Subaru 97-98 v2.21

Plug and Play ECU

Operation Manual

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 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.

SENSORS

Airflow is measured using the standard sensor which is housed in the air filter box and connected to the inlet of the Compressor Housing. This is usually the systems major parameter for monitoring load. This has been improved with the transition to a more powerful implant microprocessor.

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 which scale the throttle position sensor. These are TPS_min and TPS_max.
These must be set to ensure correct operation from the throttle-controlled parameters.
TPS_min must be set to the raw throttle value TPS_raw at closed throttle and TPS_max is set to the value of TPS_raw at full throttle.

Air temperature is measured using a sensor mounted in the intake manifold. The sensor is a negative coefficient thermistor in an automotive compatible package.

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

Engine speed and timing are measured using two sensors mounted in the Timing unit.

Manifold absolute pressure (MAP) may also be used as the primary load sensor, and with the sensor disconnected from the inlet may be scaled for use as a barometric sensor.

Mass Airflow (MAF) may also be used as the primary load sensor. Or the input used for a Barometric sensor configured for waste gate altitude correction.

The Knock sensor may be monitored, later versions
of software may support active knock control.

The exhaust gas oxygen sensor can also be monitored as a mapping aid and may be used as a weak mixture alarm.

FUEL METERING

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

Volumetric efficiency V.E., 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, Air flow, or MAP. 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 optimum 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
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

Part of V.E Table

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.

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

Throttle < Max closed throttle, CT_TPS option.
Engine_Speed > Min speed closed Throttle, CT_speed.

The VE value obtained from the grid is then modified by the operator variable factor Fuel_mod, so that :

VE (mod) = VE + (VE * 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) * 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%.

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; Warm Up with 0% to 200% range 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

The base fuel pulse width is then calculated by multiplying VE(c) with the injector flow rate option MicroSec/bit. The value for K is dependent on the expected horse power of the engine and the injector flowrate. It should be set so that the maximum VE value is around 200.

BPW = VE (comp) * K microseconds

The final fuel pulse width is then calculate 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).
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 2 dimensional lookup table controlled by scaled throttle position Throttle, called Crank Fuel table. 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 value for K is multiplied by a cold start factor obtained from the Cold_Fuel table which allows up to 3 times the normal fuelling while starting.

Fuel Pulse = VE(c) * K * Cool Tmp F

ACCELERATION ENRICHMENT
Acceleration fuel is added to the fuel pulse width.
It is set by 2 options and a table:

Accel Fuel trigger	Accel trig
Accel Fuel decay	Accel decay
Accel Fuel Amount table	Accel Amount table

It is calculated using only the positive difference between the current Throttle value and the previous Throttle to give delta Throttle. The calculation is only performed if delta Throttle (DTPS) is greater than Accel Trig.

DTPS = new Throttle - old Throttle if positive

Accel Fuel = old Accel Fuel * Accel Decay + DTPS * MSPB * Accel fuel Amount% * Fuel Pulse

To turn off the acceleration fuel set Accel Trig to 255 and the Accel Fuel table to 0.
Accel decay will reduce the current Accel Fuel every engine revolution exponentially, a large Accel decay will produce a long sustain. A typical value is 85%.

Deceleration fuel is subtracted from the fuel pulse width.
It is set by 2 options and a table:

Decel Fuel Threshold	Decel Trig

Decel Fuel decay Decel Decay
Decel Fuel amount Decel Amount table
It is calculated using the difference between the current Throttle value and the previous Throttle to give delta Throttle.

NDTPS = new Throttle - old Throttle if negative.

Accel Fuel = old Accel Fuel * Decel Decay + DTPS * MSPB * Decel fuel% * Fuel Pulse

To turn off the deceleration fuel set Decel trig to 255 and Decel fuel amount table to 0.
Accel decay will reduce the current Accel Fuel every engine revolution exponentially, a large Decel decay will produce a long fuel reduction. A typical value is 80%.

Accel Fuel is a signed 16 bit value with the range +/-65 milliseconds and is composed of the sum of both the positive acceleration fuel and negative deceleration fuel. If the Alt Accel switch in options is set on then an acceleration only fuel enrichment is used that uses a filtered throttle signal and is less sensitive to false triggering.

