Link G3 Engine Management

WIRING & INSTALLATION MANUAL

25 Oct 2007

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NOTICE

Due to frequent upgrades, PCLink is no longer distributed on CD with new Link ECU's.

PCLink is available for free download at the following web site:

www.LinkECU.com

Should internet download not be practical, a copy of the latest version of PCLink on CD can be requested from your nearest Link Dealer.

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1 – INTRODUCTION

Thank you for purchasing your Link ElectroSystems Ltd. Wire-In Engine Control Unit (ECU). Link G3 ECU's are an advanced, fully programmable microprocessor controlled Engine Management System. The LEM^{G3} is the next generation of the popular LEM ECU now based on the new G3 software platform.

The G3 software platform boasts an impressive list of features giving a new level of user adjustment. This flexibility allows the tuner to have complete control over the engine management system. G3 software employs high resolution (up to 440 zone) fuel and ignition tables with configurable load and RPM centers. When coupled with four dimensional fuel and ignition mapping, barometric pressure compensation and intake air temperature correction this gives an unprecedented level of tuning accuracy. All G3 ECU's are in field upgradeable, there is no need to return the unit for software updates.

All Link Wire-In Engine Management Systems are designed with flexibility and ease of installation in mind. Link Wire-In systems are deigned to be wired to either existing wiring or preferably as a complete re-wire. In some cases adapter looms or header boards can be purchased to allow wiring of the LEM^{G3} to factory ECU headers. Contact your nearest Link dealer for more information on these.
Link Engine Management Systems are designed with the final result in mind. Not only do they boast an impressive range of performance features, but are designed with a focus on safety, reliability and drive-ability. However, the ultimate success of your engine management upgrade is determined by how well the system is installed and tuned.

Installing and tuning any aftermarket engine management system is not to be taken lightly. The LEM^{G3} gives the tuner the control & flexibility that only top after-market engine management systems in the world can provide. While every effort has been made to keep the LEM^{G3} as user friendly as possible, it should be recognised that added features bring with it added complexity.

The complete setup of your ECU has been divided into two equally important tasks.

1. This manual covers the wiring and installation of your LEM^{G3}. While it is not strictly essential that this work is performed by an automotive electrician, the knowledge and tools available to these professionals makes it highly recommended. Regardless of who does the installation, it is of utmost importance that clean and robust connections are made throughout the installation. A significant majority of after market engine management failures are due to poor wiring practices.
2. Once the LEM^{G3} has been installed it will need to be tuned using a laptop computer with PCLink software. Information on the configuration and tuning of the LEM^{G3} is detailed in the help section of PCLink. The LEM^{G3} is pre-loaded with a base tune that should be close enough to get your engine running after the configurations have been setup and a few simple adjustments have been made. While hearing the engine running on the new ECU for the first time is always a satisfying feeling, it is important to realise that the job is not complete. The amount of tuning performed and the experience of the tuner are the two most important factors in determining how happy you will be with your engine management system.

Should any issues arise during installation, the following options exist for technical support:

1. Contact your nearest Link dealer. A Link dealer list is available on our website.
2. Link Electrosystems website: www.linkecu.com
3. Technical Support Email: tech@linkecu.com
4. Online Discussion Board: Available from the Link website.

The majority of questions received by the technical support team are clearly answered in the manuals. To speed up your technical inquiry please consult the manuals to make sure that your question has not already been answered.

2 – PARTS LIST

Your LEM^{G3} should have come with the following:

- ✔ LEM^{G3} Engine Management System (ECU)
- ✔ LEM^{G3} Wiring and Installation Manual (what you are reading)
- ✔ Two mounting brackets
- ✔ Four mounting screws
- ✔ A Link Engine Management sticker

If a 2m or 5m loom was purchased then this should contain:

- ✔ The wiring loom
- ✔ Ignition Suppressor

3 – CHOOSING A CONFIGURATION

As the LEM^{G3} functions are highly configurable, the required connections will be highly dependent on the application. Read this section carefully to ensure the correct functions are chosen.

The first step in installing a LEM^{G3} is to decide what function each of the configurable inputs and outputs will provide.

The LEM^{G3} has the following input / output pins:

- 2 Injector Drives
- 4 Ignition Drives
- 5 Analog Channels (1 TPS, 2 temperature, 2 voltage configurable)
- 7 Configurable Auxiliary Outputs Drives
- 1 Configurable Digital Input or Auxiliary Output

3.1 – INJECTOR DRIVES

The LEM^{G3} has two independent injector drives allowing only group fire fuel injection. A more advanced Link ECU must be purchased in order to use sequential fuel injection. Staged injection is also available on some applications.

3.2 – IGNITION DRIVES

The LEM^{G3} offers four independent ignition drives which can be used in a wide range of configurations from a basic distributor setup through to more complex multi-coil arrangements. The configurations shown in Table 3.1 are supported by the LEM^{G3}.

Number of Cylinders	Distributor	Wasted Spark (1 Dual Post Coil per two Cylinders)	Direct Spark (1 Coil per Cylinder)
1	–	–	✔
2	✔	✔	✔
3	✔	✗	✔
4	✔	✔	✔
5	✔	✗	✗
6	✔	✔	✗
8	✔	✔	✗
10	✔	✗	✗
12	✔	✗	✗
2 Rotor	✗	✔	✔

Table 3.1 - Possible Ignition Configurations

3.3 – AUXILIARY OUTPUTS

The LEM^{G3} has up to eight auxiliary outputs. Unused ignition channels can also be used as auxiliary outputs. Auxiliary outputs are general-purpose outputs that may be used to perform a wide range of functions. However, the following limitations apply:

- Aux 4 and DI 1 share the same header pin and therefore can not be used at the same time.
- Aux 3 and 4 can not be used for Idle Speed Control.
- A Three Terminal ISC Solenoid must be wired to Aux 1 and Aux 2.
- An ISC Stepper Motor must be wired to Aux 5, Aux 6, Aux 7 and Aux 8.
- Aux 5 to 8 and Ignition 1 to 4 when used as Aux channels can not be Pulse Width Modulated (PWM) above 300Hz. Note that PWM frequencies above 300 Hz may be required to drive a tacho for a V8 above 4500 RPM.

Auxiliary outputs supply an earth to switch loads such as a solenoid, relay, bulb or LED. All auxiliary outputs may be used as a simple switch that becomes activated at a certain value (e.g. Honda VTEC), while Auxiliary Outputs 1-8 may perform pulse-width modulation for applications such as idle speed control and electronic boost control.

Loads may be connected directly to the auxiliary output without using a relay provided they do not draw more than 2A of current. Essentially this means that a directly connected load should have a resistance exceeding 7 Ω.

Some of the functions that may be performed by auxiliary outputs include:

- ✔ Fuel Pump Relay Switching (highly recommended for safety reasons)
- ✔ Engine Coolant Fan Relay Switching
- ✔ Electronic boost control using a boost control solenoid (uses PWM)
- ✔ Variable valve timing solenoid (e.g. VTEC)
- ✔ Shift Light / RPM Switch
- ✔ Warning / Check Engine Light
- ✔ Purge Control
- ✔ EGR Control
- ✔ Any function requiring an output activated by temperature, manifold pressure (MAP), RPM, gear position, digital input state etc.
- ✔ Water Injection / nitrous oxide control (uses PWM)
- ✔ Intercooler Water Spray
- ✔ Air Conditioning Clutch / Fan

3.4 – ANALOG INPUTS

The LEM^{G3} has the following analog inputs:

- Analog / Temperature Input 1 - Configurable (Usually Coolant Temp)
- Analog / Temperature Input 2 - Configurable (Usually Air Temp)
- Analog Voltage Inputs 1 and 2 - Configurable
- Load Input 3 - Throttle Position Sensor (TPS)

Analog Voltage Inputs 1 and 2 may be configured to accept an analog signal between 0-5V. Applications include:

- ✔ Narrow-band O2 (0-1V output)
- ✔ Wide-band O2 (via external wide-band controller)
- ✔ 0-5V Voltage (eg Boost Adjust)
- ✔ Pressure (from 0-5V transducer)

3.5 – DIGITAL INPUTS

Digital Inputs are inputs that recognise either a high (+12V) or low (GND) signal. Digital inputs are typically setup to monitor the position of manual switches or connected to sensors that output a signal of variable frequency.

Note: Aux 4 and DI 1 share the same header pin and therefore can not be used at the same time.

The LEM^{G3} has 1 configurable digital input that can be configured for sensors / switches such as:

- ✔ Vehicle Speed Sensor
- ✔ Antilag Switch
- ✔ Clutch Switch (for launch control and flat shifting)
- ✔ High / Low Boost Switch
- ✔ Water Spray Switch
- ✔ Dual Fuel / Ignition Map Switch
- ✔ Nitrous Oxide Switch
- ✔ Anti-theft Switch
- ✔ AC Request Switch

3.6 – TRIGGER INPUTS

Trigger inputs are required from crank / cam angle sensor(s) (CAS) for the LEM^{G3} to calculate the current engine speed and position in the firing order.

The LEM^{G3} uses on board digital trigger decoding to to determine engine position from the given signals. Setup of the trigger inputs is performed using PCLink. Contact your nearest Link dealer for advice on wiring and setup of trigger inputs if unsure.

The LEM^{G3} has two trigger inputs named Trigger 1 and Trigger 2. Trigger 1 is used to determine crankshaft position. Trigger 2 is used to determine the engines position in the firing order. In all cases Trigger 1 will need to be used. In many cases Trigger 2 must also be used.

Refer to Section 7 for more information about trigger requirements for different ignition/injection setups.

3.7 - SUMMARY

After reading this chapter you should be able to complete a list outlining the basic configuration that will be used. It is important to write such a list as you will need to set up each output in PCLink later on. An example of such a list is shown below in Table 3.2.

Configuration: 4 Cylinder, direct spark, turbocharged	
Fuel Injector Delivery Mode	Group (using Injector Drives 1-2)
Ignition Configuration	Direct Spark (using Ignition Drive 1-4)
Auxiliary Output 1	Idle Speed Control Solenoid
Auxiliary Output 2	Fuel Pump
Auxiliary Output 3	Tachometer
Auxiliary Output 4	N/C – Used as Digital Input 1
Auxiliary Output 5	Intercooler Water Spray
Auxiliary Output 6	Shift Light
Auxiliary Output 7	Boost Control Solenoid
Auxiliary Output 8	N/C
Analog/Temp Input 1	Engine Coolant Temperature
Analog/Temp Input 2	Inlet Air Temperature
Analog/Voltage Input 1	Wide-band O2
Analog/Voltage Input 2	N/C
Load Input 3	Throttle Position Sensor
Digital Input 1	Clutch Switch
Trigger 1	Crank Angle Sensor
Trigger 2	Cam Angle Sensor

Table 3.2 - Example of usage of inputs and outputs

4 - COMPONENT INSTALLATION LOCATIONS

The LEM^{G3} Engine Management System and associated components may be installed in a variety of locations but it is important to choose component locations in accordance with the following design rules.

4.1 – ECU LOCATION

1. The LEM^{G3} requires environmental protection for both physical and electrical factors that may affect its performance. Normally this requires the device to be fitted inside the vehicle cabin. This position avoids the high temperatures associated with the engine bay and reduces the chances of the ECU getting wet. This position also offers some physical separation between the ECU and ignition components that may cause interference.
2. The main exception to this rule is where the engine is somewhat distant from the driving position, such as a boat. In these cases the ECU should be mounted in close proximity to the engine but NOT directly on, or next to, the engine (e.g. mounted just outside the engine compartment). The idea here is to minimise the length of wiring between the engine and the ECU while maintaining some physical distance to prevent heat and interference. It is preferable to have short main wiring and a longer tuning cable.
3. If water immersion or spray is likely (particularly for marine applications), additional protection may be necessary. A sealed plastic container may be employed here.
4. Allow sufficient space at both ends of ECU for the main wiring harness and tuning cables to be connected. The tuning port end of the LEM^{G3} should remain accessible so that tuning cables may be inserted and removed.
5. Four M4 tapped holes in the sides of the enclosure provide a mounting point for brackets etc. Use only the mounting screws provided and DO NOT drill holes in the case, as this will probably cause internal damage.

4.2 – IGNITION COMPONENT PLACEMENT

All components of the ignition system have the potential to radiate large amounts of interference (electromagnetic radiation) that can wreak havoc on sensitive electronic devices. Therefore it is essential that the ignition components are carefully placed and that full suppression techniques are used (see Section 8.2 on Ignition for further details).

IMPORTANT - Never mount the igniter onto or next to the ECU

Always mount igniter(s) in the engine bay as close to the ignition coil(s) as possible. This helps to minimize the length of high current wiring between the igniter(s) and coil(s). Avoid areas of high temperature such as exhausts, turbochargers and radiators since the igniter itself will generate heat at high power. If vibration levels will be excessively high, some form of soft or rubber mounting is advisable to prevent component and wiring fatigue. Preferably igniters should be mounted on the chassis rather than the engine to reduce vibration.

4.3 – MAP SENSOR LOCATION

Unlike some other Link ECU's, the LEM^{G3} has an internal MAP sensor. The MAP sensor is required for almost all applications. A length of high quality vacuum line must be run from the ECU's MAP port located by the main header (ensure the hose is a tight fit on the MAP sensor) to the inlet manifold. Refer to Section 7.2 for more information on plumbing the MAP sensor.

5 – Breakout Loom

The LEM[G3] can be supplied with a 200mm, 2m or 5m long breakout loom. This is used to connect the required inputs and outputs to the LEM[G3] ECU. Some connections are made directly to the relevant device, while others require some form of interface such as a relay or ballast resistor. Figure 5.1 illustrates the main header layout (& pin numbering) when looking into the LEM[G3] connector.

