GEMS

IMPLANT FOR MITSUBISHI LANCER EVO 1 TO 7 ECU

GENERAL ENGINE MANAGEMENT SYSTEMS LIMITED

UNIT A1/D CRABTREE ROAD

THORPE TECHNOPARK

EGHAM

SURREY

TW20 8RN

VERSION : V2.41

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SYSTEM OPERATION

Note Lancer7 Both the Crank fuel table and Setup that holds the MAP, BAR, Airflow, Mass AF, WG feedback, Alt Accel, Auto EE, TPS ALS, switches. The user defined site tables for speed, throttle angle, and Boost (also effective for airflow).

The ECU uses the sensors to determine the correct fuelling, ignition timing, and boost pressure. It then controls the injectors, ignition amplifiers, wastegate actuator valve, water spray, and cooling fans. It also interfaces with the monitoring system to allow the user to monitor and control the engine management operation.
The control's functions are set by various user programmable lookup maps, tables and options, with the aid of a PC running a GEMS supplied user interface.
Installation may require the removal of the old standard PCB from the ECU case and fitting of the GEMS implant PCB. Note the safety and RFI filter grounds are through the case to chassis. However for EVO5/6 ECUs the all plastic case has a poor earthing characteristic and the use of resistive plugs is necessary or the removal of the knock sensor, and it's wiring.
All ECU variables are displayed in Italics, for example, *TPS raw.* All programmable options, tables and maps are display in bold Italics, for example, Accel Amount.

SECURITY

Current versions of embedded software Lancer7 G2.40 and Lancer6 road G2.29 are availible with user security using dongled GW95.exe and *.GEMS installations. Lancer7 G2.41 is not secured and is compatible with Lancer7 G2.40, and can use *.ini and *.gin configuration files.

SENSORS

Airflow is measured using the standard sensor that is housed in the air filter box and connected to the inlet of the compressor housing. This is usually the system's major parameter for monitoring load.

Throttle position (*TPS*) is measured using a rotary potentiometer mounted on the throttle actuating mechanism. This input is used for starting, acceleration and deceleration fuel and control of the PBW system. There are two user programmable options that scale the throttle position sensor. These are TPS min and TPS max. These must be set to ensure correct operation of the throttle parameters. TPS min must be set to the raw throttle value *TPS raw* at closed throttle and TPS max set to the value of *TPS raw* at full throttle.

Air temperature (*Air temp*) is measured using a sensor mounted in the intake manifold. The sensor is a negative coefficient thermistor in an automotive compatible package. It may be used to convert the inlet air velocity into a mass airflow.

Coolant temperature (*Coolant*) is measured using a sensor mounted in the water jacket of the engine.

Engine speed (*Engine speed*) and timing are measured using two sensors mounted in the Timing unit. The timing sensors are mounted on the engine in their standard positions.

Manifold absolute pressure (*MAP raw*) may also be used as the primary load sensor. With the sensor disconnected from the inlet it may be scaled for use as a barometric sensor. Alternatively, it can be used to make an inlet air mass flow with air temperature correction. The Knock sensor (*Knock*) may be monitored for active knock control.

The exhaust gas oxygen (*Oxygen raw*) sensor can also be monitored as a mapping aid and may be used as a weak mixture alarm. The exhaust gas temperature (*Cat temp*) may also be monitored as a tuning aid. The conversion of the raw value may be user specified using the options Cat temp m and Cat temp c.

A knock microphone is used to detect Knock and other noise, this may be used to add additional fuel and retard the spark to quench knocking, see (*Knock Raw*).

An exhaust gas K type thermocouple may be used to prevent excessive retarding that produces excessive exhaust temperature, see (*Cat temp*).

OUTPUTS

All as standard as appropriate for a group N rally specification.
Note on EVO1-3 the Tacho is normally sourced from the ignition amplifier but since in anti-lag there can be significant amounts of ignition cutting it is necessary to source this signal from the ECU, so disconnect the wire from the amplifier.

LOAD SENSING

There are two possible sources for load MAP (boost pressure), or Airflow, both may use a back-up derived from throttle if either should fail.

MAP as Load = ((MAP_raw – MAP_min)/ (MAP_max – MAP_min)) × 130

AFLW as Load = (Flow_sum_c / (Flow_max) × 130

Flow_sum_c is the number of pulses received by the ECU in the last number of engine revolutions specified by the AF_rev option.

[old calculation was AFLW as load = Flow_sum_c × (AF_scalar/256)]
[(AF_scalar/256)=130/(Flow_Max)]

So for an old system with AF_Scalar=25, then a new system would use a Flow_Max=132, typical values of AF_High=127 and AF_Low=5 are used to trip the fault condition that will activate TPS_to_Load table.

FUEL METERING

The amount of fuel injected each cycle is dependent on the time the injector is open. This time period, or pulse width (*Fuel pulse*), is calculated by the ECU using factors for volumetric efficiency, air temperature, airflow, cold start enrichment, injector flow rate and battery voltage.

Volumetric efficiency V.E. (*Vol Eff*), the major factor, is determined by the engine load and engine speed using a three-dimensional lookup table. This 3D table is a simple grid with *Load* along one axis and *Engine speed* along the other.

The *Load* range is from 0 to 130. The load axis has 14 sites. *Load* may be derived from *Throttle*, *airflow* or MAP (*Map as load*). The engine speed axis has 21 sites, one every 400 RPM from 800 to 8000 RPM.

At each intersection of an engine speed site and load site there is a grid value. This is the volumetric efficiency value or V.E. and is directly proportional to the pulse width and therefore the amount of fuel injected.

These values are determined by running the engine on a dynamometer at each obtainable point and adjusting the V.E. values to obtain optimal performance. Values for unobtainable points, such as high-speed low load and low speed high load, are normally selected to blend in with the obtainable values.

If the engine is running at an exact engine speed site and an exact load site then the VE value at the intersection of these two sites will determine the amount of fuel injected.

So using:

		Load			
		100	110	120	130
Engine Speed	4800	130	130	130	133
	5200	135	135	135	135
	5600	142	143	144	145
	6000	150	152	155	160
	6400	165	170	175	180

If the engine speed is 5600 rpm and the load is 110 then the VE value will be 143. If the engine is running at a speed and load between sites then the VE value is determined by interpolating the four grid values around the engine running conditions.

So using fig 4.2 if the engine speed is 5850 rpm and the manifold load is 125 then the four grid values are:

143 @ 5600 rpm 110 load
144 @ 5600 rpm 120 load
152 @ 6000 rpm 110 load
155 @ 6000 rpm 120 load

Then the interpolated value is 149 which is saved in *VE(MAP)*.

The base fuel pulse width is then calculated by multiplying *VE(MAP)* from the Fuel map with the injector flow rate option, microsec/bit. The value for microsec/bit is dependent on the expected horsepower of the engine and the injector flowrate. It should be set so that the maximum VE value is around 220, for best resolution. Note there is an optimise feature using LD0MPC available in GEMSCOM see F1 in Fuel map.

Vol.Eff. = VE (comp) $\times$ microsec/bit

The *Vol.Eff.* value obtained is then modified by the operator variable factor *Fuel mod*, so that:

VE (mod) = Vol.Eff. + (*Vol.Eff.* $\times$ *Fuel mod*)

Fuel mod is controlled by the operator using the monitoring and display system, and is used to determine the optimum VE values. *Fuel mod* can be set to a pre-set value using the Fuel Offset option. At power on Fuel Offset is copied into *Fuel mod*, so it operates as an overall rich/lean setting.

VE (comp), compensated volumetric efficiency is calculated by:

VE (comp) = VE(mod) + VE(mod) $\times$ *Air Temp F*

Air Temp F is the air temperature correction factor and is set by a 2D-user lookup table named Air Comp. The table has 20 sites one every 10 degrees from -30° to 120°C. *Air Temp F* has a range of +/- 50%. Note in MASS AF mode this correction is applied to *airflow* load. Similarly *Air Prsr F* the barometric correction may be applied dependant on the condition of setup bits Bar and Mass AF.

A coolant temperature factor *Cool Tmp F* is used to give enrichment for a cold engine. The value of *Cool Tmp F* is determined from a user-defined table. The Warm Up table with 0% to 200% range is used but while in cranking the Cold Fuel enrichment table with a range of 0% to 400% is used instead.

VE (comp) = VE (mod) × *Cool Tmp F*

Now *TPS Fuel mod* obtained from the Throttle mod map is applied so that more throttle feel can be applied. Any additional *Knock Fuel* is applied here when a *Knock* voltage is detected. OX FB oxygen feedback fuel may be applied here when enabled.

Finally the individual fuel trims from the four Fuel#?_mod options are applied. These allow for a fine balance between cylinders. Note the "?" applies to firing order and not the cylinder number.

The final fuel pulse width is then calculated by adding a factor determined by battery voltage (*Bat Comp F*) and any acceleration or deceleration fuel (*Accel Fuel*).

Total Pulse width = Pulse width + *Bat Comp F* + *Accel Fuel*

This ensures the accuracy of the fuel metering at all battery voltages.

Battery Fact is set by a 2D look up table (Battery Voltage Compensation, *Battery Comp*). This table has 10 sites, one every 1 volt from 6 volts to 15 volts. The value obtained from the table is *Battery Fact* in microseconds.

