REPAIR ECU DIESEL MODULES

Electronic Diesel Injection

The Electronic Management of Diesel engines, better known as Electronic Diesel Injection, was in fact a technological advance in this area of the Heavy line. With characteristics very similar to the electronic injection of the light line, the Diesel electronic injection was developed with the objective of improving performance, consumption and, of course, the Pollutant Emission of vehicles equipped with the Diesel cycle engine. In this educational material we will cover the different Diesel Injection systems and their respective characteristics, as well as their evolution over the years.

They will be presented from the first Electronic Diesel Injection System which is called EDC (Electronic Diesel Control) used in Volvo trucks since 1994, later the UI (Injection Unit) system used by Volvo and Caterpillar, we will also observe the PLD System (Pump, Tube and Injector) which equips Mercedez Benz trucks in the late 90's and finally the Common Rail (Distributor tube common to injectors) that we find in Volkswagen, Ford and Ford and GM trucks.

We will also analyze some particularities of the Systems that will be useful when repairing the ECUs.

Another important point in this matter is regarding the diagnosis of Diesel Injection Systems Modules. Is it possible to carry out an accurate diagnosis on these systems?

We will address this issue and see how simple it is to diagnose defects in these systems and especially how to search for the components responsible for each action within the Module through mapping. With this technique it becomes possible to make diagnostics, and understand the traffic of the signals inside each module.

We hope that this material presented here will be of help to all who seek knowledge about repair of Diesel Electronic Injection Systems, and that it can help even more in your work.

Therefore, the incentive is for everyone to try to solve all the doubts they have about the subject and not to give up working in this newest area of expertise, the Repair of Diesel Power Plants.

Basics of Electronics

Although we realize the effects of electrical phenomena, many of them cannot be visualized. For example, electric current cannot be seen, yet we can feel its effects, such as electric shock, or see a light bulb light up, a motor running, etc.

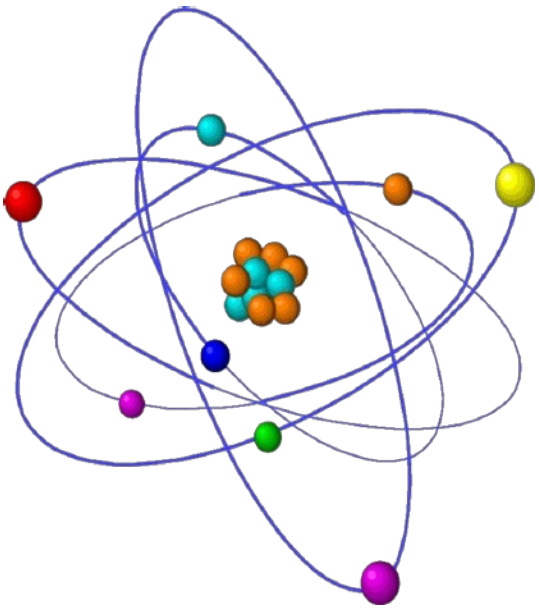
Atomic theory is used to satisfactorily explain the basic principles of electronics.

Let's look at some:

- **Matter:** It's everything that occupies a place in space, among the examples are, steel block, piece of wood.
- **Molecule:** It is the smallest portion of matter, which retains its properties, as an example the water molecule (H2O)
- **Atom:** It is the smallest part of an elementary substance that has the properties of an element. All substances are composed of grouped atoms.

In the atom there are two regions: the nucleus and the electrosphere. The nucleus is made up of two types of atomic particles: protons, which have a positive electrical charge, and neutrons, which have no electrical charge. In the electrosphere are located electrons, particles with a negative electrical charge, which rotate in elliptical orbits around the nucleus.

The negative charges on electrons are attracted to the nucleus, which has a positive charge due to the protons. This attraction compensates for the centrifugal force that tends to pull electrons away from the nucleus. In this way, the electrons keep their movement around the nucleus.



Normally, an atom has the same number of protons and electrons and is therefore electrically neutral. Electrons from the outermost layer of the electrosphere, the valence layer, are attracted to the nucleus with lesser intensity. An external force can cause the atom to lose or gain one or more electrons from that shell, becoming an ion.

An atom can have 1 to 8 electrons in the valence shell. Those that have up to 3 electrons in this shell are more likely to lose electrons. Conductive materials are made up of atoms of this type. In conductor atoms, the valence shell electrons move freely between the atoms of the material, jumping from one atom to another in a disorderly way. These are called free electrons. Due to their presence, these materials easily allow the passage of an electrical current.

As an example of conductors, we can mention metals such as copper, aluminum, gold, and some ionic solutions, such as salts and acids

Electric quantities

- **Magnetism:** The principle that keeps an atom's electrons rotating around the nucleus is magnetism, whereby charges of the same sign repel and charges of the opposite sign attract.

- **Electricity:** When a positively charged and a negatively charged material are connected by an electrical conductor, free electrons flow from the negatively charged material to the positively charged one. This flow of electrons is called electricity. For a long time it was thought that they actually flow in another way, it was too late to change the publications that existed on electricity. Consequently, for convenience, technical publications have made a commitment to assert that electric current flows from the positive to the negative side, while electrons flow from the negative to the positive side.

- **Electromagnetism:** The term electromagnetism applies to any magnetic phenomenon that takes place in an electric current. When a conductor is traversed by an electric current, there is an orientation in the movement of the particles in its interior. This orientation of the movement of particles has an effect similar to the orientation of molecular magnets. As a result of this orientation, a magnetic field arises around the conductor.

- **Force Against Electromotive:** The counter-electromotive force is an electromotive force that is contrary to or opposed to the main current flowing through a circuit. For example, when the armature coils of an electric motor rotate, a counter-electromotive force is generated in these coils by their interaction with a magnetic field.

- **Electric tension:** Called ΔV, also known as potential difference (DDP) or voltage, it is the difference in electrical potential between two points or the difference in potential electrical energy per unit of electrical charge between two points. Its unit of measure is the volt (named after the Italian physicist Alessandro Volta).

- **Electric current:** It is the ordered flow of particles carrying an electrical charge, or it is also the displacement of charges inside a conductor, when there is a difference in electrical potential between the ends. Such displacement seeks to re-establish the balance that was disrupted by the action of an electric field or other means (chemical reaction, friction, light, etc.).

- **Electrical resistance:** It is the ability of any body to resist the passage of electrical current even when there is an applied potential difference. Its calculation is given by the First Ohm's Law, and, according to the International System of Units (SI), it is measured in ohms.

- **Electric power:** It can be defined as the work performed by the electrical current in a certain period of time. The unit of measure of Power is the Watt; the ratio is defined as: P = U x I (Power = Volts x Current).

Ohm's law

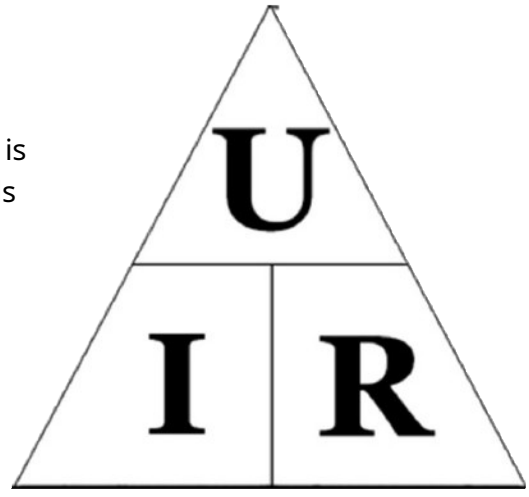
George Simon Ohm was a German physicist who lived between 1789 and 1854 and experimentally verified that there are resistors in which the variation of the electric current is proportional to the variation of the potential difference (ddp). Simon carried out numerous experiments with different types of conductors, applying various voltages to them, however, he realized that in metals, mainly, the relationship between the electric current and the potential difference was always constant. Thus, he elaborated a mathematical relationship that says that the voltage applied to the terminals of a conductor is proportional to the electric current that runs through it, mathematically it is written as follows:

V = Ri

Where:

- V is the potential difference, whose unit is the Volts (V);
- I is the electric current, whose unit is the Ampere (A);
- R is the electrical resistance, whose unit is the Ohm (Ω).

It is important to note that this law is not always v it does not apply to all resistors, as it depends on what constitutes the resistor. When it is obeyed, the resistor is ohmic or linear. Simon's mathematical expression holds for all types of conductors, both those that obey and those that do not obey Ohm's law. It is clear that the conductor that complies with this law will always have the same resistance value, regardless of the voltage value. And the driver who doesn't



obeys, it will have different resistance values for each voltage value applied to it.

multimeter

With the multimeter it is possible to carry out measurements of the electrical quantities mentioned above and in some multimeters there are also functions such as: temperature in Celsius and Fahrenheit, semiconductor (diode) test, conductor continuity test and Duthy Cicle signal percentage. Now let's see how to use it on several occasions.

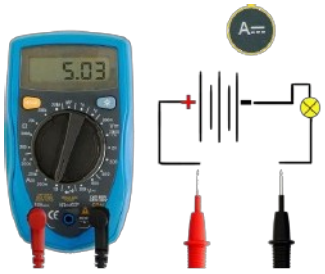
Using the Multimeter.

To measure direct current voltage we must:

1º- Place the multimeter on the Continuous Voltage scale.

2º- Place the probes correctly in the source that we want to measure the Voltage, positive side red tip, negative side black tip.

To measure Diode and Continuity of a conductor we must:



To Measure Electric Current we must:

1st- Open a consumer's electrical circuit

2º- Place the red tip at the end of the circuit that is open and the black tip at the other end as shown in the figure.

Note: Current Test must be done for a maximum of ten seconds if for a maximum current of ten amps.

Oscilloscope

Using the Oscilloscope

The oscilloscope is an essential piece of equipment in the repair of electronic centrals, as with it it is possible to diagnose the traffic of electrical signals in the electrical circuit.

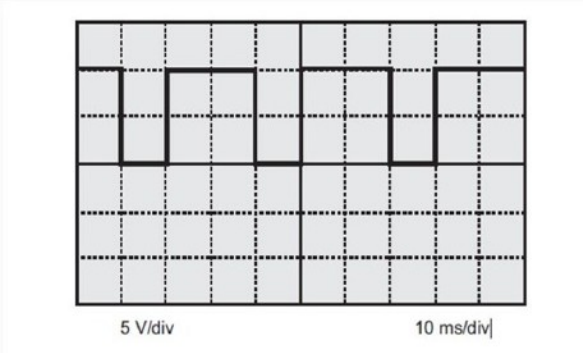
For example; with it we can identify if the processor is sending a coil's firing pulse, if this pulse is leaving the responsible component and if it is reaching the switch's nozzle connector.

Now let's see how we can use the oscilloscope and what are its most important settings. With this understanding it will be possible to interpret any signal on any oscilloscope.

Interpreting the Oscilloscope

Before reading the measured waveform parameters, we have to check what the value of the time base adjustment and the voltage scale are configured. In the example below we have:

Time base: equals 10 ms per division. It means that the horizontal scan takes 10 ms to scan the space of a horizontal division of the screen.



Voltage range: 5V per division. It means that a variation of 5V in the input signal corresponds to a vertical division of the screen.

