

LUCAS GEMS - System Overview

A cooperation between Lucas and Sagem produced the GEMS which can be found fitted to the petrol versions of the P38 from introduction until the 1999 facelift.

The GEMS is a very sophisticated system using feedback from many sensors to self compensate for wear, tolerance, climate, etc., thus helping it maintain the same running standards to which it was designed. The system also has an equally sophisticated self-diagnostic system and can self detect up to approximately 1000 different faults, ranging from very bad ones causing the engine to not start, through to logging slightly abnormal events in the normal course of vehicle usage which don't even create a warning. Sometimes multiple faults may be logged which may have been caused by the same faulty component but in this event they will all share a common thread which can help to locate the faulty part. Under certain fault conditions, the ECU stores freeze frame data. The ECU will store only one freeze frame data at the time. If another malfunction that has freeze frame data occurs, any freeze frame data stored previously will be replaced by the new conditions.

LUCAS GEMS - System Help file

Version 1.27

LUCAS GEMS - Known Fitments

Vehicle makes, models and variants known or believed to be using this vehicle system, required diagnostic lead and degree of known compatibility.

Vehicle Make	Vehicle Model	Vehicle Variant	Diagnostic Lead	Compatibility Level
Land Rover	Range Rover (P38)	<1999	Green OBDII Lead	Verified

LUCAS GEMS - Pin Outs

Details of the pin usage for the ECU connector(s).

C1017	
1	Anti Lock Brake System ECU
2	Camshaft Position Sensor
7	Fuel Level Sensor
8	Right Heated Oxygen Sensor (Post Catalyst)
10	Knock Sensors
11	Left Knock Sensor
12	Right Knock Sensor
13	Intake Air Temperature Sensor
14	Engine Coolant Temperature Sensor
15	Throttle Position Sensor
16	Mass Air Flow Sensor
17	Left Heated Oxygen Sensor (Post Catalyst)

18	Neutral Sense Diode
20	Data Link Connector (OBDII)
21	Heated Front Screen
23	Data Link Connector (OBDII)
26	Theft Alarm Unit
27	Vehicle Speed Output (Instruments)
28	Air Conditioning Switches
29	Air Conditioning Switches
30	Fuel Pressure Sensor
32	Heated Oxygen Sensors
33	Right Heated Oxygen Sensor
34	Left Heat Oxygen Sensor
35	Engine Fuel Temperature Sensor
36	Multiple Sensor Connection

C1032	
1	Compressor Clutch Relay (coil)
3	Condenser Fan Relay (coil)
6	Evaporative Emission Canister Vent Seal Valve
11	Fuel Injectors
13	Fuel Injectors
15	Idle Air Control Valve
16	Idle Air Control Valve
17	Fuel Injectors
18	Fuel Injectors
19	Evaporative Emission Canister Purge Valve
21	Heated Oxygen Sensors
22	Malfunction Indicator Lamp (MIL) (Instruments)
24	Fuel Pump Relay (coil)
28	Heated Oxygen Sensors (Post Catalyst)
30	Fuel Injectors
32	Fuel Injectors
33	Fuel Injectors
34	Idle Air Control Valve
35	Idle Air Control Valve
36	Fuel Injectors

C1033	
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1	Ignition Coils (5+8)
4	Throttle Position Sensor
5	Ground Distribution
7	MFI Load Relay
8	Satellite Fuse Box 1
9	Ground Distribution
10	Ground Distribution
11	Crankshaft position Sensor
12	Crankshaft position Sensor
13	Ignition Coils (2+3)
14	Ignition Coils (1+6)
15	Ignition Coils (4+7)
16	Ground Distribution
17	MFI Load Relay (coil)

LUCAS GEMS - Diagnostic Capabilities (Read Fault Codes)

Reads the fault code memory. The ECU can self detect around 150 different problems with itself, its wiring and its associated sensors, storing the respective code if it detects any malfunction or reading outside of predefined acceptable limits. Not all stored faults may cause the fault warning lamp to illuminate.

LUCAS GEMS - Diagnostic Capabilities (Clear Fault Codes)

This function, first reads the fault code memory to ensure that there are faults to clear, and if there are, it completely erases and clears the fault code memory. Having deleted the faults, it then rechecks the fault memory, to check that it is clear, reporting success, if it is. Failure to clear the fault memory successfully is usually due to the system re-logging the fault the moment the fault memory is clear. This indicates that the fault has not been rectified properly and as far as the system is concerned, still exists. The recheck for successful clearing of the fault code memory may be successfully executed but then the system may re-log the fault shortly after.

