Link
Engine Management
LEMV4

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By Link ElectroSystems Ltd.

This Engine Management System should start easily and tune up within an hour or two. If this is not the case then please check the inputs, earths and general wiring, as well as the obvious e.g. fuel, stuck injectors etc.

If struggling to get a result please contact your dealer or Link on +64-3-348 8854

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1. Introduction

Operational Outline: Fuel Injection

The Link Engine Management System (LEM) controls the engine fuel flow by sending electrical pulses of varying width and frequency to the injectors. When the injector is energised, a solenoid (electromagnet) opens the injector fully and fuel flows into the intake system.

The amount of fuel injected over a period of time depends on how often the injectors are opened (Pulse Rate) and the duration of each injection (Pulse Width). The actual pulse widths are quite short, typically 1.5 to 10 milliseconds (1 millisecond = 1/1000 second). The pulse rate varies with engine speed usually resulting in one injection for each crankshaft revolution. This injector timing strategy results in each cylinder receiving two injections per complete 4 stroke cycle (2 revolutions). If at the time of injection the inlet valve is closed, the fuel injected will reside at the inlet port until the next intake stroke. This arrangement permits all injectors to be fired together in groups thus reducing the number of drive amplifiers and also simplifies the injector wiring. Alternatively, the injectors may be phased to the engine and inject only while the inlet valve is open. This is sequential injection mode, which overcomes problems associated with large valve overlap times for some performance engines. The implementation however requires special crank angle sensors. For sequential injection you will require LinkPlus Engine Management which is a different computer.

The Speed Density Principle

In order to inject the correct amount of fuel, the Link Engine Management System must calculate the mass air flow of the engine and convert this air flow signal into a fuel flow signal.

The amount of air an engine is processing at any particular time depends on two main factors:

Engine Speed. The mass air flow increases in direct proportion to engine speed assuming all other factors are constant.

Cylinder Air Density. A measure of the air density in the cylinder when the inlet valve/port has just closed.

Determining the Speed

Engine R.P.M. is easily measured by feeding pulses from the crank angle or cam angle sensor to the Link Engine Management System. This pulse rate in conjunction with the CYLINDER setting determines the rate at which the injectors are pulsed. This pulse also supplies information for the computer's zoning and RPM limit functions.

Determining the Density

Direct measurement of cylinder air density is not practical, but may be calculated by measuring the inlet manifold air density and applying a correction value. The manifold air density is determined (normally) by measuring manifold air pressure (MAP) with a pressure transducer. The correction factor between manifold density and cylinder density (Volumetric Efficiency, V.E.) is found by the Link Engine Management System looking up a table in its memory and doing a series of mathematical calculations. This table (Zone Fuel) consists of 96 zones each covering a narrow operating range. Each zone may be individually or group programmed to suit the application. In some cases (e.g. performance cams) manifold air pressure may not give an accurate indication of air density due to reversion flow out of the inlet ports. An alternative scheme is to measure the degree of throttle opening with a rotary position sensor (TPS sensor).

Cold Starting

Almost without exception, all engines require additional fuel (rich mixture) during cold starting and the warm up period immediately following. The Link Engine Management System monitors engine temperature via a suitable sensor and provides automatic (programmed) enrichment. This automatic system (the normal system) monitors engine temperature and adds extra fuel at a rate proportional to the engine temperature and the user adjustable "COLD" value. For engine temperatures below an adjustable temperature threshold (default = 20^{o}C), the Link Engine Management System automatically primes the engine with a short injector burst during the initial phase of cranking.

2. Link Engine Management Features

The LEM offers the following features:

- 2 Injector Drives with Group fuel delivery
- 3 Ignition Drives for distributed or wasted spark applications
- Closed Loop Lambda Control
- Idle Speed Control for 2 wire solenoids OR Electronic Boost Control OR one high power drive switchable at a preset RPM or engine load
- Shift Light OR Tacho
- Laptop tuning using Windows and PCLink software
- Fuel pump relay
- Radiator fan relay drive

3. System Installation

This section describes how to connect all the LEM functions, remembering that the required connections will depend on the application. Read this section carefully to ensure the correct devices are connected.

i) LEM Installation

The Link Engine Management System (LEM) may be installed virtually anywhere but the following precautions must be observed.

1. Avoid areas of high ambient temperature such as exhausts and radiators etc. Preferably mount the unit inside the vehicle cabin. It is preferable that the unit is removable with sufficient cable length so that tuning may be performed while the vehicle is in motion.
2. If water immersion or spray is likely, additional protection may be necessary. Several brands of self sealing plastic may be employed here (e.g. Tupperware), particularly for marine applications.
3. Maintain maximum distance from radio transmitters and coaxial cables etc, where fitted. NEVER place next to an igniter module.
4. Four M3 tapped holes in the sides of the enclosure provide a mounting point for brackets etc. DO NOT drill holes in the case, as this will probably cause internal damage.
5. The MAP sensor (inside the ECU) MUST be connected to a source of vacuum (and pressure for turbo applications) via a suitable length of 3..4 mm vacuum hose. The fuel pressure regulator air pressure port is usually a good source of vacuum pressure.

ii) Breakout Loom

The LEM can be supplied with either a 2 or 5 metre breakout loom, used to connect various engine sensors and hardware devices. Some connections are made directly to the relevant device, while others require some form of interface such as relays or ballasting. Figure 3.0 illustrates the main header layout (& wire colours) when looking into the LEM connector.

17 Pin AMP Connector - Wire Side

Inj 1 Brown	Ig 1 Blue	Ig 2 Blue / Black	Ig 3 Blue / White		+12 V Red	Trig 1 Yellow Black Screen	E Temp Yellow	TPS In White / Blue
Inj 2 Orange	Pump Purple	RPM Brown / White	Fan Brown / Black	P Gnd Black 2.00 mm	S Gnd Black 1.25 mm	Trig 2 Blue Grey Screen	O2 White	TPS +5 Red / Blue

Fig 3.0

3.1 Injectors

The LEM offers 2 independent injector drives.

Both LEM injector drives supply an EARTH for the injectors. DO NOT connect +12V directly to these drives, as permanent damage will result.

Measure Injector Resistance. Use an ohmmeter to measure the injector resistance. If this is less than 9 ohms external ballasting will be required. The type of ballasting will depend on injector resistance.

Injector Drive	Wire Colour	mm
Inj 1	Brown	1.25
Inj 2	Orange	1.25

Table 3.2 Injector Drive Wiring.

3.2 Group Fire Multi-Point Injection

3.2.1 High Impedance Injectors

The injectors can be connected in a single group (only using one injector drive), or in two groups using the two injector drives in an anti-phase mode. This setup can improve engine throttle response but does require extra wiring.

INJ1 (Brown) Injector drive group 1. When active, provides an EARTH supply for up to 6 injectors.

INJ2 (Orange) Injector drive group 2. This drive performs an identical action to INJ1, except the pulses are time displaced to provide smoother fuel delivery when both drives are used together.

- For 6 cylinders or less, the injectors can be fired in a single or two-group configuration. See Figure 3.1

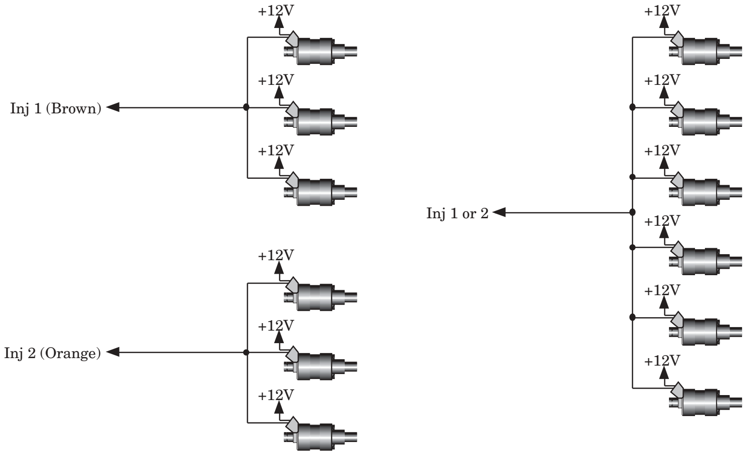


Figure 3.1. Group Fire wiring for 6 cylinders or less (High Impedance Injectors)

- For an 8-cylinder engine and above the injectors MUST be wired in two groups as shown in Figure 3.2. An 8-cylinder engine for example should use 2 groups of 4 injectors, a 12-cylinder engine should use 2 groups each containing 6 injectors.

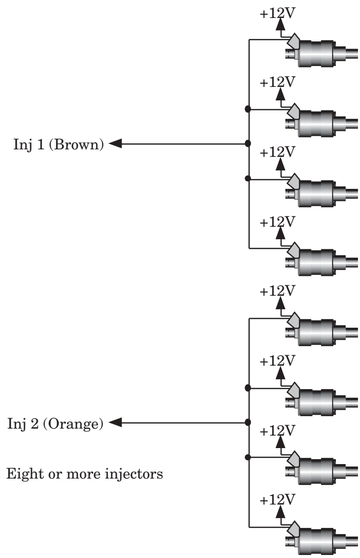


Figure 3.2. Group Fire wiring for 8 or more cylinders (High Impedance Injectors)

3.2.2 Low Impedance Injectors

If the injector impedance (resistance) is less then 9 Ohms, external ballasting will be required. The injector resistance can be measured by using an ohmmeter and probing the injector terminals. In most applications factory ballasting can be used. The same wiring configurations can be used as described for high impedance injectors. The only exception is the insertion of a ballast resistor between the LEM and injector. See Figures 3.3 and 3.4.

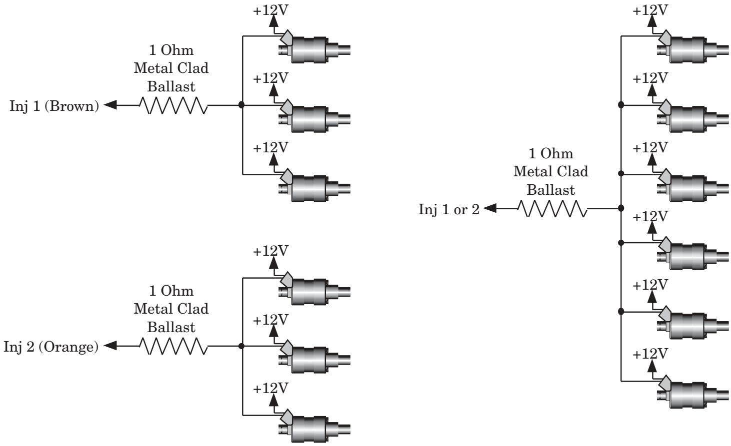


Figure 3.3 Group fire wiring for 6 cylinders or less (Low Impedance Injectors)

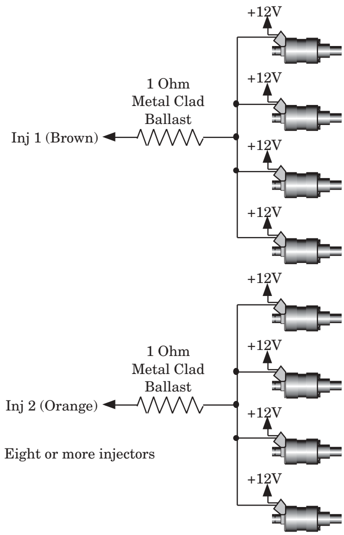


Figure 3.4 Group Fire wiring for 8 or more injectors (Low Impedance Injectors)

3.3 Single-Point Injection

When using single point injection only one injection drive is required; either INJ 1 or INJ 2.

3.3.1 High Impedance Injectors

If the injector impedance is greater than 9 ohms, no ballasting is required. A maximum of 6 high impedance injectors can be connected to one Injection drive.

3.3.2 Low Impedance Injectors

The required ballasting will depend on the number of low impedance injectors. Figure 3.7 shows how to connect single point injection for low impedance injectors

1 Injector

Injector resistance less than 2 ohms use single 2R2 ballast.
Injector resistance between 2 and 9 ohms use single 4R7 ballast.

Figure 3.7. Ballasting for single point injection.

3.4 Ignition

The LEM offers 3 Ignition drives which can be configured from a basic distributor setup through to more complex wasted spark arrangements. Table 3.5 illustrates wire colours.

Ignition		
Ign 1	Blue	0.85
Ign 2	Blue/Black	0.85
Ign 3	Blue/White	0.85

Table 3.5 Ignition Wire Colours.

DO NOT connect the ignition drives directly to ground, as this will cause permanent damage.

Before beginning any wiring, read Section 6 on Ignition. This provides information on the different configurations and the hardware requirements to make them run.

The LEM has three ignition drives that can operate in different ways, depending on the configuration setting. The ignition drives are configured as follows:

Ignition Type	IGN 1	IGN 2	IGN 3
Distributor	Normal Dwell Time	Inverted Dwell Time	Shift Light or Tacho
2 Channel	Igniter 1	Igniter 2	Shift Light or Tacho
3 Channel	Igniter 1	Igniter 2	Igniter 3

3.4.1 Igniter Mounting

Igniter(s) must be mounted well clear of the Link ECU, preferably under the bonnet, next to the coil(s). DO NOT mount inside the passenger compartment. If vibration levels are high, some form of soft or rubber mounting is advisable to prevent component and wiring metal fatigue (foam rubber blocks are recommended).

3.4.2 Ignition Suppression

The LEM employs very high-speed processors, which will behave erratically if subjected to strong radiated electromagnetic fields. These fields are generated by unsuppressed H.T. leads, which act as aerials and radiate very powerful interference signals.

ALL applications must use suppression (resistance) leads.

ALL applications must employ a suppressor capacitor connected directly to the ignition coil(s) POSITIVE terminal (0.5 - 3.0 micro Farads (most points condensers are suitable)).

3.5 Distributor

A distributed engine requires one single channel igniter. Connection to the LEM Ignition drives will depend on the type of signal required to control the Igniter.

IGN 1 (Blue). This drive uses the conventional signal polarity to control ignition. A positive voltage on this pin will place the coil in dwell mode (i.e. Coil charging). The transition from positive to ground will switch the coil off, resulting in spark. All Link Igniters use this method. Use Ignition Drive 1 and connect as shown in Figure 3.8(a). The Link Igniter is used for illustration purposes. Most factory igniters can be used.