So, we can conclude that:

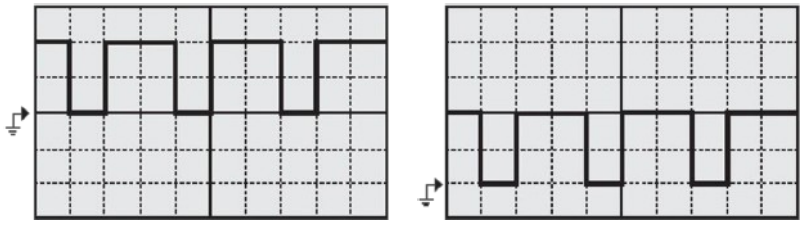
1 The signal amplitude is (2 divisions) x (5V per division) = 10V
two The negative pulse width is (1 division) x (10 ms per division) = 10 ms
3 The positive pulse width is (2 divisions) x (10 ms per division) = 20 ms
4 The period is (3 divisions) x (10 ms per division) = 30 ms

Adjusting the Oscilloscope

Oscilloscopes basically have 4 main settings:

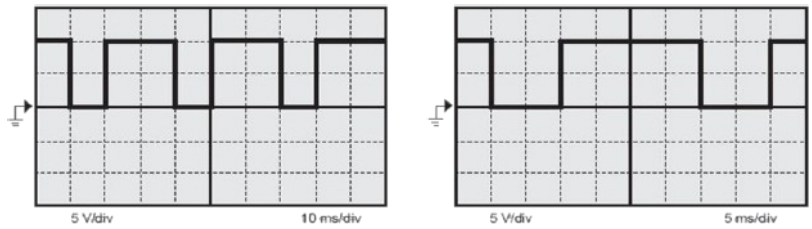
1 Offset
two time base
3 voltage scale
4 Trigger Offset

we can make the X axis of the drawn waveform be in the center of the screen or in another position as per our convenience.



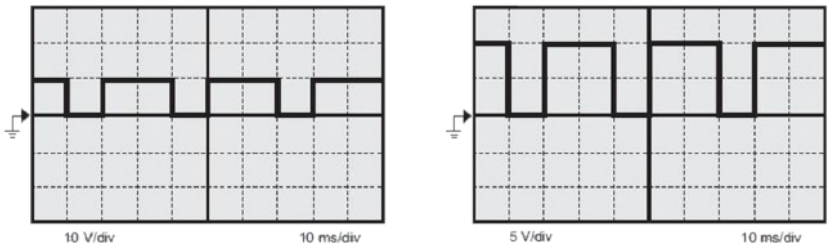
time base

With this setting we can choose the speed of the screen's horizontal sweep. Note that in both measurements the period of the waveform is 30 ms.



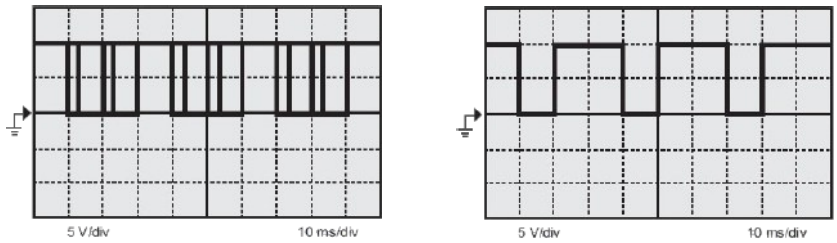
voltage scale

With this setting we can choose which input signal voltage value will be represented by each vertical division of the screen. Note that in both measurements the voltage amplitude value is 10 V.

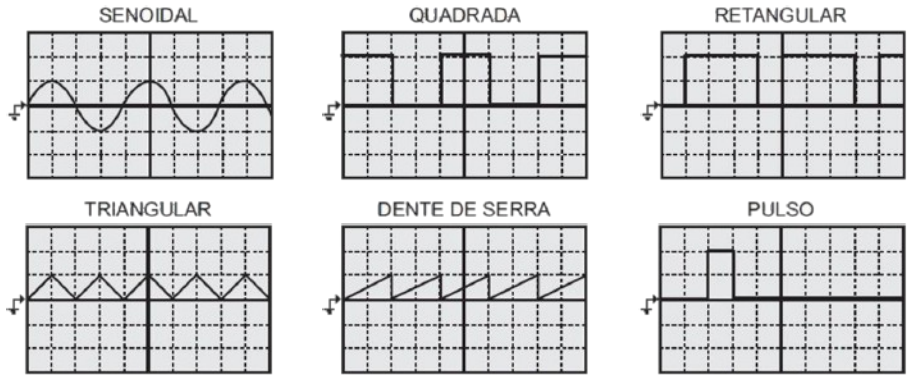


trigger

The trigger (Trigger) is a feature that synchronizes the oscilloscope's time base with the measured signal, preventing the trace from sliding horizontally. This makes the trace drawing of the measured waveform stable on the screen. The figure below illustrates a measurement with the trigger misconfigured and, on the right, the same measurement with the trigger correctly configured. With the trigger active, the oscilloscope stops drawing the waveform every time the sweep reaches the far right of the screen and only starts drawing the new trace if the trigger event occurs. This causes the waveform to always be drawn from the same point. The trigger event occurs when the measured waveform reaches the value and direction (ascending or descending) determined by the user.



Common Wave Types



With the Oscilloscope we can observe the electrical signal in its minimum and maximum amplitude, observe the cycles and frequency with which the signal occurs, in addition to analyzing the integrity of this signal (if there are no interruptions).

Resistors

Resistors are elements that present a difficulty in passing electricity and these elements can have a fixed or variable resistance. Electrical resistance is measured in Ohms (Ω).

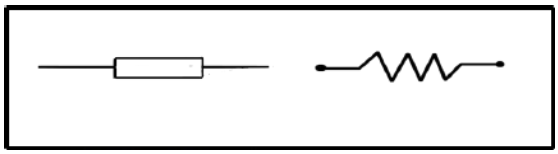
Resistors have a very Ar property:

The larger around it, the smaller the electric current that passes through it.

There are many types of resistors used, and the vast majority are too small to carry their nominal value in their body. In this way, manufacturers use color coding or numeric codes to inform their value.

Even smaller resistors, which are usually of the SMD type, soldered directly to the board do not always have their nominal value printed on the body, so it is necessary to refer to the equipment's technical manual to find out the correct value.

Resistor Symbology



How to Read a Resistor?

When reading a four-color band resistor, you need to be careful, as there is one color that is usually closer to the end than the other and this will be the first one to be considered in the reading. After identifying the color closest to the end we can associate it with the first digit of the resistor value, the second color is the second digit of the value and the third is the multiplier. For example

For a resistor that has brown, black and red color bands we will have a nominal value of

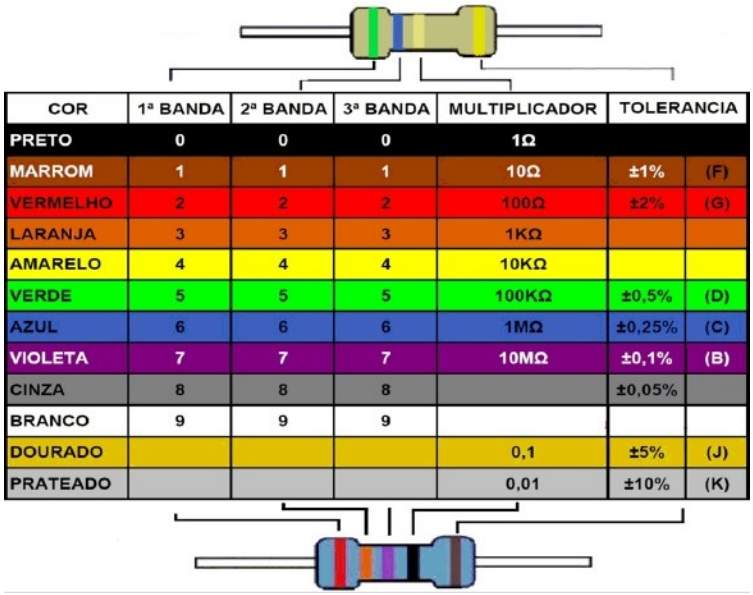
1000 Ω, as red is the multiplier.

So we have the value of the digits 10 multiplied by 100Ω, resulting in 1000Ω.

This simple way we will be able to calculate any value of resistors, including the 5-color ones, as they are also not different from the rule, just add a digit in your calculation verification. See the example on the next page.

Resistor Color Code Table.

Below we have a table describing the digits and multipliers that we can find according to the colors existing in the resistors.



COR	1ª BANDA	2ª BANDA	3ª BANDA	MULTIPLICADOR	TOLERANCIA	
PRETO	0	0	0	1Ω		
MARROM	1	1	1	10Ω	±1%	(F)
VERMELHO	2	2	2	100Ω	±2%	(G)
LARANJA	3	3	3	1KΩ		
AMARELO	4	4	4	10KΩ		
VERDE	5	5	5	100KΩ	±0,5%	(D)
AZUL	6	6	6	1MΩ	±0,25%	(C)
VIOLETA	7	7	7	10MΩ	±0,1%	(B)
CINZA	8	8	8		±0,05%	
BRANCO	9	9	9			
DOURADO				0,1	±5%	(J)
PRATEADO				0,01	±10%	(K)

SMD RESISTORS (Surface Mounting Device)

As time passes, the electronic equipment becomes smaller, and consequently the components also follow this development.

Today, within this philosophy, we can easily find SMD resistors, where these components are small, soldered on the surface of the board and have the nominal value in their body more in the form of a numerical code instead of colors.

An SMD resistor with the value equal to 2512 we can associate the first three numbers as a digit (2512) and the number two is the multiplier (100Ω) totaling 25100Ω.

In the case of the ceramic capacitor on the side, let's calculate it as follows;

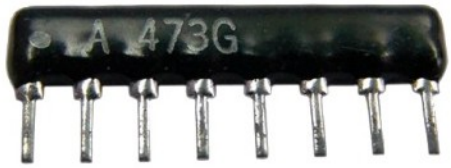
We will keep the numbers One and Zero, as they are digits.

The number Four is the multiplicative factor, and analyzing the same resistor code table we can see that the multiplier is equivalent to 10,000, but in this case it is not 10,000Ω, but 10,000pf.

In this way, the calculation of the capacitor is done as well as the resistor:
10 x 10,000pF = 100,000pF applying the Multiples and Submultiples rule this value will equal 100nF.

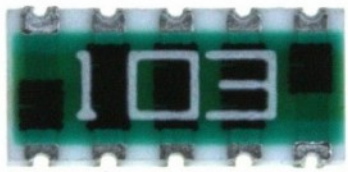
Resistive Network

A Resistive Network is nothing more than several resistors interconnected within a single package, being a common terminal for all. It is used in circuits that require space saving inside the board. A Resistive Network is commonly applied to Japanese ECUs such as Honda Civic, Toyota, Mitsubishi and others.



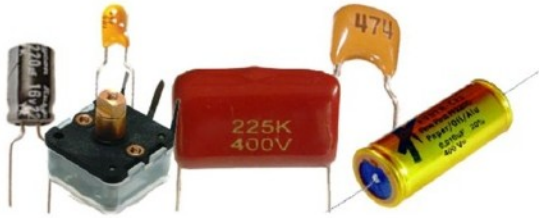
PTH component (conventional)

SMD component



Capacitors

The Capacitor is a component used in almost all electronic boards. It allows you to store electrical charges in the form of an electrostatic field and maintain it for a certain time, even if the power is removed from the circuit. Capacitors are used in power supplies and many electronic boards mainly in ECUs.