LUCAS GEMS - Diagnostic Capabilities (Settings)

Values, configuration settings, and other stored information which can be read from the ECU, edited and then rewritten back. Read settings can also be stored as a standard HTML page for reference. These pages can then later be reloaded and rewritten back to the ECU. Please note that some values may be read only due to the fact that they are supplied from the ECU's ROM or are internally calculated.

- **Security:** This is part of the contents of a specially allocated part of memory used to store security information within the GEMS ECU, which may be used in certain markets for storing unique information. It is supplied to enable total transference of identity from one ECU to its replacement.
- **Dealer ID:** This is part of the contents of a specially allocated part of memory used to store Dealer information within the GEMS ECU, which may be used in certain markets for

storing unique information. It is supplied to enable total transference of identity from one ECU to its replacement.

- **VIN number:** The last six digits of the Vehicle Identification Number (VIN), which are unique to each vehicle. The designation for the remainder of the VIN is detailed in the relevant manual.
- **Build code:** This value is a code which determines the build week and year.
- **Transmission:** Used to select between usage of the GEMS ECU with either an Automatic or a Manual gearbox.
- **Engine:** Used to select between usage of the GEMS ECU with either a 4.0 or 4.6 litre engine.
- **Market:** This is the market which this GEMS ECU is intended to be used in, denoting tunes and oxygen sensor configuration. It is factory set and not changeable.
- **GEMS:** The internal revision information displayed exactly as it is stored in the ECU.
- **Patented number:** As printed on the lid of the ECU.
- **Intel number:** Revision number of the INTEL processor used in the GEMS.
- **TMS number:** Revision number of the Texas Instruments processor used in the GEMS.
- **Part number:** OEM part number as stored in the GEMS.
- **ECU tune ID number:** An OEM reference number used to denote the specific market tune for this ECU.
- **Fuel flow rate:** The Adaptive Fuel Mass Flow Rate (FMFR) is learnt by the system over a period of time and is added to the normal fuel rate to compensate for manufacturing tolerances between fuelling components. The extremes of tolerance that GEMS allows for is +0.625 to -0.625 after which it will log a fault in its fault code memory. The value can be adjusted here but may be reset by engines using closed loop correction.
- **Air flow rate:** The Adaptive Air Mass Flow Rate (AMFR) is learnt by the system over a period of time and is added to the normal air rate to compensate for manufacturing tolerances between airflow components. The extremes of tolerance that GEMS allows for is +5.5 KG/HR to -5.5 KG/HR after which it will log a fault in its fault code memory. The value can be adjusted here but may be reset by engines using closed loop correction.
- **Short term idle:** This is the value that the GEMS uses to regulate the current idle speed to take into account current engine load, temperature etc. It can be manually altered here but may later be changed by GEMS. The value is in steps and it can be a number between 0 and 255.
- **Long term idle:** This is the value that the GEMS learns over a period of time to take into account manufacturer's tolerances on components which affect overall idle speed. This value cannot be modified, but it can be reset, forcing the GEMS to re-learn this value.
- **Closed Throttle value:** This adaptive value is stored by the GEMS so it knows when the vehicle is at idle. It is a voltage value and is compared against the voltage that the GEMS ECU reads from the potentiometer mounted on the plenum throttle spindle. The value should be around 0.6 volts. If any adjustments are made which result in the stored value being lower than the current throttle position with the throttle properly closed and the vehicle at idle, it is possible to have the GEMS relearn its new value by resetting all ECU adaptations or the value can be manually edited here.

LUCAS GEMS - Diagnostic Capabilities (Inputs)

Realtime live display of the information the electronic control unit of the selected vehicle system is currently deriving from its input sensors.

