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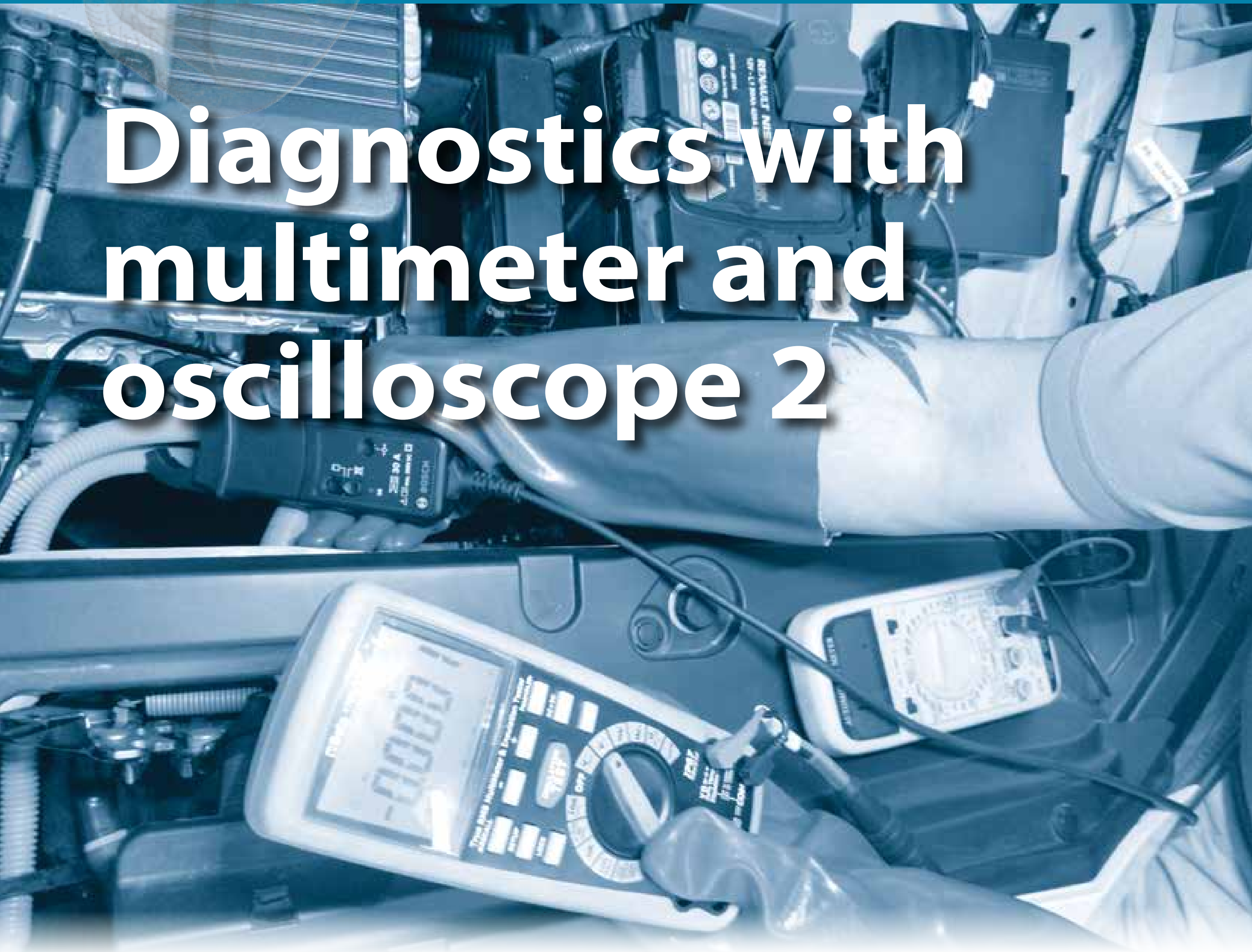

Diagnostics with multimeter and oscilloscope 2

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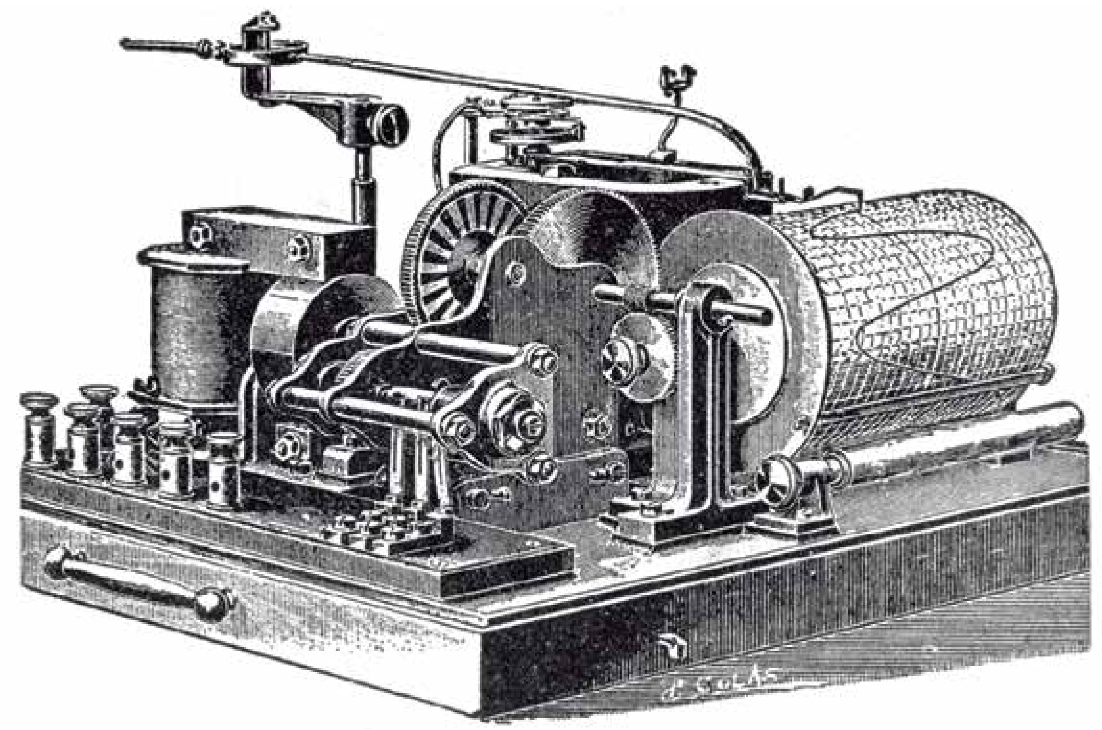
ELECTROMECHANICS AND OSCILLOSCOPES

The measurement of electric current is the method for diagnosing and checking the electrical systems, due to the intrinsic invisibility of both the power and electrical characteristics of the matter.

When the electric current values are invariable, we usually refer to them simply by their name, expressing that the voltage and intensity have a determined value, which is assumed to be constant when the circuit is active.

However, the operation of great part of the automotive electric systems is necessarily variable in order to adapt to the unpredictable driving conditions, climatology or changing safety and comfort requirements, which establishes a variable or even a discontinuous relationship between electrical values and time, called signals. The electric current variation in voltage, frequency, period, intensity, or the combination of the four of them, represents by itself the principle of operation regulation and the principle of data transmission, which allows the electrical systems to adapt to the physical variables related to its function.

