AECS Technical Article ~ Tragic Transit

This article is a true description of an AECS technical help desk problem and how it was solved.

Vehicle:
1996 2.5 Ltr Turbo Diesel (EPIC) Ford Transit van

Problem presented to the help desk
The van will fall back to idle during a long climb onto a hill, preferably when loaded with passengers. The engine has no throttle response after it happened. Turning the key off and starting again solves the problem, but it has caused some unsafe situations already.
The vehicle has the check engine light not on, and multiple fault codes were logged. All codes were erased and none came back.
The fault is intermittent and will sometimes not rear its head for weeks.

Where would you start?
An electronic controlled Diesel engine falling back to idle with no throttle response means it went into limp home mode. Limp home mode will only be activated when one or more ECU inputs are outside what the computer deems plausible.
When multiple codes are logged usually a common fault is found. That common fault can be power supplies, earths or technicians trying things. You can never be sure. We measured the power supplies and earths which all seemed fine to us. The technician involved was not the first on this job, so he could not tell us much about the history.
Okay let's think and cross components off the list which can not cause fixed idle limp home.
The pump shaft speed sensor, map sensor, fuel temperature, compensation resistors, timing position sensor, coolant temperature sensor, and intake air temp sensor could not cause this limp home situation.
None of these would be logical to check.

- A gross fault in the relation between the pump shaft sensor and crank shaft sensor could cause any sort of fault including this one.
- A fault in the 'more/less' quantity control valves could result in a limp home situation where there is no throttle response anymore.
- A fault in the 'drivers wish' signal could most certainly cause an idle limp home.

Crank shaft vs pump shaft relation
We made a recording of the relation between the pump shaft and the crankshaft sensors, during starting. During starting the 'thumping' of the engine causes the most strain on the timing belt and drive gears. Any fault will show during starting.

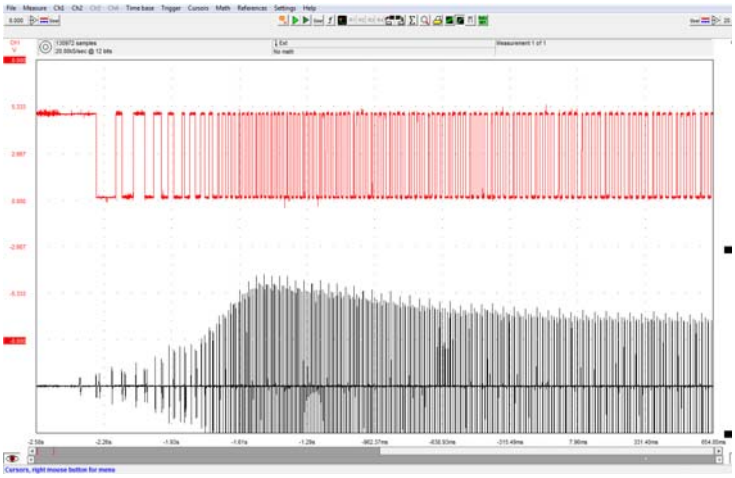

Figure 1 ATS 5000 scope recording of pump shaft sensor vs Crankshaft sensor.

You can see how the engine begins to wind over, catches on, flares and settles for idle speed by the inductive sensor's generated voltage height fluctuations. Not enough detail, so let's zoom in.

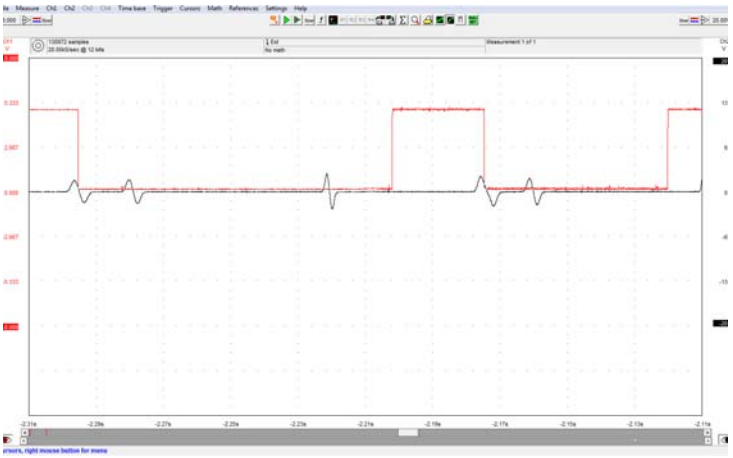

Figure 2 ATS 5000 scope recording zoomed in

Same recording, but zoomed in at the beginning of winding over. Look at the relation between the two sensors.

