ConsuLab
TRAINING AIDS

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A ConsuLab Presentation

A FRESH LOOK AT IGNITION

MAY 2018

A FRESH LOOK AT IGNITION

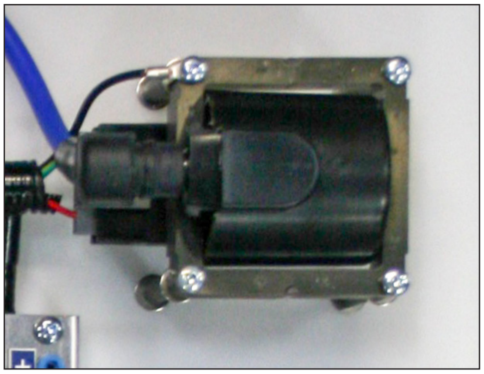
This written text will loosely follow the ConsuLab presentation of A Fresh Look at Ignition. Feel free to copy or re-duplicate and use in your classes. If possible, we always appreciate a nod to ConsuLab for supplying it. In this presentation we will look at some of the variables involved in the different systems on the road. There is no way that all systems can be covered so you will have to adapt to what you have available in your school.

You will see the use of many different DSO's in this handout. If you have a choice, use a single channel DSO to start with. Within ignition there may be a need to sometimes use a dual trace DSO.

Some Suggestions:

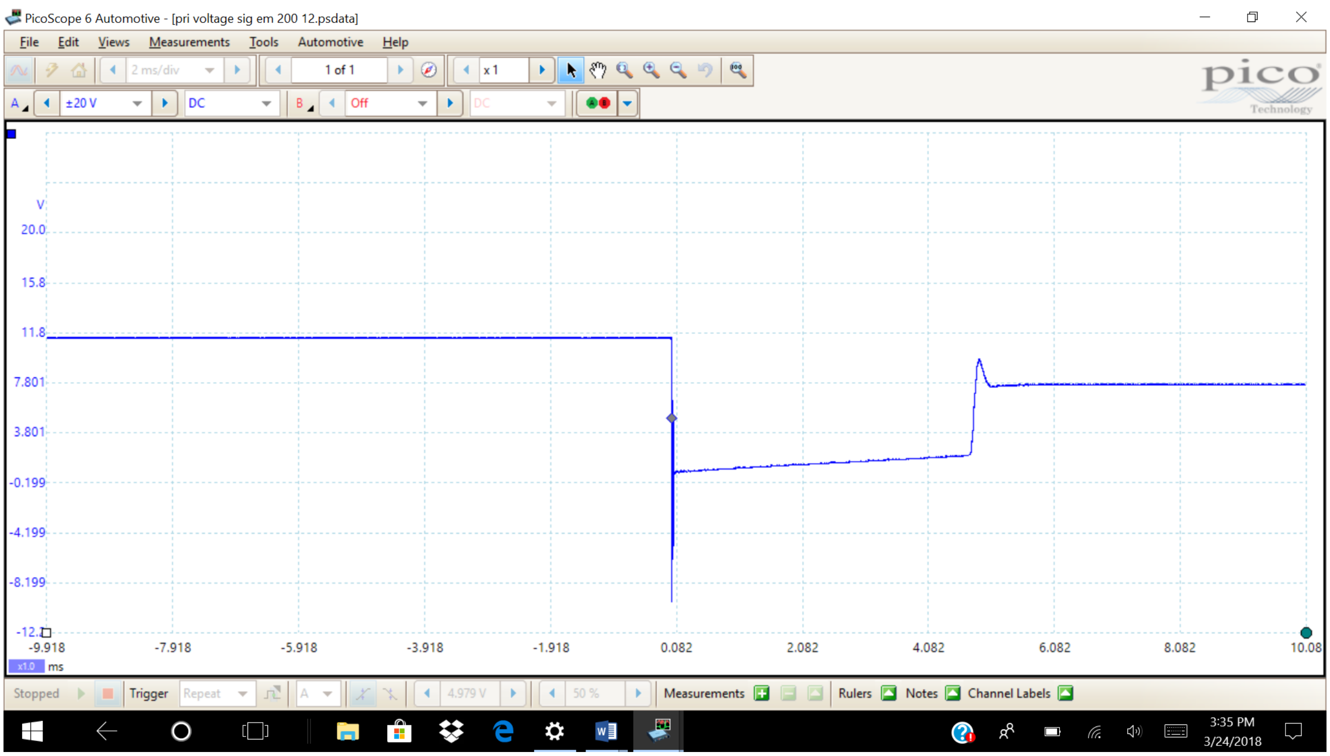
- Don't give out too much theory. Theory for theory sake will do nothing to increase your student's comprehension of ignition.
- Introduce ignition after a basic unit on DSO's. Once a student knows how to set Volts/Division, Time/Division, use trigger and measure with cursors, they are ready to use the DSO to help them understand the modern ignition system. Frequently classes do not use the DSO to introduce a system. The suggestion here is to have the students fill out a basic lab sheet filling in the blanks of voltage, time and what each number really means. In this way the DSO pattern analysis helps the student understand the sequence of events that make up the generation of the spark. Adding some current probe measurements cements the knowledge.
- Use a scanner to capture ignition data. Here is where it gets interesting since each manufacture decides what data will be displayed on the scanner. Typically, we find limited data available with some vehicles only generating RPM and ignition advance/retard. Students need to be shown that this limited data, although important, does little to help with diagnostics.
- Have a printer available. If you adopt some or all this method, your lab sheets will have patterns that your students capture. If students can walk up to a printer and print the pattern off the DSO or scanner rather than trying to draw it, the pattern can be returned to the student and he/she can begin accumulating their own textbook.
- The kiss philosophy really comes into play here. Keep it simple! Limited theory, lots of hands on activities and using the DSO to show how it works rather than why it doesn't work can greatly increase your student's comprehension.

