GEMS

SUBARU2002 PLUG N PLAY ECU

VERSION : S2.63

SYSTEM OPERATION

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.
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 Subaruk2 S2.46 onwards are only available with user security using dongled GWv3.exe and *.GIN installations.

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. Also analogue output for driving centre diff control potentiometer.

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 ***)****x*TPS_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	Always	× microsec/bit	Fuel (map)
Fuel (map)	Always	Load Fact	Fuel Ld F
Fuel Ld F	Always	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 Mod3	Fuel Pulse#3
Fuel Pulse#3		+ Bat Comp F	Injector #3
Fuel Pulse		Fuel Mod4	Fuel Pulse#4
Fuel Pulse#4		+ Bat Comp F	Injector #4

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***.

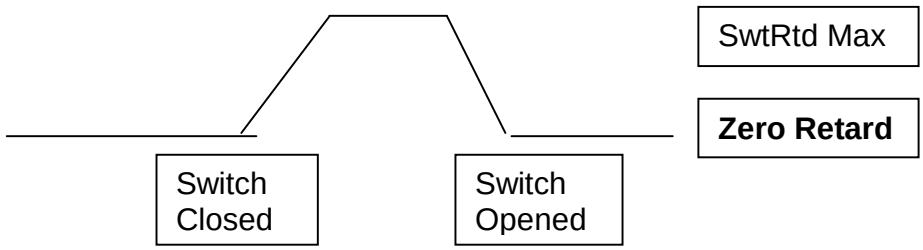
If PBW is enabled then *Air Retard* is set by a 3 dimensional look up table addressed by Throttle and Engine Speed. The Throttle axis has 14 sites, one every 10 points from *Throttle* = 0 to *Throttle* = 130 (WOT). The Speed axis has 21 sites one every 400 rpm from 800 to 8800 rpm. The values from the 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 Limit*** 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

While cranking the ignition is wasted spark so that the synchronising cam signal is not required, although it must be present by the exit speed, so Crank_Exit should be 400rpm.

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 $\times$ 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 acceptable 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. A 3 wire push/pull valve using a pulsewidth modulated signal. An additional high speed control using Idle spark is also used to stabilise the idle speed.

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.

VARRIABLE VALVE TIMING

Since the engine is horizontally opposed (boxer) type the variable valve control is duplicated for both sides. Cam#2 and Cam#3 signals are used to detect the cam positions and the two PWM signals VVC_out#1 and VVC_out#2 control their positions.

The control system consists of Valve map(s) to hold the target valve position, used by the feedback PI loop. The open loop VVC_out is taken from the Valve_Duty map(s).

The cam positions are determined by capturing the relevant cam timing edge and scaling it into degrees:

Cam#n_angle = Cam#n + Cam#n - (Crank/Tooth_time) in teeth.

Cam#n_ADV = Cam#n_angle - Cam#n_Start in degrees.

This may be further constrained by the Cam_Limit_18 option to be in the range 0-18 teeth, to allow for the wrap around effect of the 4 teeth on the cam timing wheel.

When the VVC feedback is active; above cranking speed, both cam sensors ok (Cam_F_Cnt < 3), VVC_openLoop = Off. If not ok then the VVC_Default is output, or if below cranking exit then VVC_Stopped.

The feedback PI loop is augmented by VVC_Error table output.

VVC_out#n = [VVC_Duty map] + [VVC_Error] + VVC_Int#n

VVC_Int#n(new) = VVC_err#n × VVC_FB_P + VVC_Int#n(old) × VVC_FB_I

This output duty is constrained by VVC_Out_min and VVC_Out_max

Error protection

If the captured value of Cam#n_ADV is out of range or the change since last value Cam#n_dADV is greater than the Cam_dADV_max option the VVC#N_Out remains unchanged, and the Cam#n_dADV_Error counts.

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, or GWv3.exe for widows.
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.