Alt Accel
This is a different algorithm for calculating the acceleration fuel. This uses a filtered throttle signal to detect the pedal depression, and is less prone to false triggering. The Accel Trig should typically be increased to 25. Note there is no deceleration fuel enleanment if this option is on.

ACCELERATION FUEL

When there is a large change in throttle position measured every 8 milliseconds, then some additional time is added to the base fuel pulse width.

when δ TPS +ve > + TPS_Trip option

Accel_Fuel = Accel_Fuel + (δThrottle $\times$ Accel_Extra)

Accel_Fuel is decayed every injection event or 8 mSec back-ground event thus:

Accel_Fuel = Accel_Fuel $\times$ Accel_Decay option

The decision to decay in background or every injection is dependent on option Timed_AF, if set then the fixed 8mSec rate is used. These values are best tested in the vehicle.

The filter for TPS allow for detection of smaller changes; with filter set to 0 there is no filtering, however the minimum filter value is 93% with 7% giving maximum filter.

Rev limit

The rev limit function works by cutting the fuel injection if the engine speed is greater than Rev limit.

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 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° it used when calibrating the engine to obtain optimum values for the ADV table. It can also be set to pre-set value for switch on which then acts as an overall retard/advance factor.

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 two options the Air temperature retard trigger (Retard_strt) and the Air Temperature Retard Slope (Retard_rate).
If the manifold air temperature (Air_Temp) is < Retard_start then Air Retard = 0
Else Air Retard = (Air Temp - Retard strt) * Air retard slope
The modified ignition timing:

ADV (mod) = ADV (mod) - Air Retard + TPS_rtd (m)

Water temperature retard works in the same way. Since the TPS retard is usually greater than either the air or water retards the TPS retard has twice the power of the TPS retard map value.
TPS retard is zero unless PBW is enabled.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 + Idle ADV

MONITORING AND DISPLAY SYSTEM (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 must be removed to access the internal serial connector JP2 :

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

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/SUBARU97
This contains

GEMSCOM.CFG	Configuration file lists files use.
SUBARU97.INI	Initialisation list Parameters, Maps, Tables.
SUBARU97.KEY	User key files keyboard functions.
????????.HEX	Calibration file.
????????.SCR	Screen file of display parameters.
SUBARU97.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 CONTROL

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.

← ↑ → ↓ 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 0.18° and one press of the left arrow key decreases Spark mod by 0.18°.

s The ignition advance curve is reprogrammed using s. With the engine running at a speed 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.

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

C 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.

TABLES

INJECTOR BATTERY COMPENSATION TABLE

The value of the Battery comp option is the scalar for the Battery comp table. If this option is zero then the old table in ROM (not a user variable) is used. If you wish to view the shape of the table, press F5. The injector battery compensation table is determined by the model and type of injector you are using. If you change injectors or fuel pump pressure you may need to change this table and or microsecond/bit, and re-scale the VE tables, this may also effect the optimum settings for injection open angle.

Battery comp F= table value * Battery comp (option)

If we use the Weber IW 058 (43005.010) as an example of a contemporary high impedance injector:

R = 14.5 ohms L = 7.2 mHenrys
Flow rate 384 mlitre per minute at 300kPa

Battery Volts Offset time mSec

6.0	5.387
8.0	2.028
10.0	1.217
12.0	0.806
14.0	0.558
16.0	0.391

If 8 volts is the minimum battery supply for normal operation, then we can scale the system thus:

2.028 mSec/255 for finest resolution = 8 µSec per bit

With the overall scaling of 2µSec per bit then we may chose 5 (10µSec/bit) for convenience.

Battery Volts Offset time E.C.U. units

0.0	4
8.0	255
10.0	153
12.0	101
14.0	70
16.0	49

4 for 8µSec multiplier
The missing values for odd voltages are best blended using the graphical editor (F3) in the mod program.