The Primary Circuit



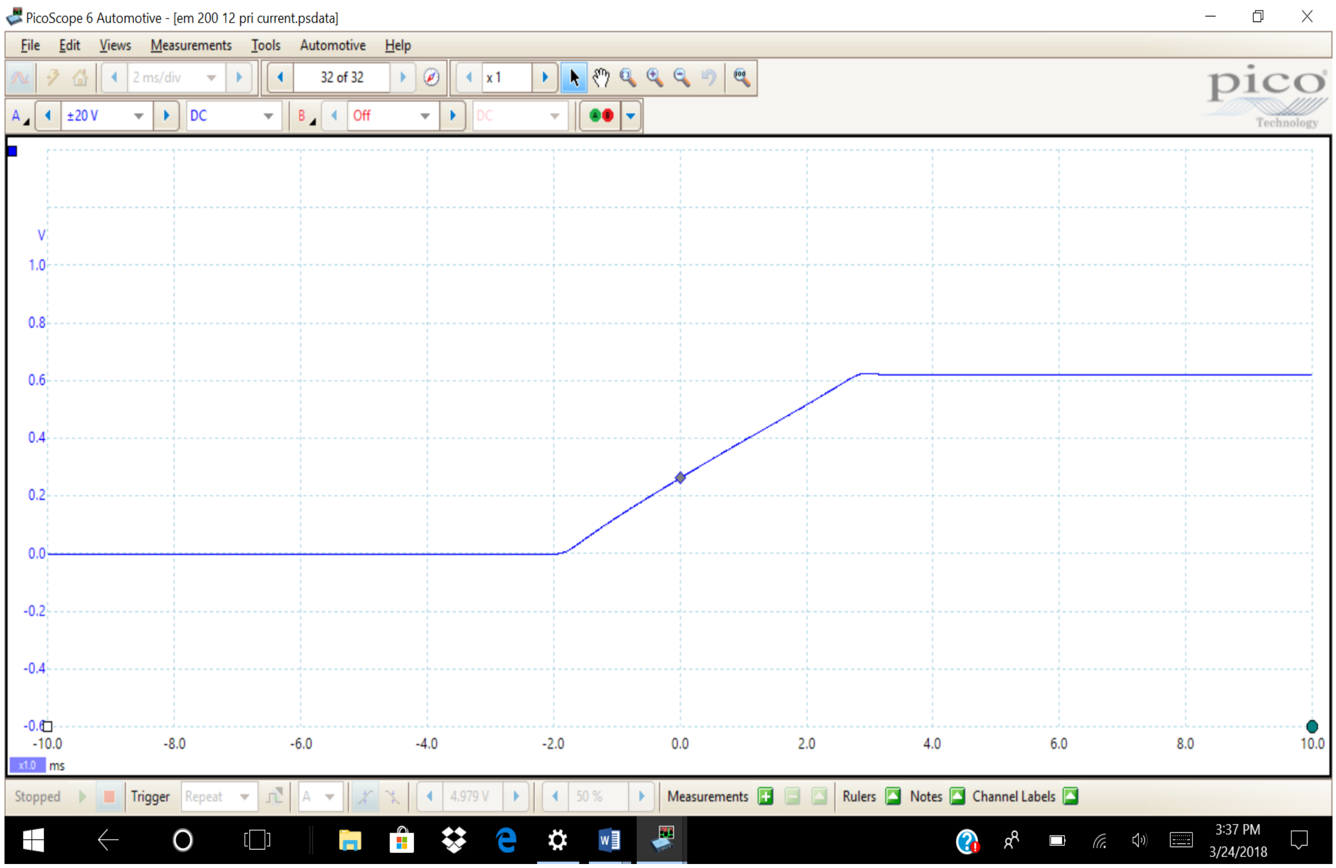
The one component in the modern ignition system that virtually all systems have in common is the ignition coil. If a student understands what happens in this component, he will understand ignition systems.

Here is where the DSO comes into play. If you have introduced the DSO to the student and he can capture a pattern, set up V/Div, T/div, use trigger and measure with cursors then he can display a pattern like this.



