HALTECH E6GM

ENGINE MANAGEMENT SYSTEM

INSTRUCTION MANUAL

Contents at a Glance

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Introduction

Congratulations on your decision to install a Haltech Engine Management System to your vehicle. Haltech EFI systems have been successfully installed on thousands of vehicles, from power off-shore boats to twin-turbo Ferraris, from pylon racing aircraft to jet skis and snowmobiles. Over the past several years, many motorsport enthusiasts have discovered that the Haltech computer is easy to use and gets the job done correctly - that job being to reliably make a lot of horsepower and torque in an engine by enabling users to precisely control ignition timing and fuel-air mixture. Precise ignition and mixture control also leads to excellent drivability and fuel economy - something that is often lacking in high-performance carburetored engines.

Haltech users have discovered that the flexibility of the Haltech Electronic Control Unit (ECU) and PC based programming software leads to the easiest possible installation on everything from traditional pushrod V8s to high performance turbocharged racing motorcycles. We are proud of the fact that some of the most respected professional racers and supercar builders in the world use Haltech equipment for the same reasons that Haltech is popular with motorsports enthusiasts: it is flexible and friendly; is installed easily; and you can tune your Haltech simply without having to make the project a major research effort.

Installation Overview

The Haltech E6GM system utilises a special-purpose programmable microcomputer designed for engine management. The E6GM system is designed to plug directly into your existing GM wiring harness, making installation easy. The standard ECU is removed and replaced with the Haltech E6GM ECU, and you're ready to start re-tuning your engine. Also included in the system is a special short wiring harness that connects into the back of the ECU (for access to communications port and special inputs), plus programming software and cable for you to tune the system includes the ECU, engine sensors, and a special wiring harness to connect them, plus programming software and cable for you to tune the system.

With the Haltech system installed, you tune it by connecting the ECU to an IBM compatible PC via the supplied communications cable. The Haltech Programming software allows you to configure and modify the ignition and fueling data stored in the ECU: it's as simple as adjusting the heights of the bar graphs displayed on your PC screen. Collectively, the bar graphs form the "Maps" that instruct the ECU how to inject fuel and when to fire the spark under different conditions. The programming software has been designed to be functional, "friendly" and intuitively easy to use.

When the time comes to start your engine, the base fuel map already loaded in the system could get you going immediately. If not, a little alteration with some assistance from this manual should get your vehicle running. You then work on fine tuning your maps to suit your engine exactly. An air:fuel ratio meter and a dyno make tuning easiest, but many people use the traditional method of "seat of the pants" feel and tuning by ear, possibly checking spark plug colour as an indication of fuel mixture. Whichever method you use, you will find that the ability to instantly change mixtures by the stroke of a key, or the twist of a knob, will make tuning your Haltech system far easier than tuning a carburetor or mechanical injection system, and with much better results.

Before You Begin...

1) **IT IS BEST TO READ THIS ENTIRE MANUAL BEFORE STARTING.**
At the very least, you should read **Section One** of the manual, and any of the Appendices that are relevant to your installation. The greater your knowledge of the operation of the Haltech system, the easier you will find it to understand what you are doing, and why.

2) Read any additional material accompanying this manual that updates the document since it was written.

3) You may need special parts or additional tools or test equipment in order to complete installation. Make sure you have these items on hand before you begin to avoid frustration. Contact your Haltech dealer if you have difficulty.

4) Don't do the minimum work possible. Carelessness in the early stages of installation can cause you major headaches later on, be it in a few days' or a few months' time. Carelessness will cost you money and frustration in finding and fixing unnecessary problems. You have the opportunity to make sure your Haltech system's operation is extremely dependable and easy to use by doing it right the first time.

There is another reason to exercise care during this installation. You will be dealing with explosive fuel under pressure, electricity and considerable heat. Inside the combustion chamber, this is a happy combination. In the garage, they are not. The same kind of danger exists when working underneath a jacked-up car. Please be careful.

Avoid open sparks, flames, or operation of electrical devices near flammable substances.

Always disconnect the Battery cables when doing electrical work on your vehicle.

All fuel system components and wiring should be mounted away from heat sources, shielded if necessary, and well vented.

Make sure there are no leaks in the fuel system and that all connections are secure.

Disconnect the Haltech ECU from the electrical system whenever doing any arc welding on the vehicle by unplugging the wiring harness connector from the ECU.

5) Electromagnetic interference (EMI) from unsuppressed spark plugs and leads can cause the ECU to fail. Please do not use them.

6) In hot climates, or with turbocharged engines, you may need to employ heat shielding to prevent heat soak and damage to electrical and fuel parts. Use the coolest surfaces of the chassis as a heat sink for components and use thermally conductive brackets where appropriate.

7) We recommend having your system tuned by professionals. An exhaust gas analyzer and fuel pressure meter make tuning vastly easier and help avoid potentially disastrous lean out conditions that could destroy your engine. Should you wish to tune this unit yourself, make sure you have some reliable means of determining if your engine is running lean.

Note: In this manual, reference will be made to MAP (Manifold Absolute Pressure - as in MAP sensor) and the fuel maps stored in the ECU. Both are common industry terms, with entirely different meanings.

How It Works

While the technology involved with electronic fuel injection is complex, the underlying principles of its operation are really quite straightforward. The object of any fuel delivery system in a gasoline engine is to determine the amount of air being drawn by the engine, and supply the appropriate quantity of fuel to "burn" all the oxygen in that mass of air.

A carburetor uses primarily only one parameter to determine fuel metering: air speed. Higher air speeds through the carburetor result in larger pressure drops across the venturis, and thus more fuel is sucked through the jets.

Electronic fuel injection revolves around the use of solenoid actuated injectors. These devices employ a coil attached to a valve. When the coil is energised, the valve opens and fuel is allowed to flow. As long as the pressure between the fuel and the air in front of the injector nozzle is held constant, the rate of fuel flow will remain the same. By accurately controlling the length of time the injector remains open, precise quantities of fuel can be metered to the engine.

Since we have no convenient means of directly measuring the amount of air entering the engine to determine the amount of fuel to deliver, we use a number of engine parameters to determine an injection opening time. We build a table that breaks the engine's operation into a series of rpm ranges. At each range, we consider the load on the engine, using either the position of the throttle or the manifold pressure as a reference to the load on the engine.

Collectively, the ranges in this table (also called a look-up table), form a *map* of the volumetric efficiency for the engine. Our standing assumption, therefore, is that for any combination of engine speed and load, we have a direct reference to the amount of air that is being drawn into the engine by means of this map.

The Haltech E6GM uses a digital microcomputer to measure engine speed and load, and uses them to access the *base fuel map*. The base fuel map is a look-up table of injector opening times stored in non-volatile memory i.e. when power is switched off, the contents of the memory are retained. By using the programming software, the contents of this memory can be changed so that you can match injector opening times to the injectors you are using, and to suit the requirements of your engine.

Having determined the base injection time, the microcomputer then performs a number of adjustments to this value. Corrections for air temperature and barometric pressure are applied, since these variables affect the density of air. Extra injection time is also added, when necessary, for transient throttle movement and the temperature of the engine. At the end of all these calculations, the final injection time is determined: the time for which the injectors are actually held open.

Injection pulses usually occur one or more times per engine cycle. The ECU uses a trigger signal locked to engine speed in order to determine when to inject. When it receives an appropriate trigger, the ECU applies a magnetising current to the injector coils for precisely as long as the final computed injection time, providing an extremely accurate delivery of fuel that will exactly suit the engine's needs.

The ignition timing is determined in a similar way to the fuel needs. The Haltech E6GM ECU has a look-up table configured in the same way as for the fuel, but instead of the fuel delivery in the table the Ignition Map contains the Ignition Advance for that point. This means that the ignition point can be controlled with much greater accuracy then ever possible with bob-weights and vacuum advance in a distributor.

Haltech E6GM Specifications

Engine Suitability

- up to 16,000 rpm
- 1, 2, 3, 4, 5, 6, 8, 10, 12 cylinders
- normally aspirated or supercharged up to 200 kPa (30 psi)
- load sensing by throttle position or manifold pressure
- multipoint injection. (Batch-fire and Staged injection patterns available by special order)
- distributed ignition systems, or direct fire systems with 1 to 4 coils

NB: Sequential and Direct Fire can not be used together.

Power Requirements

- **Power Source**
  8.6 to 16 Volts DC
- **Consumption**
  Haltech ECU: 270 mA at 12 Volts
  Injector Load: Dependent on injector type
  approx. proportional to injector duty cycle
  (typically 0.6 Amps per injector)

Physical Specifications

- **ECU Dimensions**

Length:	190 mm (7 1/2")
Width:	147 mm (5 3/4")
Depth:	41 mm (1 5/8")

- **Weight**

ECU:	760g (1.68 lb)
Loom:	100g (0.3 lb)
Shipping Weight:	1.5kg (3.3 lb) (Including manual/packaging)

ECU Outputs

- **Injector Driver**
  4 x 4/1Amp peak-and-hold current limiting drivers:
  - up to four low-impedance injectors*
  - up to eight high-impedance injectors*
  (Expandable using optional Driver Box. See Appendix C)
- **Ignition Output**
- **Fuel Pump Control**
  Features automatic priming and switch-off.

System Programming Requirements

- **Computer**
  IBM-PC or compatible, preferably laptop or notebooks
  CGA, EGA or VGA, colour or monochrome display
  640+ kb RAM

- **Disk Drive**
  3.5" Floppy Disk Drive
  (5.25" disk available on request)

- **Serial Port**
  Standard RS232C port - 9 pin D connector
  (25 pin cable available on request)
  COM1 or COM2 (selectable)

Adjustable Features

- **Base Fuel Map**
  22 Fuel ranges, every 500 RPM to 10,500, or
  17 Fuel ranges, every 1000 rpm to 16,000
  32 Load points per range, up to 16mS with 0.016mS resolution

- **Ignition Map**
  22 Ignition ranges, every 500 RPM to 10,500, or
  17 Ignition ranges, every 1000 rpm to 16,000
  32 Load points per range, up to 50° advance, with 1° resolution

- **Correction Maps**

  - **Fuel**
    Cold Start Prime - 32 points
    Coolant Temperature Enrichment - 32 points
    Air Temperature Adjustment - 32 points
    Battery Voltage Correction - 32 points
    Closed Throttle (selectable) - 16 points
    Full Throttle (selectable) - 32 points
  - **Ignition**
    Crank Advance - 32 points
    Coolant Temperature Advance/Retard - 32 points
    Air Temperature Advance/Retard - 32 points

- **Programmable Rev-Limit** - selectable as either fuel or ignition

· **Fuel Cut on Deceleration**

- **Accelerator Pump**
  Increase and sustain parameters
  Coolant enrichment factor
  Three speed ranges

- **Idle Speed Control**
  Target Idle Speed
  Cold Idle-up Rpm
  Post-start Rpm setting

- **Closed Loop Control**
  with both cruise and idle settings

- **Torque Converter Clutch Operation**

- **Thermofan Control**

- **Air Conditioning Control**

Miscellaneous

- **Map Storage and Retrieval**
  Maps may be stored to disk and re-used

- **Datalogging**
  Engine data information saved 5 times per second
  Store to memory or disk
  Limited only by available memory (approx. 11k/minute)

- **US or Metric Units**

- **Real Time Programming**
  Instant, hesitation free adjustment while engine is running

· **Optional Mixture Trim Module**
  Provides ±12½% or ±50% adjustment for fast tuning

· **Optional Ignition Trim Module**
  Provides -8° to +7° adjustment for fast tuning

- **Rugged Aluminium Casing**
  Black anodised with integral cooling fins and mounting brackets.

SECTION ONE
Getting Started

CHAPTER 1
Haltech E6GM Installation

1.1 Overview

The Haltech E6GM system comprises the following components

- Haltech Electronic Control Unit (ECU)
- Supplementary Wiring Harness
- Haltech E6GM system Instruction Manual
- Programming Cable
- Programming Disk

Optional Items

- Fuel Mixture / Ignition Timing Trim Control
- Replacement Manifold Pressure Sensor (MAP)

1.1 Installation Guide

1.1.1. Electronic Control Unit (ECU)

The Haltech E6GM is not designed to be waterproof. It is desirable that the ECU be given as much protection from the environment as possible. It is recommended that the ECU be mounted inside the passenger compartment, either on the firewall, under the dashboard or under the passenger seat.

The ECU has four mounting holes that allow it to be mounted to most flat surfaces. In extreme cases of vibration, the ECU should be mounted on rubber antivibration pads. When mounting the ECU remember that the communications connector on the loom should remain accessible for ease of programming.

Unplug the Delco ECU and plug in the Haltech ECU.

1.1.2 Install and connect the Supplementary Wiring Harness

This small harness connects into the back of the ECU. It provides connection to functions that are not available on the standard main connector. These are the two trim inputs (fuel and ignition) and the communications port. The harness is only about a foot long and can be removed once tuning is complete, and the communications port and trims are no longer required.

CHAPTER 2
Getting Online

Now that your Haltech E6GM is installed the system can be connected to the programming computer. This will allow the readings from all the sensors to be displayed on the screen and checked for correct operation.

To connect the PC to the Haltech E6GM ECU you will need the programming cable and programming disk supplied.

2.1 Connecting the Haltech E6GM to a Computer

The programming cable supplied with the Haltech E6GM is a standard serial link extension cable. One end of the cable will plug into the Main Harness **PC Interface** connector (near the main connector). The other end should plug into the mating connector at the back of your computer. The plug on the computer may be marked "Serial", "Mouse" or "COM". Almost all laptops will have this plug. If there is no 9 pin plug which it will connect to, check to see if there is a 25 pin D-type plug available (some desk top computers will have this). If this is the case, an appropriate cable can be supplied on request. Alternatively, most electronic retailers will have a 25-pin to 9-pin converter.

Any time you wish to communicate with the E6GM ECU it needs to be supplied with power. This usually involves just turning on the ignition switch. If at any stage power is not on, or the programming cable is disconnected while attempting to communicate, the programming software will display the message RECONNECT HALTECH. To rectify this, reconnect power and/or the programming cable.

2.2 Operating the Software

2.2.1 Computer Requirements

The computer required to program the Haltech E6GM can be any IBM-PC compatible personal computer from the XT onwards (i.e. the AT, 386, 486 or Pentium computers). The requirements are fairly modest. The computer must have at least 640K of RAM (with about 590kb free for executable programmes), one 3.5" disk drive and a CGA, EGA, or VGA screen. (Virtually all reasonably modern laptops running MS-DOS (version 5.00 or higher) will fit this description).

2.2.2 Installing the Software.

The Programming Disk supplied with the Haltech E6GM has an installation programme that allows you to install the software onto the PC's Hard Disk. Most modern PCs have a hard disk. If your PC does not have a hard disk, the E6GM Programme can ran directly from the disk supplied. Installing the software on the Hard Disk will speed up the programme and avoid having to fiddle around with floppy disks. The installation programme need only be run once.

If you do not have a Hard Disk, go to the section section titled **Running the Software from the Floppy Drive**.

To install the software follow these steps.

Boot up Computer

Turn your PCs power on and boot up MS-DOS as instructed by the computers Users Manual. If a shell programme or menu utility runs automatically when you boot your computer, exit it now. You should see something like this:

C:\>_

This is the 'DOS Prompt'. It is DOS' way of indicating that it is waiting for a command. The **C:** indicates that the C drive is the drive currently selected. If you do not have a hard disk, your prompt will probably look like this :

A:\>_

Select the Drive

To run the INSTALL programme, you must insert the supplied disk in the disk drive. If the drive is the A drive, then it must be currently selected. To select the A drive (or B drive if it is the required drive) type :

a : ¬ or **B : ¬**

The ¬ key is the Enter Key. On some keyboards it may be called the Return key. You should now see the prompt :

A:\>_ or **B:**\>_

Run the INSTALL Programme

To run the Install programme type :

i n s t a l l ¬

The Install programme will now run. Follow the instructions given. The programme will suggest that the software will be placed in the HALTECH directory. You can change the destination directory, but it is not recommended that you do unless you understand how directories work. When it is finished, the installation programme will tell you if the installation is successful. If it was not, consult the trouble shooting section of this manual.

The E6GM Programme is now ready to run.