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.
Valve map	VVC target advance.
Valve N map	VVC target advance if in N mode
Valve Duty map	VVC duty cycle open loop.
Valve Duty N map	VVC duty cycle open loop if in N mode

TABLES

Crank Fuel table	While cranking the base fuel, *VE* is obtained from this throttle related table.
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.
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
DAC from TPS	If neither Foot or Hand brake are active, then centre diff drive (DAC) is controlled by throttle.
Lambda table	Is used to convert the parameter oxygen raw to Lambda, for display.
VVC error table	Simple correction of VVC duty due to VVC_err

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 A Load	This is the minimum Load at which the intercooler water spray becomes 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.
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 $\times$ 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 Switch is active then this option modifies ignition.
Alt Fuel	If Alt Switch is active 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.
Foot Brake Mask	Selects from input list Foot Brake input.
Hand Brake Mask	Selects from input list Hand Brake input.
Brake Invert Mask	Allows for inverting the action of Foot and Hand Brake inputs.
DAC Foot	The DAC centre diff pot for just Hand brake active.
DAC Hand	The DAC centre diff pot for just Foot brake active.
DAC Hand Foot	The DAC centre diff pot for both Hand and Foot brake active.
DAC min TPS	If both brakes off, and throttle less than this DAC Test active.
DAC Foot max	In Foot brake mode, if throttle is greater than this DAC test active.
VVC default	The VVC duty if cam#2 or cam#3 fail
VVC FB I	VVC feedback integral constant
VVC FB P	VVC feedback proportional constant
VVC FB max	The maximum VVC output duty.
VVC FB min	The minimum VVC output duty.
VVC Gain	Modifies the signal to increase VVC error
VVC MOD * 2	Increases the control range of VVC_mod
VVC Open Loop	disables VVC feedback
VVC out swap	Swaps the signals VVC output pins
VVC period	The period 1/f of the VVC output PWM signals
VCC rate	How often the feedback loop is updated.
VVC stopped	The VVC out duty while stopped and cranking
A/C ON TPS	Throttle must be lower than this for AC clutch to activate. must be lower or same as A/C Off TPS.
A/C Off TPS	When AC clutch de activated throttle must fall below this value for AC clutch to be reinstated.
A/C In Swt Mask	Selects the AC request input see MASK encoding, check JP4

A/C In Swt Invert	Allows for inverting A/C In Swt action, active high or active low. See MASK encoding.
Swt Rtd Mask	Select which pin to use as Swt Rtd Switch Retard input.
Crank Exit	The engine speed where the change from cranking to normal running occurs.
Tooth Time Max	Tooth_Time must be less than this (typical 15000) for fuelling and ignition to commence.
Sync Cam#1	This is the value of Cam#1 to allow spark and fuel while cranking. If set to 0 this test is ignored. STI7 is usually 51.
Alt Switch Mask	Select which pin to use to activate Alt Fuel and Alt Spark
Launch Swt Mask	Select which pin to use as launch input.
Cam#n Start	Sets Cam#n_ADV = 0
Cam Bad Ignore	Usually off allows investigation of cam error effects
Cam dADV max	Used to filter out impossibly fast changes in cam position
Timing SW1 ON	Above this speed the crank timing sensitivity is reduced to make it less noise sensitive
Timing SW1 ON	Below this speed the crank timing input is returned to maximum sensitivity.
Timing SW2 ON	Above this speed the cam timing sensitivity is reduced to make them less noise sensitive
Timing SW2 ON	Below this speed the cam timing inputs are returned to maximum sensitivity.

FOOT and HAND BRAKE MASK

The Foot and Hand brake may be selected from a choice of inputs, by inserting the relevant code, inversion of input switch action requires adding the codes for pins requiring an invert.

Input Name	Pin	Code
Power steering	B24	02
Neutral	A8	04
Anti-Lag (IPA)	A17	08
AC request	A2 or A6 (JP4 select)	10
Blower (Torq2)	A9	20
Defog	A3	40
Torq3 Torq2 Torq1	C14 , A18, A19	80
Ign swt	A14 + A5	01
none		00

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.
DAC Out	The output voltage assuming 5Volts and ground on Diff+ and Diff-.
Dwell	Is the time between coil charging.