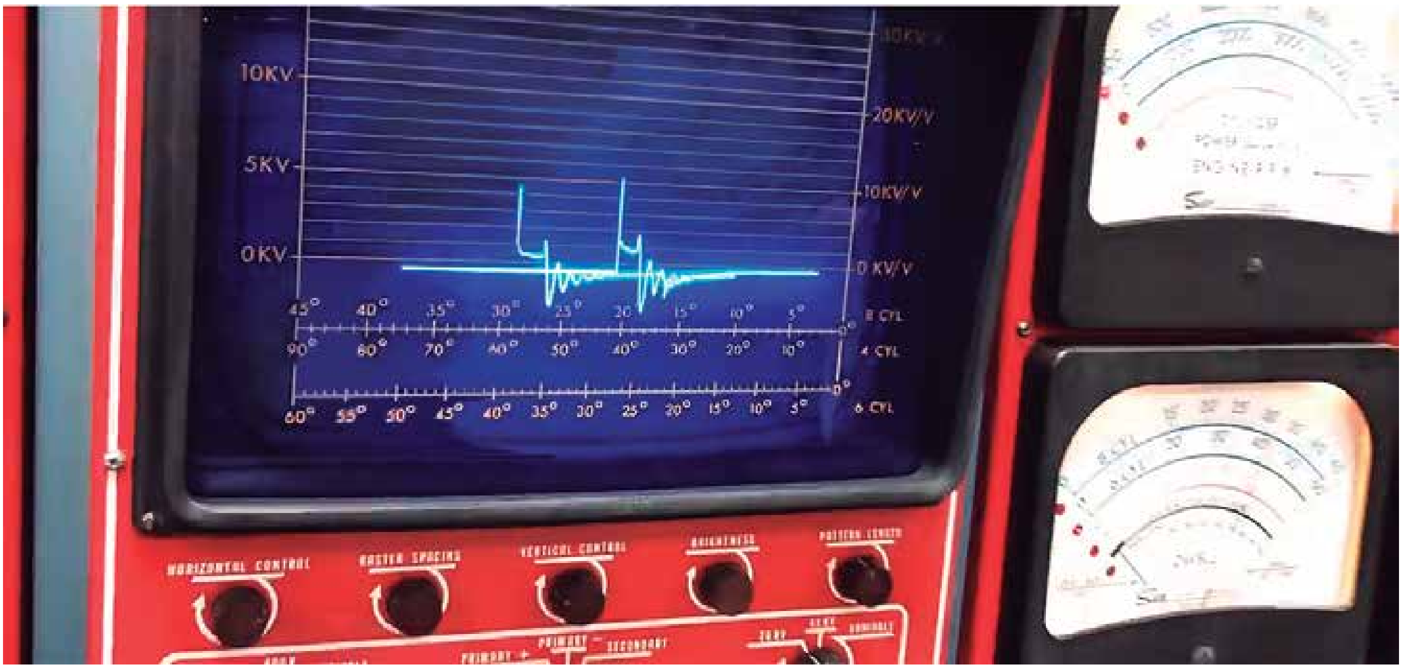
The reaction speed, regulation accuracy or increase of transferred data entails the existence of increasingly changing or fast signals. The data interpretation and analysis of their evolution in numerical format is only possible, for the human being, in the past and with obvious speed limits. For centuries, these related data are represented using diagrams to make them easier to understand. Positive quadrant graphs of Cartesian axes (in honour of René Descartes 1596-1650) are the most used ones when time is one of the variables.



The need to represent electrical signals graphically is as old as the discovery of alternating current. Nevertheless, the first tool able to perform this function in real time didn't appear until 1893, when André Blondel created the mechanical oscillograph.

The development of the first electrical oscilloscope had to wait until 1899 when forming plates and trace sweep were incorporated on the green phosphor screen, derived from the cathode-ray tube invented in 1897. Its usage was delicate and quite limited due to the difficulty to fix the image on screen for irregular pattern signals. This functionality didn't arrive until 1946, when Howard Vollum and Jack Murdock presented a synchronised sweeping system with an adjustable voltage value, derived from the military technology developed during the Second World War for the sonar equipment of submarines.

First automotive oscilloscopes were developed in the '60s and discretely reached workshops in the three following decades, as they were conditioned by their high cost and limited functionality. Their purely analogue operation set aside their usage in the ignition system diagnostics. The operating voltages of 6V and 12V of the remaining electrical equipment of automobiles were insufficient for their representation on screen without an amplification system that, being analogue, would unavoidably alter the nature of the signal, distorting in an unpredictable way their graphical representation as a function of time.



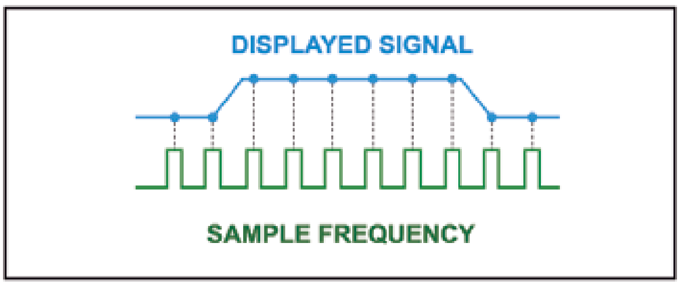
It is true that in that period there was no major need for the diagnostics and repair, being the multimeter sufficient for the measurement of the few variable signals introduced by the newly incorporated systems in cars. After the invention of the silicon transistor, firstly electronics and then informatics would change the world and automobiles, simultaneously creating the need to represent graphically electrical signals of low voltage and high speed. The tool able to do this is the digital oscilloscope.

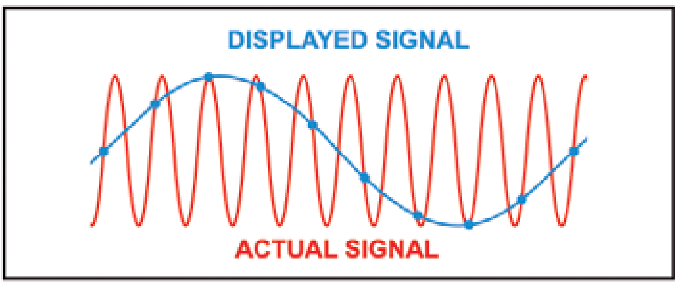
It is obvious that the expected operation of newly created electronic components and circuit can only be verified by means of a tool able to show with absolute accuracy their electrical "behaviour". To do so, it must be much faster than the signals that are sought to be evaluated. Clearly this tool created for the check and development is used as a diagnostic tool, therefore, it must be equally valid for repairs.

DIGITAL OSCILLOSCOPE

The oscilloscope is a tool developed to graphically represent the difference in electrical voltage. It is of adjustable scale and non-proportional ratio. These two features are necessary in order to analyse amplitude and frequency variations in signals, making it necessary to adjust or condition the equipment to the characteristics of the measured signal.

Digital oscilloscopes differ from analogue ones in their operating principle, which consists in transforming the periodically measured voltage values into data in binary format that duly recalculated can be represented graphically in different formats. For this purpose, they use a buffer and a processor that is able to perform the required mathematical operations in order to define the final position of each value on a grid-axis system. The value of each segment both vertically (voltage scale) and horizontally (time base) is selected by the user, allowing to visualise the signal in real time or specific duration portions of it.





The same functional structure allows the simultaneous representation of two or more signals, with several input channels available, which using the same time base and with a single trigger event allow the independent adjustment of the vertical scale or voltage. The maximum frequency of data acquisition together with the coding format of the recorded values determines the ratio between the amplitude and signal change speed that a digital oscilloscope can reliably display. This parameter is called bandwidth and indicates the frequency at which the displayed figure of a pure sine wave is 70.7% of the actual value of the maximum signal voltage.

It is considered that for reliable diagnostics, the tool bandwidth must be at least 3, but preferably 5 times the frequency of the signal that is being studied. This way, the systematic repetition of the capture allows to represent the signal with the minimum margin of error when it maintains a repetitive pattern.

The encoding format in bits indicates the number of end values available in the voltage range selected for the conversion of the input signal into digital format, giving a greater or less vertical accuracy to the displayed data.

A/D	8 bits	10 bits	12 bits	16 bits
Voltage values	256	1024	4096	65536

The voltage sampling rate and the digital encoding format limit the number of values that fit in the memory, establishing a maximum record length.

The digital nature of the tool allows to enlarge and reduce the input values with absolute accuracy, offering a very wide range of voltage measurement, limited by maximum values due to the electronic nature of the tool.

