AUTOMOTIVE ELECTRONICS

with NICK de VRIES MIAME, AMSAE, FI Diag.E.

Using a scope for vehicle faultfinding — 2

In my last column we started to look at the use of a lab scope in an automotive capacity, and this month we will explore this concept further. I am including some prints of waveshapes captured with a digital scope, to make things clearer. (Funny how the digital scope comes in so handy to illustrate an analog waveform!)

Carrying on with my theme of 'input signals', it seems (themes?) to be a good idea to mention a few of the more common waveshapes that the automotive technician has to be familiar with. Having promised to show you 'how to make sense of the squiggly lines', Fig.1 is a breakdown of the 'coil negative' signal for a traditional Kettering system, highlighting the segments of interest.

To include a view of even the more well-known faults that afflict the Kettering system would take several pages of illustrations and explanations, so I hope you will manage for now with just knowing what a good signal looks like.

With new developments in ignition coil design and manufacture, the coil negative or 'primary' waveshape has changed some of its basiccharacteristics.

Notably, the 'ringing' effect or oscillations have all but disappeared. Fig.2 shows, at 20 volts per division, the waveshape of a Ford EB fitted with a 'Transformer' coil (they were always transformers, but it sounds like a trendy name!); as you can see, aside from the different trigger point, there are significant differences from the waveshape in Fig.1.

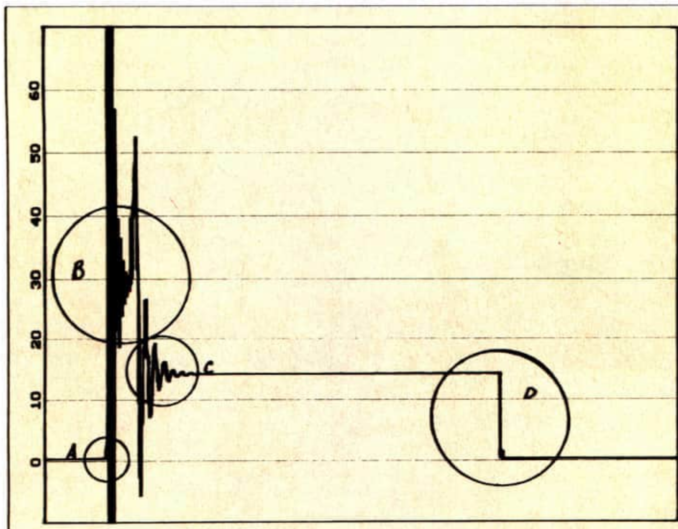
Coil positive wave

Those of you who have had some training in electronics may recognise the characteristic inductor charge-up waveform displayed in Fig.3, taken from the coil positive terminal. Only contact-breaker type ignition systems fitted with a ballast resistor in serie with the coil will have this type of wav — all other systems have the coi strapped to battery positive through th ignition switch.

If you are using a dual-trace scop on this and the coil negative signal try triggering the sweep off the rising edge of either input in 'chopped' mode to observe the timing relationship of th two signals.

The instant just before the coil is fired is the point where maximum current is drawn; to test for voltag drop in the switching circuit, measure the height above ground of the coi negative trace at this point, it should b no more than 0.3V.

Electronic ignitions have a variety of waveshapes, depending on the type of



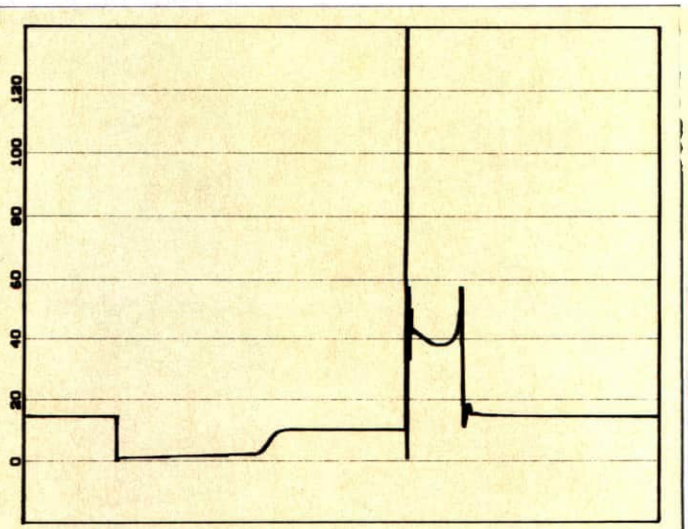


Fig.1 (left): The 'coil negative' signal of a traditional Kettering ignition system, with features of interest identified. A is where the points are opening, look for hash or arcing; at B are the primary coil oscillations, gradually decreasing over approximately 1.5ms; at C are the coil/condenser oscillations, where the coil energy dissipates down to system voltage; and finally D is where the points close again. This should be a clean switch down to ground. Fig.2 (right): Decades after Dr Kettering, we see here a very clean and hash-free primary ignition signal from Mr Ford. In fact, it's an EB Falcon six cylinder, with variable current control instead of a ballast resistor and thick film transistors instead of contact breakers.