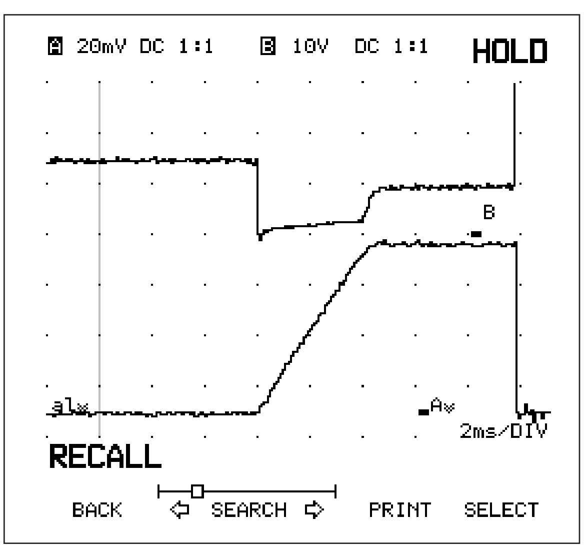
This pattern comes off the ConsuLab EM-200-12 Ford TFI ignition trainer. The DSO is connected to the negative of the coil and ground. We recommend that you start students off with a distributed system since it represents a simplified format that will give sufficient information to the student. First have the student measure B+ and record it. Next ask what happened about mid screen? The answer is the pattern shows a drop in voltage to 0 volts. 0 Volts is ground potential; so, the negative of the coil went from B+ to ground. At this point bring in voltage drop and when a voltage drop occurs we generate light, heat and magnetic field. Use a light bulb to emphasize this concept. Draw a simply coil of wire or bulb with power (B+) on one end and ground on the other. Draw a voltmeter across the coil and ask what it will read? This shows voltage drop and it is this difference that allows current to flow.

If we look at current flow for the same system at the same time it will look like this:

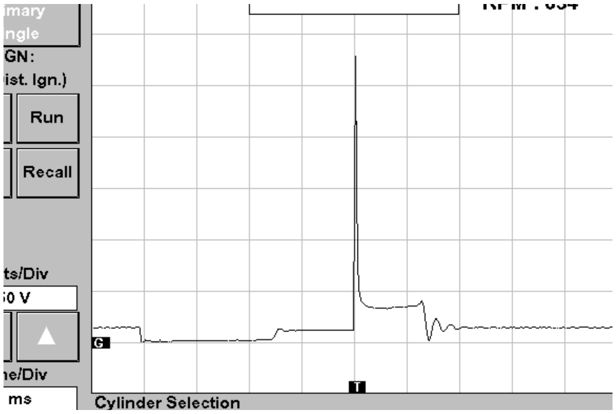


On the left is 0 amps. Once the difference between the two terminals of the coil is full voltage, current will ramp or increase from 0 to about 6 Amps. In this example we are using an amp probe that generated 100 mV for every amp flowing. We are right at 600 mV or 6 amps flowing. Take your time with this since an understanding of voltage drop causing current flow is fundamentally basic to their understanding of just about everything.

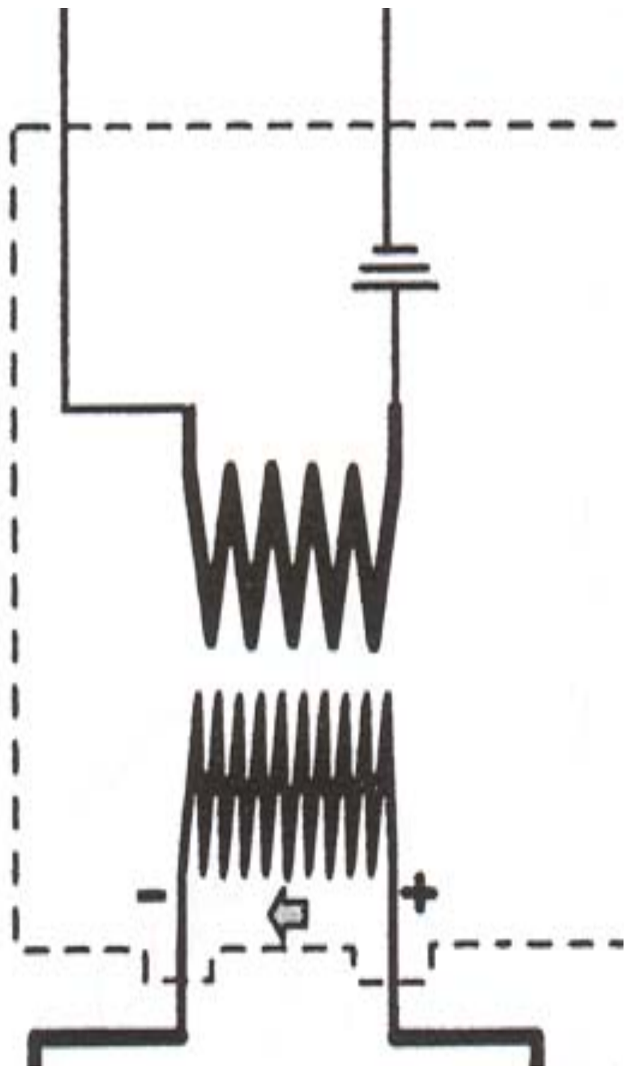
If we combine the volts display and the amps display together we can see the relationship between the two as it occurs.