CRANK FUEL

When starting the value of VE is obtained from the 2 dimensional lookup table *Crank Fuel* controlled by scaled throttle position Throttle. Throttle is scaled to 0 for closed throttle to 130 for full throttle. The value for VE is then controlled as for normal running. However the base fuel pulse is multiplied by a cold start factor obtained from the *Cold Fuel* table which allows up to 3 times the normal fuelling while starting.

CLOSED THROTTLE FUELLING

When the following conditions are met then the closed throttle table is used to obtain the value of VE:

Throttle < CT TPS, Max closed throttle.
Engine Speed > CT speed, Min speed closed Throttle.

When the anti–lag is active then the PBW closed throttle table is used to obtain VE.

ACCELERATION/DECELERATION ENRICHMENT

When there is a large change in throttle position measured every 4 milliseconds, then some additional time is added to the base fuel pulse width. When in the FAF area defined by the options FAF TPS and FAF Speed then a FAF Fuel pulse width is used instead of Fuel_Pulse.

when +*dThrottle* > TPS_Trip
(+dThrottle×Acell_M)+Accel_C)×TPS_Accel_mod×TPS_Accel_Amount×*Fuel_Pulse*

when *–dThrottle* > *TPS_Trip*
(-dThrottle×Acell_***M)+****Accel*_C ***)***xTPS_Accel_mod×TPS_Decel_Amount×*Fuel_Pulse*

when δ MAP > + MAP_Trip option
(dMAP)×MAP_Accel_mod×MAP_Ammount×Fuel_Pulse

These three potential sources of transient fuel are summed together with any Accel_Fuel from the previous calculation.

Accel_Fuel is decayed every injection event or 8 milliseconds background event thus, or if Fast Accel option is on then every 4 milliseconds.

Accel_Fuel = Accel_Fuel × Accel_Decay, (or Decel_Decay if Accel_Fuel is negative)

The decay action is applied every injection event. The filter for TPS allows for detection of smaller throttle changes; the minimum filter value is 0% with 99% giving maximum filter.

FUEL INJECTION ANGLE

The sequential fuel injection opening angle may be adjusted using ***Inj Angle*** map. The feature works in conjunction with the ***fuel sync*** option to determine the relative to the 720 degrees of crank position. This feature can be used to improve both fuel economy and throttle response.

REV LIMIT

The rev limit function works by cutting the fuel injection and/or ignition if the *engine speed* is greater than ***Fuel cut*** and/or ***Ignition cut***. The depth of cutting is set by ***Fuel cut rate*** and ***Ign cut rate***. The cuts are obtained from the *Spark and Fuel Limit Tables* except when *No ALS if TPS* option is on and *TPS ALS* option is not triggered, If TPS_defeat is active then only the full throttle values from the N tables are used.

FUEL AUDIT

Source	Condition	range/modifier	Output
Crank Fuel Table	cranking	0-255	VE
Fuel Map	Running	0-255	VE
VE	Allways	× microsec/bit	Fuel (map)
Fuel (map)	Allways	Load Fact	Fuel Ld F
Fuel Ld F	Allways	Fuel mod	Fuel (mod)
Fuel (mod)		Air Temp F	Fuel Air
Fuel Air		Cool Tmp F/Cold Tmp F	Fuel warm-up
Fuel Warm-up		Baro tmp F	Fuel Baro
Fuel Baro		Crank Fuel	Fuel Crank
Fuel Crank		Knock Fuel	Fuel Knock
Fuel Knock		Ox F.B.	Fuel OX FB
Fuel OX FB		CT Fuel mod	Fuel CT Fuel
Fuel CT Fuel		TPS Fuel mod	Fuel Pulse
Fuel Pulse		Fuel Mod1	Fuel Pulse#1
Fuel Pulse#1		+ Bat Comp F	Injector #1
Fuel Pulse		Fuel Mod2	Fuel Pulse#2
Fuel Pulse#2		+ Bat Comp F	Injector #2
Fuel Pulse		Fuel Mod2	Fuel Pulse#2
Fuel Pulse#2		+ Bat Comp F	Injector #2
Fuel Pulse		Fuel Mod2	Fuel Pulse#2
Fuel Pulse#2		+ Bat Comp F	Injector #2
Fuel Pulse		Fuel Mod2	Fuel Pulse#2
Fuel Pulse#2		+ Bat Comp F	Injector #2

IGNITION TIMING

Ignition timing is controlled in the same way as for fuel using speed and load. There are 21 speed sites, one every 400 rpm from 800 to 8000 rpm and 14 load sites one every 10 load steps from 0 to 130. At each site the timing can be set from -64 to 64 degrees BTDC. Interpolation is used for values between sites to ensure smooth curves.
The ignition advance value *ADV* from the main lookup table is modified by a user controlled value *Spark mod*. *Spark mod* is variable from -64° to +63.5° used when calibrating the engine to obtain optimum values for the ADV table. It can also be set to a pre-set value using the *Ign Offset* option. At power on *Ign Offset* is copied into *Spark mod*, so it operates as an overall advance/retard setting.

ADV(m) = Spark Adv + Spark Mod

The modified ignition advance is further modified by the air and water temperature retard or the throttle position advance modifier *Retard Mod* whichever is the more retarded.

Air Retard is set by a table called ***AIT Spark*** . The modified ignition timing:

ADV (mod) = ADV (mod) – AIT Spark + TPS rtd (m)

Water temperature retard is simpler and set by ***Cool Rtd Strt*** and ***Cool Rtd Rate***.

If PBW is enabled then *Air Retard* is set by a 3 dimensional look up table addressed by Throttle and Engine Speed. The Throttle axis has 14 sites, one every 10 points from *Throttle* = 0 to *Throttle* = 130 (WOT). The Speed axis has 21 sites one every 400 rpm from 800 to 8800 rpm. The values from the table are interpolated. The map will accept values in the range -64° to +63.5°. The output from the table *TPS retard* is then modified by the use modifier *Retard mod* such that:

TPS_rtd(m) = TPS_retard + Retard_mod
If TPS_rtd(m) < Air_Retard then,
ADV_(mod) = ADV(mod) + TPS_rtd(m)
ADV(r)= ADV(m) +Air Retard

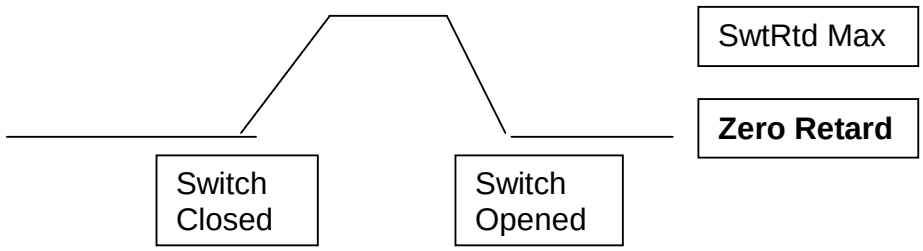
Knock Rtd is applied here if any Knock voltage is detected.

Finally the four individual ignition trim options *IGN#?_mod* are applied to the spark outputs. These should be kept to a few degrees. When the idle conditions are met then the ‘Spark scatter’ features may be used to stabilise idle. The ***Idle Spark*** table will produce a modification related to the difference from the idle set points. BEWARE this will make a none–sense of the timing indicated by a timing light.

The maximum retarded spark is limited by the ***Cat Rtd Limt*** table accessed using the exhaust mounted thermocouple.

SWITCH TORQUE REDUCTION

When *SwtRtd_Time* is not zero then the torque reduction feature is enabled, and the radiator water spray is disabled. The engine torque may be reduced by closing the torque reduce switch, or gear change switch. This switch is from the power steering demand input to ground pin B07. When the switch is closed *SwtRtd_Rtd* is increased up to the value of *SwtRtd_Max* at the *SwtRtd_Rtd rate*, until the switch is opened or the *SwtRtd_Time* has expired, then *SwtRtd_Rtd* is decreased to zero at the *SwtRtd_Adv* rate. The rate is 4.1 milliseconds and the maximum value of *SwtRtd_Time* is just over 1 second.



The *SwtRtd_Time* and *SwtRtd_Rtd* parameters may be monitored to test the action of the switch.

SPARK AUDIT

Source	Condition		Output
Spark Map	Running		Spark adv
Start	Cranking		
Spark adv	Running	Spark mod	ADV (mod)
		Coolant Rtd	ADV comp
		TPS Retard	ADV comp
		Spark Idle	ADV comp
		Accel rtd	ADV comp
		Knock rtd	ADV comp
		AIT Spark	ADV comp
		SwtRtd Rtd	ADV comp
		Knock rtd	ADV Knock
ADV Knock		IGN#1 mod	Spark#A
ADV Knock		IGN#2 mod	Spark#B
ADV Knock		IGN#3 mod	Spark#C
ADV Knock		IGN#4 mod	Spark#D

KNOCK SURPRESSION

The knock microphone responds to frequencies between 2 and 20kHz this is processed in the ECU to an energy value sampled immediately after ignition. Currently all cylinders are processed together, but it would be quite possible to detect them individually. The software processing first removes any background noise and if there is any energy left this is used to determine the extra fuel and ignition retards employed to recover from the knock condition. As a development aid *Knock Raw Pk* will hold the peak value of *Knock Raw* until it is reset with the "K" key, see f10 from parameter screen. The ***Knock Noise*** table should be filled with values from the *Knock Raw Pk* parameter to set the normal back ground level, or tolerable level of knock.

