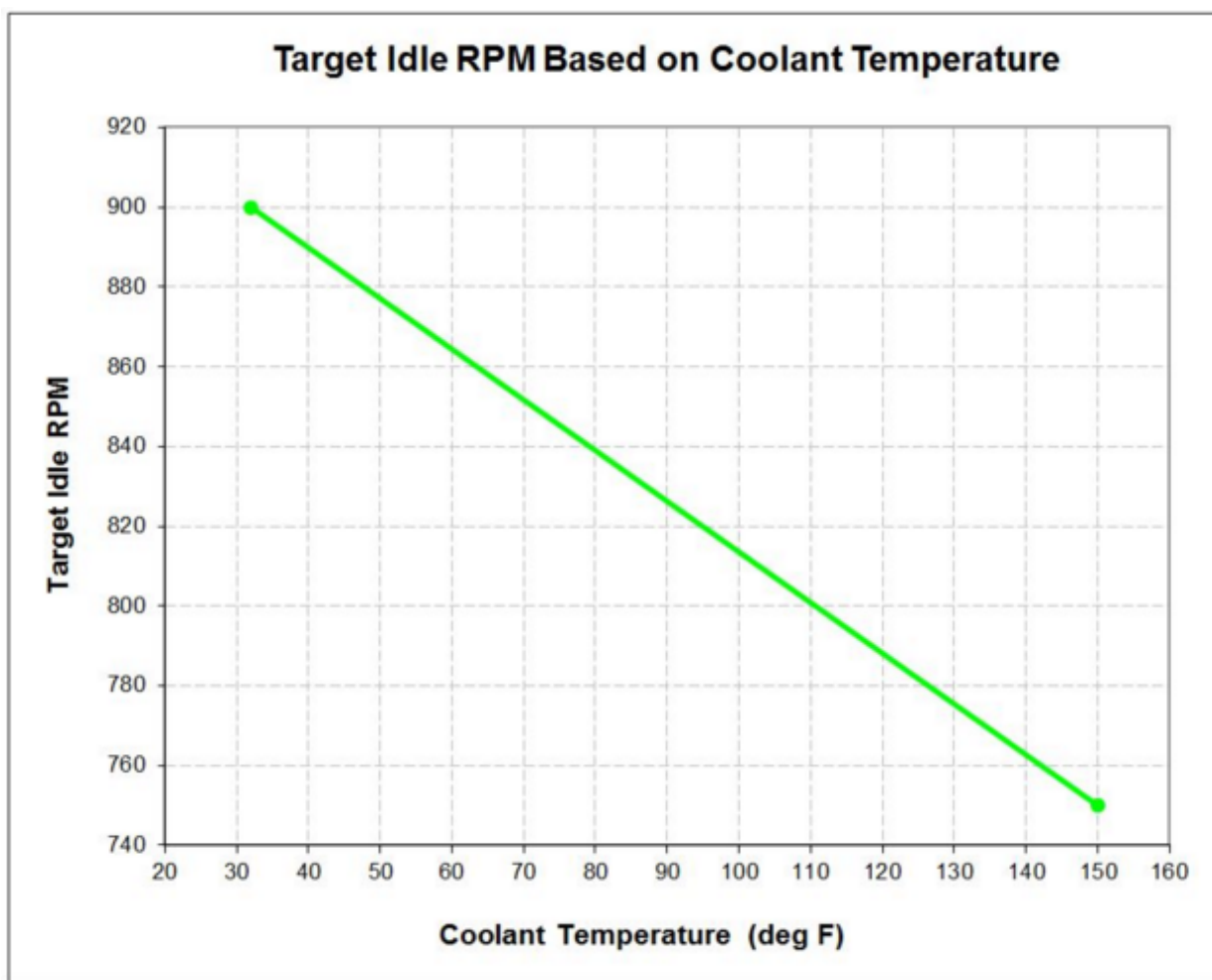
**Position Park** - This setting defines the idle motor position (in percent or steps) when the TPS value is above 'Max TPS'. If the throttle position is greater than 'Max TPS', the PE3 assumes that active idle speed control is no longer needed because the engine is under load. In this condition, the idle speed motor is 'parked' in a specific position according to this parameter. The 'Position Park' setting is generally used to control how well the engine responds when it is transitioning from under load to idle like when slowing to a stop or gradually approaching a speed bump. Generally, 'Position Park' is set such that this position generates an engine speed slightly above the normal idle speed.

**Position Min** - This is the minimum position limit for the idle motor. During the course of controlling the idle speed the PE3 will never go below this limit.

**Position Max** - This is the maximum limit for the idle motor position. During the course of controlling the idle speed, the PE3 will never exceed this limit. This setting is very important for a stepper motor because it must be set to less than the upper mechanical limit of motion.

The upper mechanical limit can be determined by running the idle control in 'Manual' mode and increasing the position until the engine speed stops changing or by visually checking the idle motor as it bottoms out in the housing. The 'Position Max' must be less than this upper mechanical limit.

**Idle RPM at 32 ° F** - This parameter sets the target idle speed when the engine is cold and the coolant temperature is at 32° F. For any coolant temperature between 32° F and 150° F, the RPM is linearly interpolated between the two temperatures. Please refer to the example below showing the target idle speed based on coolant temperature when 'Idle RPM at 32° F' is set to 900 RPM and the 'Idle RPM at 150° F' is set to 750 RPM.



Target Idle Speed Based on Coolant Temperature

**Idle RPM at 150 ° F** - This parameter sets the idle speed when the engine is warm and the coolant temperature is at 150° F. For any coolant temperature between 32° F and 150° F, the RPM is linearly interpolated (see figure above).

**Starting RPM** - 'Starting RPM' sets the engine speed that defines the transition between trying to start (cranking) and running. If the PE3 measures an RPM less than this value it assumes the engine is trying to start. If the PE3 measures an RPM greater than this value the engine is running. When the engine is trying to start the idle motor goes to the position defined by 'Position Start'. When the engine is running and in idle mode, the PE3 will actively

try to control to the target RPM.

**Max TPS** - This parameter sets the throttle position limit for idle mode. If the TPS (in percent) is less than this value the PE3 assumes that the engine is idling. When the TPS is above this, the ECU comes out of idle mode and the idle speed motor goes to the position defined in 'Position Park'.

**RPM Deadband** - When idling, 'RPM Deadband' defines how close the actual RPM must be to the target RPM before the PE3 system makes a change to the idle motor. For example, assume that the actual RPM is 875 and the target speed is 900 RPM. If the 'RPM Deadband' is set to 30, the PE3 will make no change to the idle motor because the target and actual RPM are within 30 of each other.

**RPM Filter** - The 'RPM Filter' setting allows the user to apply a filter to the measured RPM. This filter applies only to the RPM used for the purpose of idle control. Filters remove unwanted 'noise' from the measurement and help to make the measurement more steady. Filter levels can be set from 1 to 15. Level 1 is the smallest amount of filtering and level 15 is the highest level of filtering. Please refer to the ['Technical Specifications'](#) section for more information on the filters.

**Manual Position** - When in 'Manual' mode, this parameter defines the position of the idle control motor.

## **User Inputs Modify Fuel/Ignition (Tuning → User Inputs Modify Fuel/Ignition)**

The PE3 has a total of eight 'User Input' tables that can be used to modify fuel or ignition timing as a function of other measured or calculated parameters in the PE3. Each user input can be configured independently and provides a convenient way to compensate the fuel and ignition for many different conditions.

Below is an example of a user input configured to modify fuel and also descriptions of the different settings to configure the feature.



'User Inputs Modify Fuel/Ignition' Window

**Enable** - This allows the user input to be enabled or disabled from this window. When a user input for fuel is disabled, it turns the compensation to 100%. When a user input for ignition is disabled, it sets the compensation to 0° BTDC.

**Input Parameter** - The 'Input Parameter' defines the parameter used to modify the fuel amount or ignition angle. All values in the input parameter axis are adjustable by the user. In the example shown above, the user input is set to modify fuel based on the Analog Input #1 voltage. The input parameter can be defined as many different things including the following:

- Analog input #1-#8 voltages
- TPS measurement
- Thermistor inputs #5 and #7
- Idle air motor control position
- Digital output #1-#8 PWM duty cycle
- Digital input #1-#4 frequency

**Compensation** - The 'Compensation' table for the user input defines either the fuel or ignition compensation at each value of the input parameter.

- **Modify Fuel** = If the user input is set to 'Modify Fuel' (as in the example above), the compensation values are in percent (%). 0% turns the fuel off altogether and 100% does not modify the fuel at all. A value of 110%, for example would increase the fuel by 10%.
- **Modify Ignition** = Setting the input to 'Modify Ignition' allows the input to add or subtract ignition timing based on the input parameter. A positive value in the compensation table advances timing and a negative value retards the timing.

**Auto Fill** - The 'Auto Fill' function provide an easy way to fill in the 'Input Parameter' axis. See below for a description of each field.

- **Min** = The minimum requested value in 'Input Parameter'.

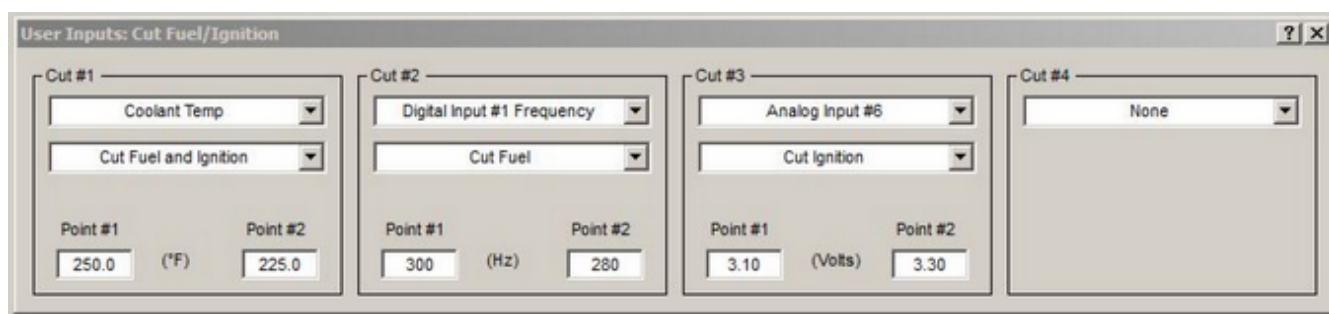
- Max = The maximum requested value in 'Input Parameter'.
- Input Parameter = This button evenly fills in the input parameter axis based on the 'Min' and 'Max' settings.

## **User Inputs Cut Fuel/Ignition (Tuning → User Inputs Cut Fuel/Ignition)**

The 'User Inputs Cut Fuel/Ignition' function allows the PE3 to cut the fuel, cut ignition or cut both fuel and ignition based on several measured inputs to the ECU. There are a total of four 'Cuts' that can be individually configured. Each cut has an input source, an action associated with the cut, and two set points which determine how the cut will function. User cuts are generally used as safety precautions to stop the engine in case of a problem like overheating, low oil pressure or over-speeding a vehicle.

Anytime a cut is active, the background of either the 'Ignition' or 'Fuel' cell in the engine data header will turn red (see ['Engine Data Header'](#)).

The figure below shows an example configuration with three cuts activated based on different inputs.



'User Inputs Cut Fuel/Ignition' Window

**Cut Input Source** - The top drop down menu in each cut is the input source. The PE3 will perform the cut based on the value of the selected source. For 'Cut #1' above, the source is the 'Coolant Temp' measurement. Cut input sources can be the following.

- Air Temperature
- Coolant Temperature
- Analog Input #1-#8
- Thermistor inputs #5 and #7
- Digital input #1-#4 frequency measurements

**Cut Action** - The second drop down menu in each cut defines the resulting action when a cut is activated. For 'Cut #1' in the example, both fuel and ignition will be suspended when the cut is active. Below are the possible cut actions.

- None = Cut is not enabled.
- Cut Fuel = Turns the injectors off during the cut.
- Cut Ignition = Does not charge or fire the coils during the cut.
- Cut Fuel and Ignition = Turns the injectors off and does not charge or fire the ignition

coils during the cut.

**Point 1, Point 2** - 'Point 1' and 'Point 2' are set points that define when and how the cut will function. Each cut has the ability to be active when the input source is either high or low.