2.2.3 Running the Software from the Hard Disk.

Boot your computer up as described earlier. If your computer is already on, make sure the C drive is currently selected. To change to the HALTECH directory type :

c D \ h a l t e c h ¬

or, if you used a different destination directory, type that path.

To start the programme type :

E 6 GM ¬

The E6GM programme will now run. The next section is on running the software from a floppy drive. You can skip this section and go straight to the section entitled **Azerty Keyboards**.

2.2.4 Running the Software from the Floppy Disk.

To run the software from a floppy drive, boot your computer up as described earlier. Insert the Programming disk in the disk drive. If the drive is the A drive, then it must be currently selected. To select the A drive (or B drive if it is the required drive) type :

a : ¬ or **B : ¬**

You should now see the prompt :

A:\>_ or **B:\>_**

To start the E6GM programme type :

E 6 GM ¬

The E6GM programme will now run.

2.2.5 Azerty Keyboards

Most countries use a keyboard where the first six letter keys across the top row are :

q w e r t y

This is called a Qwerty keyboard. Some countries use an alternative, which is called and Azerty keyboard, where the Q and W keys are swapped with the A and Z keys respectively. If you have an Azerty keyboard, you need to run the software slightly differently. When you would normally type :

E 6 GM ¬

to run the programming software (not the installation software), you need to instead type :

E 6 GM / a ¬

The /A tells the programme you have an Azerty keyboard. The programme will adjust accordingly.

2.2.6 Acknowledging the Risks

Once the program begins running a title page should appear briefly and then a warning screen will be displayed. Read the warning and only proceed if you are prepared to accept the risks involved in tuning your own engine. Faulty tuning can be dangerous and/or can damage your engine.

2.3 The Online and Offline Modes

On the E6GM system title page, the software asks whether to operate in ONLINE or OFFLINE mode. The Offline mode is very useful to familiarise yourself with the Haltech software, but should not be used to make lasting adjustments to the fuel maps unless there is a special reason for doing so. If you wish to experiment and familiarise yourself with the software press N for Offline mode, but if the ECU is installed and power is available then we suggest the Online mode be selected. Press Y to select Online mode.

2.4 Using the System Online

In the Online mode there is a two-way flow of information between the ECU and the programming computer. The communication cable must be installed and power must be available to the ECU before the system can communicate. The Online mode will be used most frequently. While using the system Online, you can view engine information directly and make adjustments. Any changes or modifications made on the computer are instantaneous and will be immediately recorded in the ECU. When the programming cable is removed and the ignition switched off, the ECU will retain all of its memory. The maps do not need to be saved, but keeping a copy on disk is always good practice and is recommended. (See 9.1)

NOTE: If power is removed or the communication cable is disconnected or interfered with, the following message will be displayed on the computer screen.

RECONNECT HALTECH

If this message appears check all connections and ensure that the communications cable is not being interfered with. Also be sure that the Haltech E6GM unit is receiving power. (i.e.. ignition switch is turned "on".)

2.5 The Main Menu

When you select Online or Offline mode the Haltech MAIN MENU bar appears. This menu bar allows access to submenus giving access to maps, file storage/retrieval, engine data and options.

2.6 How to Quit

Throughout the program you can exit from any application by using the menu bars or hot keys. Pressing § q in any page will prompt you to exit the program (i.e.. pressing q while holding down the § key).If you wish to exit Y press at the prompt.

2.7 Checking the Engine Data

The engine data option can only be used when the system is Online. This function allows all of the engine data variables to be displayed on the screen

This is a very useful function for analysing the engine sensors. To bring up the engine data press § e from any application. Otherwise it can be accessed through the menu bar by pressing ¦ O and then E for Engine Data.

Do not attempt start the engine if the Engine Identification has not been set up. Before continuing check to see if all the sensors are operating correctly by viewing the engine data page.

CHAPTER 3
Engine Identification

3.1 Checking the Identification

The Identification page tells the E6GM essential information about the engine characteristics. Without this information being correct the engine cannot run properly. The Identification is made up of several *fields*. Each field can have a number of settings, and you can change most of the fields.

Use the Up and Down arrow keys (¢ and £) to move between fields. The fields are either *Selection* type, or *Text* type. The Selection type fields give you a number of valid entries for that field. For example, the valid number of cylinders can be set to 1, 2, 3, 4, 5, 6, 8, 10 or 12. The Tab and Enter keys (© and ¬) keys are used to change this type of field. Each stroke of the Tab key will display the next selection. The Shift and Tab keys together will step backwards through the selections. Once the desired selection is displayed, the Enter key is pressed to programme that selection. Text Fields require you to enter either text or numbers. Once the field is selected, the new text can be typed in, with the Enter key to finish. An example is the Rev Limit. This field can be set between 2000 and 16000 rpm. If you want the rev limit to occur at 7000rpm, then you would need to select this field using ¢ or £ and then type 7 0 0 0 ¬ .

Here is a description of each of the Identification fields:

Cylinders: The number of engine cylinders needs to be entered here. This parameter is used to determine the engine speed.

Load Sensing: The E6GM can use either the manifold pressure or the throttle position as a means of determining the engine load. Most engines operate using manifold pressure to sense engine load. If your engine employs any form of supercharging, you must run in manifold pressure mode. Only wild cams require throttle mode - i.e.. engines whose vacuum signal is small, or fluctuates greatly. If you are unsure what to use, contact your Haltech dealer.

MAP Sensor: The E6GM needs to know the type of Manifold Absolute Pressure (MAP) sensor being used. If you do not know what sensor you have refer to Chapter 1 [1.3.1]. Enter the correct description here to match. If using throttle position mode, set this parameter to a 1 Bar sensor.

RPM Limit: The E6GM can limit the maximum rpm to which the engine will operate to. Above this level the E6GM completely cuts fuel or ignition (see below) to the engine. When the engine speed drops below the RPM Limit the E6GM will resume normal fuel or ignition delivery. This is known as hard limiting. If the RPM Limit is not needed then set this value above the highest operating point of the engine.

RPM Limit Type: The RPM Limit can either be a fuel cut or an ignition cut. This field determines what form of limit will be used. Be careful using an ignition cut on an engine with a catalytic converter, as the unburnt fuel can damage it.

Units: The Haltech E6GM programming software can display parameters in either Metric or US units.

RPM Mode: The E6GM fuel and ignition maps may be arranged either in 500 rpm increments to 10,500 rpm, or in 1000 rpm increments to 16,000 rpm. Select the high - or low - rpm mode here. Changing settings alters the way the ECU reads the Maps, and will change the tuning of the engine dramatically. Do not change this setting once tuned unless necessary.

Road Speed Value: This value calibrates the Road Speed reading. Some applications in Advanced Mode can not use the Road Speed input trigger, and this field will not be displayed.

Trim Control: The optional Trim unit can be used to control one of several parameters. This field selects the controlled parameter. If there is nothing connected to the trim plug, the trim will have no effect (except with boost control). The available functions are :

Fuel (Fine)	±12.5% adjustment of fuel.
Fuel (Coarse)	±50% adjustment of fuel.
Ignition	+7 to -8 degrees adjustment of ignition advance.

Spare Input Function: The Spare input is an analogue input similar to the Trim Control input that can be configured for one of several tasks. Its function is set by this field. The available functions are :

General	0-5 volt input; no effect on ECU operation.
Fuel (Fine)	±12.5% adjustment of fuel.
Fuel (Coarse)	±50% adjustment of fuel.
Ignition Trim	+7 to -8 degrees adjustment of ignition advance.
Baro Sensor	Barometric Pressure Sensor.
Exhaust MAP Sensor	Exhaust Pressure.(does not affect on ECU operation)

Care must be taken when setting this field. The circuit is biased to 2.5 volts. Therefore, if there is nothing connected to the plug, the input will read 2.5 volts. If one of the trims is selected, there will be no effect. But if the Barometric Sensor is selected, the reading will be incorrect, and will have a large effect on the operation of the ECU.

2nd MAP Sensor: This field is only accessible when the Exhaust MAP Sensor is selected on the Spare Input Function. It tells the software what sensor is being used (either 1 Bar, 2 Bar, or 3 Bar sensor) and how to calibrate the reading.

Chapter 4
Adjusting Haltech Maps

The tutorials presented in this chapter are examples of how you might use the available functions to make typical modifications to the maps. These tutorials are aimed at explaining both why and how some typical changes might be made. They assume that you have the software running Online on your PC, with the ECU powered and connected via the supplied programming cable.

4.1 What are maps?

The injection times needed by the engine at different conditions is stored by the E6GM in a table of numbers called a look-up table. The E6GM determines the engine's load and speed, and uses these two parameters as an index to the table. This table is called the Fuel Map. For instance, at an engine speed of 4000 rpm and at -20kPa, the relevant number in the table may be 4.35. If the engine approximates -20kPa at 4000 rpm, then the computer will extract the value of 4.35ms from the table as the base injection time. This value is then adjusted to compensate for numerous conditions, such as temperature or acceleration, and then the ECU holds the injectors open for that time on the next injection.

The Ignition Maps work in a similar way, except that it is the ignition advance that is stored in the look-up table instead of the injection time.

It is possible to programme the E6GM by directly changing the value of each number by programming in the numerical mode, but this can be extremely difficult, so the Haltech allows you to change the numbers by manipulating graphics in maps presented as bar graphs. (This is much simpler and allows you to visualise the map)

Since it is difficult to interpret all the table's values at once, the programming software divides the map by engine speed into a series of rpm ranges. Within the range, each load point is represented by a vertical bar. Thus, when you view a range from the Fuel Map, you see a bar chart of injection time versus load for all the load points in the table at that speed.

There are other tables in the E6GM, such as those used for temperature corrections. They are indexed by only one parameter, and so are not divided into ranges. These tables are also called maps.

4.2 What is mapping the Engine?

Mapping the engine is filling the look-up tables with the correct values for your engine. This is done by adjusting the heights of the bars within the maps. Bars may be adjusted one at a time, or in groups. The Haltech programming software has been designed to make engine mapping as simple and intuitive as possible.

4.3 Using the Software

In order to make the software easy to use, the programme presents you with a menus bar at the top of the display. The menu bar is accessed through simple combinations of key strokes. Once the appropriate menu has been accessed a sub-menu appears giving choices on available page heading. To increase efficiency there is also a number of hot-keys that allow you movement between pages without accessing the menu bar.

4.4 Accessing the fuel maps

Pressing ¦ m will take you to the Maps Menu. From the Sub-menu choose the fuel maps option. By using the cursor keys to move the highlight bar or pressing the underlined letter of the option required in the case F. This will produce a further sub-menu that will allow you to choose a range to be viewed.

4.4.1 Fuel Setup

The Fuel Setup works in an identical way to the Identification. It's fields are different and relate to the way the fuel is delivered to the engine. Enter the Fuel Setup by pressing ¦ s and then by pressing F key. The fields in the Fuel Setup are:

Ign / By: Ignition Divide By is the number of ignition pulses that will be counted until the next injection pulse. For almost all multipoint systems, injection should occur once per revolution and so Ignition Divide By should be set to half the number of cylinders. If the system is operating in Batch Fire or Sequential mode, or is a rotary, then a value of 1 is suggested.

Decel Cut-Off: A common fuel saving feature in original equipment computers is a fuel cut-off on deceleration. This will cut fuel delivery to the engine while coasting down hills with closed throttle. This feature can be enabled or disabled on the E6GM. It is better, when first tuning, to disable this function.

Zero Throttle Map: This feature allows the user to adjust a special fuel map that is used only when the throttle is closed. This can allow a very quick and simple adjustment of the idle fuel settings on engines with difficult idle characteristics. This option can be disabled if not required.

Full Throttle Map: This feature allows the user to adjust a special fuel map that is used only when the throttle is wide open on normally aspirated engines. With some manifold and or throttle designs, pressures in the manifold can reach close to atmospheric pressure before full throttle is applied. This effect can make tuning difficult around full throttle. This map allows the full load settings to be easily set without interfering with lighter load settings. The throttle position at which this Map is used is set by the Full Throttle Threshold field.

Full Throttle Threshold: See the Full Throttle Map field above for information on this field. This field can be set between 70 and 100.

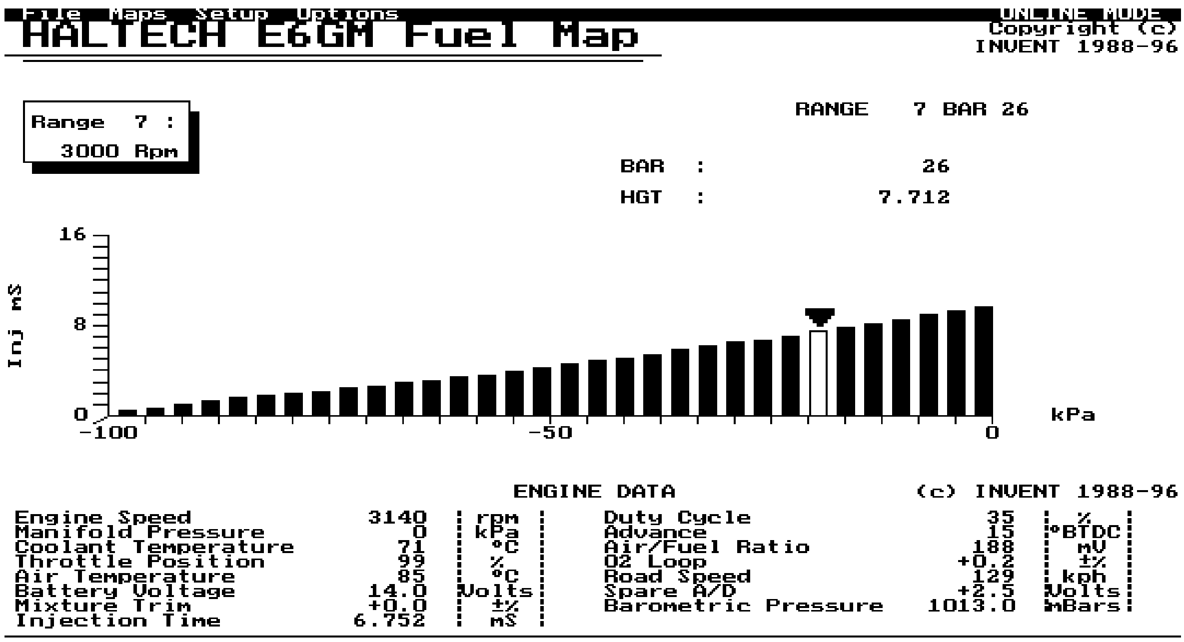
Barometric Lock: If you wish to lock the barometric value that is stored by the ECU to a set value and overide the startup barometric correction, enable this option.

Barometric Pressure Lock at (mBars): Allows you to set the barometric value to which the ECU corrections will be locked. Default is 1013mBars (= 1 Atmosphere @ sea level)

See Chapter 3, **Engine Identification** for information on how to adjust these parameters.

Once you have set up the fuel delivery via the Fuel Setup, you can view the Fuel Maps. Press ¦ m then F to view the Fuel Sub-Menu. Then chose the range you wish to view by using the function keys. While in the Fuel map, each range can be accessed by pressing the N, P and J keys to move to the next, previous range and jump to a particular range.

To view the map at the 3000 rpm range, press “ . When in the Fuel Maps sub-menu your display should look like this:



Values from this bar chart would be used whenever the engine speed falls in the range between 2750 and 3250 rpm (or, if in high-rpm mode, between 2500 and 3500 rpm).

In the top left is the range number and the speed range to which it corresponds. Opposite, in large numerals, is the current engine rpm. The bar chart shows injection time, up to 16ms, against the load parameter, either throttle position or manifold pressure. The axes are scaled appropriately from the information in the Identification Page. Across the bottom of the screen is written the number and height of the bar being adjusted, and other engine data. Above the engine speed reading is the Range and Bar number that the ECU is currently using to calculate injection time.

4.4.2 Adjusting Bar Height In The Map

The height of the Bars in the map can be readily adjusted by using the up and down arrows keys, and the PgUp and PgDn keys (³ ´). See the command summary at the end of this section for a full list of key functions. The bar that is highlighted on the computer screen indicates the bar that you are currently adjusting. To change the highlighted bar, use the left and right arrow keys (¥ ¤).