The most common function of a Capacitor is to stabilize the electrical current avoiding oscillations that can certainly damage other components inside the board.

Scale of the value of Electrolytic Capacitors and their Internal Structure.
We see in this image that we can find capacitors with values that should be respected if we change for another.

Capacitor submultiple scale.

F	Farad	
mF	mil farad	450V
uf	micro Farad	150 uF
nF	nano Farad	
Federal Police	farad peak	

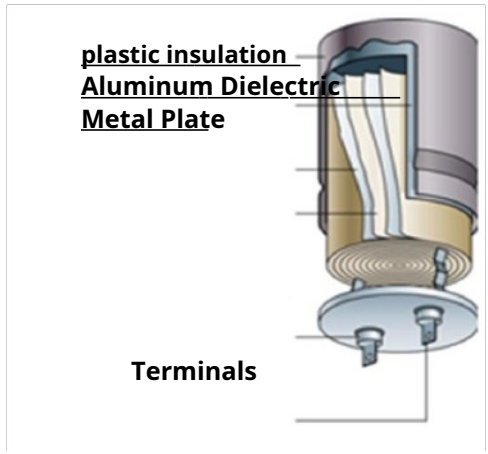
The electrolytic capacitor is formed by two conducting plates separated by an insulator called Dielectric. The plates serve to store electrical charges coming from the power supply.

When a voltage is applied to the terminals of the electrolytic capacitor, it stores negative electrical charges on one plate and positive on another.

Observe the internal structure of Electrolytic Capacitors

Capacitance is a scalar quantity that expresses the capacity of a material to store electrical energy in the form of an electrical charge.

Aluminum electrolytic capacitors usually come with polarity indication, because due to the internal construction that uses a liquid electrolyte that forms vapor, aluminum electrolytic capacitors cannot be connected with reverse polarity terminals or risk of exploding.



In addition to capacitance, the specification of capacitors must include the operating voltage. In general, the working voltage value of the capacitors has an inverse relationship with the capacitance, that is, the higher the working voltage, the lower the capacitance value and vice versa. This is due to the constructive characteristics of the capacitors: to obtain high capacitance values, the capacitors internally have a small distance between electrodes, making the maximum voltage that the capacitor supports is limited by the material's dielectric strength.

How to test an Electrolytic Capacitor?

With the Multimeter on the Continuity scale, place the black lead on the negative terminal of the Capacitor (the negative side of the capacitor usually comes with a reference strip to indicate it) and the red lead on the other terminal. We will observe that the multimeter will give an audible warning (beep) and then stop; repeat the operation, now inverting the capacitor terminals, placing the red tip on the negative terminal and the black tip on the positive one, and notice that there will also be an audible warning (beep) that will soon cease.

This procedure tells us that the capacitor is doing the function for which it was designed, storing electrical charges and discharging them.

Ceramic Capacitor

The main feature of the ceramic capacitor is to filter noise or voltage spikes in the circuit to which it is connected. They usually don't have polarity, so we don't have to worry if we change a capacitor in a particular circuit.

A great difficulty we have with respect to the ceramic capacitor of the SMD model is that, as it is very small, it does not have its capacitance value printed on its body, in this case, if a defect is found, we can take one with the same size and color and put it it in place of the faulty capacitor.

In conventional ceramic capacitors, it is possible to decipher their numerical code and know their capacitance value. The identification is the same as that of the SMD resistors, seen in the previous pages of this booklet.

1st- Place the multimeter on the diode and continuity scale (beep).

2º- In the case of the diode, pay attention to the polarity, red tip on the positive side of the diode and black tip on the negative side.

3rd- Continuity test of electrical conductor has no polarity, if the conductor is broken we will not hear the sound signal (beep).

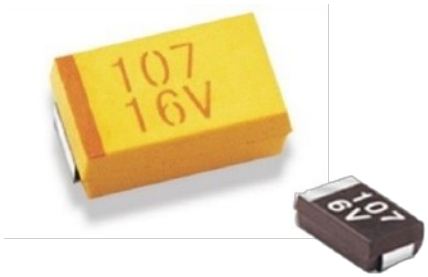
Tolerance of Ceramic Capacitors

As with resistors that have tolerance, that is, a range of variation from their nominal value, in the case of ceramic capacitors there is also tolerance, and these values are usually represented by a letter. Below is a table of values for tolerance:

Up to 10 pF	Above 10 pF
B = ± 0.10pF	G = ± 2%
C = ± 0.25pF	H = ± 3% J = ± 5% K = ± 10% M = ± 20%
D = ± 0.50pF F = ± 1pF	P = + 100% -0%
	S = + 50% -20%
	Z = + 80% -20%

Tantalum Capacitors

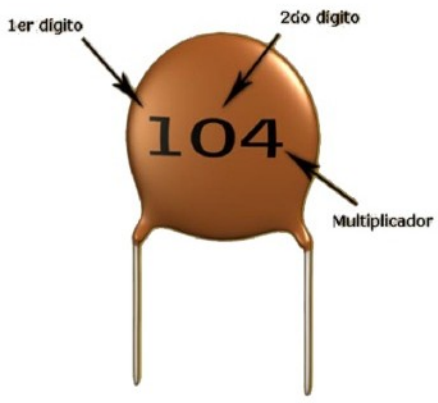
This type of capacitor is made on the basis of a compound called tantalum or tantalum. Tantalum capacitors have large capacitance values similar to aluminum oxide (electrolytic)



Tantalum capacitors are superior to electrolytic in terms of temperature and operating frequency, they are a little more expensive and are often found in Injection Centrals and devices that need high frequency, such as cell phones.

In the case of the ceramic capacitor on the side, let's calculate the following way;

We keep the numbers One and Zero, as they are digits. The number Four is the multiplicative factor, and analyzing the same resistor code table we can see that the multiplier is equivalent to 10,000, but in this case it is not 10,000Ω, but 10,000pf.



In this way, the calculation of capacitor is just like the resistor:

10 x 10,000pF = 100,000pF applying the Multiples and Submultiples rule this value will equal 100nF.

Capacitors are classified according to the material used as a dielectric. The following types of:

Ceramics – low values down to about 1µF. Polystyrene – usually on the Farads peak scale.
Polyester – from approximately 1 nF to 1000000 µF.
Polypropylene – Low Loss, High Voltage, Damage Resistant

VDR Varistor and Protection Circuit

Varistors are electronic components whose electrical resistance value is a function of the voltage applied to their terminals. As the voltage on the Varistor increases, the internal electrical resistance decreases.

Varistors are usually found in a board's protection circuit, as their sole and exclusive function is to protect the others components against voltage spikes from the source (Battery or Alternator). In this way, they are mounted in parallel to the circuit to be protected and, as they feature a voltage limiter feature, they prevent short-duration surges from reaching the circuit.

Varistor Symbology

When there is too high a current, the Varistor works like a fuse breaking and disconnecting the power supply circuit.

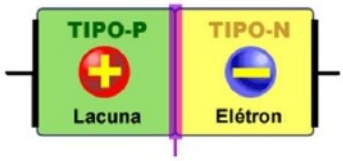
Oscillating Crystal

The crystal is a component that generates an invariant frequency (clock) signal to the processor in order to keep it running. This signal generated by the crystal is always the same regardless of vehicle speed, battery voltage or other factors that may interfere with vehicle operation. Crystal oscillators are components composed of two terminals, connected to an internal piezoelectric crystal. This crystal contracts when subjected to electrical stress, and the contraction time varies depending on the construction of the crystal. When the contraction reaches a certain point, the circuit releases the tension and the crystal relaxes, reaching a point of further contraction. Thus, the contraction and relaxation times of this cycle determine an operating frequency, much more stable and controllable than circuits with capacitors. quartz crystalssare mainly used in microcontrollers. Making a very interesting analogy, we can compare the crystal to a heart, the processor heart, will be driven so that it doesn't stop working. This signal is so vital that without it the ECU stops completely.

Diodes

A diode is an electronic device or component composed of a silicon or Germanic semiconductor material in a crystalline film whose opposite faces are doped by different gases during their formation (electrons and holes).

There are two types of diodes, the Rectifier and the Zener, where both have polarity in their application on the board so that they do their functions.



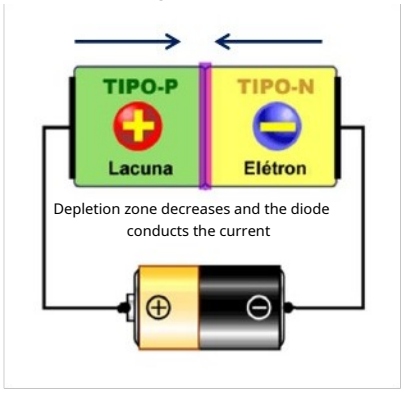
Depletion Zone

Rectifier Diode

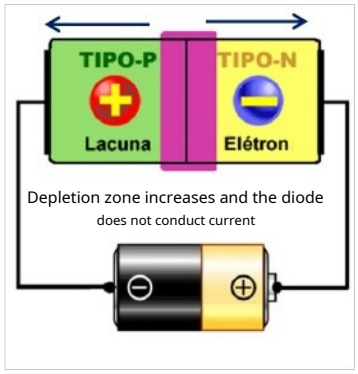
Rectifier diode is a unidirectional electronic component, that is, it conducts electrical current in only one direction. The main function is to rectify the signal. It is the simplest type of semiconductor electronic component, used as an electrical current rectifier in transformers and others.

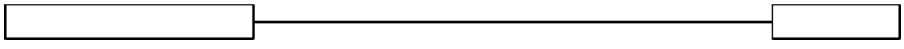
We have two situations where we can polarize the diode **DIRECT POLARIZATION and REVERSE**

Directly Polarized Diode



Reverse Polarized Diode





How to Test a Diode?

Internally the diode has a barrier (depletion zone) that separates the two elements, this barrier causes a voltage drop when the diode is directly biased (as the image above), this voltage drop can vary from diode to diode, and also the material that is made (silicon or germanium). Generally speaking, when we go to test the component, the ideal measure is that the value is between 0.2v to 0.8v (using the multimeter in the semiconductor scale).

Test: Place the multimeter on the semiconductor scale then place the red tip of the multimeter on the positive terminal of the diode, and the black tip on the negative terminal. Note that the value on the multimeter will be from 0.2v to 0.8v. If a different value appears, the component or if no value appears, the component is defective. Note: Always the side that has the range will indicate the negative terminal (Cathode).

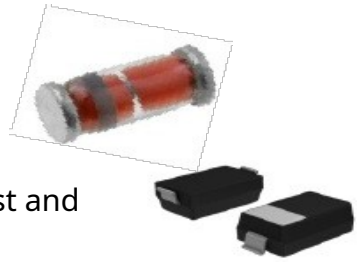
Zener Diode

Zener diodes have unique characteristics that make them suitable for maintaining a fixed voltage in a circuit. We know that the voltages found in household outlets tend to vary. On the other hand, electronic devices need constant voltages to work properly. To keep the voltage constant in electronic circuits, there are some devices, the most common being the Zeners diodes. Together with other components they can receive voltages that vary and transform them into constant voltages.