Algorithm Ignition

Knock = *Knock_raw* - ***Knock_noise***

Knock_Adv = *Knock* × ***Knock_Rtd***

If ***Knock_noise*** > *Knock_raw* ***> Knock_noise***/2

Then at the ***Knock_rate*** option:

Knock_Adv = *Knock_Adv* - Knock_inc (if less than ***Knk Rtd Max***)

Knock_noise is taken from the Knock_noise Table versus *Engine_speed*.

Note if Knock_raw < Knock_noise/2 then the bit 2 error flag in ERROR2 is set.

Fuel Algorithm

Knock_fuel = *Knock* × ***Knock_Rich*** (if less than ***Knk Fuel Max***)

If ***Knock_noise*** > *Knock_raw* > ***Knock_noise***/2

Then at the ***Knock_rate*** option:

Knock_Fuel = *Knock_Fuel* - ***Knock_dec***

STARTING IGNITION

The starting ignition timing is set by the teeth on the crankshaft timing disc. This is nominally TDC, however this can be mechanically adjusted and the resulting timing error can be adjusted out using *Delay Angle*.

TIMING SENSOR DELAY COMPENSATION

Some timing sensors, especially variable reluctance magnetic sensors have an in built drift with speed. This causes the ignition timing to retard as the engine speed increases. This is compensated for with the *Pickup comp* option. The value of *Pickup comp* is 166666/deg/RPM. So, assuming *pickup comp* is initially set to 0, if for a fixed value of *ADV(m)* the measured timing at 2000 rpm is 2 degrees different at 6000 rpm then:

Pickup comp =2 × 166666/4000
Pickup comp = 84 (83)

IGNITION COIL CHARGE TIME

The ignition coil charge time is calculated from battery voltage and engine speed. Different coils require different charge times. ***Coil_Factor*** adjusts *Charge_time* that in turn controls the level of charge held in the coil. The higher the value the more charge. It is important that the value is neither too low, weak spark, or too high, over heated coils and amplifier will result.

TORQUE CONTROL (PBW)

ENABLE CONDITIONS

The PBW system will be enabled if all of the following conditions are met:

ECU PBW Pin is at 0v (Drivers Switch)
Air temperature is < *PBW Temp* (Option)

If PBW is enabled the ignition timing is modified by the *TPS Retard* factor. And a proportion of injection events and of sparks are disabled by the limiter functions. The values for the limiters are obtained from the Spark and Fuel limiter maps. When the PBW mode is off then the TPS Retard N, Spark Limit N, Fuel Limit N maps are used.

The Spark Limiter 3D lookup table controls this:
Inputs Engine Speed and Throttle.
Speed Axis 21 sites 800 to 8000 rpm with steps every 400rpm.
Throttle Axis 14 site 0 to 130 Throttle, with steps every 10 units.
Output Limiter 0% to 99.6%, no cut to almost total cut.

To increase the control four rev limiter tables: Rev I Limit, Rev I LimitN, Rev F Limit, and Rev F LimitN, these increase the depth of the limiters when the engine speed is exceeded, again there are another set that activates if PBW is off.

Ign Limit = [*Spark Limit(N)*] + *Ign Cut* + *Ign Cut* +

Ign Cut is active when *Engine speed* ≥ *Ignition cut*

Ign Cut is active when *Engine speed* > *Ignition cut*

Ignition Cut is obtained from *Rev I Limit* table accessed with throttle.

Similarly for Fuel:
Fuel Limit = [*Fuel Limit(N)*] + *Fuel Cut* + *Fuel Cut* +

Fuel Cut is active when *Engine speed* ≥ *Fuel cut*

Fuel Cut is active when *Engine speed* > *Fuel cut*

Fuel Cut is obtained from *Rev F Limit* table accessed with throttle.

ELECTRONIC WASTEGATE CONTROLLER

The electronic wastegate controller uses a solenoid air bleed valve to control the load supplied to the waste gate actuator capsule. This allows the manifold pressure to be accurately controlled. This is an open loop system. The old active feedback has been deleted as it offered marginal performance improvement for considerable mapping and engine stress.

Load and Engine Speed are then used to address a 3D look up table to give the base waste gate valve duty cycle *WG msr*. The *WG msr* is taken from the *Waste Gate* map, accessed using *Throttle* and *Engine Speed*. The output has the range 0% to 99.6%. The output duty value *WG msr* is then modified by a user controlled factor *WG mod* to give the waste gate output value *WG msr(m)*. This allows the user to calibrate the waste gate duty cycle table.

WG msr (m) = WG msr + WG mod

The final drive value of *WG msr(m)* is limited in range to produce *WG msr(c)* that is used to drive the valve.

To prevent over boost a parameter *Boost mod* is added when *Load* exceeds the value in the ***Boost Limit*** table. *Boost mod* will increase after the ***WG max time*** is exceeded, at the ***WG max Force*** rate, untill ***WG max Limit*** is reached. When the boost returns to an acceptible value the waste-gate drive is restored back to zero at the ***WG max Back*** rate.

IGNITION TIMING

Ignition timing is controlled by a three dimensional look-up table addressed by engine speed and load. The speed axis has 22 sites 1 every 400 rpm from 800 to 9200. The load axis has 14 sites one every 10 points from 0 to 130. At each site the timing can be set from 0 to 60 degrees BTDC. Interpolation is used to ensure a smooth curves.

There are no compensation factors for ignition timing but there is a user controlled factor Spark_Mod which is used for reprogramming the ignition curves.

Spark_(mod) = Spark(map) + Spark_mod
While cranking the ignition is determined by the Start_ADV option.

When the idle condition is met, throttle is less than the Idle_Throttle option the Idle Spark table is active and the Spark_out parameter shows the effect of the high speed idle stabilisation attempting to control engine speed to Idle_set.

Spark_out = Spark_(mod) + Spark_Idle

Each trigger tooth has its own offset to allow for fine adjustment the difference should be kept to +/- 2 degrees, although the range may be 0 to 30 degrees to span a tooth gap.

Pickup_F is used to compensate for the small delays associated with sensors and ignition coils, if there is insufficient range then the Edge option should be changed as a slow edge has been selected. If required ignition retards for air inlet temperature, coolant temperature, and barometric pressure could be added. Also retards to ease gear changes and pull-away might be added, contact GEMS if required.

IDLE MOTOR CONTROL

The idle control is a compensation for engine temperature as measured by the coolant sensor, and Engine_speed, and the two optional factors A/C_Idle and >12volt_Idle. Two types of idle by-pass valves are supported; 5/6 wire stepper motor and 2 wire spring return, a 3 wire push/pull valve could be supported by arrangement. An additional high speed control using Idle spark is also used to stabilise the idle speed.

STEPPER MOTOR

When the option Idle_PW is zero then the standard stepper motor outputs are active. The five or six wire stepper motor, is driven closed at power on this is given the nominal step position of 0 and then the stepper opens the by-pass to the value specified in the Idle_step table and Idle_speed table. Idle_set is a slow proportional control parameter that is activated when Throttle < Idle_Throttle option, and constrained not to exceed Idle_set+ and Idle_set– options, when engine speed is not equal to Idle_set speed option. Idle_MOD the user variable may be adjusted to optimise the table. A/C_Idle is a response to an air conditioning request for an elevated idle. >12volt_Idle is the response due to a low battery voltage.

Idle Target =
Idle from Step Table + Idle_mod+Idle_speed+Idle_set+{A/C_Idle}+{>12volt_idle}

>12volt_Idle is added to the current IDLE value when the battery supply voltage is less than 12.5volts.

A/C_Idle is added if the air conditioning request is pulled low.

IDLE SPEED CONTROL

When Throttle is less than Idle_Throttle option the Idle_Set_spd parameter from the Cool_Idle table, is used to derive d_Idle_speed until the Hi_Idle time option has expired the Idle_set is used. The d_Idle_speed is used to access the Idle_Spark table to find Spark_Idle to modify the ignition angle. Meanwhile a slower process is moving the idle motor towards a condition suitable for the target Idle_Set options using the Idle_set parameter constrained by the Idle_set+ and Idle_set– options. There is a Hi_Idle option that will open the idle by–pass valve for the high idle condition, while Hi_Idle_count counts down.

A low value for idle will indicate a closed valve and a high value an open valve. At power on the valve is pushed closed to find it's reference point, then opens to the current idle target position.

OXYGEN FEEDBACK

The oxygen sensor signal when functioning is allowed to modulate the fuel pulse width within the limits of options OX_FB_+ve and OX_FB_-ve. The proportional and integral controller iteration rate and error scaling are set by options OX_FB_Gain and OX_FB_Rate. The error signal OX_error is derived from the oxygen switching history OX_History and the Ox_Error table. The most significant bit is the most recent condition of the oxygen sensor Oxygen_raw, compared with the nominal stoichiometric point option called OX_switch. The four most significant bits are presented to the table and a raw error returned. The raw error is scaled by OX_FB_Gain. The error is then processed by the proportional and integral controller, using the proportional and integral coefficients OX_FB_pro and OX_FB_int respectfully. If the coolant temperature exceeds Coolant_OK then the feedback signal modulates the fuel pulse width. To disable oxygen feedback set rate to zero.