Try pressing the Up arrow (£) once. Notice that the outlined bar gets taller. Now try pressing the Down arrow (¢) once. You are now changing the fuel delivery at 3000 rpm at the load shown for the bar you have selected. Make sure you move the bar back to its original height once you have tried adjusting it so as not to destroy the map you have loaded.

Now try using the ³ key. The outlined bar should jump up 0.096 mS. As the bar gets taller, the fuel delivery is increased and the engine is enriched at that speed and load. Now press the ´ key and the highlighted bar should move down 0.096 mS.

Note that the fuel delivery for the outlined bar is shown in the bottom corner of the display. Note also that the injection time does not necessarily match the bar height as the injection time is the actual injection time after various corrections have taken place. Also, the arrow indicates the bar (i.e. number) currently being accessed by the engine. If the arrow was not over the highlighted bar this would also cause the bar height and injection time to be different as the bar height is the height of the bar being adjusted, not necessarily the value of the bar currently being accessed by the engine. Try using the Control key and the Page Up key together, § ³ ,to move the bar up by 2mS. Move the Bar back down by using § ´ .

The changes you made took effect the instant you pressed the keys. You do not have to do anything else to save these changes.

4.5 How To Quit

To return to the Fuel Map Menu from any of the map display pages press § f .Or through the menus at the top of the display. Pressing § q keys simultaneously at any page or map will allow you to exit the Haltech program and will return you to MS-DOS. You should always exit the program before switching off your computer.

4.6 Accessing the Ignition Maps

Pressing ¦ m from any page will take you to the Maps Menu. From here you choose I for the Ignition maps. Or you can access the ignition maps directly through § I from any other application.

4.6.1 Ignition Setup

The Ignition Setup works in an identical way to the Identification. Its fields are different and relate to the way the ignition advance is determined for the engine. Enter the Ignition Setup by pressing ¦ S then I. The fields in the Ignition Setup for Basic Mode are:

Trigger Degrees : This field tells the ECU where to expect the Main Trigger to occur. This field is very important for the correct operation of the ignition. If it is incorrect, the spark advance will also be incorrect, which could lead to engine damage. The ECU needs to receive an input trigger at a fixed engine angle Before Top Dead Center (BTDC) for each spark. This trigger may be set between 60° and 100° BTDC. See Chapter 5 [5.2-3] for detail on how to check the timing and this field.

Lock Timing at 10 Degrees: This field is used for testing the trigger input. It allows the timing to be locked at ten degrees regardless of the engine speed and ignores the ignition map settings. This feature is further discussed in **Appendix E**

Trigger Edge : This field determines whether the E6GM is to trigger on a rising or a falling edge. Refer to **Appendix E - Trigger Interface** for details on how to determine this setting. If a Reluctor Adapter is being used, this field should be set to Falling.

Output Type: This field is used to determine how the ignition output signal is to be defined. *Constant Duty* should only be used with "intelligent" igniters or special aftermarket systems that perform dwell control. *Constant Charge* may be selected if the igniter operates simply as a switch ("dumb" igniter) and require dwell signal.

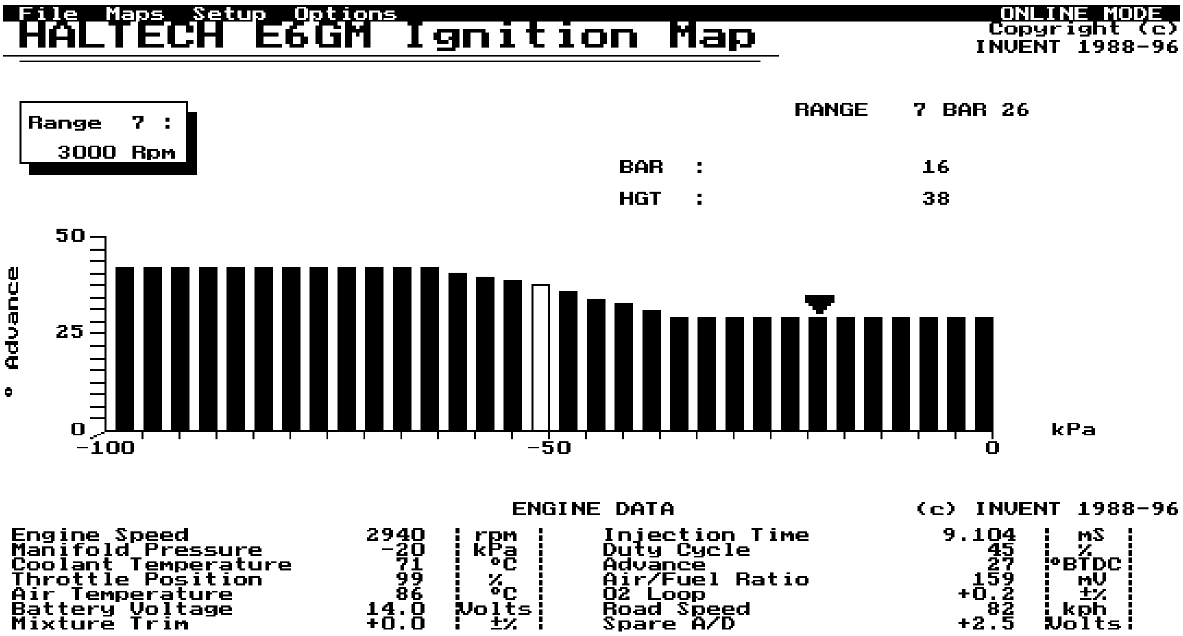
Coil Charge Time: Only required if Constant Charge selected as Output Type. This is the time require to charge the coil fully, or until the igniter's current limit is reached, typically 4-5 ms. Refer to Appendix E for additional information.

Coil Break Time: Only required if Constant Charge selected as Output Type. This is the minimum time the E6GM should allow before the coil is switched on again, usually 1-2 ms. Coil Break Time defines the ignition output signal when there is insufficient time to charge the coil fully. Refer to Appendix E for additional information.

Output Edge: The Output Edge should be falling with a 30% switch unless advised otherwise by material relevant to your application.

The Ignition Map is adjusted in a similar way to the Fuel Map. The keystrokes are the same, except that one increment is one whole degree advance or retard. The best way to initially set up the Ignition Map is to use the Library Maps, and then return to the Ignition Map later if the ignition curve needs modification. Ignition Library Maps are explained in Chapter 5 [5.4], Starting the Engine.

An example of an ignition range for a naturally aspirated engine could look like this :



4.7 Time Saving Functions

The following list of commands can be used whenever the graphs for most of the maps are being displayed by the Haltech programming software.

Note: When two keys are displayed together, such as ¦ r , this means that the second key must be pressed while the first key is held down. In this case, the ¦ key would be held down while the r key is pressed.

4.7.1 Current Location - ²

Pressing ² will take you to the range at which the engine is running, and highlight the bar that is currently being used. This bar is easily identified by an arrow directly above it pointing down. As the engine speed and load changes, the arrow moves with it. The Home key is useful for finding the engine's operation point very quickly.

4.7.2 All Ranges - ¦ r

Across the ranges, the curve of the fuel map does not change greatly. Usually the shape remains much the same, and the height changes according to the volumetric efficiency of the engine. In order for all the fuel ranges to initially be set up quickly, the Haltech E6GM system allows you to programme all rpm ranges simultaneously with the same data. ¦ r turns *All Ranges* on, and the words All Ranges appears under the title.

When the *All Ranges* function is active, a bar adjusted on one graph is copied to the same bar on all the ranges. If you use this option, you can set the shape of the map at any range, and all other ranges will be identical at every bar you adjusted. This feature enables all graphs to be given an initial shape that should run the engine, albeit rather roughly. Once you have used the *All Ranges* option for a starting point, press ¦ r once more to exit the *All Ranges* option and tailor each map individually.

This option is only available on the Base Fuel and Ignition Maps.

4.7.3 Selecting Groups of Bars

Groups of adjacent bars may be highlighted and adjusted together.
Hold § while using the left or right arrow keys, ¥ ¤ , and you will highlight a group of bars. This group will now act in unison when increasing or decreasing the height of the Bars. To deselect the highlighted Bars use the ¦ and arrow keys together.

4.7.4 Percentage Changes - ¦ p

Using this function will prompt you to enter a percentage change to the selected bars. An entry of "20" will increase each bar by 20%, while an entry of "-15" will decrease the bars by 15%. This change only affects the highlighted bar(s).

4.7.5 Linearise - ¦ l

When a group of bars is selected (more than two), this function can be used to set the values between the end points. Highlight the bars between two load points that are known to be correct and press ¦ l. The programming software will automatically adjust all the bars between the two endpoints to form a straight line. This feature facilitates fast programming and the smoothing of maps.

4.7.6 Numeric Mode - ¦ n

This will take you into numerical mode, displaying the map as a spreadsheet. This mode is available if wanted, but graphical mapping is recommended as it is much easier to use. To exit from Numeric Mode and go back to using the maps press the ° key.

4.7.7 Bar Increments - ¦ i

The Up and Down arrows, £ ¢, normally change the bar height in the maps by a pre-determined amount, usually the smallest possible increment. PgUp and PgDn change the bars also by a pre-determined amount. These increments (the value of the keystroke) can be changed by the user. ¦ i will bring you to a screen where the increments themselves can be changed.

Normally, the bars are altered by adding or subtracting a fixed amount. The adjustment keys may instead apply a percentage change on each keystroke. ¦ p on the Bar Increment Screen will switch to percentage increments, § f will return you to fixed increments.

¦ l will space out increments evenly between the Up/Down Arrows field and the Ctrl PgUp/PgDn field.

4.7.8 Help Function - ¦ h

A simple help screen can be pulled up at any time by pressing ¦ h. All key commands are summarised and listed here.

4.8 Duty Cycles

Fuel delivery is obtained by pulsing the injectors synchronised with the engine speed, allowing fuel to flow during the period that the injector is open. The time whilst open is called the injector pulsewidth. As rpm increases it is possible for pulsewidths to overlap so that the injectors are effectively switched completely on. This is referred to as 100% duty cycle.

When 100% duty cycle is reached the fuel flow from the injectors has reached its maximum. Increasing revs brings with it the danger of an engine lean out. LEANING OUT AN ENGINE WILL CAUSE DAMAGE TO THE ENGINE IN MOST CASES.

The tables and graph below show the point at which the injectors will reach 100% duty cycle. **Care should be taken that the engine cannot rev above the point when 100% duty cycle is reached as there is a danger that damage will be caused to the engine.** It is not common for this to happen but the potential for damage under these circumstances is strong so care should be taken to check this factor.

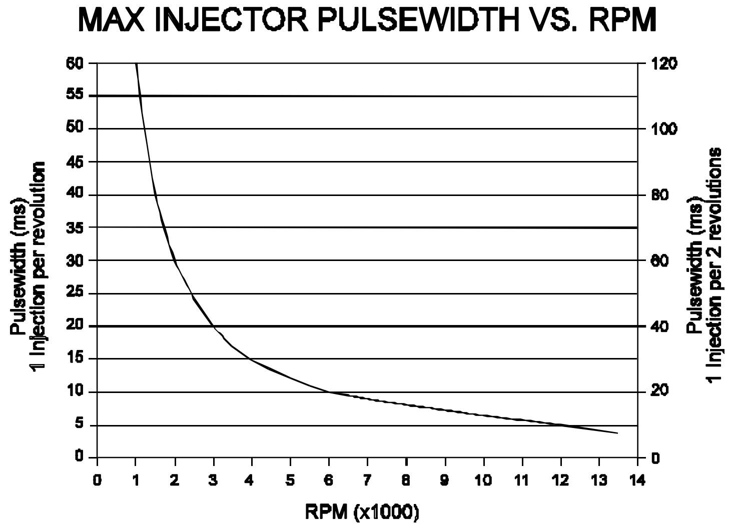
Maximum Injection Time (in milliseconds[ms]) =

$$\frac{(120{,}000 \times \text{IgnDivideBy})}{(\text{Rpm} \times \text{No. Cylinders})}$$

e.g. Maximum injection time for a four cylinder, on ign/by 2 red-lining at 6000 RPM is

(120,000 x 2)/(6000 x 4) = 10,

so the absolute maximum injection time at 6000 RPM on this engine is 10 ms. If the injection time needs to be greater than this, then your fuel system cannot meet the demands of the engine. You will need to increase the fuel supply, by increasing injector size, fuel pressure, or adding extra injectors. Refer to Appendix C for details on how to increase fuel supply. As a general rule of thumb, injectors should not run beyond 85% duty cycle.



Injector Duty Cycle appears on the Engine Data Page and on Datalogs for you to monitor the approach to maximum fuel flow.

MAXIMUM INJECTOR PULSE WIDTH VERSUS ENGINE SPEED

SPEED (rpm)	1 Inj / Rev (ms)	1 Inj / 2 Rev (ms)
1000	60.00	120.00
1500	40.00	80.00
2000	30.00	60.00
2500	24.00	48.00
3000	20.00	40.00
3500	17.14	34.29
4000	15.00	30.00
4500	13.33	26.67
5000	12.00	24.00
5500	10.91	21.82
6000	10.00	20.00
6500	9.23	18.46
7000	8.57	17.14
7500	8.00	16.00
8000	7.50	15.00
8500	7.06	14.12
9000	6.67	13.33
9500	6.32	12.63
10000	6.00	12.00
10500	5.71	11.43
11000	5.45	10.91
11500	5.22	10.43
12000	5.00	10.00
12500	4.80	9.60
13000	4.62	9.23

4.9 Command Summary for Maps

¥ , ¤	- move left/right highlighted bar(s)
£ , ¢	- increase/decrease highlighted bar(s)
³ , ´	- increase/decrease highlighted bar(s)
¨ ³ , ¨ ´	- increase/decrease highlighted bar(s)
§ ³ , § ´	- increase/decrease highlighted bar(s)
§ ¤ , § ¥	- select (highlight) next bar
¦ ¤ , ¦ ¥	- deselect end bar
¦ P	- enter Percentage change to highlighted bars
¦ L	- Linearise between end points of highlighted bars
¦ H	- bring up Help screen
¦ I	- set Increments
¦ N	- enter Numeric mode
¦ R	- toggle All Ranges mode
N	- move to Next range
P	- move to Previous range
J	- jump to range of value entered
²	- go to current engine range/bar
©	- switches option in setup pages

Chapter 5
Starting the Engine

There are a few things that need to be done before the engine should be started. Make sure that the ECU is powered (ignition on) and the Haltech Software is Online. Go to the Engine Data Page to check that the ECU is communicating properly, and that the sensors are reading correctly. Check again that the Identification, the Fuel Setup and the Ignition Setup are all set correctly. In particular, check the No. Cylinders, Ign Div/By, Load Sensor and Injection Mode parameters. If any of these are incorrect, the engine may run, but proper tuning will be impossible.

5.1 Calibrating the Throttle Position Sensor

The throttle sensor must be calibrated so that the ECU knows the start and stop positions of the sensor. Set the idle throttle opening using the idle adjust screw. If the required opening for idle is not known, make an estimate but keep in mind that this may be the reason for poor idle later on, and further adjustment may be needed. Choose the "calibrate throttle" option from the options menu and follow the instructions on the screen.

5.2 Checking the trigger

It is a good idea to check that the E6GM is receiving a reliable trigger signal. Remove the 20A fuse from the fuse block. This will prevent the fuel pump from running and the engine from starting. The engine should then be cranked over on the starter and the rpm displayed on the engine data page should read about 100 to 300 rpm. If the engine speed is zero or is erratic then refer to the section in Chapter 1 [1.3.14] regarding trigger setup. If the trigger is operating correctly then replace the 20A fuel pump fuse.

5.3 Checking the Base Timing

The E6GM uses a timing reference taken from either the cam angle sensor or flywheel sensor. This give the E6GM the reference on which to position all ignition timing. If the timing is wrong then the E6GM cannot function correctly. To ensure that this base timing is set correctly the E6GM has a **TIMING CHECK FLAG**

When the Timing Check Flag is set, the ignition timing is forced to 10° Before Top Dead Center (BTDC). This is regardless of whatever ignition timing Maps are currently in the E6GM.