- **If 'Point 1' is greater than 'Point 2'** - The cut will be active when the input source is greater than or equal to 'Point 1' and will deactivate when the input is less than or equal to 'Point 2'. A good example of this type of cut is shown in 'Cut #1' above. In this example, 'Cut #1' is configured to shut the engine down if the engine overheats. When the coolant temperature is greater than or equal to 250° F, both the fuel and ignition will be cut until the temperature falls below 225 ° F.
- **If 'Point 1' is less than 'Point 2'** - The cut will be active when the input source is less than or equal to 'Point 1' and will deactivate when the input is greater than or equal to 'Point 2'. 'Cut #3' above is an example of this type of cut. It is configured to cut the fuel in the event that the oil pressure signal falls below 3.10 volts.

## **Digital Inputs (*Tuning* → *Digital Inputs*)**

The PE3 system has a total of seven digital inputs that can be used for various functions. Digital inputs 1-5 are all activated by applying 5-20 volts to the input. Digital inputs 6 and 7 are activated by pulling them to battery GND. Please see the [Technical Specifications](#) for trigger levels.

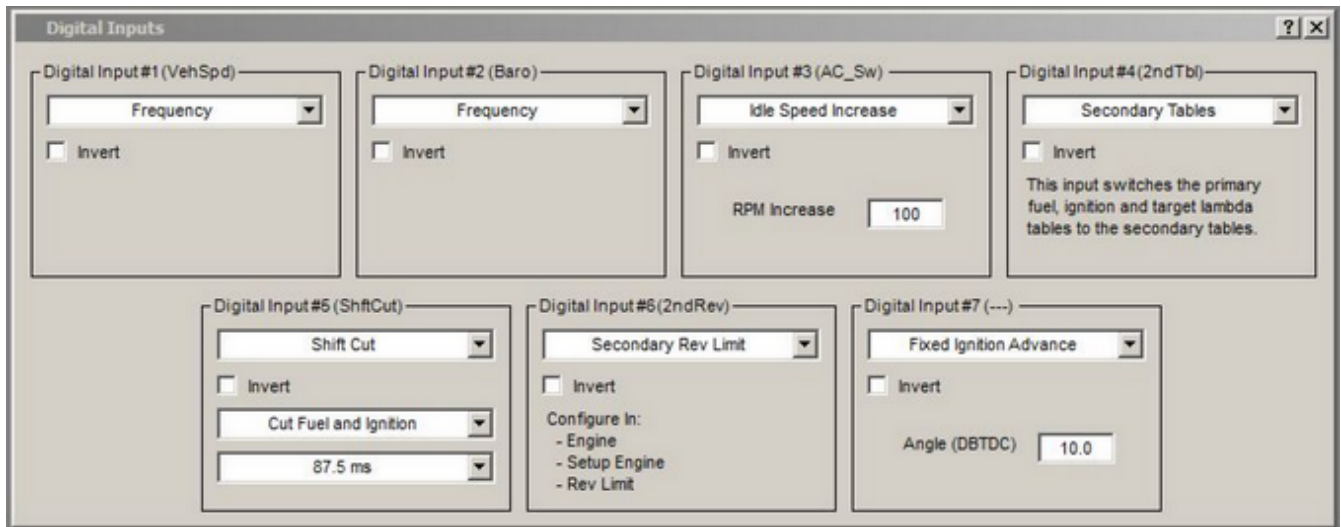
The first four digital inputs (Digital Inputs 1-4) can be used to measure frequency for determining vehicle or shaft speeds.

Whenever a digital input is active (or a frequency is present on inputs set to 'Frequency'), the corresponding green light in the data header will light up (see ['Engine Data Header'](#)).

The figure below shows the Digital Input configuration window with examples of several types of inputs. Each digital input listed in the window corresponds directly to a physical pin on the PE3 ECU. Please refer to the [Wire Diagram](#) for pin locations for each of the inputs.

The PE3 gives the user the ability to name each input for easy tracking. This is visible in the configuration window below, next to the label for each channel. The text in the parentheses ('VehSpd' for Digital Input #1) is the user assigned label for that input. Labels can be entered in the ['Setup Digital Names'](#) window.

Some digital input settings require configuration changes elsewhere in peMonitor. A good example of this is the secondary rev limiter below in Digital Input #6. To use a secondary rev limit you must also configure the limit RPM under the 'Setup Engine' tab. Whenever additional configuration is required somewhere else in the software, instructions will appear below the digital input drop-down box informing the user.



'Digital Inputs' Configuration Window

Drop down boxes allow the user to choose a specific function for each input. Below the drop down box is a check box labeled 'Invert'. This box has no meaning for frequency inputs, but for all other on/off inputs it forces the active state and inactive state to invert.

Below is a description of the different functions available for the digital inputs.

### Available Functions for Digital Inputs

- Off = With this selection, the digital input takes no action.
- Cut Fuel = Prevents the injectors from opening when the input is active.
- Cut Ignition = Prevents the ignition coils from charging and firing when the input is active.
- Cut Fuel and Ignition = Prevents the injectors from opening and the ignition coils from charging and firing when the input is active.
- Secondary Rev Limit = Activates a secondary rev limit for that input. Please refer to the ['Rev Limit'](#) tab under 'Setup Engine' for more information.
- Idle Speed Increase = Increases the idle speed set point by the entered amount when the PE3 is controlling idle speed. This is sometimes helpful to use with accessories like air conditioning so the engine does not stall when the air conditioning clutch engages.
- Secondary Tables = Switches the main fuel, main ignition and main lambda tables from primary to secondary. See the ['Secondary Tables'](#) section for more information.
- Disable Lambda Control = Provides an input to disable the lambda control.
- Shift Cut = Suspends fuel, ignition or both for a specified length of time after the digital input becomes active. The type of cut (fuel only, ignition only or fuel and ignition) as well as the length of time (12.5 ms to 200 ms) for the cut are adjustable.
- Traction Control Arm = Arms the traction control module allowing it to operate. See the 'Traction Control' section for more details.
- Fixed Ignition Advance = Sets the ignition timing to the value listed regardless of the ignition tuning tables in the ECU.
- Close Idle Air = If the idle air control system is used, this input closes the idle air

valve.

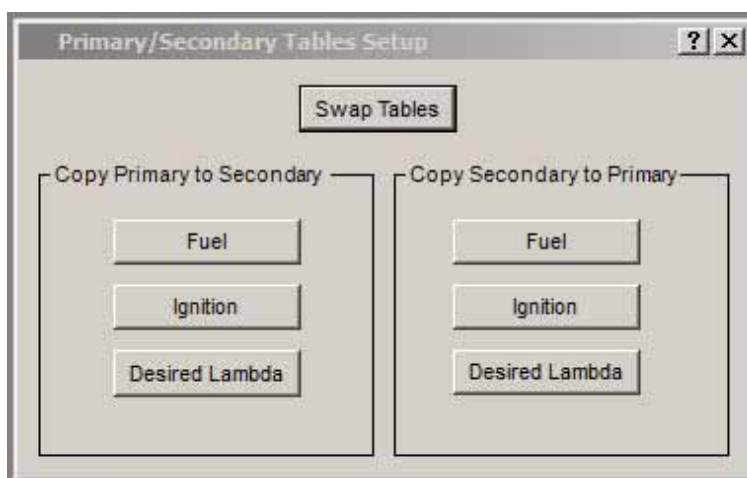
- Frequency = Sets the input to measure frequency so that speeds can be determined. Refer to [Technical Specifications](#) for electrical details for frequency inputs.

## **Secondary Tables (Tuning → Secondary Tables)**

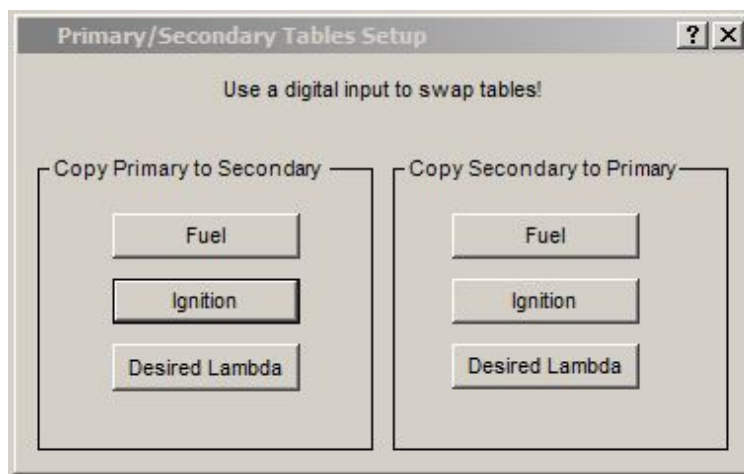
The 'Secondary Tables' feature provides a simple way for the user to store both primary and secondary fuel and ignition tables in the PE3 engine controller at one time. This feature is designed to allow a second set of tables to be switched into operation, without the need to connect a PC and load a new tuning file. Secondary tables can be 'hot-swapped' as the engine is running by using a digital input to select the tables (See [Digital Inputs](#) to configure the input). It is not recommended, however, to swap tables under heavy engine loads.

There are four tables that are switched between Primary and Secondary. These include the Main Fuel table, Main Ignition table, closed loop Target Lambda/AFR table and the Long Term Factor table. Only one set of tables is used at any given time. Primary and Secondary tables are sometimes used for switching between alcohol and gasoline or for running a 'street' versus 'race' configuration.

Below is the Secondary Tables Setup window in peMonitor. The layout of the window changes slightly whether or not the PE3 is online.



'Secondary Tables' Setup Window with ECU offline



'Secondary Tables' Setup Window with ECU online

The setup windows shown above provide a way to move and copy tables while the PE3 is on or offline. Below is a description of the functions.

**Swap Tables** - This button is only visible when the PE3 is not communicating with the peMonitor (top figure above). Using this button to 'Swap Tables' makes the opposite set of tables visible in the main Fuel, Ignition and Target Lambda windows so they can be modified when the ECU is not online.

**Copy Primary to Secondary/Copy Secondary to Primary** - These buttons copy the associated Fuel, Ignition or Target Lambda tables from Primary to Secondary or Secondary to Primary.

In the default mode, the PE3 only uses the Primary set of tables. Secondary tables can only be initiated on a running engine by configuring a digital input and toggling it accordingly. Secondary tables can be viewed and modified just like the Primary tables when they are enacted while connected to the PE3. Secondary tables can also be manipulated offline by using the 'Swap Tables' button in the setup window.

The user can determine which tables are active by looking in the upper left hand corner of the Main Fuel, Main Ignition and Target Lambda tables. The title of the window will change from 'Primary' to 'Secondary' depending on which tables are active. The figures below show these different labels as the Main Fuel Table is changed from Primary to Secondary.

Primary - Fuel Table - Injector Open Time (ms)								
<input checked="" type="checkbox"/> Enable Fuel	<input type="checkbox"/> Enable Tracer	Clear Tracer						
	400	450	600	750	900	1050	1200	
100.0	11.48	11.48	12.11	12.66	13.28	13.83	14.45	
96.0	11.48	11.48	12.11	12.66	13.28	13.83	14.45	
92.0	11.48	11.48	12.11	12.73	13.28	13.91	14.53	
88.0	11.48	11.48	12.11	12.73	13.28	13.91	14.53	
84.0	11.48	11.48	12.11	12.73	13.36	13.98	14.61	
80.0	11.48	11.48	12.11	12.73	13.36	13.98	14.61	

Primary Fuel Table Label



Secondary - Fuel Table - Injector Open Time (ms)							
<input checked="" type="checkbox"/> Enable Fuel	<input type="checkbox"/> Enable Tracer	Clear Tracer					
	400	450	600	750	900	1050	1200
100.0	14.38	14.38	15.16	15.86	16.56	17.27	18.05
96.0	14.38	14.38	15.16	15.86	16.56	17.27	18.05
92.0	14.38	14.38	15.16	15.94	16.56	17.42	18.13
88.0	14.38	14.38	15.16	15.94	16.56	17.42	18.13
84.0	14.38	14.38	15.16	15.94	16.72	17.50	18.28
80.0	14.38	14.38	15.16	15.94	16.72	17.50	18.28

Secondary Fuel Table Label

## **ECU Notes (Tuning → ECU Notes)**

'ECU Notes' provides a convenient way to store notes with any PE3 tuning file. The notes are displayed at the bottom left corner of the main peMonitor screen and are always visible. The notes can be up to 64 characters long and are a good way to provide information about the tuning file itself.

