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With

Auto-Solve

Topic 8

Electronic Fuel Injection (Part 3)

This is a continuation of last month with our look at the sensors that affect the injection duration.

Air Flow Meters

Moving Vane

This type of Air Flow Meter is probably the most popular version and has been used on systems such as Bosch L, LE, LE3 and Motronic, Ford EEC IV. Several Japanese manufacturers have also based their systems around this tried and tested unit. The air vane meter adopts the principle of the airflow flowing into the engine and passing through the metering unit via a spring loaded flap, which in turn will move in proportion to the amount of air entering the engine. The air vane's movement is recorded by a 'wiper arm' moving across a carbon track, whose output is reported back to the Electronic Control Module (ECM) and gives the correct amount of fuel for the air recorded.

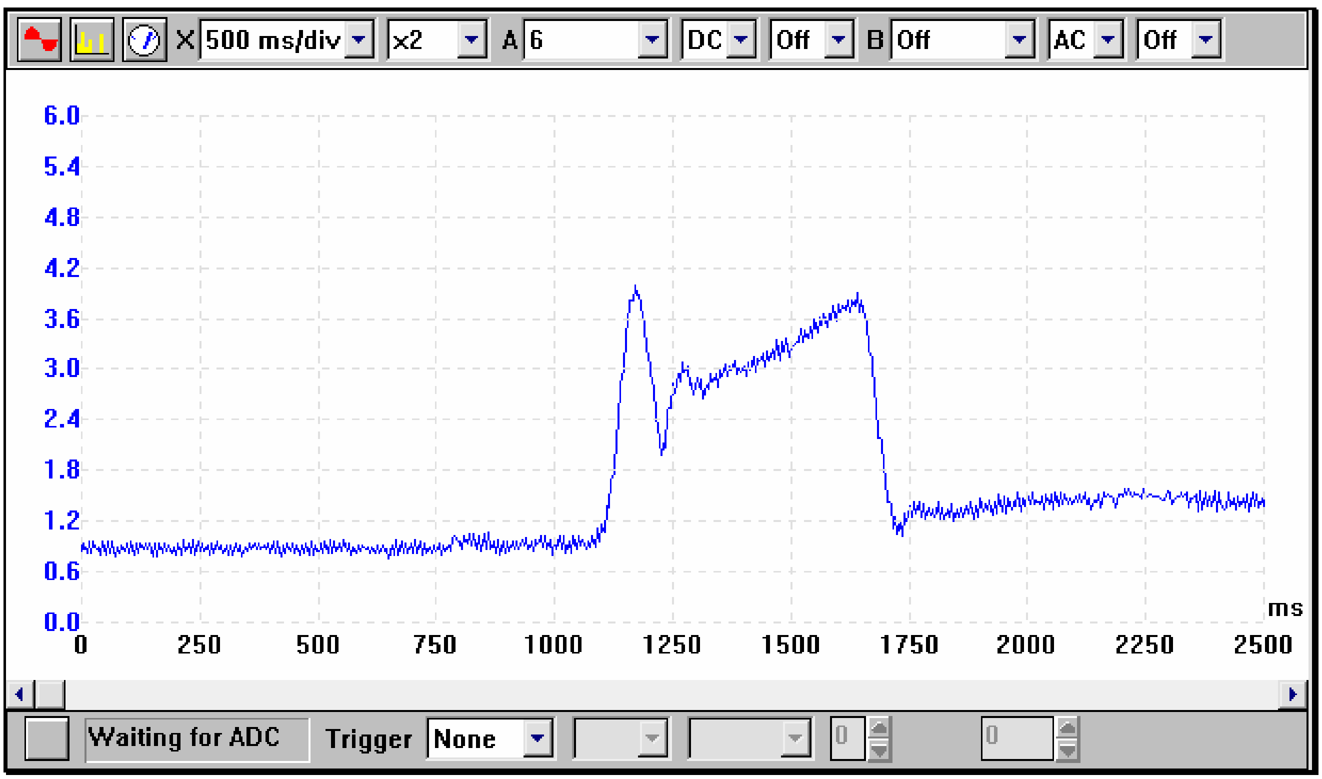

Fig 1.0

The voltage output from the internal track should be linear to flap movement and this can be measured on an oscilloscope and should look as detailed on the example shown in **Fig 1.0**.The waveform should show approximately 1.0 volt when the engine is at idle, this voltage will rise as the engine is accelerated and will produce an initial peak. This peak is due to the natural inertia of the air vane and drops momentarily before the voltage is seen to rise again to a peak of approximately 4.0 to 4.5 volts. This voltage will however depend on how hard the engine is accelerated, so a lower voltage is not necessarily a fault within the AFM. On deceleration the voltage will drop sharply as the wiper arm, in contact with the carbon track, returns back to the idle position. This voltage may in some cases 'dip' below the initial voltage before returning to idle voltage. A gradual drop will be seen on an engine fitted with an idle speed control valve, as this will slowly return the engine back to base idle as an anti-stall characteristic. A time base of approximately 2.5 seconds plus is used; this enables the operator to view the AFM's movement on one screen, from idle, through acceleration and back to idle again. The waveform should be clean with no 'drop-out' in the voltage, as this indicates a lack of electrical continuity.

The AFM will also have an internal compensation chamber that will stabilise the movement of the flap and avoid erratic movement from induction pulses. The co-mixture content adjustment when applicable, will be via an internal air by-pass or a potentiometer, depending on the version.

The AFM can have a varying number of electrical connections, from four electrical connections to seven.