current limiting used and the voltage at this same point will vary from 0.6 volts (one transistor) to about 9.6V with current limiting.

Purpose-built automotive scopes sometimes make this measurement for you and display a digital value of the reading just to make things easy; but as we are doing this with a general purpose scope, we'll have to persevere doing things manually.

Another common although little understood signal (from a testing point of view) is the oxygen sensor output. In the March edition of *EA* I included a snapshot of an oxygen sensor output signal, when the throttle was being oscillated between closed and about 50% open as rapidly as possible to observe the full scale transition and speed of the sensor.

In the interests of saving space, trees and ink, I'll leave the illustration out this time; however, the principle here is that the voltage ranges between zero and one volt depending on fuel mixture strength, and it also does it in a reasonably rapid manner.

The sensor in my VL Commodore measures about 80ms rise (lean to rich) and 40ms fall (rich to lean). A sensor that is 'dying' might take 150ms to fall from maximum rich to lean, which is much too slow when you consider how fast things are happening in the combustion chambers.

Knock sensor

On to another rare gem from the blurred category I alluded to in April's column under 'input signals'. Fig.4 shows the output of the knock sensor, caught in the act of 'hearing' a severe knocking or detonation in an over-advanced ignition timing condition. This is the familiar 'marbles in the cylinders' sound, often heard when inattentive drivers forget to change down a gear to drive around a corner.

The promise of technology in this application is that, providing the sensor is placed in the appropriate spot in the engine block, the signal is sent to the ECU at the onset of engine knock.

The ECU responds by retarding the ignition timing (or firing point of the next ignition cycle) by about two or three degrees, and gradually restores the full advance over a period of engine cycles.

If the engine is of a quiet enough design, with well-damped cam chains and hydraulic rocker arms, the ECU can be tuned to only retard the firing point on the offending cylinder, rather than a blanket 'all cylinders' approach. Some engine designs use this function, but I suspect that it is somewhat difficult to achieve with any sort of reliability in an overhead camshaft engine.

I believe some of the more exotic offerings from Europe have one knock sensor per cylinder, in an attempt to provide the maximum amount of advance possible for each cylinder and therefore not sacrifice too much power when fuel quality — for example — is not quite up to scratch.

At an Adelaide SAE meeting in February this year, guest speaker Ken Stanford, an engineer with Ford Motor Co., gave us an interesting snippet about knock sensor operation.

In the new EF series six cylinder engine, to eliminate any confusion in the ECU, it only 'listens' to the knock sensor when it is approaching the correct phase of the engine's ignition cycles. This blocks out any unwanted goings on at a similar frequency (7kHz), to prevent them from influencing the ECU unnecessarily.

Variable voltages

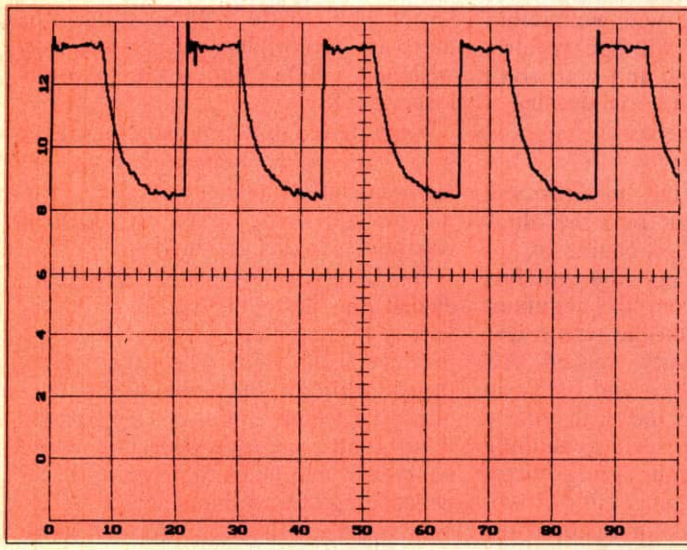
Now it's time to look at some signals from the 'Category Two' variable voltage group. This group contains only analog signals, with no timing implications whatsoever.