To enable this flag, press ¦ S from the Sub-Menu select the Ignition Setup. Using the arrow keys move to the Timing Lock option. If it reads **Timing Check On**, the flag is enabled. If it reads **Timing Check Off**, then the flag is disabled. The flag is toggled by pressing © . If the Timing Check is on, the ECU will lock the timing to where it believes 10° advance to be.

To check the base timing you should now start the engine with the Timing Check on. The engine should now start and run although with only 10° of ignition advance the idle speed may be lower than usual.

<u>If the engine does not start</u> it may be because the fuel requirements are not right. If this is the case, it is suggested that you remove the 20Amp fuse for the fuel pump and do the timing check while cranking. This will require two people : one to crank the engine and one to operate the timing light. It can be difficult to check the timing accurately at cranking speeds. Removing the spark plugs will help the engine to rotate at an even speed. Once you have checked the timing at crank, leave the Timing Check on, skip the next section on loading an Ignition Library Map and go to the section on Determining Engine Fuel Needs. Once you have the engine starting and idling, return to this section, check the timing again, and then load the Library Map.

Use an ignition timing light to check that the ignition timing is set to 10° BTDC. See the workshop manual for your engine for details on checking ignition timing and the use of a timing light.

The timing should be locked at 10° BTDC. If it is not then the angle at which the ECU is being triggered is not the same as the angle in the **Trigger Degrees** field in the Ignition Setup. If the timing is miles out, go back and check all the angles again. If you have guessed the trigger angle, try and calculate it properly. Remember that the angle is in crank degrees, not distributor degrees. Also make sure the the trigger edges are correct. These can have a very large affect on the trigger angle.

If the angle is a little out, it is just a matter of aligning up the actual trigger angle with the angle in the **Trigger Degrees** field. There are a few ways to do this :

If the timing reference is taken from a distributor, then you may be able to rotate it while using the timing light until the engine is at 10° BTDC. Be wary about adjusting the base timing in this manner by any more than a few degrees as it can upset the rotor phasing. For details on rotor phasing, see Appendix F.

If the reference is taken from a cam angle sensor (such as in a distributorless direct fire engine), then if it is possible, rotate the sensor while using the timing light until the engine is at 10° BTDC. With a cam angle sensor, there is no need to worry about rotor phasing.

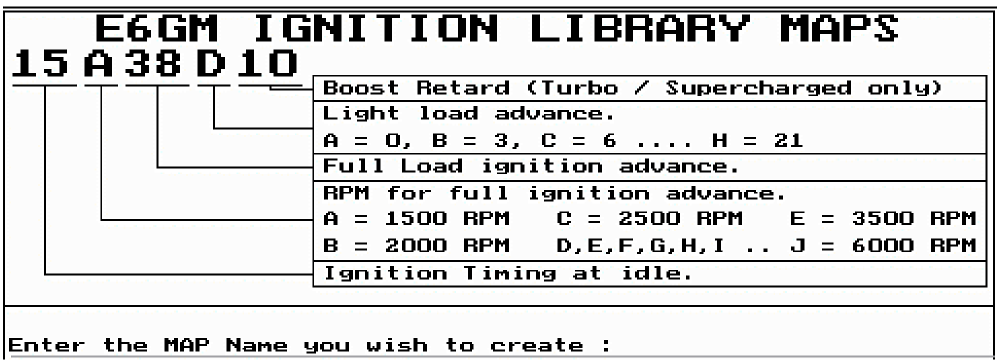
The last method is to change the **Trigger Degrees** field in the Ignition Setup. (See the previous Chapter for details on how to change this field). If you are using a crank angle sensor then this is the easiest way to adjust the base timing. The Trigger Degrees field tells the ECU where the trigger is occurring. Once the ECU receives this trigger, it calculates how many engine degrees to delay until it has to fire the spark. For example, if the trigger is at 70° BTDC, and the Timing Check is on, the ECU will delay 60° and then fire the spark at 10° BTDC. If however, the trigger was actually at 80° BTDC, but the Trigger Degrees had a value of 70, the ECU would still delay the 60° and the engine would fire at 20° BTDC. Changing the value of the Trigger Degrees field to 80 would increase the delay from 60° to 70°, and the engine would now fire at 10° BTDC. When adjusting the parameter, do so in small steps, say 5 or 10 degrees at a time. This will allow you to check that you are moving in the right direction.

You must now ensure that the timing does not move as the engine speed changes. Give the engine a few quick revs while using the timing light to check that the ignition timing stays at 10° BTDC. If the base timing is locked at 10° BTDC and does not change with engine speed then you are ready to load an Ignition Timing Map and clear the Timing Check Flag.

If the ignition does change with engine speed then see the Troubleshooting procedure in Appendix A

5.4 Loading an Ignition Library Map

The E6GM has an effective and time saving method of programming the ignition curve using Library Maps. Each ignition timing Map in the library is slightly different. By becoming familiar with the library you should be able to select an ignition timing Map that will suit your engine. Each ignition timing Map in the library is accessed by a different name. The name reflects the characteristics of the Map. Names can be up to eight alphabetic or numeric characters in length. The ignition timing library Maps use these eight characters as shown, where the first character is always a number.



- The first two characters in the ignition timing Map name specify the ignition timing to be used at idle. The example Map name shown has 15 degrees of advance at idle.

- The third character in the ignition timing Map name specifies the Rpm at which maximum advance occurs (i.e.. how quickly advance changes with engine speed). This character is a letter of the alphabet. Option A has full advance in by 1500 Rpm. Option B has full advance in by 2000 Rpm. Option C at 2500, etc. up to J for 6000 Rpm.

- The fourth and fifth characters in the ignition timing Map name specifies the maximum advance at atmospheric pressure. Cruise or light load advance is added to this value, while retard on boost for turbocharged or supercharged engines is subtracted from it.

- The sixth character in the ignition timing Map name specifies the extra ignition advance to use at light loads such as highway cruise. This is equivalent to the vacuum advance on a distributor. If this character is A, there is no extra advance under light load. Each successive letter of the alphabet after A adds 3 degrees of ignition advance to the full load advance under light load, up to the letter H. (H = 21°)

- If the engine is turbocharged or supercharged then the seventh and eighth characters specify the ignition retard the engine is to get under boost. This value is subtracted from the atmospheric pressure advance value. If the engine is not turbocharged or supercharged, then leave the name only six characters in length.

A description of each parameter is displayed on the Library Maps page to save you referring to this manual.

As mentioned above, it is suggested that the timing be checked before starting the engine. If the ECU successfully locks the timing at 10° then you should load a library map that will get the engine started. Try be conservative : you should not be looking to gain the last few percent in performance immediately. If you know the factory settings for idle, vacuum and full load advance for your engine you can use those values to load an extremely effective Library Map.

5.5 Determining Engine Fuel Needs

You should now be ready to start the engine. At this stage, you should not be using the Zero Throttle Map. Check that it is disabled in the Fuel Setup. Go to the Fuel maps and display the 0 rpm range. During cranking, the pointer will appear across this page, until the engine speed picks up and lifts into the 500 and 1000 rpm ranges. Press the 2 key to jump to the current load point immediately.

If you are using manifold pressure as the load sensor, the engine will be close to atmospheric pressure during cranking. If you are using throttle position, then the E6GM will be using bar 1 while cranking and idling. Once the engine is tuned, you should not need to apply any throttle to get the engine to fire. When cranking the engine watch for the indicator arrow over the bars. This will tell you what bar the E6GM is using to calculate the fuel. The bars that the arrow indicates are the Bars that will need to be adjusted to get the engine to run.

If the engine is not firing at all, check that spark is available. Also check that the spark plugs are clean and are not wet. It is unwise to crank on the starter motor for extended periods. The engine should fire and run within the first few seconds of cranking.

If the engine misfires and blows black smoke then the mixture is rich and the bars need to be lowered. If the engine will not fire or fires but will not continue to run then the mixture could be lean and the bars need to be increased.

5.5.1 Tuning for Idle

The idle mixture is very sensitive to correct bar height. Idle injection times are usually around 1.5 to 2.5 mS. If the injection time at idle is much lower than this, it may become difficult to set accurate idle and cruise air:fuel ratios.

If the engine is hunting at idle, then the map is probably too lean, particularly at the 500 rpm point. Watch the movement of the map arrow carefully. The map arrow should remain stable while the engine is idling. If the arrow is moving excessively in a MAP based system, then it may be necessary to use the Zero Throttle Map.

Remember that the E6GM interpolates against both rpm and load. If the engine is idling at 800 rpm, then the injection time is computed as 60% of the value from the 1000 rpm range, and 40% of the value from the 500 rpm range, so both ranges would have to be adjusted to get the correct mixture. Similarly, if the idle mixture is reacting poorly to changes of the bar indicated by the map pointer, then try adjusting the adjacent bars. Wait for the engine to heat to operating temperature before performing further changes to maps.

5.5.2 Tuning with No Load

Using the throttle only, increase the engine speed to 1000 rpm. If the engine is at exactly 1000 rpm then only that range needs to be adjusted. Adjust for the crispest engine response. Engines will usually idle rich, then head towards stoichiometric mixture at higher speeds. Repeat for 1500, 2000, 2500, 3000 etc. The engine should now start and fast-idle evenly. You should also have the engine running at operating temperature before going further. Go to the Engine Data Page at this point and check all the sensor inputs are reading correctly, and that the temperatures have stabilised before continuing.

While free-revving at higher engine speeds, check the Engine Rpm reading on the computer. If it becomes erratic, or fails to follow the actual engine speed correctly, check the section in Chapter 1 on setting the trigger. Also make sure that the information in the Identification and Setups is correct.

5.5.3 Loading the Engine.

Once the engine has been tuned properly for no load conditions it is possible to begin loading the engine. The best method of applying load to the engine is using a dynamometer. However, if access to a dyno is not possible the engine can be tuned on the road.

5.5.4 On the Dyno

Whether the vehicle is on a chassis dyno, or the engine on an engine dyno, the principles of programming the Haltech E6GM are the same. Take the engine rpm up to 1000 and apply partial load and adjust the 1000 rpm range. Return the engine to idle and on the 1000 rpm range adjust the bars to draw a straight line from the idle point through the part load setting tested. Continue, adding more load, up to the full load settings. This should be a fairly good approximation to the required curve. Repeat this for the 1500 range, 2000, 2500 etc. The engine should be fairly drivable at this point.

Full load tuning should be approached with caution. An engine at full load that is too lean may begin to detonate and destroy pistons and crankshafts. Before loading the engine, increase the heights of the rightmost bars so that they are higher than the line projected by drawing a straight line from the idle and free-rev settings and through the part-load settings. **Run the map rich, and lean it to the correct mixtures. Do not run the map lean and attempt to enrich to the correct mixtures.**

5.5.5 On the Road

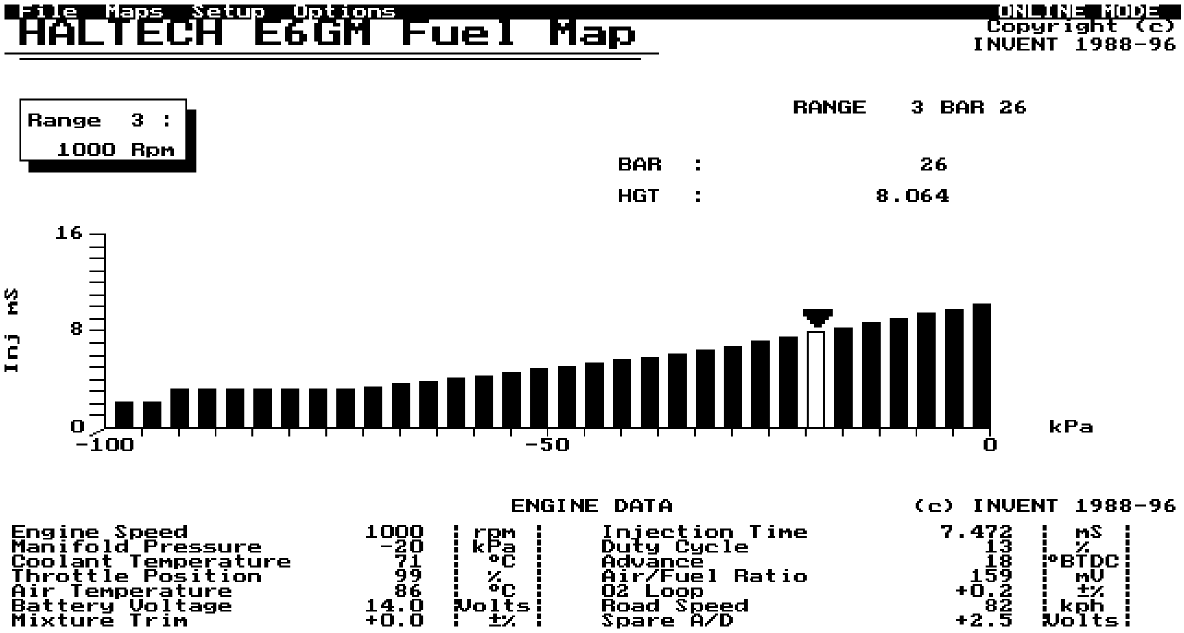
Tuning on the road is similar to tuning on the dynamometer, but with hills, acceleration, gear-ratios and brakes providing the necessary retarding force. Although it is harder to maintain constant load and speed, it is still possible to use the same procedure used on the dyno. It will be necessary to have one person drive while another does the tuning.

Load the engine by selecting an appropriate gear and either driving up a constant grade hill, applying the brake or handbrake. **Be very careful using the brake to load the engine. The brakes can get very hot and suffer from brake fade (reduced braking capability) and the cars handling may become unstable. All road testing should be done at low speed.**

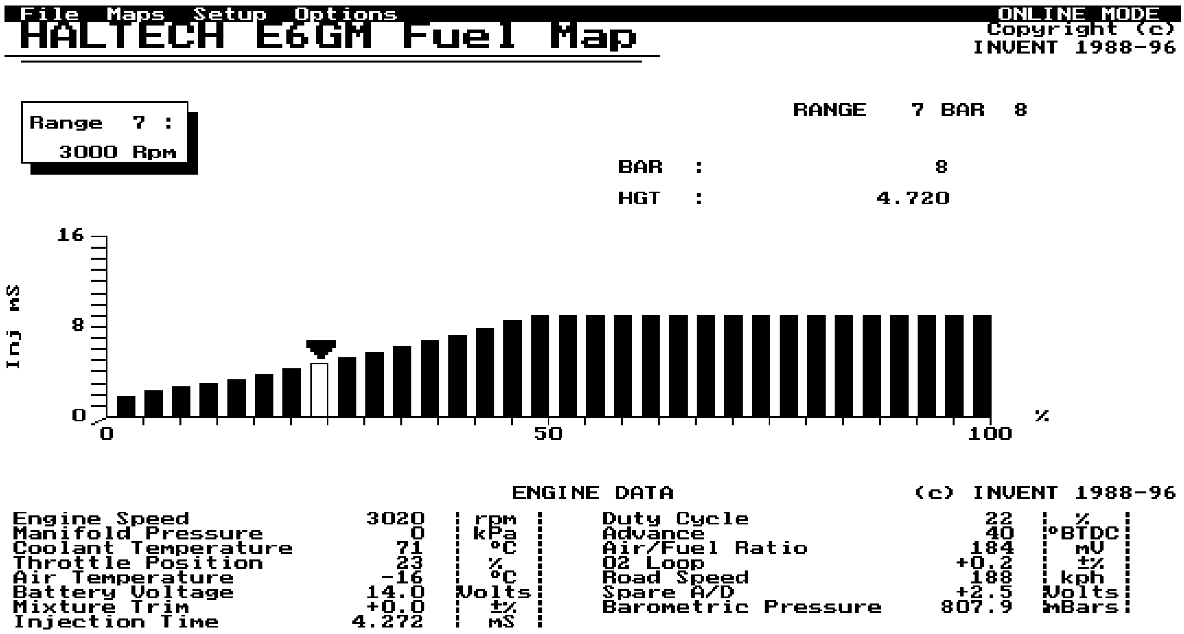
5.5.6 Fine Tuning the Engine

When fine tuning the engine for the road, the same principles apply to all engines. Under full load at all rpm the fuel mixture should be rich. On non turbo cars an air to fuel ratio of around 12.5:1 to 13.5:1 is usually best (high performance turbo vehicles may go as low as 10.5). When cruising (light to medium load) the mixture should be as close to stoichiometric (best mixture) as possible and decelerating conditions may allow the engine to be run lean to save fuel. This will result in a particular shape for the map. A typical map is shown below. The absolute values will vary greatly, but the shape should be similar.