IGN 2 (Blue/Black). Some factory igniters such as Honda and some Ford devices use the opposite polarity. Dwell occurs when the signal is at ground, producing spark on the transition from 0V to positive supply. Use Ign 2 Drive and connect as shown in Figure 3.8(b).

IGN 3 (Blue/White) ignition drive #3 for multi-coil ignitions. Special instructions and wiring diagrams will be included for this mode of operation as required. When not used for ignition this drive has 2 user selectable options:

Shift Light Used in conjunction with a dash mounted LED light this provides a programmable gear shift indicator for racing purposes.

Tachometer Driver Produces a 12V P–P, one millisecond wide pulse train to drive low level tachometers etc. There is one output pulse for every spark produced irrespective of the number of cylinders.

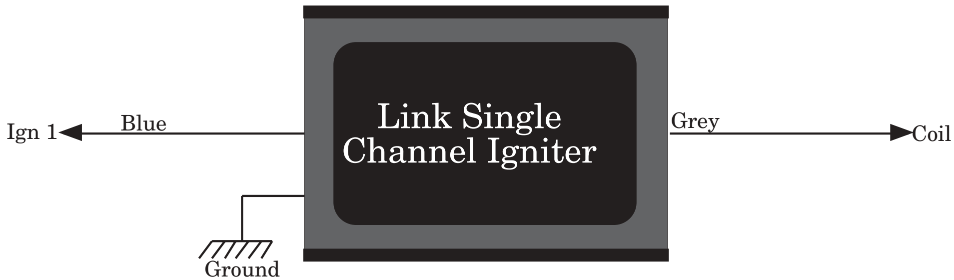


Figure 3.8 (a). Distributor setup with conventional igniter signal (Ign).

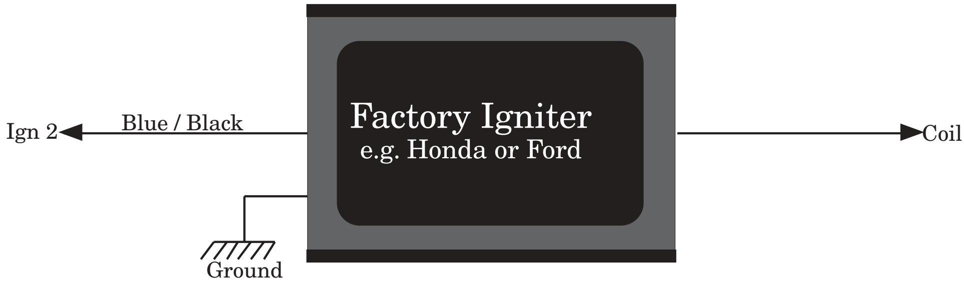


Figure 3.8 (b). Distributor setup with inverted igniter signal (Ign 2).

3.6 Multi-Coil: Wasted Spark

The following section illustrates how to wire for a wasted spark configuration. To ensure each ignition drive is matched to the correct cylinder, the firing sequence will need to be determined. Note this option is only possible when the engine has an even number of cylinders.

The first ignition drive is labelled “IGN 1”. This drive will control the ignition on the first cylinder in the firing sequence (i.e. 1st cylinder to fire after the sync pulse). When using a wasted spark arrangement this drive will also control its opposing cylinder 360° ahead. The ignition drive labelled “IGN 2” should be connected to the second cylinder in the firing sequence (i.e. 2nd cylinder positioned after the sync pulse), and its opposing cylinder and so on. Table 3.9 summaries this for a range of cylinders. The left-hand column is the position of the cylinder with respect to the sync pulse. The 1st represents the first cylinder in the firing sequence, the 2nd represents the second cylinder in the firing sequence on so on. In most situations the location of this sync will be unknown so refer to the application specific diagrams at the end of this manual. See examples 3.4 for more information.

Firing Sequence	Cylinder Number 4	6
1st	Ign 1	Ign 1
2nd	Ign 2	Ign 2
3rd	Ign 1	Ign 3
4th	Ign 2	Ign 1
5th		Ign 2
6th		Ign 3

Table 3.9

3.6.1 Wiring Example

Wasted Spark setup for a 4 cylinder.

Typical firing order: 1-3-4-2.

(a) If the sync is on the crank there will be two signals per engine cycle. Otherwise the sync will be at camshaft speed and there will be only one signal per engine cycle.

Sync Position: Between cylinders 1 - 3 with sync on the camshaft.

OR: Between cylinder 1 - 3 & 4 -2 with sync on the crank.

The 1st cylinder to reach TDC after the sync signal is cylinder 3, resulting in the firing sequence 3-4-2-1. Figure 3.14 illustrates the correct connection.

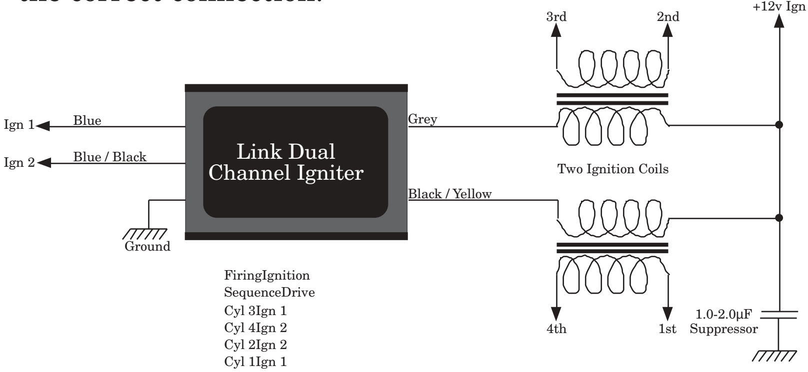


Figure 3.14. Wasted spark example for a 4 cylinder.

(b) Sync Signal - Between cylinders 3 - 4 with sync on the camshaft.

Between cylinders 3- 4 and 2-1 with sync on the crankshaft.

Cylinder 4 is the first to fire after the sync signal. The firing sequence will therefore begin with this cylinder and should be connected the “IGN 1”. The firing sequence is therefore 4-2-1-3. See Figure 3.15.

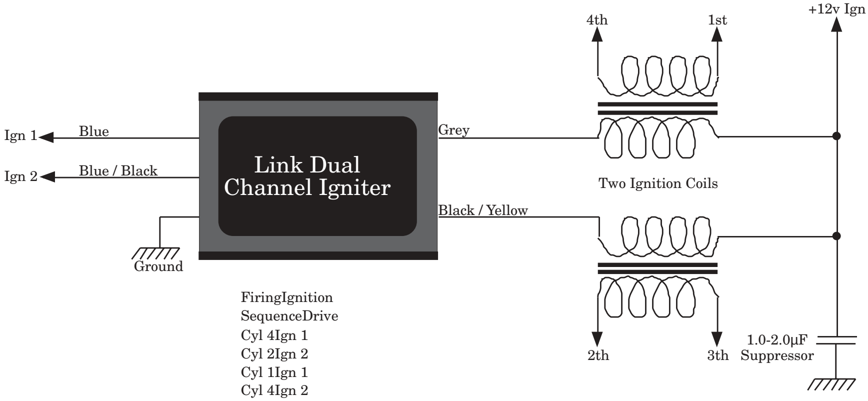


Figure 3.15. Wasted spark setup for a 4 cylinder.

3.6.2 General Installation Guide

The following examples provide a general guide to wasted spark installation. The label "1st cylinder" represents the first cylinder in the firing sequence, "2nd cylinder" represents the second cylinder in the firing sequence etc. All setups show the Link Igniter module, although most factory igniters can be used.

- 4 Cylinder

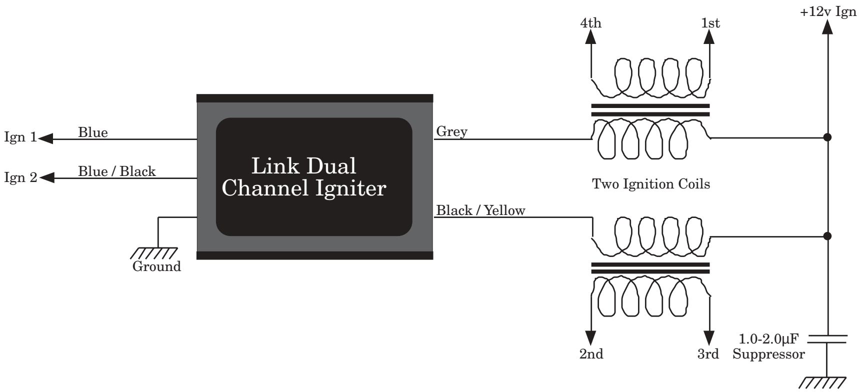


Figure 3.16 Wasted Spark 4 Cylinder

- 6 Cylinder

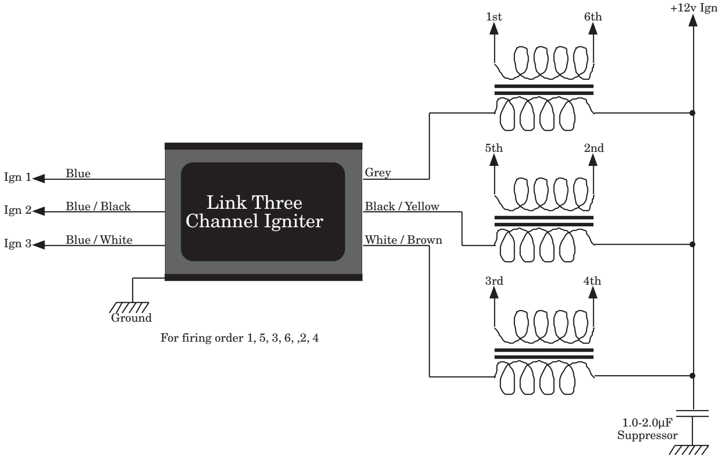


Figure 3.17 Wasted Spark 6 Cylinder

3.7 Low Power Drives

There are 2 low power drives used to switch currents less than 100mA. For this reason, these drives MUST only be used to switch a relay on by supplying an EARTH.

STOP

One relay per drive only

NEVER apply +12V directly. ALWAYS wire the drives to supply a relay earth for pins 85 or 86.

3.7.1 Fuel Pump (Purple)

Fuel pump relay drive. This output provides an EARTH to activate the fuel pump relay only while the engine is running, or when the key is first switched on to prime the fuel system.

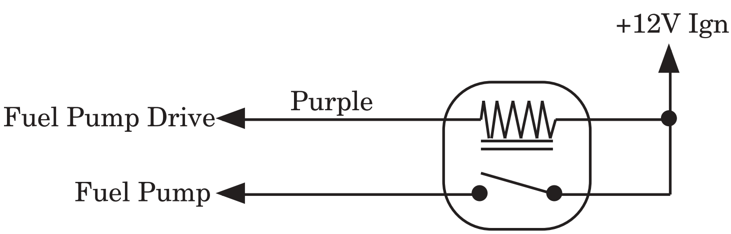


Figure 3.18

3.7.2 Fan (Brown/Black)

Radiator fan relay. This output provides an EARTH to activate the radiator fan relay when a preset engine temperature is exceeded. The fan will continue running until the temperature has fallen 4 degrees below the preset value, to eliminate short fan cycles.

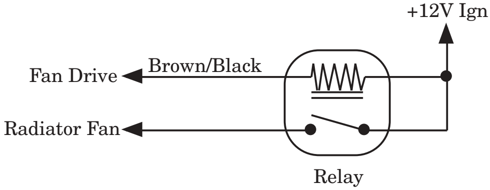


Figure 3.19

3.7.3 IGN 3 (Blue/White) Shift Light Configuration

In software version 4 (LEM V4) the IG3 Drive is user configurable. Use to operate a shift light (LED ONLY) or a tachometer. [Tachometer setup in section 3.7.4.]

Used in conjunction with a dash mounted LED light, the shift light provides a programmable gear shift indicator for racing purposes. This drive will supply power to a high intensity LED.

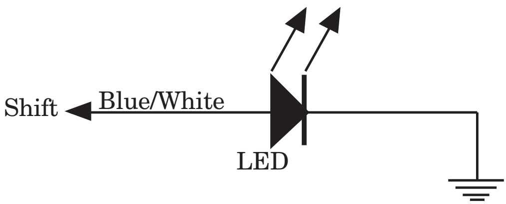


Figure 3.20

DO NOT connect a relay or filament bulb to IGN3

3.7.4 IGN 3 (Blue/White) Tacho Configuration

Tachometer Drive produces a +12V Peak—Peak, two-millisecond wide pulse train to drive low level tachometers etc. There is one output pulse for every spark produced irrespective of the number of cylinders. Connect this wire directly to the tachometer.

The LEM tacho signal will NOT drive a tachometer designed to run from the coil negative.

3.8 High Power Drive

Each of the following functions use the high current drive switching to EARTH. The amount of current flow is controlled entirely by the internal resistance of the device connected to a drive. If the current is excessive it will cause a PCB fusible link to rupture at approximately 5 Amps.

DO NOT connect +12V directly to this drive.

3.8.1 RPM Drive (Brown/White)

A multi-function, user programmable, EARTH sourcing driver which may be configured as a RPM switch (RPMSW), boost control (WSTGATE) or idle speed control (IDLE). The required mode is selected using the Link Tuning Module which will then cause the appropriate menu items to be displayed.

3.8.1.1. RPM SWITCH

Allows the value of the RPM sensitive drive to be changed. The RPM drive will become active above the programmed value to control the appropriate device. e.g. manifold runner, VTEC, cam control etc. An external relay may be used to "invert" the signal if the device being controlled requires +12V rather than earth (especially Honda VTEC solenoids).

Figure 3.26(a) shows an example of switching an inlet solenoid or part (b), a VTEC solenoid, that requires a +12 supply. In example (b) RPM Drive supplies the earth for the relay and does not switch the solenoid directly.