'ECU Notes' window

## **Save Settings to ECU (Tuning → Save Settings to ECU)**

Tuning parameters can be modified using peMonitor while the engine is running or not running. When tuning parameters are modified while connected to the ECU, changes immediately take effect. However, unless the data is permanently stored, it will be lost once power is removed from the ECU. To store permanently, the user must save data to the PE3 using the 'Save Settings to ECU' command.

The 'Save Settings to ECU' command is available in several locations within peMonitor. All locations perform the same function. The command is available as a drop down selection in the main header ('Tuning-Save Settings to ECU'), as the black 'ECU' button in the upper left corner of peMonitor (Fig A below), as the black 'ECU' button in the upper right corner of peMonitor (Fig B below) and as a shortcut (Alt+S). Also, the button in the upper right corner has a unique feature that tells the user that tuning parameters have changed but not been permanently saved. Anytime this condition exists, the word 'ECU' in the button becomes '\*\*ECU\*\*' (Fig C below).



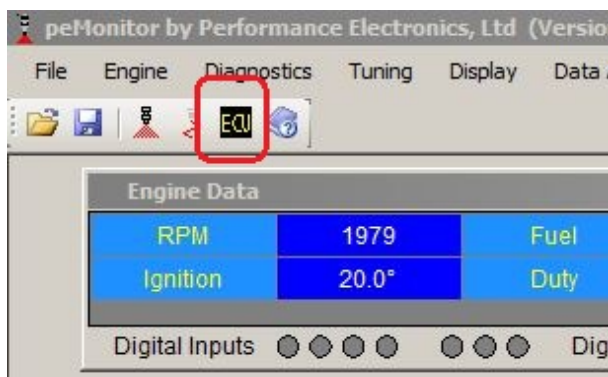


Fig A - 'Save Settings to ECU' Button, Top Left Corner of peMonitor

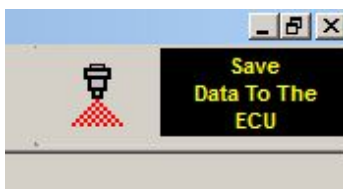


Fig B - 'Save Settings to ECU' Button, Top Right Corner of peMonitor

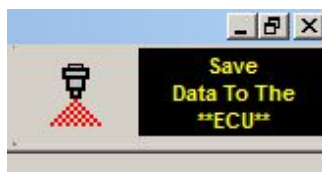


Fig C - 'Save Settings to ECU' Button, Parameters Not Saved

## **Password Protect ECU (*Tuning* → *Password Protect ECU*)**

The PE3 has the unique ability to be password protected. If protection is enabled, the user will be prompted to enter a password after peMonitor has established communication with the ECU. Without entering the correct password, users are still able to access important operating and diagnostic information but are not able to view or change the tuning parameters. The 'Password Protect ECU' command brings up the window below. To protect the ECU, the user must enter and confirm a password that is up to eight characters long and then save the settings to the ECU.



'Password Protect ECU' window

**Password** - Enter the desired password. This can be up to eight characters long.

**Confirm** - Confirm the password entered above. You must enter the same string of characters as the field 'Password'.

**Reset** - The 'Reset' button clears the current password and returns the PE3 to a state that is not protected.

**OK** - After the password has been entered and confirmed, clicking the 'ok' button sets the password. The user must ['Save Settings to ECU'](#) to store the changes. The next time the PE3 is powered on, access will be limited by the password.



cleared in ['System Status'](#).

**Air** - Current air temperature measurement.

- Yellow Background - The sensor is currently out of range. This error can be viewed and cleared in ['System Status'](#).

**Battery** - Current battery voltage.

**Lambda** - Oxygen sensor measurement. The sensor response can be displayed as either lambda or AFR (Air Fuel Ratio) depending on how the sensor is configured.

- Yellow Background - The sensor is currently out of range. This error can be viewed and cleared in ['System Status'](#).

**Ignition** - Final calculated ignition timing. Positive values are degrees BTDC and negative values are degrees ATDC. The value displayed in this box is the ignition timing with all compensation terms applied except for individual cylinder compensation (if configured).

- Yellow Background - A warning is present. The most common warning for Ignition is that the coil charge time has been clipped. This simply means that the engine is running too fast to charge the coils for the full charge time as defined in the engine setup. Hovering the cursor over the yellow box will display the reason for the warning.
- Red Background - Ignition is being cut. This can be due to a number of reasons including but not limited to a rev limit, one or more digital inputs, a user input cut or a secondary rev limit being reached. Hovering the cursor over the red box will display the reason for the cut.

**Duty** - This is the duty cycle of the injectors each time that they are opened. This measurement is displayed in percent.

- Yellow Background - Open time is being clipped at 80%. This warning means that the injector duty cycle (and therefore open time) is being clipped at 80%. The largest duty cycle that the PE3 can accommodate is 80%.

**MAP** - Current Manifold Absolute Pressure measurement.

- Yellow Background - The sensor is currently out of range. This error can be viewed and cleared in ['System Status'](#).

**Coolant** - Current coolant temperature measurement.

- Yellow Background - The sensor is currently out of range. This error can be viewed and cleared in ['System Status'](#).

**Barometer** - Current barometric pressure measurement.

- Yellow Background - The sensor is currently out of range. This error can be viewed and cleared in ['System Status'](#).

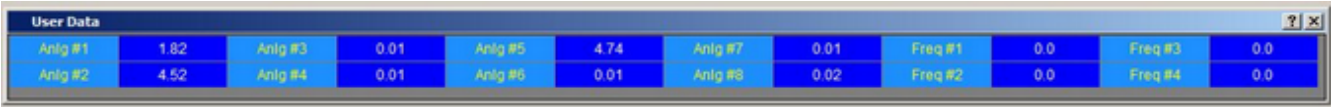
**Desired** - Desired lambda or AFR based on the current operating conditions and the target lambda table.

- **Blue Background** - If the 'Desired' block has a blue background, this indicates that the fuel system is currently operating in closed loop. This means that the PE3 is constantly updating the injector open times in order to try to meet the target lambda/AFR values.
- **Yellow Background** - The yellow background will be accompanied by the words 'Open Loop' in the block. This indicates that the fuel system is currently not running in closed loop but rather open loop. In this case the ECU is simply calculating the fuel values based on all of the static tables and current operating condition to determine the injector open time. The ECU is not trying to meet the target lambda/AFR values.

**Digital Inputs** - At the bottom of the Engine Data Header are several digital 'lights' that indicate the condition of the Digital Inputs coming into the ECU. If the PE3 recognizes the Digital Input is active (or a frequency is present on inputs set to 'Frequency'), the round light will be green in color. If the input is inactive, the light will be grey in color. There is one light for each Digital Input. Digital Input #1 is all the way to the left and they increment from left to right across the screen. In the figure above Digital Input #1 is currently active.

**Digital Outputs** - Next to the Digital Inputs are several additional 'lights' that indicate the condition of the Digital Outputs from the ECU. Anytime the Output is on, the round light will be green in color. If the output is off, the light will be grey in color. There is one light for each Digital Output. Digital Input #1 is all the way to the left and they also increment from left to right across the screen. In the figure above Digital Output #10 is currently on. Some of the Digital Outputs have the ability to be pulse width modulated (PWM). This means that the output is repeatedly turned on and off very quickly for a certain percentage of time. If the digital output is used in this mode the light is green anytime the duty cycle is greater than 0%.

## **User Data Header (*Display → User Data*)**



User Data											
Anlg #1	1.82	Anlg #3	0.01	Anlg #5	4.74	Anlg #7	0.01	Freq #1	0.0	Freq #3	0.0
Anlg #2	4.52	Anlg #4	0.01	Anlg #6	0.01	Anlg #8	0.02	Freq #2	0.0	Freq #4	0.0

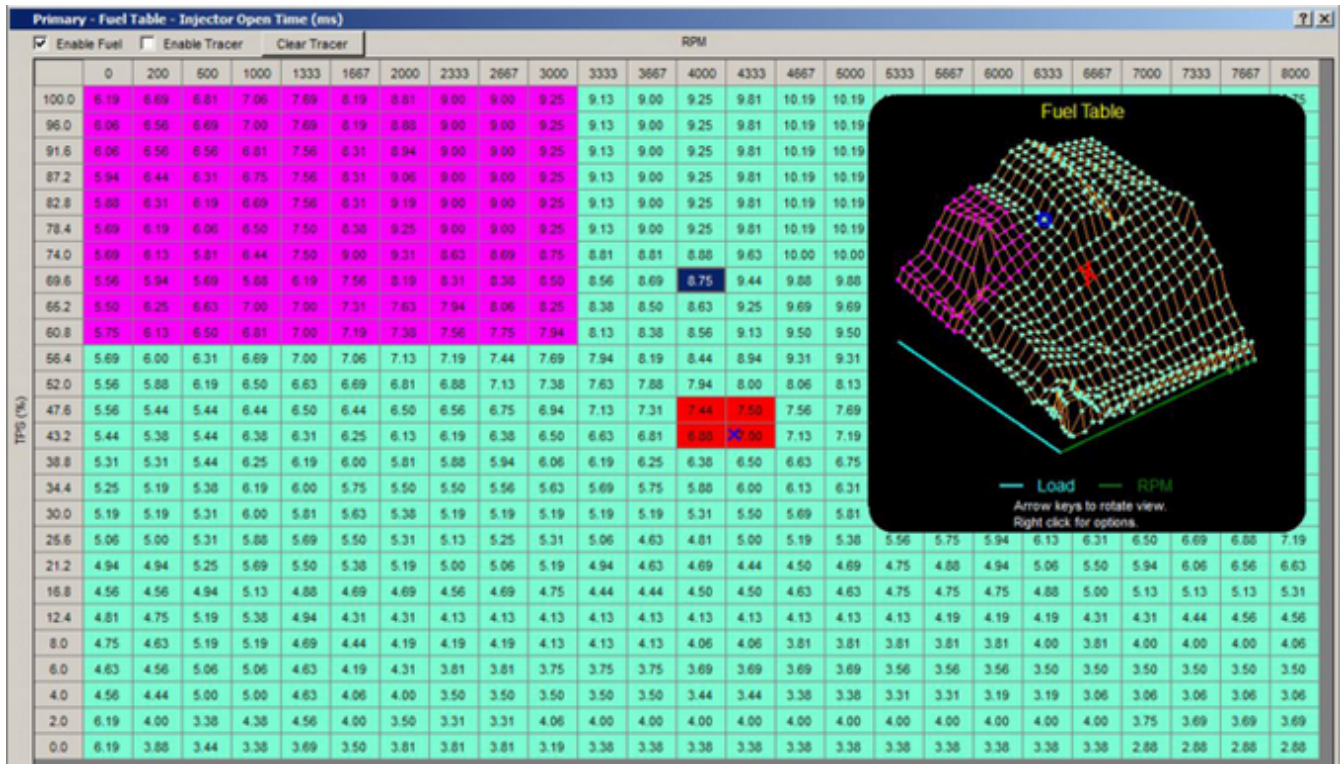
User Data Header

Like the Engine Data Header, the User Data Header provides real time information during tuning. The data displayed is based on the user data configuration which can be modified in '[Setup User Data](#)'. Inputs can be calibrated and named in the setup Window. This data is updated in real time whenever the PE3 is powered on and online with peMonitor.

## **3D Table Plots (*Display → 3D Fuel Plot, ...3D Ignition Plot, ...3D Target Lambda Plot, ...3D Long Term Factor Plot*)**

The 3D Table Plots are graphical representations of the main tables. The figure below shows a main fuel table and the corresponding 3D Fuel Plot. The plot can be re-sized or zoomed by right clicking on the plot and selecting the appropriate action. 3D plots can be displayed for the following tables; Main Fuel Table, Main Ignition Table, Target Lambda Table and the Long Term Factor Table. The 3D Table Plots have several notable qualities including the following:

- Can be re-sized and zoomed (right click on the table for options).
- Can be rotated by using the arrow keys.
- Shows the engine's current operating position in the plot with a red 'X'.
- Shows the current cursor position in the table with a blue 'O'.
- Displays the user configurable colored cells from the main table (Except for the Long Term Factor Table which displays colors from the Main Fuel table).