FUELLING

- **Loop status:** This confirms the current status of the GEMS loop tuning system and tells if it is currently active and working correctly. Options are:
 - **OPEN NOT YET SATISFIED CONDITIONS:** The engine is not running or is still too cold to use the feedback from the sensors so when there is nothing wrong, the system is open loop.
 - **CLOSED USING O2 SENSORS NORMALLY:** Proper operation with no faults.
 - **OPEN DUE TO DRIVING CONDITIONS:** The system has been using the sensors and there are no problems, but it has decided not to use them at the moment as the feedback is not required for correction.
 - **OPEN DUE TO A DETECTED FAULT:** There is a fault with the sensor and the system has reverted to using the pure map without the aid of closed loop correction.
 - **CLOSED BUT AN O2 SENSOR IS FAULTY:** This can only happen in vehicles fitted with 2 sensors per bank (NAS). Although the system knows one of the sensors is faulty it can switch to using the other one to give closed loop fuel correction.
 - **Pre cat O2 Sensor:** This is the returning voltage value from the odd/even banks front (pre-catalyst) Oxygen sensor, which under normal operation (closed loop) should switch between very low values (near zero volts) when the mixture is too rich and very high values (near 5.0 volts) when the mixture is too weak. This switching may pause for brief periods, which is normal. Some markets (mainly Australia) had no sensors fitted and work entirely open loop.
 - **Post cat O2 Sensor:** This is the returning voltage value from the even banks rear (post-catalyst) Oxygen sensor, which under normal operation (closed loop) should switch between very low values (near zero volts) when the mixture is too rich and very high values (near 5.0 volts) when the mixture is too weak. This switching may pause for brief periods, which is normal. Sensors are only fitted after the catalyst in some countries like North America (NAS) and are used mainly for confirming the correct operation of the catalytic converter although this sensor can be used in the event of failure of the main pre-catalyst sensor.
 - **Fuel trim long term:** The percentage of alteration from the map value that the system is applying, to compensate for engine temperature, air temperature, fuel temperature, current engine load and other related conditions.
 - **Fuel trim short term:** The percentage of alteration from the map value that the system is applying, to momentarily compensate for feedback information, acceleration and other load conditions.
 - **Adaptive FMFR:** The Adaptive Fuel Mass Flow Rate (FMFR) is learnt by the system over a period of time and is added to the normal fuel rate to compensate for manufacturing tolerances between fuelling components. The extremes of tolerance that GEMS allows for is + 0.625 to -0.625. After which it will log a fault in its fault code memory.
 - **Fuel temperature:** This is the value obtained from the fuel temperature sensor, which is located on the metal fuel rail in-between, the cylinder heads. When the engine has been running and is then stood for a short time, heat escaping from the engine can super heat the fuel trapped in the fuel rail, meaning that when restarting an already hot engine, problems can arise (hot starting problems). Having the fuel temperature information means that the GEMS can compensate for this by increasing the injector opening (pulse) period when the fuel temperature is high. This sensor is treated as fail-safe by GEMS with the system substituting a value of 40 degrees centigrade upon

detection of its failure.

- **Fuel level:** This is the measured voltage indicating current fuel tank level, which is used by GEMS for internal evaporative emission tests. The value is inverted, meaning the closer to the maximum of 5 volts it becomes, the emptier the fuel tank is and the closer to the minimum of zero the value becomes, the fuller the fuel tank.
- **Oxygen configuration:** This is the numerical value obtained from GEMS, which denotes its expected oxygen sensor layout. Options are:
- **Pre Cat O2 Sensor Heater:** This value shows the returning voltage from the front pair of (pre-catalyst) oxygen sensor heaters, which corresponds to their current heat output. The value should fluctuate as the GEMS switches or pulses the Heaters power on and off to regulate the temperature. If the value remains fixed in normal operating conditions one of the heaters may be faulty.
- **Post Cat O2 Sensor Heater:** This value shows the returning voltage from the rear pair of (post-catalyst) oxygen sensor heaters (when fitted), which corresponds to their current heat output. The value should fluctuate as the GEMS switches or pulses the Heaters power on and off to regulate the temperature. If the value remains fixed in normal operating conditions one of the heaters may be faulty.