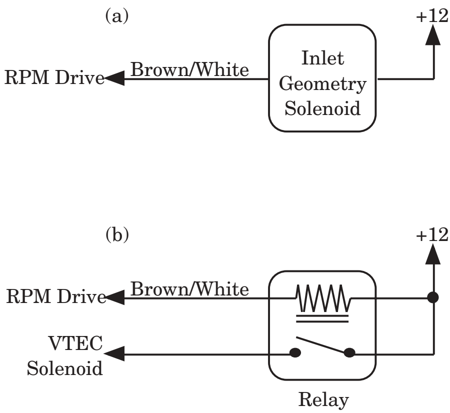


Figure 3.21

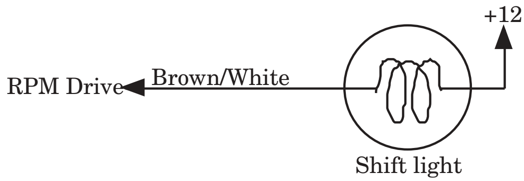


Figure 3.22

3.8.1.2 Idle Speed
The LEM can be wired for 2 wire solenoid idle speed control only.

Auxiliary Air Valve: Some engines use an auxiliary air bypass valve as a way of controlling the idle as the engine warms up. This allows air taken from before the butterfly to be bypassed into the inlet manifold as a function of temperature. This device contains a bimetallic strip, which is heated both from engine temperature and electrically. As the engine warms up the bypassed air is reduced and the idle is returned to its normal level. This type of device cannot be pulse width modulated to control idle. It is intended ONLY as an idle up when the engine is cold.

Solenoid Control Using RPM Drive: There is 1 pin to control a 2 wire (ISC) solenoid. Figure 3.32 is a 2 terminal.

- 2 Terminal Solenoid
  Connect one terminal to a switched +12V supply and connect the remaining terminal to the RPM wire. See Figure 3.32. The orientation of these wires do not matter.

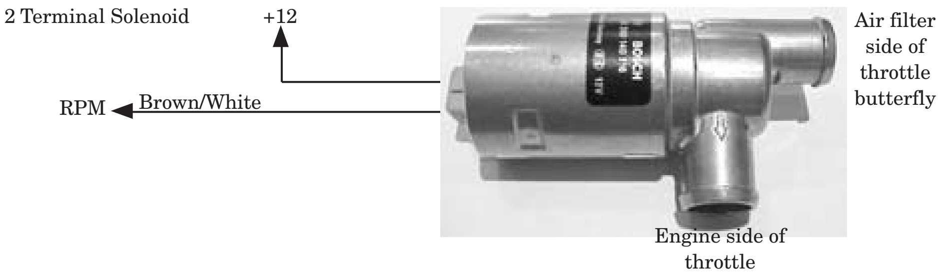


Fig 3.32

Refer to Chapter 10 for wastegate operation.

3.8.1.3 Waste Gate Option

When Electronic Boost Control is required this wire should be connected to the boost control solenoid. This will electronically modify the pressure signal produced at the compressor outlet to control the waste gate actuator. An optional "defeat" switch can be fitted which removes power from the solenoid, allowing the system to run at minimum boost. This may be useful if driving conditions are adverse, alternatively a hidden switch may be installed to prevent unauthorised high boost operation. For more information read Section 10. Connect as shown in Figure 3.23

Note: The W'GATE signal wire from the LEM provides an EARTH for the solenoid.

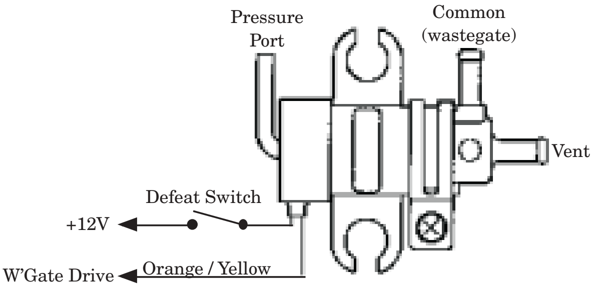


Figure 3.23 Three port boost control solenoid.

3.9 Power Supply

3.9.1 Positive 12 Volts (Red)

LEM +12 volt supply input. This should be connected to an ignition switched 12-volt supply. Current drain is quite low, (approx. 0.5 Amps) and may be fused if required. This input is polarity and over- voltage protected, but take the usual precautions when arc-welding on the vehicle.

Check the voltage does not fall below 7.5 volts when the engine is cranked. This is a common fault causing the LEM to reset and will prevent the engine from starting.

DO NOT use the Coil positive as a power supply for the LEM. Wherever possible use a separate +12V supply.

3.9.2 Power Ground (BLACK)

LEM high current ground. This input supplies the high current earth supply for the injector and other output drives. Since this wire will carry substantial currents, ensure it is well terminated to a clean earth point, preferably the engine block, (see note in "Signal Ground" below).

3.9.3 Signal Ground (BLACK)

LEM signal ground. This input supplies the low current earth supply for all low-level signal processing of the computer, and forms the reference value for all engine mounted sensors. As such, it is ESSENTIAL this wire is connected to the ENGINE BLOCK rather than the chassis or battery negative. Failure to do so will result in unstable sensor readings causing erratic computer operation.

IMPORTANT!
SIG GND and PWR GND **MUST** be run as SEPARATE wires. DO NOT be tempted to join both together at the computer and run as a single wire. Also beware of poor earth points around the engine. Some manifolds and other attaching parts may be rubber mounted and therefore have poor earth bonding. A good rule of thumb is to use the engine BLOCK rather than attaching parts. The screened cable is earthed to the signal ground.

3.10 Trigger

3.10.1 Trig 1 (YELLOW (Black Screened Cable))

This is the cylinder pulse trigger input. This will come from either a distributor or Crank/Cam Angle Sensor (CAS) and is used to control injectors, ignition timing, RPM limits/switches and fuel pump etc. The actual type of signal and its origin is specific to the application and the computer will be dispatched with the appropriate internal module fitted to process the signal, as well as the corresponding wiring diagram and any other special information required. This is a very important signal and must arrive at the computer free of noise and interference.

3.10.2 Trig 2 (BLUE (Grey Screened Cable))

Sync trigger input. Used for multi-coil or decoding factory diagnostics i.e. 24T Toyota. This input provides a synchronising pulse(s) to establish the correct firing order for the ignition system. Information will be provided as above (TRIG1) when required.

NOTE: Trig 1 and Trig 2 are both within the earthed-screened cable. This is to reduce the chance of any interference entering the system at this point.

3.11 TPS +5V Out (RED/BLUE)

This provides a regulated +5 Volts to the Throttle Position Sensor (TPS).

The TPS is used in idle speed control, boost control, mixed mode scheduling and fuel cuts. It should be connected if any of these options are required.

3.12 Inputs

The following table 3.10 is a summary of the LEM inputs.

Inputs	
E Temp	Yellow
TPS	White/Blue
O2	White

Table 3.10

3.12.1 Etemp (Yellow)

Engine Temperature input. Provides engine temperature information to control cold starting and radiator fan control. Normally the factory NTC type sensor is suitable and should be used if present. An optional Link Temperature Sensor is available if the factory unit is not suitable or unavailable. Connect the yellow wire to one terminal on the temperature sensor. The other terminal should be connected to an engine block ground.

Note: The orientation of the two wires is not important.

3.12.2 TPS (White/Blue)

Throttle Position Sensor input. This is used in a number of areas.

- Idle Speed Control
- Boost Control
- Mix Mode Scheduling

If any of the above options are required the TPS should be connected. To wire either the factory sensor or one provided by Link, an ohmmeter is required. Two of the terminals will show a fixed resistance as the TPS is moved. Connect these terminals to +5V and Ground. The result is that the TPS output voltage will increase with throttle position. +5V and ground can be connected to either of these two terminals. The last terminal must show a variable resistance between the +5V and the ground terminal. Refer to Figure 3.24.

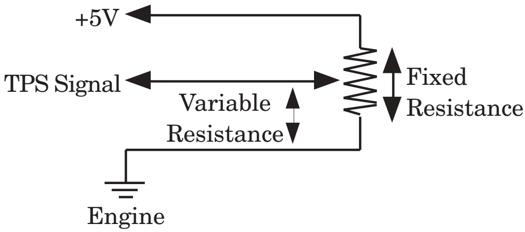


Figure 3.24 TPS Schematic.

IMPORTANT

On some factory systems a throttle switch is used instead of a variable resistance. This can NOT be used with the LEM. If a TPS based function is required, a TPS must be fitted to the throttle shaft.

When a TPS is connected, the span MUST be setup to ensure the correct operation of a TPS based function. Take time to read the Utilities section 8, which explains in detail how to do this.

4. Fuel

The LEM offers Group fire for up to 12 cylinders.

i) Group Injection

The injectors are wired in either one single group, or more commonly in two groups for higher cylinder engines. Since several injectors are operating simultaneously, each inlet port will be on a different phase of the engine cycle i.e. some cylinders will be on intake phase while others may be on compression, exhaust etc. The injection rate is once per engine cycle and is locked to the engine RPM (synchronous), but not indexed (phased) to the engine cycle.

ii) Mixture Compensation at high altitudes

The low density at high altitudes requires a leaner air-fuel mixture. This is achieved by reducing the injector duration by a calibrated amount to maintain a constant AF ratio. As the LEM operates from a speed-density principal, any change in altitude, hence density, is automatically compensated for.

4.1 Functions

To edit the following Fuel functions, connect the Link Tuning Module and move to the *   FUEL   * heading. The EDIT buttons can be used to scroll through this menu.

4.1.1 Master Fuel

Controls overall fuel injection scheduling and is effective throughout the entire operating range from idle to full power. The scale ranges from 0..255, the higher the value, the greater the overall fuel.

4.1.2 Rowfuel

Allows the ZONE FUEL table to be adjusted a WHOLE ROW at a time. i.e. All values on the current ROW will be adjusted up or down irrespective of the RPM. e.g. current zone = 230 (ROW 2, RPM = 3000..3500), 4 units are added (UP) to zone 230, then ALL zones along ROW 2 (200..295) will have 4 units added to their current values. ROWFUEL is primarily intended as a coarse adjustment to allow broad shaping of the ZONE FUEL table during initial tuning, and would normally be used after MASTER has been set, but before ZONE FUEL is used.

Careful use of ROWFUEL will eliminate the need to spend large amounts of time in ZONEFUEL trying to make major changes overall by wandering about the table making localised corrections. (It is quite difficult to hold the engine in any one of 200 zones while corrections are made even under the most favourable conditions.) The current ROW is displayed in parenthesis to show the currently active ROW, but the RPM information is suppressed since this feature is not RPM dependent.

4.1.3 ZoneFuel

There are 96 fuel zones arranged in a rectangular grid consisting of 6 ROWS by 16 COLUMNS. The ROWS progress in steps of Manifold Air Pressure or Throttle Position to provide the "load" axis, and the COLUMNS progress in steps of RPM. Therefore, each zone represents a unique engine operating condition allowing fuel changes to be made in small, localised areas. The selection of zones is completely automatic, depending on the actual RPM and MAP values at that instant. The current (active) zone is identified to allow correlation to the zone sheet and to give an indication of where you are in the table. The zone numbering system is not linear, but designed to provide a clearer indication as to effective location. For example zone 110 = ROW 1, 1000..1500 RPM, zone 255 = ROW 2, 5500..6000 RPM zone 545 = ROW 5, 4500..5000 RPM etc. Adjustments are made by operating the ADJUST buttons as required and the actual value is displayed on the right hand side of the display. Adjustment scale = 0..255.

5. Fuel Auxiliary

5.1 Functions

The following adjustable functions are available under the Fuel Auxiliary heading.

5.1.1 Clamp

This will clamp the Manifold Air Pressure signal to a minimum value (high vacuum) to stabilise the RPM at idle. This helps prevent idle surge present in some engines with large intake volumes. The value shown in (xxx) is the actual MAP value and the far right value = the clamp value. Typical values range from 30. . 35 for normal engines. The clamp is only active below 1500 RPM.

5.1.2 Accel

When the throttle is abruptly opened, the air-mixture is leaned out briefly. To achieve good throttle response, acceleration enrichment is required. There are 4 ACCEL zones, the first 3 covering a 2000-RPM span, the last zone covering a 4000 RPM span. By definition:

ACCEL zone 1 covers 0 - 2000 RPM
ACCEL zone 2 covers 2000 – 4000 RPM
ACCEL zone 3 covers 4000 – 6000 RPM
ACCEL zone 4 covers 6000 – 8000 RPM

By using 4 zones it allows the enrichment to be optimised and set for varying conditions. The two inputs available to calculate enrichment are MAP or TPS, selectable from the * Configuration* heading. The amount of enrichment is dependent on rate of change, and engine temperature. Note that ACCEL is only effective during the actual movement of the throttle to cover any brief flat spots occurring at that time. The actual zone is selected automatically, and is shown as Z=x where x = the currently active zone. e.g. Z=2 indicates transient zone 2 (2000..4000 RPM range).

5.1.3 Cold (Post-Start warm-up)

Controls cold start and warm up enrichment by adding extra fuel to the engine. The adjustment value is shown on the right hand side of the display and will gradually reduce to zero as the engine temperature rises towards 70°C. Note this is the temperature-decayed-value rather than the full cold value. The number shown in parenthesis (xxx) is the actual engine temperature for monitoring purposes.

Note: The far right characters on the Tuning Module will display N/C if the sensor is not connected.

5.1.4 Volts Correction

Provides a compensation value for fluctuations in battery voltage caused by heavy electrical loads being switched on and off e.g. headlights, heaters, fans or engine cranking. The opening time of the injector will vary with battery voltage. In order to compensate for this, the LEM will increase injection duration with a falling voltage supply. This will prevent surging idle speeds and is of particular significance on crank when the battery voltage can drop as low as 8 Volts.

Initially set the value to "15" (STORE) and tune the engine with minimum electrical loads switched on. Once a satisfactory tune is found, allow engine to idle and switch on maximum electrical loads. Readjust the VOLTS value to restore the "unloaded" idle quality and STORE the result. The actual battery voltage is also displayed for monitoring purposes.

Note that the adjustable value does not represent actual voltage but is a trim value with no particular units.

5.1.5 Crank Enrichment

This is the amount of extra fuel added while the engine is cranked and for a short period after starting. It is a temperature dependent enrichment and only effective when the engine temperature is below 50oC. The actual value used by the LEM will provide more crank enrichment with decreasing engine temperature and will decay with time (see crank decay).

The SMALLER the number, the GREATER the enrichment. The base default value is 70.