Operation

When directly polarized, a Zener diode conducts like a rectifier diode, that is, from approximately 0.6V of voltage between its terminals, a current starts to circulate. In this situation the voltage stabilizes at approximately
0.7V. The big difference between rectifier diodes and Zener diodes is in the negative bias region. Conventional diodes withstand the reverse voltage up to a certain limit. Remember that when reverse-biased, a diode does not conduct. However, when it reaches the limit of the reverse voltage that the diode supports, it conducts very intensely and soon ends up burning when it reaches the avalanche region.

SMD Diodes



They follow the same logic as the SMD resistors, where, as the electronic equipment got smaller, the internal components too and consequently the diodes followed the same line getting small and to save
space were soldered directly to the surface of the board. But the test and values are the same as PTH Diodes (conventional).

Transistors

The history of the transistor—also known as the “transistor—began back in the days when tubes were used in computers. The focus of research at the time was precisely the improvement and reduction in the size of the valves, in addition to increasing their efficiency, as they consumed a lot of energy.

Therefore, it was necessary for the valves to be replaced with a new, smaller and cheaper component. Military research began to become more and more complex and demanded that computers be reduced in size and could work at higher frequencies. The valves were not capable of this, leading electricians to look for other components.

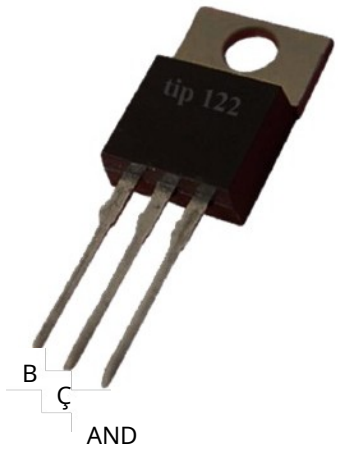
In November 1947, scientists at the Bell Telephone laboratory discovered the transistor, although their research tried to go in another direction. They found that when a certain voltage was applied to one of the component's terminals, the signal that was output at the other terminal was amplified. Thus, the transistor became responsible for signal amplification, in addition to serving as a controller that interrupts or releases the passage of electrical current.

Its low cost allowed it to become an almost universal component for non-mechanical tasks. Transistors today have replaced almost all electromechanical devices in most control systems, and appear in large quantities in everything from electronics to cars.

Darlington Transistor Operation

Every transistor has three terminals, Collector, Base and Emitter. One of the terminals receives the electrical voltage (Base), and the others send the amplified signal (Collector to Emitter). The Base terminal is responsible for controlling this process, since the electrical current that enters and leaves the Collector and Emitter only when electrical voltage is applied to the Base terminal.

For simplicity, we can think of the transistor as a faucet.



The side of the pipe coming from the street is the inlet terminal (Collector) and the side from which it exits to the water is the outlet terminal (Emitter). When you turn the faucet on or off, your hand acts as the terminal (Base). However, we must remember that in Darlington transistors there are only two stages, it will either be on or off, comparing again with the tap, or it will be fully open or fully closed.

How to Test a Darlington Transistor?

NOTE: Use the multimeter on the Semiconductor scale.

1st test: the red tip must be on the **BASE** as a reference and when measuring it should not be removed, place the black tip on the **COLLECTOR** the measurement should be 0.3V to 0.8V. Then place the black tip on the SENDER and the measurement will be greater than 0.7V.

2nd test: put the black tip on **COLLECTOR** or on the carcass, and the red tip on the **BASE** and the measurement will be from 0.3 to 0.8v. Then put the red on the**ISSUER** the measurement should also be from 0.3v to 0.8V.

None of the terminals should be shorted.

Mosfet Transistor Operation

Physically it is the same as the Darlington transistor, but internally it has changes. The Mosfet transistor controls the current flowing between the “Source and Drain” terminals, through the voltage applied to the Gate terminal. Application codes for Mosfet Transistors usually have the initials IRF, 2SK and BUZ.

When voltage is applied to the Gate terminal, it allows electrical current to flow through the other Source and Drain terminals. The amount of voltage applied to the Gate (or control terminal) will determine how much current will be output through the terminal. If no voltage is applied to the control terminal, there is no electric current flowing.

Comparing again to a faucet, the more you open the register, the more water tends to come out, as with the Mosfet transistor, the greater the voltage applied to the Gate terminal, the greater the electric current that will flow from the Source to the Drain.

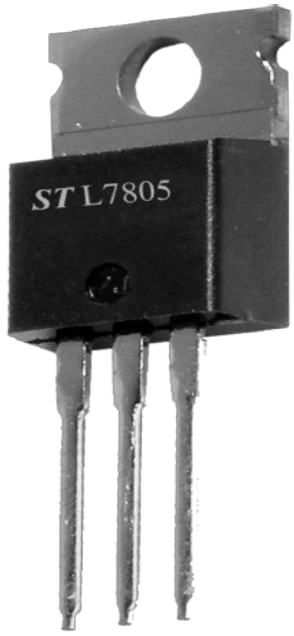
How to Test a Mosfet Transistor?

With the multimeter on the semiconductor scale, place the red tip into the SOURCE terminal and the other black tip into the SOURCE terminal. **DRAIN** the measurement will be 0.3V at 0.8v.

None of the terminals should be shorted.

REMINDER: To identify the component's function, it must be verified through datasheet (data sheet), because physically we have several equal components, the only difference (visual) is the numbering.

Voltage regulator



A voltage regulator is a device, usually made up of semiconductors, such as Zener diodes and integrated voltage regulator circuits, whose purpose is to maintain the output voltage of an electrical circuit. Its main function is to keep the voltage produced within the limits required by the electrical system it is supplying and for that it is necessary that the input voltage is higher than the output voltage.

A voltage regulator is unable to act by compensating for voltage or current drops across its input to deliver adequate voltage. For this purpose, in addition to regulation, the functions of a generator (battery, transformer, power supply, dynamo, alternator and the like) would be expected from it, since power outage compensation is only obtained with power generation.

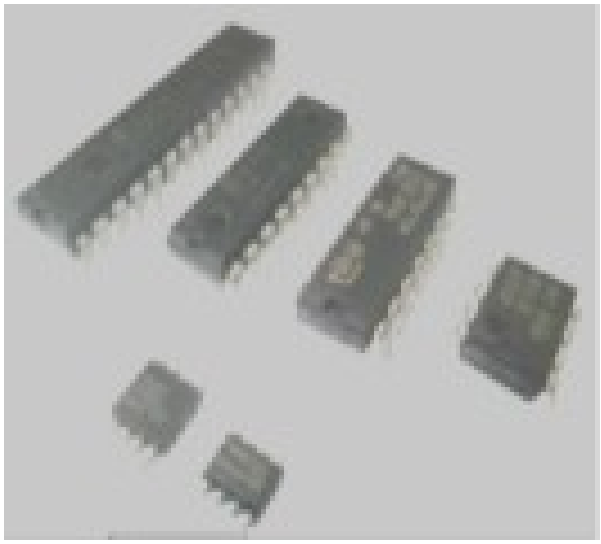
Voltage regulators on automobile electronic boards are very similar to transistors, as they have the same packaging, but care must be taken not to confuse them.

Usually the initial of the Voltage Regulator application code is the letter 'L' 78, which in this case is Positive, whereas the L' 79 are for potential Negatives. Another important point is that the working voltage is determined by the final numbers, in the case of the image below (05) is 5 volts.

Integrated Circuit (IC)

The scale of integration has miniaturized electronic components such that integrated circuits have the equivalent of thousands of components in their internal makeup. An integrated circuit, also known as a chip, is a microelectronic device that consists of many functions. Its dimensions are extremely small.

The importance of integration lies in the low cost and high performance, in addition to the reduced size of the circuits combined with high reliability and operational stability. Since the components are formed instead of assembled, their mechanical resistance allowed assemblies that were increasingly more robust to shocks and mechanical impacts, allowing for the conception of portability of electronic devices.



Memoirs

We know that information such as the immobilizer password is stored in memories **Eprons.**

Memories are components that store data. There are several types of memories.

The memories **ROM (Read-Only Memory - Memory Only Reading)** they are given this name because data is written to them only once. After that, this information cannot be erased or altered, only read by the computer, only through special procedures. Another characteristic of ROM memories is that they are of the non-volatile type, that is, the recorded data is not
lost in the absence of electrical power to the device. Here are the main types of ROM memory:

PROM (Programmable Read-Only Memory): this is one of the first ROM memory types. Data recording in this type is performed using devices that work through a physical reaction with electrical elements. Once this happens, the data recorded in the PROM memory cannot be erased or changed;

EPROM (Erasable Programmable Read-Only Memory): the memories **EPROM** Has as main feature is the ability to allow data to be erased from the device. This is done with the aid of equipment that emits ultraviolet light. In this process, the recorded data is completely erased.

Only dperopgoriasmdaisdsoor;is that a new recording can be made through a **EEPROM (Electrically Erasable Programmable Read-Only Memory):** this type of ROM memory also allows data rewriting, however, unlike what happens with EPROM memories, the processes to erase and write data are done
electrically, making it not necessary to move the device from its place to a special device for re-recording to take place;

Flash: Flash memories can also be seen as a type of EEPROM, however, the writing (and rewriting) process is much faster. Furthermore, Flash memories are more durable and can hold a high volume of data;

The memories **RAM (Random-Access Memory)**
they are one of the most important parts of computers, as they are where the processor stores the data it is dealing with. This type of memory has an extremely fast data writing process, compared to various types of ROM memory. However, recorded information is lost when there is no more electricity, that is, when the computer is turned off, and is therefore a type of volatile memory.

It is quite common for the electronics manufacturer to ask the chip manufacturer (in this case Motorola and Bosch) to uniquely identify the chip, thus protecting it against copying attempts, industrial espionage, etc. For internal control of the chip manufacturer, it uses customer codes, we have hundreds of masks related to the real commercial chip.

This list is quite complete, in a compilation of more than 485 Masks (secret codes) of Motorola® electronic product chips present in electronic equipment such as electronic injection centers and around 185 Masks related to Bosch electronic components.

Bosch and Motorola Component Masks.

chip mask	Commercial Part Number
1E53M	XC68HC711P2
C85W	XC68HC711L6
IH96P	XC68HC711KS8
D61N	XC68HC711KA4
C45A	XC68HC711D3
D41V	XC68HC705BE12
E41C	PC68HC916Y1

Welding of SMD and PTH Components

Important Tips on Welding Components of a **ECU.**

1º- Always use the correct power welder, for example: 30 W, 40 W or 60 W.

2º-When using the rework station, be very careful with the components around the component you want to remove.

3º-Before removing the component, mark its reference on the board. The reference will always come in the form of a ball, cut or even with the manufacturer's brand.

4º-Keep the welder away from everything, except the point to be welded. The welder is very hot and can easily burn whatever comes in contact with it and damage another component.

5º-Make sure you have a damp sponge at hand to clean the welder tip, any contaminant can impede a good welding.

6º-Always make sure that the tip is tinned when the welder is on. Tin protects the tip and improves heat transfer.