The voltage difference of the input signal must never exceed the values established by the manufacturer, being the use of input attenuator required for the analysis of signals of greater amplitude. The use of a microprocessor with superior performance features than the strictly necessary for the signal representation allow to implement additional functions of signal detection, capture, retention and measurement by means of specific additional software.

OSCILLOSCOPE IN THE CAR WORKSHOP

In the last 50 years, automobiles have turned from fundamentally mechanical devices into a compilation of electromechanical components controlled by electronic units, as established in a working programme known as software.

The software is also the basis of self-diagnostics, which by means of mechanisms of logical or mathematical deduction, monitors the results and detects poor performance of components and functions. When there are fault codes available, their precision is relative. The fault may be one, but its possible causes may be several. The repair depends on a procedure of logical, effective and ordered diagnostics.

Currently, the diagnosis of great part of the components, both electrical and electromechanical, implies to check one or several electrical signals, many of them variable and high-frequency signals. Due to the nature of the signals used nowadays, in both data communication and operation regulation, on many occasions this check is only accurate and valid if using an oscilloscope.

In car electronic systems, in many cases, the check must be performed dynamically, with the vehicle driving to reproduce the conditions under which the improper operation is produced. The cumulative measurement of oscilloscopes, the possibility to programme the conditions of data acquisition and even to memorise them are an unquestionable advantage in the detection of intermittent faults if compared with the multimeter, even when it comes to continuous signals.

The enormous evolution of informatics has contributed to the development of digital hand-held oscilloscopes. Those oscilloscopes that are specific for the automotive sector stand out by their working power supply of 12V or 5V, which allows the signal check while driving without limitations supplied by connection to the vehicle electrical system or by USB port.

Nowadays, consumer computing provides general public with portable devices whose graphics and calculation performance largely exceed the requirements of an automotive oscilloscope, encouraging the development of interface oscilloscopes. Their objective basically consists in the digitalisation and transmission of the measured voltages, offering the same advantages as the integrated equipment, but at lower cost. Together with the work software installed in a compatible device, they allow to afford a hand-held workshop oscilloscope with a wide and colour display panel, which is very useful when working with several signals simultaneously, a task that multimeters cannot perform either.

Many self-diagnostic tools incorporate the function oscilloscope. However, they cannot be compared due to the channel limitation and excluding condition of their integration, which prevents from visualising simultaneously the self-diagnostic data and signals by means of the oscilloscope.

Technical specifications of an oscilloscope interface for their usage in a car workshop are as follows:

	Channels	Bandwidth	Sample rate	Input voltage	A/D	Temperance
Minimum	2	5 MHz	10 MS/s	0 – 80 V	8 bits	1 MΩ
Optimal	4	≥ 10 MHz	≥ 20 MS/s	0 – 200 V	≥ 10 bits	10 MΩ

Note: In some digital oscilloscopes, the sampling capacity and on occasions the bandwidth as well are distributed between the number of active channels.

As we will see later, the number of channels needed is at least two, being highly recommended to have 4 and impractical to have more than four.

We must bear in mind the electrical insulation of interface channels between them and with respect to the power supply. In many oscilloscopes, channel grounds communicate internally. This peculiarity has the advantage that the reference negative or zero of all signals does not have to be connected to operate and the inconvenient is that, if reference lines are connected to different electrical potentials, a short circuit will be produced through the tool. In devices with isolated grounds, the difference in operating voltage between them is usually limited as well.

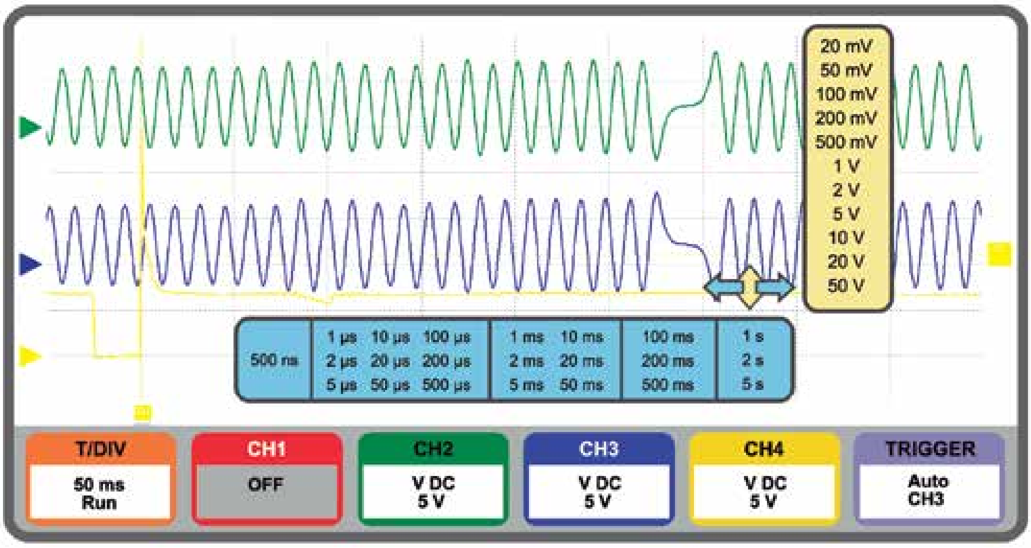
The characteristics of the used IT support depend on the work software and must correspond or exceed the specifications of the interface manufacturer. It is recommended to choose a device with a touch screen of 10'' or higher, with both Wi-Fi and Bluetooth connectivity and two independent USB ports.

The interface + equipment configuration facilitates the location of the interface in the surroundings of the testing area and control device area and visualisation at certain distance, which turns out to be very practical, especially in dynamic tests. The shorter length and exposure to the measuring lines as well as comfort are a factor to be taken into account too.

PRECAUTIONS AND INITIAL ADJUSTMENT

The oscilloscope graph panel is formed by a grid that displays voltage in its vertical axis and time in its horizontal axis. The value of each segment or partition can be adjusted by several multiples and submultiples of the main units of these two magnitudes, defining the measurement amplitude and time duration of the signal recording. This adjustment defines the vertical and horizontal scale in which the signal is displayed and conditions its graphic representation in the available area.

In the automotive field, an **initial adjustment at 5V and 1 ms** is usually sufficient to frame most of the signals in the field of vision. Afterwards, lower values must be selected to increase the signal size or higher values to reduce it. If on the scale of 10V by partition, the signal or part of it is not displayed on the screen, it is very probable that its maximum voltage exceeds the voltage difference of the maximum input measurement, which makes it necessary to use a signal attenuator to avoid the irregular operation and any possible damage to the tool.



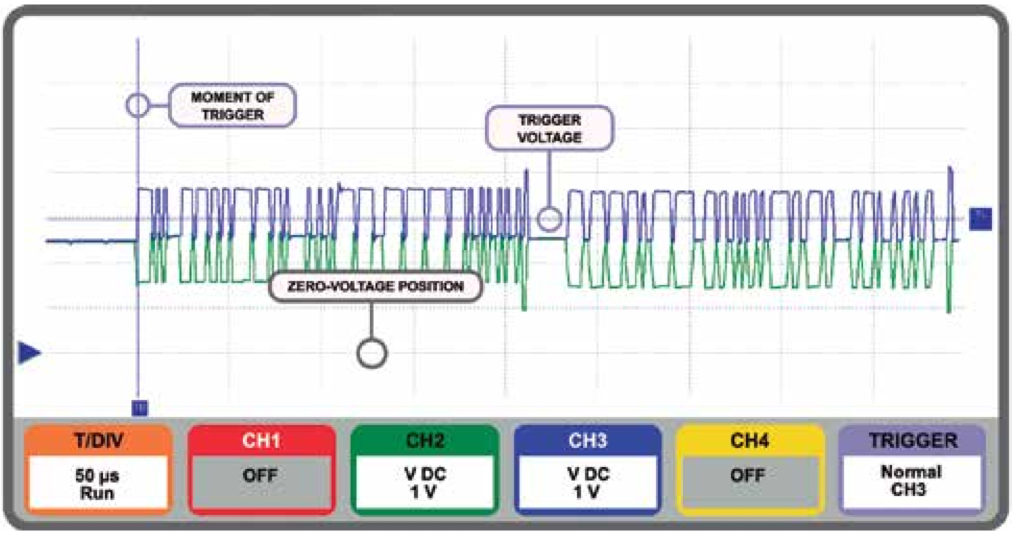
Adjust the voltage scale of the channel until the signal occupies between 50 and 70% of the vertical space.