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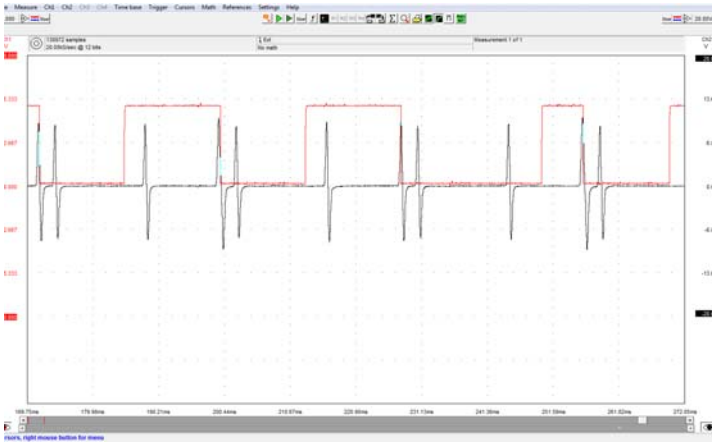

Figure 3 Same recording again but now while the engine has settled for idle.

Same recording again but now while the engine has settled for idle. Look again at the relation between the two signals.

I am happy that the tiny variations between the sensors signals are not the cause of any limp home condition. That is 10 minutes or so in time down the drain, but at least we where sure.

More or less

Let's look at the more or less valves on the pump. The more or less valves control the quantity of fuel entering into the high pressure part of the pump, so control the amount of diesel delivered to the injectors. The amount of Diesel controls the engine speed.

Even though the vehicle was not faulty at the time of testing it is good to check as something might stare you in the face.

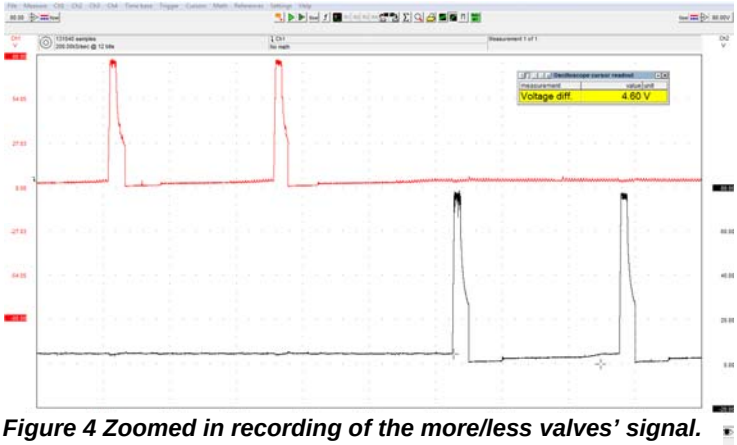

Figure 4 Zoomed in recording of the more/less valves' signal.

The recording of the more/less valves showed that both where working at almost the exact same voltages, which indicates to me that it is highly unlikely that one of them is faulty. Equally unlikely is that both develop the same fault at the same time. Again a few minutes down the drain, but it's good to gain confidence.

Accelerator position sensor

Next measurement on the list would be the accelerator position sensor. The accelerator position sensor has four circuits inside. An idle switch, a full load switch and two position sensors. All to check each other.

If only one position sensor were to be used on the pedal position sensor and a fault made the signal voltage increase, then the engine speed would increase accordingly. Nice if this happens when you are driving!

Math

First check the relation between the two position sensor tracks with a function build into the scope called 'math'.

The scope will run an extra trace where the voltages of channel 1 and channel 2 are added up (or subtracted). Since the two signals are each other's mirror image the outcome should be a steady 5 volt. With the math function you can see at any given moment if the signals stack up. A fault in one of the signals will affect the 'flat line' at 5 volts.