Note: All maps for all engines should be smooth. A map with a "lumpy" curve is most likely wrong. If, when you have finished tuning, the map does have lumps in it, try to make it visually smooth.



Above: a typical fuel curve for a naturally aspirated engine at idle speeds.
Below: a typical fuel curve for a TPS mapped engine.



SECTION TWO
Other Adjustable Features

Chapter 6
Throttle Effects

6.1 Throttle Response

Where the procedures described in the previous chapter tune for constant load running, the functions outlined in this section will improve the throttle response of your engine.

The manifold pressure sensor used with the E6GM is very fast. It can respond much faster than is required to track any sudden changes in load on your engine. The manifold pressure seen at the sensor input does not change as quickly, due partly to the length of the connecting pipe. This can be improved by keeping the length of vacuum hose between the inlet manifold and the pressure sensor as short as possible. Even with very short vacuum hose lengths there may still be a lag between a transient pressure occurring and the pressure reaching the sensor.

Further, when the throttle is cracked open, the sudden change in pressure forces fuel out of atomisation and onto the manifold walls, so it fails to enter the combustion chamber properly atomised, and the engine hesitates. This can be corrected by adjustment of the Throttle Pump parameters.

To overcome any lean out during sudden throttle movement, the Haltech system uses a throttle accelerator pump function. This function delivers extra fuel during sudden throttle movements. The Throttle Pump is accessed from the **Fuel Maps and Setup Menu**.

Six single bars will appear on the screen. The two bars on the left are used below 1500 rpm. The two bars in the middle operate between 1500 and 3000 rpm and the two bars on the right are used above 3000 rpm. These bars set the amount of extra fuel that will be added to the current fuel value during a sudden change in throttle. This extra fuel is added progressively as the throttle movement continues.

The increase bars determine how much extra fuel the engine gets when you open the throttle. Once the throttle movement stops the extra fuel value decays at a rate set by the sustain bars. This feature is used to allow the engine to catch up to the transient that has occurred and, consequently, its value will be dependent on manifold design.

The heights of the increase bars and the sustain bars are adjusted using the same keys that are used for adjusting the fuel curve bars. The left and right arrow keys allow you to move from one bar to the next.

The throttle pump values should be set up after the fuel and maps are correctly tuned for steady load running. Attempting to smooth out engine transients before the fuel maps have been optimised for steady state running may become confusing. The six throttle response bars should be adjusted by trial and error to give optimum throttle response in each rev range. Generally, you may not need much above 3000 rpm, but could expect much higher values below 1500 rpm.

Note that throttle response can also be affected by poor manifold design. If you have designed your own inlet manifold you may find that although the engine runs well at steady load it leans out if the throttle is opened suddenly. This will occur if the fuel injectors are poorly positioned and the fuel is wetting down the walls of the inlet manifold rather than remaining as a mist.

The final parameter on the Throttle Pump page is the Coolant Factor. Generally, when the engine is cold, accelerator pump values need to be increased slightly. The E6GM therefore applies a coolant correction to the throttle pump in the same way as it does to the base map.

The Coolant Factor may be set with values from 0 to 4. Setting it to 0 will negate all coolant correction to the throttle pump. The default setting for this parameter is 0.5.

6.2 Zero Throttle Map

One problem that often occurs with performance engines is rough idling. The manifold design, cam characteristics, etc. can cause instability in the air flow. This makes fuel metering difficult. In particular, the Map sensor often can not correctly read the manifold pressure, as it is either non existent, weak, or pulsing too much. In many cases though, once the engine has some speed, the manifold pressure signal is usable.

The best method of mapping the engine is using the manifold pressure as the load. If in this configuration idling is causing a problem, the Zero Throttle Map should be tried. This Map maps the fuel delivery at zero throttle below 2000 rpm. There are a few requirements that need to be met before you can use this Map. Firstly, your throttle position sensor must be calibrated properly. Secondly, the Map relies on there being a consistent air flow at zero throttle for a given engine speed. That means that devices such as idle speed motors that vary the air flow at zero throttle will not allow the Zero Throttle Map to operate correctly.

6.3 Full Throttle Map

The manifold and throttle body design can also cause problems tuning at full throttle on normally aspirated engines. In some cases, the manifold pressure can reach close to atmospheric pressure before full throttle is reached. This means that bars close to the full load bar on the Fuel Maps can interfere with the full load bar due to the interpolation between the two bars.

If you are experiencing difficulties maintaining air : fuel ratio at full throttle, it may be necessary to use the Full Throttle Map to set the full throttle mixtures. The Full Throttle Map is activated above the value set in the Full Throttle Threshold in the Fuel Setup, and has one programmable bar every 500 rpm up to 16000 rpm.

Chapter 7
Cold Starting and Running

The Haltech E6GM has four features to modify fuel delivery and ignition timing to aid in starting and running a cold engine. The Cold Start Prime map gives a cold engine an initial burst of fuel just as the engine begins cranking. The Coolant Correction Map modifies the normal fuel injection until the engine reaches normal operating temperatures. The Ignition Cranking Map set the crank advance for different coolant temperatures. And finally, the Ignition Coolant Map modifies the ignition advance from the Ignition Map for different coolant temperatures.

7.1 Cold Cranking

At cold crank the air speed at the inlet manifold is very low. As a result a lot of fuel that would normally travel in the air, sticks to the manifold walls and doesn't enter the engine. The cylinder chamber temperatures are also low which leads to poor combustion. To overcome these inefficiencies, it is necessary to prime the engine with a long pulse of the injectors at the start of cranking to ensure that the engine has enough fuel in the cylinder to fire.

The E6GM provides a cold start fuel prime that is adjustable at all engine temperatures. This allows the duration of the prime pulse to be optimised for cold cranking under a wide variety of conditions. Access the Cold Start Prime function from the Fuel Maps and Setup Menu.

The cold prime map specifies an injection time based on engine coolant temperature. The height of the bars define the actual duration that the injectors are open. A typical map is already loaded into your E6GM and this should not need to be modified unless you are having trouble cold starting the engine. Any changes like this should be done Online, so the change can be reversed if the engine becomes harder to start.

Over priming the engine will cause it to flood and not start. To clear a flooded engine, open the throttle fully and continuously crank the engine. Do not pump the throttle as this will only worsen the problem.

The ignition timing can also be set for cold cranking. As with the Cold Prime Map, the Crank Ignition Map sets the ignition timing to be used while cranking according to the coolant temperature. This Map is set flat to 15° at factory, but it can be adjusted to give better starting at all temperatures.

7.2 Fuel Correction Versus Coolant Temperature

Once started, an engine requires more fuel when it is cold than when it is hot. This is a result of low manifold and in-cylinder temperatures where fuel sticks to the walls and doesn't burn properly. The Haltech system corrects for this by using the Fuel Coolant Map to define the relation between engine temperature and extra fuel required. The E6GM will automatically reduce the amount of coolant correction applied to the engine as the throttle is opened and air speed increases. The Fuel Coolant Map should no be adjusted until the Fuel Maps are correctly tuned at operating temperature.

Access the Fuel Coolant Map from the Fuel Maps and Setup Menu. The map defines the percentage increase in fuel at any given engine temperature. The E6GM is supplied with a default coolant map which may not need to be modified. If the coolant map requires modification, the changes should be done Online and while the engine is warming. Start the cold engine and adjust the Fuel Coolant Map so that the engine idles evenly. You should not touch the throttle while adjusting this map. Follow the arrow as the engine warms to provide good running mixtures up to operating temperature, where there should be zero coolant correction.

Chapter 8
Correction Factors

The Haltech E6GM has two further correction maps to compensate the fuel for changes in inlet air temperature and battery voltage, and also two correction Maps to adjust ignition timing for coolant and inlet air temperatures. MOST USERS SHOULD NEVER ADJUST THESE MAPS. These maps are factory set to provide excellent correction for almost all engines. These maps should not be adjusted unless the user has experimentally derived data that the correction factors could be better customised to suit a particular engine. When the E6GM software is run in the Offline mode, the software will load factory-set correction maps unless other maps are loaded.

8.1 Fuel Versus Air Temp Map

The mass of air entering the inlet manifold varies with the temperature of the air. To compensate for this, the E6GM uses the Fuel Air Correction Map. The values supplied in your ECU have been mathematically determined to give the optimal correction for most engines.

The Fuel Air Correction Map is accessed via the Fuel Maps and Setup Menu. Across the bottom of the map displayed is the inlet air temperature. An arrow appears showing which bar the system is currently using.

The map displayed is split by a horizontal line. Bars above this line indicate a positive correction making the mixture richer. Bars below the line indicate a negative correction making the mixture leaner.

A typical Fuel Versus Air Temp Map was loaded into your E6GM at the factory. You should not modify it unless you experience trouble with variation in engine performance with air temperature.

8.2 The Battery Voltage Map

The Haltech E6GM uses intelligent fuel injection driver circuitry that compensates for changes in battery voltage. This compensation can be insufficient for the full range of battery voltages that a vehicle's electrical system may experience. As the battery voltage falls, the injectors will take longer to turn on and so reduce the effective open time. To compensate, the E6GM applies the Battery Voltage Map to increase the injector on-time as the voltage drops. This map should not be altered unless the system is connected to a fuel injector test bench that will allow the injectors to be accurately flow tested over a range of battery voltages and the corrections calculated accordingly.

8.3 The Ignition Coolant Map

The Ignition Coolant Map allows up to 10° advance or retard of the spark timing based on engine coolant temperature. This Map should only be used if there is a need to adjust the timing for low or high temperatures.

8.4 The Ignition Inlet Air Temperature Map

This Map allows up to 10° advance or retard of the spark timing based on the inlet air temperature. Normally this Map would not need to be used, but in some cases such as high inlet air temperatures on turbo/supercharged engine, retarding the spark may help preserve the engine.

8.5 Barometric Correction

Fluctuations in barometric pressure varies the density of the intake air of the engine. At lower barometric pressure, the engine can not breath in as much air, and therefore the amount of fuel delivered to the engine must be reduced. In mapping in Throttle Position Mode, the Map sensor provides a reading used for Barometric Correction. When in Manifold Pressure Mode, there are three forms of Barometric Correction performed by the E6GM.

The Manifold Absolute Pressure Sensor (MAP Sensor) supplied with the E6GM measures the absolute pressure of the air in the inlet manifold, and therefore automatically correct for small changes in barometric pressure. For a given geographical area, small fluctuations in the barometric pressure can be adequately handled by the MAP Sensor. This is the first form of correction performed.

Larger fluctuations in barometric pressure are usually caused by a change in altitude. When the E6GM is powered on it runs a small test to determine the barometric pressure. As you should have read earlier, the ECU switches the fuel pump on at start up (fuel pump prime). If the engine is not started, the fuel pump will be switched off. At this time, the ECU also reads the MAP Sensor. If the engine is not running, the MAP sensor will indicate the prevailing barometric pressure. The ECU remembers this pressure and uses it to perform a barometric correction on the fuel delivery. Small changes in the barometric pressure from that point are then handled by the MAP Sensor. This is the second form of barometric correction the E6GM performs.

If at start up the engine is cranked before the fuel pump prime has finished the ECU can not read the barometric pressure from the MAP sensor as the engine will be applying a vacuum to it. In this case, the E6GM will use a pressure reading stored in its memory. This reading is set to one atmosphere at sea level (1013 millibars) at the factory. This value can be reset to a pressure that is close to what is expected in the geographic area the engine will be used in. To reset this value, follow these steps :

1. Firstly make sure the throttle position sensor is properly calibrated. It must exceed 96% throttle for this to work. Also make sure that the MAP Sensor is set correctly in the Identification.

2. Switch the ignition off.

3. Apply full throttle.

4. Switch the ignition on but **DO NOT crank the engine.**

5. Wait till the fuel pump prime finishes (about 5 seconds) then release the throttle. The current barometric pressure as read by the MAP Sensor will be programmed into the ECU's memory.

It is not necessary or advisable to perform this reset regularly. It should only be done if the vehicle's regular place of garage is moved or if problems are suspected in the barometric correction. For example, if an engine is tuned at sea level but is intended to be used mainly at a higher altitude, then the reset should be performed once it reaches its new regular location. After that, the automatic reading done at start up will be sufficient.

The third form of Barometric Correction is performed using a separate Barometric pressure sensor. With a 1 Bar MAP Sensor (left open to atmospheric pressure) connected to the Spare Input, any changes in barometric pressure can be compensated for immediately. This is necessary when a large change in altitude is expected during a driving period (a Hill Climb event such as Pikes Peak in the USA is a good example).

SECTION THREE
Software Features

Chapter 9
File Storage and Retrieval

Once your Haltech E6GM system is configured you should store the entire set of maps and the Identification to disk. In fact, it is wise to save maps regularly during tuning so that you can return to a known map while you are experimenting in different areas. You can use the file storage and retrieval to enhance the flexibility of your race engine by storing the optimum maps for each race track.

The File storage and retrieval functions can be accessed from the Main Menu by pressing ¦ f for files. This function allows you to load engine maps and identification from computer disk. You can also save the engine maps and the identification to computer disk.

9.1 Saving Maps and Identification

9.1.1 The Save Command

To store all the maps and identification to computer disk with the system running Online, press ¦ **f** then **S** at the Files sub-menu. The list of maps already stored will appear on the screen.

You can save maps that you have generated Offline to later be loaded into the ECU. You can also save different versions of a map to save time while tuning track-side. You can even have different maps for different circuits.

9.1.2 Giving Your Map A Filename

Choose a name to identify your saved file. If you choose the same name as a map that has already been saved, the old file will be overwritten and replaced with the file you are currently saving with the same name. If you do not wish to erase any files already saved, choose a new filename - one that does not appear on the screen.

The name you choose should not include any spaces or full stops and can be up to eight characters in length. The name must start with a letter from the alphabet, not a number. For the sake of your own memory, try to select a name that you will be able to recognise in six months time.

As you perfect the maps for a particular application you might add a number to the end of the name to indicate which map is most recent. For example you might call the maps for a Turbo, Turbo1, Turbo2, etc.

After you have chosen a name for the maps, you must enter the name in the space provided. The system will pause and ask if it is OK to continue with the save. If everything looks correct, continue by pressing Y. If you entered the name incorrectly, abort the Save function by pressing N, or R to re-enter a name.

9.2 Loading Maps and Identification

While the ECU system is Online, you can load previously saved map information from computer disk into your Haltech ECU. The contents of the ECU are erased and replaced with the new maps you have chosen. If you are Offline, you can load previously stored maps, view and edit them, then save them for later use.

To load new complete maps and identification into the ECU, you must first be Online. Press ¦ f then l from the Files sub-menu. The load command erases the contents of the ECU and replaces it with the set of maps stored on the disk you are loading into the system. **Remember to save any maps currently in the ECU that you wish to retain before loading new maps from a disk.**

Although the loading of the maps should not affect the running of the ECU, it is best that the engine is not under load while maps are being loaded.

Select the name of the map you wish to load by using the arrow keys to highlight that name and press return. If there are more files then will fit in the window, you can scroll down through the extra files using the arrow keys. If you know the name of the file, you may type it in. The computer will then pause to ask if everything is OK before continuing the load. If you are ready to proceed, press Y. If there is an error, abort by pressing N. The load will take approximately two minutes.

9.3 File Management

The ECU's map information is stored as a file on disk. You may think of these files as books in library, where the filename is the title of the book. So that the books do not become difficult to find as your library grows, there are a few features that help you to organise your files.

9.3.1 Erasing Unwanted Maps

The Erase function in the Files sub-menu will delete old files from disk. Press E from the Files sub-menu to enter this function. The list of maps stored on the disk will appear. Use the Up and Down Arrows to select the map you wish to erase, or else type in the name of the map, then press return (¬). The computer will pause to check that everything is OK. Press Y to continue to erase, or else N to abort.