Voltage is the B channel (on top) and current is the A channel (0n bottom). The current begins to ramp up just as the voltage drops to zero. When the coil positive is at B+ and the negative is at zero, current flows. Ohms law tells us that if the difference between positive and negative is 12 and the resistance of the coil is 2 ohms then 6 amps will flow as our previous illustration shows. Later we will see that it is not just the resistance of the coil that will determine the amount of current. The module will have a lot to do with this function.

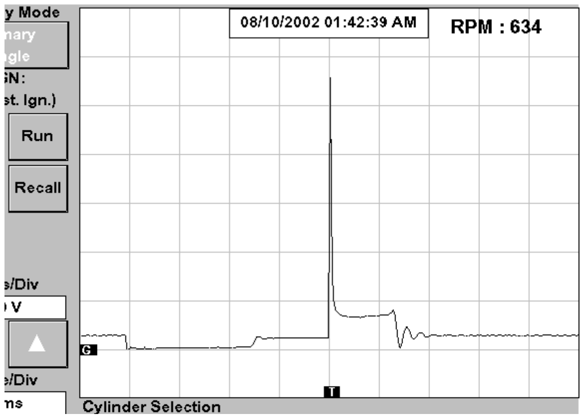


If the DSO can show the entire primary event it will reveal, in order, primary circuit turn on and off. When the turn off occurs the magnetic field will collapse across the windings of the coil and produce the spike you see at about mid screen. Each division of the DSO is set to 50V/Div. The spike goes up to 5 and a half divisions. 5.5 X 50V=275V. So, the collapsing magnetic field created a voltage spike of about 275V in the primary. 275V is not enough to jump the air gap of the plug but it is a start.



Let's look at the other side of the coil, the secondary. The secondary consists of many more windings than the primary and it is this ratio of primary to secondary that allows the coil to produce a voltage high enough to jump the gap of the plug. For example, if the secondary has 10 times more windings and there is 275V in the primary than the secondary could produce 2,750V or 10 times the primary. If the secondary has 100 times the windings then 27,500 volts could be produced in the secondary, etc.

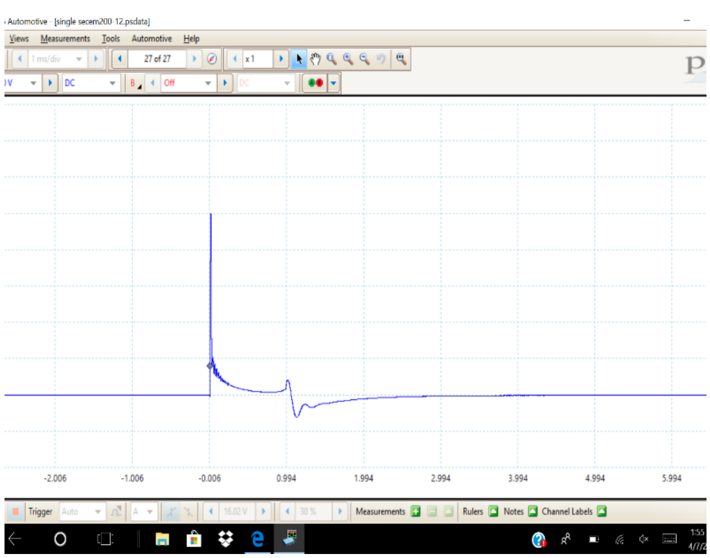
Remember and teach that the primary winding is composed of hundreds of turns of thick wire (to handle the current) and thousands of turns of thin secondary wire. The secondary can be made with thin wire since there is very little current flowing in the secondary. It is the high voltage that needs to jump the spark plug gap and not the current.



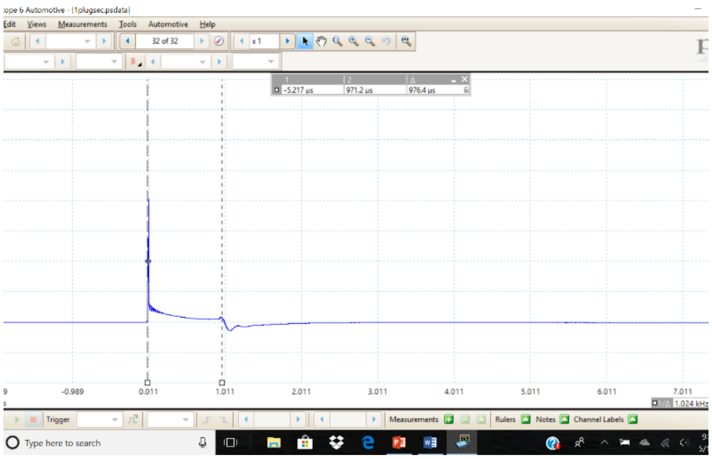
Probably the most important thing for a student to consider other than did the plug fire, is how long did it fire for? This is called burn time. Engineers have determined that the ideal spark will last longer than .8mSec. Anything less is likely to produce an ignition misfire. Typically, you will find that the spark will last between .8 and 2.0mS. Longer spark than 2.0mS could reduce spark plug life. We can measure the spark duration or burn time by looking at either the primary or the secondary voltage waveform. The horizontal line after the induced voltage spike is the burn time. In this example, burn time is about 1.25mSec or between .8 and 2.0mSec.