7º-Be careful not to remove the protective coating from the welder tip.

8º-Do not keep the welder for a long period (more than 10 seconds), since many electronic components, or the printed circuit board itself, can be damaged due to prolonged and excessive heat. Too much heat can damage tracks, compromise ICs, diodes, transistors and other components.

Soic/Psop/Plcc and Dip

Keeping in mind these precautions we will be able to solder any component inside a printed circuit board, mainly Soic, Psop, Plcc and Dip which are types of packages for the most known memories inside the ECUs.

Repair of Diesel Plants

ECU Operation Strategy

The Diesel electronic injection system works with all components connected to a module, considered the brain of the system. With a digital language, the sensors and actuators work to maximize fuel injection at any level of engine operation.

The system has its main component called the electronic injection module. Also known as MCE, electronic control module, this component has a high-speed processor that processes the information coming from the sensors and also commands the action of the actuators. A package of information about the best amount of fuel to be injected, under the most diverse operating conditions of the engine, is recorded in a ROM Read Only Memory. This memory stores data that was recorded at manufacturing, with folders that simulate any engine operating condition.

Another component within the module is RAM, Randon Access Memory. This component is volatile memory. This memory assembles information folders coming from each working frequency cycle of the sensors. The processor then compares the information in RAM with the ROM and determines the best fuel supply strategy such as injection time and spark spark advance.

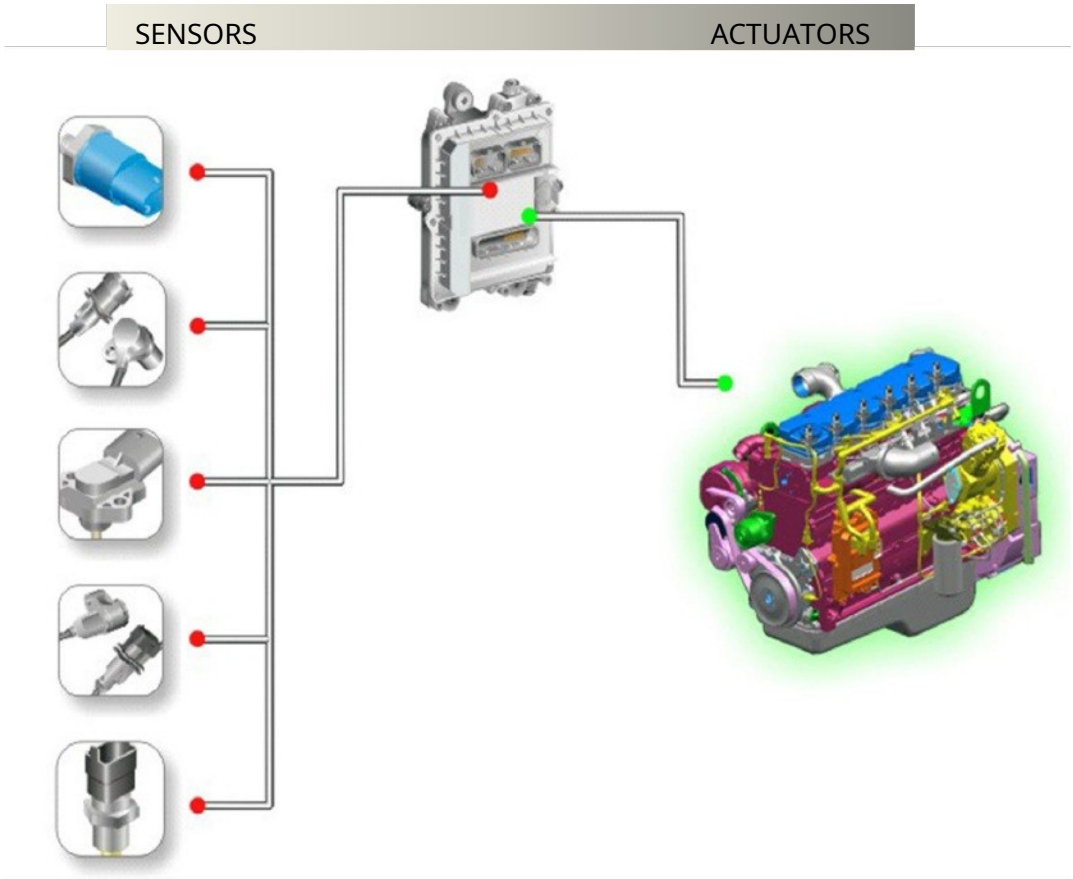
The speed of this information is practically instantaneous, therefore, each variation felt by the sensors is translated into milliseconds and converted into an action in the engine. For example, the air pressure sensor perceives its variation in the intake manifold, as the working frequency of the module processor is very high, it already assembles a folder with this information and determines that the injection time should increase the engine gains rotation.

The Electronic Diesel Injection System is fascinating, due to the speed of calculation to determine the opening time of the injectors and for determining the exact injection rate for each engine frequency cycle, with the objective of saving fuel and reducing polluting gases.

Most systems have a self-diagnosis strategy, and are self-adaptive, which allows automatic correction (idle speed and injection time).

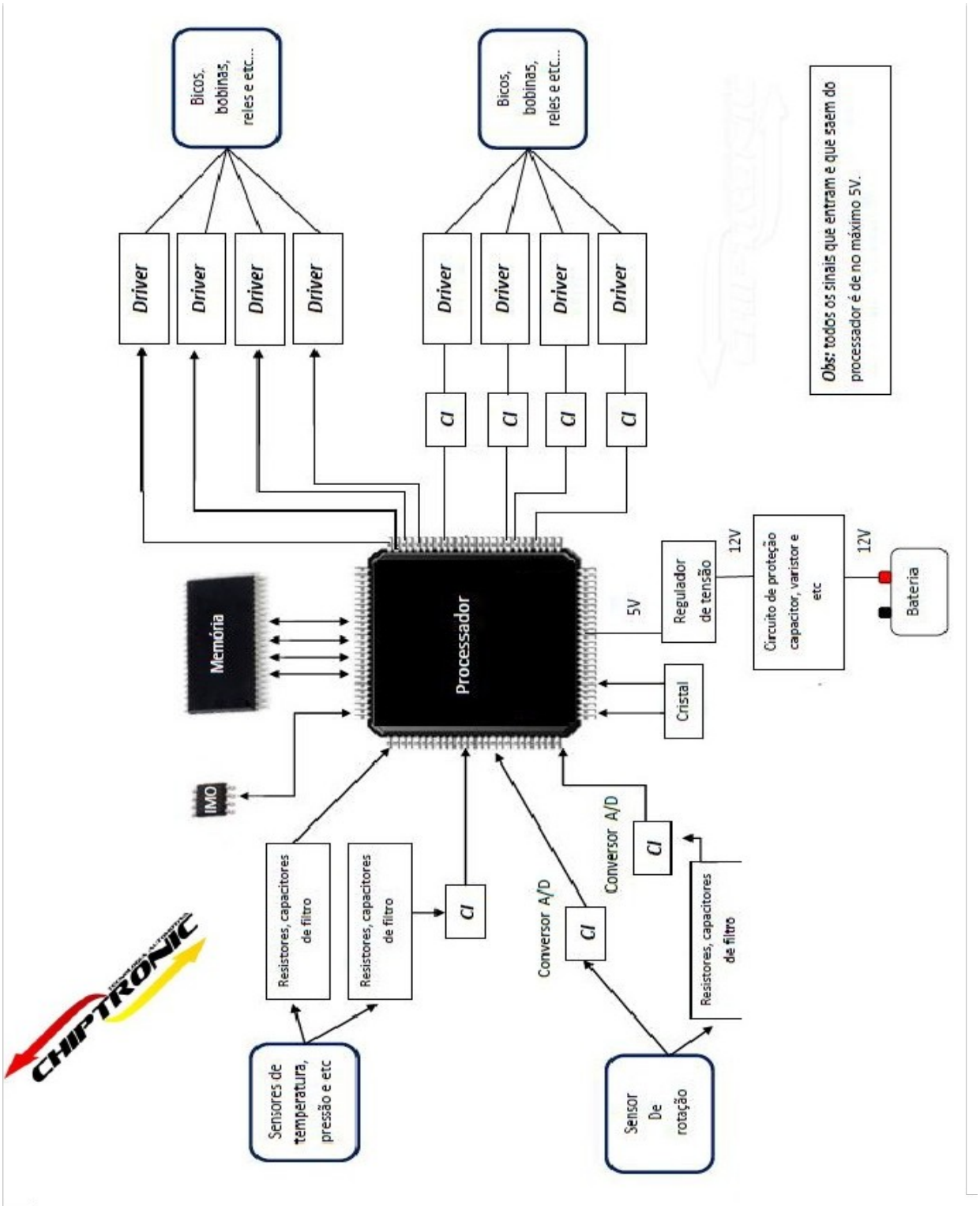
Some of the models have an engine start lock. Through the immobilizer system, which aims to protect the vehicle against theft.

Diesel System Operation Strategy



The sensors are responsible for sending signals to the ECU to process and command the actions of the actuators, according to the operating strategy adopted.