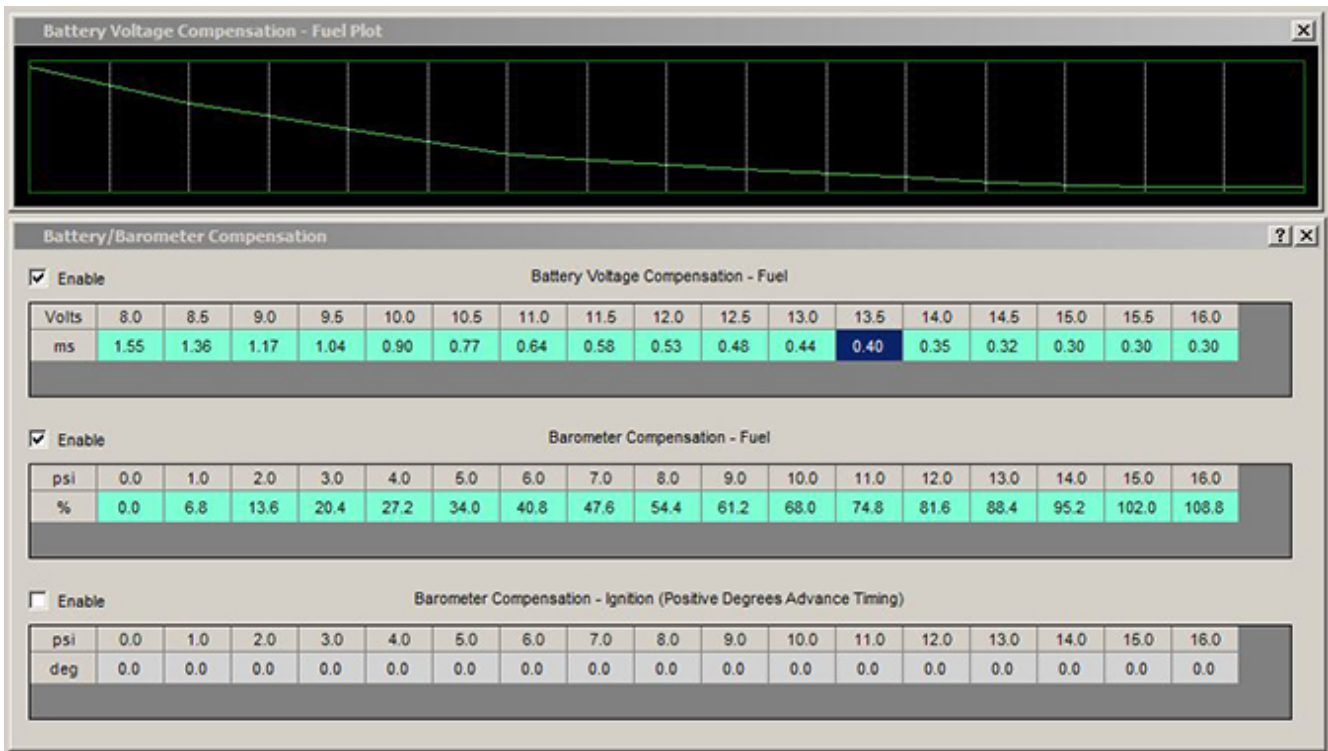


Main Fuel Table with 3D Fuel Plot

## 2D Parameter Plot (*Display* → 2D Parameter Plot)

The 2D Parameter Plot can be used to graphically visualize any of the two dimensional tables in peMonitor. These tables include Battery Voltage Compensation, Barometer Compensation, Fuel Angle, MAP Compensation and User Input Compensations. Open the 2D Parameter Plot and then click on the table to visualize that table. The figure below shows the 2D Parameter Plot of Battery Compensation at the top with the associated table below.

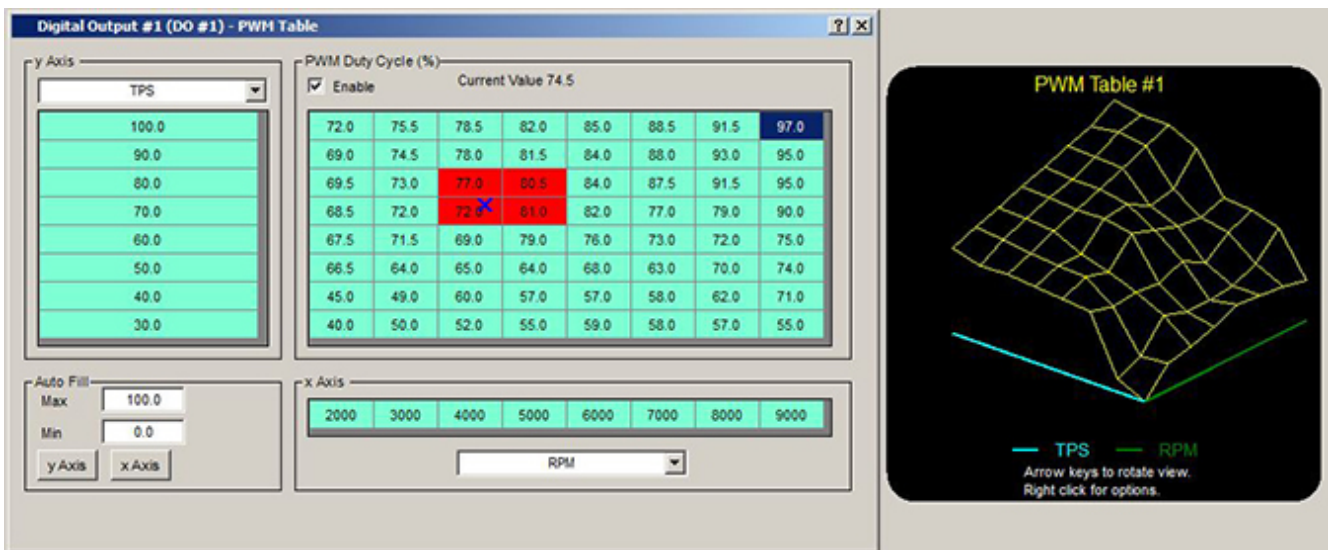




Example 2D Parameter Plot Showing Battery Voltage Compensation

### 3D Parameter Plot (*Display* → *3D Parameter Plot*)

The 3D Parameter Plot is used to graphically visualize any of the three dimensional parameter tables. These tables include Air Temperature Compensation, Coolant Temperature Compensation and the Digital Output PWM tables. To open the 3D Parameter Plot go to 'Display → 3D Parameter Plot' and then click on the table to visualize. The figure below shows a 3D Parameter Plot of a PWM table for Digital Output #1. The PWM table is on the left with the 3D plot for the table to the right. These plots can be increased or decreased in size, zoomed and also rotated. Right click on the plot for a listing of the display options.

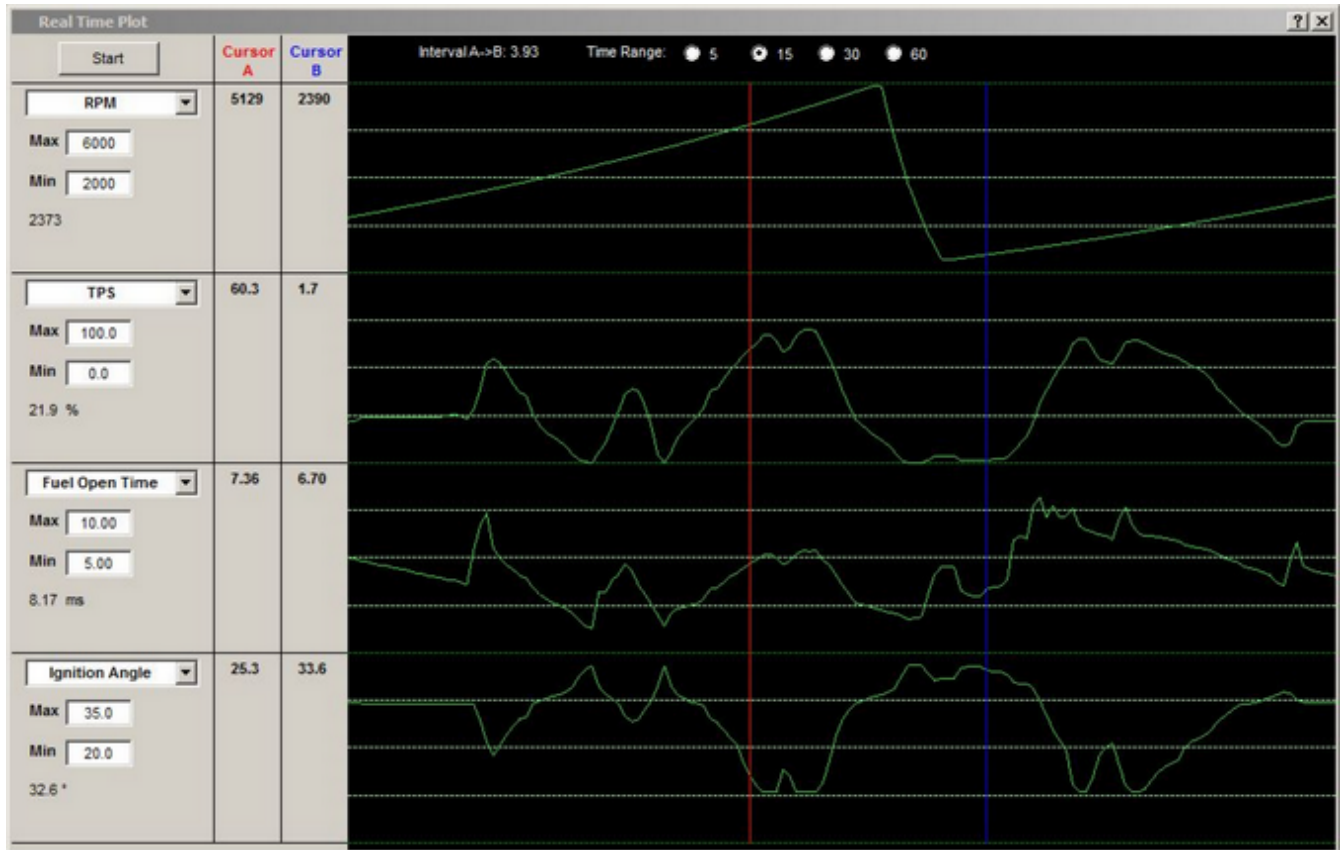


Example 3D Parameter Plot Showing PWM Digital Output Table



## **Real Time Plot (*Display* → *Real Time Plot*)**

The 'Real Time Plot' in peMonitor gives the user the ability to view input signals and calculated values from the PE3 as the engine is running. This feature is especially helpful during the tuning process to observe subtle changes in how the engine is running. The user can choose up to four parameters to view at one time. The figure below shows an example of the Real Time Plot.



Example 'Real Time Plot'

The four drop down boxes along the left side of the window allows the user to choose the parameters that are plotted. 'Min' and 'Max' limits for each of the plots are also adjustable.

The real time plot can be initiated by pressing the 'Start' button in the top left corner of the window. The length of time displayed in the window can be adjusted using the 'Time Range' at the top of the window.

Two cursors are also provided in the display. The 'Cursor A' (red) and 'Cursor B' (blue) can be moved to any time within the display window. The values of each parameter at the two cursors are displayed on the left side of the window. Current values for each of the parameters are displayed under the 'Min' setting.

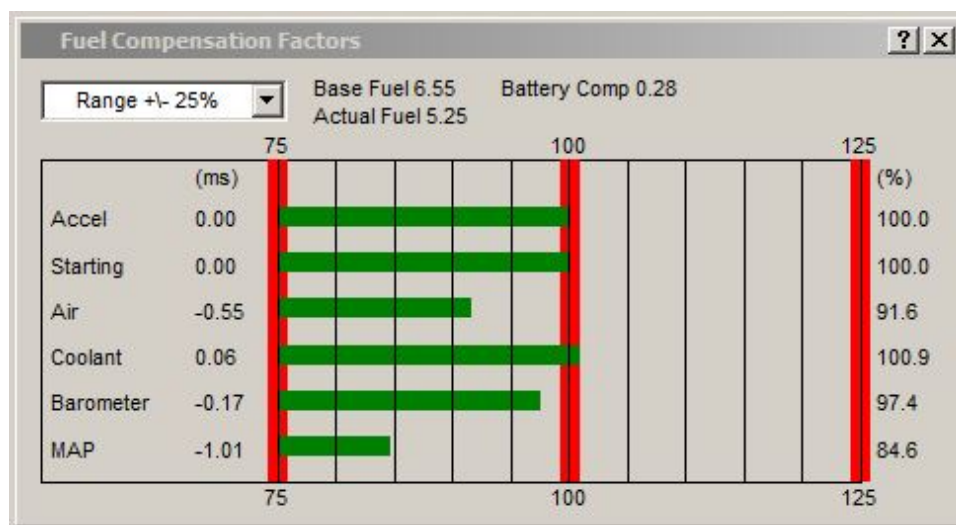
## **Fuel Compensation Factors (*Display* → *Fuel Compensation Factors*)**

The 'Fuel Compensation Factors' window displays all of the factors that are combined with the main fuel table to determine actual or total injector open time. The display is a bar graph that adjusts real-time as the engine changes. Any enabled compensations are automatically displayed

on the graph. Each of the compensation terms is a multiplication factor for the main fuel table. 100% indicates that the open time was not modified at all by that particular factor. Less than 100% means that the fuel was reduced and more than 100% indicates that additional fuel was added.