MONITORING AND DISPLAY SYSTEM (IBM PC CONFIGURATION)

To allow the user to monitor the operation of the engine management system and to reprogram the user data, the system interfaces with any IBM PC or compatible computer using GEMSCOM.EXE.
To connect the IBM PC to the ECU a special cable is required. Three wires are required, the lid of the ECU must be removed to access the internal serial connector JP2 :

JP2 is numbered anti-clockwise from the key:		9 way	25 way
1 E.C.U. TX	PC RX	PIN 2	PIN 2
2 E.C.U. GROUND	PC GND	PIN 5	PIN 7
3 E.C.U. RX	PC TX	PIN 3	PIN 3

Note this cable should only be used in a controlled electro-magnetic environment as these signal lines are not filtered. The lid must be refitted for normal operation.

SETTING UP THE IBM PC

Place the GEMS floppy disc in drive A: and copy the contents to a directory and sub-directory on your hard disc. Then type GEMSCOM to run the application. Note the gems directory should be pathed.

The Directory structure should be:

C:/GEMS This contains GEMSCOM.EXE and GEMS.EXE.

With at least one sub-directory:

C:/GEMS/LANCER5
This contains

GEMSCOM.CFG	Configuration file lists files use.
LANCER5.INI	Initialisation list Parameters, Maps, Tables.
LANCER5.KEY	User key files keyboard functions.
????????.HEX	Calibration file.
????????.SCR	Screen file of display parameters.
LANCER5.POT	Optional "pot box" alternative to keyboard.

PARAMETER DISPLAY

Up to 20 parameters may be displayed, use F3 to select parameters, and F2 to save the screen configuration.

USER INPUT FUNCTIONS

There are various functions and modes that can be initiated by the IBM PC, that allow the user to control the operation of the management system and to reprogram the calibration data, the F10 function will show the .Key file functions.

ON LINE ENGINE CONTROL

Ignition advance and fuel mixture can be controlled using the arrow keys. F10 will list the functional keys.

The "up arrow" and "down arrow" keys control the fuel mixture by modifying the volumetric efficiency value using a factor called *Fuel mod*. One press of the up arrow key will increase *Fuel mod* by 0.39% and one press of the down arrow key will decrease *Fuel mod* by 0.39%. If the SHIFT key is pressed at the same time as the up and down arrow keys then *Fuel mod* will be increased or decreased by 3.9%.

The "left arrow" and "right arrow " keys control the ignition timing by modifying the advance using a factor called *Spark mod*. One press of the right arrow key increases *Spark mod* by 0.5° and one press of the left arrow key decreases *Spark mod* by 0.5°.

PROGRAMMING FUNCTIONS.

There are 3 keys that will re-program the calibration data.

THE ‘S’ PROGRAM KEY

The ignition advance curve is reprogrammed using ‘s’. With the engine running at a speed and load site, pressing ‘s’ will program the advance value in *Spark mod* into the curve at that site. *Spark mod* is reset to zero. If the engine speed is not within 100 rpm of a speed site then it will not be reprogrammed and the PC will give an audible warning.

THE ‘F’ PROGRAM KEY

The fuel map can similarly be programmed using the f key, with *Fuel mod* being adjusted.

THE ‘C’ PROGRAM KEY

The *checksum*, which is used to check that the calibration data has not been corrupted, is reprogrammed by pressing c. This will recalculate the checksum using the present calibration data and will program this value into the checksum location. If any changes are made to the calibration then c should be used to correct the checksum.

If changes to Maps, Tables, or Options are made with the ECU powered and connected to the PC, then these changes will alter the ECU. Care must be taken while altering values especially if the engine is running!

If there is no serial communications then the off-line flag is set and only the WORKMAP.HEX is altered.

Cal_Name allows the end user to set up to eight alpha-numeric characters to identify the ECU and or its’ calibration.

MAPS

Fuel map	The base fuel VE is derived from this map. *Load* may be selected from the three possible sources *Throttle*, *MAP*, and *Airflow*.
Ignition map	The base ignition *Spark adv* is derived from this map with the same functionality as the Fuel map.
TPS retard map	The base throttle controlled ignition retard, *TPS retard* is derived from this map, active if *IRTD* is set.
Spark limit map	This is the spark cutting percentage that will be used if *ILMT* is activated.
Waste Gate map	The duty or force applied by the waste gate valve, *WG MSR* is derived from this map.
Fuel limit map	This is the fuel cutting percentage that will be used if *FLMT* is activated.
Boost Target map	This is the anticipated load value to be obtained for the current speed and throttle, and used in the wastegate feedback mechanism.
Inj angle map	This map allows for precise control over the injector opening relative to crank position.
TPS retard N map	The base throttle controlled ignition retard, *TPS retard* is derived from this map, active if *IRTD* is set when the PBW mode Off.
Spark limit N map	This is the spark cutting percentage that will be used if *ILMT* is activated set when the PBW mode Off.
Fuel limit N map	This is the fuel cutting percentage that will be used if *FLMT* is activated set when the PBW mode Off.
Throttle mod map	This produces a throttle related correction of the load based fuel map to compensate for throttle position, if PBW mode ON.
Throttle_mod_N map	This produces a throttle related correction of the load based fuel map to compensate for throttle position, if PBW mode Off.

TABLES

Crank Fuel table	While cranking the base fuel, *VE* is obtained from this throttle related table. Note moved in lancer7!
Speed table	This determines the values for the speed sites used in all maps. For backward compatibility define these to start at 800rpm, and 400rpm steps. ie 800,1200,1600,,,,,,,,7200,7600,8000.
Boost table	This determines the values for the load sites used in some maps and tables. For backward compatibility define these to start at 0, and steps of +10. ie 0,10,20,30,,,,,,100,110,120,130.
TP Angle table	This determines the values for the speed sites used in some maps and tables. For backward compatibility define these to start at 0, and steps of +10. ie 0,10,20,30,,,,,,100,110,120,130.
Air comp table	The amount fuel may be corrected for different air temperatures with this table. The change from standard is +/-50%. Note the minus should be entered after the value.
Battery comp table	The injector dead time correction against battery voltage is derived from this table.
TPS to Load table	If the MAP or Airflow derived Load is out of range then a Load value derived from the current Throttle signal, this will allow a more appropriate Load to be used compared to the default Load of 130.
Warm Up table	This is the normal fuel correction versus engine Coolant temperature with a range of 0% to 200%, where 100% gives no change to the fuel.
Cold Fuel table	This is the cranking fuel correction versus engine Coolant temperature with a range of 0% to 400%, where 100% gives no change to the fuel.
Accel Amount table	This is the amount of additional fuel to be added to the current fuel if *Accel Trip* is exceeded, dependent on Engine Speed.
Decel Amount table	This is the amount of fuel to be subtracted from the current fuel if *Decel Trip* is exceeded, dependent on Engine Speed.
CT Fuel PBW table	When the Throttle is less than *CT TPS* and *Engine Speed* is greater than *CT Speed* then the base fuel is taken from this table, if the anti-lag feature is active.
CT Fuel norm table	When the *Throttle* is less than *CT TPS* and *Engine Speed* is greater than *CT Speed* then the base fuel is taken from this table, if the anti-lag feature is inactive.
Start Extra table	This is the *percentage* extra fuel required to start the engine dependant on coolant temperature.
Start Decay table	This is the time over which the start extra fuel decays to zero, dependant on coolant temperature.
Start Pulse table	This is an additional pulse of fuel added to the first injection to help start the engine dependent on coolant temperature.
Boost Error table	This produces WG MSR err to correct the wastegate drive to

	obtain the load value specified in the Boost target map.

TABLES continued

Idle Cool table	This positions the idle by pass stepper motor dependent on coolant temperature.
Knock Noise table	This is the level of back ground normal noise detected by the knock system in raw units versus engine speed.
Idle Speed table	This is a modifier of the idle step table related to engine speed below 2600rpm.
Idle Spark table	This table will move the ignition advance when the engine is in idle, relative to the difference between desired idle speed and actual engine speed.
Cat Rtd limit table	This table will limit the amount of ignition retard dependant on exhaust temperature, to prevent over heating.
Boost limit table	This table determines the maximum boost with engine speed when the table value is exceeded then the boost_mod value is added into the wastegate drive.
AIT idle table	This table will allow an offset to the idle by pass position dependant on inlet air temperature while in the idle condition.
AIT Spark table	This table will modify the spark advance with inlet air temperature.
OX FB I Const table	This table holds engine speed related values for the oxygen feedback integrator .
OX Error table	This coverts the OX History in to an unscaled oxygen error value.
Cool Idle table	This finds the idle set spd dependent on coolant temperature.
FAF fuel table	The air flow meter may read then an operating area may be defined so that the accel fuel calculation uses this throttle based table for base fuel pulsewidth.
Rev I limit table	Selects a spark rev limiter using Throttle in PBW on mode
Rev I limitN table	Selects a spark rev limiter using Throttle in PBW off mode
Rev F limit table	Selects a fuel rev limiter using Throttle in PBW on mode
Rev F limitN table	Selects a fuel rev limiter using Throttle in PBW off mode
Lambda table	Is used to convert the parameter oxygen raw to Lambda, for display.