Inj 1 Brown/Black	Aux 1 Orange/Gree n	Aux 3 White/Green	Aux 5 White/Yellow	Aux 7 White/Brown	Ign 1 Blue	Ign 3 Blue/White	Analog Volt 1 White	Analog Volt 2 White/Orang	TPS Yellow/Oran ge	Analog Temp 1 Yellow	Analog Temp 2 Yellow/Black	Ground Black
Inj 2 Brown	Aux 2 Purple	DI 1 / Aux 4 Orange/Yello	Aux 6 White/Black	Aux 8 White/Blue	Ign 2 Blue/Black	Ign 4 Blue/Brown	+ 14 V In	+8V Out Red/White	+5V Out Red/Blue	Trigger 1	Trigger 2	Ground Black

Looking into ECU Header (or back of wiring connector)

Figure 5.1 – ECU Pinout

6 – WIRING OF POWER AND GROUNDS

Correct wiring of the power supplies is a very important part of the installation process. The following sections describe wiring of power supplies to the ECU and also power supplies from the ECU.

6.1 – POWER SUPPLIES

Figure 6.1 (next page) shows the recommended wiring arrangement for the power supplies. The following key points are worthy of noting:

1. The switch labeled 'ignition switch' is really the key. The wire that is used to turn on the main relay should be energised when the key is in the 'ON' position. Do not use a source that provides power when the key is in the ACC position as these are typically cut while the starter motor is being cranked.
2. Each relay uses it's own fuse. Ideally these should be located as close to the battery as possible to minimise the length of un-fused wiring.
3. When the main relay is turned off all other relays will turn off. However, the high current supplied by the other relays is NOT drawn through the main relay.
4. The power for the ignition coil is taken from the fuel pump relay. This ensures that the coil does not receive power before the ECU is powered and running.

6.2 – +12V IN

The red wire is used to provide power for the LEM^{G3}. As shown in Figure 6.1 this should be connected to a relay that provides power when the key is in the 'ON' position.

Although the ECU does not draw a large amount of current, the voltage applied to the '+12V In' wire must remain above 7 Volts at all times. This is especially important while the starter motor is being cranked. A significant drop in voltage will result in the ECU undergoing a reset that will stop the engine from running. As a result, it is important that the battery is in good condition and suitable for the application. Also, make sure that all wiring to the battery and associated terminals are clean and free from corrosion.

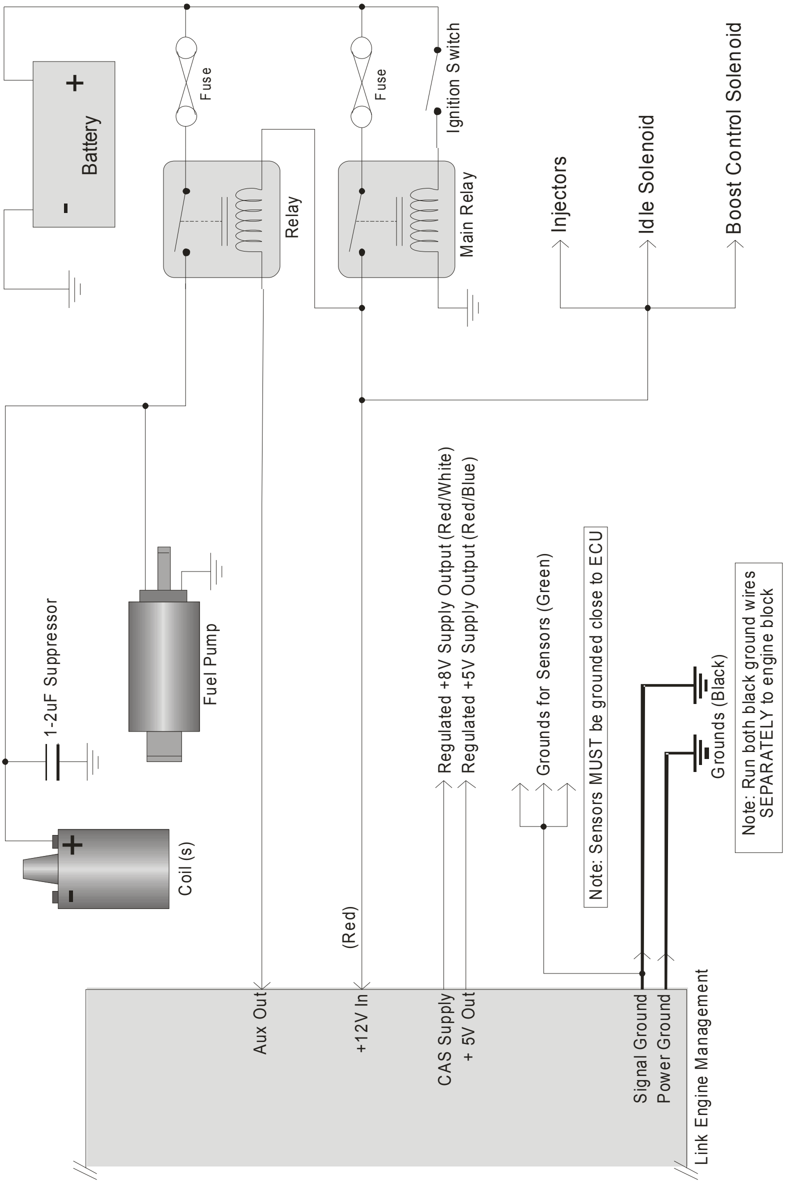


Figure 6.1 - Wiring of Power Supplies

6.3 – POWER GROUND

These two wires supply the high current earth for the output drives. Since this wire will carry substantial currents, ensure it is well terminated to a clean earth point **on the engine**.

6.4 – SIGNAL GROUND

This input supplies the low current earth supply for all low-level signal processing of the computer. It must be well terminated to a clean earth point on the engine.

IMPORTANT!

> Signal Ground and Power Ground 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 or HEAD rather than attaching parts.

6.5 – SENSOR GROUND

These wires are used to supply a ground reference for the sensors used by the LEM^{G3}. As such, it is ESSENTIAL that these wires are used for all sensors that require a ground (e.g. throttle position sensor, water temperature sensor, etc.). Failure to do this may result in unstable sensor readings causing erratic computer operation.

6.6 – +5V OUT

This wire supplies a regulated 5V to be used by sensors that operate from a 5V supply. The most common example is a throttle position sensor (TPS) and some manifold absolute pressure (MAP) sensors.

6.7 – CAS SUPPLY (+8V OUT)

This wire supplies a regulated 8V to be used for the Crank Angle Sensor (CAS) if optical or hall sensors are being used. **Do not use this wire to supply power for other devices.** Care must be taken as some optical and hall sensors are designed to use a 5V supply and may be damaged if supplied with 8V. If a 5V supply is required then the '+5V Out' may be used.

7 – INPUT SIGNAL WIRING

The following sections describe wiring of the various types of sensors used as inputs to the LEM^{G3}.

7.1 – TRIGGER INPUTS

Trigger inputs are required for the LEM^{G3} to calculate the current engine speed as well as the current position in the firing order. In all but the most basic applications both Trigger 1 and Trigger 2 must be used. These must be connected to crankshaft or camshaft angle sensors to provide the required information.

In applications using direct spark, Trigger 2 must always be driven from a sensor on the **camshaft** or a sensor using a trigger wheel that performs one revolution for each 720 degree engine cycle. For most wasted spark applications, only a cranks sensor will be required (note that a special trigger wheel will need to be used.

There are a large number of triggering variants used by different engine manufacturers. The important differences are the type of sensors used, the number of pulses sent from the sensors during an engine cycle and the timing of the pulses in relation to the engine cycle.

Where the ECU was ordered for a specific application, an insert may have been fitted in the back of this instruction manual to guide wiring of triggers.

There are two types of sensors that are commonly used. It is important that the sensor type is known, as the wiring for each type is completely different.

Reluctor/magnetic sensors have a toothed trigger wheel that passes across the face of the sensor. These sensors usually have two wires as the sensor itself generates a voltage. One wire is the ground while the other is the signal output. The polarity of the two wires is very important and must be correct. Some reluctor sensors have a second ground and therefore have three wires.

Optical/Hall sensors have a slot to allow a trigger wheel to pass through.

These sensors typically use a trigger wheel with slits cut out to generate pulses. These sensors require a power supply and therefore have three wires. The Trigger 1 and Trigger 2 cables each include two wires surrounded by a braided shield. These have the following functions.

Trigger 1 Cable (BLACK)

Yellow - Sensor signal input
Brown – Sensor Ground

Trigger 2 Cable (GREY)

Blue - Sensor signal input
Green – Sensor Ground

The braided shield in both cables should be left unconnected at the sensor end.

The CAS Supply supplies a regulated 8V for optical or hall sensors. These wires are not used for reluctor sensors. Note: many hall sensors will not tolerate 12V and require a 5V or 8V regulated supply.

7.2 – MAP SENSOR

Unlike some other Link ECU's, the LEM^{G3} has an internal MAP sensor.

A MAP sensor will be required in all cases except for naturally aspirated engines with very aggressive camshaft profiles. The MAP fluctuations caused by large amounts of overlap result in a very unstable MAP reading especially at idle. Also note that multi-butterfly engines often give a poor vacuum signal. In these cases, it is best to use the throttle position (rather than MAP) to indicate the engine load. In all cases where forced induction is used, a MAP sensor is required.

The MAP sensor must be connected to the inlet manifold via a suitable length of 3mm vacuum hose. The take off point must be between the engine and throttle plate so that the MAP sensor registers vacuum (as well as pressure on turbo applications). The take off point must be from a common chamber that is connected to all cylinders rather than off a single intake runner. The fuel pressure regulator's pressure signal is usually a good take-off point. However, do not be tempted to share the MAP sensor vacuum hose with other devices such as a boost gauge or in particular a blow off valve. Figure 7.1 shows the most suitable take-off points.

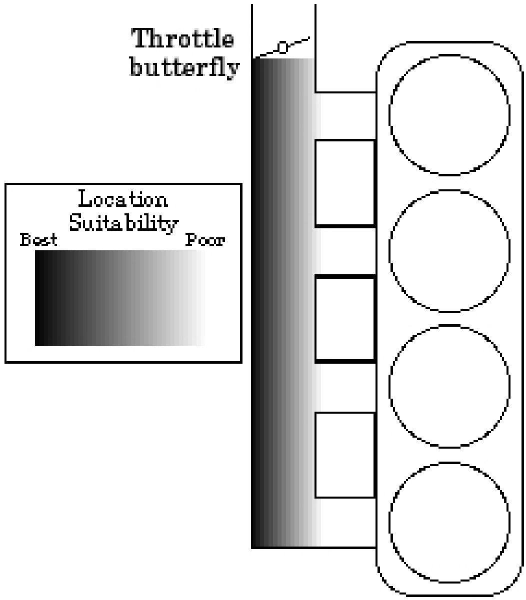


Figure 7.1 - Suitable manifold take off points for MAP sensor hose

Ideally the ECU should be mounted higher than the inlet manifold so that moisture will not condense in the MAP sensor.

7.3 – THROTTLE POSITION SENSOR

A Throttle Position Sensor (TPS) is connected directly to the end of the throttle shaft to measure the current angle of throttle opening. Even if the throttle position sensor is not required for load sensing, it is still highly recommended to use one. Throttle position is used for a number of other functions including:

- ✔ Acceleration enrichment (much better than using MAP)
- ✔ Overrun fuel cuts
- ✔ Idle Speed Control
- ✔ Boost Control (in some cases)

IMPORTANT

The throttle position sensor must be a potentiometer (variable resistance) and operate over the entire range of throttle movement. Partial range sensors and idle/full-throttle switches are not suitable and may not be used with the LEM^{G3}.

Ensure the TPS mounting position allows the throttle to move through its full range of motion. The TPS should be adjusted so that it is not reaching the end of its movement at either closed throttle or full throttle.

A typical TPS has 3 terminals. To wire either the factory TPS or a custom fitted sensor, an ohmmeter is required. Two of the terminals will show a fixed resistance as the TPS is moved. Connect these terminals to the 5V Out wire (Red/Blue) and Ground Out wire (Green) on the LEM^{G3}. The orientation of the +5V and ground does not matter. The result is that the TPS output will either increase or decrease in voltage with throttle position. The LEM^{G3} will automatically detect this so either option is acceptable. The third terminal must show a variable resistance between the +5V and the ground terminal. This is the TPS output and should be connected to the TPS wire (Yellow/Orange) on the LEM^{G3}. This is shown in Figure 7.3.

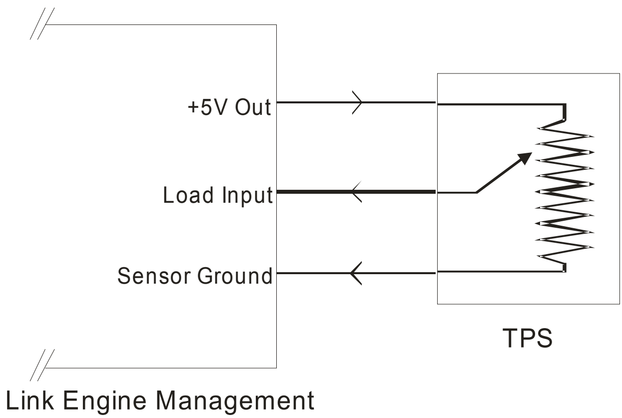


Figure 7.3 - TPS Wiring

7.4 – ENGINE COOLANT TEMPERATURE (ETEMP)

The engine coolant temperature is required primarily for fuel enrichment during cold starting and during the warm-up period that follows. This sensor should always be mounted on the engine side of the thermostat.

The LEM^{G3} is designed to measure the temperature using a thermistor sensor. These sensors have a resistance that changes with temperature and are commonly used in automotive applications. When wiring thermistor sensors the polarity is NOT important. **An Analog Temp wire should be connected to one terminal on the sensor while the other terminal must be connected to the Ground Out (green) wire**.