In addition to displaying the actual factor in % on the right side of the graph, the corresponding open time in millisecond (ms) is also displayed on the left of the graph. The 'Actual Fuel' (or total calculated open time) that the engine is receiving is displayed in milliseconds above the graph. This final value includes the 'Base Fuel' from the main fuel table, all of the compensation factors, and the addition of the battery voltage compensation ('Battery Comp').

The limits of the bar graph can be modified by changing the 'Range' drop down box in the upper left corner.

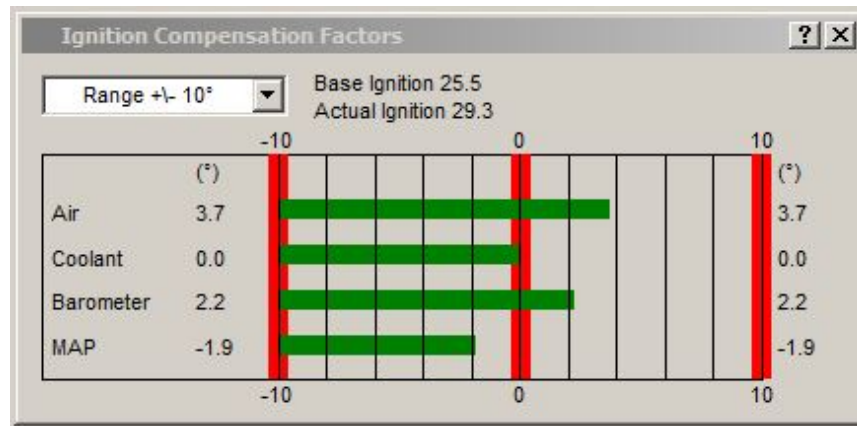


'Fuel Compensation Factors' Window

## **Ignition Compensation Factors (*Display → Ignition Compensation Factors*)**

The 'Ignition Compensation Factors' window displays all of the factors that are combined with the main ignition table to calculate the total ignition timing at any given time. The display is a bar graph that adjusts real-time as the engine changes. Positive degrees in the graph indicate degrees of advance and negative degrees indicate degrees of retard. Any enabled compensations are automatically displayed on the graph. Each individual compensation term shown is summed with the 'Base Ignition' from the main table to determine 'Actual Ignition' (total advance).

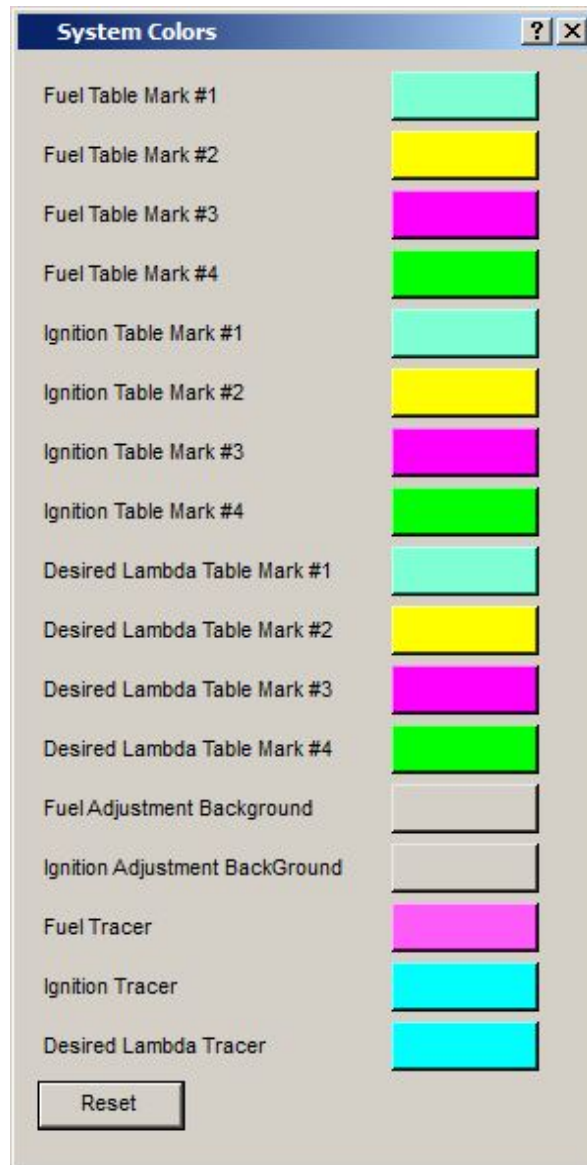
The limits of the bar graph can be modified by changing the 'Range' drop down box in the upper left corner of the window.



'Ignition Compensation Factors' Window

## **System Colors (*Display* → *System Colors*)**

The 'System Colors' window can be used to change the various colors in peMonitor. Simply click on any of the color blocks in the window to change the color for the particular function.



'System Colors' Window

### **Copy Display to Clipboard (*Display* → *Copy Display to Clipboard*)**

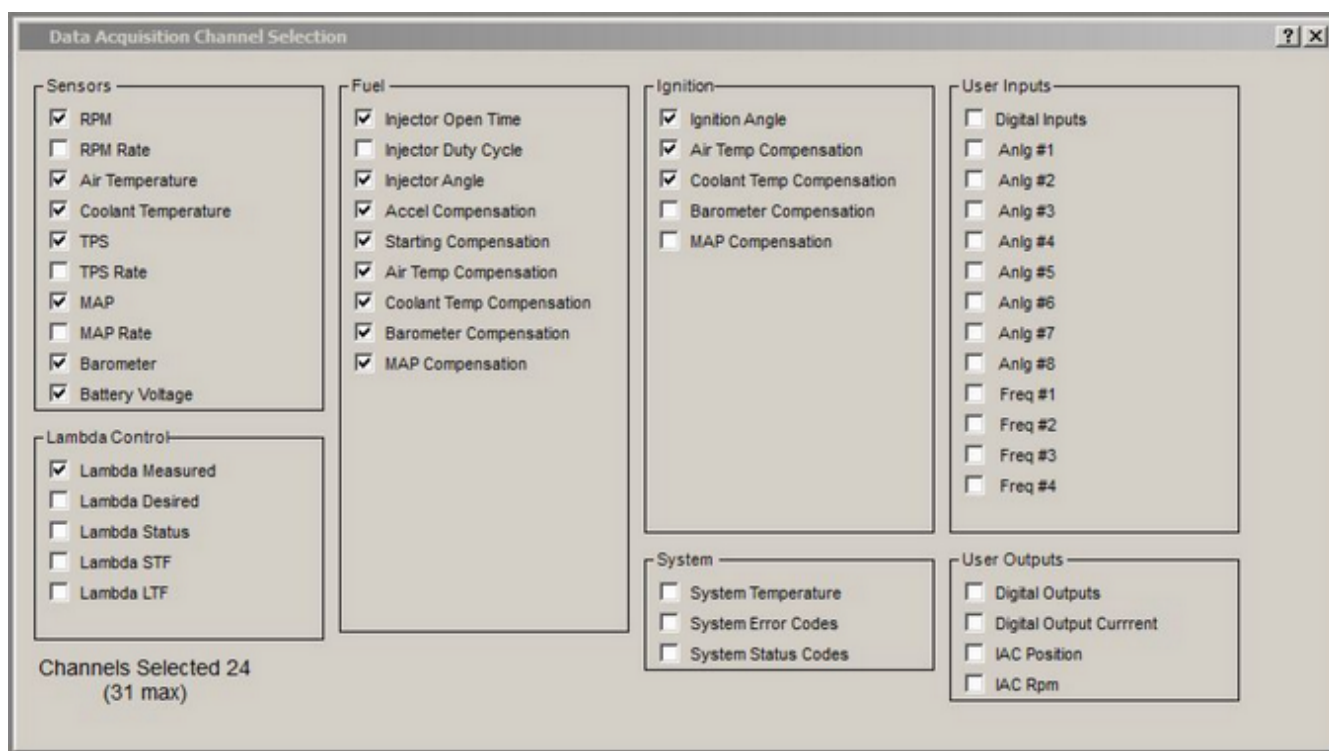
The 'Copy Display to Clipboard' function copies the entire peMonitor display to the clipboard. It provides an easy way to do a screen shot at any time.

## Data Acquisition Drop Down Menu

The sections below describe the different elements that are located under the 'Data Acquisition' drop down menu at the top of the main screen in peMonitor. These menus include the setup parameters required to configure and run the on-board data acquisition system of the PE3.

### **Channel Selection** (*Data Acquisition* → *Channel Selection*)

The 'Channel Selection' menu allows the user to choose which parameters are internally logged in the PE3. The available channels are broken down by function in the window. Putting a check mark next to the parameter tells the PE3 to log that specific channel. The user can log up to 31 channels of data at a time. The bottom left corner of the window tells the user how many channels are selected at any given time. Once the desired channels have been selected, the remaining data acquisition configuration can be accomplished in ['Setup and Control'](#).



'Channel Selection' Window

### **Setup and Control** (*Data Acquisition* → *Setup and Control*)

The 'Setup and Control' window for data acquisition configures how and when the PE3 records the channels set in ['Channel Selection'](#). This window allows the user to configure the data acquisition system as well as manipulate data files stored on the ECU. The PE3 comes with 1Mb of onboard storage for data acquisition. The length of time that data can be collected is dependent on the size of this memory, the sample rate and the number of channels being recorded. Data uploaded to the PC is stored in a Comma Separated Values (.CSV) file format. CSV files are text files that can be viewed in a text editor, a spreadsheet program or in the viewer supplied by Performance Electronics, peViewer. The table below shows approximate run times based on number of channels and sample rate.

**NOTE:** The PE3 is programmed to stop recording once the memory is full. Data files must be uploaded and deleted from memory to continue recording after memory has been filled.

**Approximate Run Time in Minutes to Fill Data Acquisition Memory**

<div>Sample Rate # Chan</div>	20 Hz	25 Hz	33 Hz	50 Hz	100 Hz
<b>2 Channels</b>	1160	930	700	460	230
<b>5 Channels</b>	580	460	350	230	110
<b>10 Channels</b>	310	250	190	120	60
<b>15 Channels</b>	210	170	130	80	40
<b>20 Channels</b>	160	130	100	60	30
<b>30 Channels</b>	110	90	60	40	20

Data Acquisition Run Time

The PE3 will collect data when either the trigger conditions are met or the 'Manual Start' button is depressed. Manual start is only designed to enable data acquisition temporarily until power is cycled to the ECU. Once the user manually starts the data acquisition, recording can be stopped by pressing the 'Manual Stop' button.

Every time the data acquisition starts and stops, a new file is created on the PE3. Each file is given a 'File Number' which is displayed along with the 'Start Page' and the 'Stop Page' in the Stored File Status window. The start and stop pages refer to pages in memory and indicate the overall size of each file (see figure below).

The PE3 is designed to save a maximum of 100 files. Once the 100 file limit is reached the ECU will no longer record additional data regardless of the amount of memory left in the system. Because of this, it is important to limit the number of very short files by carefully considering the trigger conditions. For example, it is not advisable to use a trigger condition of engine RPM at a level right around the idle speed of the engine. As the idle fluctuates around the normal idle speed, the data acquisition system might generate unnecessary runs just due to the idle speed bouncing around the trigger RPM.

At any given time, the PE3 provides feedback in the 'Data Acquisition Status' area of the window (see Figure below). In addition to the overall status (e.g. Armed, Running or Waiting for Erase) peMonitor also reports the percent of memory that is full. When the data acquisition system is running, 'Percent Full' will increment. In addition to real-time status, the PE3 ECU can be configured to drive an external lamp that indicates when the data acquisition system is running. Refer See ['Info Light Config'](#) for more details.

Listed below are the functions associated with the controls for data acquisition 'Setup and Control'.

