Making Sense of Sensors

For your stand alone engine management the choice of sensors can be bewildering.
The following is a guide for must haves and optionals. In subsequent posts we will do a guide for sensors for vehicle/driver performance evaluation.

Must haves for the engine to run & for best tuning results;

Crank Reference sensor (aka crank index, RPM)
This is the primary sensor that gives the ecu information on the crank position in the engine cycle & its current speed (rpm). Reliability wise most factory trigger systems are fairly good although many are a compromise regarding the best tooth pattern. The more teeth on the trigger wheel the more often the ecu is updated as to the cranks shafts exact position in its cycle and its rate of change in rpm. For instance some of the early Mitsi evos only have a maximum of 4 edges that can be used which means the ecu is only updated every 90deg of crank rotation which is far from optimal. A more reasonable tooth count would be 36 teeth, then the ecu is updated every 10deg of crank rotation. Life Racing believe engine position tracking is so import they have an extra micro-processor dedicated solely to engine tracking. However the ecu can only act on the information it receives, so if there is a low update rate from a low tooth count then we are compromised.

To determine the cranks position relative to TDC many factory trigger setups have to use the sync/cam sensor as a reference point. A better way of doing this is to have a missing tooth on the crank trigger wheel (eg 36 tooth with a 1 tooth gap). This gives the crank sensor a reference point to determine the crank position that is fixed & not subject to cam belt flex or whip altering the relative position to the cam sensor. It then only uses the cam/sync sensor to initially determine which part of the 720deg cycle (TDC firing or TDC overlap) and then can actually ignore the cam/sync sensor once triggering synchronisation has been established on start up.

Other sub-optimal factory triggering systems include many Nissan arrangements where there is no actual crank reference sensor on the physical crank shaft but is actually run on the cam shaft. This means that there can be an error in what the “crank” sensor is reporting and reality due to cam belt flex & whip.

So sometimes we are better off replacing the factory triggering system with an after market or custom arrangement for best results. How ever if this is not done correctly many difficult to diagnose problems can be introduced due to poor design & implementation, please contact for advice.

Sync Sensor (aka Cam, Home sensor)

The primary role of this sensor is to provide the ecu information as to which part of the cycle the engine is currently in. For a 4 cycle engine the crank reference sensor can determine the crank position but as the crank does 2 revolutions to the cam it does not know if the TDC is TDC firing or TDC overlap. The Sync sensor provides this information.

If the engine is equipped with continuously variable cam control the ecu will also use this sensor to determine the current position of that cam shaft & be supplemented with further cam position sensors for the other cam shafts.

MAP sensor

MAP stands for manifold absolute pressure. Like the name says it measures the absolute pressure in the intake manifold. For many applications this is the primary sensor the ecu uses to determine the current load the engine is operating under & part of the information used to determine how much air is entering the engine.

It is best to select a MAP sensor with a range that exceeds the intended boost pressure by a reasonable amount so the ecu has some hope of being able to provide the engine with the correct amount of fuel & ignition timing in an overboost situation. If the MAP sensor can only read to 240kpa & we intend running 230kpa then if we get an overboost to say 260kpa the ecu can only provide accurate control up to 240kpa.

TPS sensor

Throttle position sensor. The ecu determines the throttle blade position from this. For all applications the ecu uses the rate of change of this sensor for transient fuel (accel fuel) control strategies. For naturally aspirated engines with large overlap cam shafts it will be the primary sensor that the ecu uses for engine load and for boosted engines with large overlap cam shafts it will be included as part of the information along with the MAP sensor to determine engine load.

If the application is drive by wire the TPS sensor will include a secondary sensor for safety and a dual channel driver peddle position sensor will also be required.

Most factory TPS sensors are fairly reliable, however we have seen some poor quality aftermarket TPS sensors and aftermarket throttle body supplied sensors which can lead to hard to diagnose tuning problems.

ACT sensor (aka IAT, MAT)

Air charge temperature or inlet air temperature sensor. Advises the ecu of the temperature of the air entering the intake manifold. This is part of the information needed to determine the amount of air entering the engine.

For best results we recommend mounting this isolated from the intake manifold. The intake pipe leading into the throttle body is ideal as it is insulated from direct engine heat. If it is mounted directly into the intake manifold then during extended idling periods engine heat will heat soak into the intake manifold & into the ACT sensor making it report a falsely high reading leading to incorrect fuelling.

ECT sensor (CLT)
Engine Coolant temperature sensor. The name is self explanatory. It is used by the ecu to adjust many control functions for the different requirements engine operating temperature demands.
For custom set ups it is essential the sensor is mounted before any thermostat. If it is mounted after the thermostat is will read cold until the thermostat opens.

Wide Band Lambda Sensor
Provides the ecu with the current fuel mixture (air fuel ratio) reading. An essential sensor for the initial tuning process. Can be used by the ecu as part of its fuelling control as well as closed loop mixture control. Can be used by the engine protection system to provide engine protection for over lean conditions.
The 2 most common & reliable sensors are the NTK L2H2 and the Bosch LSU 4.9.
As the sensors are reading the oxygen content in the exhaust it is important there are no exhaust leaks prior to the sensor.

Must have Extras;

FP Sensor
Fuel Pressure sensor. Often used by the ecu for control strategies. Also vital for engine protection systems. It is best to mount these & similar sensors like engine oil pressure remotely from the engine. The vibration & harmonics of the engine can cause the sensor to fail prematurely.