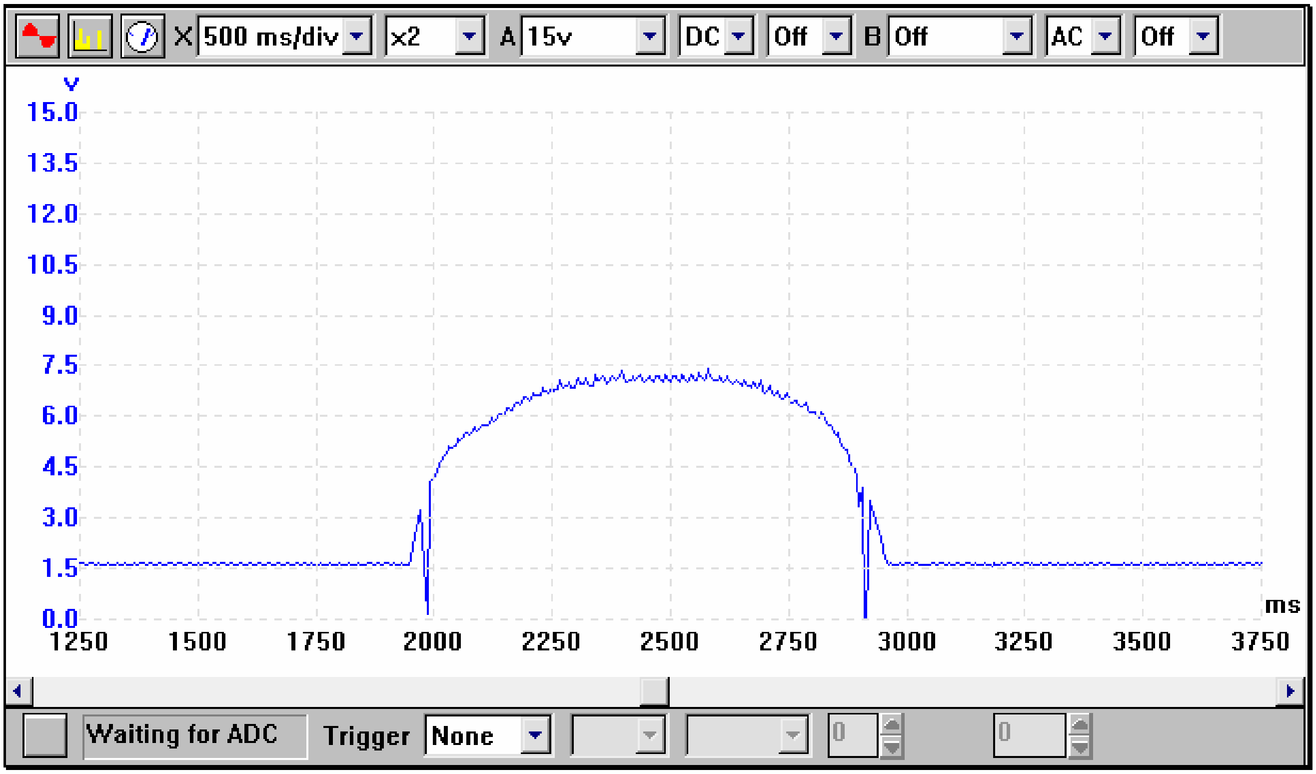

Fig 1.1

This particular 12 volt supplied Air Flow Meter (AFM) was used on early electronic injection systems and has the same operational qualities as the later 5 volt versions. The voltage *should* be seen to rise as the air vane is moved with no breaks or loss of continuity. The example shown clearly demonstrates that just as the vane moves a loss of contact is seen, with the same fault occurring again as the throttle is released and the engine returns to idle.

An AFM with this particular output would produce 'flat-spots' or 'hesitations' when driven. As the carbon tile has sustained damage the only way to rectify this problem is to change the unit for a new one. Removal of the plastic cover will invariably show the white plastic of the tile clearly visible through the carbon track. However this may only become apparent when the track is cleaned with a contact cleaning solvent.

Hot Wire/Film

The hot wire air flow meter is, in many ways, advantageous over the conventional air vane meter as it offers very little resistance to the flow of incoming air. The mass air flow is measured by the cooling effect on a heated wire that is suspended in the air passage, and it is the air flow's cooling effect on the wire that signals to the Electronic Control Module (ECM) the quantity of incoming air.

The AFM is once again located between the air filter and the throttle butterfly. Inside the component are two wires, one of which is used to convey the temperature of the incoming air and the other wire is heated to a high temperature (approximately 120°C) by passing a small current through it. As the air flows across the heated wire, it will have a cooling effect on it causing a temperature change; a small circuit inside the component will increase the current passing through the wire to maintain the temperature, and it is the recognition of this current that signals to the ECM the mass air flow.

The current supplied to the heated wire will alter proportionately to the airflow - any wire that is constantly heated will form an oxide coating. To clean the wire after each journey, a current is passed through the wire heating it to approximately 1000°C, burning off any build up, ensuring a clean wire for the next time the vehicle is started.

The operating principles for the ‘hot film’ version are almost the same but with a greater reliability factor, due to the absence of the heated wire that is now replaced with a solid-state component.