**Sample Rate** - The 'Sample Rate' defines how many times per second that data is measured and stored to the PE3. This parameter is in samples per second or Hz. The larger this number, the faster that data is collected and the sooner that available memory will be filled. All channels are measured at the same sample rate. Available rates are 20, 25, 33, 50 and 100 Hz.

**Get Directory** - The 'Get Directory' button returns the files that are currently present on the PE3 unit. These files are listed in the 'Stored Files' section of the window (see Figure below). In the example in the Figure, the PE3 currently has a total of 11 files.

**Get File** - 'Get File' downloads the selected files from the PE3 to the PC. After hitting 'Get File' the user will be prompted to name the file and directory. For some versions of Windows, the

target directory MUST be a different directory than the installation directory for peMonitor due to Windows write restrictions. Holding the 'Shift' key down will select all files between mouse clicks and holding the 'Ctrl' key allows multiple individual files to be selected at one time. Data uploaded to the PC is in Comma Separated Values (.CSV) file format. When uploading, peMonitor automatically appends the entered filename with the file number to keep multiple runs of one upload separate.

**Erase** - 'Erase' erases all data stored in the PE3. This is required to free up memory once data has been uploaded to the PC.

**Manual Start/Manual Stop** - 'Manual Start' and 'Manual Stop' work in conjunction. 'Manual Start' starts the data acquisition without the trigger conditions being met. Manual start is only designed to enable data acquisition temporarily until power is cycled to the ECU. Once the user manually starts the data acquisition, recording can be stopped by pressing the 'Manual Stop' button.

**Format** - 'Format' formats the data acquisition memory. This is similar to formatting a hard drive on a PC. All existing data will be lost after formatting.

### **Start Configuration**

- **Switch** = This drop down box allows the user to configure the data acquisition to start and stop based on a change in state (e.g. external switch) on Digital Inputs #1 - #7.
- **Logical Operator** = The 'Logical Operator' allows an external 'Switch' to be combined with some other condition to provide a trigger for the data acquisition. If the logical operator is 'Or' then either the switch or the secondary condition ('RPM Greater Than 250' in the figure below) will start the acquisition. If the logical operator is 'And' then both the switch and external condition must be true.

**NOTE:** The data acquisition system can be stopped at any time by changing the 'Start Configuration' setting. For example, with the settings in the Figure below, the PE3 would be collecting data anytime the engine was idling above 250 RPM. To stop the data recording while the engine is running, the user could simply change the 'Greater Than' to 'Less Than'.



**Data Acquisition Setup and Control**

Sample Rate: 100 Hz

Get Directory

Get File

Erase

Manual Start

Format (68 seconds)

File Number	Start Page	End Page
1	0	1090
2	1091	2893
3	2894	4553
4	4554	8843
5	8844	9679
6	9680	9936
7	9937	10064
8	10065	10286
9	10287	10433
10	10434	10587
11	10588	10895

Stored Files

Data Acquisition Status

Data Acquisition Status: Armed

Percent Full: 33.3 (%)

Start Configuration

Switch: None

Logical Operator: Or

RPM Greater Than 250

Trigger Conditions

'Data Acquisition Setup and Control' Window

**Procedure for Configuring the Data Acquisition System to Record**

1. Choose the channels to be recorded from the '[Channel Selection](#)' window.
2. Configure the 'Start Configuration' to turn on and off under the appropriate conditions.
3. Use the 'Get Directory' button to see what files are already stored in the PE3. If necessary, upload data files to the PC.
4. Use the 'Erase' button to remove all existing files from the system and clear memory.
5. The PE3 is now ready to record data once the start condition is met.

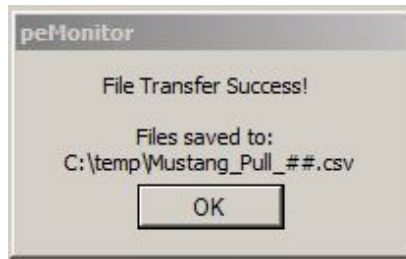
**Procedure for Uploading the Data from the PE3**

1. Click on 'Get Directory' to upload a list of the files on the PE3.
2. Choose the files for upload from the list.

3. Click the 'Get File' button. peMonitor will prompt for a filename and file location. Enter this information and click 'Save'.

**NOTE:** For some versions of Windows, the upload directory MUST be different than the installation directory for peMonitor due to Windows write restrictions.

4. Depending on the number and size of the files, uploading may several seconds. After the upload is complete peMonitor will display a message similar to the following.



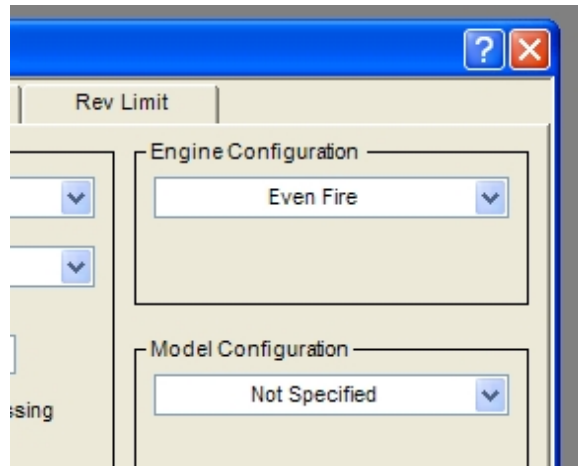
5. The data is now available for viewing in the chosen directory.

## Help Drop Down Menu

The sections below describe the different elements that are located under the 'Help' drop down menu at the top of the main screen in peMonitor.

### **Manual** (*Help* → *Manual*)

The 'Manual' command opens either the pdf version or the Windows help file version of the PE3 manual. In addition to these two versions of the manual, the user can also click on the '?' in any window and then click on a topic in the window to initiate the context sensitive help function (see the '?' in the figure below).



Context Sensitive Help '?' in Window

### **Wire Diagram** (*Help* → *Wire Diagram*)

The 'Wire Diagram' command opens a pdf file of the PE3 wire diagram. A copy of the wire diagram is also included in the back of this manual in ['Wire Diagram'](#).

### **About** (*Help* → *About*)

If the PE3 is online, the 'About' command brings up a window similar to the one shown below. In addition to the version of software, the 'About' window also displays the firmware that resides on both processor 1 (P1) and processor 2 (P2) in the ECU. Also included is the hardware ID, hardware revision level, serial number and IP address of the ECU.

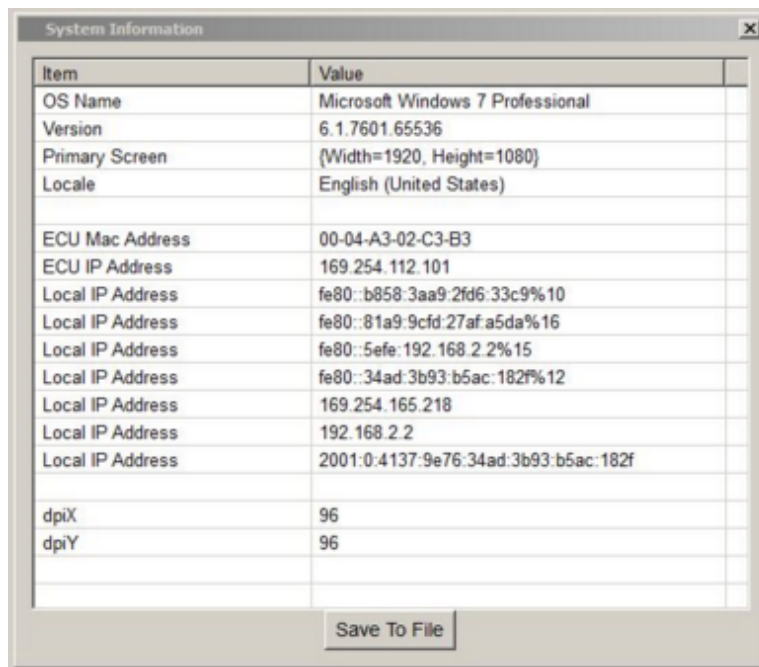
In order for the PE3 to communicate with peMonitor, the version of firmware (P1 & P2) in the ECU must match the version of peMonitor.



Example 'About' Window While C onnected to the PE3

## **System Info (Help → System Info)**

'System Info' is a diagnostic command that is primarily used to collect PC system information. This can be helpful in debugging some communication issues with the PE3. Below is an example 'System Information' window.



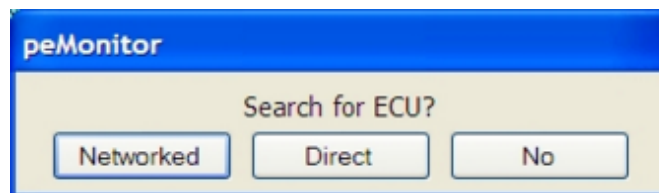
Example 'System Info' Window

## **Update Firmware (Help → Update Firmware)**

Firmware refers to the software that runs in the PE3 engine control unit. At any time, the user can download new firmware to the PE3 controller through peMonitor. Firmware and peMonitor versions are a matched set. You must have the same version of both in order to communicate with the controller. New versions of both the firmware and peMonitor are constantly being released, free of charge, through the PE web page ([www.pe-ltd.com](http://www.pe-ltd.com)).

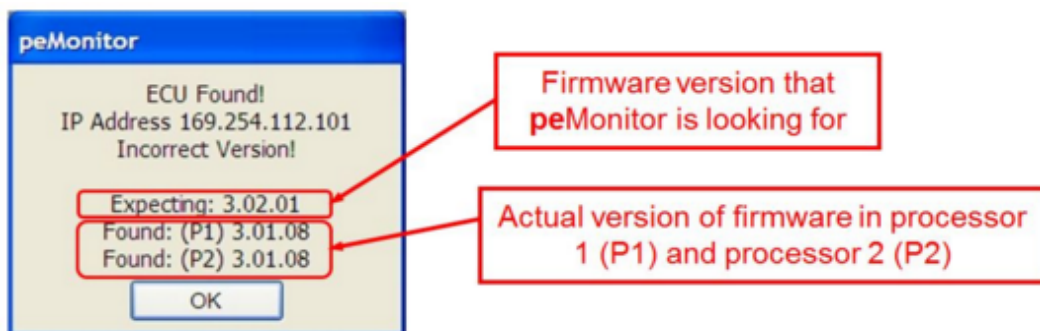
The procedure for upgrading firmware and peMonitor are provided below. Please follow the instructions carefully.

1. This procedure assumes that you are successfully able to communicate with the ECU using a current version of the tuning software and firmware. If this is not the case, please refer to instructions on establishing communication with the ECU.
2. Connect both the Main harness (34-pin connector) and the Communication harness (26-pin connector) to the ECU. Connect the Ethernet connector from the Communication harness to the PC.
3. Before installing the new software, establish communication with the ECU and save your current tuning file to your PC. DO NOT skip this step if you currently have a good tune in the ECU.
4. Power off the ECU and close the current version of peMonitor before continuing.
5. Install the new version of peMonitor on your computer by running the file 'peMonitorInstaller.msi' provided by Performance Electronics, Ltd.
6. Power up the ECU.
7. Start the newly installed version of peMonitor and search for the ECU based on your type of connection. **DO NOT** attempt to download new firmware to the ECU using a wireless connection.



'Search for ECU' Window

8. Because you are trying to establish communication with a newer version of peMonitor, the following error will be displayed. Despite the error, the ECU has been found. Click 'OK'.

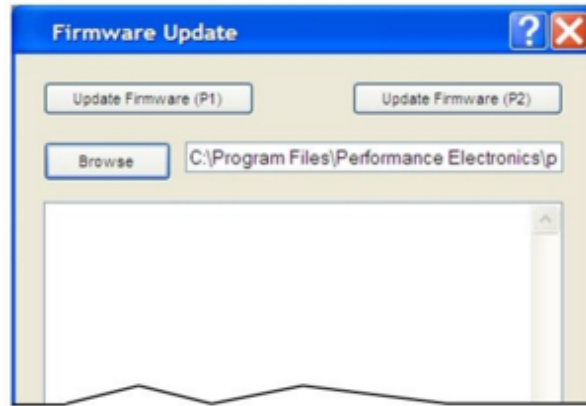


Firmware and peMonitor Version Mismatch

9. If you are updating from a version of firmware that starts with v3.02.## you must erase the PE3 memory before continuing. Do this by going under 'Help', 'ECU

Diagnostic/Reset' and clicking on the 'Reset EEprom' button.