Fig.5 is the output from an air mass meter, with the engine accelerating from idle to high speed over a period of about 900ms. The initial surge is used by the ECU to calculate acceleration enrichment, similar to the accelerator pump in carburettors. Although the signal drops back to just above the idle value, the engine speed takes quite a bit longer to return to idle.

It would be nice to show you the acceleration and deceleration curves superimposed on this picture, but I don't have a tacho with a suitable analog output to use as a 'B' channel input. Does anyone have a circuit for such a device?

Here's a question, regarding the AMM signal of Fig.5. I haven't yet come up with a reason for the oscillations in the high speed range, perhaps someone can enlighten me?

The oscillations in the low speed end of the curve I'm happy to attribute to pulsations in the inlet manifold, the amplitude of which smooths out after the engine speed increases by about the 300ms mark, and the in-coming air stream becomes one continuous draft.



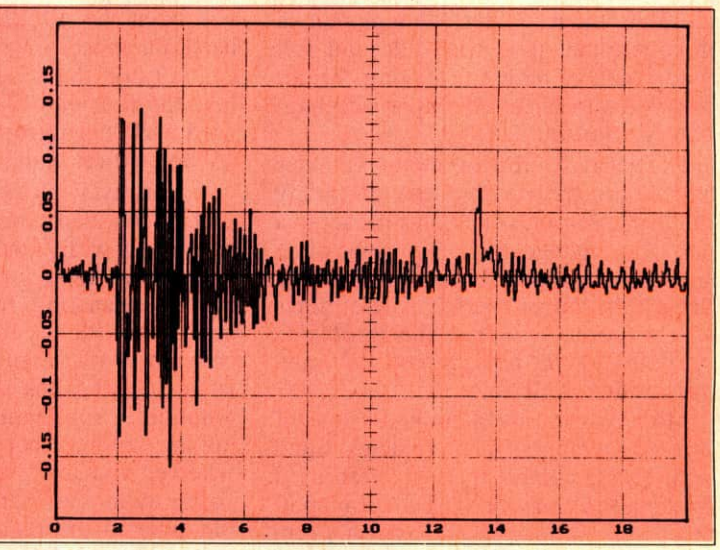
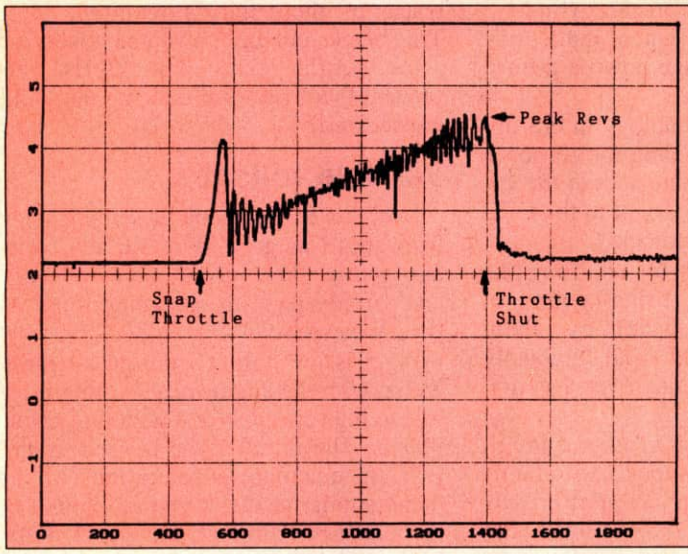


Fig.3 (left): The coil positive signal in a 'ballasted' Kettering system. Your DMM won't show this sort of detail... Fig.4 (right): Who's that knocking at my door? A knock sensor in full voice, care of an Audi in need of premium unleaded fuel. Your DMM definitely won't show you this, either!