OPTIONS

Light Time	This is the time that the check engine lamp will flash on for while PBW mode changes
WG max time	This is the permissible over boost time.
WG max Force	This is how fast the wastegate drive is modified, after the WG max time.
WG max Back	This is how fast the wastegate drive is restored when boost is below boost limit.
WG max Limit	This is the maximum change in waste gate drive permitted.
PBW Idle	This is an offset added to the current Idle target if IDLO PBW ON is on, note range is ±255.
Flow max	Scales Flow sum c in to 0-130 for Airflow and Load if Airflow = On.
Road Speed M	This scales VSSRAW in to the Road Speed parameter.
AIT Cut rpm	If the PBW air limit is exceeded then this fuel based speed limiter is activated.
AIT Fcut rate	This is the amount of fuel cut employed to limit the engine speed when the AIT Fcut speed is exceeded.
AIT Fcut TPS	This is the value of Throttle that if exceeded then the AIT Fcut is disabled.
Ign cut	This is the depth of ignition cutting used to limit engine speed when the Ignition limit speed is exceeded.
Ign cut+	This is addition cutting above the ignition speed limiter trip point.
Fuel cut	This is the depth of fuel cutting used to limit engine speed when the fuel limit cut speed is exceeded.
Fuel cut+	This is addition cutting above the fuel speed limiter trip point.
Knock rate	This is the restoring rate in engine revolutions to return the fuel and spark back to nominal conditions after knock has been detected and quenched.
Knock Rtd	This determines the amount of ignition retard applied when knock is detected.
Knock inc	When Knock is quenched the ignition will be advanced back to standard at this rate.
Knock rich	This is the amount of extra fuel added related to knock energy to quench the knocking condition.
Knock dec	This is the rate that normal fuel will be restored after knock is quenched.
Knk Rtd Max	The maximum permissible ignition retard due to knock.
Knk Fuel Max	The maximum permissible additional fuel due to knock.
Engine ok	This is the minimum engine speed at which oxygen feedback may be applied to engine fuelling, or DFCO deceleration fuel cut-off.
Min AFUEL	If the acceleration fuel exceeds this value the oxygen feedback is temporarily frozen.
DFCO Load	If the engine load is less than this value DFCO (deceleration fuel cut off may be active.
DFCO speed	This is the minimum engine speed at which DFCO may be applied.

OX FB +ve	This is the maximum amount of additional fuel the oxygen feedback system may apply.
OX FB –ve	This is the minimum amount of subtactional fuel the oxygen feedback system may apply.
OX switch	Is the set point for the oxygen feedback system in raw units of Ox raw
OX FB Gain	Scales the values from the oxygen error table, and is a two exponential divider.
OX FB Rate	This is the rate at which the feedback integrator is run, typical value is 100mS, 0 will disable the feedback system.
OX FB P	This is the proportional constant employed by the feedback integrator, typically 10.
OX Step	If the oxygen sensor has read lean for three consecutive samples a rich step amount of additional fuel may applied.
OX Load	This is the maximum throttle value at which the feedback system is active.
OX Speed	This is the maximum engine speed at which the oxygen feedback system is still active.
12 Volt idle	If the battery supply voltage is less than 12 volts the idle motor may be adjusted to increase engine speed and increase the alternator output.
A/C idle	If the air conditioning is active then this offset may be applied to the by–pass valve to maintain engine speed.
Idle rate	This is the rate of adjustment of the stepper motor used to control the idle by–pass valve.
Idle throttle	This is the minimum throttle value to initiate the idle condition.
Idle set+	The maximum positive movement of the idle by–pass valve allowed to stabilise the idle.
Idle set–	The maximum negative movement of the idle by–pass valve allowed to stabilise the idle.
Hi Idle Add	This is additional engine speed for the high idle condition.
Hi Idle time	This is how long the high idle condition is allowed to persist.
Hi Idle Set	This is the offset applied to the by–pass valve while Hi Idle is active.
Max Idle	This is the maximum engine speed for the idle condition.
TP filter	This is the amount of filtering applied to the throttle for the acceleration fuel feature.
Accel M	This is the proportional modifier of dThrottle to make dZThrottle.
Accel C	This is the constant modifier of dThrottle to make dZThrottle.
Accel limit	This is the limit for accel fuel related to current fuelling.
LD0MPC	This is part of the fuel map optimisation system, if inactive should be 255.
F Pump speed	The high volume condition is active above this engine speed.
F Pump TPS	When throttle exceeds this value the high volume rate fuel pump is active.
IGN Offset	This is an overall ignition advance/retard option with the range +/-64°.

Fuel Offset	This is an overall fuel amount modifier with the range +/-50%.
Fuel Sync	Is the fuel synchronisation control and determines the injector firing relative to a synchronising point in the 720° engine cycle range 0 to 7.
TPS min/max	Are used to scale the TPS raw signal to the 0 to 130 range of Throttle.
MicroSec/Bit	Is the major scaling factor for converting VE in the Fuel map to the injector Fuel Pulse.
Accel Trig	The minimum positive increase in throttle to provoke additional acceleration fuel.
Accel Decay	The acceleration must eventually die away, this option controls the rate at which this is achieved.
Decel Trig	The compliment to Accel Trip for deceleration fuel.
Decel Decay	As above for Accel Decay.
FLMTPBW ON	Enables the Fuel Limiter when PBW active.
ILMT PBW ON	Enables the Ignition Limiter when PBW active.
IRTD PBW ON	Enables the ignition retard when PBW active.
IDLO PBW ON	Enables the Idle motor to open when PBW is active
EGRO PBW ON	Enables the EGR valve to open when PBW is active
IG F PBW ON	If cylinder is fuelled always ignite.
FLMTPBW OFF	Enables the Fuel Limiter when PBW inactive.
ILMT PBW OFF	Enables the Ignition Limiter when PBW inactive.
IRTD PBW OFF	Enables the ignition retard when PBW inactive.
IDLO PBW OFF	Opens the Idle motor to open when PBW is inactive.
EGROPBW FF	Enables the EGR valve to open when PBW is inactive.
IG F PBW OFF	If cylinder is fuelled always ignite.
Air Rtd Strt	This is the minimum air temperature at which the Air Retard will have effect.
Air Rtd Rate	This is how much Air Retard will be made for each degree Celsius above the Air Rtd strt temperature.
Spray Air	This is the minimum Air temperature at which the intercooler water spray is activated. Was named spray start V1.16
Spray Cool	This is the minimum coolant temperature at which the radiator water spray is activated. Note this is new to V1.17 and useful in very hot climates.
Spray A on	Is the on time in seconds for the intercooler water spray.
Spray A off	Is the off time in seconds for the intercooler water spray.
Spray C on	Is the on time in seconds for the radiator water spray.
Spray C off	Is the off time in seconds for the radiator water spray. Is the off time in seconds for the radiator water spray.
Spray A Load	This is the minimum Load at which the intercooler water spray becomes active.
Spray C Load	The minimum Load for the radiator water spray to become active.
Fan #1 start Fan Fast	This is the minimum coolant temperature to turn on the 1st radiator fan. Or for two speed fan should be higher than Fan Slow.
AF Scalar	Scales the raw airflow signal to a load signal. Typically 208 will give

	maximum range, valid range 0 to 255. When Alt AF Cal option bit is set on then a different scaling is used.
Pickup comp	This is used to correct for systematic delays in the sensors and ignition coils used with the ECU.
Delay Angle	This is used to determine the nominal ignition reference point by adding an angular delay to the timing signal.
Coil Factor	This adjusts the charging time for the coils used with the system. Typical value for ford Zetec coil pack is 24.
AF high	If flow sum c exceeds this value then the Load will be taken from the TPS to Load table.
AF REV	Determines over how many engine cycles are used to average the flow pulses, if New AF Cal is off then use 6. Valid numbers are 1 to 7.
AF low	If flow sum c is less than this value then the Load will be taken from the TPS to Load table.
WG feedback	When on WG_MSR_err is active.
MASS AF	This will apply any barometric and inlet air temperature correction to the velocity reading from the inlet airflow meter to produce a mass airflow load to access the relevant maps and disable any output correction in the fuel calculation.
BAR	This will activate the air pressure correction factor calculation, to be used if the pressure sensor is measuring ambient air pressure.
MAP	The Load parameter will be derived from a pressure sensor sampling the engine inlet pressure, else Load will come from the airflow sensor or Throttle, Air Pres F will be 0%.
AFLW	The Load parameter will be derived from the airflow sensor, or else Load will come from MAP or Throttle.
Alt Accel	Uses a filtered throttle signal to trigger a fuel enrichment, and Accel Trip is typically 25 rather than 5 for the unfiltered trigger.
Auto EE	will reprogram the EEROM rather than just writing to the volatile memory, "c" must still be used to update the checksum. This mode of programming may be more prone to producing slight miss fires. Note this will slow down file writes to the ECU.
TPS ALS SWT	When set to ON then if the accelerator pedal is depressed at key on the anti lag system will be enabled.
PBW Air	This is the minimum air temperature to activate PBW so that the ON settings for ILMT,FLMT,IRTD are used.
PBW ON speed	When ALS is active this engine speed must be exceeded for PBW to operate.
PBW OFFspeed	When ALS is active this engine speed must be below for PBW to deactivate.
PBW OFF GO	When TPS ALS is ON then the PBW OFF settings will become active when this speed is exceeded.
Idle speed	This is the maximum Engine Speed for the Idle Advance table to still to be active.