AIR AND IDLE

- **Current throttle position:** The value returned from the Throttle position potentiometer, which is located on the side of the Throttle body. During normal idling this should be around 0.5 to 0.65 volts, increasing towards 5.0 volts as the throttle pedal is pressed and the engine approaches 5500 RPM. This input signal is fail-safe, as failure in the closed position results in the GEMS limiting the engine RPM to 1740, above which is restricted by the over run fuel cut-off being applied.
- **Stored throttle position:** This Adaptive value is stored by the GEMS so it knows when the vehicle is at idle. If any adjustments are made which result in the stored value being lower than the current throttle position with the throttle properly closed and the vehicle at idle, it is possible to have the GEMS either re-learn its new value by re-setting all ECU Adaptations or the value can be manually edited in the Settings section.
- **Adaptive air flow value:** The Adaptive Air Mass Flow Rate (AMFR) is learnt by the system over a period of time and is added to the normal air rate to compensate for manufacturing tolerances between airflow components. The extremes of tolerance that GEMS allows for is + 5.5 KG/HR to -5.5 KG/HR. after which it will log a fault in its fault code memory.
- **Current air flow:** This is the current reading taken from the Air Flow Meter. It should be around middle 20's at idle rising steadily with engine RPM until around 200 KG/HR at 5500 RPM.
- **Intake air temperature:** The current value read from the Temperature sensor, which is mounted in the side of the air filter box. Used by GEMS to compensate for climatic variances. The sensor is fail-safe with GEMS substituting a value of 50 degrees centigrade in the event of sensor failure.
- **Air flow sensor voltage:** This value is the pure voltage reading taken from the Air Flow Meter that GEMS uses to work out the flow rate in Kg/Hr. At idle, the value should be around 20 - 25Kg/Hr.
- **Secondary air status:** Commanded Secondary air Status. Options are:
 - **1:** Upstream of first catalytic converter.
 - **2:** Downstream of first catalytic converter inlet.
 - **4:** Atmosphere / off.

Any other value is invalid.

- **Current run line position:** This value is the number of steps for the current run line position.
- **Long term adaptive idle:** This is the value that the GEMS learns over a period of time to take into account manufacturers' tolerances on components which affect overall idle speed. It can be reset, forcing the GEMS to re-learn this value or it can be manually altered in the settings section.
- **Short term adaptive idle:** This is the value that the GEMS uses to regulate the current idle speed to take into account current engine load, temperature, etc. It can be manually altered in the settings section.
- **Idle speed reference :** This is the target idle speed in RPM that the GEMS uses as a reference when self adjusting the idle speed. This is not settable and is pre-set into the ECU.
- **Idle air control valve:** The Idle Air Control Valve (IACV) has a stepper motor mounted on it, which controls its position in steps thereby regulating the air flow at idle and thus the idle speed. The position of this stepper motor is adjustable and should be such that a warm engine at normal idle should cause the stepper motor to be at between 15 and 30 steps. The value can be between zero (closed) and 200 (open).
- **Engine speed RPM:** The current Engine RPM.
- **Gearbox retard:** This is derived from a signal sent by the Automatic Gearbox (where fitted) and is used to inform the GEMS of gear changes, torque and load so that GEMS may retard the ignition accordingly, producing smoother gear changes. At idle this should be 17% increasing towards 100% as and when ignition retarding is required.
- **Calculated load value (%):** This is an internal value where the GEMS keeps a track on the load that the engine is under it is used in internal fuelling calculations.
- **Current gearbox status (D/P):** This status is used by the GEMS so that idle may be better maintained as the Automatic Gearbox load is applied to the engine.

ENGINE AND OTHERS

- **Coolant temperature:** The value obtained from the engines coolant temperature sensor.
- **Battery(v):** The current state of the battery at the GEMS ECU. Some GEMS ECUS built around 1996 were faulty and did not correctly report the voltage, instead supplying a fixed signal which incorrectly indicates 16 volts.
- **Road speed (mph):** The road speed as supplied to the GEMS ECU from the ABS ECU.
- **Road speed (km/h):** The road speed as supplied to the GEMS ECU from the ABS ECU.
- **Air conditioning request:** When the A/C button is pressed an active low signal is output to the GEMS ECU (The Request). This then looks at factors like engine temperature, load, current acceleration etc., and when these conditions allow, grant Air conditioning. This involves it engaging the clutch to drive the Air Conditioning pump, altering its internal fuelling to compensate for the load imposed by the pump, managing along with the Hevac the Condenser fans, and also telling the Hevac that Air Conditioning has been Granted. This shows the current status of the request line from the Hevac ECU.
- **Front screen load:** This is an input which tells the GEMS ECU that the heated front windscreen is being switched on so that it can compensate for the heavier electrical load on the alternator.
- **Ignition switch:** The current ignition switch state as determined by GEMS.