The type of signal must be selected, indicating if it is alternating or continuous. In alternating mode, the data processor eliminates the continuous component of the signal, displaying only the variable component on the 0-volt line. This adjustment is very useful for analysing continuous signals whose variation is very small with respect to the average value of the signal.

After the vertical frame, the signal should try to be stabilised and located horizontally to make its analysis and measurement easier. To do so, the **trigger** should be **regulated**, adjusting the voltage and start event edge (trigger condition) and selecting an operating mode and graphic refresh. The options that are usually available are:

- **Auto**: It displays the data achieved in the interval defined by the time base, refreshing the image without the need of trigger condition. If the trigger is produces repeatedly in the recording time, the image is fixed in an approximate manner.
- **Normal**: It only achieves and refreshes the image when the signal meets the trigger condition, displaying a new event after the recording time has run out.
- **Single**: It displays the signal that fits in the recording time after the trigger condition has been fulfilled in a single and static representation that is only refreshed manually.

The edge can be rising or falling, indicating evolution to positive or negative value respectively.



Typically, the trigger is provided on the same channel as the signal that we wish to visualise. The practical adjustment of the trigger depends on the type of signal:

Analogue signals that are non-repetitive or discontinuous in time: automatic mode, trigger voltage lower than the signal minimum value and rising edge. The signal will be displayed continuously and will refresh cyclically on the screen when the selected acquisition period or maximum recording length has finished (whatever occurs first).

Analogue signals that are repetitive, inductive (sinusoidal) or square: automatic mode and trigger voltage at 50% of the signal amplitude variation. Possibility to change into normal mode to fix the image with higher accuracy. (If the signal is not a continuous or a regular-cycle signal, the image will freeze). Indifferent edge except in actuators controlled by ground, in which falling edge is better.

The time-base control determines the portion of displayed signal. Ideally, the integrity of the individual signal (complete cycle) and signal continuity should be displayed, increasing the time base to confirm the repetition of the shape pattern in several consecutive working cycles.

WHAT SHOULD I PAY ATTENTION TO?

After framing the signal in the visual space available and fixing its position, the signal should be checked, which consists in measuring it and analysing its shape pattern.

For many years, the general opinion has been that for the diagnostics with oscilloscope, a wide knowledge of signal patterns was required in order to compare the image displayed on the screen with the theoretically correct one. This consideration was acceptable 40 years ago, in the age of analogue workshop oscilloscopes and the analysis of the ignition system. During the coil charging time, the voltage development used to display the condition of the points, capacitor or even the contact breaker itself, in the same way that the evolution of the spark voltage used to indicate the compression, nature of the air-fuel mixture and condition of the high-voltage distributor or ignition cables. To sum up, many variables in only two signals.

Nowadays, the ignition system is static, offering such high levels of performance, reliability and capacity of self-diagnostics that their relationship with oscilloscopes is practically inexistent.

Over the past 30 years, electrical knowledge of repair professionals has significantly increased thanks to training, both initial and continuous, and the appearance of technical-support platforms. The edited information for the diagnostics and repair in many cases include reference patterns for signal checks, facilitating labour, which in fact is not so complicated. On most occasions, it is about continuity, verticality, horizontality and logics.

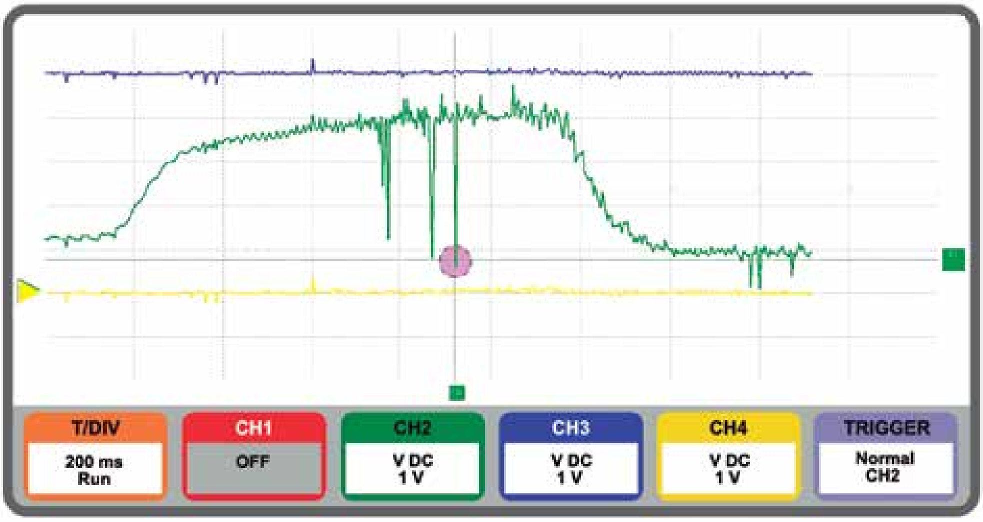
Continuity

Particularly, in analogue-type signals such as the ones of temperature sensors, position potentiometers, distance Hall sensors or pressure sensors, and in power supply voltages, the sporadic or occasional interruption of the signal, even for milliseconds, is the cause for fault codes, associated or not to faulty operation. When the cut is very short, it is improbable, almost impossible to confirm it by self-diagnostic parameters or by measuring with a multimeter.

The “almost continuous” data acquisition of the oscilloscope (thousands of times per second) and the trigger adjustment in normal mode turn out to be infallible in these situations.

The acceptable measuring and voltage range of the signal in this type of sensors is defined by the voltage that they receive minus a reduction percentage aimed at detection. The self-diagnostics detects the interruption, line derivation to positive or to ground, when the signal voltage exceeds or does not reach the values of a valid working range.

By adjusting the trigger in automatic mode with a large time base, the signal refresh will be cyclic, displaying the progress of the valid and acceptable working values. The adjustment in normal mode of the trigger threshold and voltage level under (falling edge) or above (rising edge) the “normal” working values seen before, with a short time base, conditions the graphic representation of the signal, which will be only produced in the event of non-valid voltage and the graphic confirmation of the fault will remain on the screen until the fault reappears again.



In positive power supply voltages, the same strategy, by adjusting the trigger voltage in a value of 10% lower than the usual one or theoretical one, allows to detect insufficient or faulty power supply circuits. The existence of intermediate connectors with excessive resistance, burnt relay contacts or faulty transistors are usually the cause for these variations.

The technique for negative power supplies is the inverse one. It is considered that a negative power supply, power or electronic, is not correct when its value with respect to the vehicle ground exceeds 150-200 mV. By adjusting the trigger in rising edge, normal mode and 200 mV voltage, the graphic representation of the signal will indicate the fault in the line or unit, which provides the power supply.

We can consider this adjustment mode of the trigger as a weight trap to hunt elusive animals. When it is strategically placed, well-adjusted and permanently assembled, if the animal passes over, the trap will capture it.