max Idle TPS	This is the maximum Throttle for the Idle advance table still to be

	active.
MAP min	This is the value of the MAP raw signal to give the Load value of 0 when MAP is used to generate Load, below this value the TPS to Load table is used.
MAP max	This is the value of the MAP raw signal at full load for a MAP derived load, if this value is exceeded the TPS to Load table will be used. A typical value is 0 to 3 for a 3Bar system. 5 to 10 for a 1 bar system.
MPRESS	This scales the pressure signal for use as a barometric correction signal. Range 0 to 32,000.
KPRESS	This scales the pressure signal for use as a barometric correction signal. Range +/-32,767. Air Pressure (kPa) = (MAP_raw * MPRESS) + KPRESS
CT Speed	This is the minimum speed to activate the closed Throttle fuel table.
CT TPS	This is the maximum Throttle value to activate the closed throttle fuel table.
WG period	Is the cycle time for the pulse width modulated drive of the waste gate, typical value 150µSec, min value 26µSec.
Cool Rtd Strt	This is the minimum coolant temperature at which the Cool Retard will have effect.
Cool Rtd Rate	This is how much Cool Retard will be made for each degree Celsius above the Cool Rtd strt temperature.
Fan #2 start Fan Slow	This is the minimum coolant temperature to turn on the 2nd radiator fan. Or for two speed fan should be lower than Fan Fast.
Air Temp min	The minimum valid air temperature.
Air Temp max	The maximum value air temperature.
Air Default	The value of air temperature to use when the previous limits are exceeded.
Coolant min	The minimum valid coolant temperature.
Coolant max	The maximum value coolant temperature.
Cool Default	The value of coolant temperature to use when the previous limits are exceeded.
AFLW switch	Signals to the airflow meter that high flows are expected, normal value 37 for Lancer EVO4, and 20 for Lancer EVO5&6.
REV light#1	This is the minimum engine speed to illuminate the 1st engine warning light.
REV light#2	This is the minimum engine speed to illuminate the 2nd engine warning light.
ALS on time	When in TPS_ALS mode this is the time in seconds that engine speed must be below PBW_OFFspeed for the ALS to be turned off.
ALS off time	When in TPS_ALS mode this is the time in seconds that engine speed must be between 400 and 800 rpm for the ALS to be activated again when PBW_ON_speed speed is exceeded.
NO ALS arm	If set ON, then the ALS will not require engine speed to be held at 700rpm to become active in TPS ALS mode.
WG invert	This will swaps the MSR mark space ratio for the wastegate drive. So what was open becomes close.

Idle P save	If on the idle stepper motor is unpowered, when not required to move to reduce heating.
2×TPS Retard	Doubles the range of the TPS retard tables.
Alt Not Lan	Launch dissabled Alt Spark and Alt Fuel options active instead.
NO ALS if TPS	This will disable all Anti Lag features if TPS ALS is set to on but not triggered at ignition on.
Idle R/S stop	If on the idle motor will periodically reset if engine stopped.
IGN#? Mod	Are the individual ignition angle modifiers, there range should be kept to a few degrees.
FUEL#? Mod	Are the individual fuel trims.
CAT temp M	Are used to calculate CAT_Temp the exhaust gas temperature.
CAT temp C	Cat_temp = (CAT_raw × 256)/Cat_temp_M+Cat_temp_C
FAF TPS	Used to define the FAF area, useful for airflow meter calibrations.
FAF Speed	Used to define the FAF area, useful for airflow meter calibrations.
Alt Spark	If Alt Not Launch then this option modifies ignition.
Alt Fuel	If Alt Not Launch then this option modifies fuelling.
Launch Off	The Road Speed at which Launch feature is disabled.
SwtRtd Rtd	This is the rate of retarding when the torque reduction activates.
SwtRtd Max	This is the maximum torque reduction retard.
SwtRtd Adv	This is the rate of advancing when the torque reduction completes.
SwtRtd Time	This is the maximum allowable time for the torque reduction. If zero then the radiator spray is enabled.

DISPLAY PARAMETERS

Accel Fuel	Is the amount of accel/decel fuel currently used, note this has the range +/-65,500 µSec.
Accel rtd	The dThrottle triggered ignition retard.
Accel Trig	This counts the number of accel/decel events.
ADV (mod)	Is the base ignition after being summed with Spark mod.
ADV Knock	The effect of knock retard on spark advance.
Airflow	Is the currently calculated value of Load using airflow.
Air Pressure	Is the scaled value for air pressure in kPa.
Air Prsr F	Is the fuel correction due to air pressure, see BAR switch option.
Air Retard	Is the amount ignition retard produced due to air temperature, see Cool Rtd strt and Cool Rtd rate options.
Air Temp	Is current air temperature.
Air Temp F	Is the output of the Air comp table.
ALS On/off	Is the time in seconds for the ALS enable and disable options ALS on time and ALS off time.
Bat Comp F	Is the output of the Battery Comp table.
Battery	Is the supply voltage to the ECU if this is significantly different to the battery voltage while running check for poor wiring or bad battery.
Boost limit	This is the value of Boost limit obtained from the boost limit table.
CAT temp	This is the scaled conversion of CAT raw.
Cat Rtd Limit	The maximum permissible spark retard due to CAT temp.
Charge Time	Is the time that the coils are filled with current.
Coolant	Is the current coolant temperature.
Cool Temp F	Is the fuel correction due to the Warm Up or Start Fuel tables.
Cool Retard	Is the amount ignition retard produced due to air temperature, see Cool Rtd strt and Cool Rtd rate options.
CYCCNT	Is the cycle counter used in the airflow measurement
+dThrottle	The current positive change in throttle.
–dThrottle	The current negative change in throttle.
+dZThrottle	The latest positive scaled change in throttle.
–dZThrottle	The latest negative scaled change in throttle.
Max +AFuel	The maximum amount of acceleration fuel that may be applied.
Max –AFuel	The maximum amount of deceleration fuel that may be applied.
Dwell	Is the time between coil charging.

DISPLAY PARAMETERS continued

ERROR	Is a binary encoded byte that carries fault information, if all bits are zero there are no errors, a one indicates a fault, the most significant bit (bit7) is the left most and the least significant bit (bit0) is rightmost.
Bit7	Checksum not correct, press c to recalculate and set value.
Bit6	Airflow over-speed has occurred, TPS to Load table active.
Bit5	Crank timing fault, not functional.
Bit4	Sync timing fault, not functional.
Bit3	Coolant sensor fault.
Bit2	Air sensor fault.
Bit1	MAP pressure sensor fault.
Bit0	TPS throttle sensor fault.
Gear Ratio	The division of VSS raw by Engine Speed.
Hi Idle count	Time in the high idle condition.
Flow per rev	Is the number of complete airflow meter pulses.
Flow Sum raw	Is fractional number of airflow meter pulses.
Flow Sum c	Is mass flow corrected number of airflow meter pulses.
Fuel Limit	Is the output of the Fuel Limit map used if FLMT PBW is active.
Fuel Lmt (m)	Shows the effect of Fuel Limit after Fuel Lmt mod applied.
SwtRtd Rtd	The current amount of torque reduction retard.
SwtRtd Time	The current torque reduction time out timer.

DISPLAY PARAMETERS continued

Fuel Lmt mod	The key adjustable modifier of the fuel cutter, FLMT PBW function.
Fuel mod	The key adjustable modifier of the Fuel map value.
Fuel (mod)	The base fuel pulse corrected by Fuel_mod.
Fuel Air	The fuel pulse corrected by air inlet temperature factor.
Fuel Warm-up	The fuel pulse corrected by Cool tmp F or Cold tmp F.
Fuel Baro	The fuel pulse corrected by Air prsr F.
Fuel Crank	The fuel pulse corrected by Start fuel.
Fuel Knock	The fuel pulse corrected by knock fuel.
Fuel OX FB	The fuel pulse corrected by oxygen feedback.
Fuel Pulse	This is the amount fuel calculated for the current conditions with no Accel Fuel or Bat comp F but including TPS Fuel mod.
Fuel Pulse#?	These are the individual amounts of fuel calculated for each injector.
Injector#?	These are the total on times for each injector.
IDLE or Idle target	Shows the activity on the idle stepper motor. 0 is fully closed 255 fully open.
d Idle Speed	The speed error from the desired idle speed.
Idle Mod	The user modification of idle position.
Idle Set	The idle modification due to d Idle speed.
Ign limit	Is the output of the Spark Limit map, used if ILMT PBW is active.
Ign lmt (m)	Is the ignition cut after Ign lmt mod has taken effect.
Ign Lmt mod	Is the key adjustable modifier of the ignition cutter, ILMT PBW function.
LMTSTAT	Is the current status of the fuel and ignition limiters. From left to right: Injectors limiters cylinders 4 to 1, bits 3 and 2 are not used, bit1 cylinders 2&3 ignition cutting, bit0 cylinders 1&4 ignition cutting.
Knock Raw	Is the raw unscaled Knock microphone signal.
Knock Raw Pk	Is the highest recorded Knock Raw, reset by “K” see .Key file.
Knock	The scaled knock signal above knock noise.
Knock rtd	The amount of spark retard form knock detection.
Knock Fuel	The additional fuel from the knock detector.
Lambda	Is the scaled exhaust gas oxygen signal 100= Stoichimetric fuelling, this will need further refinement but is a useful logging parameter.
LOAD	Is the parameter used to access the Fuel, Spark and Waste Gate maps. See MAP AFLW switch options.
MAP AS LOAD	Is the current MAP derived signal scaled for Load.
MAP raw	Is the unscaled pressure signal used for MAP and barometric compensation, see MAP min and MAP max options.