6. Ignition

The LEM offers 3 Ignition drives which can be configured from a basic distributor setup through to the more complex wasted spark arrangements. The following configurations in Table 6.0 are supported by the LEM.

i) Ignition Drives
The igniter drives (labelled IGN1 – IGN3) are used to control an external igniter module producing ignition spark under programmed control. The output from these drives is a pulse waveform with the following features.

- The igniter signal can equal or be advanced in timing with respect to the input trigger signal.

  NOTE
  The LEM may advance the timing but cannot retard beyond the base (input) timing.

  Below 500 RPM the engine will run ONLY on base timing. The LEM will not generate electronic advance.

- The dwell angle varies with engine speed to produce maximum coil output with minimum wastage. Essentially the LEM switches the coil current on at a calculated time before the spark is required, so as to just reach maximum energy. This system eliminates holding the coil current at high levels thus greatly reducing heat build up and electrical power wastage.
- Under limiting conditions (excessive RPM or boost) the output pulses are progressively inhibited to provide a soft-limiting feature. The limit values may be programmed using the appropriate controller.

ii) Igniter
The Igniter module is a device used to switch the coils off or on by supplying a ground for the coil negative. A link igniter module is shown in Figure 6.0. The igniter is basically a solid state switch, which also limits the coil current to a predetermined value. This limiting feature eliminates ballast resistors and provides consistent output over a wide range of battery voltages. Over voltage clamping is incorporated to prevent damage to the igniter should a high-tension lead become disconnected or similar.

The signal used to control this is fed from the ignition drives on the LEM, labelled ‘IGN1 to IGN3’. If the factory igniter cannot be used, the Link igniter/s should be mounted inside the engine bay as these carry coil primary current. DO NOT mount the igniter inside the passenger compartment or close to hot engine components such as exhaust manifolds. NEVER mount the Igniter next to the LEM

Figure 6.0 Link Igniter

iii) Coil Type
Low resistance coils (i.e. 1 ohm or less) must be used for maximum output energy, although higher resistance types will still function satisfactorily. This applies to both single and dual post coils in distributed and multi coil applications.

6.1 Tuning Module Functions

The LEM contains all the necessary software to run any configuration from Table 6.0. To select a setup, plug in the Link Tuning Module and select the * IGNITION * heading. Press the EDIT DOWN button once to enter the ignition menu. Use the EDIT buttons to scroll through this menu. The Tuning Module functions appear in the following order.

6.1.1 Zone IGN

There are 96 ignition zones arranged in a rectangular grid consisting of 6 ROWS by 16 COLUMNS. The ROWS progress in steps of Manifold Air Pressure or Throttle Position to provide the "load" axis and the COLUMNS progress in steps of RPM. Each zone therefore represents a unique engine operating condition allowing ignition changes to be made in small, localised areas. The selection of zones is completely automatic, depending on the actual RPM and MAP/TPS values at that instant. The current (active) zone is identified to allow correlation to the zone sheet and to give an indication of where you are in the table. The zone numbering system is not linear, but designed to provide a clearer indication as to the effective location. e.g.

zone 110 = ROW 1, 1000..1500 RPM

zone 255 = ROW 2, 5500..6000 RPM

zone 545 = ROW 5, 4500..5000 RPM etc.

The adjustment value is shown as degrees of advance, displayed on the right hand side of the display. This value is the actual interpolated number and hence the current advance generated by the LEM. To change a setting use the ADJUST buttons. To edit any static advance angle (i.e. edit the actual zone advance), use the zone editor. The current operating zone is displayed in the centre of this menu.

6.2 Setting Static Timing

This is defined as the mechanical advance of the engine with the LEM producing no addition timing (i.e. zero degrees electronic advance). The LEM default ignition curve is based on a 10BTDC base timing so this should be checked before driving the vehicle. Any variation in the base timing will need to be considered when adjusting the advance curve. Also note that below 500 RPM (especially cranking) only the base timing is effective and should be set for optimum starting characteristics.

Under Limits menu select ADVANCE LIMIT and set advance limit to zero. With engine at idle or low speed, set ignition initial timing by distributor position. This value will vary depending on engine type etc., but 10° BTDC (Before Top Dead Centre) would be a good starting point. Once set, reset ADVANCE LIMIT to required limit value, and check advance operation with timing light.

6.3 Multi-Coil: Wasted Spark

6.3.1 Definition

Wasted spark will fire two cylinders simultaneously, using a common dual post coil. During a crankshaft revolution, one cylinder is fired on the compression stroke, the other offset by 360^{o} crankshaft angle (i.e. the opposing stroke = exhaust stroke). One crankshaft rotation later, these two cylinders are two working stokes further ahead and the spark plugs fire again, but now with reversed roles. The result is that one coil will be fired twice per engine cycle hence the term "wasted spark". This setup can ONLY be used on engines with an even number of cylinders. The maximum number of cylinders the LEM can drive on wasted spark is 6.

6.3.2 Trigger & Hardware Requirements

Cylinder Pulse

For the correct timing of ignition, the crank or cam sensor MUST provide a signal that can be decoded to produce one pulse per engine TDC. On a 4-cylinder engine for example, this is 2 TDC pulses per crankshaft revolution (4 per Camshaft revolution) and an 8-cylinder engine will have 4 TDC per crankshaft revolution (8 per camshaft revolution)

Sync Pulse

To determine the correct firing sequence, a sync pulse is required as a reference to determine engine position. The sync pulse can only appear once on the crankshaft (1 signal per engine revolution) or once on the camshaft (1 signal per engine cycle).

Dual Post Coils

One Dual post coil is required per 2 cylinders with a primary resistance less than or equal to 1 ohm. Figure 6.1 shows a typical coil. The coils should be positioned so they minimise the length of the HT Leads. This will help reduce the noise generated when the spark plugs are fired.

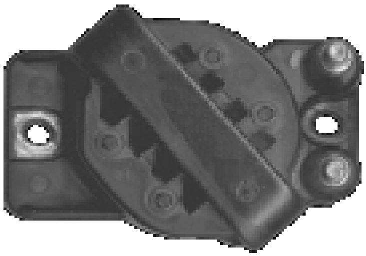


Figure 6.1 Dual Post Coil

Important Points for Wasted Spark

- When two spark plugs are fed from one dual post coil they are connected in series, meaning one plug is "incorrectly" polarised.
- The main concern when using dual post coils is the generation of interference. When two spark plugs are fired together there is twice the spark energy generated and hence twice the radiation produced per engine TDC. This noise level increase can interfere with ECU operation and cause unwanted static on car radios. The following precautions should be used to minimise these effects.

First install 'Resistive Spark Plugs' if the engine does not currently use them. This will reduce radiation levels and also help even out spark energy distribution. Without it, the spark plug with the least load (exhaust stroke) tends to monopolise spark.

Secondly, ALWAYS use suppressed HT leads, which can be identified by measuring their resistance. Typically they vary from 1000 ohms to 5000 ohms depending on lead length. DO NOT use copper leads under any circumstances.

Lastly always fit a Coil suppresser to the coil positive. Any value between 1uF and 10uF will be suitable.

Therefore when using Dual Post Coils combine the following:

- Resistive sparks plugs
- Suppressed Leads
- Coil Suppresser (1uF – 10uF)

7. Limits

7.1 Functions

The following functions are available from this heading.

7.1.1 Rpm Limit

Sets the RPM limit. Limiting is achieved by 100% fuel cut until the RPM drops below the preset value. A soft limit is evoked 200 RPM before this by removing alternative spark.

7.1.2 Advance Limit

Sets the absolute maximum ignition advance irrespective of any value programmed into the ZONE IGNITION table. Note this is a numeric limit only and does not invoke any actual ignition or fuel cuts.

7.1.3 Map Limit

Sets Manifold Air Pressure limit to prevent over boost. Values are expressed in absolute pressure so all values above 100 kPa represent boost pressures. The LEM will 'soft' limit the engine 10kPa before the MAP limit. If the engine reaches the actual MAP limit a hard limit will be evoked, cutting all fuel and ignition.

e.g. 150 kPa	=	9 psi boost
200 kPa	=	15 psi boost

8. Utilities

8.1 Functions

The following functions are available under the Utilities heading.

8.1.1 Overrun Vacuum

This represents the engines MAP when it is running in overrun vacuum. It is a target value used by the LEM to aid in idle speed and fuel control. When the engines manifold air pressure drops below this target, various tasks are actioned by the LEM. As this value is a function of the engine modification state, it will vary, and should always be adjusted as described in section 8.1.1.1

8.1.1.1 Overrun Vacuum Setup

Observe the engines Manifold Air Pressure as the throttle is fully opened. Allow the engine to reach around 4- 5000 RPM then snap the throttle closed to put the engine in overrun vacuum. Now record the LOWEST MAP. Use this number subtract 2 and enter this value as the overrun vacuum number. The units are kPa.

8.1.2 RPM Setup

This is a power drive capable of switching up to 5 amps. It can be configured to turn ON at a preset RPM or engine load. This should be setup from the *Configuration* heading. This menu allows the switching point to the adjusted.

8.1.3 Shift Light

This sets the RPM at which the shift light is turned ON. Use the ADJUST buttons to change the value in steps of 100RPM.

8.1.4 Temp Switch

Sets the value at which the temperature sensitive drive becomes active. This drive is primarily intended for radiator fan control and uses the engine temperature sensor to measure coolant temperature. The value is displayed in degrees Celsius, above that the fan will operate. Note that there is a 4-degree difference between switch on and switch off to prevent repetitive, short fan cycling.

8.1.5 Throttle Position Sensor (TPS) Span

This allows the TPS to span the zones from closed to WOT. The menu will display "TPS Span xxx" where 'xxx' represent the TPS span. For example if the TPS Range was 20 - 100, this menu will setup the TPS span ensuring it points to 20 at closed throttle (i.e. "xxx" = 20) and 100 at wide-open throttle (i.e. "xxx" = 100).

The throttle position sensor is used in the control of:

- Idle Speed Control
- Boost Control
- Mixed Mode Scheduling

If any of these functions are required, the TPS MUST be connected. Section 3.12.2 describes the setup procedure.

9. Closed Loop Lambda Control

Closed loop operation involves the use of an exhaust gas oxygen sensor (Lambda probe) to provide the computer with a feedback signal indicating the actual fuel/air ratio. This signal allows the computer to make instantaneous corrections to the injector fuel flow until the required air/fuel ratio is achieved. This automatically compensates for all the variables that may cause incorrect fuel scheduling, having two modes of operation;

1. Automatic programming: (Tuning Module Connected). The computer is able to "tune" itself throughout the entire operating range simply by driving the vehicle and allowing the computer to do all the work. The air/fuel ratio "targets" may be set to any required value depending on the application.

When the Tuning Module is connected and Closed Loop lambda is activated, the LEM will ONLY correct fuel if the following menus are selected.

- ZONE FUEL
- INJECTOR DUTY CYCLE
- TEST RPM
- CURRENT LAMBDA TARGET

If a different menu is selected closed loop control will be halted.

2. Continuous mode: (No Tuning Module) The computer normally operates in continuous mode after Auto or manual tuning is complete and compensates for all the day-to-day variables that cause the air/fuel ratio to drift, resulting in absolutely consistent running and low exhaust emissions.

In either mode, closed loop lambda will only change the current fuel zone to match the lambda target. There will be NO change to the MASTER value or ROW FUEL adjustment.

9.1 Functions

The following functions are available from the Lambda heading.

9.1.1 Lambda ON

Press the ADJUST UP button to switch ON the Closed Loop Lambda Control. To switch OFF press the ADJUST DOWN button.

The oxygen sensor (and associated wiring) must be 100% serviceable if the tuning option is to be used. Failure to meet this requirement may result in engine damage if not carefully monitored.

9.1.2 Lambda Target

The next 6 menus allow the lambda targets to be edited. Refer to 10.5 on how to adjust these.

9.2 System Requirements.

Hardware for closed loop (LAMBDA = ON) operation is essentially the same as for open loop (LAMBDA = OFF) with the following exceptions;

1. An exhaust gas oxygen sensor (Lambda probe) mounted in the exhaust manifold as close as possible to the cylinder head (rather than down the tail-pipe) to ensure fast response. The probe temperature must exceed 300 degrees Celsius for normal operation, and most types have a built-in electrical heater to assist with this requirement. The heater also allows the system to come on line faster after a cold start and ensures that temperature is always adequate during prolonged idle running. Connect the heater wires to earth and an ignition switched +12 volt supply. Typical current draw is 1 to 2 amps.

   Wire colours vary between manufactures, but the following colours are fairly common;

Bosch	White wires	=	heater (polarity not important)
	Black wire	=	output signal
Nissan	Red and Black wire	=	heater
	White wire	=	output signal

   All sensors have M18 x 1.5 metric threads, and a boss will need to be welded into the exhaust manifold for mounting purposes. Handle the probe CAREFULLY since the internal ceramic material is easily cracked if sharp blows are applied. For prolonged operation on leaded fuels, a lead tolerant sensor must be used. These have an extra shroud with small gas sampling hole around the sensing tip to prevent lead deposits from fouling the sensitive material. Failure to use this type will result in inaccurate readings after several hours of running with subsequent incorrect operation.

3. A Link Tuning Module will be required for setting up all aspects of operation including both manual and automatic tuning modes.

9.3 Operation and setup

1. The closed loop mode is enabled by moving to the " LAMBDA " heading on the Tuning Module and selecting LAMBDA = ON by pressing the ADJUST UP button.

2. The system should first be tuned in open loop mode (LAMBDA = OFF) until a reasonable state of tune is achieved. This step allows the subsequent AUTO-TUNE system to achieve a faster lock-on since it should not have to make major corrections if the initial tune is about right. Closed loop operation will only occur if the following conditions are met

   - Engine Temperature above 50°C

   - Engine been running for 90 seconds after start

   - Manifold above overrun vacuum

   - No acceleration (transient) fuel pending

   If the above conditions are met the system will automatically start adjusting the ZONE FUEL, matching the actual lambda voltage to the lambda targets. The system samples and corrects at a rate proportional to engine speed. This rate allows sufficient time for fuel changes to take effect and appear at the exhaust. (The feedback system is not instantaneous and therefore needs a short stabilising period)

3. The following function will change when the LAMBDA control is switched on:

   ZONE FUEL : Fully automatic zone fuel tuning. The current operating zone will be tuned to match the lambda targets. This means corrections will ONLY affect one zone at a time. While closed loop is switched ON the ADJUST switches have no effect.