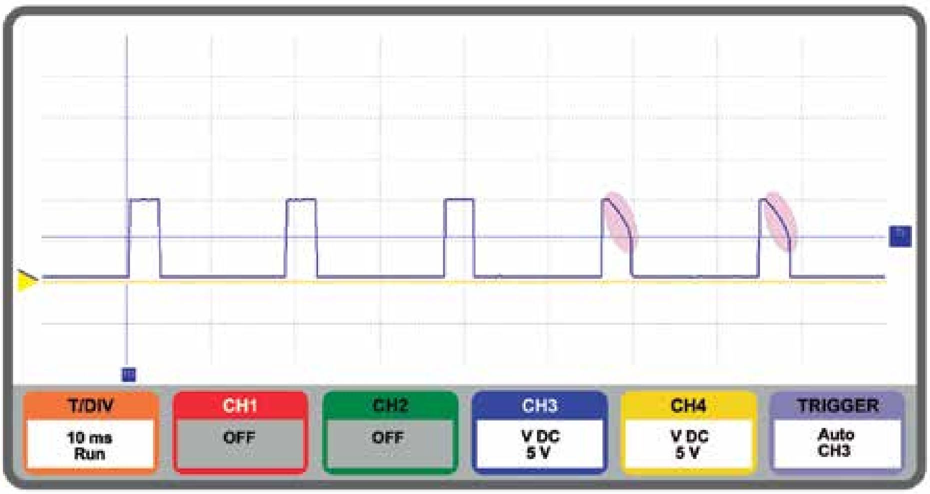
Verticality

The verticality analysis in the displayed signals always remains subject to the used time base. It is only valid when the time base is short, that is, for fast signals.

The graphic representation as a continued line is the union of successive points or voltage values.

Instantaneous voltage changes are typical for electronics and not typical for most of the components or electric circuits that are not electronic, in other words, resistive, inductive, electromagnetic, etc.

An instantaneous voltage change derived or caused by a real variation of temperature, position, pressure or acceleration is physically impossible. Except for the light, the other physical parameters related to automobiles cannot change so fast, therefore, any transaction that is too vertical in analogue signals of this nature indicates electrical faults, in other words, in the circuit or sensor element.



For the detection, it is recommended to adjust the trigger in automatic mode, which coincides with the average value of the signal and a fast time base (lower than 10 ms). The existence of vertical lines or needles is not acceptable. By adjusting the trigger in single acquisition mode on the approximate average value of the observed vertical lines, the snapshot of the anomaly can be captured in order to determine its importance. The comparison of the vertical line with the progression or evolution of the signal before or after the trigger event turns out to be the most effective tool for the evaluation.

In contrast, in electronic circuits and signals, verticality of signals is characteristic, correct and necessary. The working speed and capacity of these systems is precisely based on the possibility of semiconductors to change their condition instantaneously, allowing or not the flow of currents, usually of low-intensity and reduced voltage.

In this case, verticality and quadrature of signals is required and must be checked. The appearance of saw teeth, diagonal lines, irregular transactions or curves indicates problems in the emitter, receiver or electrical conductor that joins them.

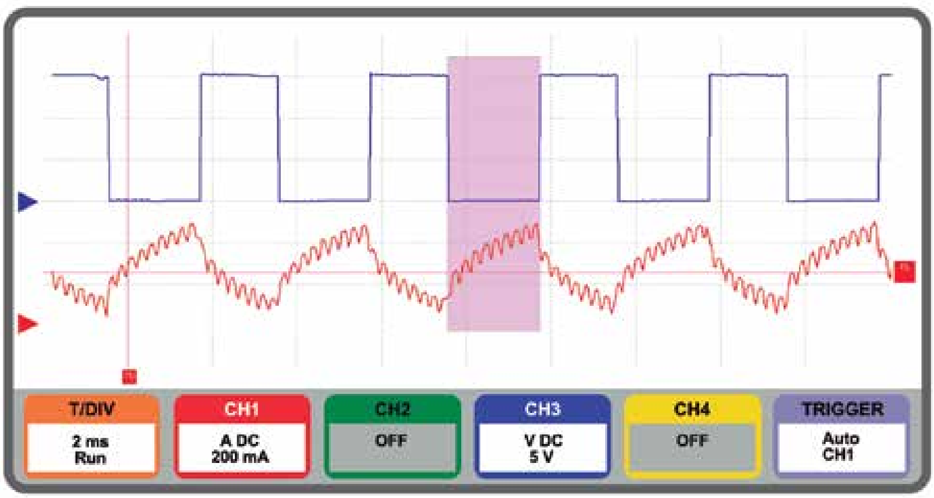
Horizontality

Digital-type signals (square), control lines by connection to negative/positive, stabilised power supplies (usually 5V) or ground must keep stable values in their periods.

Graphically, this voltage maintenance is displayed as horizontal lines, which must be straight and without variations, at least when the line operates actively, that is, when current flows through it. This is the reason why, in the first place, we should know the active period of the line.

In data communication or electronic control lines, the active period is 100% of the signal. They are lines of between two or more electronic elements in which the current intensity is very low.

However, in control lines of electromechanical devices, the active period is the one that controls the work performed by the consumer, modifying the electrical power that the actuator receives. This regulation can be continuous or intermittent and, in some cases, determines the working moment and duration. In these cases, in order to identify the active period, if the signal pattern is not previously known, it is necessary to use a second channel in the oscilloscope that displays the evolution of the electric current.



To that end, it is necessary to use an accurate current clamp, arranged on the control or power supply line of the actuator. The active period of the signal coincides with the cycles in which current intensity is different from 0.

Control signal horizontality must be checked in the periods in which current increases or is stable. Any variation of more than 200 mV indicates a problem. However, when current is null or decreasing, the voltage variation above this value is not relevant, as it does not modify the applied power. During the non-active period, the potential measured in signal lines is caused by the electrical continuity of the consumer, which receives the same continuous voltage through the opposite end.

The measuring range of the current clamp must be adjusted as much as possible to the maximum electrical consumption of the component that is being tested. Generally, current clamps with an operating margin of between 20 y 60Ah are sufficient. Digital automotive oscilloscopes have an adjustment menu that allows to select the measuring range of the equivalent current or voltage.

In electromagnetic actuators, it is recommended to place the measuring ring of the current clamp at a safe distance from the component connector in order to prevent the magnetic field from altering the measurement.

By widening or reducing the time base, we can obtain the detail of a single control cycle or the visualisation of several consecutive cycles, which allows to observe the coherent evolution, alteration o even interruption if produced.

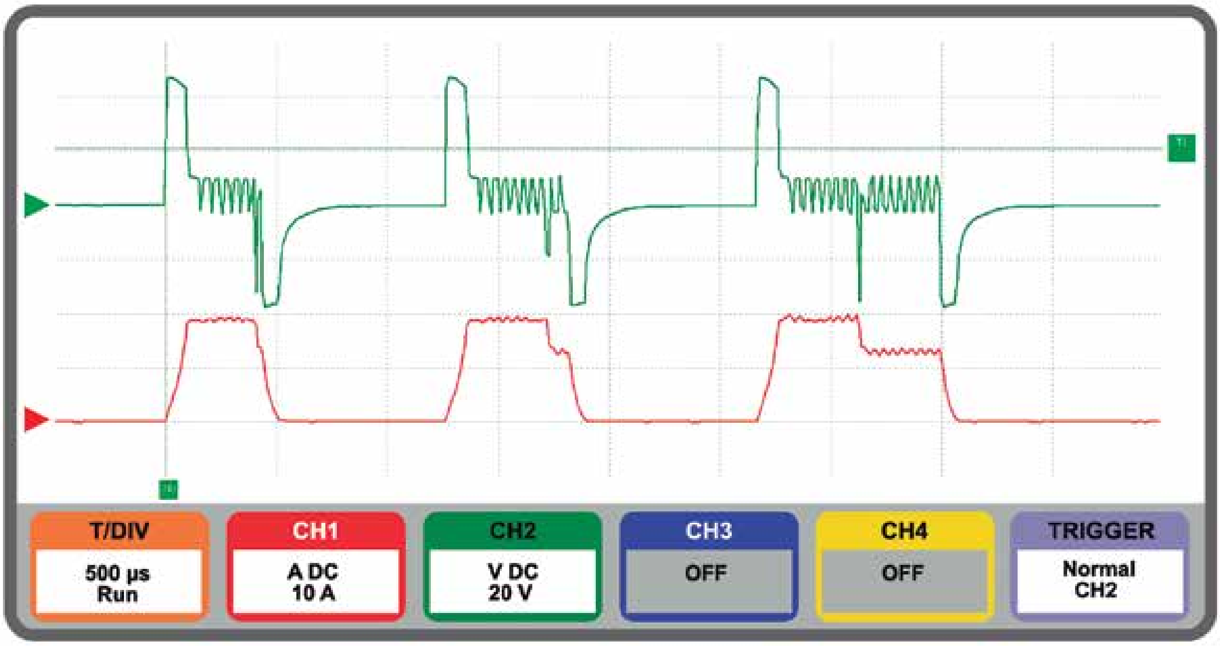
By placing the trigger on the channel that displays intensity, at half signal height, rising edge and in normal mode, we will obtain the signal refresh that coincides with each new working cycle. The synchronism of the trigger with the current intensity in normal acquisition mode is a very useful technique to impede the image refresh due to line voltage changes that are not effective. They are common, when one of the power supply lines is shared with two or more actuators, such as in the case of fuel injectors.