DISPLAY PARAMETERS continued

Oxygen raw	Is the unscaled oxygen signal 0 to 255 = 0 to 5 volts.
Ox History	Is the bit–wise rich/lean condition of the exhaust.
Ox Error	Is the scaled output from the OX Error table.
Ox No Toggle	The number of integrator loops without a rich/lean change.
OX F.B.	The change in fuelling due to the oxygen feedback control.
P time	Debugging Aid.
PBW MODE	The eight bits are shown B7 to B0. These bits are determined by the action of the PBW switch and PBW start options. When active the bit will show 1, zero is inactive.
Bit7	Key on TPS triggered ALS mode.
Bit6	SALS
Bit5	IGFUEL If cylinder is fuelled always ignite.
Bit4	EGRO exhaust gas recirculate.
Bit3	IDLO idle control. Move Idle motor to PBW Idle position.
Bit2	IRTD ignition retard.
Bit1	ILMT ignition cutter.
Bit0	FLMT fuel cutter.
Retard mod	Is the Key adjustable modifier for the IRTD ignition retard PBW function.
Reset Count	A debugging aid indicating extraneous ECU resets.
Spark adv	Is the output of the Ignition map.
Spark mod	Is the key adjustable modifier of the ignition map value.
Spark#?	Are the individually adjusted spark advances for each cylinder.
Spark Idle	The ignition modification due to d Idle speed.
Throttle	Is the scaled value of throttle position.
TPS raw	Is the unscaled value of throttle position.
TPS retard	Is the output of the TPS retard map, used if IRTD PBW is active.
TPS rtd (m)	Is the TPS retard after Retard mod has taken effect.
TPS fuel mod	The effect of the TPS fuel mod map on engine fuelling.
VE (comp)	Is the VE (mod) fuel calculation after compensation by coolant and air temperature and optionally air pressure have been included.
VE (mod)	Is the VE value from the Fuel map adjusted by Fuel mod.
Vol. eff.	VE or volumetric efficiency out of the Fuel map.
Waste mod	Is the user key adjustable modifier for the waste gate control.
WG MSR	Is the output of the Waste Gate map.
WG MSR (m)	Is the waste gate drive after modification by Waste mod.
WG MSR err	Is the waste gate drive after modification from the Boost error table.
Idle set speed	This is the set speed for the idle feedback using Idle set ± and the idle spark.

LAUNCH CONTROL

If the alternator status line pin B3 is pulled low then the launch control is active and the 8000 rpm speed line is used irrespective of actual engine speed. This is a temporary feature. If it works fine then seven separate load and TPS related tables will be provided.

ROAD EVO3/PROTON

This version supports air-conditioning: Pin B15 is A/C request, Pin A22 is A/C out, Launch switch is now NOT ACTIVE, Water spray is now on Pin B2. When A/C request is pulled low and Engine_speed is greater than 800 rpm and throttle is less than the A/C_Fload value then the A/C out will be pulled low. The value of A/C_jack is used to open the idle motor enough to provide sufficient power for the A/C compressor.

LOGGING DATA STREAM

1		HEADER	$55
2	Engine Speed	ERPM	50 rpm/bit
3	LOAD	LOAD	0–208
4	Throttle	TPSVAR	0–208
5	Air Temp	ATEMP	signed degree/bit
6	Coolant	CTEMP	signed degree/bit
7	Battery	BATT1	0 to16 Volt
8	Vehicle speed	VSS	km/Hr/bit
9	Oxygen raw	OXAD	0 to 1.66 Volt
10	Knock raw	KNKRAW	0 to 5 Volt
11	Error	ERROR	bit encoded
12		check sum	

Data transmitted every 4.1mS at 9600Baud 2 stop bits no valid parity.

GT4PBW
This is a version of the GEMS anti-lag software running in a Toyota Celica. The differences are associated with the timing pattern, 24 teeth in the engine cycle. Teeth are numbered 0 to 23 starting after the G2 synchronising pulse. The normal ignition sync value is 8. The fuel sync allows for optimisation of the synchronous fuel injection.
Bench testing suggests idle period should be set to 10mS. The idle duty cycles should be chosen to suit the depth of anti-lag action. All other features are active.

The Knock input is used as ALS switch.

The fuel pump is a two-speed type with a series resistor to reduce current when in the idle condition see max_idle_TPS and Idle_speed.

GT4PBW2 V2.17
Water injection features: controlled by PBW mode: WINJ. The injector will pulse twice per revolution.

Water_Pulse=
{Water_(map)×Water_μS/bit}×(1+Water_mod)×(1+Water_AIT)+{W_Bat_Comp_F}

If {Water_(map)×Water_μS/bit}×(1+Water_mod)×(1+Water_AIT) is greater than the option Min_W_inject, else no water is injected to conserve resources.

W_Bat_Comp_F = value from Battery_Comp table × W_Bat_Comp_K option

Water_mod is the user modifier see F10 for .key file control, this is loaded from the Water_Offset option at power on.
Water_AIT is modifier based on inlet air temperature obtained from the Water_comp table.

AIT_ADV is a new derived parameter to allow finer control than the Air_Retard with ignition advance, obtained Air_comp_Ign table.

Since both the fuel and water injectors use the same Battery voltage compensation table a new option has been created F_Bat_Comp_K to scale Battery_Comp table this should be set to 10μS.

Note the opportunity was taken to remove the ambiguity with TPS_retard being applied twice when it exceeds both Air and Coolant retard.

PINOUT LANCER EVO 4/5/6

The water spray control can be wired to the ECU using Pin A22 to activate a relay to turn the water pump on and off. For best results please note that a 1mm diameter is placed in the rubber pipe between compressor housing and the Tee piece. The boost dump valve should be turned around to get best boost; this is because some valves do leak. Drill out and add extra holes in Exhaust gas recirculation banjo bolts

```
|A01|~|A13|   |B01|~|B08|   |C01|~|C06|   |D01|~|D11|
|A14|~|A26|   |B09|~|B16|   |C07|~|C12|   |D12|~|D22|
   (B-59)          (B-60)          (B-61)          (B-62)
```

Lancer numbering
Cable entry view.

B-59

A01	1	YEL/BLU	INJECTOR 1
A02	2	BLUE/GRN	INJECTOR 3
A03	3	WHT/BLK	FUEL PRESSURE VSV
A04	4	BLU/LGRN	IDLE MOTOR
A05	5	WHT	IDLE MOTOR
A06	6	BRN	EGR VALVE
A07	7		NC
A08	8	BLK/BLU	MAIN FUEL PUMP
A09	9		NC
A10	10	BLK/LGRN	CYLINDER 1&4 COILS
A11	11	BRN/WHT	WASTE GATE
A12	12	RED/ORN	12V FROM MAIN RELAY
A13	13	BLK	EARTH CHASSIS
A14	14	YEL/BLK	INJECTOR 2
A15	15	LGRN/WHT	INJECTOR 4
A16	16		NC
A17	17	YEL	IDLE MOTOR
A18	18	GRN	IDLE MOTOR
A19	19	BLU	AIR METER SWITCH
A20	20	BLU	RADIATOR FAN (HI) CONTROL
A21	21	BLU	RADIATOR FAN (LO) CONTROL
A22	22	GRN/WHT	A/C RELAY O/P * WATER SPRAY CONTROL*{fuelp}
A23	23	BLK/GRN	CYLINDERS 2&3 COILS
A24	24		NC
A25	25	RED/ORN	12V FROM MAIN RELAY
A26	26	BLK	EARTH CHASSIS Timing return

B-60

B01	31		NC
B02	32		* **RADIATOR SPRAY** *
B03	33	BLU/WHT	ALTERNATOR LOAD ((o/p)) *__LAUNCH CONTROL SWITCH__ *
B04	34		NC
B05	35		NC
B06	36	LGRN/WHT	ENGINE CHECK LIGHT *__REV LIGHT__*
B07	37	YEL/BLK	PWR STEERING PRESSURE SWITCH *__GEAR CUT__*
B08	38	RED	MAIN ENGINE CONTROL RELAY
B09	39	BLU	FUEL PUMP SPEED CONTROL
B10	40	BLU/WHT	CHECK CAT LIGHT *__REV LIGHT__ * (NOT LANCER7)
B11	41	WHT	Charging system input
B12	42		NC
B13	43		NC
B14	44		NC
B15	45	NGRN/BLK	A/C RELAY NUMBER 2 I/P (ACRQIN) *__ACON OFF__*
B16	46		NC

B-61

C01	51		Transmit TO PC OR MONITOR (RED)
C02	52		Receive FROM PC (BLUE)
C03	53		NC Serial Ground
C04	54		NC
C05	55		NC
C06	56	LGRN	DIAG CON.
C07	57		NC
C08	58		I/P TACHO
C09	59		NC
C10	60		NC **Oxygen heater return**
C11	61		NC
C12	62	ORNG	DIAG CON.