It is a good idea to erase old maps as soon as they become obsolete. This is particularly true if you are trying to build a library of maps. It can become difficult to remember later which maps are current and which are obsolete.

9.3.2 Changing Directories

If files can be likened to books in the library, then directories are analogous to names on the shelves. Directories can be used to group related files together.

To change directories when loading, saving or erasing maps, press ¦ C. The Files List will now display all directories in square brackets. Select the directory you want using the Up and Down arrows, and pressing Return. Directories can exist within other directories, so you may change several times before reaching the directory you seek. Once you have found it, hit °. The symbol [..] indicates the parent directory to the one you are in

Chapter 10
Printing Maps

10.1 The Print Function

You can print the maps and identification information to printers that accept IBM emulation mode, such as IBM compatible dot matrix printers (consult your printer manual). The Print function should work with other dot matrix printers, but some special characters such as °, ±, etc. may not print correctly. Select the print function by pressing p from the ***Options*** sub-menu

The system will present you with options on which data you wish to print. There are four options. Their meaning is as follows:

1) **Setup Information** - this will print only the setup pages (ie. Fuel, Main and Ignition pages).

2) **Maps** - Prints all the maps in the system (ie. Fuel, Ignition and Coolant).

3) **Output Options** - This function will print the current settings and the status of the output options of the ECU. (ie. Turbo Wastegate).

4) **Print All Information** - This will print all of the above information

The system will ask for a name to print at the top of the printed output. This allows you to differentiate between printouts if you have printed more than one set of maps. The name can be up to ten characters in length. Type in the name and press Enter (¬).

The system pauses to allow you to set up the printer. If you do not want to print you can leave the print function by pressing ° . Pressing any other key starts the printing. Before you start printing the printer must be Online and must have power and paper. Once the printing has started you can abort the printing by pressing ° .

Chapter 11
DataLog

11.1 The Datalog Option

This option records the Engine Data information at approximately five times per second while the engine is running. This datalog is useful for tracking the system's behavior through changing rpm. It also facilitates trouble-shooting, as all the ECU's working parameters are recorded faster than they can be read on the Engine Data Page.

The Datalog Menu is accessed through the ***Options*** Menu. (Press ¦ O). Then select the D key to make a datalog, the IBM software must be running and Online. Or it can be accessed directly by using § D

11.1.1 Setting Up the Datalog Page

Before beginning a datalog the data page can only display eight parameters which are selectable through a simple menu. To access the configuration menu press C and follow the instructions that are presented with the selection menu.

11.1.2 Creating a Datalog

You can choose to record the datalog either in memory or directly to disk. To record to memory, press D in the Datalog sub-menu. This will record engine data in a continuous loop, up to about three minutes i.e.. when you stop the datalog, it has a record of the previous three minutes of engine data.

Alternatively, you can datalog directly to disk by pressing A. The software will ask you for a filename to enter. When recording to disk, you are limited only to the free memory left on disk. The datalog consumes about 11kbytes per minute of running. Thus, on the disk supplied, there is over 20 minutes of datalog space. The disadvantage in datalogging in this manner is that there will be small "gaps" in the datalog of a few seconds as blocks of information are written to disk. If datalogging to hard disk, these gaps become insignificant.

You should save the Maps being used at the time of the Datalog to disk. It is advised to do this before the Datalog is taken. Saving the Maps makes sure that all the engine information (including the Identification and the setups) are saved to disk. If the Datalog is view offline at a latter date, the Maps will need to be loaded so that the programming software knows the setup of the ECU and can calibrate the data properly.

To stop the datalog press Space Bar. If you are performing a datalog to memory, the screen will instantly jump back to the Datalog sub-menu. If you have been recording to disk, there will be a moment's pause as the file is closed.

11.1.3 Viewing the Datalog

To view the datalog you have just taken, press V from the Datalog sub-menu. The Engine Data information will appear as rows across the screen, with a time index at the end of the row.

At the bottom of the screen is a list of the command keys. They are described in detail here:

£ - scroll up datalog one line
¢ - scroll down datalog one line
3 - scroll up datalog one page
´ - scroll down datalog one page
2 - jump to start of datalog
¶ - jump to end of datalog
? - jump to page #
S - show statistics (max., min. & avg. of each parameter)
° - exit

If the power to the ECU is interrupted while a datalog is running, the datalog will stop until the power resumes. This will save memory while ignition is switched off.

11.1.4 Datalog File Management

Datalog files may be saved to disk, loaded and erased in exactly the same manner as maps. From the Datalog sub-menu, you can do the following:

S - save datalog to disk. This function is only relevant if you have previously performed a datalog to memory.
L - load a datalog from disk.
E - erase a datalog from disk.

When saving a Datalog to disk, you should also save the Maps being used at the time of the Datalog. It is advised to do this before the Datalog is taken. Saving the Maps makes sure that all the engine information (including the Identification and the setups) are saved to disk.

Before loading a Datalog from disk, you should load the Maps that were saved with it so that the programming software knows the setup of the ECU and can calibrate the data properly. **Do not load a Datalog when Online to the ECU, or else the Maps you load will overwrite the Maps in the ECU. If you want to view a saved Datalog, switch to offline mode, load the appropriate map, and then load the Datalog.**

11.1.5 Printing Datalogs

You can print datalogs to any ASCII parallel printer, such as IBM compatible dot matrix printers. **This will print the current view only.** If you wish to print another view, switch to that view and print again. To print a datalog press P in the Datalog sub-menu.

The information in the datalog is divided into pages of data. The total number of pages in the current datalog is displayed. The software will ask for the numbers of the first and last pages you want to print. If you want to print the entire datalog , enter 1 for the first page, and the number displayed as the last page.

The system pauses to allow you to set up the printer. If you do not want to print you can leave the print function by pressing °. If you want to re-enter the start and end page numbers press R. Any other key begins the printing. Before you start printing the printer must be Online and must have power and paper. Once the printing has started you can abort the printing at any time by hitting °.

Chapter 12
Customising the Software

12.1 The Setup Page

The Setup window allows you to change the way the software works for you. If you alter any of the parameters on this page, the programming software will remember the changes you have made and they become the default settings. The next time you run the Haltech programme, the settings will be as you left them.

The Setup Window is accessed from the Setup menu by pressing ¦ s. Or by pressing § p. Then follow the keystroke instructions outlined at the base of the windows to make your settings.

The Data Setup window is accessed through the Options Menu by pressing ¦ o. Then selecting d. the data page window will allow you to select the data which you wish to view at the base of the maps. This is particularly useful when using the CGA video mode as the size of the map is reduced to allow all the engine data to be viewed. By reducing the number of data parameters the size of the map is increased letting small changes in bars more visible.

12.1.1 The Display

The Haltech programming software has been written to suit a graphical CGA, VGA or EGA monitor. In most cases, the programming software will detect what sort of display you have an select the appropriate mode.

You can also choose to operate in colour or monochrome. Since many laptop computers are not in colour, the monochrome setting should provide better contrast to read the screen.

12.1.2 Com Port

The programming software can talk to the Haltech ECU through either COM1 or COM2. Select the com port you are using here.

SECTION FOUR
E6GM Optional Outputs

Chapter 13
Software Access

13.1 The Output Options Page

The Output Options Page is where all E6GM options are enabled/disabled and programmed. This page may be accessed in either Online or Offline mode. Remember that any changes you make in Offline mode will not affect the ECU.

Pressing ¦ o will take you to the Options Menu. Press O to go to the Output Options Page. Alternatively use the § o hot key combination

Here, the five E6GM options are shown in five windows. Current settings are displayed for each of the options. Use the left and right arrow keys to highlight the function you are interested in and press ¬ to select the one you want.

To adjust the parameters of the Idle Speed Control or the Closed Loop Control functions, hit ¬ when that function is highlighted. In the case of the three Auxiliary Outputs, highlight the channel, then use the up and down arrows to move through its parameters. Strike ¬ if you wish to make a change. Some functions have maps associated with them, which are accessed through their Options' windows.

A keystroke guide is available at the bottom of the screen. Further, a simple Help window may be opened by pressing ¦ H. This will describe the function you are currently looking at, and offer some explanation as to how its parameters are to be used.

13.2 Enabling Options

Every option has an Enable flag at the top of its window. Toggling this flag allows you to switch that option on and off. The settings for an option that is switched off will not change when you switch it back on later. When a map is loaded from disk, output functions that do not match what is in the ECU are automatically disabled. After loading a map, return to the Output Options Page and check the functions you want enabled.

Any change you make in the Options page will not affect the ECU unless you are Online. If you are making changes Offline, then be sure to save your data to disk so that it may be later uploaded.

Chapter 14
Idle Speed Control

14.1 Description

A bipolar stepper motor may be used to control the ingress of additional air to the engine while the throttle is closed. This is useful for maintaining steady idle under changing load conditions, e.g. as air conditioner compressors or headlights are switched on and off. The stepper motor may also be programmed to increase the idle rev-rate just after starting, or while the engine is still cold.

14.2 Using the Idle Speed Motor

In order to use the idle air control function, you must have a suitable idle speed stepper motor fitted to the engine

The idle air circuit draws filtered air into the engine around the throttle plate, as suggested in figure 14-1. Normally this is done via an air bleed into the manifold. A valving arrangement is used so that the idle speed motor pinches off the air into the engine. When the engine is below the desired idle speed, the stepper motor's plunger retracts to allow more air to enter the engine. When the idle speed is too high, the plunger extends. If your engine does not already possess an idle air bypass circuit, a suitably machined aluminium block is available to mount the idle speed motor. A balancing system or plenum arrangement should be used if employing individual throttle bodies, so that all cylinders benefit equally from the additional air.

NOTE: You must ensure that the manifold's air bypass aperture is sufficiently small so as to not over-rev the engine when stepper motor is fully retracted. Fitting a large idle air valve to a small capacity engine can lead to poor idle control and dangerously high engine rpm with no throttle control.

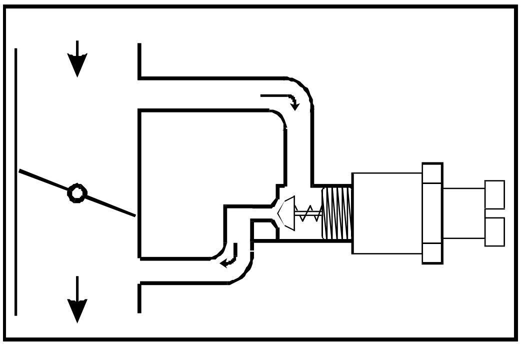


Fig 14.1. The idle-air circuit.

There should be sufficient airflow around the closed throttle plates to permit the engine to idle slowly even with no air passing through the idle bypass circuit. The throttle stop should be adjusted to ensure this is the case. Remember that the throttle position sensor will need re-calibration if the throttle limits are altered.
Install the idle air circuit and the stepper motor,

and attach the idle speed motor to its connection on the E6GM harness. Run the E6GM programming software Online and go to the Output Options Page. Ignition will need to be switched on.

The idle speed motor is only adjusted when the ECU determines that the engine is in an idle condition; that is, throttle closed (0%), and engine speed and manifold pressure within limits (see below).

14.3 Adjusting the Idle Speed Control

There are ten parameters to be adjusted in the idle speed control.

Enable/Disable: The Idle Speed Control can be switch on or off.

Target Idle Speed: This is the engine speed that the ECU attempts to maintain at idle.

Cold Idle-Up RPM: This speed is added to the Target Speed when the engine temperature is cold.

Pulse Divider: With a value of 1, the stepper motor would be pulsed every 4mS. In some cases this may be faster than the motor is capable of reacting, or may cause the engine speed to oscillate. Increasing this parameter reduces the rate at which the stepper motor is pulsed.

Post-Start RPM: This value is added to the Target Idle Speed for the first 20 seconds after starting. It is of particular use in preventing stalling due to heat soak when starting a warm engine.

Norm Idle Bar: When manifold pressure is used as the load sensor, excessive vacuum can be used as an indication that the engine is not at idle (i.e.. the wheels are driving the engine), and so the E6GM will not alter the idle speed motor. To determine this value, go to the fuel maps while the engine is idling and press 2 . The range and bar numbers will appear in the top right corner of the screen. Enter that bar number in this field - the idle motor will be ignored at a lower manifold pressure.
NB: If using throttle position as the load parameter, set this value to 1.

Cold Temperature Limit: the temperature below which the engine is defined as being cold, and thus the Cold Idle-Up would apply.

Rpm Operation Limit: If the engine rpm is above this speed, the idle motor will not be moved. To ensure the system will never "hang" with the idle valve open, choose a speed higher than that at which the engine will run with the idle air-bypass passage fully open.

Hot Opening Value: The Idle Speed Motor can be opened up by a programmable amount when the ignition is first turned on. The Hot Opening value determines what amount to open when the engine is above the Cold Temperature Limit. The value is a number between 1 and 100, but is not a percentage of the total opening range. The value should be set to give the desired flare up Rpm when the engine is hot.

Cold Opening Value: The Cold Opening value determines what amount to open the Idle Motor when the engine is below the Cold Temperature Limit. The value is a number between 1 and 100, but is not a percentage of the total opening range. The value should be set to give the desired flare up Rpm when the engine is cold.

Chapter 15
Closed Loop Control

15.1 Description

By using the oxygen sensor fitted to the exhaust system of an engine, the E6GM is able to perform a feedback correction to maintain a consistent air-fuel ratio around stoichiometric mix; i.e.. when exactly the correct amount of fuel is provided to consume all the oxygen of the air drawn into the engine, without any unburned fuel remaining after combustion. Using closed loop fuel control adapts for small variations in fuel quality and day-to-day running, provides better fuel economy and lower emissions.

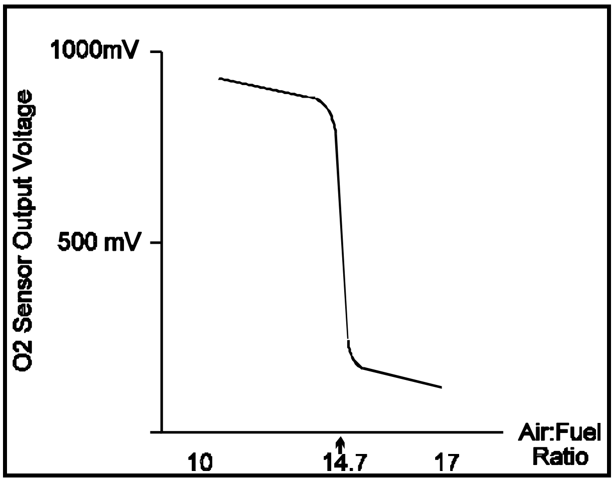


Figure 15.1 Typical lambda sensor output.

An oxygen sensor (or lambda sensor) is placed in the exhaust gas stream usually after the collector but before the catalytic converter. The O2 sensor possesses an output voltage characteristic similar to that in figure 15-1. When the exhaust gas is free from oxygen (i.e.. mixture is rich), the sensor reads around 1 volt. When there is an excess of oxygen, the sensor reads closer to 0 volts. Most oxygen sensors' transfer curves change very suddenly around stoichiometric mixtures.

The object in closed loop control is to measure the voltage of the oxygen sensor, determine whether the engine is running lean or rich, and compensate accordingly by adjusting the injection time. The ECU may overcorrect slightly, and then will pull the mixture back towards the desired air-fuel ratio. This slight oscillation either side of stoichiometric mixture aids the function of the catalytic converter.

15.2 Using Closed Loop Control

In order to use the closed loop fuel control function, you must have the an appropriate lambda sensor mounted in the exhaust stream. Run the E6GM programming software ONLINE and go to the Output Options Page. Switch the Ignition to ON. Select Closed Loop Control and adjust the following parameters as necessary.

Lower RPM Limit: The engine must be running above this speed for the closed loop function to operate. Normally this would be set a few hundred rpm above or below idle, depending on whether you wish closed loop control to occur at idle speeds.

Upper Throttle Limit: It is generally undesirable to run an engine at stoichiometric air-fuel ratio when under load. This parameter is used to determine when the driver is demanding sufficient engine output to disengage the closed loop function. The smaller this number, the earlier the feedback control will drop out.