Logics

In many cases, logics and observation allow to detect the electrical or mechanical malfunction of the actuators thanks to the existing relationship between voltage difference, current intensity and electrical resistance.

In non-electromagnetic actuators, this relationship is graphically represented as a parallelism between the applied power supply voltage and the current that flows through the consumer, which must meet a certain pattern of vertical synchronisation, in other words, in time. If voltage is maintained and current fluctuates, this indicates that the inner resistance of the consumer is variable, which is not acceptable except in heating elements and self-regulated glow plugs.

In electromagnetic actuators, the graphic parallelism as such does not exist, but the rule of vertical synchronisation that allows to identify intermittent faults is met. In general, current intensity increases progressively after the voltage rise due to the opposite voltage that induces the increasing magnetic field.



For these checks, we will take the voltage channel of the signal as a trigger and refresh reference, by adjusting the trigger to the average activation value and we will observe the current development in several consecutive working cycles, using a time base that is sufficiently wide, but that allows a clear visualisation of the control pattern. The increase of irregular and abnormally strong current that do not correspond to voltage increase indicates short circuits or derivations to ground in the actuator coil. The reductions indicate problems of inner continuity or power supply.

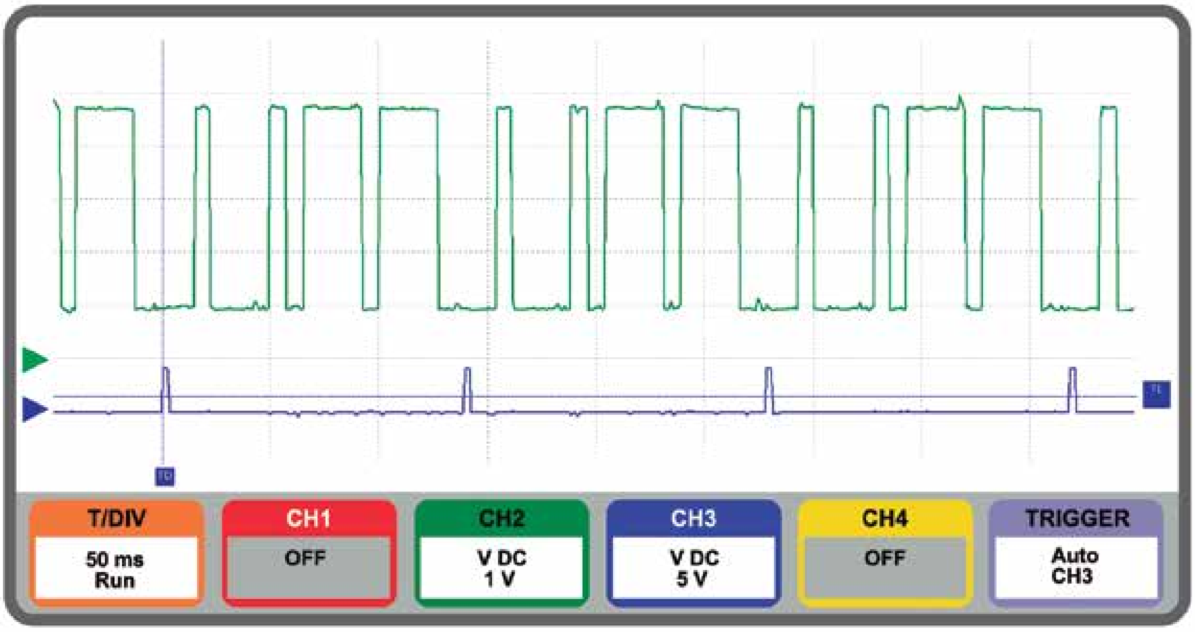
The relationship between voltage difference, current and magnetism allows to detect physical or mechanical anomalies in solenoid valves, injectors and even engines. Depending on whether their physical operation is continuous, proportional or intermittent, we should observe the same characteristics in the current that they consume, always in relation to the voltage that they receive. Variations in the current without voltage correspondence are not justifiable and indicate that the transformation ratio of the electric energy into other type of energy does not experience alterations. These alterations are caused by the variation of some physical parameters that are influent in the transformation, being usually mechanical resistance or temperature variations.

DO I NEED 2 CHANNELS?

According to what we have seen in the previous point, the answer is obvious. Two channels are needed if the aim is to see electricity as a whole, in other words, the electric current and the potential difference that generates it. However, there are other reasons that justify this need.

Auxiliary Trigger

Cyclic signals with irregular pattern are becoming more and more common, especially the square type ones. They are used to know the angular position and speed of all types of axes or for transmitting two or even three different data through the same line without the need of a communication protocol. Their nature implies trigger events of variable period that coincide in both voltage and edge, turning out to be a refresh of the graphically non-coincident image that impedes the correct visualisation and makes testing difficult.



The solution to this problem of “counterproductive” graphic refresh consists in using a trigger event that is external to the signal, which is known as external trigger. To that end, it is essential to have a second channel that will connect to a signal with regular repetitive pattern and frequency that is mathematically proportional to the one that we wish to observe. By placing the trigger on this auxiliary channel, a regular-frequency image refresh is achieved as well as the graphic coincidence of the main channel signal. In the event of camshaft or crankshaft Hall sensors, the injector control signal or even the ignition coil of a cylinder complies perfectly with this function. The operating mode can be both automatic and normal. If we take the different cylinders as a trigger reference, the integrity of the angular position signal of the crankshaft and the position reference mark can be observed.