The LEM^{G3} is compatible with any thermistor sensor. The recommended sensor is a Bosch 0 280 130 026 sensor. A number of pre-calibrated sensor options are also provided in PCLink. Note that most factory sensors will use the Standard Bosch NTC calibration. In order to use a sensor with a different calibration you will need to know how the sensor's resistance changes with temperature and enter this information into the LEM^{G3} via PCLink

7.5 – INLET AIR TEMPERATURE

Using an inlet air temperature sensor allows fuel and ignition corrections to be made for changes in the temperature of the air entering the engine. The air temperature sensor must be setup to most accurately measure the temperature of the air entering the combustion chambers of engine. On a naturally aspirated engine this normally means any position between the air filter and inlet manifold. However, on a turbocharged/supercharged engine the sensor must be placed **AFTER** the turbocharger and any intercooler.

On most applications (both naturally aspirated and turbocharged) the recommended mounting position is in the inlet pipe just before the throttle plate. The sensor may also be placed in a section of the inlet manifold that is subject to high airflow. However, in some applications the inlet manifold may get very hot and heat soak the sensor causing a reading that is not representative of the air entering the combustion chambers.

It is very important on a turbocharged/supercharged engine that the air temperature sensor can react fast enough to track the rapidly changing temperature. For this reason, an open element sensor is required. The recommended sensor is a Bosch 0 280 130 085. On naturally aspirated engines this sensor may be substituted for a 0 280 130 039, which is cheaper and easier to fit.

The LEM^{G3} is designed to measure the temperature using a thermistor sensor. These sensors have a resistance that changes with temperature and are commonly used in automotive applications. When wiring thermistor sensors the polarity is NOT important. **The Inlet Temperature Sensor must be connected to the Sensor Ground (green) wire and an Analog Temp wire.**

The LEM^{G3} is compatible with any thermistor sensors. The default calibration is for either of the Bosch sensors listed above. In order to use a sensor with a different calibration you will need to know how the sensor's resistance changes with temperature and enter this information into the LEM^{G3} via PCLink. Note that most commonly used sensors calibrations are available by selecting them in PCLink.

7.6 – Narrow Band Oxygen Sensor

A narrow-band exhaust gas oxygen (EGO) sensor is very accurate at air/fuel ratios near 14.7:1 (for petrol). At richer or leaner are/fuel ratios there is a very small output signal change for large changes in air/fuel ratio. This makes the narrow-band sensor very good at detecting either a lean or rich condition, but not very useful for detecting how lean or rich. For this reason, a narrow-band sensor is not recommended for tuning purposes.

There are many variations of EGO sensors although most are identical in terms of the output signal. The principal differences are mostly physical involving lead tolerance, heated or unheated, mounting methods, and whether or not a signal ground wire is supplied.

7.6.1 – Lead Tolerance

The lead additives used in most high-octane fuel (avgas or race gas) will reduced the lifespan of the sensor considerably. Some probes are shielded and are more tolerant than others.

7.6.2 - HEATING

Many probes incorporate an electrical heating element, which is powered by the vehicles 12 Volt supply. These heaters allow the probe to be mounted in cooler portions of the exhaust system and significantly improve the probe performance at idle and during warm up phases of operation. This is because the probe temperature must exceed 300ºC before accurate readings are possible.

7.6.3 - MOUNTING

Most probes have an M18 x 1.5 metric thread designed to screw into a mating boss. Some variants use a bolted flange arrangement, but these are relatively uncommon.

Almost all EFI engines will have a probe installed as original equipment in the exhaust manifold or turbo housing.

If the vehicle does not have a factory fitted EGO sensor, it will be necessary to manufacture a sensor mount according to engine type and layout.

The ideal mounting position of the sensor in the exhaust can vary depending on the application. Most of the time the preferred position is in the exhaust manifold collector on a naturally aspirated engine or after the turbocharger on a turbocharged engine. However, a location further down the exhaust is acceptable provided the probe is adequately heated. Note that it is also possible to get an EGO sensor too hot which also causes an inaccurate reading. Therefore in applications with particularly high exhaust gas temperatures (e.g. turbo engines, rotary engines) it may be necessary to either use an unheated sensor or move a heated sensor further down the exhaust.

Caution: EGO sensors use ceramic material internally and are susceptible to impact damage. Handle probes carefully to avoid impacts at all times.

7.6.4 – OXYGEN SENSOR WIRING

Typically narrow-band EGO sensors can be recognised as having one, two, three or four wires. These have the following functions.

Single Wire Sensor - The wire is the signal output and should be connected directly to an Analog Voltage Input. Note that the Ground Out (green) wire on the LEM^{G3} must be connected to the body of the sensor.

Two Wire Sensor - One wire for the signal output (to Analog Voltage Input). The other is the signal ground (to Ground Out (green)).

Three Wire Sensor (Heated) - One wire for the signal output (to Analog Voltage Input). Two wires for the heater. One of the heater wires should be connected to an ignition switched 12V supply. The other heater wire can be connected to a convenient ground. Heater polarity is not important. The Ground Out (green) wire on the LEM^{G3} must be connected to the body of the sensor.

Four Wire Sensor (Heated) - As for three wire sensor, but with an extra wire for the signal ground which must be connected to Ground Out (green).

The recommended narrow-band EGO sensor is a Bosch 3-wire lead-tolerant unit with Part Number 0 258 003 070. As with other Bosch 3 wire sensors, the wire colours are:

2 white wires	=	heater (18 watts)
1 black wire	=	output signal
body	=	signal ground

Some other common types are listed below:

Nissan - red and black (heater), white (output signal), sensor body (signal ground)

Honda - 2 black wires (heater), white (output signal), green (signal ground)

7.7 – WIDE BAND OXYGEN SENSOR

Wide-band exhaust gas oxygen (EGO) sensors are able to accurately measure air/fuel ratios over a very wide range from very lean to very rich. This makes these devices very suitable for tuning purposes.

AN Volt 1 or AN Volt 2 may be used to accept the signal from a wide-band EGO sensor controller. Note that the LEM^{G3} cannot accept the signal directly from a wide-band sensor. A wide-band controller works as an interface between a wide-band O2 sensor and the LEM^{G3}. The controller should connect directly to the sensor and output a voltage between 0 and 5V. The 0-5V output of the wide-band control should be connected to the desired analog input on the LEM^{G3}. The signal ground on the wide-band controller should be connected to the Sensor Ground wire (Green) on the LEM^{G3}. If the wide-band controller does not have a separate signal ground then its ground should be carefully terminated to the engine block.

The only restriction is that the wide-band controller must have a linear output in the range of 0-5V. The sensor calibration (the voltages that correspond to given air/fuel ratios) must be known and this information must be entered into the LEM^{G3} via PCLink.

7.8 – PRESSURE SENSING

AN Volt 1 or AN Volt 2 may be used as inputs from a pressure sensor. The only restriction is that the sensor must have a linear 0-5V output. The sensor calibration (the voltages that correspond to given pressures) must be known and this information must be entered into the LEM^{G3} via PCLink. Wiring of the pressure sensor will be the same as for a MAP sensor except that the signal wire for the sensor will be connected to the desired analog input.

CAUTION

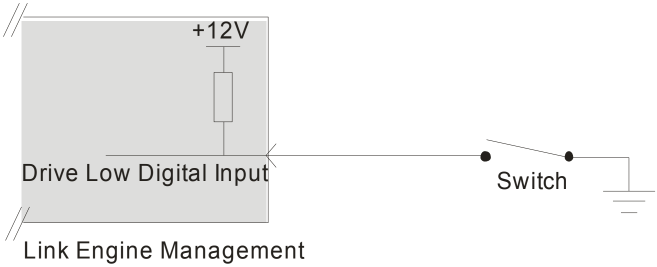
> Do not use a sensor designed to measure air pressure to measure fuel, oil or water pressures.

7.9 – DIGITAL INPUT WIRING

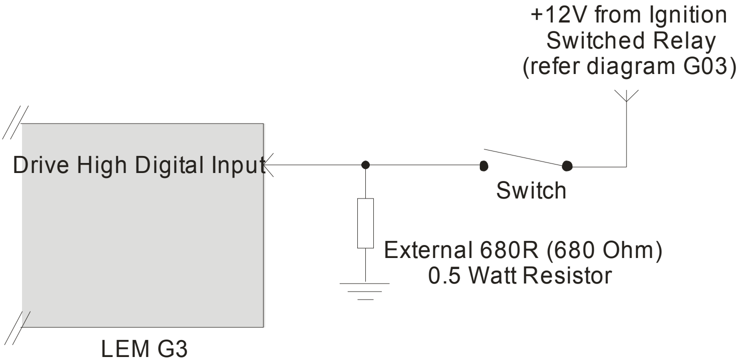
Digital inputs may be connected to switches to control various functions including launch control (clutch switch), anti-lag, high/low boost, water spray, dual fuel/ignition maps, nitrous oxide, air conditioning request and anti-theft.

The LEM^{G3} has one Digital Input that shares a header pin with Aux 4.

Figure 7.4 shows the two methods of wiring Digital Inputs to a switch. When wiring other devices such as controllers it will be necessary to determine if these devices are active low or active high. If using a device or switch that goes high when active, an external pull down resistor must be fitted as shown in Figure 7.4b.



A) Drive LOW Digital Input



B) Drive HIGH Digital Input

Figure 7.4 - Wiring of a Switch to a Digital Input

7.10 – VEHICLE SPEED INPUT

Vehicle Speed may be calculated using the output from a digital speedometer drive or in some cases from the speedometer assembly itself. This may be connected directly to the Digital Input.

8 – OUTPUT WIRING

The following sections describe wiring of output devices to the LEM^{G3}.

8.1 – FUEL INJECTOR DRIVES

The injector drives on a LEM^{G3} work by supplying an EARTH to turn the injectors on. A switched (key ON) 12V (refer to Figure 6.1) must be supplied to the other terminal on the injector. The polarity is not important.

WARNING

DO NOT connect +12V directly to any of the injector drives.

Injectors are commonly available as either high impedance or low impedance. Either type may be used with the LEM^{G3}, however low impedance injectors MUST be used with ballast resistors.

Use an ohmmeter to measure the resistance across the two terminals of the injector;

- If the injector resistance is greater than 6 Ω then the injectors are high impedance and no ballast resistors are required
- If the injector resistance is less than 6 Ω then ballast resistors will be required.

8.1.1 – HIGH IMPEDANCE INJECTORS

The LEM^{G3} can drive up to six high impedance injectors off each Injector Drive. It is recommended to separate the injectors into two even groups, so that half the engines injectors are run from each Injector Drive. This will halve the current through each of the LEM^{G3}'s Injector Drives, reduce pulsations on the main power supply, reduce pulsations in the fuel pressure and smooth fuel delivery as each group of injectors is fired at a different time.

Wiring for high impedance injectors is shown in Figure 8.1.

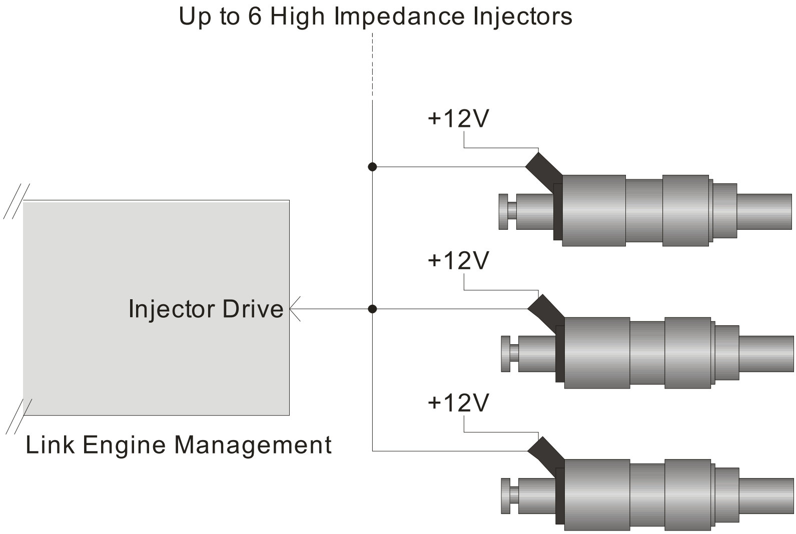


Figure 8.1 – High Impedance Injector Wiring

8.1.2 – Low Impedance Injectors

The LEM can drive up to 4 low impedance injectors on one Injection Drive WITH BALLAST RESISTORS FITTED. Ballast resistors must be used to limit the current through the injectors and injector drive to avoid damage.

WARNING !

DO NOT WIRE LOW IMPEDANCE INJECTORS DIRECTLY TO THE LEM^{G3}'S INJECTOR DRIVES WITHOUT USING BALLAST RESISTORS AS DESCRIBED IN THIS SECTION.

As with high impedance injectors it is recommended that injectors are wired in two groups. This will halve the current through each of the LEM^{G3}'s Injector Drives, reduce pulsations on the main power supply, reduce pulsations in the fuel pressure and smooth fuel delivery as each group of injectors is fired at a different time.

There are two methods of wiring ballast resistors. The first method as shown in Figure 8.2a uses a single 1 Ohm ballast resistor for each group of injectors.