NOTE: All corrections made by the AUTO-TUNE system are temporary until a STORE is carried out. All other Tuning Module functions remain unchanged.

9.4 Lambda "target" system

The actual required fuel/air ratio is dependent on the operating conditions prevailing at the time and is generally "load" sensitive. During operation at idle and light throttle cruise, the A/F ratio should be fairly lean in the interests of fuel economy and low exhaust emissions. At high power however, the A/F ratio needs to be richer to produce satisfactory horsepower, reduce cylinder head temperature, and control detonation. Both engine RPM and manifold air pressure (MAP) are used to select one of six Lambda "target" values for the system to use as a reference.

9.5 Adjusting Lambda Targets

A separate block of zones are used to store the target values, adjustable from the * LAMBDA * heading on the tuning module. The default values loaded will depend on the type of "ROW STEPS" selected from the * Configurations * heading (For more information on ROW STEPS see section 12.2).

These values were determined after much testing and should be correct for the majority of applications. The target values are displayed as a voltage, which the software compares to the actual probe voltage and makes the necessary correction. e.g. 60 = 0.6 volts.

NOTE: The "cruise" target (zone 27) MUST be smaller than or equal to the "power" target (zone 28). The simple interpolator used on the lambda targets will not handle negative (reverse) trends.

9.5.1 Row Steps = Vacuum

In this mode the LEM will use the Zone Sheet shown in Appendix B, allowing a maximum of 96 fuel zones on a normally aspirated engine. Figure 9.1 illustrates the zones covered by each lambda target.

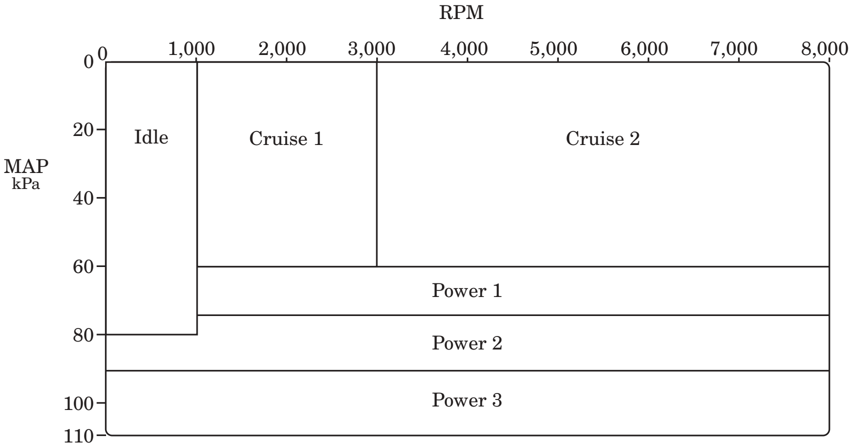


Figure 9.1. Lambda Target with Vacuum Row Steps selected.

Zone	Target Area	Target Value
26	Idle	84
27	Cruise 1	78
28	Cruise 2	79
29	Power 1	80
30	Power 2	81
31	Power 3	82

Table 9.0

The default lambda values are shown in Table 9.0

These values can be edited by moving to the * Lambda * heading on the tuning module, and selecting the appropriate zone.

9.5.2 Row Steps = Map, TPS, MAP+TPS

In this mode the LEM will use the Zone Sheet shown in Appendix A. Figure 9.2 illustrates the zones covered by each lambda target.

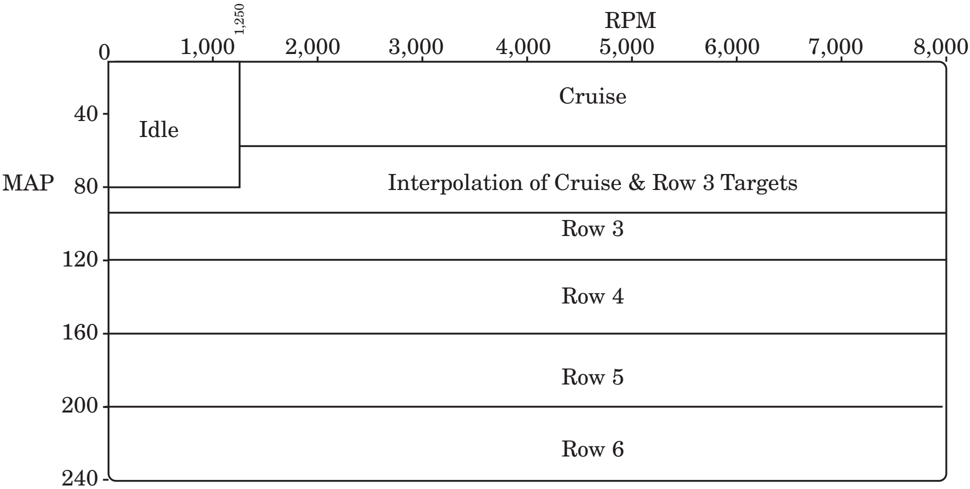


Figure 9.2 Lambda Target ROW STEPS = MAP, TPS, MAP+TPS

Zone	Target Area	Target Value
26	Idle	84
27	Cruise	78
28	Rows 3	82
29	Rows 4	83
30	Rows 5	85
31	Row 6	87

Table 9.1

The default lambda values are shown in Table 9.1

These values can be edited by moving to the * Lambda * heading on the tuning module, and selecting the appropriate zone.

9.6 Probe Voltage vs A/F Ratio

The relationship between Lambda probe voltage and the A/F ratio is not very linear since the Lambda probe shows a steep voltage step at stoichiometric mixtures. This transition voltage indicates that no excess oxygen or fuel is present i.e chemically perfect combustion, and is the desired voltage for minimum exhaust emissions. At low to medium power, the system should be "rocking" back and forth over this transition line so that the catalytic converter can do its job. The actual voltage at which this occurs lies between 0.4 to 0.6 volts. Tests have shown that if the target is set much below 60 (.6 volts) undesirable idle surging will result in some engines. Some experimentation may be necessary. Above the stoichiometric point the curve flattens out as the A/F ratio becomes richer. The maximum voltage produced is normally about 0.92 volts which equates to VERY rich A/F ratios. The targets should never be set above 90 (.9 V) for this reason. As a rough guide:

VOLTAGE	%CO	A/F RATIO (approx)
< 0.6	< 1.0	> 15:1
0.72	1.0	14:1
0.76	2.0	
0.80	3.0	
0.84	5.0	13:1
0.86	6.0	12:1
0.88	8.0 +	11:1

Note: Enrichment becomes fairly compressed at higher voltages i.e. small voltage changes = large ratio changes.

9.7 System Annunciators

LAMBDA has a series of indicators to show the systems status. These appear on the "ZnFuel" menu on the tuning module. The far right character will display one of eight possible annunciators:

T Timer. The system waits for 90 seconds after starting before becoming active.

E Engine temp. below 50 C. System = standby

A Acceleration fuel is present. System = standby

V Vacuum is abnormally high (over-run condition). System = standby

X maX allowable correction. System is limited to a maximum of +/- 21 units with the remote connected. This will prevent gross errors due to failed probe etc. The system may be cleared by initiating a STORE, giving another 21 units of trim. Be suspicious of large corrections. There may be a fault somewhere in the system. (max. trim = 8 if remote is not connected)

= Exhaust oxygen = target value. This should flash up fairly regularly.

+ System is increasing the fuel.

- System is decreasing the fuel.

10. Mixed Mode scheduling

Mixed mode scheduling refers to the way in which the zone table ROWS are selected. There are four options available, each one specific to an engine configuration. The default mode is MAP meaning ROW selection is based ONLY on the engines Manifold Air Pressure. When using high lift, long duration cams this can create problems for EFI systems due to irregular, low manifold vacuum at low RPM. This results in the engine being "over fuelled" since the MAP sensor interprets the poor vacuum as the throttle being mostly open, when in fact, the throttle is closed on the idle stop. Although the over-fuelling can be tuned out using the ZONE FUEL table, the actual zone selected by the software is incorrect since the zone in use is also a function of the "incorrect" MAP signal. The following options are available.

STOP

The actual injector pulse width is still a function of MAP at all times, so mixed mode scheduling will ONLY effect the zone table ROW selection.

10.1 MAP Mode

Application: Normally aspirated OR Turbo charged engine.

This allows Manifold Air Pressure to select the current zone table ROW. This will give 3 tuning rows for a normally aspirated engine and allow a maximum of 3 rows for a turbo charged engine. See Appendix A for the zone sheet. To effectively use this mode the engine should have good idle vacuum, operating in ROW1. This will maximise the number of rows available for tuning. If the engine exhibits poor vacuum as discussed in the introduction use one of the following modes.

10.2 MAP+TPS Mode

Application: Turbo Charged engines ONLY.

If the MAP of the engine is going to exceed 110kPa (1.5PSI boost) due to turbo charging or forced induction and the engine exhibits poor idle vacuum, this mode should be selected. The TPS is used to select the vacuum rows 1,2 and 3 helping to stabilise ROW selection. As soon as the engine comes on boost, greater than 1.5PSI (110kPa absolute), the row selection will automatically revert to MAP zoning. To ensure correct operation the TPS should be set to span 20-100. This means at the crossover point (110kPa) there will be no sudden fuel steps in the selected zone, i.e. the "MAP" selected zone and the "TPS" selected zone should be the same.

10.3 VACUUM Mode

Application: Normally Aspirated engines ONLY

Use this mode ONLY on a normally aspirated engine. DO NOT select if the engine is turbo charged. The zone table has been scaled to span 6 ROWS of vacuum as shown in Appendix B. This structure provides more rows to tune with when compared to the default MAP Mode, which allows only 3 rows for a normally aspirated engine. These additional rows are useful on engines with low vacuum by providing finer control over idle and cruise mixtures

Note: Rows 4 - 6 of the zone table are configured by default for a turbo charged engine. When spanning 6 rows for a normally aspirated engine, the timing will be overly retarded and fuel overly rich in these rows. The computer MUST be retuned.

10.4 Throttle Position Sensor (TPS) Mode

Application: Normally Aspirated Mode

Use this mode ONLY if the engine is normally aspirated and MAP or VACUUM modes have produced unsatisfactory results. The purpose of selecting rows using TPS is to provide stable zone selection when the MAP signal is fluctuating due to special cams etc. When using this mode ensure the TPS span is setup correctly as described in the next section.

Note: Do not select TPS mode unless the TPS sensor is fitted and wired.

The LEM is supplied by default with ROW STEPS = MAP and a Zone Table configured for a turbo charged engine.

10.5 Selecting TPS Span

This section ONLY applies if the TPS option has been selected in ROW STEPS, i.e.ROW STEPS = TPS + MAP or

ROW STEPS = TPS

Before starting section, read section 8.15, which explains the TPS Span.

The "TPS" values are user defined and control the numbers of ROWS available for tuning. Hence the purpose of this step is to setup the number of ROWS required for tuning, by selecting a suitable "TPS low" and "TPS high" values. For example a TPS range of 20 to 100 would access 3 ROWS, since two zone boundaries (40, 80) were crossed, while a span of 20 to 200 would allow access to 5 ROWS.

The ROW boundaries are as follows;

ROW	SPAN	CENTRE	ZONES
ROW 1	0 to 40	(20)	[100..175]
ROW 2	41 to 80	(60)	[200..275]
ROW 3	81 to 120	(100)	[300..375]
ROW 4	121 to 160	(140)	[400..475]
ROW 5	161 to 200	(180)	[500..575]
ROW 6	201 and above	(220)	[600..675]

NOTE - The zoning structure for ZONE ADVANCE is identical to ZONE FUEL.

ROW STEP = TPS+MAP

The TPS range MUST always be set between 20-100.

"TPS low" = 20

"TPS high" = 100

ROWSTEPS = TPS

The "high" value should be selected based on the required tuning Rows. For example:

1) 3 Rows Required for tuning
Set TPS span between 20 – 100

2) 6 Rows required for tuning
Set TPS span between 20 – 220

11. Boost Control

Wastegate Overview

Turbo charger boost control is achieved using a wastegate to bypass the correct amount of exhaust gas around the turbocharger. This can be achieved by employing either an integral wastegate (Fig 11.2) or an external wastegate (Fig 11.4).

In either case, the wastegate is opened and closed by a pneumatic actuator. When sufficient pressure reaches the actuator, the wastegate is opened to vent excess exhaust gas around the turbocharger. This has the affect of limiting boost pressure. If no pressure reaches the actuator then the wastegate never opens. As a result all exhaust gas must pass through the turbocharger. This causes the boost pressure to rise to whatever the turbocharger is capable of generating.

Electronic Boost Control Overview

Electronic boost control is achieved by modifying the pressure signal from the turbocharger compressor outlet to the wastegate actuator using a solenoid.

The minimum boost pressure that can be achieved occurs when the solenoid is de-energised. This pressure is entirely dependent on the wastegate/actuator construction.

The maximum boost pressure that can be achieved occurs when the solenoid is energised. This pressure is dependent on the turbocharger/engine combination. Typically this pressure exceeds that which can be safely tolerated by the engine.

By varying the on/off ratio (duty cycle) of the boost control solenoid, a boost pressure between the minimum and maximum (outlined above) can be achieved. Since the ECU measures the manifold air pressure (MAP), this information is used to sense the current boost pressure so that changes are continuously made to achieve the target boost pressure.

11.1 Integral Wastegates

11.1.1 Three Port Solenoid

Figure 11.1 shows the recommended three-port solenoid for use with integral wastegates. These can be supplied by any Link dealer.

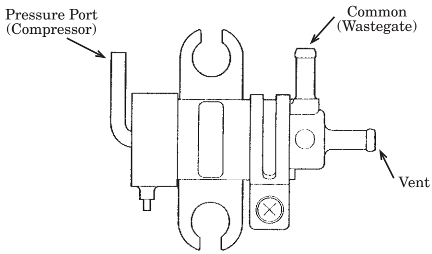


Figure 11.1 Nippon Denso Three-port Solenoid for use with an Integral Wastegate

This solenoid should be connected as described below and shown in Figure 11.2.