10. In the newly installed version of peMonitor, go under 'Help', 'Update Firmware'. The following window will be displayed.



Firmware File Selection Window

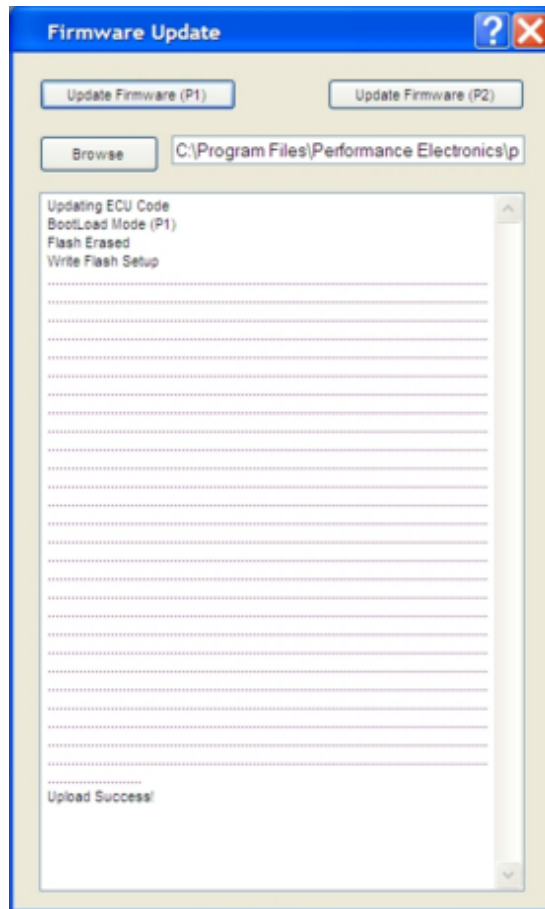
11. Click on the 'Browse' button to search for the firmware file. This will open up the default location of the new firmware. The firmware file is copied to your computer during the installation of peMonitor and will be located in the subdirectory shown below. Select the firmware file, 'pe3.peb', and click 'Open' to select.

**Windows XP and Prior:** C:\Program Files\Performance Electronics\peMonitor vX.XX.XX

**Windows 7:** C:\Program Files(x86)\Performance Electronics\peMonitor vX.XX.XX

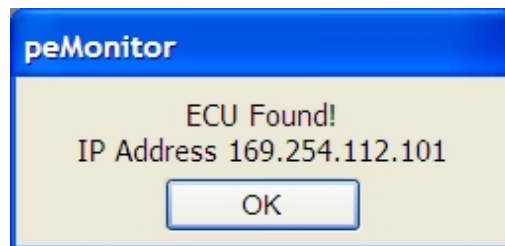
**Where:** vX.XX.XX is the version of peMonitor and firmware.

12. Once you have selected the correct firmware file, click on 'Update Firmware (P1)'. If peMonitor responds with 'ECU Not Found', the ECU is busy transitioning to a download mode. Wait for several seconds and click on 'Update Firmware (P1)' again.
13. After (P1) has finished updating, the message below will be displayed. Click on 'Update Firmware (P2)' to update P2. Once P2 is finished you will be notified that this update was a success also.



Window Showing Successful P1 Upload

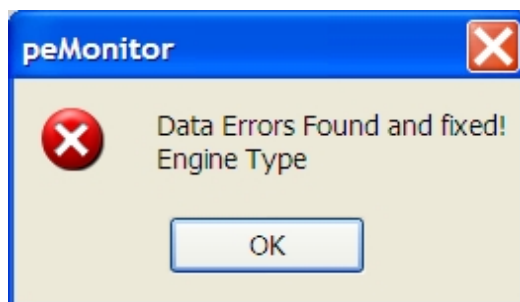
14. After P1 and P2 have updated successfully power down the ECU and close peMonitor.
15. Power the ECU back up and start the updated version of peMonitor. Search for and connect to the ECU. You should now be able to find the ECU and communicate normally.



Successful Communication Window

16. Depending on the differences between the old and new tuning file structure, the following warning may appear after establishing communication. This message lists any data errors that were found and fixed by the ECU. In the case below 'Engine Type' was corrected. Click on 'OK' to proceed.



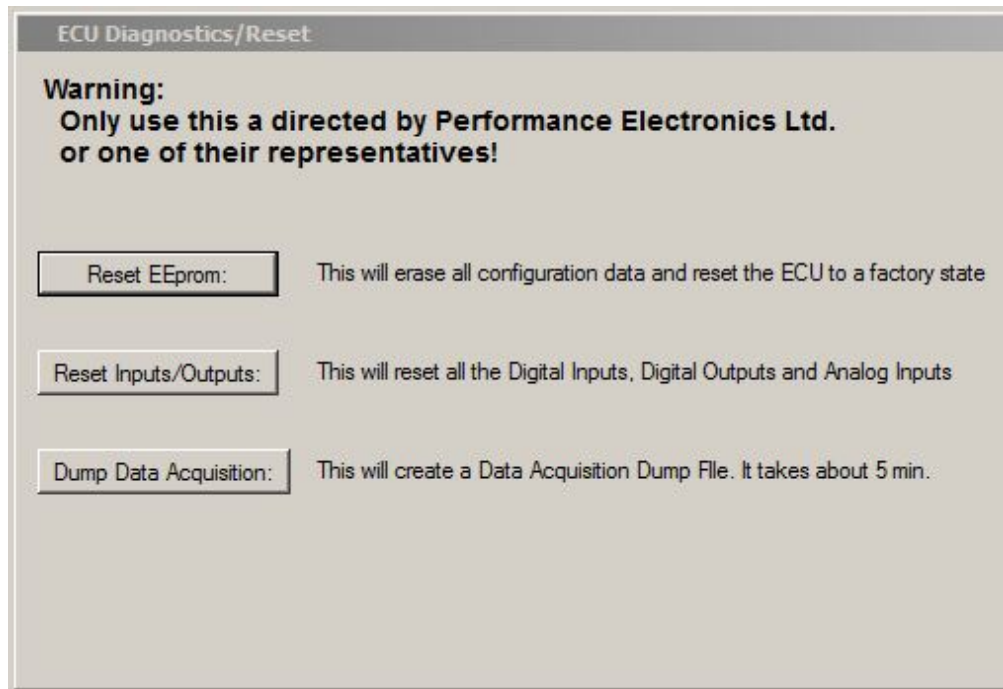


'Data Errors' Warning

17. In order to eliminate any confusion between the old data stored in the ECU and the new peMonitor, it is important to reset the memory in the ECU. Go to 'Help', '[ECU Diagnostics/Reset](#)'. Click on the 'Reset EEprom:' button. This will erase all tuning data and take the ECU offline. Close the 'ECU Diagnostics/Reset' dialog box.
18. Reconnect with the ECU to load in the tuning file that was saved prior to the upgrade. Go to 'Engine', 'Find ECU' and connect to the ECU.
19. Load the tuning file that was saved out before the upgrade ([Open](#) command). The peMonitor may again find and fix potential conflicts between the old tuning file and the new monitor version. Click 'Yes' to send data to the ECU.
20. Save the tuning file to the ECU ([Save Settings to ECU](#) command).
21. It is strongly recommended that you review your tuning file for accuracy and to verify that all data was updated correctly. Please use caution when first running the engine after an upgrade.
22. Format the data acquisition memory to eliminate any data conflicts between the old and new versions of firmware. Go to 'Data Acquisition', '[Setup and Control](#)' and hit the 'Format' button.
23. The upgrade is complete.

## **ECU Diagnostic/Reset (Help → *ECU Diagnostic Reset*)**

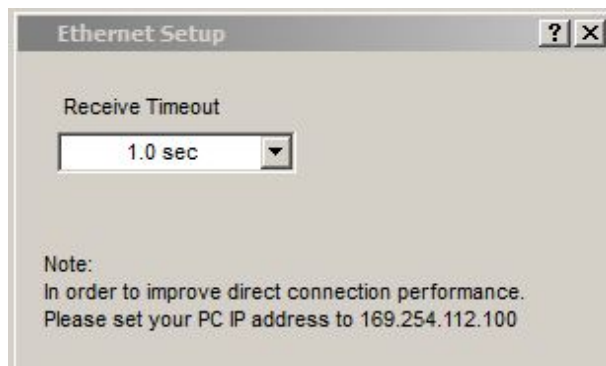
The 'ECU Diagnostic/Reset' window contains some additional diagnostic functions for the PE3. Generally, unless you are instructed to use these as part of a firmware upgrade or by an authorized dealer, you should never use these functions.



'ECU Diagnostic Reset' Window

## **Ethernet Setup (Help → Ethernet Setup)**

The Ethernet setup screen allows the user to adjust the timeout period that the PE3 will wait to receive communication commands before going offline. The default for this timeout is 1.0 sec. Increasing this value can sometimes improve the stability of wireless connections with the ECU.



'Ethernet Setup' Window

# peMonitor Shortcuts

## General Shortcuts

<b>Shortcut</b>	<b>Command</b>
Ctrl+O	Open tuning file from PC
Ctrl+S	Save tuning file to PC
Ctrl+U	Find ECU
Ctrl+Q	Quick find ECU
Ctrl+E	Setup engine
Ctrl+K	Stop (kill) engine
Alt+O	Output diagnostics
Alt+N	Input diagnostics
Alt+T	Trigger/Sync diagnostics
Alt+P	Injector diagnostics
Alt+Shift+S	System status screen
Ctrl+F	Open fuel table
Ctrl+A	Open injection angle table
Ctrl+I	Open ignition table
Ctrl+T	Open target lambda table
Ctrl+L	Open long term closed loop factor table
Ctrl+M	Open closed loop lambda control window
Ctrl+Shift+A	Open air temp compensation fuel table
Ctrl+Shift+C	Open coolant temp compensation fuel table
Ctrl+Shift+Y	Open cylinder compensation fuel table
Alt+Shift+A	Open air temp compensation ignition table
Alt+Shift+C	Open coolant temp compensation ignition table
Alt+Shift+Y	Open cylinder compensation ignition table
Ctrl+Shift+M	Open MAP compensation tables
Ctrl+B	Open battery/barometer compensation tables
Ctrl+D	Open starting/accel/decel compensation
Ctrl+1	Open user input #1 modify fuel/ignition table
Ctrl+2	Open user input #2 modify fuel/ignition table
Ctrl+3	Open user input #3 modify fuel/ignition table
Ctrl+4	Open user input #4 modify fuel/ignition table
Ctrl+5	Open user input #5 modify fuel/ignition table
Ctrl+6	Open user input #6 modify fuel/ignition table
Ctrl+7	Open user input #7 modify fuel/ignition table
Ctrl+8	Open user input #8 modify fuel/ignition table
Ctrl+C	Open user inputs cut fuel/ignition
Ctrl+N	Open ECU notes window
Alt+S	Save settings to ECU
Alt+D	Open engine data header
Alt+U	Open user data header
Alt+F1	Open 3D fuel plot
Alt+F2	Open 3D ignition plot
Alt+F3	Open 3D target lambda plot
Alt+F4	Open 3D long term factor plot
Alt+2	Open 2D parameter plot
Alt+3	Open 3D parameter plot
Alt+R	Open real time plot
Alt+F	Open fuel compensation bar graph
Alt+I	Open ignition compensation bar graph
Alt+C	Close current window
Alt+W	Close all windows

**General Shortcuts (continued)**

<b>Shortcut</b>	<b>Command</b>
Alt+F5	Open data acquisition channel selection window
Alt+F6	Open data acquisition setup and control window
Ctrl+F1	Open manual
F12	Open update firmware window
Ctrl+Tab	Tab between open windows

**Table Manipulation Shortcuts**

<b>Shortcut</b>	<b>Command</b>
Ctrl+Add	Add to highlighted cells in table
Ctrl+Subtract	Subtract from highlighted cells in table
Ctrl+Multiply	Multiply highlighted cells in table
Ctrl+Divide	Divide highlighted cells in table
Ctrl+H	Smooth highlighted cells in table
Alt+Add	Add to the red block in table
Alt+Subtract	Subtract from the red block in table
Alt+Multiply	Multiply the red block in table
Alt+Divide	Divide the red block in table
Ctrl+C	Copy highlighted cells
Ctrl+V	Paste highlighted cells
Ctrl+Z	Undo last action in the table

**3D Plot Display Shortcuts**

<b>Shortcut</b>	<b>Command</b>
+	Zoom in
-	Zoom Out
Page Down	Increase image size
Page UP	Decrease image size

## ECU Mounting and Installation

The PE3 should be securely mounted away from excessive heat and vibration. Care should be taken to place the controller sufficiently away from sources of radio frequency noise such as the spark plug wires and ignition coils. Also, plug wires with some noise suppression characteristics should be used to avoid interference with the electronics. Do not use solid core plug wires as these are known sources of excessive noise.