Secondary Voltage

Changes in the vehicle have made actual measurements of the secondary voltage difficult. If there are no plug wires, then measuring secondary voltage is virtually impossible. There are some adapters that will give us a relative voltage. If we compare the spikes on a 4-cylinder vehicle with each other they should all be about the same. Paddle probes can be placed on the ignition coil and give us this “relative” secondary voltage.



Placing the probe on an ignition coil of a Ford TFI ignition system produced the following pattern. The spike tells us that a spark did occur and the horizontal line (burn time) tells us how long it sparked. The scale at the bottom or the screen can be interpreted to give burn time, but an easier method is to use cursors.

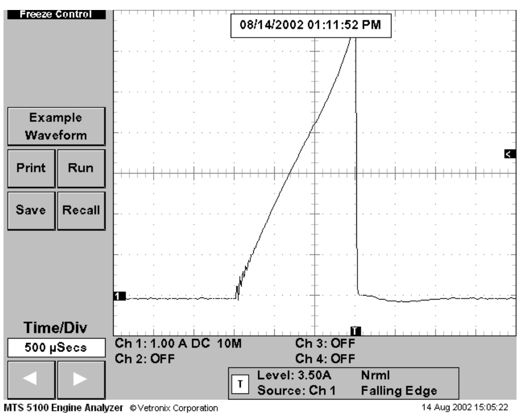


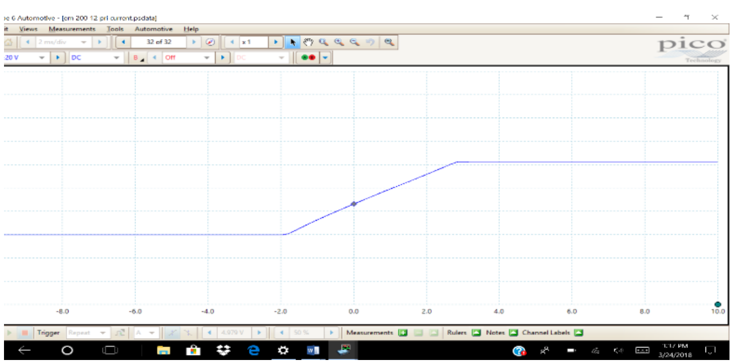
The box mid screen top shows that burn time was .976mSec, which is between .8 and 2.0mSec. The voltage shown on both displays is only a relative voltage since every coil will generate a different voltage for the capacitance coupled paddle probe. Use it to determine that there was a spark. The value of the probe is in its ability to show this spark. However, it can be used to measure how long the spark or burn time was. Burn time is probably the most important thing to teach.

Module Function

The key to understanding the ignition system is in the various functions of the module. Where is the module located? It could be just about anywhere. It may be on the distributor, or in the distributer, assuming there is one. It could be under the ignition coils, mounted on the radiator support, inside the ignition coil, or the function of the module might be in the ECM or the PCM. Have the students check the wiring diagram since it will usually tell them where it is located.

The ignition module is a multi-function device. All modules will have at least 2 functions: turn on primary current and turn it off. Some modules will add variable dwell (primary on time) and/or a current limit function. Frequently a look at a primary current waveform will tell the story.





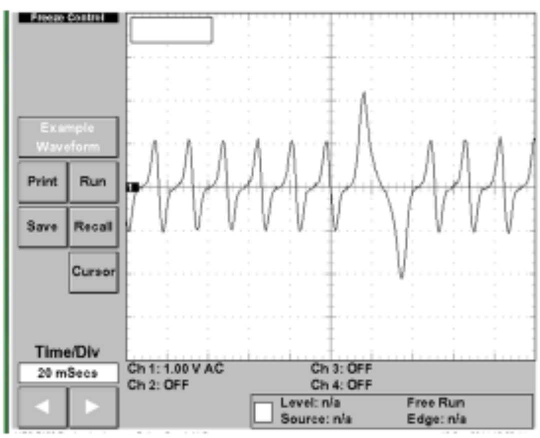
The pattern on the left is from a system that has 2 functions: turn primary current on and then off. During the ramping or saturation time, current builds and causes the magnetic field to also build. At the end of the ramp or saturation the module turns off the current and the trace goes back to zero. The amount of current in this system will be proportional to the resistance of the coil. A 2-ohm coil will draw 6 amps if 12 volts is across the winding. However, the pattern on the right shows something different. Once the current reaches a specific level the module controls or limits the amount and we see a flat line after the ramp.