DISPLAY PARAMETERS continued

ERROR1	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	Not Used
	Bit4	Not Used
	Bit3	Coolant sensor fault.
	Bit2	Air sensor fault.
	Bit1	MAP pressure sensor fault.
	Bit0	TPS throttle sensor fault.
ERROR2	Further error information (Bit 0 rightmost)	
	Bit4	Misconfigured output assignment
	Bit3	Not Used
	Bit2	Knock sensor – no signal or disabled
	Bit1	Not Used
	Bit0	Oxygen sensor – Out of range or not ready
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.	
Cam#n Angle	The relevant first transition measured against engine cycle. n= 1, 2, 3.	
Cam#n ADV	Scaled Cam#n_Angle	
Cam#n dADV error	Cam#n dADV greater than Cam dADV max counter	
Cam#n dADV	The change of Cam#n ADV from last sample.	
VVC out#n	The VVC PWM duty	
VVC target	Value in Valve map in degrees	
VVC duty map	The value in VVC duty map.	
VVC err#n	The error between VVC target and Can#n_ADV	
VVC Int#n	The PI feedback contribution to VV_Out#n	
VVC correct#n	The Valve error table contribution to VV_Out#n	

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 pin selected by Launch_Swt_Mask is pulled low then the launch control is active and the 8000 rpm speed line is used irrespective of actual engine speed. This pin was assigned by the Blower, a fan request to up the idle in the OEM configuration, since the GEMS configuration does not support this request the new action is of no consequence except the blower switch may cause launch.

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.

INTERNAL LOGGING

All 15 logged parameters 7 fast and 8 slow must be set in the log list, reached via internal logging on GWv3.
The logging conditions may be set to trigger the logging; always, engine running, PBW (anti-lag). The unloading of the logging must be done with the engine stopped. Note the logged data will be preserved as long as the permanent battery supply is maintained.

512k log options supports bigger memory chips 512kBytes as opposed to initial 128kByte version. As yet the loop logging memory wrap is not supported.

D9	C7	E6	B9	A7 A1
D21	C16	E12	B19	A15
D31	C24	E17	B28	A22

ECU connector wire entry view latch at top

Subaru WRX & Sti 2002				
Subaru	WRX	Sti	Comments	Wire Colour
A1	Road Speed	As WRX		Orange
A2	Main Relay Coil	Air Con Request	AC in	Pink-Black
A3	Rear Defroster	As WRX	Input,Defroster On Defog	Blue
A4				
A5	Diagnostics	12 Volts Ign On	Line End Plug (GT)	Green-Red
A6	Air Con Request	Main Relay Coil	AC in	Lt Green
A7	0 Volts	As WRX	As A15/E1	Green-White
A8	Neutral Switch	As WRX		Green-Red
A9	Fan On Signal to ECU	As WRX	Blower	Green/Red
A10	Diagnostics		Flash Memory	Red-Green
A11				
A12				
A13	Fuel Pump Control	As WRX	12V Pump On	Lt Green-Red
A14	Ignition On 12 Volts			Orange
A15	0 Volts		As A7/E1	Green-White
A16	12 Volts Starter	As WRX	12 V Engine Cranking	White-Red
A17	ILM Anti-Lag switch	As WRX	Anti-Lag switch	Black-White
A18			Torq2	
A19			Torq1	
A20	Diagnostics	As WRX	Data Link	Black-Red
A21	Diagnostics	As WRX	Data Link	Lt Green-Black
A22	0 Volts			Black-White

Subaru	WRX	Sti	Comments	Wire Colour
B1	Sync FIXED Mag +	As WRX		Red
B2	CRANK Mag +	As WRX		White
B3				
B4	Knock Sensor	As WRX		Yellow
B5	Immobiliser	As WRX		
B6				
B7	TPS Signal	As WRX		Lt Green
B8	MAP Signal	As WRX		Yellow-Black
B9	Sensor 5 Volts	As WRX		Lt Blue
B10	SyncFIXED Mag -	As WRX		Green
B11	CRANK Mag -	As WRX		Black
B12	DIFF+		5Volt Diff Pot input	White-Red
B13	TGV Position LH Bank DIFF	Not Used	0 to 5 Volt DAC drive for Centre Diff	
B14	Immobiliser	As WRX		
B15				
B16	EGT	As WRX	May Need AMP	
B17	Rear LAMBDA +	As WRX		Blue
B18	Water Temperature	As WRX	Check Calibration	Black-Yellow
B19	Sensor 0 Volts	As WRX		Red-Green
B20				
B21	Ref/Sync Shield	As WRX		Gray
B22	Knock Shield	As WRX		Gray-Red
B23	TGV Position RH Bank DIFF-	Not Used	0Volt Diff Pot input	
B24	Power Steering Switch	As WRX	PwrSteer	Black
B25	Fuel Level Sub.			
B26	Rear La Shield	As WRX		Gray-Blue
B27	Air Temp	As WRX		Blue-White
B28				