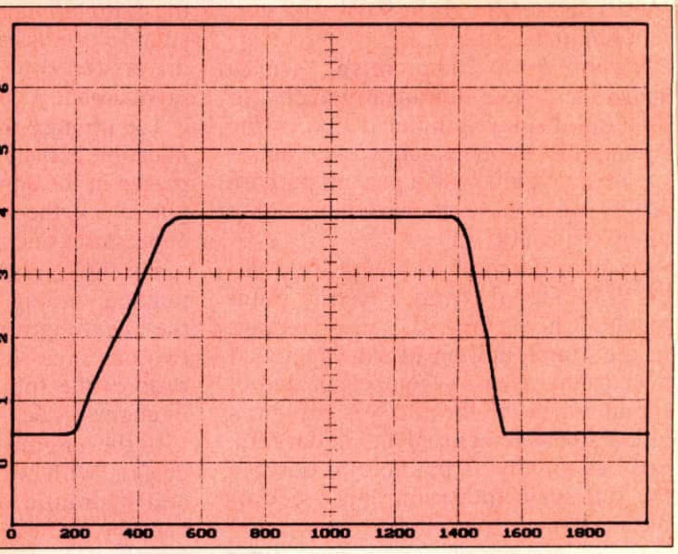


Fig.5 (left): An air mass meter with a problem? The engine was accelerating from idle to high speed over about 900ms. Note the oscillations, dying away and then building again as the engine revs increase. Can anyone explain what causes them? Fig.6 (right): Is the output from your throttle position switch as clean as this? This one isn't quite adjusted correctly, though.

But what's happening at the peak revs end?

Drop us a line, or give me a call on (085) 63 0607. Perhaps you have an idea what's going on, or maybe you would like to see an article devoted to a particular aspect of Automotive Electronics in a future edition...

Throttle sensor

An important function to test in EFI vehicles is the quality of the throttle position sensor (TPS) signal. There are three types that I am aware of; the early 'D' Jetronic EFI systems employed a type of grid and wiper switch, to give a digital signal that indicated both throttle position and the speed of opening or closing. Later systems employed a three-terminal type with idle and full load contacts built in, leaving the air flow/mass meter to determine acceleration enrichment.

The current crop of motor vehicles tend to use the variable resistor variety of throttle sensor, which must be set to a particular voltage at idle by means of an adjustable slotted clamping bracket. From this sensor the ECU determines idle position, how fast the throttle is opened ('struth, he's floored it!'), and the position at all times.

Most drivers use a limited range of throttle openings, and vehicles fitted with cruise control that are often used for long trips may develop a 'wear spot' at a particular load/speed position. From a servicing point of view there is little mileage in trying to repair the microswitch types, however it is sometimes possible to extend their life by judicious applications of 'contact cleaner'.

Triggering your scope to capture the signal from the variable resistor type of TPS 'on screen' long enough to critically inspect the waveshape is quite a ticklish little problem with an analog scope, and this is where the digital storage scope really shines.

Even so, it took me a couple of attempts to catch the trace crossing the screen at just the right moment and end up with the trace central in the screen (Fig.6).

If you set the trigger point for a rising edge on the external trigger input, and touch the probe for the trigger input on the battery positive terminal just before you open the throttle with your other hand, the sensor trace will appear fairly centrally on the screen and you won't lose the first part of the rising edge. I used a 200ms/div timebase setting and 1V/div vertical scale.

A tip: my vehicle has an electronic voltage regulator built into the alternator, and with 'key on engine off', I could just make out a high pitched squeal emanating from the regulator area. The TPS trace on the screen was covered with regularly spaced AC spikes about 50ms apart and 0.25V in amplitude, similar to the hash you're hoping to see/not see, depending whether you make your living out of fixing motor cars. Unplugging the two-pin plug to the regulator restored the trace to smooth DC.

Things to look out for are 'hash' at the beginning and end of the TPS trace where the throttle sits at idle, and also at the lower end of the rising and falling edges of the slopes where you would expect the throttle to spend most of its working life.

Now that I'm looking at the printout of Fig.6, I've just realised that the sensor isn't quite set correctly! The closed voltage should be 0.5 - 0.9V and the fully open voltage should be 4.0 - 5.0V. I'll be back in a minute, after I fix it...

Back again, and it's time for some philosophy. I hope you are beginning to realise the importance that the oscilloscope is playing in diagnosing customers' complaints about their motor cars. The digital multimeter or 'DMM' is a great tool and I wouldn't know what to do without mine, but there are some jobs you just can't do without a CRO or digital storage oscilloscope (DSO).

As technology brings new and ever more complex enhancements to everyday affordable motor cars, technicians are being asked to lift their capabilities higher and higher.

One approach is a list of voltages for every pin on every ECU of every variety of motor car, but this is likely to produce technicians who cannot think things through to a diagnostic conclusion. I feel the only sensible solution is to train yourself, with the aid of equipment that helps to promote an understanding of how things work.

In my final episode in this scope series, we will look at some ECU output signals and how the ins and outs interact. ❖