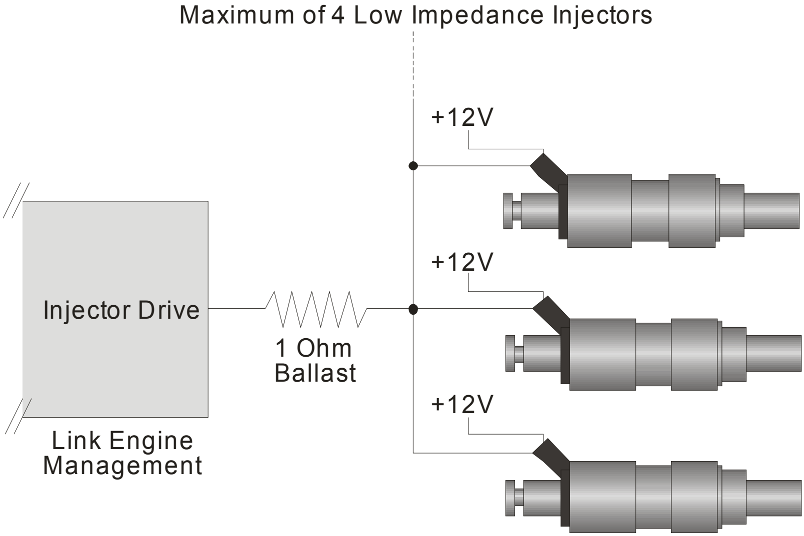
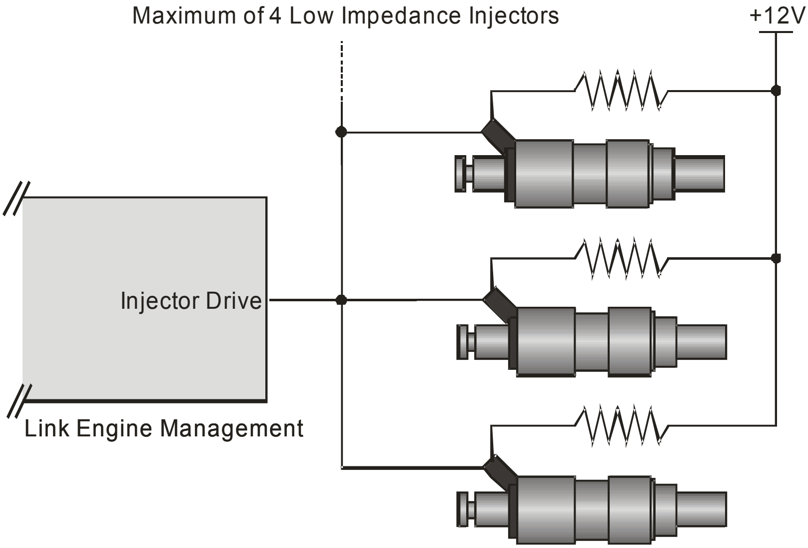


Figure 8.2a - Injector wiring for injectors one ballast resistors

The second and preferred method of wiring ballast resistors is shown in Figure 8.2b. This method uses a separate ballast resistor for each injector.

It should be noted that ballast resistors get quite hot at high injector duty cycles. Therefore these should be mounted on a heat sink and this should be bolted to the chassis. Typically ballast resistors should be mounted in the engine bay.

Do not be tempted to use common 0.25 W or 1.0 W resistors, as these will burn out almost immediately. 25 W resistors should be used. These are relatively uncommon at hobbyist shops, but are readily available from your Link dealer in groups of 2, 4, 6 or 8 resistors on a heat sink.



If the injector impedance is LESS THAN 2 Ohms, use 2R2 (2.2 Ohm) ballast.

If the injector impedance is between 2 and 6 Ohms, use 4R7 (4.7 Ohm) ballast.

If the injector impedance is greater than 6 Ohms, use no ballast.

8.1.2 – INJECTION MODE

The LEM^{G3} has 2 independent injector drives. This means that for most engines a form of group injection will be required. There are 5 Injection Modes available:

- **Single Point Group**
- **Multi-point Group -**
- **Sequential -**
- **Group/Staged -**

8.1.3 – SINGLE-POINT GROUP INJECTION

A single injector (sometimes two) is used to supply fuel for all cylinders. Normally this injector is placed just before or just after the throttle body. In this mode the injector(s) are fired once per TDC. The injector should be driven by Inj1. If two injectors are used then the second injector should be driven by Inj2.

8.1.4 – MULTI-POINT GROUP INJECTION

This mode should be used if each cylinder has its own injector, but there are too many cylinders or insufficient triggering to use sequential injection. In this mode the injectors are fired in two out-of-phase groups with each group firing once for every 360 or 720 degrees of crankshaft rotation (depending on the Injection Rate setting).

8.1.5 – GROUP/STAGED INJECTION

This mode allows the use of staged injection where the engine uses primary injectors that operate at all times and secondary injectors that only operate at high load/rpm. This arrangement is useful in applications with very high fuel delivery requirements that would normally require extremely large injectors. Very large injectors make tuning difficult at low loads (idle and low power operation). With staged injection one smaller set of injectors operates at low load giving more precise control. At higher loads both sets of injectors become active to supply the required fuelling needs. Wire the primary injectors in one group to Inj 1 and the secondary injectors in another group to Inj 2. Refer to the wiring diagrams earlier in this section for information on grouping injectors.

8.2 – IGNITION DRIVES

The LEM^{G3} offers 4 independent ignition drives which can be used in a wide range of configurations from a basic distributor setup through to more complex multi-coil arrangements. The LEM^{G3} supports the configurations shown in Table 8.3.

Number of Cylinders	Distributor	Wasted Spark (1 Dual Post Coil per two Cylinders)	Direct Spark (1 Coil per Cylinder)
1	–	–	✔
2	✔	✔	✔
3	✔	✗	✔
4	✔	✔	✔
5	✔	✗	✗
6	✔	✔	✗
8	✔	✔	✗
10	✔	✗	✗
12	✔	✗	✗
2 Rotor	✗	✔	✔

Table 8.3 - Available Ignition Combinations

8.2.1 – IGNITER REQUIREMENTS

An igniter acts as an interface between the LEM^{G3} and the ignition coil(s). The Igniter is used to drive the coil(s) by supplying a ground for the coils negative terminal. Wiring of an igniter and coil is shown below in Figure 8.3.

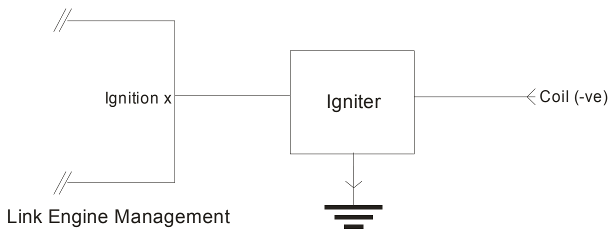


Figure 8.3 - Wiring of igniter and coil

The igniter is basically a solid-state switch, which may also limit the coil current to a predetermined value. This limiting feature eliminates coil ballast resistors and provides protection of the coils if the dwell time (time the coil is charged for) is set too long. Over voltage clamping is incorporated to prevent damage to the igniter should a high-tension lead become disconnected or similar.

Each one of the 4 ignition drives on the LEM^{G3} may be used to switch a separate channel on an igniter. Each channel on the igniter is used to switch an ignition coil. The following examples show the requirements for some common ignition configurations:

Example - 4 cylinder engine with direct spark

- All four ignition drives must be used
- A four channel igniter (or 2 x 2 channel igniters) must be used
- Four Single Post Coils must be used

Example - 4 cylinder engine with wasted spark

- Only two ignition drives are used (Ig 1 and Ig 2)
- One two channel igniter must be used
- Two Dual Post Coils must be used

Example - Engine with a single distributor driven ignition

- Only one ignition drive is used (Ig 1)
- A single channel igniter must be used
- One Single Post Coil must be used

Conventional igniters begin to charge the coil when their input is high. Spark occurs when the input goes low. This is known as a Rising 'Dwell Edge'.

Many factory Ford, Honda igniters, MSD ignitions and some other units work in the opposite sense. The coil begins to charge when the input signal goes low while spark occurs on the transition from low to high. In these cases, a Falling 'Dwell Edge' must be selected in PC Link.

Always mount igniter(s) in the engine bay as close to the ignition coil(s) as possible. This helps to minimize the length of high current wiring between the igniter(s) and coil(s).

NEVER mount the igniter(s) next to the LEM^{G3}

Avoid areas of high temperature such as exhausts, turbochargers and radiators since the igniter itself will generate heat at high power. If vibration levels will be excessively high, some form of soft or rubber mounting is advisable to prevent component and wiring fatigue.

8.2.2 – Coil Requirements

Use only coils designed for high-energy transistor/inductive ignition systems. The coils primary resistance must be between 0.4 Ω and 1.0 Ω. This applies to both single and dual post coils in distributed and multi coil applications.

8.2.3 – Ignition Suppression

Without exception ALL ignition systems must be suppressed. Failure to do so may cause the ECU to behave erratically, especially at high power. Symptoms include misfiring, erratic RPM readings and the ECU performing repetitive resets. The following rules must be followed:

- Unsuppressed H.T. leads act as aerials and radiate very powerful interference signals. ALL applications must use suppression leads, preferably resistance type rather than spiral wound or inductive. Typically these vary from 1000 ohms to 5000 ohms depending on lead length. NEVER use plain wire leads.
- ALL applications must also employ a suppressor capacitor (0.5 - 3uF) connected directly between the ignition coil(s) POSITIVE terminal and ground. Most points condensers are suitable. Multiple coils can share a single suppressor. ‘V’ and boxer engines with multiple coils must have a suppressor on each bank.

- Isolate the ignition system as much as possible from other sensitive devices, especially the ECU. Do not run non-ignition related wiring close to igniters, coils or HT leads wherever possible. Maintain maximum distance from radio transmitters and coaxial cables etc.
- Always use resistor spark plugs. These can be checked by measuring the resistance between the top of the spark plug and the centre electrode. On a resistor plug the resistance will be several thousand ohms.
- If insufficient ignition energy is causing a high-power misfire (especially on turbo/super charged engines), it may be necessary to reduce the spark plug gap. Gaps as small as 0.5mm (.020') may be necessary. This also reduces the amount of radiated electrical noise due to the lower firing voltage.
- Keep the input wiring to the igniter (from the ECU) separate from the output wiring of the igniter (to the coil(s)) as shown in Figure 8.5.

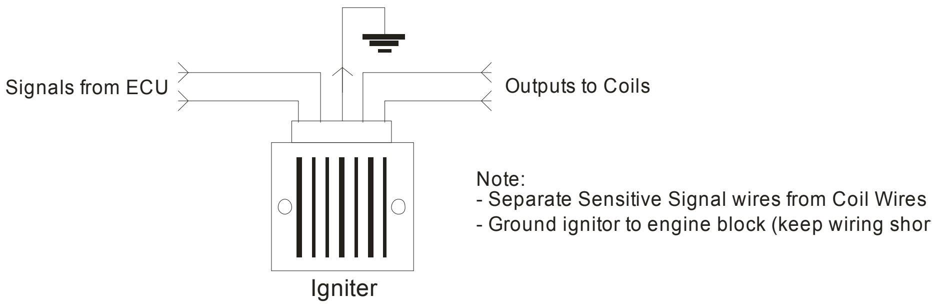


Figure 8.5 - Separation of igniter input and output wiring

8.2.4 – DISTRIBUTOR IGNITION

A distributor rotates at half the crankshaft speed and routes the high voltage generated by the coil to the intended spark plug via a rotor and HT wiring. A distributed engine requires one ignition drive and a single channel igniter. Use Ignition Drive 1 to switch the igniter. Figure 8.6 shows the wiring for a distributor ignition.

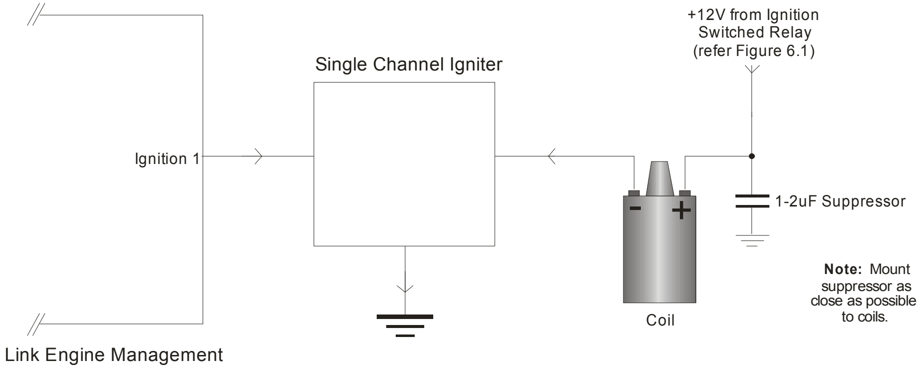


Figure 8.6 - Ignition Setup for Distributor Ignition

Because the rotor will only point to each post on the distributor cap for a short amount of time, the rotor timing dictates the range of ignition advance angles that may be used without misfiring or unnecessarily losing spark energy. A wider tip on the rotor will also allow a wider range of timing values to be used. The tip of rotor should be just leaving the post when the crankshaft is positioned at the minimum timing that will be used (typically at about 10 degrees BTDC). The point where the leading tip of the rotor arrives at the post is the most advanced timing that should be used. These positions are shown in Figure 8.7.

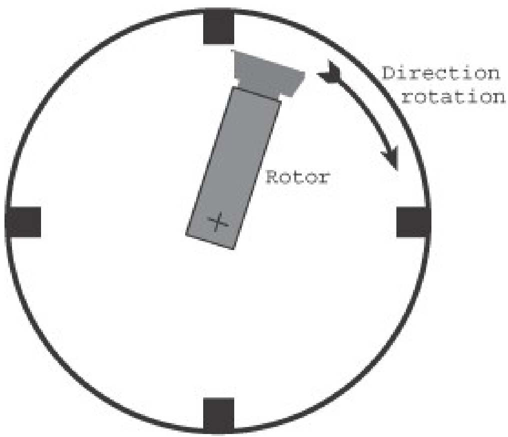


Figure 8.7 - Correct Rotor Timing

8.2.5 – MULTI-COIL: WASTED SPARK

Wasted spark will fire two cylinders simultaneously, using a common dual post coil. When a dual post coil is fired, two cylinders receive a spark. One cylinder is fired conventionally on the compression stroke while the other cylinder has its piston in the same position but on the 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 each 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.

One dual post coil (with a primary resistance between 0.4 and 1.0 ohms) is required per 2 cylinders. Figure 8.8 shows a typical coil. The coils should be positioned so they minimise the length of the HT Leads. This will help reduce the electrical noise generated when the spark plugs are fired.