Subaru	WRX	Sti	Comments	Wire Colour
C1	VSS GROUND		spray air	
C2				Red/Black
C3				
C4	Injector Cyl 4	As WRX	12 Ohms	Pink-Green
C5	Injector Cyl 3	As WRX		Pink-Black
C6	Injector Cyl 2	As WRX		Pink-Blue
C7				
C8	0 Volts	As WRX		Black-Yellow
C9	Tacho Signal	As WRX		Orange-White
C10	Idle Control	As WRX		Black-Red
C11				
C12				
C13	Rear Lambda Heater	As WRX		Red-White
C14			Torq3	
C15	F Pump Cntrl Pin 8	As WRX C16		Lt Green-Black
C16	F Pump Cntrl Pin 8	As WRX		
C17	0 Volts	As WRX		Black-White
C18	0 Volts	As WRX		Black
C19				
C20				
C21	Ignition Cyl 4	As WRX		Yellow-Green
C22	Ignition Cyl 3	As WRX		Yellow-Red
C23	Ignition Cyl 2	As WRX		Yellow-Black
C24	Ignition Cyl 1	As WRX		Yellow

Subaru	WRX	Sti	Comments	Wire Colour
D1	Injector Cyl 1	As WRX	12 Ohms	Pink
D2	12 Volts	As WRX	From Main Relay As Pin D3	Yellow-Blue
D3	12 Volts	As WRX	From Main Relay As Pin D2	Yellow-Blue
D4	Front La Heater	As WRX	As Pin D5	Black-Red
D5	Front La Heater	As WRX	As Pin D4	Black-Red
D6				
D7				
D8	0 Volts	As WRX	As Pin D9	Black-White
D9	0 Volts	As WRX	As Pin D8	Black-White
D10	Constant 12 Volts	As WRX		Black-Red
D11				Green
D12	???	Alternator		Blue
D13				
D14				
D15	Check Engine Light	As WRX	Shift Light	Red-White
D16	Purge VSV	As WRX		White-Blue
D17	Coolant Fan 1	As WRX		White-Blue
D18	Front La Shield	As WRX		Gray
D19	Front La -	As WRX		Black (white)
D20				
D21				
D22				
D23				
D24	Boost Cntrl VSV	As WRX		Black-White
D25				
D26				
D27	Air Conditioner Clutch	As WRX		Brown-Red
D28	Coolant Fan 2	As WRX		Green-Red
D29	Front La +	As WRX		White(black)
D30				
D31				

Subaru	WRX	Sti	Comments	Wire Colour
E1	0 Volts	As WRX	As A7/A17	Green-White
E2		Cam3 Pos Snsr RH +		White
E3		Cam3 Pos Snsr RH -		Green
E4	RH TGS VSV Pin 1	Not Used		
E5	RH TGS VSV Pin 2	Not Used		
E6		Cam Timing VSV RH +		Red-Black
E7	AFM Air Temp 0Volts	As WRX		Black-Green
E8	AFM Shield	As WRX		Gray
E9		Cam2 Pos Snsr LH+		Red
E10	LH TGS VSV Pin 1	Not Used		
E11	LH TGS VSV Pin 2	Not Used		
E12		Cam Timing VSV RH -		Green-White
E13	AFM Signal 0 to 5Volts	As WRX		Green
E14		Cam2 Pos Snsr Shield		Gray-Red
E15		Cam Pos Snsr LH -		Black
E16		Cam Timing VSV LH -		Green-Black
E17		Cam Timing VSV LH +		Red-White