B-62

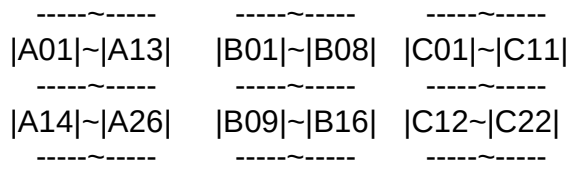
D01	71	BLK/LGRN	CRANKING 12V activates relay on B08
D02	72	RD/BLU	AIR TEMP
D03	73		NC
D04	74	PK	CAT TEMP
D05	75		NC
D06	76	WHT	OXYGEN
D07	77	WHT/BLU	CAT TEMP TPS/CLT/AIR METER SENSOR 0V
D08	78	WHT	KNOCK
D09	79		NC (diagnostic connector)
D10	80	RD/BLK	12V PERMENANT
D11	81	GRN/BLU	TPS/AIR METER 5 volts
D12	82	BLK/WHT	12V FROM IGNITION SWITCH (IG1)
D13	83	YL/GRN	COOLANT TEMP
D14	84	GRN/WHT	TPS
D15	85	YL/WHT	AIR METER BAROMETRIC SENSOR
D16	86	YL	SPEEDO * **ALS SWITCH ACTIVE LOW** *
D17	87	YL/RD	TPS IDLE SWITCH *__ALS SWITCH LANCER7__*
D18	88	BLU/RD	CAM SIGNAL
D19	89	BRN/GRN	CRANK SIGNAL
D20	90	WHT/RD	AIR METER FREQUENCY SIGNAL
D21	91	BLK	ANALOGUE 0V
D22	92	BLK	EARTH CHASSIS

AIR METER CONNECTIONS VIEWED FROM CABLE ENTRY

01	GN/BL	5V
02	YL/WH	BAROMETRIC SENSOR *__MAP SENSOR SIGNAL__*
03	WH/RD	AIRFLOW FREQUENCY
04	RD/OR	12V
05	BLK	0V *__BLACK WIRE TO AIR TEMP SENSOR SPLICED HERE__*
06	RD/BL	AIR TEMP *__GREY WIRE CUT AND SPLICED TO THIS WIRE__*
07	BLU	CONTROL SWITCH

PINOUT LANCER EVO 1/2/3 AND PROTON
The layout of the connectors is viewed from the wire side looking in at the ECU. The largest plug has been named "A". Moving from left to right we then have “B” and “C”.

The water spray control can be wired to the ECU using Pin A22 to activate a relay to turn the water pump on and off. For best results please note that a 1mm diameter is placed in the rubber pipe between compressor housing and the Tee piece. The Dump valve should be turned around to get best boost because some valves leak. Drill out and add extra holes in exhaust gas recirculation banjo bolts.



CONNECTOR A		
Pin number	GEMS number	Description
01	A01	INJECTOR 1
02	A02	INJECTOR 3
03	A03	RADIATOR FAN
04	A04	IDLE VALVE BLUE
05	A05	IDLE VALVE WHT
06	A06	EXHAUST GAS RECIRCULATION
07	A07	NC
08	A08	FUEL PUMP
09	A09	****AIRCON/OFF TPS**** PURGE VALVE
10	A10	IGNITION SIGNAL TO AMPLIFIER A
11	A11	NC
12	A12	12 VOLTS FROM MAIN RELAY
13	A13	POWER GROUND + TIMING GROUND
14	A14	INJECTOR 2
15	A15	INJECTOR 4
16	A16	RADIATOR FAN
17	A17	IDLE VALVE
18	A18	IDLE VALVE
19	A19	AIRMETER DRIVE
20	A20	NC
21	A21	NC
22	A22	AIR CON. OUTPUT ******WATER SPRAY*******
23	A23	IGNITION SIGNAL TO AMPLIFIER B
24	A24	BLK/BLU NC. TO 22 WAY CONNECTOR
25	A25	12 VOLT POWER
26	A26	POWER GROUND + TIMING GROUND

CONNECTOR B		
Pin number	GEMS number	Description
31	B01	TACHO ***** DISCONNECTED ******
32	B02	***** WATER RADIATOR SPRAY *****
33	B03	FUEL PR VSV
34	B04	OCTANE ADJUST
35	B05	OXYGEN HEATER OPEN COLLECTOR FRONT
36	B06	**** REV LIGHT****** CHECK LIGHT
37	B07	POWER STEERING INPUT
38	B08	MAIN RELAY ACTIVATED BY C12
39	B09	NC
40	B10	BOOST CONTROL OUTPUT
41	B11	***** REV LIGHT ******
42	B12	Test con. TX
43	B13	Test con. RX
44	B14	NC
45	B15	AIR CON.INPUT ***LAUNCH CONTROL INPUT***
46	B16	NC

CONNECTOR C		
Pin number	GEMS number	Description
51	C01	STARTER MOTOR SWITCH
52	C02	AIRMETER (AIR TEMP SIG)
53	C03	NC
54	C04	NC
55	C05	OXYGEN SENSOR REAR
56	C06	OXYGEN SENSOR FRONT
57	C07	GROUND TEMP SENSOR
58	C08	KNOCK SENSOR (SIG)
59	C09	NC
60	C10	12V PWR BATTERY BACKUP
61	C11	AIRMETER,TPS GRN/RED (5V)
62	C12	MAIN RELAY,12 VOLTS START KEY
63	C13	WATER TEMP SENSOR (SIG)
64	C14	THROTTLE SENSOR(SIG)
65	C15	AIRMETER PINK (BAROMETRIC SIG)
66	C16	CAR SPEED SENSOR ******ALS SWITCH*******
67	C17	THROTTLE SENSOR (SWITCH)
68	C18	TIMING SIG WHT (TDC SIG)
69	C19	TIMING SIG BLK (CRANK)
70	C20	AIRMETER WHT/BLK (SIG)
71	C21	INPUT TRANSMISSION TYPE DETECT
72	C22	BLK ANALOG 0V

LANCER6W

This is a special version of LANCER6 2.22 with water injection using the now defunct CAT warning light pin B10 the driver transistor Q27 will require up-rating to RFD12N06RLE or equivalent. When the Water Inject option is set on the Launch feature is inactive and the alternator load input B03 is used to activate water injection.
The water injector is pulsed one per engine revolution, and the fuel pulse is modified by the Water Fuel option and the ignition modified by the Water Spark option.

The water pulse duration = (value from Water Inj map × Water MSPB) + Bat Comp F

LANCER6 in EM20

Appendix A PIN OUT The 36 way AMP connector junior timer type, external view.

GEMS numbering: ROW A 1 2 3 4 5 6 7 8 9 10 11 12 Latch at top
B 1 2 3 4 5 6 7 8 9 10 11 12
C 1 2 3 4 5 6 7 8 9 10 11 12

1A	1st ignition coil drive ROVERK-D.
2A	Injector 3 drive (INJC).
3A	Stepper motor Idle#4 drive (IDLE4).
4A	Main power (INJPWR) now not used.
5A	Power ground (RTN).
6A	Analogue ground (0V).
7A	Crank timing input (T1).
8A	Timing ground (GND).
9A	Coolant temperature sensor input (CTEMP).
10A	Engine bay temperature sensor (AUX).
11A	Cam timing input (T2).
12A	Waste–gate drive (IGN2)
1B	Injector 1 drive (INJA).
2B	Injector 2 drive (INJB).
3B	Idle stepper motor drive 3 (IDLE3).
4B	Water spray or error/rev light (CANPRG).
5B	Fuel pump relay drive (FPUMP).
6B	MAP sensor input (A/C OUT).
7B	Oxygen sensor ground (OXGND).
8B	PBW switch active low anti–lag or Nox switch (T3).
9B	Inlet air temperature sensor (ATEMP).
10B	Knock sensor input (KNOCK).
11B	Serial data to ECU (RX).
12B	2nd ignition coil drive.
1C	12 volt sensor power (HALPWR).
2C	Idle stepper motor drive 2 (IDLE2).
3C	Idle stepper motor drive 1 (IDLE1).
4C	Injector 4 drive (INJD).
5C	Serial data from ECU(TX) and logging serial data stream.
6C	Radiator fan relay drive (FAN).
7C	Exhaust oxygen sensor (OX).
8C	Throttle position sensor signal (TPS).
9C	5 volt sensor power (TPSPWR).
10C	Air flow–meter sensor input (T4).
11C	Permanent 12 volt power (PERM) now main power .
12C	Air flow–meter sensitivity control output or Nox control relay (TACHO)

This is Lancer 6 control squeezed into an EM20 ECU, many secondary features are no longer supported:
Twin speed fuel pump.
Exhaust gas re–circulation valve.
2nd fan relay control.
Tachometer this may be taken directly from the crank timing sensor via a 2K2 resistor.
Rev lights are now available on TX if Error light is set on.
Exhaust gas temperature, this could be read through AUX if requested.

NOx support added G2.20

The NOx relay activates and enables the Alt_Fuel and Alt_Spark options if:

Pin B8 switched to ground (0v)
Throttle > Alt_TPS_On
Alt_Speed_ON < Engine_Speed < Alt_Speed_OFF
Alt_Load_ON < Load < Alt_Load_OFF

The system deactivates if:

Pin B8 left floating (5v)
Throttle < Alt_TPS_OFF
Alt_Speed_ON > Engine_Speed > Alt_Speed_OFF
Alt_Load_ON > Load > Alt_Load_OFF

Note Alt_TPS_On must be greater than Alt_TPS_Off

G0.23
Error light if ON then the spray feature becomes a rev light when engine speed exceeds Rev light # speed the driver will turn on, active low.