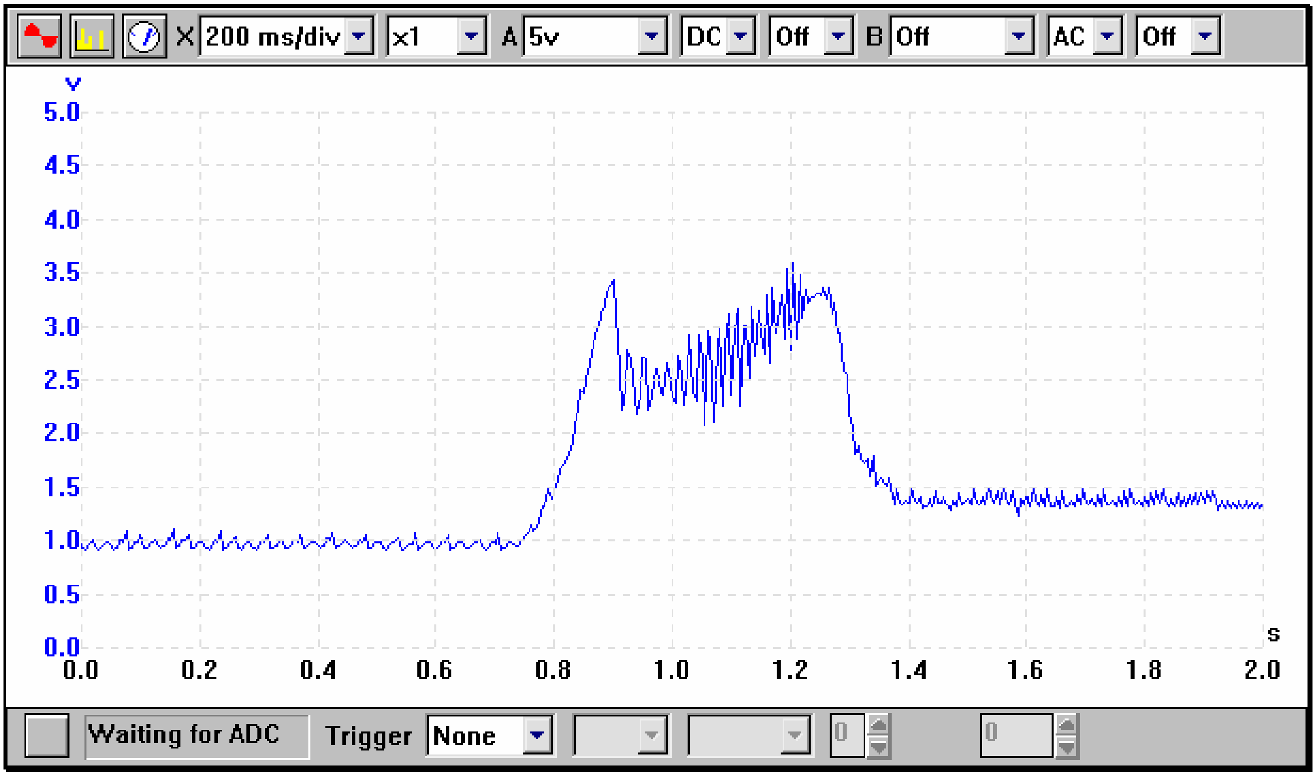

Fig 1.2

In the above example, Fig 1.2, there is evidence of 'hash' on the resultant waveform. This is caused by the cooling effect/pressure change caused by the induction strokes of the engine. This is quite normal to see. Once again the final voltage is higher than the initial voltage, due to the engine revving slightly higher as a result of the idle speed control valve operating an anti-stall factor.

MAP Sensors

The Manifold Absolute Pressure (MAP) sensor is employed to measure the vacuum in the inlet manifold. It is this output that when sent back to the engine management system can determine either the fuelling or the amount of vacuum (or light load) advance.
The sensor is a three wire device which will have:

- A 5 volt supply voltage
- An earth connection
- A varying analogue output
- A vacuum connection to the inlet manifold

Fig 1.3

This particular component can be either an integral part of the electronic control module or an individual component. The output from the external sensor will show a rise and fall voltage depending upon the vacuum seen.

When the engine is stationary or the throttle is wide open, zero vacuum will be recorded and a voltage approaching 5 volts will be seen; as a vacuum is applied the voltage will reduce. The example waveform clearly demonstrates that at idle a voltage of around 1 volt is seen, and as the throttle is opened the vacuum in the manifold drops and a higher voltage for these conditions is seen. In this particular case the voltage is rising to almost 5 volts. The 'hash' on the waveform is due to the vacuum change from the induction pulses as the engine is running.

Fig 1.3 shows the position of the MAP sensor and diagnostic connection made into the electrical circuit.

All voltages are similar between different manufacturers and a lower than anticipated voltage will produce a loss of power due to fuel starvation and conversely a higher voltage will cause over fuelling and could eventually result in the failure of the catalytic converter if subjected to long term abuse. This high voltage could result from any number of problems but may be as simple as a split vacuum hose or incorrectly adjusted tappet clearances. The voltage from an integral MAP sensor can only be evaluated when a Fault Code Reader (FCR) is used due to the lack of access to the output voltage.

In next months topic we will look at emissions related components and actuators