- common port is connected to the wastegate actuator
- pressure port is connected to the turbocharger's compressor outlet
- bleed port is vented to the atmosphere (usually via a filter)

When the solenoid is de-energised the common and pressure ports are connected and compressor pressure is allowed to fill the actuator and open the wastegate. When the solenoid is energised the common and vent ports are connected and the air pressure in the actuator is bled off to atmosphere.

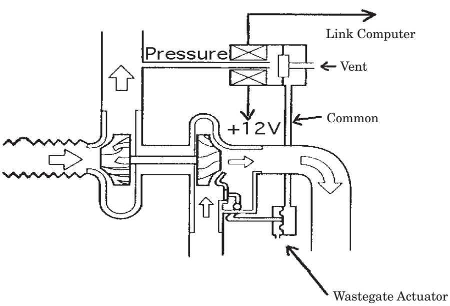


Figure 11.2 Fitment of three-port solenoid to Integral Wastegate

11.1.2 Two Port Solenoid

Some factory-fitted boost control systems use a simple two-port solenoid rather than the three-port type previously described (especially Nissan and Mitsubishi). These basically work as variable bleed and require some form of restrictor between the turbocharger's compressor (pressure source) and the boost control solenoid. This is shown in Figure 11.3.

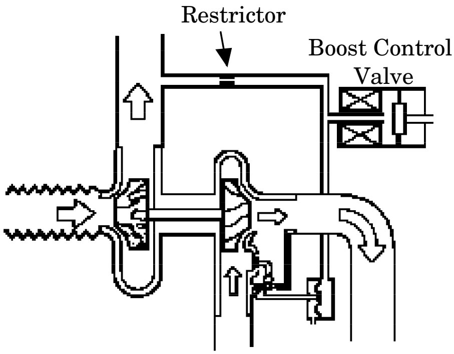


Figure 11.3 Fitment of two-port solenoid to Integral Wastegate

A typical size for the restrictor is 1.00 to 1.50 mm in diameter. The required size varies as it is dependent on factors such as the wastegate construction, the length of the hose and the diameter of the hose.

If the restrictor is too small then boost will tend to overshoot since it limits the rate at which the wastegate will fill and therefore move the actuator arm. If the restrictor is too large the ECU will be unable to achieve high boost operation. This is because the solenoid is unable to bypass sufficient pressure so the wastegate opens prematurely.

It is recommended that two-port solenoids are only used for small to moderate increases in boost pressures over the factory setting while the three-port types may be used for high boost applications requiring more precision and better control.

11.2 External Wastegate

In some applications, a factory-fitted integral wastegate in its fully open position may be unable to bypass a sufficient amount of exhaust gas to maintain the desired boost pressure. This condition is typically recognised when boost pressure rises uncontrollably at high engine speeds. In this case a larger diameter wastegate is required. Typically fitting an external wastegate is the easiest solution.

While both types of wastegates perform the same function, external wastegates have some important differences when compared to integral wastegates. Typical external wastegates actuators pull to open the wastegate rather than pushing it. Therefore, pressure must be applied to the bottom side of the diaphragm to open the wastegate. Either the 2-port or 3-port solenoids designed for integral wastegates can be used as long as the connection to the wastegate actuator is made beneath the diaphragm. However, this method is not recommended.

The preferred option is to use a second line from the compressor outlet to the topside of the actuator. It is recommended that the top and bottom of the wastegate actuator are fed by separate pressure lines. The boost control solenoid is then plumbed into the line connected to the top of the actuator as shown in Figure 11.4.

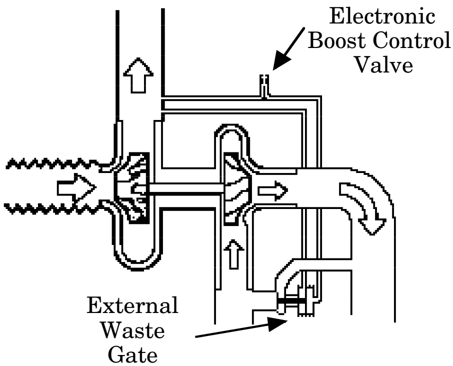


Figure 11.4 Fitment of three-port Parker solenoid to External Wastegate

However, the sense of operation is reversed with this system. Applying more pressure to the topside of the actuator CLOSES the wastegate and INCREASES boost pressure. Therefore a solenoid with reversed sense is required. This solenoid must allow the top of the wastegate actuator to vent to atmosphere when de-energised, and fill the top of the actuator with boost pressure when energised. Figure 11.5 shows the Parker solenoid that is suitable for this application. Conventional two-port and three-port solenoids may not be used.

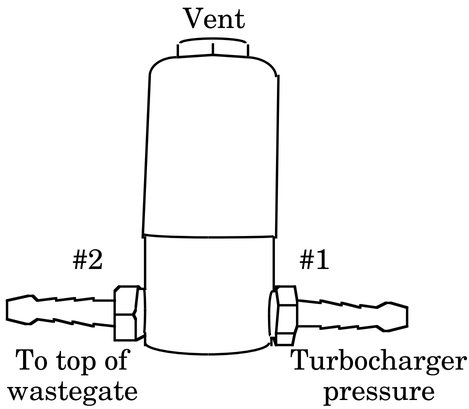


Figure 11.5 Parker Solenoid for use with external wastegates

Port #1 is plumbed to the turbocharger, while port #2 is plumbed to the top of the wastegate.

11.3 Wiring & Mounting of Boost Control Solenoid

It is important that the correct type of solenoid is used. Devices intended for electronic boost control should be used wherever possible. Some types of plastic bodied units may work effectively but may not withstand the constant cycling imposed upon them and subsequently fail after several hours of service.

A solenoid's operation can be checked by blowing through its ports with the solenoid both energised and de-energised.

For wiring information refer to section 3.10.2. Remember the throttle position sensor (TPS) MUST always be connected when using boost control. The solenoid should be mounted in the engine compartment as close to the wastegate as possible. This will keep the pressure line to the solenoid as short as possible and minimise any signal delay.

11.4 Setting up Boost Control Software

The computer software features a number of adjustment facilities for closed loop boost control and may be accessed using a Link Tuning Module or PCLink software.

11.4.1 Boost Target Values

An extra row of zones has been added to the zoning system to hold target boost values for each 500 RPM interval between 500 & 10000 rpm. This allows the boost curve to be tailored for the application. The boost may be held at lower levels through the mid range to suppress detonation and then allowed to rise at higher rpm where detonation is less likely. The target values may be changed by using the EDIT mode (for individual adjustment) or by selecting BOOST, which adjusts all 20 zones simultaneously (action similar to "ROW FUEL"). All boost targets are shown in kPa (absolute) and may be cross-referenced using Appendix C.

11.4.2 Waste Gate Settings

The following settings must be adjusted to achieve the required result. Turbochargers, wastegate actuators, control solenoids, and engine characteristics all have an effect on the dynamics of the system. Therefore each system must be configured differently. The recommended procedure is to make small adjustments and fully evaluate the result before further changes are made.

i) WGATE SENS. (Sensitivity Control)
All closed loop (feedback) systems require an optimum sensitivity level, which is a compromise between fast response time and overall stability. High sensitivity values produce fast response at the expense of overshoot followed by oscillation around the target value. Low sensitivity values result in boost moving slowly towards the target.

Experience has shown that in most systems, a "WGATE SENS xx" value between 1 and 10 is used. Never set the value to 0.

ii) WG Base
This value is used for calculating the initial duty cycle that the ECU will apply to the boost control solenoid as a "first guess" when trying to control boost.

When the engine rpm increases above the value set by WG RPM and the throttle is increased above approximately three-quarters open, the ECU will change from its lockout state (where the ECU is not trying to control boost) to its active state where the ECU will begin to control boost.

Each time the ECU changes into its active state, the initial duty cycle applied to the solenoid is calculated using information including the WG Base. The WG Base is not equal to the initial duty cycle, however a higher WG Base will lead to a higher initial duty cycle and vice versa.

Ideally the WG Base is set so that the duty cycle required to maintain the desired boost is already being applied during lockout. Therefore when the ECU changes into its active state it does not need to significantly change the duty cycle being applied to the boost control solenoid.

If the WG Base is too high, then the initial duty cycle will be too high and the boost pressure will overshoot.

If the WG Base is too low, then the initial duty cycle will be too low and the boost pressure will increase slowly to its target value.

iii) WG RPM
WG RPM sets the engine rpm at which the boost control lockout will be disabled provided that the TPS value is also sufficient for the lockout to be disabled. The lockout is required because at low rpm there may not be sufficient exhaust gas to fully spool the turbo. Therefore, regardless of what the boost control system is doing, it would be impossible to reach the boost target. Under these conditions without a lockout feature, the ECU would try in vain to increase the boost by increasing the solenoid duty cycle. When enough exhaust gas is produced to spool the turbo the boost pressure would grossly overshoot since the solenoid would be continuously open (100% duty cycle) leading to the wastegate being fully shut.

The ideal WG RPM value is highly dependant on the turbo size in comparison to the engine it is being run on. The WG RPM should be set approximately equal to the engine RPM where the turbo begins to produce boost. Typical values usually fall between 3,000 and 4,500 rpm. If boost control is set up satisfactorily in low gears, but overshoots at low engine rpm when driving in higher gears (4th or 5th gear etc.) then the solution is usually to increase the WG RPM.

iv) Boost Hold (only available with some software)
This feature will hold the boost control solenoid fully open (and the wastegate fully closed) until the engine's manifold air pressure has reached a set percentage of the boost target. This feature is designed to improve the boost response times. The default value is 80%. Take for example a target of 200kPa (approximately 1Bar of Boost). The solenoid will be held fully open until 180kPa (approximately 0.8Bar of Boost). After this point the boost control system will revert to operation as normal.

v) Target Ref (only available with some software)
This feature allows selection of how the throttle position, as measured by a throttle position sensor or TPS, affects boost control. There are two options:

Normal (Nom) - The boost control system is in lockout until the TPS value reaches a non-adjustable threshold (usually at a TPS reading of 70 in most software variants).

Throttle Proportional (TPS) - The boost pressure is proportional to the throttle position. For example, at 70% throttle only 70% of the boost target should be achieved.

vi) Map Limiting
The MAP Limit is a safety feature, which prevents an engine being subjected to damagingly high boost pressures. The MAP Limit is in kPa (absolute) to allow correlation to the boost target values. This limit should be set about 10-15 kPa above the highest boost target value to allow for the slight overshoot which is inherent in closed loop systems. This can be adjusted from the Limits heading in LinkPlus/LEMV4.

11.5 Boost Control Diagnostics/Troubleshooting

The following diagnostic guide ranges from "no operation at all" through to tuning and fine adjustment of a serviceable system.

11.5.1 Installation Tests (Electrical)

i) Key ON, engine stationary, all devices connected. Apply boost pressure to Manifold Air Pressure sensor (MAP) using a "Mityvac" or similar pressure pump device. Set boost hold to 0 if applicable. Increase pressure to at least 0.4 Bar (1.4 Bar absolute or about 6 psi) and the Boost Control Solenoid should start "buzzing" at a moderately low frequency. If so, go to 11.5.2 Installation Tests (Mechanical). If not progress to the next step.

ii) Remove the pressure being applied to the map sensor. Locate the boost control solenoid (BCS) wire coming out of the ECU. With the key ON, engine stationary and with the ECU fully connected, measure the voltage by back-probing the ECU's connector. This should read about battery voltage (approx. 12 volts). If so, go to step iv). If not progress to the next step.

iii) Key off, remove the wire to the BCS from the ECU connector by lifting the pin retaining tab with a suitable needle/probe and sliding the connector pin out of the connector body. Reconnect the ECU connector with the BCS wire now free. Key ON, measure the voltage on BCS wire. If it now reads about 12 volts then there is a "drive" problem with the ECU. Return the ECU for repair. If not check the following:

- The wiring between ECU and BCS (open or short circuit to EARTH)
- The +12 volt supply to BCS (ensure all relays/fuses are intact)
- The BCS operating coil resistance (e.g. not open circuit)

iv) Use a suitable length of wire to EARTH the ECU to BCS wire. As the EARTH is applied and removed the solenoid should make a clicking sound. If so, go to Installation Tests (Mechanical), if not check the following:

- Excessively high BCS coil resistance (typically about 10-30 Ohms)
- BCS seized (disconnect from system and apply 12 volts directly across to the BCS to confirm)
- The +12 volt supply to the BCS cannot supply sufficient current.

11.5.2 Installation Tests (Mechanical)

A “Mityvac” or similar pressure/vacuum pump makes these tests a lot easier to perform.

<u>Integral Wastegates</u>:

i) Verify that with no pressure applied to the actuator, the wastegate is fully shut and sealing adequately.

ii) With the BCS de-energised (or BCS electrically disconnected), apply pressure to the solenoid “pressure” port. This port would normally be connected to the turbocharger compressor outlet or other source of boost pressure before the throttle butterfly. There must be a flow of pressure directly to the wastegate actuator with no bleeding-off. The wastegate should open if there is sufficient pressure applied to the system. Also note the pressure at which the wastegate opens since this is the minimum pressure that the system can operate at. The wastegate should remain open with pressure applied as the actuator should not leak over a reasonable period of time.

iii) Keep pressure applied as in the previous step so that the wastegate is open. Energise the solenoid by whatever means is convenient. The wastegate should now close.

<u>External Wastegates</u>:

The following test is for an external wastegate setup utilising both the top and bottom ports of the wastegate and a Parker BCS.

i) Apply pressure to the port on the bottom of the wastegate actuator. With sufficient pressure applied the wastegate should open. Many external wastegate actuators tend to leak pressure from the bottom side of the diaphragm. This makes it difficult to verify that the wastegate opens at the desired pressure.

ii) Energise the BCS. Apply pressure to the solenoid pressure port which normally connects to the to the turbochargers compressor outlet. The pressurised air should not leak over a reasonable period of time. A leak indicates a possible diaphragm failure.

iii) De-energise the BCS. The pressurised air in the top of the wastegate actuator should now be vented to the atmosphere through the BCS.

11.5.3 Further Troubleshooting

The following tests assume that the system passed the basic electrical and mechanical tests and that a Remote Tuning Module is connected and working.