Variable dwell is another way of limiting the amount of saturation but can only be shown live. If you observe how long the saturation time is and change the speed of the engine the time will change with speed or not change. If it changes, the module has a variable dwell. The resistance of ignition coils has dropped from as high as 10 ohms, years ago, to less than one ohm for many coils today. It is an unreliable test to measure the ohms of the coil primary. It could be low because the coil is shorted or low by design. The most reliable test will be the DSO.

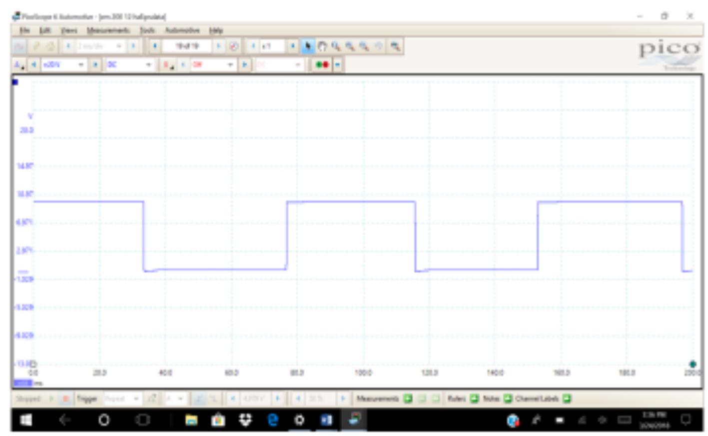
Determining Timing

When the spark is delivered to the plug is a very important function. To achieve a full burn of the air/fuel, the plug must fire at the precise time in the intake, compression, power, exhaust cycle. This will be done by the module looking at many inputs and will vary from vehicle to vehicle. However, all systems must know the speed of the engine (RPM) and the position of the pistons. This will be done typically with either AC magnetic sensors or Hall-Effect sensors.

AC Magnetic

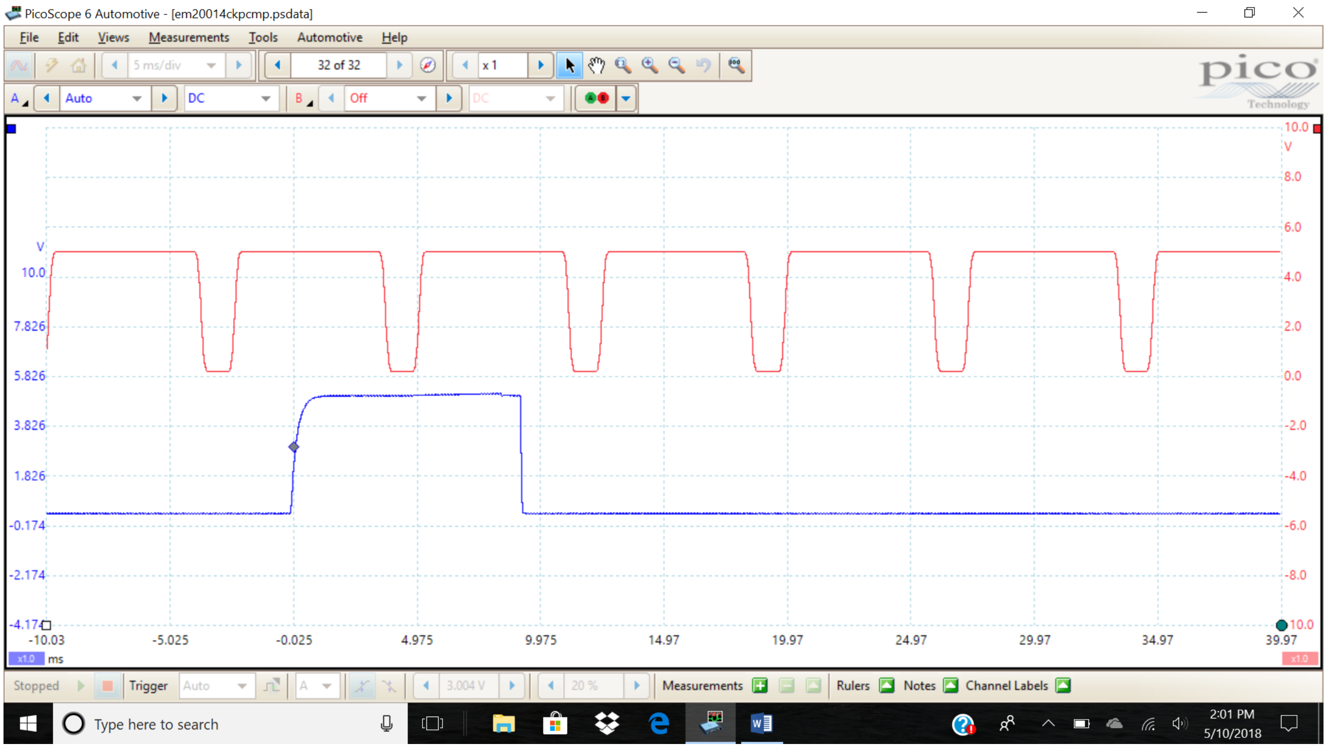


DC Hall Effect



Frequently the information needed is supplied by a crankshaft position sensor (CKP) for engine speed and a camshaft position sensor (CMP) for position.