Figure 8.8 - Dual Post Coil

The main concern when using dual post coils is the generation of electrical interference. This can interfere with ECU operation and cause unwanted static on car radios. The ignition suppression techniques outlined earlier are particularly important. All wasted spark systems should use 'Resistive Spark Plugs' if the engine does not currently use them.

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. When using a wasted spark arrangement, an ignition drive will fire cylinder pairs that are 360° apart in the firing order.

Ignition Drive 1 always needs to be connected to cylinder number 1 and its corresponding cylinder (360° apart in the combustion cycle).

Ignition Drive 2 should be connected to the next cylinder in the firing order and its corresponding cylinder (360° apart in the combustion cycle).

If more cylinders exist (6, 8, 10 & 12 cylinder engines) then the pattern should be continued. For example Ignition Drive 3 fires the next cylinder in the firing order and its corresponding cylinder.

Table 8.4 summarises this information for applications up to 8 cylinders. 1st represents cylinder number one, 2nd represents the next cylinder in the firing order etc:

Cylinder in Firing Order	Number of Cylinders			
	2	4	6	8
1st	Ign 1	Ign 1	Ign 1	Ign 1
2nd	Ign 2	Ign 2	Ign 2	Ign 2
3rd		Ign 1	Ign 3	Ign 3
4th		Ign 2	Ign 1	Ign 4
5th			Ign 2	Ign 1
6th			Ign 3	Ign 2
7th				Ign 3
8th				Ign 4

Table 8.4 - Wasted spark Ignition Wiring

Example - Wasted spark setup for a 4 cylinder engine with 1-3-4-2 firing order.

- Ignition Drive 1 fires cylinders 1 and 4
- Ignition Drive 2 fires cylinders 2 and 3

Figures 8.9 - 8.11 show wiring for 4, 6 and 8 cylinder engines with wasted spark.

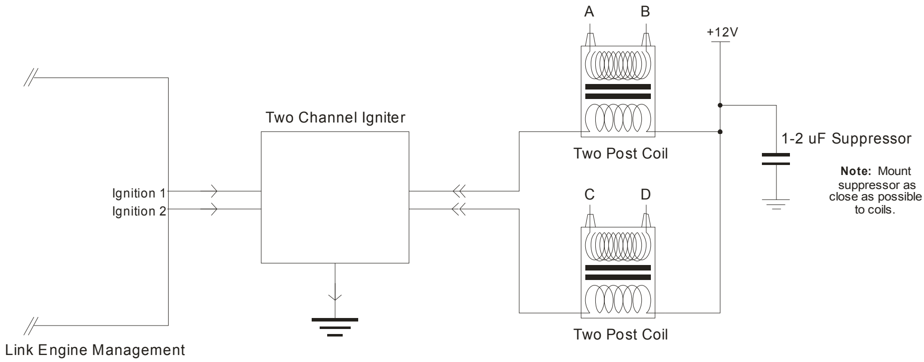


Figure 8.9 - Wasted Spark on a 4 Cylinder Engine

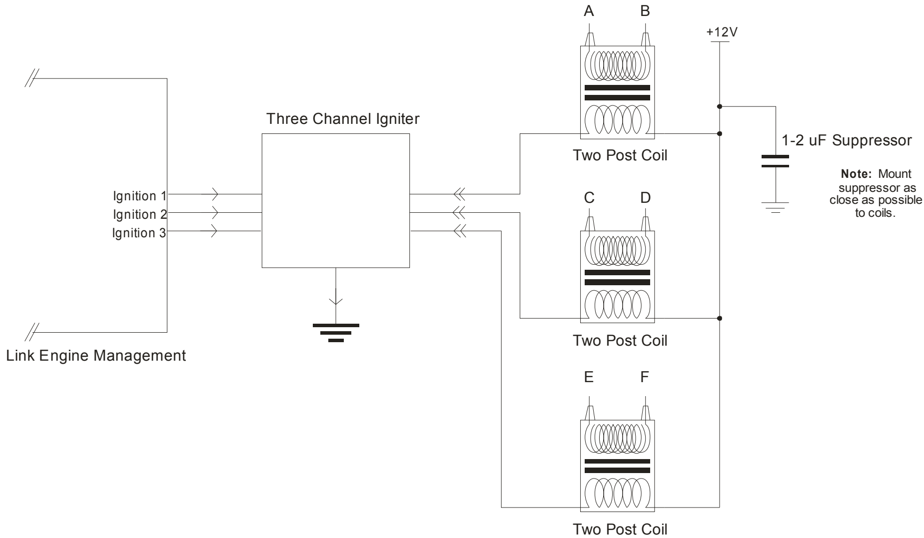


Figure 8.10 - Wasted Spark on a 6 Cylinder Engine

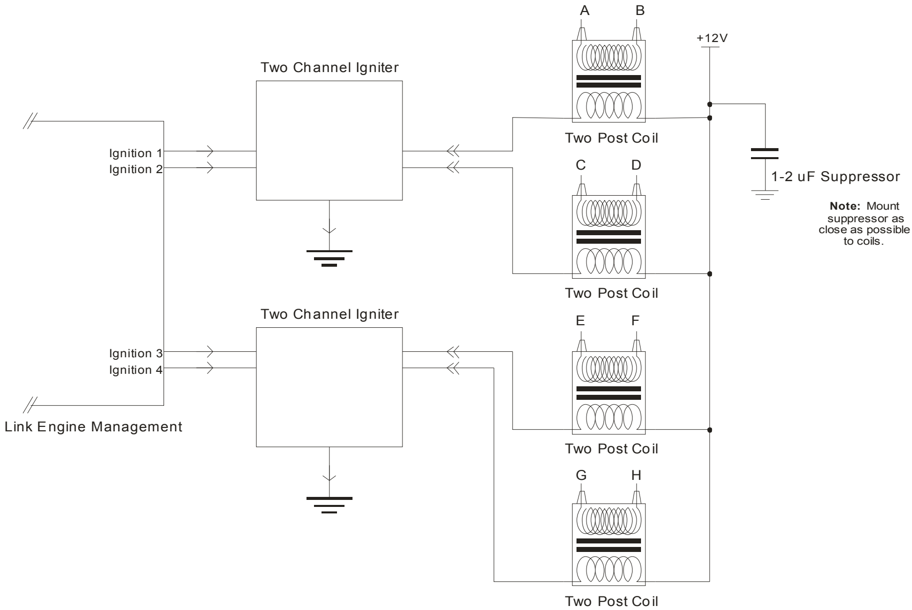


Figure 8.11 - Wasted Spark on an 8 Cylinder Engine

8.2.6 – MULTI-COIL: DIRECT SPARK

Direct spark uses an ignition coil per cylinder, firing each cylinder once per engine cycle (2 crankshaft revolutions). If multi-coil operation is required for an odd number of cylinders, the only option is to use an ignition coil per cylinder. The LEM^{G3} has 4 ignition drives allowing 4 individual coils to be controlled. Therefore, this mode may only be used on engines with 4 cylinders or less.

Engines using direct spark ignition must have a way for the ECU to calculate the current order in the firing sequence. Because an engine may be at one of two possible positions in the firing sequence given a crankshaft position, a trigger wheel rotating at crankshaft speed is not sufficient for direct spark ignition. Therefore a second sensor mounted on the camshaft (or driven at camshaft speed) is required to send a sync pulse. If an engine does not have an appropriate sensor then either one will need to be fabricated or another ignition mode must be used.

Some factory set-ups using direct spark have a coil and igniter in one package, mounted on top of the spark plug. These are normally three terminal devices requiring 12 volts, ground, and the signal from an Ignition Drive.

When using a non-factory arrangement 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.

Each ignition drive **MUST** be connected via an igniter channel to a coil.

Example - 4 cylinder engine with direct spark

- All four ignition drives must be used
- A four channel igniter (or 2 dual channel igniters) must be used
- Four Single Post Coils must be used
- Drive the igniter for cylinder one from Ign 1, cylinder 2 from Ign 2, cylinder 3 from Ign 3 and cylinder 4 from Ign 4.

When wiring an ignition system using direct spark, the firing order of the engine is not important as it will be entered into the LEM^{G3} via PCLink.

Ignition Drive 1 must fire cylinder 1, Drive 2 to cylinder 2, 3 for 3, etc. Figure 8.12 shows an example of how to wire direct spark ignition for a 4 cylinder engine.

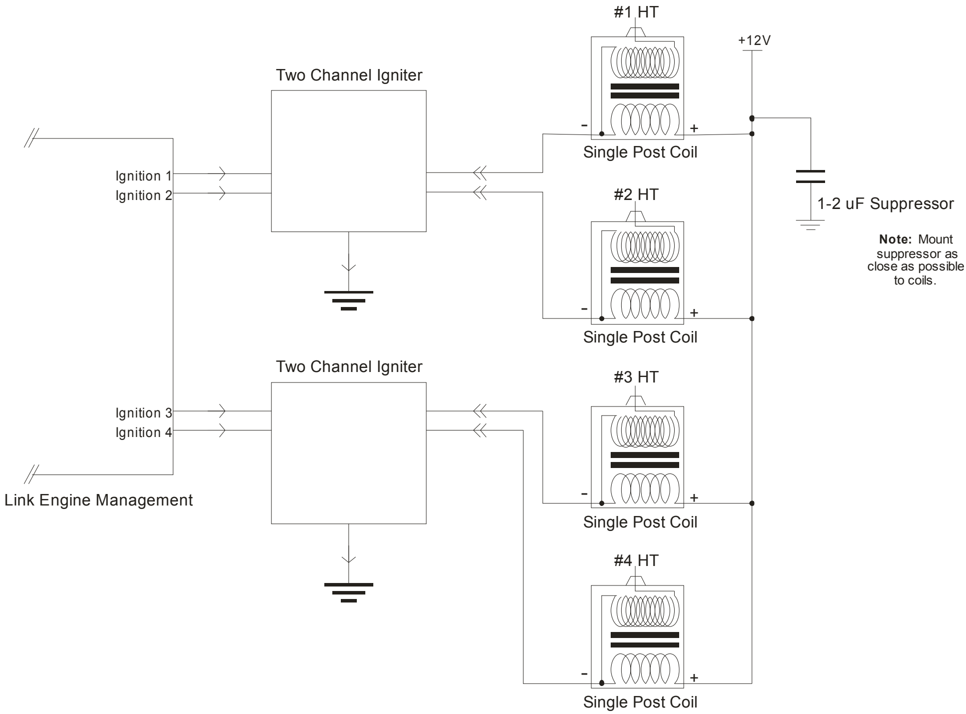


Figure 8.12 - Direct spark on a 4 cylinder engine

8.2.7 – Rotary Ignition Wiring

The LEM G3 supports the two ignition modes commonly used on injected 13B Rotary engines. Wire channels as follows (refer to Figures 8.9 to 8.12 for actual wiring connections):

Ignition Channel	3 Coil Option	4 Coil Option
Ign 1	Leading (front and rear)	Leading Front
Ign 2	Trailing Rear	Leading Rear
Ign 3	Trailing Front	Trailing Front
Ign 4	N/C	Trailing Rear

8.3 – Idle Speed Control

Note: Idle speed control can not be wired to Aux 3 or 4.

Idle Speed Control (ISC) is required to provide an acceptable idle speed when the engine is cold or when loads (AC etc.) are applied. Without idle speed control, an engine will idle too slowly when cold. Often the cold idle speed will be so low that the engine stalls. Likewise, extra load loads will decrease the idle speed and may cause the idle to stall or become unstable. The ISC system regulates the engine idle speed by adjusting the amount of air which is bypassed around the throttle. This air may be bypassed using either a solenoid or stepper motor.

The LEM^{G3} can be wired to provide idle speed control using either a 2 or 3 terminal ISC solenoid or a 4 or 6 terminal ISC Stepper Motor. While a solenoid and stepper motor operate very differently they both achieve the effect of bypassing air around the throttle plate to increase the idle speed.

IMPORTANT NOTE FOR USING ISC STEPPERS

When using an ISC Stepper, the ECU must return the motor to its home position after the key is turned on. This is achieved by moving the motor to its fully open position, then returning it to the required position for starting.

If the engine is allowed to start during this period a large over-rev may occur. The “Key-on Fuel Lockout” adjustment is provided to prevent the engine starting during this period.

Higher end Link ECU's have the ability to keep themselves powered after the key has been turned off to perform the stepper reset, ensuring it is ready for the next start.

To date this has only become an issue on V5-6 Subaru Sti/WRX's due to their slow moving stepper motor. These engines require a three second “Key-on Fuel Lockout”.

Some engines use a non-electronic system to control idle speed as the engine warms up. This system contains a bimetallic strip, which is heated by the engine coolant and/or electrically. As the engine warms up, the amount of bypassed air is reduced and the idle is returned to its normal level. The LEM^{G3} cannot control this type of device. It is intended ONLY as an idle up when the engine is cold.

8.3.1 – Two Terminal ISC Solenoid

Note: a two terminal ISC solenoid may be wired to Aux 1, Aux 2, Aux 5, Aux 6, Aux 7 or Aux 8.

Two terminal ISC solenoids need only one auxiliary output to open the solenoid. A spring is used to automatically close the solenoid. Connect one terminal to a switched +12V supply and connect the remaining terminal to an Auxiliary Output. See Figure 8.13. The orientation of the wires does not matter.