The original internal table would look like this:

0.0	9
8.0	255
9.0	139
10.0	79
11.0	52
12.0	30
13.0	20
14.0	11
15.0	9
16.0	7

9for 18 µSec multiplier option

WARM-UP TABLE
This is a table that controls how much additional fuel to use at any engine temperature from -20°C to 120°C, while in normal running 800 rpm has been exceeded.

COLD FUEL TABLE
This is a table that controls how much additional fuel to use at any engine temperature from -40°C to 100°C, while at cranking speed less than 600 rpm.

CRANK EXTRA TABLE
This is an additional amount of fuel added, dependent on coolant temperature, while the engine is starting.

CRANK DECAY TABLE
This table determines how quickly the additional crank extra fuel is decayed over time. This decay is a linear decay in seconds after cranking commences.

CRANK PULSE TABLE
This is a single shot of fuel that may be injected into the engine at Key on, or at the start of cranking if the Key_on_Fuel option is set Off. The value in the table selected dependent on temperature is multiplied by the microsec/bit option to give the parameter Start_Pulse in micro-seconds.

WG BARO MOD TABLE
This table produces WG_Baro_mod that adjusts the wategate drive mark space ratio (MSR) to compensate for altitude. The MAF input is used to read a barometric pressure sensor that may be mounted inside the ECU, with a 0 to 5 Volt output range. The Baro_raw signal is scaled by Baro_M and offset by Baro_c options to produce a 0-128kPa signal. If with in the range 35 to 115kPa it is used to access this table, else an error (bit 6) is annonced and the WG_Baro_Dflt forced into WG_Baro_mod.

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 delay compensation PUDLY option 19. The value of PUDLY is 166666/deg/RPM. I.E. with PUDLY 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

PUDLY =2 $\times$ 166666/4000

PUDLY = 84 (83)

TORQUE CONTROL (PBW)

Enable conditions

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

TPS_ALS is OFF then PBW active if all following met:

ECU PBW Pin is at 0v (Drivers Switch)
Air temperature is < PBW_Temp
Engine_Speed > PBW_ON_Speed

TPS_ALS is OFF then PBW inactive if any:

ECU PBW Pin is at not 0v (Drivers Switch)
Air temperature is < PBW_Temp
Engine_Speed > PBW_OFFSpeed

TPS_ALS is ON then PBW active if all following met:

TPS_raw > 128 at power on
Air temperature is < PBW_Temp
Engine_Speed > PBW_ON_Speed

TPS_ALS is OFF then PBW inactive if any:

TPS_raw > 128 at power on
Air temperature is < PBW_Temp
Engine_Speed > PBW_OFFSpeed

If PBW is enabled the ignition timing is modified by the TPS Retard factor and a proportion of sparks are disabled by the Ignition Limiter function.

This controlled by the Spark Limiter 3D lookup table:

Inputs Engine Speed and Throttle.
Speed Axis 21 sites 800 to 8000 rpm,400 steps.
Throttle Axis 14 site 0 to 130 Throttle, 10 steps.
Output Limiter 0% to 99.6%,no cut to almost total cut.

ELECTRONIC WASTEGATE CONTROLLER

The electronic wastegate controller uses an 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 1. This allows the user to calibrate the waste gate duty cycle table.

WG msr (m) = WG msr + Waste mod + WG Baro 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. Note WG_Baro_mod is only active if the Bar is set to on, ensure MAF is set to off.

IDLE CONTROL

The pulse rate of the pulse width modulated idle control is set with the Idle_period option. There are three conditions for idle speed control;
1 Engine_speed < Idle_speed and Throttle < max_Idle_TPS; then the Idle Duty table is active.
2 Engine_speed > Idle_speed or Throttle > max_Idle_TPS and PBW is off, then Idle_High is active.
3 Engine_speed > Idle_speed or Throttle > max_Idle_TPS and PBW is on, then Idle_PBW is active.

MONITORING AND DISPLAY SYSTEM (P.C. 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 P.C. or compatible computer using a special terminal emulation program available from GEMS. To connect the IBM P.C. to the ECU a special cable is required.

Setting up the IBM P.C.