Select "WG BASE (xxx%) " on the remote and observe the BCS duty-cycle figure (xxx%) during the following steps.

i) Symptom - Boost pressure is below the target value
Bring engine/vehicle up to about mid-range power and give engine full throttle. After a short delay, the ECU should sense that the boost pressure is below the target value and try to compensate for this by increasing the duty-cycle being applied to the BCS. If this occurs then the duty value should climb quickly to a high value (over 95%) and remain so until the throttle is closed. This indicates that the system software is operating correctly, but a mechanical condition is limiting the boost pressure. In this case the following should be checked:

- Exhaust gas leaks ahead of turbocharger (e.g. cracked manifold, blown gasket, loose flanges)
- Boost leaks somewhere in the system (e.g. around hose clamps, inter-coolers, dump/blow-off valve leaking)
- Airflow restrictions (e.g. air-filter, throttle plate/butterfly area, FIA restrictor, collapsed hoses
- Exhaust restrictions (e.g. collapsed muffler/catalytic converter, impact damaged exhaust)
- Exhaust back-pressure opening the wastegate prematurely (especially external wastegates)
- Damaged turbocharger (internally)
- The turbocharger may not have sufficient flow for the task. Consult a turbocharger specialist for help.
- Damaged engine or associated systems
- Gross mis-tuning of fuel and/or ignition timing
- Control system limiting (MAP LIMIT or similar).

If duty-cycle stays low (or does not change) the following should be checked:

- MAP LIMIT is set too low. Set limit to at least 10 kPa ABOVE the HIGHEST boost target.

- TPS SPAN not exceeding at least 70 at full throttle.
- Minimum boost pressure not rising above the 0.4 Bar (about 6 psi) needed to activate the system.
- WG RPM set too high. System is active only when this rpm value has been exceeded
- WG SENS set to ZERO

ii) Symptom - Boost pressure is above the target value

- WG RPM may be set too low
- WG BASE may be set too high
- WG SENS may be set too high
- Boost Hold (if applicable) may be set too high
- Wastegate may not be able not flow sufficient amounts of exhaust gas to limit boost (normally seen as boost increasing from target at high rpm)

12. Idle Speed Control

The LEM offers 1 idle speed control option:

- 2 Terminal Solenoid

The 2 terminal Solenoid option can be driven directly from the LEM, with no additional hardware required.

For the Idle speed system to function correctly, the TPS MUST be connected. Ensure the TPS "low" value is set at 20. See section 8.0 for information on how to do this.

12.1 Functions

The following functions are available under the Idle Speed heading.

Solenoid Annunciators (z)

A Acceleration fuel is pending

V Engine in overrun vacuum

T Throttle is open

= Idle Speed equals target value

+ System is increasing idle speed

— System is decreasing idle speed

12.2 Idle Duty Cycle Defaults

This menu is only adjustable if solenoid has been selected as the idle device. There are 2 default values labelled "Idle Hot" and "Idle Cold". These are used by the software to preset the ISC duty cycle to about the correct value during gear shifts, over run vacuum, returning to idle etc.

12.3 Idle Cold

When the engine is below 20°C the "Idle Cold" value is the default duty cycle. Between this temperature and 50 the software will interpolate to create an intermediate duty cycle. To change use the ADJUST buttons.

12.4 Idle Hot

When the engine is above 50°C, the "Idle hot" value is the default duty cycle forced into the solenoid. This should provide an idle RPM close to the required value. To change use the ADJUST buttons.

12.5 Solenoid Idle Speed Setup

The Idle speed control system has three main adjustments for correct operation.

1. "IDLE (xx%) yyyz" sets the required idle speed in steps of 50 rpm. The (xx%) value shows the actual duty cycle to assist settings and monitoring. Use the ADJUST buttons to select the idle RPM.

2. Two default values for cold and hot engines.

   Hot Engine

   Select "IDLE (xx%) yyy z" on the remote and set the required idle speed. Once the idle rpm has stabilised note the duty cycle value shown in parentheses (xx%) and record the value. Select the "Idle Hot   xx%" menu and enter the recorded value +/- 2%.
   e.g. Duty Cycle = 43% (stable hot idle) then enter a value of 45%

   Cold Engine

   Use the same procedure as above except note the duty cycle shortly after a cold start. Enter this value using the menu " Idle Cold xx%" under the "IDLE SPEED" heading. The engines idle will always be higher when it is cold implying the IDLE COLD value will be larger than IDLE HOT.

   Store the new value by moving to a STORE menu and holding both ADJUST buttons until the display shows "********" and then release.

   Note that the software also generates an intermediate (warm) value, which is the average of the cold and hot settings but is not independently adjustable. If the target rpm is changed at a later date, the HOT and COLD default values may require adjustment.

3. To aid in the control of the Idle Speed solenoid the software uses TPS to determine throttle position. Always ensure the TPS "low" value is 10. This is the value used to determine closed throttle and

MUST be set to ensure the correct operation of the Idle Speed system. See the * UTILITIES * Section 8 for TPS setup information.

4. The Idle speed system will perform idle correction under the following conditions

- TPS < 13 (Throttle Closed)
- RPM < 1500
- Engine MAP > Overrun Vacuum Target

All other conditions will cause the idle system to enter hold mode, where "Idle Hot" and "Idle Cold" are used to determine duty cycle.

Note: For the correct operation of the Idle Speed System ensure the TPS has been setup as described in section 8.2 and the Overrun Vacuum Target as outlined in section 8.1.1. Failure to set up these parameters will result in incorrect operation.

13. Configuration

To edit any of the below settings scroll to the * CONFIGURATION * heading and use the EDIT buttons to move through this menu.

13.1 Functions

The following functions are available under the Configurations heading.

13.1.1 Cylinder Setting

Displays the current number of cylinders. Changes are made by pressing the ADJUST buttons and must be stored and power recycled before the new settings become active.

13.1.2 Row Steps

This control allows the zone table row selection to be setup in one of four modes. These are Map, Vacuum, MAP+TPS, and TPS. To scroll through these modes used the ADJUST buttons. Not all options will be selectable as this well depend on the engine aspiration.

Non Turbo : Row Steps available – MAP, Vacuum, TPS
Turbo : Row Steps available – MAP , MAP+TPS

Be aware that the default zone table is configured for Vacuum and Boost.

If the ROW STEPS are changed to Vacuum or TPS, for use on a naturally aspirated engine, the fuel and ignition numbers will need adjusting. The fuelling will be too rich and the ignition too retarded. The LEM MUST be retuned.

13.1.3 Ignition

Choose the ignition configuration, distributor or multi-coil. Refer Section 6.

13.1.4 Temperature Sensor

This selects either the factory negative temperature coefficient (NTC) or the Link IC type sensor. Confirm the correct choice by viewing the "TEST ENGT" or "COLD" menu on the tuning module. The displayed temperature should be approximately correct. (There is a huge difference between the two. The correct selection will be obvious). Press SELECT UP to select the Link temperature sensor or SELECT DOWN for the NTC sensor.

13.1.5 RPM Switch

The LEM can run either a RPM switch or idle speed or boost control Refer to Section 3.8.

13.1.5.1 RPM
To control a shift light or VTEC solenoid or inlet runner control.

13.1.5.2 Wastegate
For turbocharger boost control.

13.1.5.3 Idle
For two wire idle speed control

13.1.6 IG3

13.1.6.1 Shift Light
RPM based switch to drive a LED light only. Refer 3.7.3.

13.1.6.2 Tachometer
Low level tachometer drive. Refer 3.7.4.

13.1.7 Store

Store saves changes to eprom memory. Perform STORE by pressing BOTH ADJUST buttons together until the display shows "****************" and then release.

13.1.8 Reload

This process presets all zones to typical values to allow a base for subsequent tuning.

For example the fuel numbers and lambda targets for a normally aspirated engine running ROW STEPS = Vacuum will differ when compared to a turbo changed engine.

For safety reasons a Reload CANNOT be executed while the engine is running.

RELOAD is initiated by pressing BOTH ADJUST buttons together until the display shows "****************" and then released.

CAUTION: RELOAD will over-write all values currently stored in the LEM memory and should only be used during initial setup or if you wish to restart the tuning procedure again from scratch.

14. Diagnostics

The section provides basic engine information for diagnostic and monitoring purposes. All information is temporary stored and will be lost when power is removed from the LEM.

14.1 Trigger Signals

This menu will display "Cyl=xxx Sync=yyy". This provides conformation the LEM is receiving the required trigger pulses. This menu will only function while the engine is running or being cranked.

xxx = Y : LEM receiving correct cylinder pulse.

xxx = N : No Cylinder pulse detected. This will also show up on the TEST RPM menu as zero RPM.

yyy = Y : LEM receiving correct sync pulse.

yyy = N : No Sync pulse detected.

Yyy = N/A : Sync pulse not required for current configuration.

14.2 Max RPM

This menu displays the engine maximum RPM. This menu is used to check for trigger glitches, indicated by an unrealistic RPM figure.

14.3 Max Map

Displays the maximum manifold air pressure for turbo charged engine.

14.4 Max Injector Duty Cycle

Displays the maximum duty cycle of the injector. If this value is between 90 – 95% the fuel system is struggling to supply enough fuel to the engine. A value of 99% means the fuel system cannot delivery the required fuel. See section 17.1 on how to check a fuel pump by performing a fuel flow test.

15. First Time Setup

The following checks and adjustments are mandatory before attempting to start the engine. Connect the tuning module to the LEM and switch the ignition key on. DO NOT attempt to start the engine before reading this section.

Move to the * CONFIGURATION * menu and adjust the following

- Select the required ignition; Distributor or 2 Channel or 3 Channel.

Move to the * UTILITIES * menu.

- If the TPS is required adjust the TPS Span.

Adjust the following options from the *CONFIGURATION * heading.

- Select the correct number of cylinders
- Select the required ROWSTEPS
- Select the correct temperature sensor
- Lastly perform a reload.

16. Tuning Port

The fourteen pin connector located at one end of the LEM allows connection of various tuning and diagnostic tools to the system. All devices use a fourteen line flat ribbon cable, and connectors are keyed to prevent incorrect installation. The following devices are currently available.

Ignition switch (key) must be OFF before installing any device. When the key is switched on, the LEM will automatically determine which device is fitted and run the appropriate software to support it.

16.1 Tuning Module

The Link Tuning module allows all aspects of fuel, ignition, boost and utility functions to be adjusted, edited and stored.

16.1.1 Menu Structure

Each function is allocated a menu from which adjustments can be made. The first 7 menus are read only providing real-time information about the engine. The remaining adjustable functions for simplicity have been grouped under an appropriate heading, designated by the '* ' symbol. For example, all functions related to the fuel map such as MASTER, ROWFUEL, ZONEFUEL have been grouped under one heading. These tuning functions can only be accessed from this heading using the EDIT buttons. All read only menus and headings are displayed in upper case and all adjustable functions displayed in lower case. Figure 16.1 illustrates this menu structure.

16.1.2 Tuning Module Buttons

The SELECT Buttons allow scrolling through the read only menus and main headings. From any main heading (shown by the * symbol), pressing EDIT down will allow access to the grouped tuning functions. Pressing EDIT up will return the menu to its main heading. The EDIT buttons are also used to move through the Zone Editor, which appears as the last menu. To change a value use the ADJUST buttons.

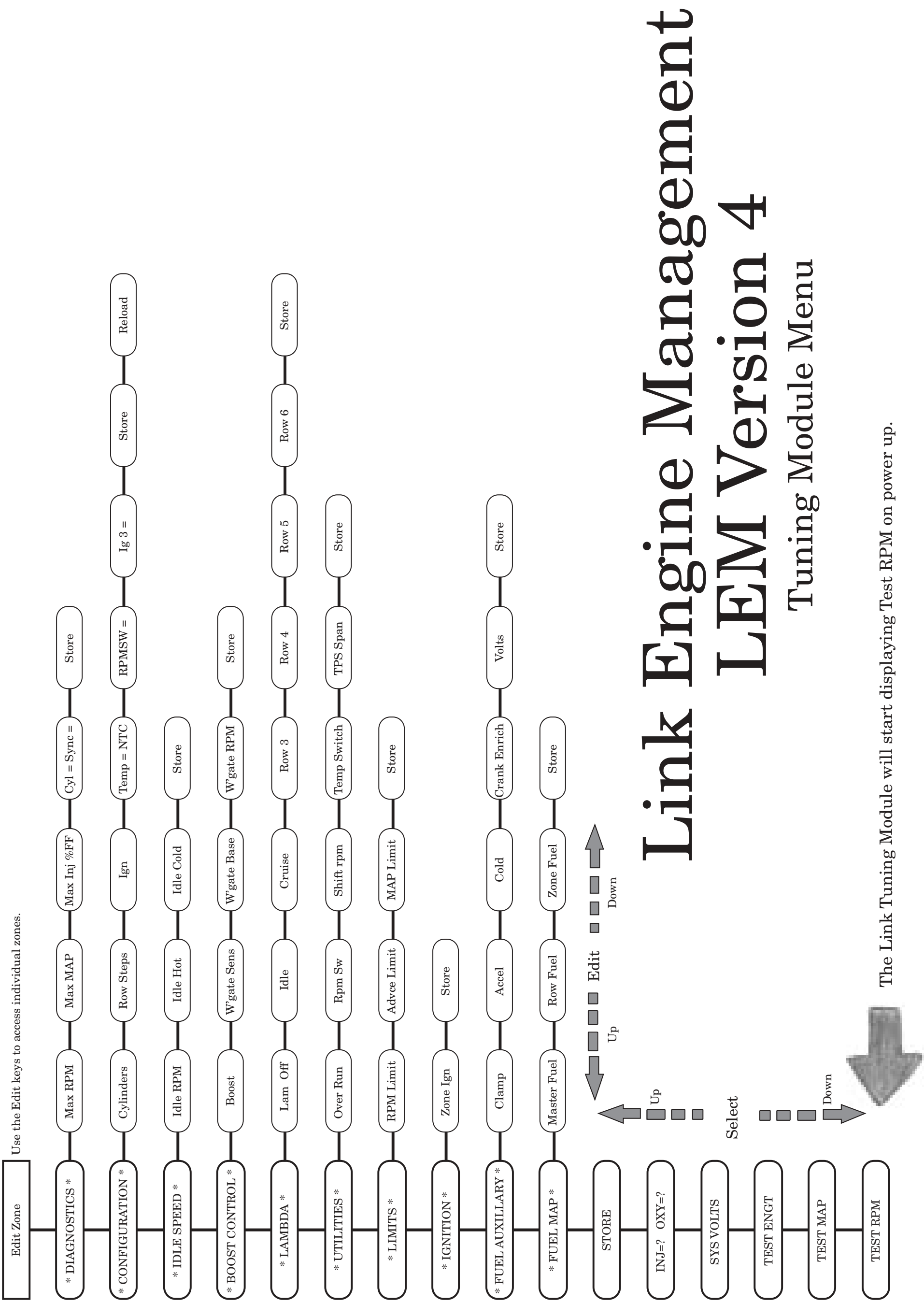
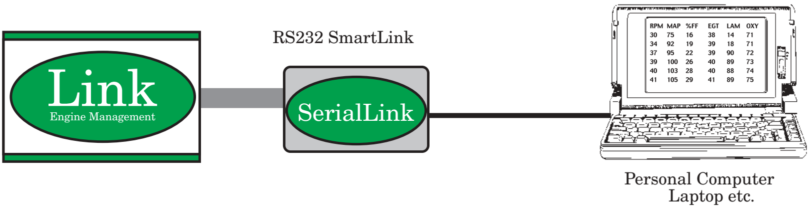


Figure 16.1. Tuning Module menu structure.