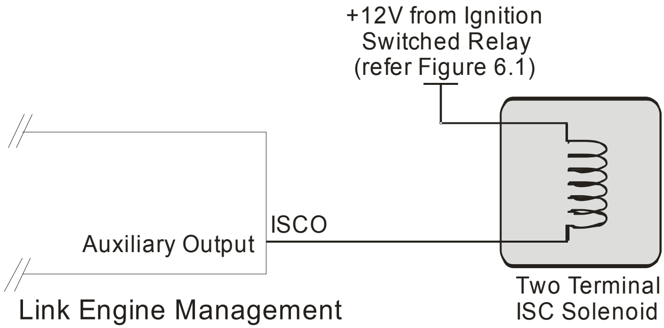


Figure 8.13 - Wiring for two-terminal ISC solenoid

8.3.2 – Three Terminal ISC Solenoid

Note: A Three Terminal ISC Solenoid must be wired to Aux 1 and Aux 2. Aux 1 is ISC Close, Aux 2 is ISC Open.

Three terminal ISC solenoids needs one Auxiliary Output to open the solenoid and another Auxiliary Output to close it.

Use an ohmmeter to find the common terminal (usually the centre). Figure

8.14 shows the schematic. Next measure the resistance between the common and remaining two terminals. This should be greater than 10 ohms. Apply +12V to the common terminal of the solenoid. Ground one of the other terminals. If this terminal causes the valve to open, connect it to an Auxiliary Output 2 and note that this output should be configured as 'ISC Solenoid'. Likewise if the valve closes, connect the terminal to an Auxiliary Output 1 and note that this output should be configured as 'ISC Solenoid Slave'.

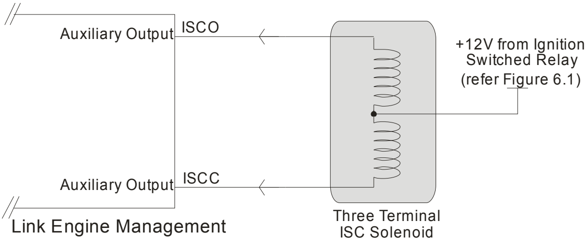


Figure 8.14 - Three terminal ISC schematic

8.3.3 – Four Terminal ISC Stepper Motor

Note: An ISC Stepper Motor must be wired to Aux 5, Aux 6, Aux 7 and Aux 8.

Figure 8.15 shows a schematic of a four-terminal stepper motor. Note that there are two coils. Use an ohmmeter to pair the terminals with a common coil. Aux 5 and 6 must be connected to the terminals for one coil, while Aux 6 and 7 must be connected to the terminals for the other coil. If it is found that the stepper motor runs in the opposite direction to that expected, reverse the wiring to Aux 5 and Aux 6 channels.

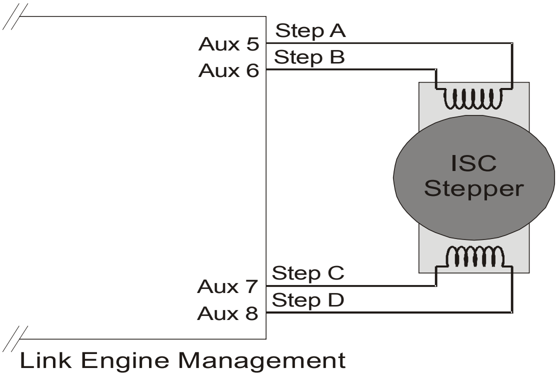


Figure 8.15 - Four-terminal ISC Stepper Motor

8.3.4 – SIX TERMINAL ISC STEPPER MOTOR

Figure 8.16 shows a schematic of a six-terminal stepper motor. These are similar to a four-terminal Stepper Motor, but each coil has a centre-tap that must be connected to 12V. Like the four-terminal version, Aux 5 and 6 must be connected to the terminals for one coil, while Aux 7 and 8 must be connected to the terminals for the other coil. If it is found that the stepper motor runs in the opposite direction to that expected, reverse the wiring to Aux 5 and Aux 6 channels.

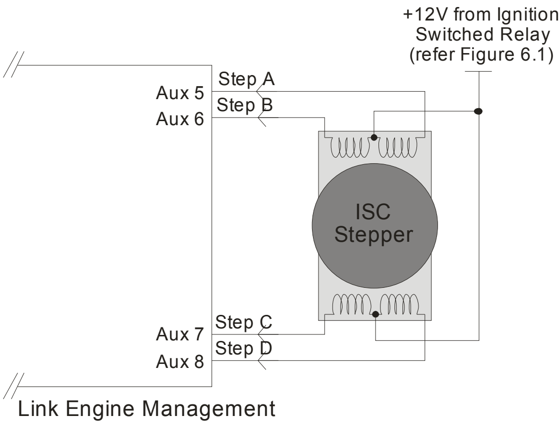


Figure 8.16 - Six-terminal ISC Stepper Motor

8.4 – TACHOMETER

An auxiliary output configured as 'Tacho' produces a 0-12V pulse train to drive a low-level tachometer. There will be one output pulse for each time a cylinder reaches TDC. Connect an Auxiliary Output directly to a low-level tachometer.

The LEM^{G3} will NOT drive a high-level tachometer. High-level tachometers must be triggered by a coil's negative terminal. Using a high-level tachometer on a multi-coil engine presents some problems, as each coil is not firing as often as a distributor engine's coil would. In this case the preferred solution is to modify the high-level tachometer to accept a low-level signal.

Note: In some cases an external pull-up resistor will be required to drive the tachometer. If the tachometer fails to operate, operates erratically or will not read over a certain RPM, connect 1 kOhm 0.25 Watt (1000 Ohm ¼ watt) resistor between the tacho signal wire and its power supply. Also check that the auxiliary output is configured to have the correct duty cycle in PCLink.

Aux 5 to 8 and Ignition 1 to 4 when used as Aux channels can not be Pulse Width Modulated (PWM) above 300Hz. Note that PWM frequencies above 300 Hz may be required to drive a tacho for a V8 above 4500 RPM. A four cylinder tacho can be driven to 9000 RPM on these channels.

8.5 – AUXILIARY OUTPUTS

The LEM^{G3} has up to eight auxiliary outputs. Unused ignition channels can also be used as auxiliary outputs. Auxiliary outputs are general-purpose outputs that may be used to perform a wide range of functions. However, the following limitations apply:

- Aux 4 and DI 1 share the same header pin and therefore can not be used at the same time.
- Aux 3 and 4 can not be used for Idle Speed Control.
- A Three Terminal ISC Solenoid must be wired to Aux 1 and Aux 2.
- An ISC Stepper Motor must be wired to Aux 5, Aux 6, Aux 7 and Aux 8.
- Aux 5 to 8 and Ignition 1 to 4 when used as Aux channels can not be

Pulse Width Modulated (PWM) above 300Hz. Note that PWM frequencies above 300 Hz may be required to drive a tacho for a V8 above 4500 RPM.

Auxiliary Outputs are used to supply a GROUND to actuate solenoids, relays, LEDs or lights. The amount of current flow is entirely dependant on the internal resistance of the device connected to a drive. The load must not draw more than 5 Amps of current. This means that a directly connected load should have a resistance exceeding 2-3 Ω. If the resistance is lower than this a relay should be used. **DO NOT** connect +12V directly to any auxiliary output.

On a typical two-terminal solenoid, the Auxiliary Output should be connected to one terminal to supply a ground, while the other terminal should be connected to an ignition switched (key ON) 12V source. A warning/shift light may also be wired the same way. This configuration is shown in Figure 8.17.

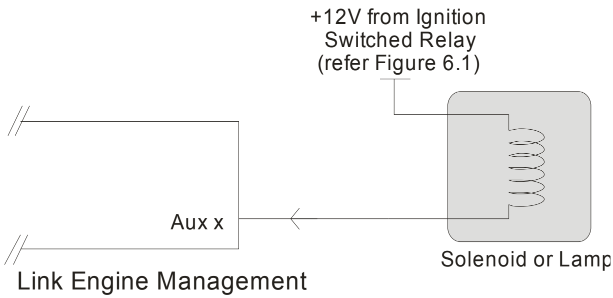


Figure 8.17 - Wiring for two terminal solenoid or light

Some single terminal solenoids are grounded through the engine block (e.g. most Honda VTEC solenoids). Therefore 12V must be applied to the terminal on the solenoid to turn it on. In this case, a relay must be used, rather than connecting the auxiliary output directly to the solenoid. This configuration is shown in Figure 8.18.

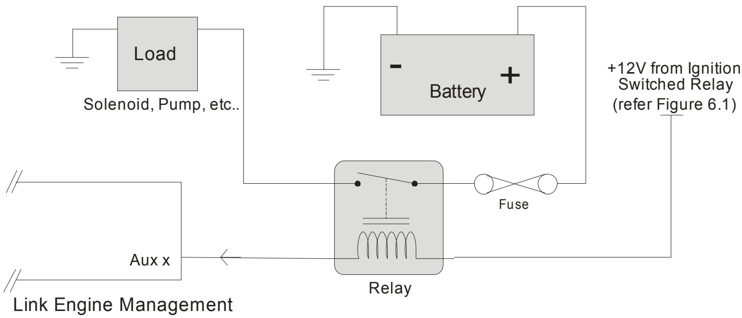


Figure 8.18 - Wiring for single terminal solenoid using a relay

A solenoid/light driven off of a high power drive may be switched at a given RPM, MAP, engine temperature, injector duty cycle etc.

8.6 – ELECTRONIC BOOST CONTROL

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 spring and wastegate sizing.

The maximum boost pressure that can be achieved occurs when the solenoid is always 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, the ECU can adjust the boost pressure to anything between the minimum and maximum outlined above.

8.6.1 – RECOMMENDED BOOST CONTROL SOLENOID

The recommended boost control solenoid is shown in Figure 8.19 and is available from your Link dealer. This solenoid may be used with both internal and external wastegates, although the plumbing for each type is very different. Although this solenoid has three ports, only two ports require connection.

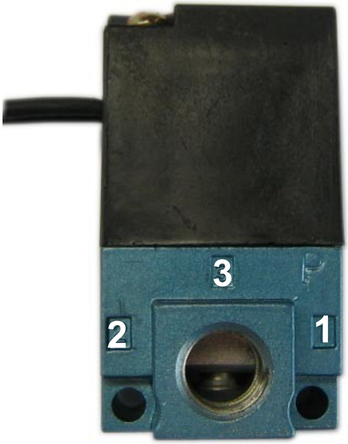


Figure 8.19 - Recommended Boost Control Solenoid

8.6.2 – Integral Wastegates

The solenoid should be connected as described below and shown in Figure 8.20.

- Port 1 is vented to the atmosphere (usually via the air filter)
- Port 2 is connected to the wastegate actuator canister
- Port 3 is connected to the turbocharger's compressor outlet

When the solenoid is de-energised, ports 2 and 3 are connected and the compressor pressure is allowed to fill the actuator and open the wastegate. When the solenoid is energised Port 3 is blocked and Ports 1 and 3 are connected together. This allows the air pressure in the actuator to be bled off to atmosphere.

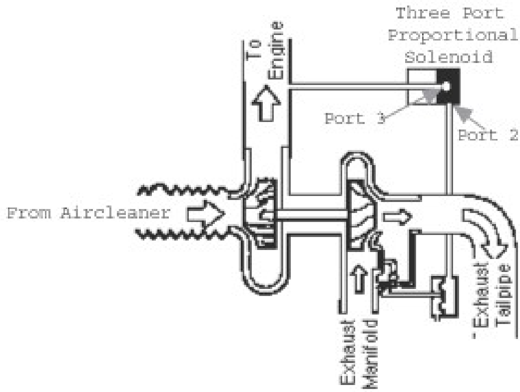


Figure 8.20 - Plumbing of three-port solenoid to Internal Wastegate

8.6.3 – External Wastegates

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 an external wastegate.

The preferred option is to use a second line from the compressor outlet to the topside of the diaphragm. The boost control solenoid is then plumbed into this line. The solenoid should be connected as described below and shown in Figure 8.21.

- Port 1 is connected to the turbocharger's compressor outlet
- Port 2 is connected to the port on the wastegate ABOVE the diaphragm
- Port 3 is vented to the atmosphere (usually via the air filter)

The port on the wastegate BELOW the diaphragm is connected to the turbocharger's compressor outlet (along with Port 1 on the wastegate solenoid).

The boost level is increased when more pressure is applied above the diaphragm. When the solenoid is de-energised, port 1 is blocked so that the top of the wastegate is at atmospheric pressure. When the solenoid is energised ports 1 and 2 are connected and the compressor pressure is allowed to fill the topside of the wastegate (above the diaphragm).

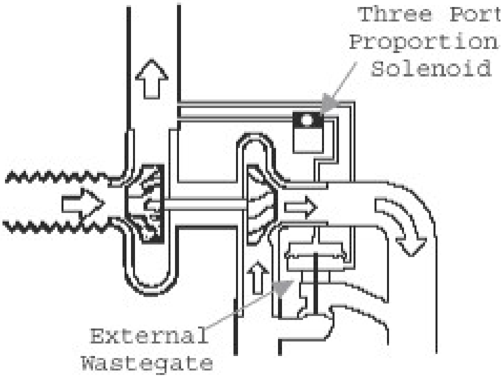


Figure 8.21 - Plumbing of three-port solenoid to External Wastegate

8.6.4 – WIRING AND MOUNTING OF BCS

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

To keep the length of the pressure lines as short as possible, the solenoid should be mounted close to the wastegate. However, the solenoid must not be placed too close to hot exhaust manifolds and turbine housings as eventual failure may result.

Remember that an Auxiliary Output connects directly to one terminal on the solenoid to provide an EARTH. The other terminal on the solenoid must be connected to an ignition switched (key ON) 12V source. The orientation does not matter. Wiring is shown in Figure 8.22.

There are several options for referencing the boost targets. Boost may be setup at a fixed level, high/low boost on a switch (using a digital input), boost by gear (using a vehicle speed sensor connected to a digital input), TPS referenced and RPM referenced. Keep in mind that the inputs required for the chosen boost control mode must also be connected.