This dual trace pattern is from a Honda Civic and uses 2 Hall-Effect sensors. CKP is in blue and CMP is red.



Design Variables

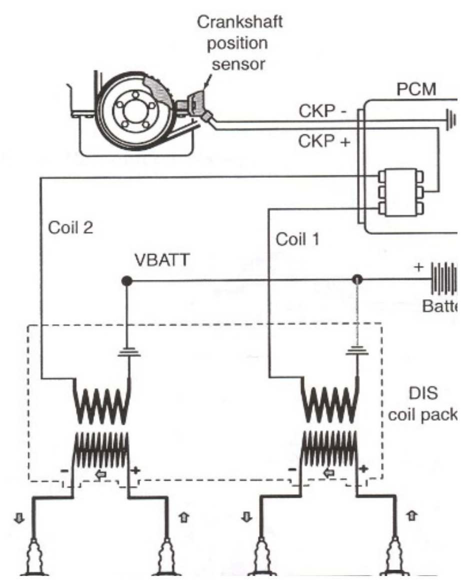
There are many designs under the heading of Ignition Systems. The first, and the one you might decide to cover first are those with distributors (DI). From a practical standpoint, there are still DI systems on the road, but few manufactures are currently using one. The switch over to multiple coils has been dramatic. It allows a single coil to have plenty of time to saturate the primary and fire either one of two plugs. On a DI system the single coil must do everything for every plug. This leaves little time to cool down or "rest" between firings.

Type One Distributerless

A type one system will have all coils molded into one housing and will typically fire two plugs at a time. They are usually referred to as being waste spark since each plug fires first on compression while the companion plug is firing on exhaust. The exhaust spark does little and is therefor waste. Hence the name.

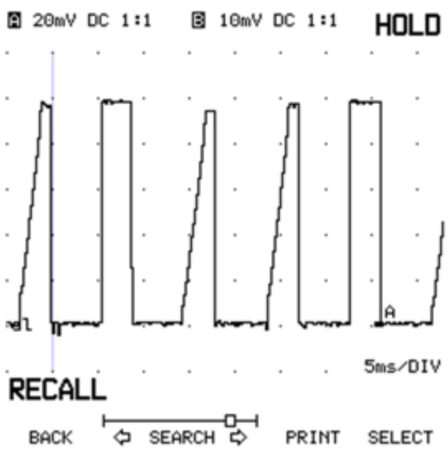
Type two system function the same as a waste spark system only the individual coils are replaceable.

The wiring diagrams for either a type one or a type two will look the same.

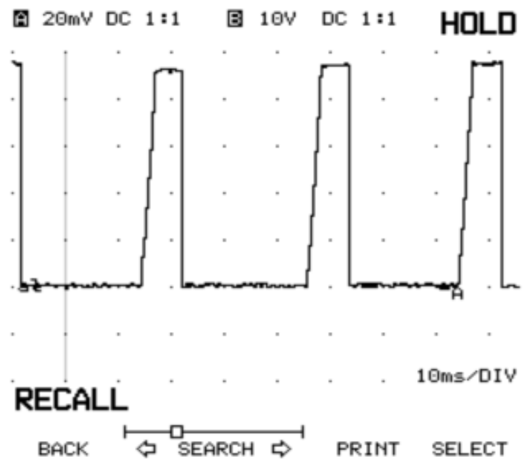


Notice that the PCM is functioning as the ignition module controlling primary current to each coil individually. A CKP is being used as the input device for speed and position. On these systems it is virtually impossible to capture a primary voltage waveform, so primary current is used. It can be used to compare each coil. Control the time/Div so the number of pulses on the screen slightly exceed the number of coils.

Shorted Coil



Normal Coils

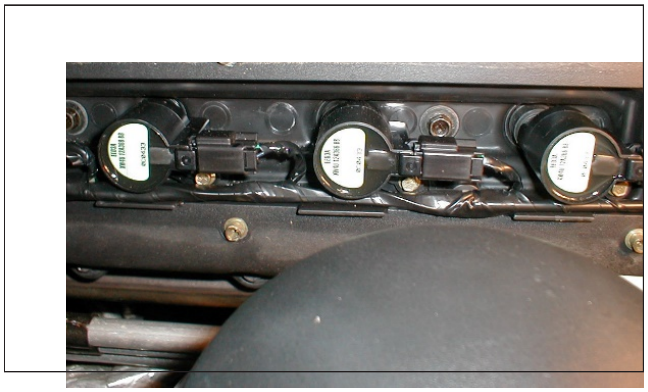


If a shorted or open coil is present the normal pattern will not be seen. Instead for a short, the pattern will go straight up and with an open it will stay at zero and leave a gap in the pattern. This pattern also shows a flat top of the coil current, so the current limit function of the module is present.