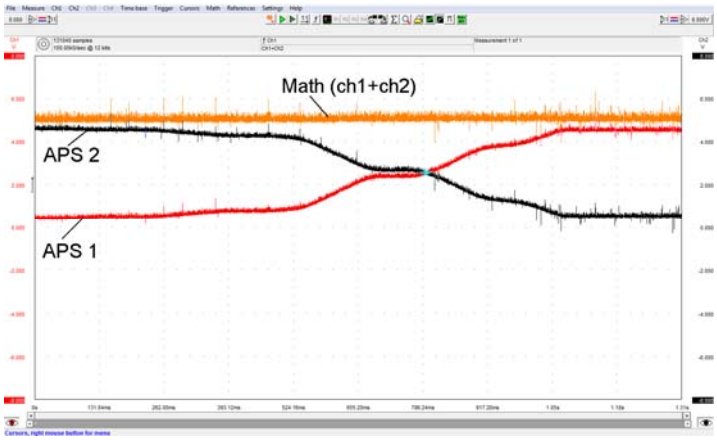

Figure 5 Dual channel ATS 5000 recording with math function.

Despite the hash on the signal there is no obvious fault in any of the two signals.

Let's record one of the traces in combination with the idle switch:

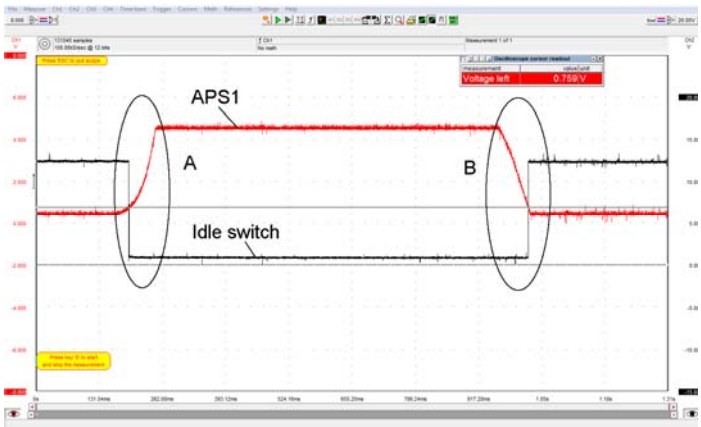

Figure 6 ATS dual channel APS 1 vs the idle switch recording.

Clear from this recording is that the idle switch functions correctly. It closes at 0.75Volt (A) and opens again at the same APS1 voltage (B

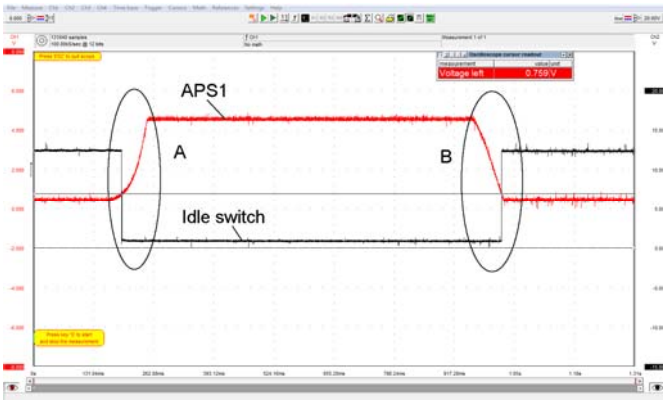

Figure 7 ATS dual channel APS 1 vs the idle switch recording.

Clear from this recording is that the idle switch functions correctly. It closes at 0.75Volt (A) and opens again at the same APS1 voltage (B).

Now record one of the traces in combination with the WOT (wide open throttle) switch:

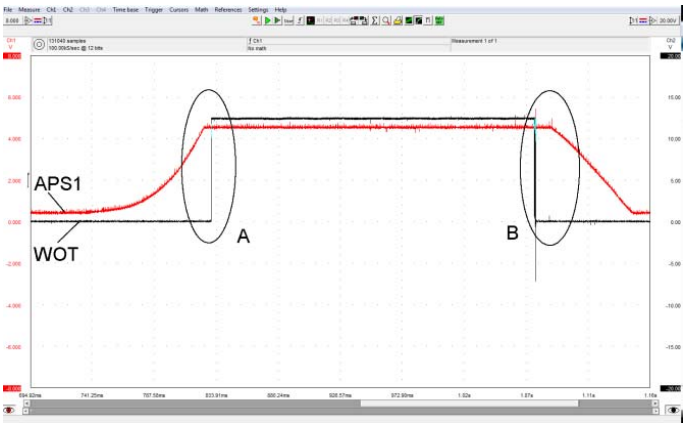

Figure 8 APS 1 vs WOT switch.