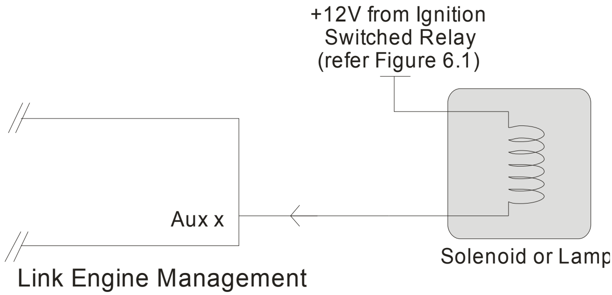


Figure 8.22 - Wiring of boost control solenoid

8.7 – SWITCHING THROUGH A RELAY

To switch any large load through a relay, the wiring shown in Figure 8.23 should be used. Examples of such loads include fuel pumps, engine coolant fans and air conditioning compressor clutches.

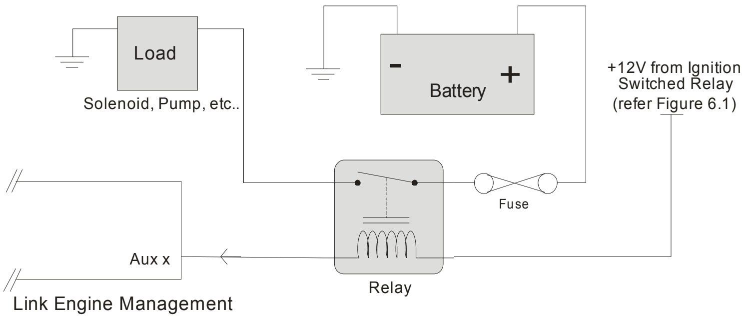


Figure 8.23 - Wiring for large loads switched off a relay

8.7.1 – FUEL PUMP RELAY

When the fuel pump is switched using an Auxiliary Output the fuel pump will be activated for a few seconds after the key is turned ON. This will prime the fuel system and build up fuel pressure. When the engine is cranked the fuel pump will begin running continuously. When the engine is stopped the fuel pump will turn off regardless of the key position. This ensures that in the event of a crash the fuel pump will not run continuously. For this reason, it is highly recommended that the fuel pump relay be controlled via an Auxiliary Output and not using a dash mounted switch. As explained earlier, always use the auxiliary output to switch a relay and not the pump itself.

Fuel pump and fuel pump relay wiring is shown in Figure 6.1.

8.7.2 - ENGINE COOLANT FAN RELAY

This function activates the radiator coolant fan when the set temperature is exceeded. As explained earlier, always use the auxiliary output to switch a relay and not the fan motor itself. Wire according to Figure 8.23.

8.7.3 – AIR CONDITIONING CLUTCH

An auxiliary output may be used to switch the relay for the air conditioning fan or clutch when the air conditioning request signal is activated (via a digital input). This allows the LEM^{G3} to perform idle speed and fuelling correction before latching the relay and loading the engine. As explained earlier, always use the auxiliary output to switch a relay and not the load itself. Wire according to Figure 8.23.

8.7.4 – INTERCOOLER WATER SPRAY

This is used to switch a pump to spray water mist over an air/air intercooler. As explained earlier, always use the auxiliary output to switch a relay and not the pump itself. Wire according to Figure 8.23.

8.8 – WATER OR NITROUS OXIDE INJECTION

An auxiliary output may be used to provide control of water or nitrous oxide injection. In either of these cases the auxiliary output may be connected directly to a solenoid placed before the injection nozzle. The auxiliary output can then control when the water or NO2 is injected based on the conditions set by the user. Note that a the Dual Ignition Table function can be used to provide ignition retarded for NO2. The second ignition table can be configured to be activated when the NO2 is activated.

8.9 – SWITCHING AN LED

Auxiliary outputs may be connected to a high intensity LED to provide a shift, or warning light. However, a 1k_ (1000_) current limiting resistor is required to be placed in series with the LED. Failure to install the resistor will result in permanent failure of the LED. A bulb may also be used instead of an LED (and it does not require a resistor). Figure 8.24 shows how to connect an LED.

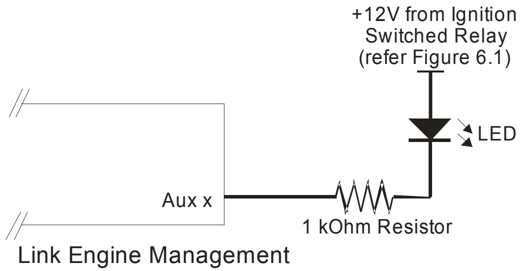


Figure 8.24 - Connection of an LED to an auxiliary output

8.10 – EXHAUST GAS RECIRCULATION (EGR)

In interest of emissions, a portion of exhaust gas may be fed back into an engines intake to take part in the combustion process. Typically a solenoid controls this process and may be activated by an auxiliary output. Wire according to Figure 8.22.

8.11 – PURGE CONTROL

As fuel evaporates from the fuel tank, hydrocarbons are released into the atmosphere. In the interest of emissions, the fuel tank can be vented into a charcoal canister. As the canister is small it must be continually regenerated. At low load, air is drawn through the canister and into the engine by switching the purge control solenoid or relay on. At high load the solenoid will be switched off. Wire according to Figure 8.23.

9 – PC TUNING

The LEM^{G3} offers PC/laptop tuning using the PCLink application running on a Windows based computer. PCLink may be downloaded from www.LinkECU.com. Note that when new versions of PCLink are released they are posted on the website and may be downloaded at no cost. Also note that a LEM^{G3} will not work with early versions of PCLink.

WARNING !!!

The LEM^{G3} has on board USB.
BEFORE connecting the ECU to your laptop, the Link ECU USB drivers must be installed. Failure to install the drivers on your laptop first may result in windows assigning incorrect drivers. These drivers may not work with the Link ECU and are dificult to uninstall.

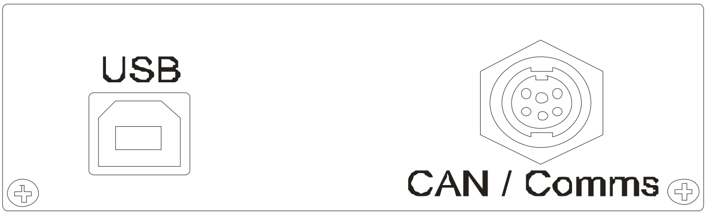


Figure 9.1 – LEM G3 Communication Ports

9.1 – INSTALLING LINK ECU USB DRIVERS

Before connecting the LEM^{G3} to your laptop or PC, the Link ECU USB drivers must be installed. Due to frequenct upgrades, theses drivers are not distributed with the Link ECU and must be downloaded from our website www.LinkECU.com. These can be found in the support section of the website under 'Downloads and Software Updates'. Should internet download not be practical, a copy of the drivers on CD can be obtained from your nearest Link Dealer.

Installation instructions for the drivers can be downloaded from the above website. These should be followed carefully during installation.

The Link ECU USB driver download is a self installing program. After downloading, double click the install file and follow the on screen instructions.

Part way through the installation process you will be prompted to connect the laptop to your Link ECU. You do not need to power up the ECU during this process.

Connect the LEM to your laptop using a standard USB-A to USB-B cable (as used on most USB printers). This cable is available from most computer stores or you nearest Link Dealer.

9.2 – INSTALLING PCLINK

Due to the frequent updates PCLink is no longer shipped with each Link ECU. You will be required to download the latest version of PCLink for the Link website:

www.linkecu.com

Should access to an Internet connection be impractical, the latest version of PCLink can be requested from your nearest Link dealer on CD.

9.2.1 – INSTALLING PCLINK FROM THE WEB

1. Go to the above website and navigate to the downloads and software updates section.
2. Download the latest version of PCLink. When prompted to run or save the file, select save. It is recommended to save this file on the desktop.
3. Double click the saved file (called setupVX.X where X.X is the version number) and follow on screen instructions.
4. When installed, open PCLink by double clicking on the PCLink icon that has been placed on the desktop.

9.2.2 – INSTALLING PCLINK FROM A CD

1. Insert the PCLink disk into you computer's CD ROM.

2. Click ‘Start’ and then ‘Run’.
3. Type ‘d:\setup.exe’ (assuming ‘d’ drive is your CDROM) and press Enter.
4. This will open the PCLink installer. Follow the instructions to install PCLink on your computer
5. When installed, open PCLink by double clicking on the PCLink icon that has been placed on the desktop.

9.3 – Communicating With Your Link ECU

After installing both the Link ECU USB drivers and PCLink, you will be able to connect to the LEM^{G3} to perform setup and tuning work.

1. Connect the LEM to your laptop using a standard USB-A to USB-B cable (as used on most USB printers). This cable is available from most computer stores or you nearest Link Dealer.
2. Start the PCLink application by double clicking on the PCLink icon on the windows desktop.
3. Switch the key to the ON position. This will provide power to the LEM^{G3}.
4. In PCLink, under the 'Options' menu, select 'Connection'. The connection options dialogue will open. Select the correct Com Port number from the drop down list. Note: If the com port number is unknown, you will have to try each possibility until a connection is established.
5. PCLink offers both mouse and keyboard control. To establish a connection between the PC and LEM^{G3} using the mouse, click the ‘L’ icon located near the top centre of the PCLink screen. Alternatively, using the keyboard, press and hold the Ctrl, Shift and L keys. The same process can be used to disconnect. If a successful connection is established, PCLink will download settings from the Link ECU, otherwise you will be warned that an error has occurred.
6. Make sure the Link Connection shows “ONLINE” in the top right corner of PCLink. The Link oval should also be spinning. The tables should also become white rather than yellow.
7. Remember to STORE any changes before disconnecting the PCLink software from the LEM^{G3}.

10 – First Time Setup

This section of the manual details a generic procedure for first time setup of the LEM^{G3}. These procedures also provide a good means of becoming familiar with both the LEM^{G3} and PCLink tuning software. It is recommended that these procedures are followed for every setup, no matter how experienced you are!

10.1 – Pre-Start Setup

To avoid potential engine damage and wasted time, the adjustments presented in the following sections **must** be made before attempting to start the engine. For further help on any of the settings discussed below, consult the online Help in PCLink. Online help can be invoked by pressing F1, or right clicking any item and selecting 'What's this?'.

10.1.1 – Pre-Setup Checks

Before attempting to configure the LEM^{G3}, ensure the following tasks have been completed:

1. Ensure the LEM^{G3} and all associated components are connected and correctly wired/installed.
2. Fully charge the vehicle's battery, as the engine will be required to be cranked during the setup procedure.
3. Check all oil and water levels are correct.

10.1.2 – Connecting to PCLink

As detailed in Section 9.3, use the following procedure to establish a connection between your Link ECU and PCLink tuning software.

1. Connect the LEM to your laptop using a standard USB-A to USB-B cable (as used on most USB printers). This cable is available from most computer stores or you nearest Link Dealer.
2. Start the PCLink application by double clicking on the PCLink icon on the windows desktop.
3. Switch the key to the ON position. This will provide power to the

LEM^{G3}.

4. In PCLink, under the 'Options' menu, select 'Connection'. The connection options dialog will open. Select the correct Com Port number from the drop down list. Note: If the com port number is unknown, you will have to try each possibility until a connection is established.
5. PCLink offers both mouse and keyboard control. To establish a connection between the PC and LEM^{G3} using the mouse, click the ‘L’ icon located near the top centre of the PCLink screen. Alternatively, using the keyboard, press and hold the Ctrl, Shift and L keys. The same process can be used to disconnect. If a successful connection is established, PCLink will download settings from the Link ECU, otherwise you will be warned that an error has occurred.
6. Make sure the Link Connection shows “ONLINE” in the top right corner of PCLink. The Link oval should also be spinning. The tables should also become white rather than yellow.

10.2 – Initial Configuration

After all checks described in Sections 10.1.1 to 10.1.2 have been performed, the LEM^{G3} is ready to be configured for a particular application. The following setup procedure should be used on all installations as a minimum:

10.2.1 – Fuelling Setup

If the LEM^{G3} is to be used to control fuel injection, all of the following steps must be performed. If the LEM^{G3} will not be controlling fuel injection, then only steps 1 and 2 are required.

1. If you have a .pcl file containing a base configuration, this is the time to load it into the LEM^{G3}. To do this, select ‘Open’ form the ‘File’ menu. Select the required .pcl file and then select ‘Ok’. When prompted if you want to load the file into the Link ECU, select ‘Yes’.
2. Click on the ‘Configuration’ heading in the tuning function tree (top left of PCLink screen):
    a. Select the correct number of cylinders.
    b. Enter the engines firing order.

3. Click on the ‘Fuel’ heading, then ‘Fuel Setup’:
    a. Select the desired Injection Mode (eg Sequential or Group).
    b. Select Injector Control method (eg Saturated or Peak and Hold). Note that Peak and Hold is only available on certain G3 ECU’s.
    c. Set load axis control parameter (eg MAP or TPS).
4. Click on ‘Accel Enrichment’:
    a. Turn Accel Mode OFF for first time setups.
5. Click on ‘IAT Fuel Correction’:
    a. If air temperature correction is to be used and an air temperature sensor is fitted, select the required ‘IAT Mode’ (eg 2D Table or 3D Table). Note that the default 2D Table is recommended for the majority of applications.
    b. Turn OFF air temp correction (under ‘IAT Mode’) if air temperature correction is not going to be used
6. Click on ‘Injector Deadtime':
    a. Select the appropriate Injector Type. If the required injector type is not listed, select the closest type available. The injector dead time table will be set up later when the engine is running.
7. Click on ‘Fuel Temp Correction’:
    a. Set ‘Fuel Temp Mode’ to OFF if not required.
    b. If fuel temperature correction is required and a fuel temperature sensor has been fitted, set ‘Fuel Temp Mode’ to the desired type.
8. Click on ‘Overrun Fuel Cut’:
    a. Set ‘Fuel cut Mode’ to OFF.
9. Click on ‘Fuel Advanced’, then ‘Dual Fuel Table’:
    a. Set 'Dual Table Mode' to OFF.
10. Click on ‘4D Fuel Table’:
    a. Set ‘Fuel Overlay Mode’ to OFF.
11. Perform a Store by clicking the ‘S’ button on the toolbar (top centre).