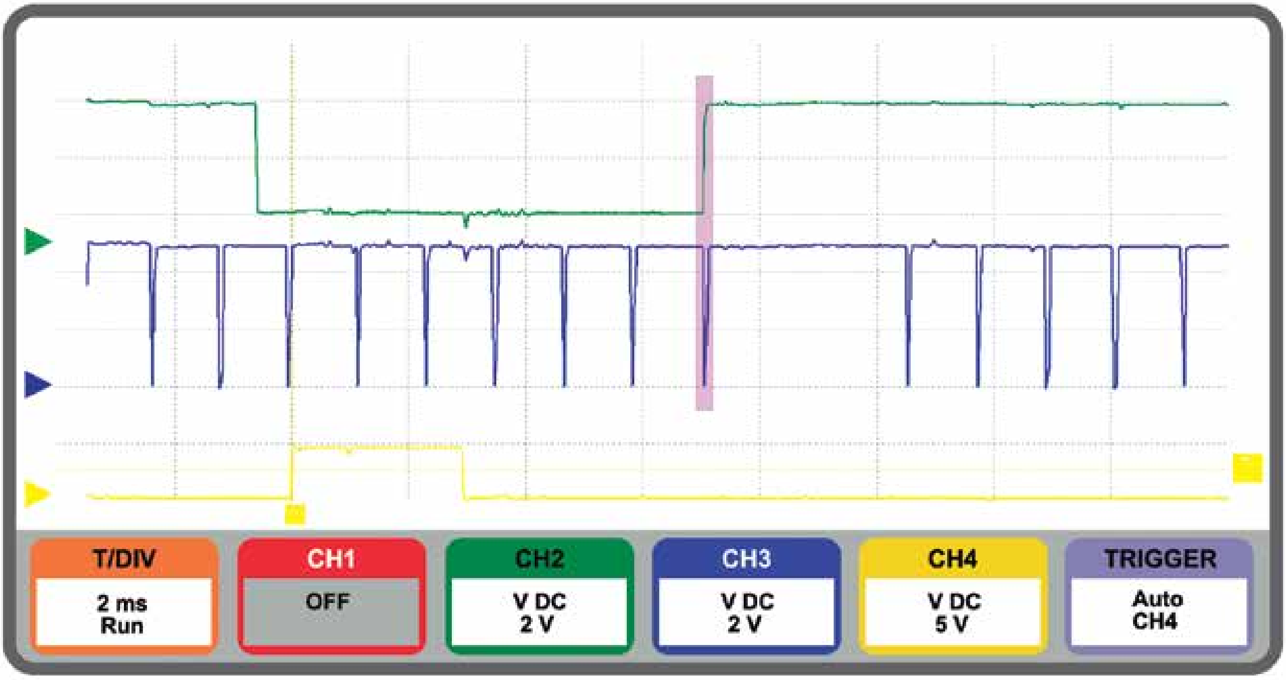
Mechanical Synchronism

Mechanical synchronism is essential and crucial in 4-stroke engines and for the operation of many electromechanical systems. The check of synchronisms and controls is only possible by observing the two variables that are simultaneously related in time, therefore, two signals at a time and two channels measured under the same time base.

The check consists in adjusting the signals separately, in a format that allows to clearly display a complete working cycle with enough vertical resolution.

Then, if both channels are placed very close or even superimposed on the same horizontal position, attention should be paid to the separation of the most vertical lines. If signals correspond to an invariable and necessary synchronism, the separation between the characteristic vertical lines must remain invariable. Any variation is attributed to a mechanical clearance.

In this case, the trigger channel is indifferent, being the normal mode preferable. If signals are synchronous, their position in the horizontal plane will be maintained in each acquisition cycle.



Measuring Coherence

The adaptation of electromechanical systems to the environment is based on the measurement of the influential variables and control of the performed work in order to obtain the optimal result. If measurement fails, the regulation will operate properly, but in no case will be the optimal one and it will most likely be unacceptable or incorrect.

The operation of analogue sensors can be tested by using an equivalent auxiliary transducer, which performs the same function as the sensor. In other words, it delivers a voltage that is proportional to the physical variable. We have already seen the first of them with the current clamp, but there are some others.

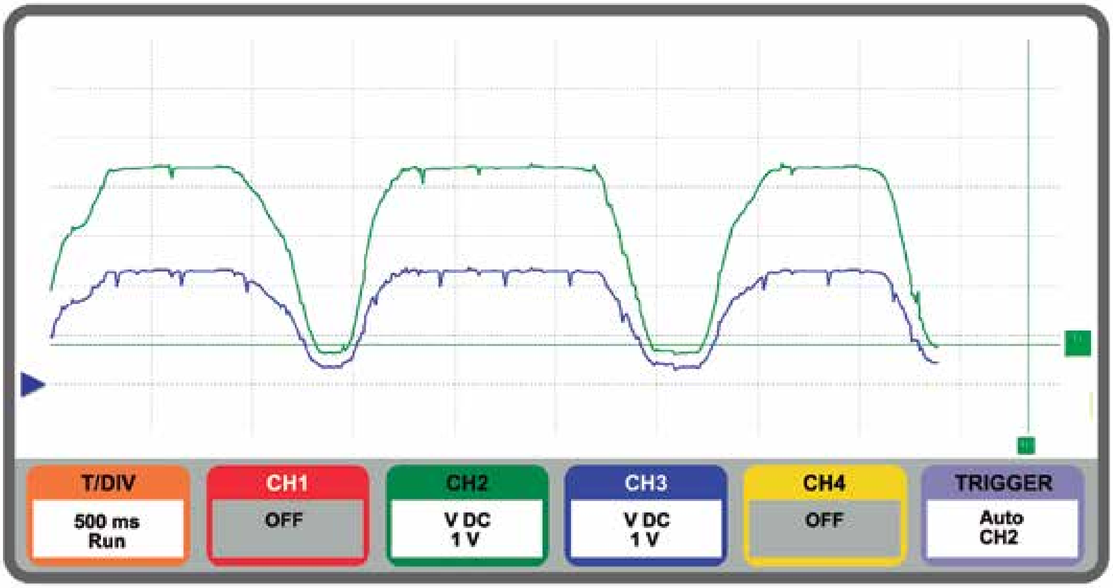
Pressure sensors for gases and liquids with different operating ranges are very interesting. When connected by means of a tube, they make an interconnection and deliver a difference of electrical voltage just like the vehicle's sensors, so that both signals must evolve in a synchronised way, even though their values are different.

The trigger must always be arranged on the auxiliary sensor, whose operation is supposed to be correct. Any incoherence in the evolution of the signals indicates a failure in the original sensor. The vertical synchronism of minimum and maximum voltage is also a determinant check factor.

Regulation and Measurement Coherence

The objective of actuators is opposite to the one of sensors. Their operation consists in modifying a physical variable starting from an electrical signal.

For a fast and accurate regulation, the result from the operation of great part of proportional actuators must be evaluated, using a sensor for it. This combination creates a working loop between the electromechanical actuator and the sensor, establishing a relationship between their signals. The graphic parameters that regulate this relationship depend in all cases on the nature of the signals received and sent by the elements, which may be of the same type or not, being time always prevailing.



The most favorable possibility is that both signals are analogue, in a way that the simple visual comparison allows to detect any anomaly. The clearest case is found in dual sensors or sensors with redundant signal, used when maximum accuracy is required in the measurement or maintenance of a sufficient functionality in case of electrical failure. Elements such as accelerator position sensors or brake switches deliver two signals whose visual relationship is obvious because of symmetry or mathematical proportion, both direct and inverse.

If this relationship of coherence between signals is not maintained, fault codes of implausible signal or signal incoherence are displayed.

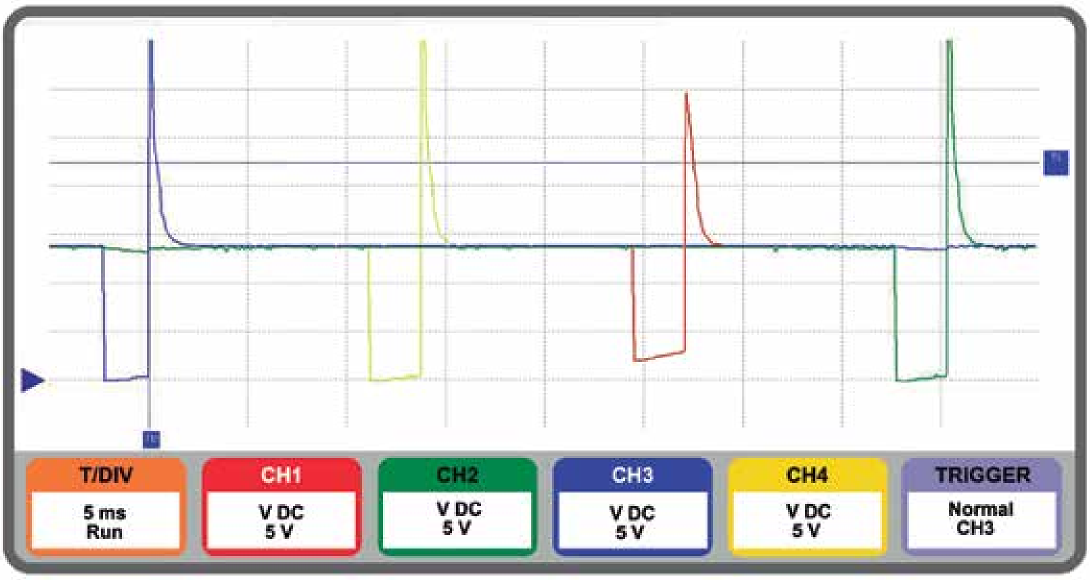
In regulation closed loops, comprised of an actuator and a sensor that evaluates the performed work, signals are usually of different nature. The most appropriate thing in these cases is to give priority to the visualisation of the actuator control signal, adjusting the trigger in its channel to fix the image and clearly identify the regulation mode used. Once it is defined, its evolution and changes must be compared with the ones of the feedback signal provided by the sensor.