Engine Cycles Between Corrections: The oxygen sensor does not respond immediately to the exhaust gases of the combustion which has just taken place. There is a gas transportation time from the engine to the sensor, plus the sensor reaction time itself. Consequently, the ECU counts a number of engine cycles before accepting the reading from the oxygen sensor. If the closed loop function is responding erratically, constantly overdriving to the adjustment limits, or if there is insufficient oscillation in the air-fuel ratio for the catalytic converter to operate, increasing this parameter may help. If it is set too high, the feedback loop will be noticeably slow to respond to change.

O2 Sensor Threshold Voltage: This is the sensor voltage by which the E6GM determines whether the engine is lean or rich; it is the target that is sought to be maintained. This is normally set to the voltage that corresponds to an air-fuel ratio of 14.7:1, around 600mV. It is also known as the sensors reference voltage.

Maximum Fuel Increase: The closed loop algorithm will be permitted to increase the fuel injection time no further than this limit while attempting to enrich the mixture. The valid range for this limit is 5% to 12.5%.

Maximum Fuel Decrease: Again a range of 5% to 12.5% applies to this parameter which is the limit of correction permitted to the base fuel injection time when leaning the mix.

NB: It is preferable to keep the increase and decrease limits small (say around 5-10%). Excessive swinging of the air-fuel ratio can result in surging and poor operation of the catalytic converter. The closed loop algorithm should never be used as means to correct bad mapping.

Engine Cycles at Idle: Exhaust gas transportation time is much higher at idle, when the engine is breathing the least. If running the closed loop at idle, a longer time must be allowed to pass before performing a feedback correction response.

O2 Sensor Threshold at Idle: It is unlikely that the engine will run at idle smoothly at the same air-fuel ratio as at cruise. Typically, a richer mix is necessary. This parameter allows a different threshold voltage to be targeted during closed loop correction at idle.

O2 Sensor Type: The type of sensor used should be selected here. Choose the sensor that best describes the sensor you are using. It is also possible to attach a 5 Volt sensor, such as a UEGO probe, to the E6GM. Since these sensors are expensive, and have limited life, it is unlikely that they would be used in general running of the car for closed loop feedback control, but rather as an aid during tuning. To use a 5 volt sensor, a jumper shunt needs to be installed on the E6GM circuit board. This shunt may be later removed when the UEGO probe is replaced by the standard 1 Volt sensor once tuning is complete. Please contact your Haltech™ representative for details on using this feature.

Chapter 16
Auxiliary Outputs

16.1 Description

The E6GM possesses three output channels, each of which may be programmed to perform a certain function. Each output channel is a pull-to-ground style signal suitable for switching solenoids, relays or low-power dashboard lamps.

Do not connect any device which requires more than 1 amp continuous current directly to the ECU - it will not operate properly. If you are switching high currents, use a suitable relay, either mechanical or solid state, and control the operation of the relay with the ECU.

The three outputs available are: Torque Converter Control, Thermofan, and Air Conditioning Control. These functions are described below.

16.2 Torque Converter Lockup (TCC)

This function controls the clutch lockup solenoid on automatic transmissions. Locking the torque converter reduces the amount of energy lost through the transmission, providing better fuel economy.

The solenoid activates whenever the road speed is greater than a programmed value for a given throttle position. The solenoid will only activate if the engine temperature is higher than 46°C (118°F), and will be disengaged if the throttle position exceeds 70% or road speed falls below 64kph. The TCC function also provides for a 4th gear/transmission over-temperature switch input. This signal indicates that the transmission is hot, and engaged in top gear. When this is the case, the lockup solenoid is activated regardless of road speed whenever the throttle is more than 4% opened.

To use the TCC function, you must have a square wave signal road speed indicator whose frequency is proportional to road speed. Once the wiring is complete, run the E6GM software in Online mode and go to the Identification page. The parameter Road Speed Value must be set with the number of pulses expected per kilometer. If you are unsure of the exact value for this parameter, enter an appropriate number and check against the vehicles speedometer. Adjust the Road Speed Value until the Road Speed displayed on the Engine Data Page and the actual vehicle speed agree.

Go to the Options page in the software, and select the Torque Converter Lockup function on the appropriate output. The map for the TCC function indexes the vehicle road speed against the throttle position. When, for any given throttle position, the road speed is greater than that displayed in the map, the solenoid will be energised. The road speed must then fall 8 kph (5mph) for the clutch to be disengaged. This 8 kph hysteresis should prevent solenoid oscillation during cruising near the cut-off point. The default map activates the solenoid at 70 kph at smallest throttle opening, and increases the activation threshold to 160kph at 70% throttle. Although this map may be customised as required, it is advisable to never engage the lockup below 60 kph (40 mph).

16.3 Electric Thermatic Fan Control (TF)

This function can be used to switch on a thermofan when the engine temperature exceeds a certain value. The fan will stay on until the engine temperature drops below a second value. The Thermofan output is always enabled to prevent the fan being switched off unintentionally.

To adjust the Thermofan settings, run the E6GM programming software and go to the Options page. Select the Thermofan function on the appropriate output and set the two temperatures as required.

Switch On Temperature: The temperature the engine coolant must exceed to switch the fan on.

Switch Off Temperature: The temperature the engine coolant must drop below before the fan will be switched off. This parameter should be at least 5° lower than the Switch On temperature to prevent the fan from switching in and out repeatedly.

16.4 Air Conditioning Control (ACC)

The Haltech E6GM can be used to control the Air Conditioning Clutch on vehicles with air conditioning fitted. The ECU receives an air conditioning request from the dash switch. The ECU then uses the throttle position and the engine rpm to determine if the clutch should be disengaged. This allows maximum power to be delivered to the engine.

There is one programmable field, and the enable, that can be adjusted. The field is the Rpm above which the clutch is disengaged. Also, the clutch will be disengaged when the Throttle Position exceeds 96%.

SECTION FIVE
Appendices

Appendix A
Troubleshooting

This Appendix is devoted to trouble shooting problems that may occur during setting up the E6GM on your engine. To use this Appendix, firstly identify the closest symptom or symptoms from the list below, and then follow the checklist for possible solutions.

A.1 Overview

Control Programme Problems

- The Haltech Programming Software will not load up
- The Haltech Programming Software will not operate in Online mode.
- The Engine Data Page is displaying unusual sensor readings

Starting Problems

- Fuel Pump does not prime when ignition switched on.
- The engine makes no attempt to start

Idling Problems

- The engine will not idle when cold
- The engine idles too slow
- The engine idles too fast
- The engine surges at idle

Light Throttle and Cruising Problems

- Engine will not run at light throttle

Full Power Problems

- Engine dies under full throttle
- Engine surges under full throttle
- Engine lacks power at full throttle

Throttle Response Problems

- Poor throttle response
- Poor throttle response when cold

Cold running problems
- Engine runs poorly when cold

Fuel Economy problems
- Poor fuel economy - city cycle
- Poor fuel economy - Highway cycle

A.2 Control Programme Problems

Haltech Programming Software will not start up
The Haltech programming software should run on any computer that meets the requirements in Chapter 3. If, after following the instructions in Chapter 3, the programme will not run, the most likely cause will be insufficient memory. If this is the case, you must make more free memory available before running the software.

Do not try running the Haltech software from out of another shell programme - always start from the DOS prompt. If you are loading a number of TSR (Terminate and Stay Resident) utilities during bootup, you may need to disable them before running the Haltech software. Refer to your computer and DOS reference manuals on memory management.

Alternatively, you may make your Haltech disk bootable by placing it in floppy drive A: and typing:

c:\> sys a:

We recommend that you make a backup of the original disk before trying this. You should then be able to restart your computer with the disk in drive A:, and the Haltech software will load and run automatically.

If the software still does not run, and you see the message "Error ### at xxxx:xxxx", record these numbers (or letters) and contact your Haltech dealer.

Haltech Programming Disk will not run Online
If the Haltech ECU does not respond to the Programming software requesting information, then the message RECONNECT HALTECH will be displayed. This situation will occur under the following conditions

- ECU is not powered up
- Programming Cable is not connected
- Incorrect COM port selected - see Chapter 13
- Wrong Programming Disk (i.e. disk does not match ECU)
- Programming Cable is damaged
- Serial port of programming computer is faulty.

If the disk is the wrong version or you suspect that the cable is faulty, contact your Haltech dealer.

Engine Data Page Displays Unusual Readings

If the air temperature sensor, or coolant temperature sensor is showing a FAULT condition then the sensors are either not operating correctly or are disconnected. Check that the sensor wires are not damaged. Check continuity between the pins and the Main Connector.

If the Throttle Position Sensor is showing a fault condition then re-calibrate the throttle sensor and check the wiring

If the Manifold Absolute Pressure Sensor does not read near atmospheric pressure with the engine off, or if it shows a fault condition, then check that the sensor is connected correctly. Check that you have the correct model sensor and that the Identification page information has been set correctly.

If the Engine Speed reading is erratic, the trigger is most likely picking up ignition noise from incorrect plugs or leads, electrical noise from cooling fans, starter motor, alternator or other electrical devices in the vehicle.

If the Engine Speed is steady but wrong, check that the Identification page contains the correct information regarding number of cylinders.

If engine parameters are all showing unusual variation, make sure that the ECU is grounded properly. Also check the engine and chassis grounds to the battery.

A.3 Starting problems

Fuel Pump doesn't prime when ignition switched on

The Haltech E6GM will attempt to run the Fuel pump for about 2 seconds just after the ignition is switched on. The fuel pump relay should be heard clicking in and out with the fuel pump. If the relay clicks but the fuel pump doesn't work then check the wiring of the fuel pump and its relevant fuse.

Engine makes no attempt to start

Check the following:

- ECU is operating (will communicate Online) during cranking
- Battery voltage and connections
- Fuel Pump runs
- Injector fuse is OK and injectors fire
- Ignition system is operating properly and spark is available
- Ignition timing is correct

If the engine is flooding, reduce the bars in the fuel map that are being used during cranking in the fuel map, the coolant correction map and the cold prime map.

If the engine is not receiving enough fuel and increasing those bars does not help, check that fuel pressure is available and that the injectors operate properly (are cleaned and flow-tested).

A.4 Idling Problems

If the engine will not idle when cold but will when the engine is warm then the coolant correction map needs to be adjusted.

If the engine idles too fast or too slow, and you are using an Idle Air Control Motor, firstly check that the Idle Speed Control is enabled, and then lower the target idle setting if necessary. If not using the idle air control motor then adjust the idle using the idle adjust screw on the throttle body. Check for any air leaks in the manifold.

Check the ignition timing at idle and adjust if necessary.

If the engine surges or hunts at idle then the mixtures and timing are wrong. Readjust the fuel maps near idle conditions.

In some circumstances it may be necessary to use the Zero Throttle Map. Consult Chapter 6 [6.2] for information on using the Zero Throttle Map.

A.5 Light throttle and Cruising Problems

If the engine falters under light load then the mixtures might be too lean, check the Fuel Maps.

A.6 Full Power Problems

If the engine gasps under full throttle then the mixture may be too lean. If the engine bogs down and blows smoke then the mixture is rich. Recheck the fuel maps.

If the maps appear to be correct then ensure that the fuel pressure is not falling out of regulation by using a fuel pressure gauge. Flow test and clean the fuel injectors.

In some circumstances it may be necessary to use the Full Throttle Map. Consult Chapter 6 [6.3] for information on using the Full Throttle Map.

A.7 Throttle Response Problems

Throttle response of the E6GM is set using the three pairs of throttle pump settings. If the engine gasps and flat spots (misfires) when the throttle is suddenly opened then the throttle setting is not high enough or is much too high. If the engine bogs down but continues to run then the mixture is too rich. Experiment with the throttle pump settings to achieve the optimum.

The throttle pump coolant factor affects the throttle pump only when coolant correction is being applied, i.e. before the engine has reached operating temperature. Set the throttle pump increase and sustain figures only when the engine is warm. Wait until the engine is cold again, and the coolant correction map has been set for good stable running, before changing the coolant factor.

A.8 Cold Running Problems

If the engine idles poorly when cold then the coolant map may need adjusting. If the engine is hunting slightly when cold, then the coolant correction map is just too lean, and so needs a small amount of enrichment. Slight advance with the coolant temp. can help. If the engine is difficult to drive when cold, particularly with gear changes, try increasing the coolant correction factor for the throttle pump.

An engine that will idle when warm, but fails to idle cold unless a tiny amount of throttle is applied may require idle speed control, with a fast-idle function for when the engine is cold. The E6GM can control an Idle Air Control motor that will perform this function.

A.9 Fuel Consumption

Poor fuel consumption is a result of a too rich mixture. If the fuel consumption in traffic is poor but the highway consumption is good, then it could be the areas of the map used for accelerating that need to be leaned out. The throttle pump may also waste fuel if its values are too high. Also try using the fuel cutoff on deceleration feature.

If the city consumption is fair but highway cruising uses too much fuel then lean out the light load bars on the 2000 rpm to 3000 rpm maps (This is where most cruising takes place).

If the cold start map is supplying too much fuel on warm-up this will also affect the fuel consumption of the vehicle.

Appendix B
Injector Impedance

Electrically, there are two different types of electronic fuel injectors. One type of injector, characterised by a high coil impedance (> 12Ω) is known as *saturation* injectors. The other sort of injector, typically with coils of less than 6 ohms impedance, is known as *peak-and-hold* injectors. The names are derived from the current waveform that accompanies the injector when it is switched on.

Saturation, or high impedance, injectors, require a simple switch to operate. When a 16 ohm injector has 12V applied to it, the current that is expected to be drawn is 0.75 amps (by Ohm's law). However, the current in a coil cannot change instantly. When power is applied to this injector, the current builds in the coil over a period of around half a millisecond, until it reaches its 0.75 Amp maximum, i.e. saturation. The coils remain in saturation until power is switched off at the end of injection.

In order to reduce opening time, the coil impedance can be reduced. Very low impedance would result in very large continuous currents, resulting in a great deal of heat and waste of energy. However, a much smaller current is needed to hold the injector open than is needed to initially switch it on. Thus, such an injector is described by two currents: a peak current for opening, and a hold current for maintaining the fuel flow. These peak-and-hold, or low impedance, injectors, are particularly good for high rpm engines needing large fuel-flow rates.

Peak-and-hold injectors come with a wide variety of current requirements. Most peak-and-hold injectors need 2A to switch on with 0.5A hold current (2/0.5A peak-and-hold), or are 4/1A peak-and-hold. Some very high performance injectors need as much as 6A to switch on, especially under high fuel pressures.

B.1 The E6GM Injector Drivers

The solid state devices within the E6GM ECU that are used to switch the injectors are known as the *injector drivers*. The E6GM possesses four heavy-duty injector drivers that can be used on either saturation or peak-and-hold injectors. Each driver limits its current draw to 4 amps, and, upon reaching that limit, clamps the current to just 1 amp.

The drivers used in the E6GM are each capable of firing two saturation injectors. Thus, with four drivers, a total of eight injectors can be used. Each is also capable of firing one or two 2/0.5A peak-and-hold injectors. If using 4/1A peak-and-hold injectors, you should not employ more than one injector per driver. Most high current motorsport injectors can also be fired (one per driver) providing fuel pressures are not excessive (>5 Bar). Running two high current, low impedance injectors from one driver can result in difficulty in obtaining stable air:fuel ratios when injection times are short (around idle and light load).

In general, an E6GM driver will reliably fire two injectors with more than 2.5 ohms coil resistance. Coil resistance can be measured with an ordinary low-ohm resistance meter. If you do not have enough driver power then you will require an Extra Driver Box. If unsure, contact your Haltech dealer for advice. NB: Under no circumstances should you mix saturation and peak-and-hold injectors on the one driver. This will lead to erratic injector operation.

Appendix C
Fuel Systems

The best EFI installation will yield poor results if the fuel system does not meet the demands of the engine. Insufficient fuel flow can lead to engine lean out and detonation which could cause serious damage. For the safety of your engine, we urge you to check your fuel system's capacity and ensure that there will be sufficient supply at all times. A fuel pressure meter should be used during testing and tuning to ensure that fuel pressure does not fall out of regulation i.e. that the pressure does not drop or oscillate.