16.2 PCLink

This allows the LEM and PC to perform 2-way communication using the SerialLink. Once the PCLink software has been installed from CD the LEM can be tuned from laptop or personal computer. For more information see Section 17.

16.3 SerialLink



The SerialLink allows communication between the LEM and a personal computer via the PC's RS232 serial port for data-logging and downloading of the LEM settings. While the engine a stream sent to the PC shows all major engine parameters such as RPM, pressures, temperatures and flows. The information may be recorded using the PC' s memory / disk drive. Graphs etc. may be created using spread sheets etc.

The Software used to view and store this data is called "Comlink" and can be copied from the CD supplied with the LEM. (Alternatively it can be downloaded from our web site www.link-electro.co.nz.) Place the CD in the CD ROM drive and select the directory "PCLink\PCLink Software Installer\Comlink.exe". Copy comlink.exe to the hard drive where the program can be executed. Connect the 14 way flat ribbon cable between the LEM and SerialLink. Next connect the standard serial cable between the SerialLink and an available COM Port on the PC. Now start Comlink. There are 2 setup options

- First select the correct COM Port. Use the keyboard buttons Q & A to change the settings. Once configured press the Enter button on the keyboard
- Next select the correct baud rate using the Q and A Keys.

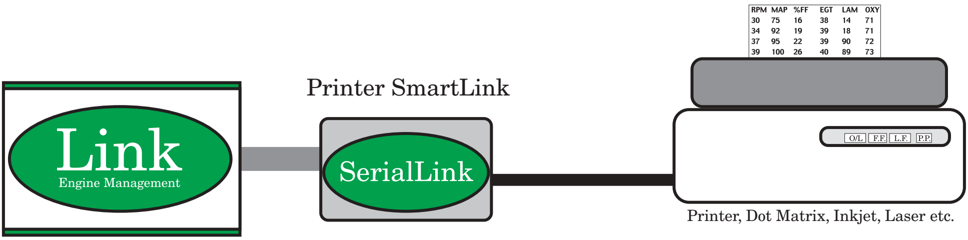
  The LEM uses 9600.

  Once configured press the Enter key on the keyboard

- Switch the ignition key ON. The initial data dump will be in the same format as the Zone Table shown in Appendix A or B. The first 2 rows are configuration and tuning functions. Next is the Fuel table, followed by the ignition table, and lastly the boost table.
- Now start the engine and observe the runtime data. Follow the onscreen help for storing this data.

16.4 PrintLink

The PrintLink is similar to the SerialLink above except that the PrintLink connects directly to any type of printer for instant hard copy data. An alternative option is to use a battery backed "printer buffer" to store information while test driving and then downloading the buffer to a printer. Typical buffers allow in excess of one hours logging time.



17. Windows Laptop Tuning

The LEM offers PC/Laptop tuning using PCLink Software. A copy can be found on the CD supplied with the computer or from our web site: www.link-electro.co.nz. It allows real time 2-way communication between the LEM and Laptop computer.

Installing PCLink Software from CD

- Insert PCLink CD into the CD ROM drive.
- The software in located in the "PCLink\PCLink Software Installer\Setup.exe" folder.
- Double click on the "setup.exe" file to start the installation process.

  During the installation process a PCLink icon will be generated and place on the desktop. To start, simply double click on this icon.
- For detailed information on the operation of the PCLink software, start the program and read the online Instructions.
- A Tutorial is also available and can be copied from the CD in directory, "PCLink\PCLink Tutorial\PCLink_Tute.pdf". This is PDF document, which requires Acrobat reader. A copy of this software is also available on CD if required.

PCLink hardware connection.

This requires one 14-way flat ribbon cable, one SerialLink, one standard serial cable and a PC.

- Connect one end of the ribbon cable to the Link Tuning Port, the other end should connect to the SerialLink.
- Take a standard serial cable and connect one end to the SerialLink. Connect the other end to an available COM Port on the PC.
- Start the PCLink Software by double clicking on the desktop icon or using the START, programs menu.
- Switch the ignition on which will power up the LEM

  NOTE. The SerialLink should ALWAYS be connected before the ignition key is switched ON.

- The PCLink offers both mouse and keyboard control. To start the connection between PC and LEM using the mouse, move to the "Link Control" menu and select "Connect Link". Using the keyboard, press and hold the Ctrl, Alt and L keys. This will bring up an "Options" box. Check the following settings
- Make sure the Link Connection shows "ONLINE"
- Select the correct COM Port
- Click the OK button. Once the PC is communicating with the LEM, tuning can begin. Remember to STORE any changes before disconnecting the PCLink software from the LEM.

18. Fault Finding & Diagnostics

Before calling Link for technical support, have the following information available.

- Connect the Tuning Module and apply power. Press and hold the EDIT UP button on the "TEST RPM menu. This will display the current software version. Take note of this.

18.1 Fuel Flow Check

A Fuel flow check should ALWAYS be done to ensure the fuel pump is capable of delivery the required fuel to the engine. This applies to both normally aspirated and turbo-charged engines. The test involves measuring the volume of fuel returning to the tank over a fix time period.

Symptoms
- Engine missing under boost or high power
- Injector duty cycle greater than 95%

Before checking remove any possibility of spark by disconnecting the igniter(s).

Disconnect the fuel return line from the output of the fuel pressure regulator. Reconnect another (longer) fuel line to the output of pressure regulator and place the hose in a measuring vessel.

If the engine is normally aspirated leave the vacuum reference on the pressure regulator at atmosphere. If the engine is turbo charged place the desired boost on the pressure reference. This can be done using a mityvac.

18.1.1 Fuel Requirements

1 litre of fuel per minute per 200 hp. For a 200hp engine the fuel pump MUST be able to deliver 1 litre of fuel at the return line per minute. For 300hp the fuel requirements are 1.5Litres per minute etc.

The best method is to measure the volume of fuel over 10 seconds and multiply the volume by 6. Switch on the ignition key, with the Tuning Module on the "TEST RPM " menu and press down the edit button. This will activate the Fuel Pump so start timing once this button has been pressed.

Fuel Pressure is not a good indication of Fuel Flow. The fuel system can still have pressure with very little flow. The analogy of a garden hose can be used. Turn the garden tap on and block the end of the hose. There will be no flow but the hose will show good pressure.

18.2 Engine Misfire

- Check for stable "TEST RPM" on the Tuning Module
- Ensure the plug gap is not too large. Typical value range from 25 to 35 thou.
- Read Section 14.5 and 14.6.

18.3 Idle Surge

If fuel cannot smooth out an engines idle, one method is to advance the engine with falling idle speed. For example, if the engine is idling in zone 105, enter a larger advance number into zone 100 and perhaps zones 100 and 200.

18.4 Engine will not start or is hard to start

The first check is for low voltage on crank. Connect the Tuning Module and move away from the "TEST RPM " menu. Now try and start the engine. If the Tuning Module resets to the "TEST RPM" menu, the LEM has been put through reset because the supply voltage has dropped below 7.5V. Check to ensure the power supply is not going through the ignition switch, as this can create voltage drops on crank. Wherever possible, always use a relay to supply +12V directly from the battery to the LEM.

Appendix A: Zone Sheets

Link Engine Management

Vacuum Only

Miscellaneous								Drives		TPS		Wastegate			
Clamp 0	Mast 1	R.Lim 2	M.Lim 3	A.Lim 4	Mode 5	Cyl 6	Volts 7	RPM 8	Fan 9	Low 10	High 11	Sens 12	O'Run 13	Base 14	RPM 15

						Accel				Lambda Targets					
Cold 16	Crank 17	IDHot 18	IDCold 19	Idle 20	Shift 21	22	23	24	25	Idle 26	Cruise 27	Row3 28	Row4 29	Row5 30	Row6 31

Accel: 0 2 4 6 — RPM x 1,000

Lambda Targets: 0 20 40 60 80 100 — MAP (kPa)

Zone Fuel

0 1,000 2,000 3,000 4,000 5,000 6,000 7,000

Bar																
0.2	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175
0.4	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275
0.6	300	305	310	315	320	325	330	335	340	345	350	355	360	365	370	375
0.8	400	405	410	415	420	425	430	435	440	445	450	455	460	465	470	475
1.0	500	505	510	515	520	525	530	535	540	545	550	555	560	565	570	575
1.2	600	605	610	615	620	625	630	635	640	645	650	655	660	665	670	675

Zone Ignition

0 1,000 2,000 3,000 4,000 5,000 6,000 7,000

Bar																
0.2	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175
0.4	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275
0.6	300	305	310	315	320	325	330	335	340	345	350	355	360	365	370	375
0.8	400	405	410	415	420	425	430	435	440	445	450	455	460	465	470	475
1.0	500	505	510	515	520	525	530	535	540	545	550	555	560	565	570	575
1.2	600	605	610	615	620	625	630	635	640	645	650	655	660	665	670	675

Link Engine Management

Vacuum and Boost

Miscellaneous								Drives		TPS		Wastegate			
Clamp	Mast	R.Lim	M.Lim	A.Lim	Mode	Cyl	Volts	RPM	Fan	Low	High	Sens	O'Run	Base	RPM
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

						Accel				Lambda Targets					
Cold	Crank	IDHot	IDCold	Idle	Shift					Idle	Cruise	Row3	Row4	Row5	Row6
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

Accel: 0 2 4 6 RPM x 1,000

Lambda Targets: 0 40 80 120 160 200 MAP (kPa)

Zone Fuel

Bar	0		1,000		2,000		3,000		4,000		5,000		6,000		7,000	
	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175
0.4	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275
0.8	300	305	310	315	320	325	330	335	340	345	350	355	360	365	370	375
1.2	400	405	410	415	420	425	430	435	440	445	450	455	460	465	470	475
1.6	500	505	510	515	520	525	530	535	540	545	550	555	560	565	570	575
2.0	600	605	610	615	620	625	630	635	640	645	650	655	660	665	670	675

Zone Ignition

Bar	0		1,000		2,000		3,000		4,000		5,000		6,000		7,000	
	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175
0.4	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275
0.8	300	305	310	315	320	325	330	335	340	345	350	355	360	365	370	375
1.2	400	405	410	415	420	425	430	435	440	445	450	455	460	465	470	475
1.6	500	505	510	515	520	525	530	535	540	545	550	555	560	565	570	575
2.0	600	605	610	615	620	625	630	635	640	645	650	655	660	665	670	675

Boost Targets

0		1,000		2,000		3,000		4,000		5,000		6,000		7,000	
700	705	710	715	720	725	730	735	740	745	750	755	760	765	770	775

Appendix B: Pressure Conversion

kPa (Absolute)	InHg
32	20
35	19
39	18
42	17
45	16
49	15
52	14
55	13
59	12
62	11
66	10
69	9
72	8
76	7
79	6
83	5
86	4
89	3
93	2
96	1
100	0

kPa (Absolute)	Pressure (PSI)
100	0.00
105	0.73
110	1.45
115	2.18
120	2.90
125	3.63
130	4.35
135	5.08
140	5.80
145	6.53
150	7.25
155	7.98
160	8.70
165	9.43
170	10.15
175	10.88
180	11.60
185	12.33
190	13.05
195	13.78
200	14.50
205	15.23
210	15.95
215	16.68
220	17.40
225	18.13
230	18.85
235	19.58
240	20.31
245	21.03
250	21.76
255	22.48
260	23.21
265	23.93
270	24.66
275	25.38
280	26.11
285	26.83
290	27.56
295	28.28
300	29.01

Appendix C: Absolute to % Conversion

%	Absolute	%	Absolute
1	3	51	130
2	5	52	133
3	8	53	135
4	10	54	138
5	13	55	140
6	15	56	143
7	18	57	145
8	20	58	148
9	23	59	150
10	26	60	153
11	28	61	156
12	31	62	158
13	33	63	161
14	36	64	163
15	38	65	166
16	41	66	168
17	43	67	171
18	46	68	173
19	48	69	176
20	51	70	179
21	54	71	181
22	56	72	184
23	59	73	186
24	61	74	189
25	64	75	191
26	66	76	194
27	69	77	196
28	71	78	199
29	74	79	201
30	77	80	204
31	79	81	207
32	82	82	209
33	84	83	212
34	87	84	214
35	89	85	217
36	92	86	219
37	94	87	222
38	97	88	224
39	99	89	227
40	102	90	230
41	105	91	232
42	107	92	235
43	110	93	237
44	112	94	240
45	115	95	242
46	117	96	245
47	120	97	247
48	122	98	250
49	125	99	252
50	128	100	255

Appendix D: Zone Sheet Conversion

This section explains how to convert the zone numbers from an old percentage driven LEM to the new absolute numbers as used in the V4 LEM. Firstly note the V4 LEM uses ALL absolute numbers and not percentage, as is the case with the old LEM. Use Appendix C to convert any percentage to an absolute number.

> Example: Take a MASTER value of 50% on the old LEM. This will require conversion, using Appendix D, giving a value of 128.
>
> Take the Accel Enrichment value of 8%. Conversion to an absolute number gives a value of 20.

The following items require conversion.

- Master
- Cold Start
- Accel Enrichment
- All Zone Fuel numbers