Internal Architecture of Plants



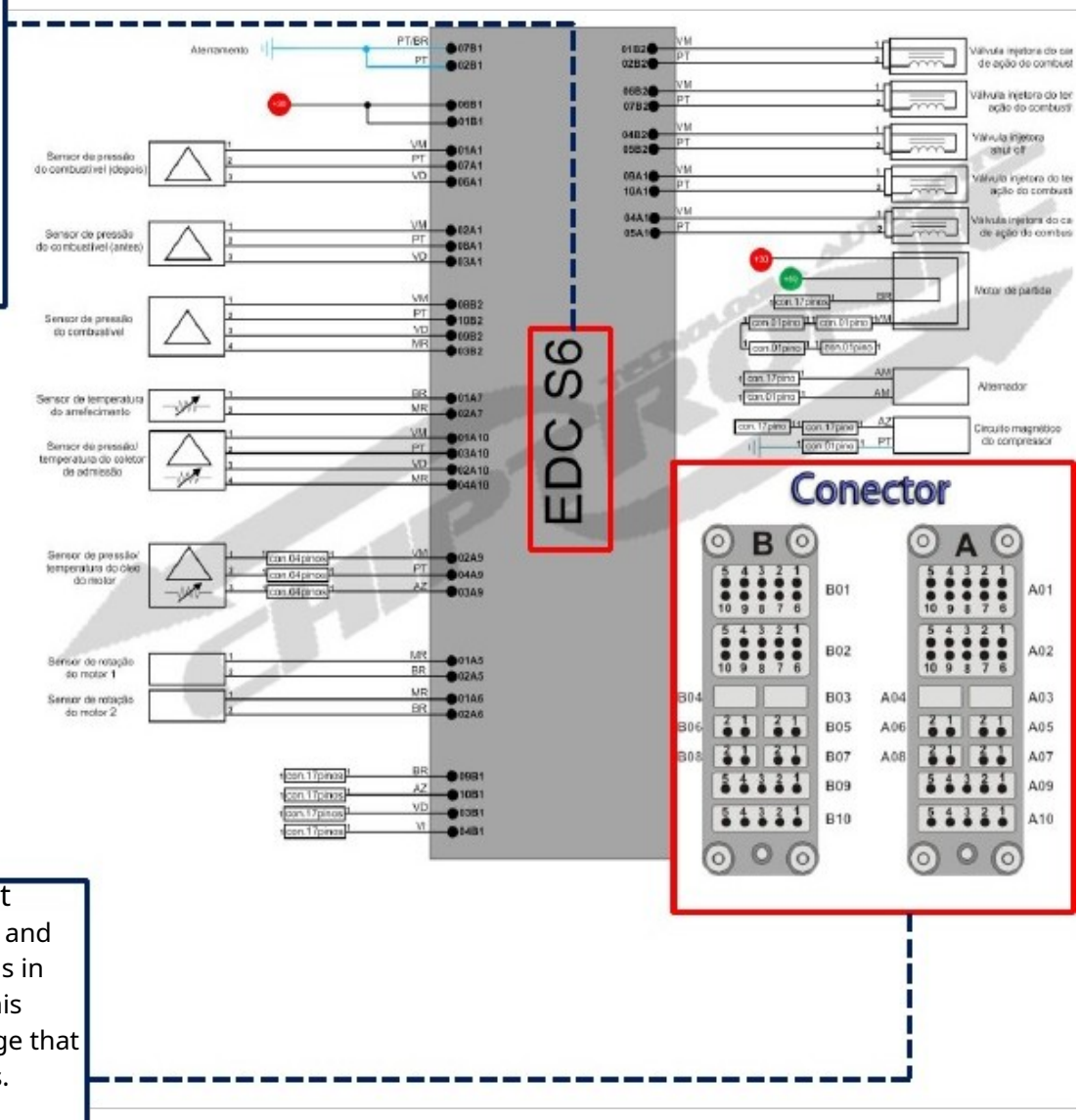
Electric scheme

Electrical Schematic Interpretation Technique

To understand how to interpret an electrical diagram, let us take as an example the partial diagram of the EDC S6 Diesel Injection System.

Interpreting a schematic is very simple and a fundamental step to carry out a Mapping in the ECU's, so it is important to understand this procedure very well.

The first step is identify the Scheme Electric regarding ECU that if have in hand.



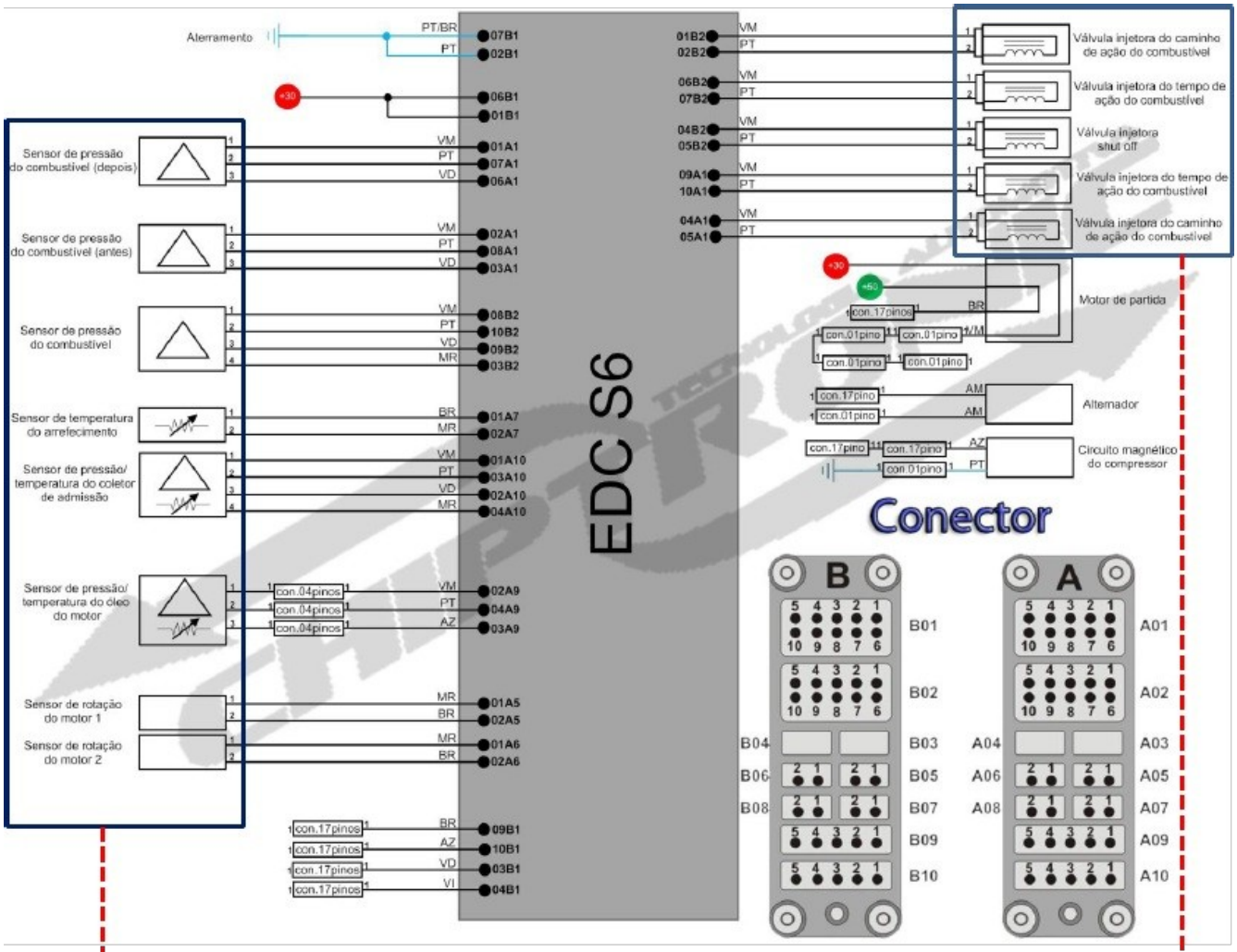
Next step; we must analyze the positions and numbering of the pins in the mouthpiece, in this case we have an image that helps us discover this.

After these first 2 important steps, it is possible to analyze the schematics and take readings of sensors and actuators.

Symbology of Electrical Schemes

Another and no less important step in the interpretation of electrical diagrams are the symbols that we find in it. Let's

look at some of them:



Sensor area:
We have the electrical signal for each sensor with its respective connection wire, including the color legend of each wire to facilitate searching the Truck.

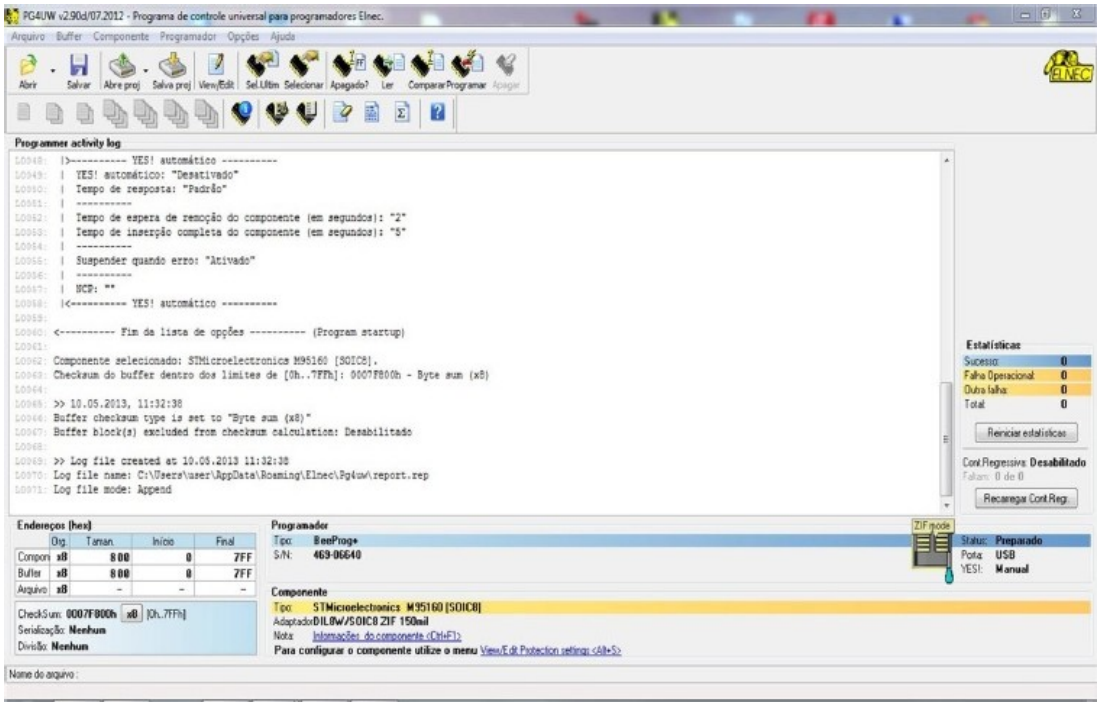
Actuators Area:
Note that as actuators there are injection units with their respective wires as well as the color corresponding. In this case we have a terminal that serves as a common that connects a bank of two injector units.

Eprom programmer

An important step in the repair of **ECUs** is the schedule. As it is a microcomputer, sometimes inconveniences arise in relation to the files stored inside the memories. A very common thing is the fact that files stored in memory can be erased, in part or completely, when this happens we say that the file is CORRUPTED. This can happen perhaps due to voltage overload or lack of it. If this happens the vehicle will not work due to the lack of vital information that was in the EPROM that got corrupted.

However, it is possible to solve defects like this through an Eprom programmer, where we can program a new file into memory that is corrupted, but it is important to point out that to perform this procedure it is necessary to have the file in question in a proper database, and most importantly, the file must be correct, ie it must be consistent with the ECU we are going to program. In this section we will learn in practice how to perform these procedures using ELNEC's EPROM Programmer, BEE PROG.

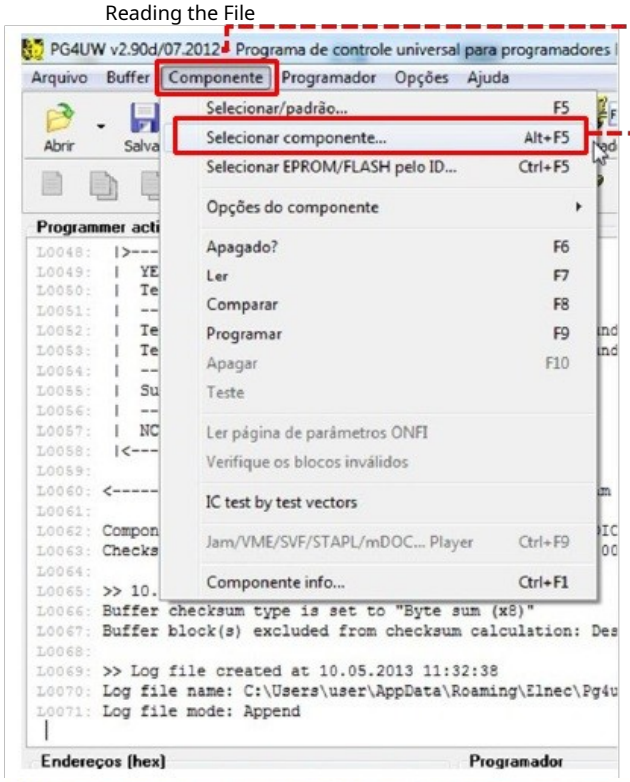
Reading from a File.
With this procedure we will be able to read an Eprom and mainly save the read content in a proper database, in addition to checking the file as to whether it is deleted or not.