It is clear to see that this is not okay! At A the wide open position has been reached some time before the switch opens. The same happens just before throttle back off at B. Also there is not a clear cut off line at B.

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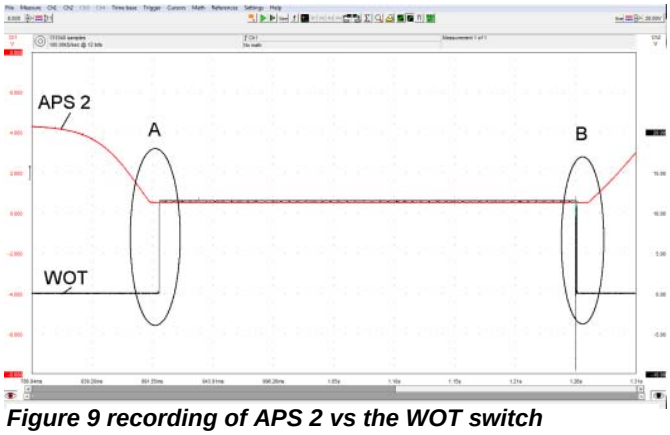


Figure 9 recording of APS 2 vs the WOT switch

The same can be seen during the recording of APS 2 vs the WOT switch.

Zoom in

Zoomed in on the falling slope of the WOT switch the problem becomes apparent:

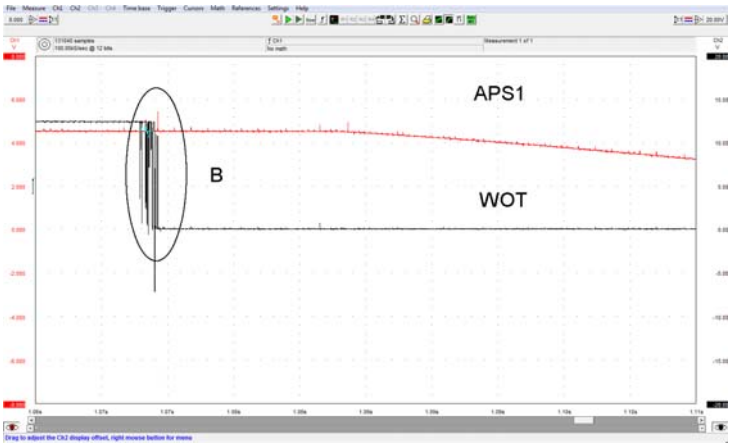


Figure 10 APS 1 vs WOT switch recording zoomed in

Found it!

The signal of the WOT switch flickers for a period of 1.5 milliseconds. This will send conflicting messages to the ECU!

Both the APS tracks inform the ECU of wide open throttle, yet the WOT switch sends a different message! Keep doing this for long enough and the ECU will not believe any of it anymore and falls back to idle limp home.

No the vehicle would not fail during the diagnostic process, but I am sure that this is where the problem came from. During full load driving (up hill loaded with passengers) the WOT switch gets actuated a lot and for a long period of time. During these prolonged periods you only need to have the switch playing up for a couple of seconds before the ECU decides that it has been enough.

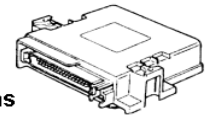
Fixed!
The APS has been replaced and the vehicle has not played up anymore.

Conclusion
How would you have solved this without your fast dual channel (or 4 channel) large buffer recording ATS scope and without support? Tell the customer to wait till the problem gets worse? How do you operate a passenger transport service when your technician tells you to persevere a bit longer? It does not increase the credibility of both the passenger service and the garage.

Please realise that there is no way that the fault could have been found with a multi meter, nor with a scan tool, as both these do not respond to fluctuations that happen multiple times within a milli second (1 msec x 1000 = 1 second).

System knowledge and the correct tooling made this job profitable and took away the doubt about what to replace or service. All time spend was charged for at a diagnosticians rate.

Automotive Electronic Control Systems



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For *AECS*
H.P. Leijen
(Trainer/Research)
Web: www.aecs.net
E-Mail: hpleijen@aecs.net
Ph 06 8749 077