10.2.2 – Ignition Setup

If the LEM^{G3} is to be used to control ignition, all of the following steps must be performed. If the LEM^{G3} will not be controlling ignition, then only step 14 is required.

12. Click on 'Ignition' then 'Ignition Setup':
    a. Select the correct type of 'Ignition Mode' for the application.
    b. Set 'Maximum Advance' to a suitable value.
    c. Enter appropriate values for coil dwell time in the 'Ignition Dwell Time' table.
13. Click on 'ECT Ign Trim':
    a. Set 'Engine Temp Correction' to OFF (for now).
14. Click on 'IAT Ign Trim':
    a. Set 'Air Temp Correction' to OFF (for now).
15. Click on 'Ignition Advanced' then 'Individual Cyl Ign Trim':
    a. Set 'Indiv Ign Mode' to OFF (for now).
16. Click on 'Dual Ign Table':
    a. Set 'Dual Table Mode' to OFF (for now).
17. Click on '4D Ign Table':
    a. Set '4D Ign Mode' to OFF (for now).
18. Perform a Store by clicking the 'S' button on the toolbar (top centre).

10.2.3 – Limits Setup

At this stage it is not necessary to precisely set all limits. However, it is essential to ensure they are set to values that will not interfere with tuning procedures. It is advisable to err on the conservative side when setting limit values.

19. Click on 'Limits' then 'RPM Limit':
    a. Select the desired 'RPM Limit Mode'
    b. Enter the required RPM limiting value for each engine temperature in the 'RPM Limit Table'.
20. Click on 'MAP Limit':
    a. Select the desired 'MAP Limit Mode'
    b. Enter the required MAP limiting value for each engine

temperature in the 'MAP Limit Table'.

21. Click on 'Vehicle Speed Limit'
    a. Set the 'Vehicle Speed Limit' to a high enough value to ensure it is not invoked during tuning. Note that this limit will only be effective if a vehicle speed sensor is correctly wired and configured.
22. Perform a Store by clicking the 'S' button on the toolbar (top centre).

10.2.4 – AUXILIARY OUTPUT SETUP

This section configures the LEM^{G3}'s Auxiliary Output drivers for the device they have been wired to. Preparing a configuration table as shown in Section 3.7 of the LEM^{G3} Wiring and Installation Manual will greatly simplify setup of Auxiliary Outputs. Note that one auxiliary channel should be wired and configured for the fuel pump relay drive.

23. Click on 'Auxiliary Outputs' then select the first Auxiliary Output that requires configuration:
    a. Select the required 'Function' for the Auxiliary Output channel.
    b. Configure the channel as required. Refer to PCLink's online help for more information on adjustments.
24. Configure each additional Auxiliary Output channel. Ensure unused channels have their 'Function' set to 'Not Selected'. Note that the 'Test On' function can be used to test wiring of auxiliary output devices.
25. Perform a Store by clicking the 'S' button on the toolbar (top centre).

10.2.5 – DIGITAL INPUT SETUP

This section configures the LEM^{G3}'s Digital Input channels for the device they have been wired to. Preparing a configuration table as shown in Section 3.7 will greatly simplify setup of Digital Inputs.

26. Click on 'Digital Inputs' then select the first Digital Input that requires configuration:
    a. Select the required 'Function' for the Digital Input

channel.

    b. Configure the channel as required. Refer to PCLink's online help for more information on adjustments.

27. Configure each additional Digital Input channel. Ensure unused channels have their 'Function' set to 'OFF'.
28. Perform a Store by clicking the 'S' button on the toolbar (top centre).

10.2.6 – ANALOG INPUT SETUP

This section configures the LEM^{G3}'s Analogue Input channels for the device they have been wired to. Preparing a configuration table as shown in Section 3.7 of the LEM^{G3} Wiring and Installation Manual will greatly simplify setup of Analogue Inputs. Essential inputs are configured in this section. All steps must be performed on all applications.

29. Click on 'Analogue Channel' then 'Load Input 1'.
    a. If a MAP sensor is used for load measurement, 'Load Input 1' must be set to 'MAP Sensor'.
    b. Select the correct "MAP Sensor Type'.
    c. Perform a MAP Sensor Calibration. Do this by selecting 'MAP Sensor Calibration' from the Tools menu and following on screen instructions. Also refer to Section 4.1.1.
30. Click on 'Load Input 3':
    a. Set 'Load Input 3' to TPS.
    b. Perform a TPS Calibration. Do this by selecting 'TPS Calibration' from the Tools menu and following on screen instructions.
31. Click on 'AN Temp 1':
    a. Select the appropriate sensor location under 'Temp Channel #1'.
    b. Select 'Temp Sensor Type'. If a custom type sensor is to be used then the resistance vs. temperature values should be entered now.
32. Click on 'AN Temp 2':
    a. Select the appropriate sensor location under 'Temp Channel #1'.
    b. Select 'Temp Sensor Type'. If a custom type sensor is to

be used then the resistance vs. temperature values should be entered now.

33. Click on 'AN Volt 1':
    a. Select the desired function for Analogue Voltage Input 1. Set to OFF if not used.
34. Click on 'AN Volt 2':
    a. Select the desired function for Analogue Voltage Input 2. Set to OFF if not used.
35. Perform a Store by clicking the 'S' button on the toolbar (top centre).

10.2.7 – Trigger Setup

Trigger setup requires entering information regarding the way in which engine speed and position is measured. Consult the PCLink online help for further information on functions.

WARNING: These are probably the most critical setup values. Do not attempt to start the engine unless you are 100% confident that these values are correct.

If trigger information is unknown, consult your nearest Link dealer for further assistance.

36. Click on 'Triggers' then 'Trigger Setup':
    a. Configure triggers as required.
37. Click on 'Trigger1':
    a. Select correct trigger type and setup.
38. Click on 'Trigger2':
    a. Select correct trigger type and setup.
39. Perform a Store by clicking the 'S' button on the toolbar (top centre).

10.2.8 – Additional Setup

It is important that all features not required for initial tuning are either disabled or correctly setup. It is recommended that features be initially disabled to ensure they do not complicate tuning.

40. Click on ‘Motorsport’ then ‘Antilag’:
    a. Set ‘Antilag Mode’ to OFF.
41. Click on ‘Launch Control’:
    a. Set ‘Launch Control Mode’ to OFF..
42. Click on ‘Flat Shifting’:
    a. Set ‘Flat Shifting Mode’ to OFF.
43. Click on ‘Boost Control’ (only visible if an Auxiliary Output is configured for a Boost Control Solenoid) then ‘Boost Setup’:
    a. Configure Boost Control as described in the PCLink online help.
44. Click on ‘Dual Boost Maps’:
    a. Set ‘Dual Boost Mode’ to OFF.
45. Perform a Store by clicking the ‘S’ button on the toolbar (top centre).

10.3 – TRIGGER CALIBRATION

The following instructions assume that all pre-start setup instructions given in Sections 10.1.1 to 10.1.3 have been completed. Only after all pre-start checks have been made should an attempt be made to crank the engine. The following steps must be performed before an attempt is made to start the engine to ensure the LEM^{G3} is calibrated to precisely measure engine position.

1. Connect to PCLink (refer to Section 10.1.2).
2. Click on the ‘Configuration’ heading in the tuning function tree (top left of PCLink screen):
3. Select 'Fuel', then 'Fuel Setup':
    a. Set ‘Injection Mode’ to OFF. This will prevent the engine from trying to start while the triggers are calibrated.
4. Click on ‘Triggers’ then ‘Calibrate Triggers’.
5. Perform the correct trigger calibration procedure as described in the PCLink online help.

Note that trigger calibration must be performed again once the engine is running. Due to the acceleration and deceleration of the crankshaft at low speeds, an inaccurate measurement of engine timing is usually made. Also it is often harder to see timing marks with a timing light at slow engine speeds. Trigger calibration should be checked again at between 2-4000 RPM where engine speed is stable and a more consistent timing reading can be obtained.

10.4 – First Time Startup

After performing all setup instructions given in Sections 10.1 to 10.3, including trigger calibration, the engine is now ready to be started. The following procedure should be used for first time start-up:

1. Turn the ignition key OFF then ON. The fuel pump should prime momentarily upon power up.
2. Connect to PCLink (refer to Section 10.1.2).
3. Click on each of the runtime value tabs (located about two thirds of the way down the screen) and check that all values are as expected. Where possible operate sensors (eg TPS) to ensure correct readings are displayed. The following values should be checked:
    a. TPS – spans from 0 to 100% when throttle is pressed. If not, perform a TPS Calibration.
    b. MAP – should read approx 100 kPa (at sea level) with the engine running. If not, check the MAP Sensor Type setting and perfroma MAP Calibration.
    c. ECT – should read current engine temperature.
    d. IAT – should read current intake air temperature.
    e. Digital Inputs – Operate switches connected to any digital inputs while watching the runtime value to ensure they operate as expected.
4. Rectify any faults found in Step 3.
5. Click on the 'Fuel' heading, then 'Fuel Setup':
    a. Locate the 'Master' setting. This will need to be adjusted during or just after start-up.
6. Crank the engine until it starts. Some throttle may be required for first time start-up due to imperfect tuning. If necessary adjust the Master setting to enrich/lean the engine (increase to enrich).
7. If the engine fails to start after several attempts, do not crank it endlessly. Stop and determine the problem before continuing.
8. Once the engine starts, adjust the 'Master' setting to achieve best possible running.
9. The engine should now be allowed to fully warm up. It may be necessary to readjust 'Master' several times to maintain smooth running. Don't forget to keep an eye on engine temperature.
10. Once the engine is warmed up and running well, perform another

trigger calibration (known “as setting the base timing”).

10.5 – ESSENTIAL TUNING ADJUSTMENTS

It is assumed that at this stage all setup procedures described in Sections 10.1 to 10.4 have been completed and the engine is running. The following steps detail correct setup procedures for some of the more critical ECU parameters (note that MAP Sensor Calibration should have already been completed by now):

10.5.1 – MAP SENSOR CALIBRATION

At key on and engine not running the Manifold Absolute Pressure (MAP) Sensor should always match the Barometric Absolute Pressure (BAP) Sensor. As well as providing altitude correction, the BAP sensor also allows the MAP sensor to be calibrated prior to tuning.

Link ECU's use an on-board barometric sensor that is calibrated prior to dispatch. This ensures that all Link programs (PCL Files) give a consistent state of tune throughout our ECU range. This allows a PCL file to be transferred between G2/G3 based ECU's giving an equivalent state of tune providing all factors affecting VE are equal.

Without the ability to calibrate all the available types of MAP Sensors to the BAP Sensor there would be significant affects on the accuracy of the resulting tune, especially when tuning with Manifold Gauge Pressure (MGP) as a load index.

To calibrate the MAP sensor, select the 'MAP Sensor Calibration' item in the PCLink 'Options' menu and follow on screen instructions.

10.5.2 – INJECTOR VOLTAGE CORRECTION

There is always a delay between the injector being energised and the injector actually opening. Likewise, there is a small delay between the injector being de-energised and the injector closing. The opening time is considerably longer than the closing time, however the overall result is that less fuel will flow for a given pulse width than would be expected with an 'ideal injector'. To compensate for this the injector pulse widths are increased to compensate for this 'dead-time'. The dead-time for a given injector is a function of the battery voltage, differential fuel pressure and the type of injector driver (saturation or peak and hold). A typical dead-time at 3Bar differential fuel pressure and 14 volts is just under 1ms (ms = millisecond = 1 thousandth of a second).

In applications with a linear 1:1 fuel pressure regulator (ie not a rising rate regulator), the differential fuel pressure (difference between manifold pressure and fuel pressure) will be constant. Therefore the only variable that is changing will be the battery voltage (this changes with electrical load and sometimes engine speed). Without correction, the changes in dead time will cause the engine to run lean when the voltage drops. If the Injector Voltage Correction is properly setup then changes in the battery voltage will not affect the air/fuel ratio.

The injector dead-time table allows the dead- time for different battery voltages to be entered. The values represent the dead-time in milliseconds. These should increase with falling system voltage.

Injector dead time for a particular set of injectors can be determined using a flow bench or on a running engine.

To determine the injector dead-time using a flow bench, the injectors need to be operated at the intended operating pressure (normally three bar) and at a constant duty cycle as well as a set voltage. Vary the supply voltage to the injector and measure the resulting loss in injector flow, adjust the pulse width to return to the same flow as originally tested, the resulting **change** in pulse width is the required dead-time for that injector at that tested voltage.

To determine inector dead time on a running engine, with the engine fully warmed and operating at stable air/fuel ratios (a very precise AFR meter is required – a narrowband O2 sensor will not suffice), electrical drain needs to be applied to the system; the preferred method is disconnecting the alternator main fuse.

Watching the air fuel ratios change while the battery voltage drops, the dead-time table can be trimmed to maintain the same stable air/fuel ratio. Injector Dead-Time can be viewed as a row graph. A smooth curve needs to be maintained at all times.

NOTE: any change to the fuel pressure or injectors will require a recalibration of the injector dead-times.

10.5.3 – MASTER

Master should be set so that the numbers in the middle of the fuel table end up around a value of 50. This is to allow sufficient span of the numbers in the main fuel table.

10 – CONNECTING A DISPLAYLINK

The DisplayLink can be used with the LEM^{G3}. Connecting the DisplayLink is simple.

Figure 10.1 - LEM^{G3} CAN/Comms connector location.

Consult the DisplayLink manual to determine the correct cable required to connect the DisplayLink to the LEM^{G3}'s CAN/Comms connector.

After correctly connecting the DisplayLink, it must be configured to communicat with the LEM^{G3}. This is done by selecting 'G2/G3' as the 'ECU Type'. This setting is located in the 'Display Settings'. Consult the DisplayLink manual for further information on this procedure.