EOP Sensor
Engine oil pressure sensor. Another must have for engine protection systems.
As the name of the motorsport game is to generate as much g-force in all directions oil surge (& fuel surge) can be a real problem and many race engines have been destroyed by this. After doing an install & tune we have had customers contacting us after they have been to the track for the first time to tell us the sensor must be faulty because it is activating an engine protection trip. Upon reviewing the logging it always turns out that the surge is real & that in the past they have had engine failures!

Knock Sensor/s
Used by the ecu to track & control engine knock. The factory position for the knock sensor/s is usually the best. Please contact for advice on the correct knock sensor for your application.

Driver Strategy Switches.
These can range from a simple on/off switch to enable strategies like antilag or launch control to multi-position driver driver switches. For more capable ecus like Life Racing the multi-position switch can select complete strategies like dry/intermediate/wet where a range of control strategies like boost control, traction control, DBW torque maps are changed to suit the conditions.
And/or there can be dedicated multi-position switches for each strategy. Eg a pair of multi-position switches to allow the driver to fine tune the slip target and gain control for the traction control system.

Extras depending on application & exotics;

Gear Position sensor
The principal sensor for gear shift control, be it flatshift, throttle blip or paddle shift. It provides more than just the current gear, it advises the ecu the current position of the shift cam shaft mechanism inside the gearbox during the shift.

Gear Shift Force sensor. (aka gear lever force)
This is a strain gauge sensor that provides the ecu with information on how much force the driver is applying to the gear lever/shift linkage during a shift. From this the ecu can determine that the driver is requesting an up shift or down shift and initiate a gear cut sequence or throttle blip sequence accordingly. If paddle shift is used then this sensor is not used and the shifts are initiated via the paddle switches instead.

GSP Sensor
Gear system pressure sensor. For paddle shift systems this sensor provides the ecu with the current gear shift actuator tank pressure & allows the ecu to control the air pump accordingly to maintain a consistent pressure.

Clutch Switch or clutch pressure or clutch peddle position.
For safety lockouts a paddle shift gear system will require some way of knowing if the clutch is engaged. This can be accomplished with a simple switch. To use this for other systems such as launch control the more detailed information that a clutch pressure or position sensor can provide may be more appropriate.

EGT Sensors
Exhaust Gas temperature sensors. Most commonly used to provide the ecu with temperature information on the exhaust gas leaving each exhaust port. This can provide the tuner with another layer of tuning information and be used by the ecu for some tuning strategies & engine protection.

EOT Sensor
Engine oil temperature sensor. Can be used by the engine protection system.

ECP Sensor
Engine coolant pressure sensor. Can be used by the engine protection system for over pressure (eg from a failed head gasket) or for a sudden loss of pressure (eg a burst radiator hose). On initial installation these sensors often show how poorly many radiator caps work as far as allowing the system to build & maintain correct cooling system pressure.

CCP Sensor
Crank case pressure sensor. These measure the pressure or vacuum in the engine crank case. These can be utilized by the engine protection system for when excessive engine blow by due to piston sealing failure. For sealed breathing dry sump systems they are used to help set up the optimum amount of crank case vacuum.

Turbo Speed Sensor.
This provides the ecu with turbo rpm. For ecus like Life Racing this can form part of the boost control strategy (particularly for turbo restrictor applications). This can also be used for evaluating turbo performance & diagnostics as well as making sure the turbo is not over speeding leading to damage. Many contemporary turbos are now supplied with a mounting boss for these making installation much easier.

COP Sensor
Compressor outlet pressure sensor. Measures the pressure of the air charge leaving the turbo compressor. This can be used for evaluating turbo performance as well as intercooler performance. When compared to the MAP sensor value we can then determine the pressure drop across the intercooler. A reasonable intercooler will have the COP around 1 to 2psi higher than the MAP value, anything much higher than this & the intercooler is too restrictive & costing power.

COT Sensor
Compressor Outlet Temperature sensor. Measures the temperature of the air charge leaving the turbo compressor. When compared to the manifold air temperature sensor the amount of temperature the intercooler is removing can be determined. As the temperature exiting the compressor is usually in excess of 120degC we are going beyond what a normal NTC temperature sensor can handle, so often a thermocouple style sensor is used here.

TIP Sensor (exhaust manifold pressure)
Turbine Inlet Pressure sensor. Measures the pressure in the exhaust manifold or put another way the pressure at the turbo's turbine inlet. This is a critical parameter for evaluating of how well matched the turbine is to the engine, particularly for high overlap engines. Because the temperature here is obviously high the sensor needs an arrangement to protect it from that heat, please contact for advice.
If we have exhaust EGT sensors in each runner then we also know the turbo's turbine inlet temperature, and in combination with an EGT probe post turbine we can determine the temperature drop across the turbine for performance evaluation.

AFT (aka airbox temp)
Air filter temperature sensor. Here we are measuring the temperature of the air at a point where the engine is drawing from, Usually in the air filter box, or turbo compressors intake pipe. Here we can make sure the engine is drawing the coldest possible air for best power.

The list goes on with sensors like Fuel Composition Sensor (aka Flex fuel, Ethanol content sensor), temperature sensors for gearbox, differential/s, power steer fluid, fuel, pre & post fluid coolers to evaluate cooler performance, fuel tank level and other fluid tank levels.