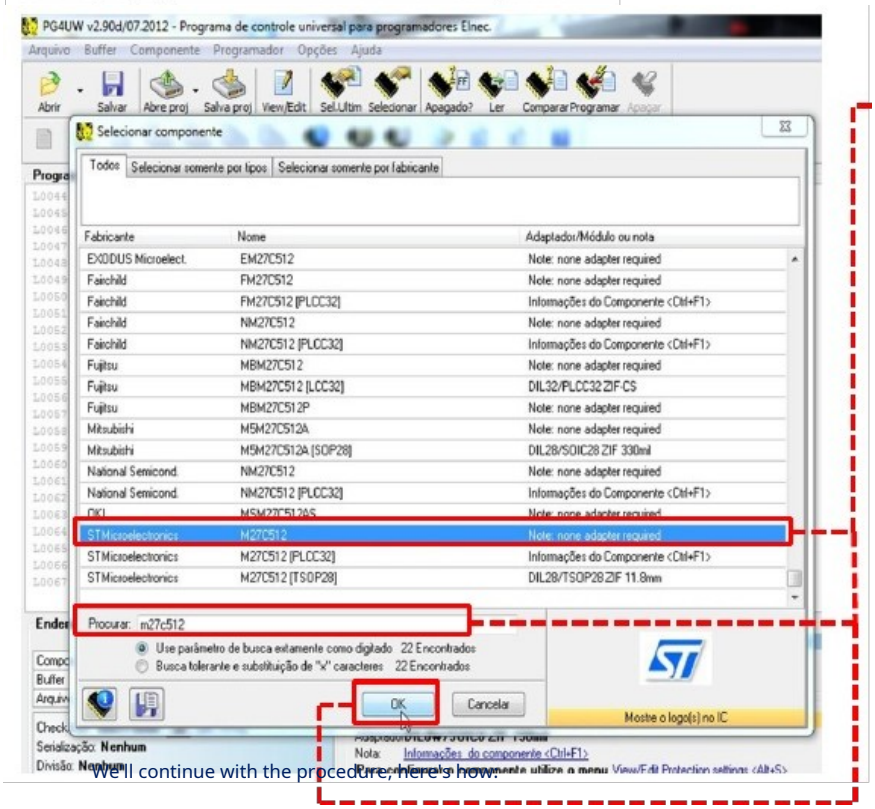
Bee Prog Software Home Screen.

Reading the File

Reading the File



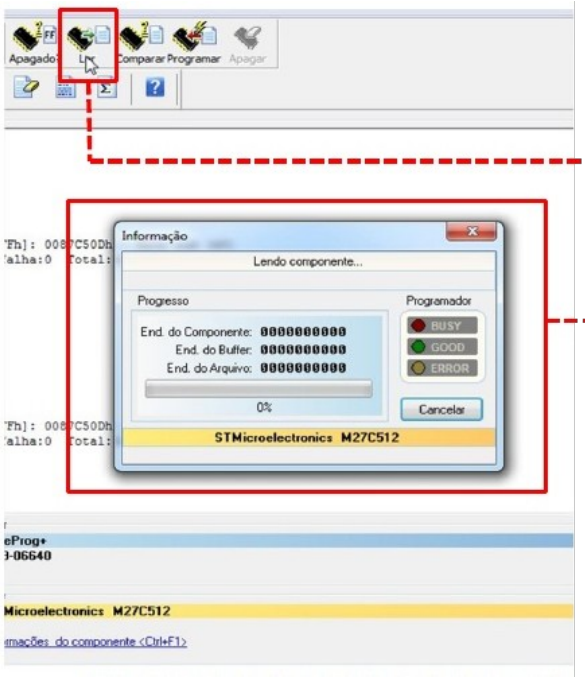
In these two fields we are going to make the selection process of the Eprom that we want to read the File, for that we must use the **nomenclature that is printed on it and choose the correct one for the procedure to work.**



In this step we will enter the component number in the bar "Search", in this case let's use as example the component of the ST brand Microelectronics with nomenclature M27C512de DIP encapsulation. After the selection we click on “Ok” ”kO and we continue the reading procedure.

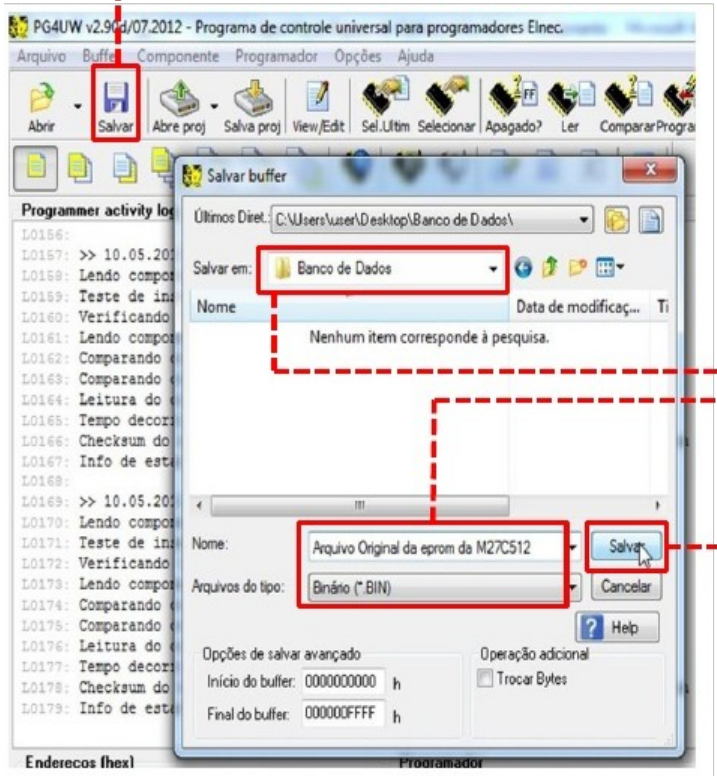
We'll continue with the procedure, here's how:

We'll continue with the procedure, here's how:



In the upper Taskbar in the Elnec software, click on the highlighted icon with the —READ function.

One new Window will appear showing the progress of reading the file (from 0 to 100%), and if, by chance, any pin of the component does not make proper contact with the socket of the programmer one error message in will appear and will inform the reason for which wasn't possible to read.

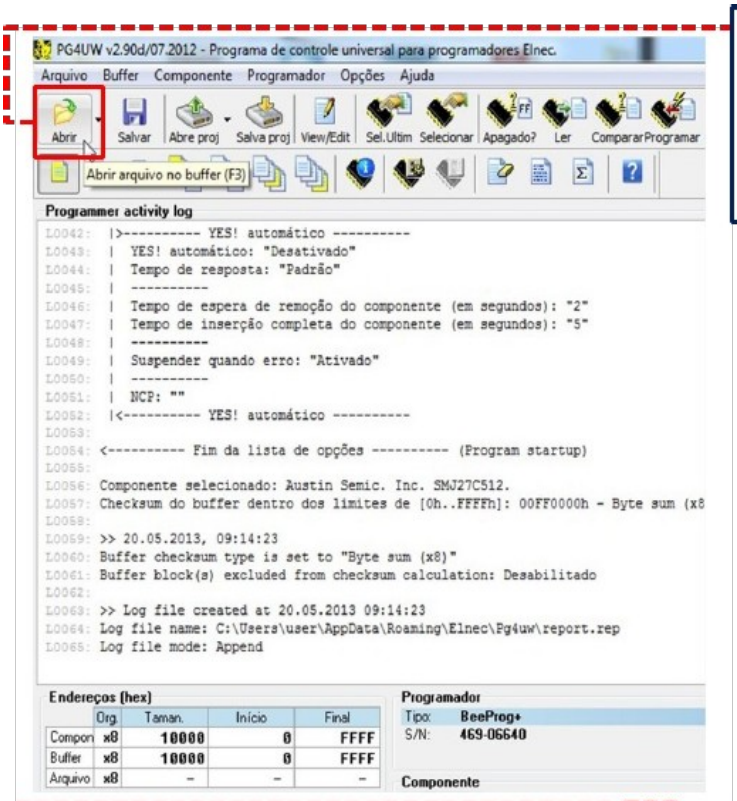


To save the file you just read, click on the corresponding icon.

Create a folder to serve as a database and save your duly renamed files there to facilitate searches later.

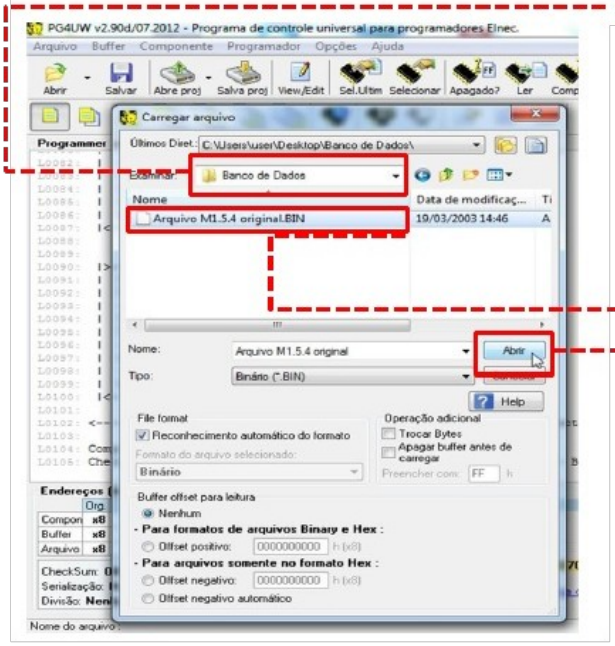
Click on save and that's it, the Eprom signal file is stored on the computer in the Database folder.

Programming a File



The next step we will learn is the write a file into memory eprom, for this do the following mode:

On the initial screen of the Elnec software, click on the option "Open" to access your database and open the file that want to program in Eprom memory

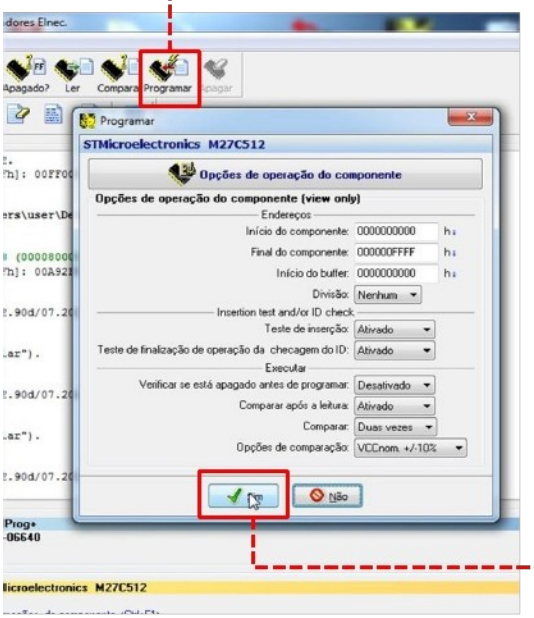


After clicking the "Open" button, a new window will appear. In it we can choose the folder that contains the file I want to program, in this case it is in the Database folder.