The GEMS floppy disk with the user interface program GEMSCOM.EXE and the SUBARU97.INI,SUBARU97.KEY should be loaded on to your computers hard disk. A .POT file is required if the potbox or potboxes are required to control the ECU as an aid to mapping.

Type "Gemscom" at the DOS prompt.

Refer to the GEMSCOM manual for details, note the F1 key will give context sensitive on screen help.

BACKWARD COMPATIBILITY

Although new features have been added such as improved Accel/Decel features old configuration files .DO may be read and altered with GEMSCOM, so when converting an old calibration particular attention should be taken when checking the options as the scaling is now predominantly in engineering units, and some options such as Accel Amount is now a table.

The PBW mode on and off are the torque controls used above the PBW temp and below respectfully. I_LMT (bit 1) is the spark cut function, F_LMT (bit 0) is the fuel cut function and IRTD (bit 2) is the TPS ignition retard function. By displaying PBW mode the 3 least significant bits can be interpreted.

MAP min and MAP max are used when load is derived from a MAP sensor and are the appropriate unscaled values of the raw MAP signal. The full scale Air Pressure signal is assumed to be 3.4 Bar shown as 338.7 Bar%.

The wastegate control is simpler as there is no boost table only the Waste Gate map to be set.

The user controls are listed from the .KEY file using the F10 key. Note the write through to the ECU while running must be used thoughtfully.

Mass Air Flow to Load Calculation.
When MAF is set ON, MAP and BAR must be set OFF, then the MAF_signal is used to derive Load. Make sure WG_Bar_mod table and WG_Bar_Dflt are set to 0%.
First The MAF_signal is filtered then linearized using an internal table to make Air_flow. Air_flow is then corrected for engine speed to produce MAF_raw which in turn is converted to MAF_as_Load using the options MAF_min and MAF_max.

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.

TABLES

CRANK FUEL TABLE
While cranking the base fuel, VE is obtained from this throttle related table.

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.

START 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.

IDLE DUTY TABLE
The idle duty controls the amount of by-pass air when the idle conditions are met: Engine_speed less than Idle_speed.

WG BARO MOD TABLE
Generates WG_Baro_mod to correct waste gate drive with barometric pressure.

OPTIONS

Inj*mod These are the four individual fuel modifiers.

MAF_min/max Are used to scale the MAF_raw signal to the 0 to 130 range of MAF_as_Load. Typical values are 70 for MAF_min and 10050 for MAF_max.

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. Note old calibrations before G1.15 should have this value doubled.

TPS min/max Are used to scale the TPS raw signal to the 0 to 130 range of Throttle.

MicroSec/Bit Or k is the major scaling factor for converting VE in the Fuel map to the injector Fuel Pulse.

Fuel Cut Is the engine speed at which the fuel cutting engine speed limiter will activate to protect the engine.

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.

FLMT PBW 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
IG F PBW ON If cylinder is fuelled always ignite.

FLMT PBW 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
IG F PBW OFF If cylinder is fuelled always ignite.

Retard strt — This is the minimum air temperature at which the Air Retard will have effect.

Retard rate — This is how much Air Retard will be made for each degree Celsius above the Retard strt temperature.

Spray start — This is the minimum Air temperature at which the water spray is activated.

Spray Load — This is the minimum Load at which the water spray becomes active.

Fans#1 start — This is the minimum coolant temperature to turn on the primary radiator fans.

Fans#2 start — This is the minimum coolant temperature to turn on the secondary radiator fans.

TPS_ALS — If this is set on then the anti-lag system is enabled if the throttle is depressed at power on, none of the PBW features will be enabled until PBW_ON_speed is exceeded. Else the dashboard switch is activated.

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.

BAR	This will activate the air pressure correction factor calculation for the wastegate. Set MAF to OFF.
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%.
MAF	The Load parameter will be derived from the mass airflow sensor, 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.
PBW_Air	This is the minimum air temperature to activate PBW so that the ON settings for ILMT,FLMT,IRTD are used. Note if this forces the system out of PBW mode then the error light will be illuminated.
PBW_ON_Speed	This is the minimum engine speed at which the anti-lag features are possible.
PBW_OFFSpeed	This is the maximum engine speed at which the anti-lag features are disabled after being activated.
Idle_Period	This is the period of the pulse width modulated signal applied to the idle by-pass valve.
Idle speed	This is the maximum Engine Speed for the Idle duty table to still to be active.
max Idle TPS	This is the maximum Throttle for the Idle duty table to 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 511.
KPRESS	This scales the pressure signal for use as a barometric correction signal. Range +/-32,767. Air Pressure = (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.
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.