If there is no electrical sensor that informs of the regulated physical parameter, actuators should be checked by means of tools for auxiliary measurement, such as gauges, thermometers or exhaust-gas analysers.

ARE 4 CHANNELS BETTER THAN ONE?

Yes again. If they are not needed, they are deactivated and are not displayed on the screen. Therefore, they are not in excess and do not hinder.

First, having several channels allows a new testing technique. The visual comparison of both informative and control signals turns out to be very practical when there are several actuators or sensors that perform the same function, although not simultaneously.

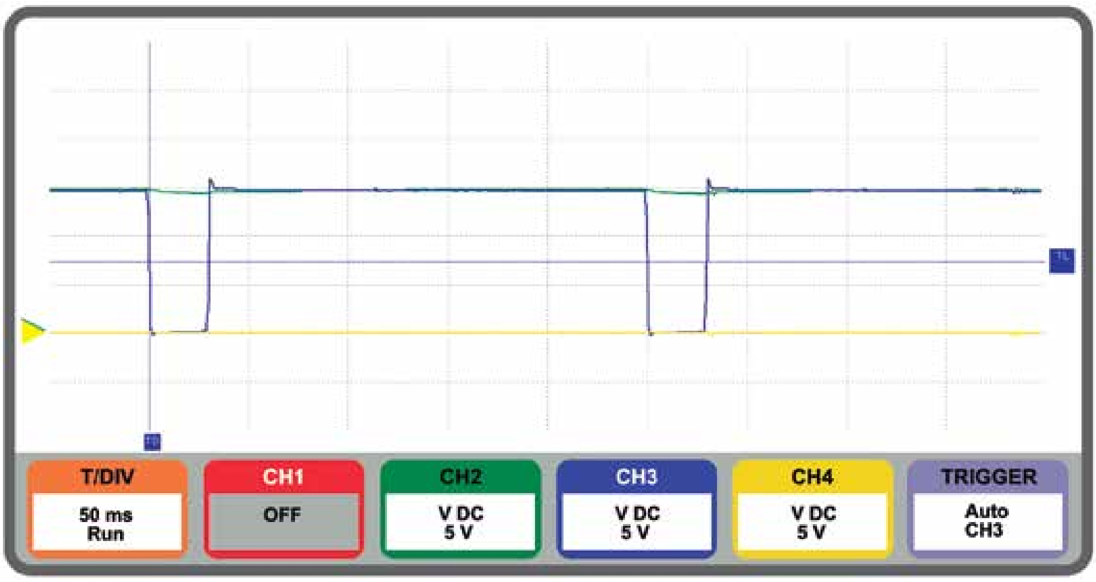


In the event of injectors or wheel speed sensors, the mathematical logic and comparison come together to make the diagnostics of the discordant signal easier. It is not necessary to know the correct signal pattern, it is enough to change the channel trigger and pay attention. Three very similar patterns and another different pattern are not a simple coincidence, they indicate a problem. In many cases, once the channel and the element that shows anomalies are identified, it is possible to exchange the sensor or actuator with another similar one to determine whether the visual difference is caused by the electrical line, related physical parameters or component.

By selecting a sufficiently wide time base, the signals of the 4 channels can be visualised at the same time, in a way that if they are placed on the same horizontal plane and on the same voltage scale, a horizontal comparison of values can be carried out.

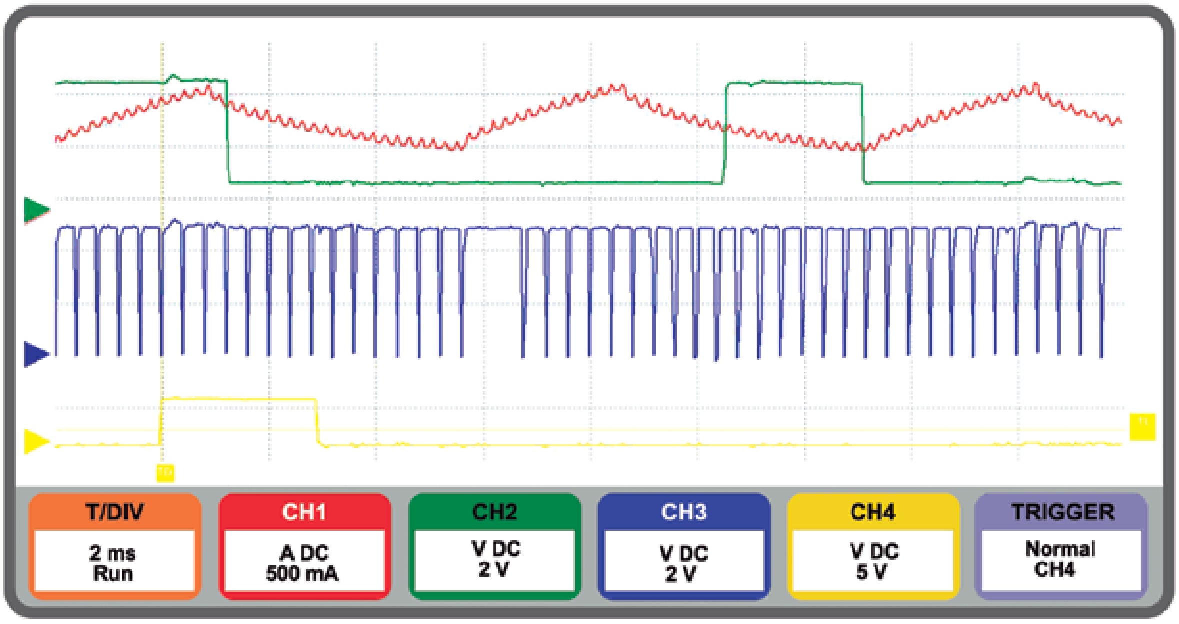
Moreover, the 4 channels allow to perform several checks on the same component at the same time.

With 3 channels, the negative and the positive power supply as well as the signal of the same sensor can be checked. Also, the voltage power supply, control signal and operating current.



With four channels, power supplies, control signal and working feedback signal can be checked in many actuators.

Logical arrangement of channels and trigger adjustment on the signal help to assimilate at a glance the function and status of each channel. On the same zero-voltage plane and by using the same voltage scale, the power supplies and signal clearly show their similarities or differences, allowing to identify when variation in the power supply affects the signal.



This technique of integral check prevents from the erroneous diagnostics of many elements whose real problem is a faulty or variable power supply with installation problems that are only produced in dynamic conditions due to derivations to ground, loosen contacts, joints that get warm or parasitic voltages.

At this point, the utility of an oscilloscope in a car workshop is obvious. With enough channels and the required components, the oscilloscope allows measurements and checks in dynamic conditions and continuously with no further requirement than the preparation of the required connections. To do so, it is convenient to provide yourself with needles, connectors and good-quality wiring with different lengths to make measurement easier. The time invested in having a reliable and safe wiring is amortised with the safety that implies diagnosing with the minimum margin of error.

The need is relative and depends on the business profile. However, without a doubt, it is increasing.

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