Within this folder select the correct file for programming.

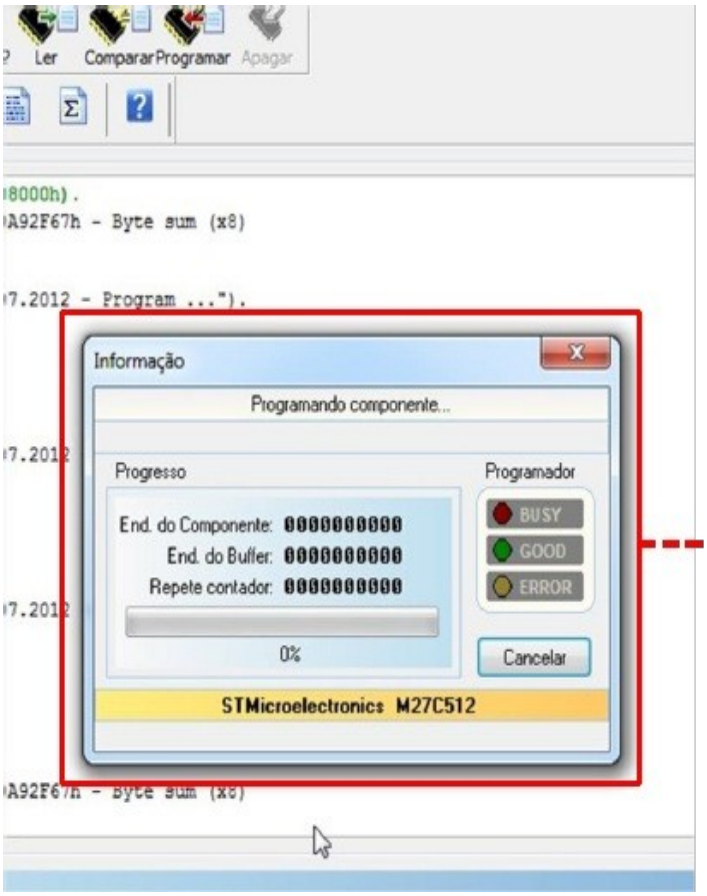
Now just click on the "Open" option and the selected file will be opened within the software and ready to program.

Now see how the programming of the file is executed:



In the upper Taskbar click on the "Schedule" icon; a new window will appear with some options about testing the component and checks of the same.

If all the options are correct, click on the "Yes" button within the new window that has appeared.



After clicking the "Yes" button, a new window will appear. In this window it will be possible to observe the Programming status (from 0 to 100%) and if there is any error it will also be possible to observe and correct it. At the end of the process the EPROM will have the new file and ready to be inserted into the ECU.

What is a Checksum?

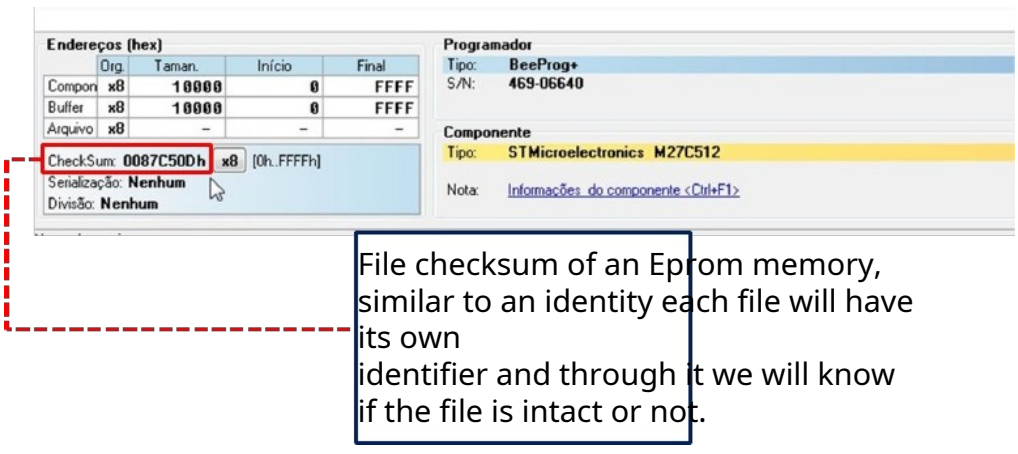
Every time we read a file or open it within the Elenc software, a set of numbers and letters will appear on a screen in the lower left corner. This alphanumeric set is the Checksum of the file in question. But what is a
CHECKSUM?

The name Checksum comes from the English which is the "checksum", this set of characters is used to check the integrity of the file in question. We can compare it as the file's identity, and each one will have its own Checksum identifier, and through it we can know if the file is corrupted or not. The Checksum is obtained by calculating the sum of all data stored in non-volatile memory (**EPROM or FLASH)** and noting the last 4 hexadecimal characters.

In order to check if the data of a certain memory in question is whole (without alteration), a memory read is performed again and the reading software will then provide the sum of the data, thus obtaining its new Checksum. So you can compare it to the local Memory Checksum. If the Checksum is the same, it is unlikely that the memory has its contents changed, but if it is different, the memory has certainly been corrupted, and needs to be fixed.

Some centrals have checksum verification by hardware, that is, the central itself reads the data and checks if the sum is integrated. If not, the anomaly light will turn on and an error will be noted. This is quite common to occur on injection systems that have been remapped. Generally, the remapping of plants is done with the purpose of converting fuel (from gasoline to alcohol or gas) or even increasing engine power. For these cases, Checksum correction software is used. These software create certain values in unused memory locations, which when added to the other memory data correct the Checksum, that is, give the same value as the local Checksum, thus tricking the hardware, making the system think that the data was not changed.

To help identify the Checksum we have a comparison table for some system models, so we'll know exactly the file integrity.

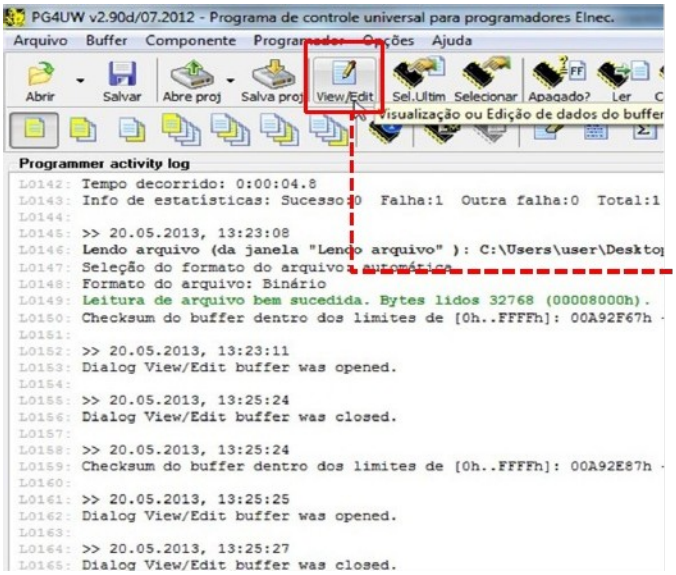


File checksum of an Eprom memory, similar to an identity each file will have its own
identifier and through it we will know if the file is intact or not.

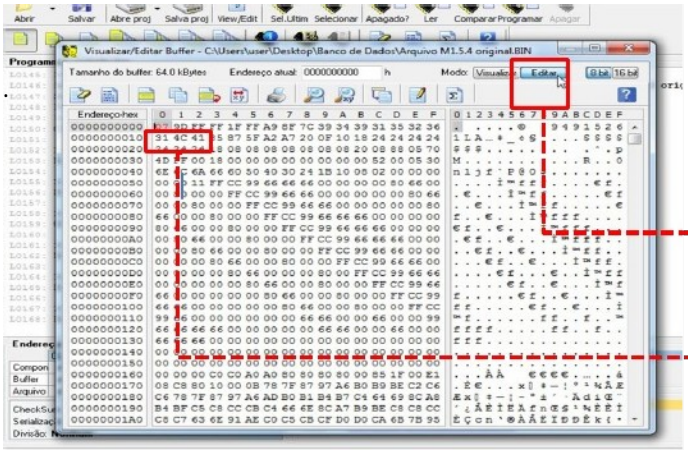
Editing Hexadecimal Files

With this option in Elnec's software, you can edit the file you want, but you need to be very careful and especially master the subject, because if you don't know what you're doing, it's likely that the file will be corrupted, the Checksum will be modified and the vehicle do not go live or run into management difficulties
electronic.

See step by step the execution of this procedure.



with the file open in software from Elnec, click on the button "View//Edit in **taskbar** superior in the software. A new one will open.



In the new window that appears, just click on the "Edit" button, and you can change the characters of given address. It is good to remember that any changes that if you do it without proper knowledge you can compromise the Checksum and consequently the functioning of the vehicle.

Use of New Genius as a Programmer.

The New Genius is a device that provides readings from heavy line centrals files as well as programming them in trucks through the diagnostic connector.

New GENIUS allows intuitive use, thanks to its touch-screen panel and a really user-friendly operative system: reading operations and
Programming are carried out without any connection to a PC to offer the greatest independence and avoid slowdowns or blocking linked to a possible presence of viruses or, in general, the effect of the multitasking nature of the computer.

New GENIUS represents the perfect tool for the best professionals as well as new tuners: the direct interface with the vehicle's engine via **E-OBDII** or diagnostic taking. CAN-BUS, K/L-line (KWP), J1850 communication protocols are supported to cover all ranges of automobiles, light commercial vehicles and trucks.

The removable 512 Mbyte SD CARD (Secure Digital), expandable up to 4 Gbytes, allows the storage of an almost unlimited number of srcnal / tuned files.

New GENIUS is a real asset for every tuner thanks to the impossibility of performing wrong operations: detailed instructions appear on the screen and drive the tuner until the car is programmed. Thanks to its new and advanced technology, it has never been simpler to achieve the satisfactory result.

New Trasdata

It is a versatile equipment used for reading and programming centrals with memory added to the processor (similar to ST10), but it covers much more light gasoline and flex line systems and is capable of performing these procedures in light and medium diesel vehicles (trucks) .

Truck -Test Plant Simulator

What is a Switchboard Simulator?

With this equipment, we can perform more accurate tests regarding the activation of the injection system actuators and also regarding the ECU's response when receiving electrical signals from certain sensors.

As it is an electronic equipment, some important care regarding its use is necessary. Another important point that must be highlighted, the Truck Test will not show the possible diagnosis on the screen, as it is not a Scanner, but it will require logical reasoning from the User for the interpretation of certain defects such as, for example, the non-activation of an Injection Unit .

Something very practical that the simulator provides is communication with a multi-brand scanner, being only necessary to use a specific cable to perform this procedure.

In ECU repair labs it is interesting to have a simulator, first to perform a more accurate diagnosis, and secondly to assess the efficiency of the repair that was required on the ECU.

TEST THE DRIVE:

Injection Units
Top Break
Account turns
Start relay
Tachometer

SIMULATES THE SENSORS:

- Rotation (Digital)
- Water Temperature
- Oil Temperature
- Oil Pressure
- Air pressure
- Fuel Temperature
- Accelerator Pedal