The PE3 should never be mounted such that it is supporting any mechanical load or rubbing against another object. Failure to do so can lead to electrical failure in the ECU or broken connectors. The example below shows a controller that was internally damaged due to repeated mechanical loading of the ECU case. It is the responsibility of the end user to verify the suitability of the PE3 mounting. Performance Electronics, Ltd. will not warranty controllers that show any sign of external mechanical damage or wear.



Mechanical Damage to the EC U Resulting in Premature Internal Failure

If using a PE3 controller in an aluminum enclosure (non-potted), it is advisable to mount it out of contact with moisture. Doing so will extend the life of the connectors and circuit contacts located on the ECU. Inside the vehicle's passenger compartment is a good location mount the controller.

Please refer to the [Technical Specifications](#) section for environmental limitations.



Aluminum Enclosure PE3 Unit in Optional Mount

## PE3 Technical Specifications

### **PE3 Mechanical/Electrical Specifications**

- Size: 4.3" x 4.8" x 1.2" (11 cm x 12 cm x 3 cm)
- Weight: Both aluminum enclosure and potted waterproof enclosure are approximately 0.8 lbf (0.4 kgf)
- Operating voltage: 6v-22v DC
- Typical operating temperature range (depends on loading): -22°F to 167°F (-30°C to 75°C)

### **5-volt Supply Specifications**

Max Total External Current Draw: 1.0 A (for external sensors)

### **Injector Driver Specifications**

- Type of Driver: Saturated or Peak and Hold low side driver (software selectable)
- Number of Drivers: Up to 8
- Driver Protection: Internally current limited to 10.0 amps per driver
- Maximum Current (before shutdown): 10.0 amps
- Peak Current Maximum: 8.0 amps
- Hold Current Maximum: 3.0 amps

### **Ignition Coil Driver Specifications**

- Type of Driver: Inductive ignition driver
- Number of Drivers:
  - Up to 4 direct coil drivers (no external igniter required, can drive inductive coil directly)
  - Up to 8 smart coil or external igniters
- Driver Protection: Internally current limited to 10.0 amps per driver
- Max Current (before shutdown): 10.0 amps

### **Digital Output Specifications**

- Number of Drivers: Up to 10
- Type of Driver
  - Low side driver, on/off (all Digital Outputs)
  - Pulse Width Modulated (Digital Outputs 1-8)
- Driver Protection: Internally current limited to 3.0 amps per driver or 15.0 amps total for all drivers
- Max Current (before shutdown): 3.0 amps per driver or 15.0 amps across all drivers

### **Dedicated Tach Output Specifications (Pin M-17)**

- Duty Cycle: 30% 'on' (Vbat) and 70% 'off' (0v)
- Voltage: Vbat

### **Digital Input Specifications**

- Active Voltage High: Greater than 3.25 volts



- Active Voltage Low: Less than 2.0 volts
- Frequency Input Range (Digital Inputs 1-4): 0-6000 Hz, Frequency must be greater than 0.5 Hz to register something other than 0 Hz.
- Max Continuous Voltage Input: 22v
- Digital inputs activated with 5-22 volts are pulled low internally (Digital inputs #1, #2, #3, #4 and #5)
- Digital inputs activated with GND are pulled high internally (Digital inputs #6 and #7)

### **Trigger/Sync Input Specifications**

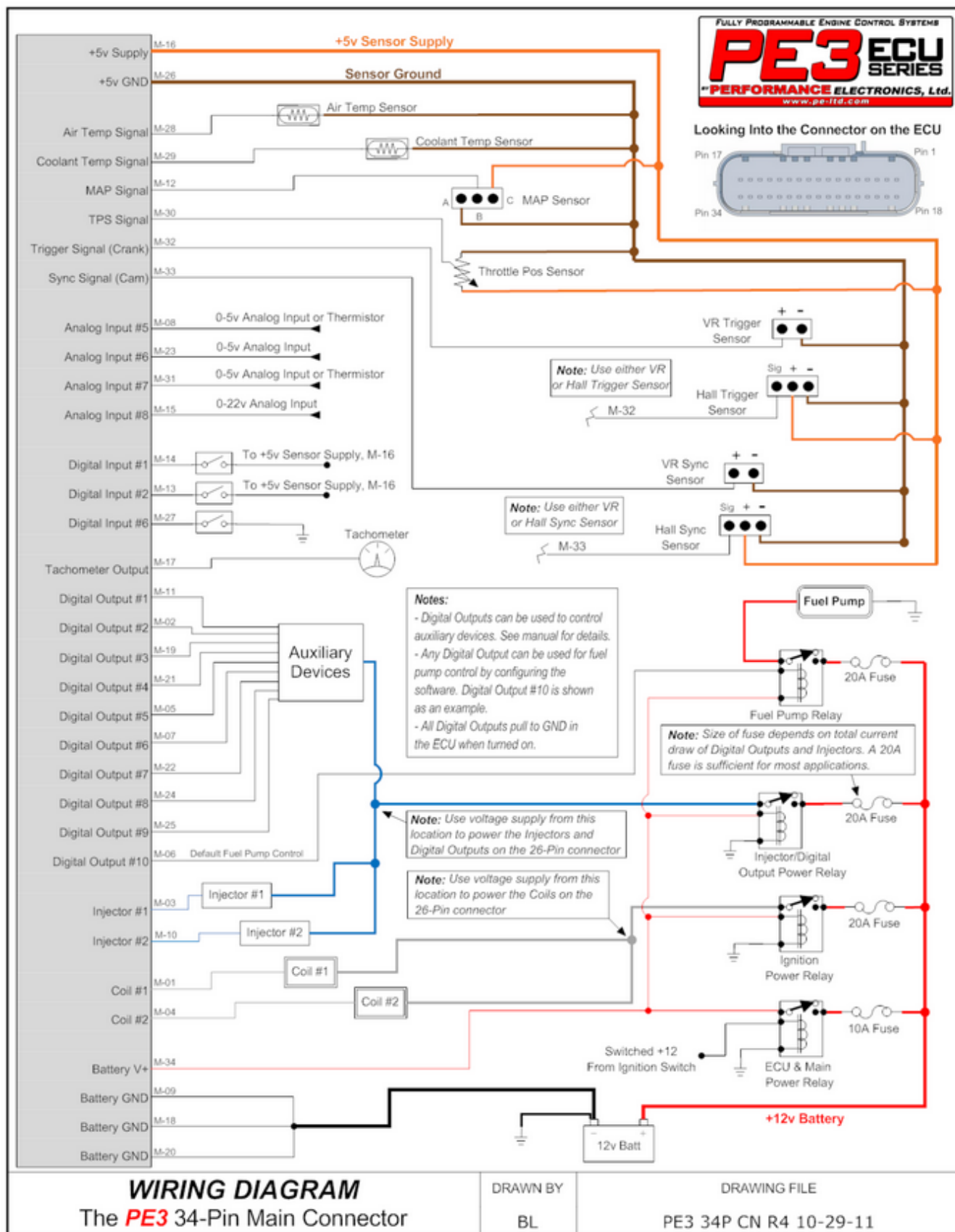
- When Configured as Hall Effect Sensor
  - Max Input Voltage: Up to Vbat
  - Input Voltage Threshold to Trigger: Greater than 4.0 volts high side, less than 400 mv low side
- When Configured as Variable Reluctance Sensor
  - Max Input Voltage: 100 volts
  - Min Input Voltage to trigger: +/- 250 mv (0 to peak)

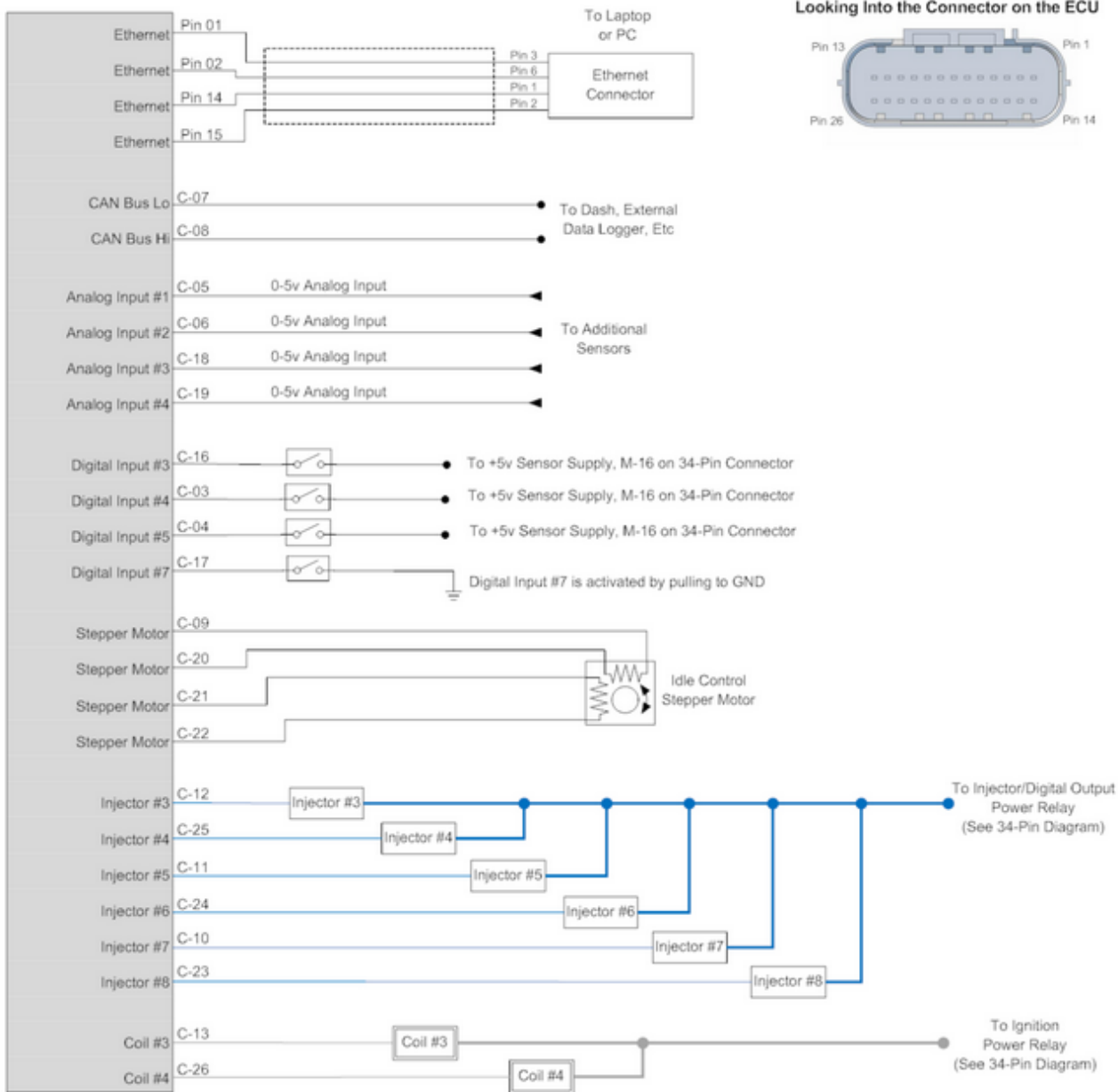
### **Sensor and User Data Filter Characteristics**

- Filter Type: Single-Pole, low-pass digital filter with configurable break frequencies
- Filter Break Frequencies based on the table below

<b>Filter Setting</b>	<b>Break Freq (Hz)</b>
Off	No filter applied
Level 1	73
Level 2	62
Level 3	51
Level 4	40
Level 5	30
Level 6	20
Level 7	16
Level 8	10
Level 9	5
Level 10	4
Level 11	3
Level 12	2
Level 13	1
Level 14	.5
Level 15	.2

# PE3 Wiring Diagrams





**WIRING DIAGRAM**  
The **PE3** 26-Pin Comm Connector

DRAWN BY  
BL

DRAWING FILE  
PE3 26P CN R4 10-29-11

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