- **ABS volts:** The ABS has the ability to inform the GEMS ECU that the vehicle is encountering unusually rugged terrain. Thus, should the GEMS think that it has had a engine misfire during such driving it can be persuaded not to falsely log a misfire fault in its fault code memory.
- **Security learn:** When the ignition is turned on, the BECM providing it is in receipt of a valid mobilisation code and is therefore not in an alarmed or immobilised state, sends a coded signal to the GEMS which the GEMS then compares against a mobilisation code it has stored in it. If the two codes compare OK the GEMS allows the engine to start. This forms the basis of the immobiliser. If the GEMS ECU, the BECM, or the lockset & key fob is replaced, or other data in the BECM is changed, it may be required for the GEMS to re-learn a new mobilisation code. This is done by putting the GEMS into Security learn mode whereby the next coded signal it receives is not compared, but is instead stored as the master copy. When security learn mode has been entered, the ignition has to be turned off and turned back on to trigger the BECM into sending the code. The GEMS will check the incoming code and should accept it; however, if there is an error, however slight in the codes makeup, the GEMS can reject it; in such a case there will be no valid code stored. This status indicates whether the system has a valid code stored or not and is only valid in the ignition cycle in which is learned.
- **Security mobilised:** This shows the status of the engine immobiliser built in to the GEMS.
- **Transfer box (v):** This signal is only valid for the North American specification (NAS) vehicles. It allows the Transfer box to signal to the GEMS situations which affect emissions.
- **Ignition timing advance (deg):** An internal record of calculated timing advance applied by the GEMS.

LUCAS GEMS - Diagnostic Capabilities (Outputs)

- **Malfunction indicator lamp:** This output flashes the MIL lamp or Check Engine light on the instrument cluster to check correct operation and confirm full control of the lamp by GEMS ECU. The lamp is permanently ON when ignition on, and OFF with the engine running.
- **Oxygen sensor heater:** Turns On and Off the power to the heaters, which are built into the oxygen sensors to check correct operation and confirm full control of the heaters by the GEMS ECU. (voltage measurement)
- **Fuel pump relay:** Turns On and Off the power to the fuel pump relay to check correct operation and confirm full control of the fuel pump by the GEMS ECU.
- **Air condition grant:** Turns On and Off the grant line to the AC to check correct operation. A fluctuation of a voltmeter needle between 0V and 5V can be seen when connected on PIN 1 of the big black connector of the GEMS ECU.
- **Condenser fan:** Turns On and Off the power to the Air conditioning's condenser fans control relay to check correct operation and confirm control of the fans by the GEMS ECU.

LUCAS GEMS - Diagnostic Capabilities (Other)

Choice of functions that can be performed:

- **Security learn mode:** When the ignition is turned on, the BECM, providing it is in receipt of a valid mobilization code and is therefore not in an alarmed or immobilised state, sends a coded signal to the GEMS which the GEMS then compares against a mobilization code it has stored in it. If the two codes compare OK, the GEMS will allow the engine to start. This forms the basis of the immobiliser. If the GEMS ECU, the BECM, or the lockset & key fob is replaced or other data in the BECM is changed, it may be required for the GEMS to re-learn a new mobilization code. This is done by using this function to put the GEMS into Security learn mode whereby the next coded signal it receives is not compared but is instead stored as the master copy. When security learn mode has been entered the ignition must be turned off and turned back on to trigger the BECM into sending the code. The GEMS will check the incoming code and should accept it; however, if there is an error no matter how slight in the codes makeup, the GEMS can reject it, in which case there will be no valid code stored. This situation can be checked by looking at the security learn status in **Inputs - Engine and Other** which denotes whether the system has a valid code stored or not.
- **Reset all adaptive values:** As the GEMS runs, it keeps a long-term tally of the constant adjustments it is making to keep values on target. After a while it realises that it is always adding or subtracting more or less the same amounts and so stores these adjustments as long term adaptive values (those it always uses). These adjustments are really designed to compensate for tolerance in components, natural leakage through gaskets, or air spillage etc. If, however, major rebuilds are undertaken or major components replaced, these values could suddenly become very wrong. This function deletes the current adaptive values (except short term idle) for the stored closed throttle position, which controls the idle speed, and for adaptive AMFR, which controls the fuel mixture, and makes the system re-learn them. Unfortunately a zero value can be as wrong as the previous value, so having performed the reset it is possible that the engine may not run as smoothly as before; however it will correct itself as the system re-learns the new values after several driving cycles. On vehicles with no oxygen sensors the Adaptive Air Mass Flow Rate (AMFR) will have to be manually set as the system has no feedback to learn this value. This can be done in the Settings section and requires an external CO meter.