This appendix offers guidelines to testing your fuel system and suggests some solutions if there are supply problems. If you find you need to modify your fuel system and are unsure what to do, contact a Haltech dealer for advice.

Fuel is dangerous. Beware of flames, cigarettes, electrical sparks, etc.

C.1 Fuel Requirement

If you can estimate the power output of a gasoline engine, you can make a reasonable guess at the fuel flow requirement. A simple rule of thumb, thus, may be expressed in metric or imperial units.

Every 100 hp needs around 50 lb/hr (8.0 US gal/hr) of fuel
(6.6 Imp gal/hr)

Every 100 kW needs around 670 cc/min (40 L/hr) of fuel

This assumes a brake specific fuel consumption of 0.50. The actual fuel flow necessary by injectors and pump are likely to exceed a figure derived this way. This is due to the overheads in injector dead time and pumping return fuel to maintain regulation.

C.2 Injector Flow Capacity

If you have purchased second hand injectors, or have removed the current injectors while doing work on the engine, we strongly recommend that you clean and flow test them. If you have bought new injectors, it is worth flow testing them anyway if you do not know their flow rate. Make sure that you test the injectors at the fuel pressure that your regulator is operating.

Your total injector flow capability is given by the sum of the injector flow rates. Injector flow rates are usually specified in either cc/min or lb/hr. Check that you have enough injector flow to match the estimated power output comfortably. Keep in mind that you do not want to exceed 85% duty cycle injection on time, and that at high rpm, injector dead time can consume a significant amount of available injection time.

If you find that your injector flow is insufficient, you can change to larger injectors, add extra injectors, or increase fuel pressure. Raising fuel pressure to increase injector flow rate is not recommended if the desired flow is more than 20% than the system currently achieves. Fuel flow is not in direct proportion to fuel pressure. Increasing fuel pressure will increase injector dead time and reduce the flow rate of the pump.

C.3 Fuel Pump Capacity

You should ensure that your fuel pump is capable of supplying sufficient fuel to feed the engine at maximum power. With the engine switched off (injectors closed) feed the return line of the fuel pressure regulator to a measuring container. In the case of a turbo- or supercharged engine, pressurise the manifold pressure port of the fuel pressure regulator to the maximum boost of the engine. This is necessary as the flow rate of the pump decreases with output pressure. Power the pump for one minute and calculate the hourly fuel flow rate of the pump.

Since the pressure regulator operates on a return system, there should always be fuel being returned to the tank, even when fuel flow to the engine has reached its maximum. If this fails to happen, the fuel pressure will fall out of regulation. Therefore the fuel pump must be capable of delivering significantly more fuel than the engine is going to use. As a guide, the pump should flow 30% more fuel than consumed by the engine.

If you cannot achieve the required fuel flow from one pump, you can employ two pumps in parallel. If you choose to use a low pressure pump to augment the fuel flow of a high pressure pump, place a check valve after the low pressure pump.

C.4 Fuel Rails and Pressure Regulators

A long fuel rail with narrow internal diameter will suffer from pulsation in the fuel rail. The internal rail diameter should be around 12mm (½"). Even so, oscillations may occur, particularly if the injectors are large. A fuel damper can help in removing these oscillations. If running a multipoint setup, batch fire injection will also reduce oscillation amplitude. Oscillations may occur only within a certain rpm range, so a fuel pressure meter should be monitored throughout the driving range of the engine.

On V configuration motors, it may be more practical to employ two regulators, one on each bank's rail. The fuel from the pump can be split to the two rails, and the return line from the two regulators can be joined. Since pressure regulators work within certain flow limits, this may also save having to purchase an expensive high pressure / high flow regulator.

Appendix D
Ignition Output

The E6GM ECU has one dedicated ignition output. The output signal of the E6GM is a square edge signal with 70/30 duty cycle (i.e. 70% off time, 30% on time) and the falling edge indicates the required ignition point. **The ignition signals cannot be used in any circumstances to drive an ignition coil directly: they must drive some form of igniter.** The E6GM ECU does not directly control dwell (coil on time).

A field in the Ignition Setup allows the signal polarity to be changed. Some high performance ignition systems require similar points to trigger, and this can be provided by changing the signal polarity. After market ignition systems can be used with the E6GM providing they are compatible with the factory hardware, and the E6GM Ignition Output is configured properly.
An igniter is a device which is capable of sinking the large currents required to charge the coil.

Constant Duty Cycle vs Constant Charge

The E6GM is best suited to intelligent igniter modules that perform their own dwell control. A constant duty cycle signal may be used to fire such igniters. The duty cycle of a square wave is the ratio of its high time to its period. E.g. a 70/30 duty cycle signal is high for 70% of its period and low for the remaining 30% regargless of frequency, as shown in figure D1. Constant duty can also be used on aftermarket capacitive-, inductive- or multiple-spark discharge systems such as MSD or Jacobs.

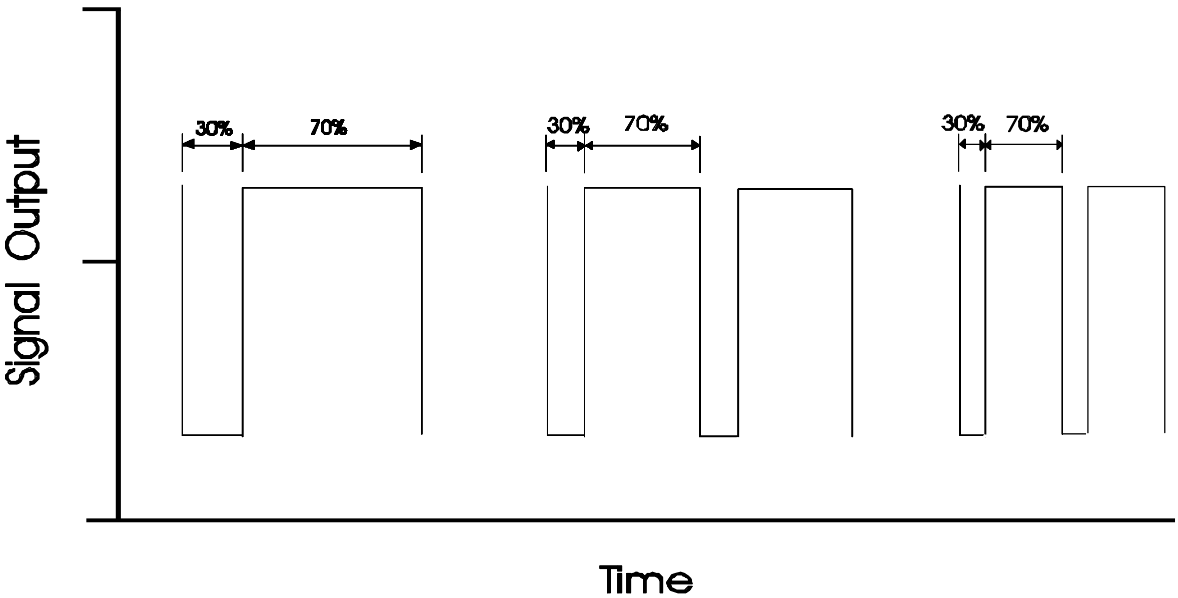


Figure D1. Illustrate constant duty against frequency

A "dumb" igniter is one that does not perform any sort of dwell control, thus input signal directly controls switching of the coil. A constant duty cycle signal is not the best signal to use with this sort of igniter as it will overheat the coil at low frequencies (ie low revs). and not allow enough charge time at high frequenices (ie high revs) Since the coil charge time remains approximately the same regardless of frequency, it is appropriate for the ECU to constantly charge the coil for exactly that time before firing.

The coil's charge time can be determined from the coil -ve signal. When the coil switches on, voltage drops to zero. As the coil charges, the voltage rises slightly, until a sharp rise where the igniter current limits. Leaving the coil switched on any longer will not increase the energy in the coil or of the spark. See figure D2.

When the ignition firing frequency is high, there will not be enough time to charge the coil completely. After firing the spark, the E6GM will wait for a short period, then switch the coil on again, regaining much of the lost energy in "ringing". This break time should normally be 1 to 1.5ms.

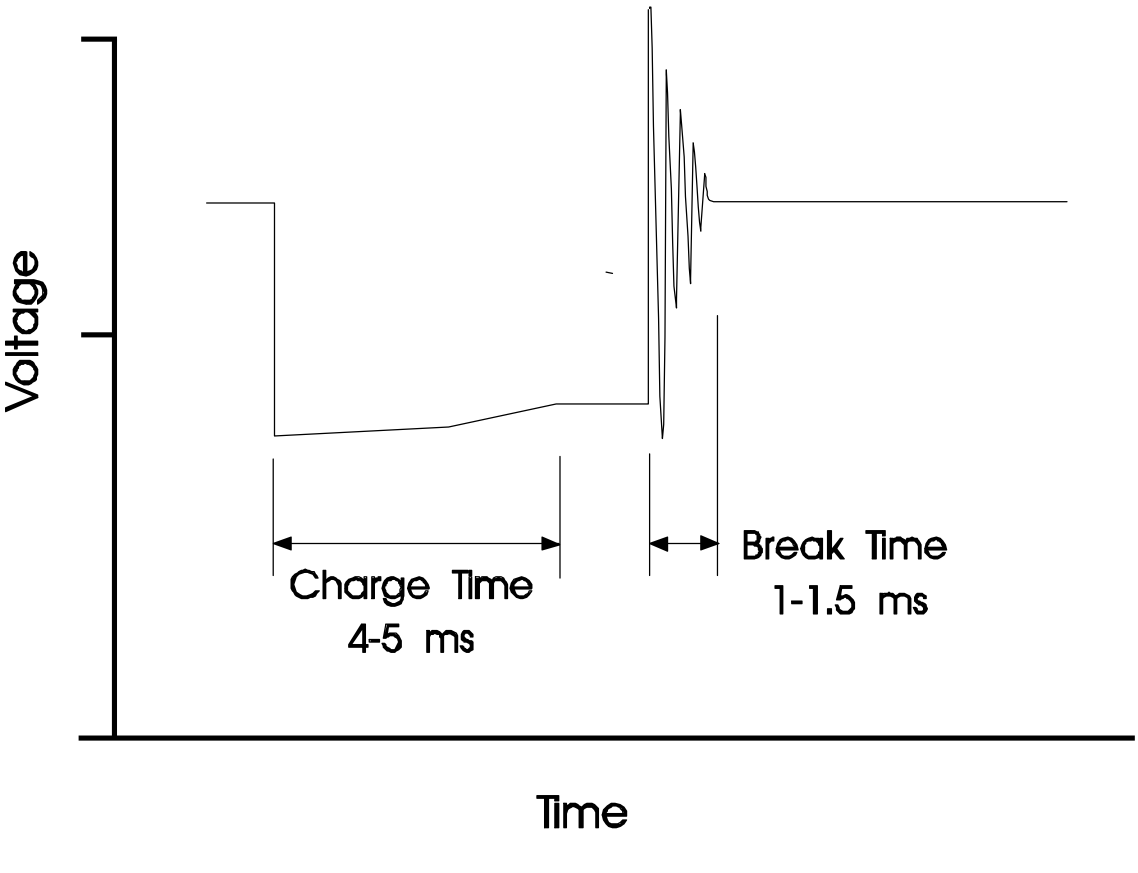


Figure D2. Illustrates Charge Time & Break Time

Constant charge time ignition using a dumb igniter is moderately inferior to that using an intelligent igniter with dwell control as it does not compensate for power variations or thermal effects.

Most GM ignition modules have an ignition bypass input from the ECU. This input tells the module to ignore the ECU’s timing signal and fire its own spark at 10° BTDC. This gives a more reliably timed spark for cranking. This input is controlled by the E6GM and allows the ignition module to control spark below 450 rpm.

Appendix E
Rotor Phasing

One of the most important aspects to consider when modifying a distributor or trigger is the Rotor Phasing. Take, as an example a distributor that uses a Hall effect sensor with a chopper wheel attached to the distributor shaft, the Hall effect sensor being mounted to a plate that is rotated by a vacuum advance mechanism and by centrifugal bob weights. This is a fairly conventional set up used in many vehicles with electronic ignition. Simply removing the advance mechanisms and locking the plate so that it can't move may not be all that is required. The trigger edges generated by this modified distributor will probably fall outside the 60° to 100° BTDC window allowed by the E6GM. Something will have to be moved to allow the trigger edges to fall within the required window.

If the distributor shaft is rotated so that the chopper wheel now triggers the sensor at 70° BTDC then a problem of rotor phasing may have been induced. By the time the ignition pulse occurs, which could be up to 60° later, the rotor button would have passed the plug lead terminal in the rotor cap and this could lead to arcing in the distributor cap. The arcing could even be to the wrong plug lead terminal. If arcing doesn't occur, then the back EMF in the ignition coil primary could damage the igniter or the ignition system. Either way, the engine is not going to run correctly, if at all.

The correct way is to move the plate that the sensor is mounted on. *Remember that all degrees referred to here are crankshaft degrees, distributor degrees would be half those numbers referred to*. Our example is an engine that has the following timing requirements :-

Minimum Timing	10° BTDC
Maximum Timing	40° BTDC

This gives a mid point, half way between the minimum and maximum timing, of 25°. Align the center of the rotor button with one of the plug lead terminals. It does not matter which one. This is where the rotor button has to be when the engine is 25° BTDC. Now rotate the distributor shaft so that the rotor button is where it should be when the engine is at 70° BTDC. i.e. move it back 45° <u>crank</u> degrees. This is where the rotor button has to be when the chopper wheel triggers the sensor. Let's assume that the trigger point of the sensor is exactly in its center. Move the plate the sensor is mounted on so that one of the vanes of the chopper wheel is leaving the sensor. Adjust the position of the plate so that when the shaft rotates in its normal direction, the center of the sensor will become exposed. If it is not possible to move the sensor, it will be necessary to rotate the trigger wheel relative to the shaft and the sensor.

Rotor phasing is not only a problem on distributors with advance mechanisms. Several factory distributors have their triggers at points outside 60 - 100°. It is not advisable to just rotate the distributor until the trigger is within this window. Care must be taken to ensure that the rotor phasing will not cause a problem.

Appendix F
Wiring Diagrams

PUMP RELAY	A1	B1	
	A2	B2	
	A3	B3	CRANK GND
	A4	B4	
	A5	B5	CRANK INP
+13.8V	A6	B6	
TCC CONTROL	A7	B7	
	A8	B8	A/C REQ
	A9	B9	
VSS	A10	B10	
MAP+MAT GND	A11	B11	
GND	A12	B12	
THFAN CONTROL	C1	D1	GND
A/C CONTROL	C2	D2	T+C GND
IDL2	C3	D3	GND
IDL1	C4	D4	EST OUT
IDL3	C5	D5	BYPASS
IDL4	C6	D6	O2 SENS GND
4TH GEAR	C7	D7	O2 SENSOR
	C8	D8	
	C9	D9	
COOLANT	C10	D10	GND
MAP	C11	D11	
AIR TEMP	C12	D12	
THROTTLE POS	C13	D13	
+5V	C14	D14	
	C15	D15	INJ1
	C16	D16	INJ2

PLUG 2

RX	A1	B1	GND
TX	A2	B2	
IGN TRIM	A3	B3	GND
+5V	A4	B4	
+5V	A5	B5	GND
FUEL TRIM	A6	B6	

LIMITED WARRANTY

Invent Engineering Pty Ltd trading as Haltech warrants the Haltech™ Programmable Fuel Injection System to be free from defects in material or workmanship for a period of ninety days from the date of purchase.

Proof of purchase, in the form of a bill of sale or receipted invoice, which indicates that the product is within the warranty period must be presented to obtain warranty service. Invent Engineering Pty Ltd trading as Haltech suggests that the purchaser retain the dealer's dated bill of sale as evidence of the date of retail purchase.

If the Haltech™ Programmable Fuel Injection System is found to be defective as mentioned above, it will be replaced or repaired if returned prepaid along with proof of purchase. This shall constitute the sole liability of Invent Engineering Pty Ltd trading as Haltech.

To the extent permitted by law, the foregoing is exclusive and in lieu of all other warranties or representations, either expressed or implied, including any implied warranty of merchantability or fitness. In no event shall Invent Engineering Pty Ltd trading as Haltech be liable for special or consequential damages.