Idle_High	This is the duty cycle applied the idle valve when not in idle and PBW is not active.
Idle_PBW	This is the duty cycle applied the idle valve when not in idle and PBW is active.
ALS on time	When in TPS_ALS mode this is the time in seconds that engine speed must be between 500 and 800 rpm for the ALS to be activated. ALS will not function till PBW_ON_speed speed is exceeded.
ALS off 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.
NO ALS arm	If set ON, then the ALS will not require engine speed to be held at 700 rpm to become active in TPS ALS mode.
Baro c	Used to offest the scalled barometric sensor reading.
Baro M	Used to change Baro Raw to Barometric.
WG Baro Dflt	When Barometric is outside of 35 to 115 kPa this is set into WG_Baro_mod.
New Switch	The AC input now controls AC output. ALS switch is now neutral pin C09, and water spray is pin A16.
A/C invert	Changes the output relay active condition.
A/C throttle off	When A/C is active, the A/C out will be inhibited if Throttle is greater than this value.
Idle A/C	When A/C is active then this is added to the idle drive to compensate for the extra engine load.
Rev Light	When engine speed exceeds this value pin A05 is pulled low.
No MAP average	This removes the smothing effect of the sampled MAP/boost signal and also makes it less suseptible to timing errors.
A/C invert	Inverts the action of the A/C request input.

DISPLAY PARAMETERS

Accel Fuel	Is the amount of accel/decel fuel currently used, note this has the range +/-65,500 µSec.
ADV (mod)	Is the base ignition after being summed with Spark mod.
Air Flow	Is the currently calculated value of airflow no units.
Air Pressure	Is the scaled value for air pressure in Bar%, with a range of 0 to 127.5 Bar%.
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 Air start and Air Slope 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.
Barometric	The barometric pressure derived from the MAF input if Bar is on.
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.

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 right most. Bit7 Checksum not correct, press c to recalculate and set value. Bit6 Mass Airflow over-speed, TPS to Load table active. Or Baro. 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.
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 has been applied.
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 Pulse	This is the amount fuel calculated for the current conditions with no Accel Fuel or Bat comp F.
Fuel_PW_#*	These are the four individual injector fuel pulses after modification by the Inj*mod options.
Inj_PW_#*	These are the total pulsewidths applied to the injectors.
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	Is the raw unscaled Knock microphone signal.
Lambda	Is the scaled exhaust gas oxygen signal 100= stoichmetric 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.
MAF AS LOAD	Is the current MAF derived signal scaled for Load.
MAF raw	Is the unscaled pressure signal used for MAP and barometric compensation, see MAF min and MAF max options.
MAF_signal	Is the mass airflow sensor output scaled in volts.
Oxygen raw	Is the unscaled oxygen signal 0 to 255 = 0 to 5 volts.
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 TPS ALS mode Bit6 Bit5 Bit4 Bit3 IDLO idle control. 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.
Spark adv	Is the output of the Ignition map.
Spark mod	Is the key adjustable modifier of the ignition map value.
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.
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.

CONNECTOR

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 "C","B". An Air temperature sensor can be wired into B15 signal and B13 ground. There is a relatively easy way of modifying the loom to accept an air temperature sensor. Move the power steering wire in C01 which is red/white to B15. This wire terminates at a 12 way connector on the engine harness by which time it has changed colour to pink pin 8. The ground for the sensor can be spliced into a green wire in pin 10.

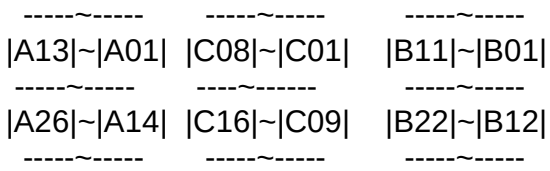
----------	01.green/white	07.No con.
01 02 03 04	02.white/green	08.pink
----------	03.black	09.No con.
05 06 07 08	04.white/black	10.green/red
----------	05.black/white	11.red
09 10 11 12	06.No con.	12.l green/white

----------	01.green/white	07.No con.
01 02 03 04	02.white/green	08.green
----------	03.yellow	09.No.con = Air signal
05 06 07 08	04.blue	10.green = ground
----------	05.black/yellow	11.red
09 10 11 12	06.No con.	12.white

Map Sensor 3 way	black plug	GM Map sensor
1.red	5v	Pin C
2.yellow/black	signal	Pin B
3.blue	ground	Pin A

The water Spray/injection control can be wired to the ECU using Pin A21 is used to activate a relay to turn the water pump on and off active low.

The ALS input is activated by switching pin C10 to ground active low.



Wire entry veiw

PINOUT SUBARU97

		Use	Function
A01	108	Y	IDLE AIR VALVE
A02	107	Y	IDLE AIR VALVE
A03	008	Y	WASTEGATE CONTROL SOL.
A04	007	Y	×**WASTEGATE INVERT×**
A05	006	N	Rev light
A06	005	N	PRESSURE EXCHANGE SOL
A07	004	Y	FUEL PUMP RELAY WITHOUT IMMOBILISER
A08	003	N	MALFUNCTION LAMP ALS light
A09	002	Y	IGNA CYL 3 & 4
A10	001	Y	IGNB CYL 1 & 2
A11	103	Y	INJ4
A12	102	Y	INJ3
A13	101	Y	INJ2
A14	110	Y	TRANNY GND
A15	109	Y	MAIN PWR 12V
A16	016	N	see New Switch new Water Spray
A17	015	Y	FUEL PUMP WITH IMMOBILISER
A18	014	N	
A19	013	N	
A20	012	N	
A21	011	Y	AIR CON ×***WATER SPRAY×**** see New Switch
A22	010	N	×** IGN ×***
A23	009	N	×** IGN ×***
A24	105	Y	IGN GND
A25	106	Y	INJ RTN
A26	104	Y	INJ1

C01	024	N	PWR STEERING
C02	023	Y	STARTER
C03	022	N	VEHICLE SPEED INPUT JOINT CONNECTOR
C04	021	Y	CHECK CONNECTOR RX from PC
C05	020	Y	CHECK CONNECTOR TX to PC or Logger
C06	019	N	
C07	018	N	
C08	017	Y	RAD FAN
C09	032	N	NEUTRAL SWT see New Switch
C10	031	Y	AIR CON ×**ALS SWT×*** see New Switch
C11	030	N	
C12	029	N	IMMOBILISER
C13	028	N	IMMOBILISER
C14	027	Y	TACHO
C15	026	N	PURGE
C16	025	Y	RAD FAN

B01	114	Y	PWR 12V FROM MAIN RELAY
B02	113	Y	PWR 12V FROM MAIN RELAY
B03	040	Y	COOLANT TEMP INPUT
B04	039	N	KNOCK SIGNAL
B05	038	N	SIG OX
B06	037	N	SIG AIRMETER
B07	036	N	0V AIRMETER
B08	035	Y	CAM SIGNAL IMMOBILISER SWAP WITH CRANK
B09	034	Y	0V SPEED SENSORS PIN 4 JOINT CONNECTOR
B10	033	Y	CRANK SIGNAL IMMOBILISER SWAP WITH CAM
B11	111	Y	PWR 12V
B12	116	Y	PWR RTN
B13	115	Y	SENSOR 0V JOINT CONNECTOR
B14	048	Y	SENSOR SUPPLY 5V
B15	047	N	*****Airtemp Input*******
B16	046	Y	TPS SIGNAL
B17	045	Y	BOOST MAP SIGNAL
B18	044	N	
B19	043	N	
B20	042	N	
B21	041	N	
B22	112	Y	ACTIVATE MAIN RELAY