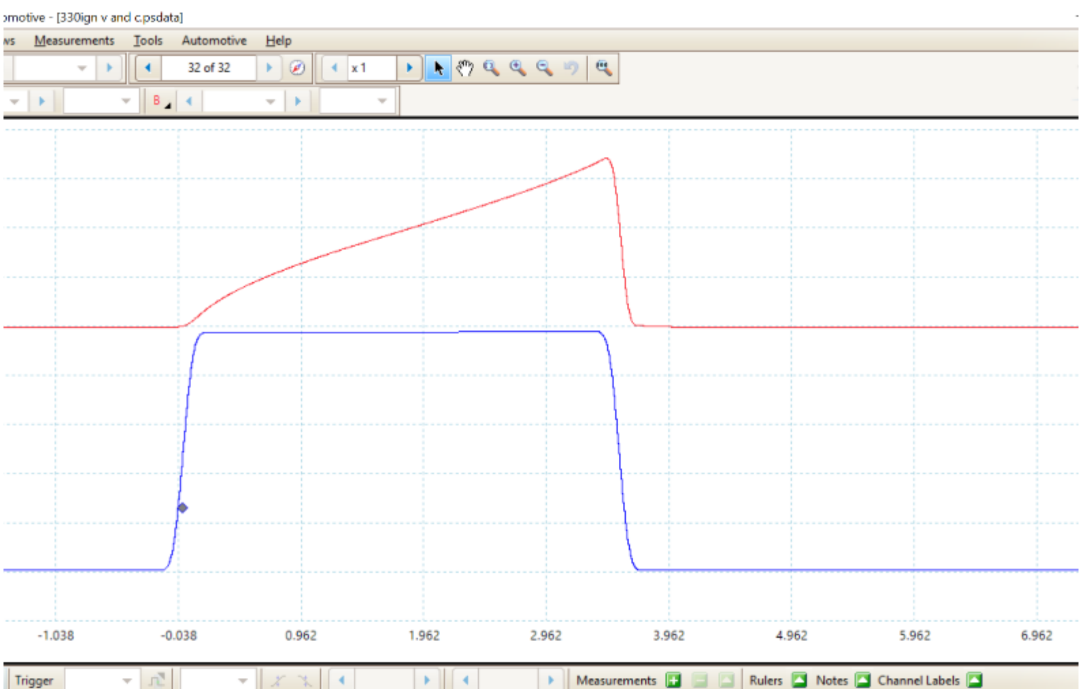
Coil on Plug (COP)

The COP systems have really taken over the market. They are frequently found with the module contained within the ignition coil. They are fired with a signal from the ECM/PCM. In a class, this is an effective use of a dual trace DSO since it will allow a comparison between the signal and the current ramp of the primary. Most of these systems have no ability to capture a primary voltage signal.

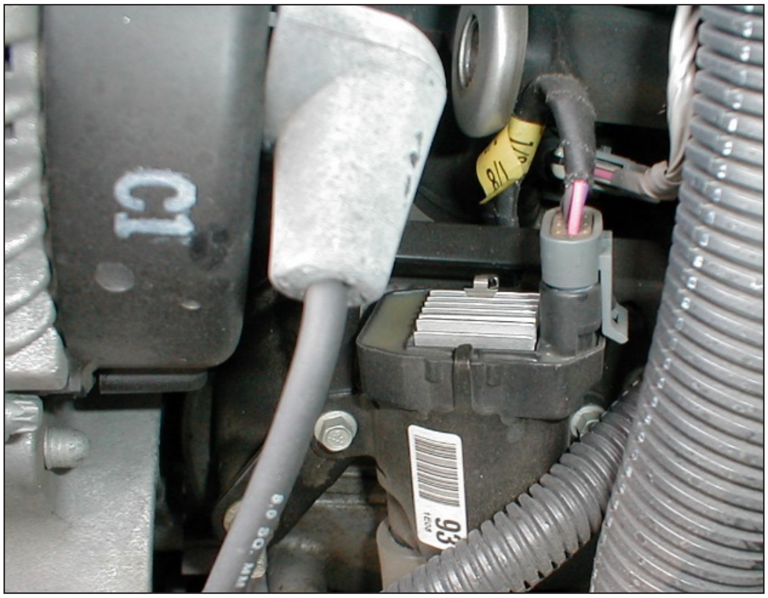
The student must rely on the primary current ramp and the paddle probe to get the burn time, saturation time, and firing voltage. The blue trace is the signal from the ECM/PCM and the red trace is coil current. These two will match when compared for time and they represent the saturation time or dwell of the coil. These signals come off of the EM-330 Engine Management Trainer.



There are some systems that use a multi spark configuration. This Ford Coil On Plug system will fire the plugs multiple times at idle and switch over to a single firing once the vehicle is above idle (about 1000 RPM). The patterns for this system will confuse students and beginning technicians so make sure you go over them toward the end of the unit.



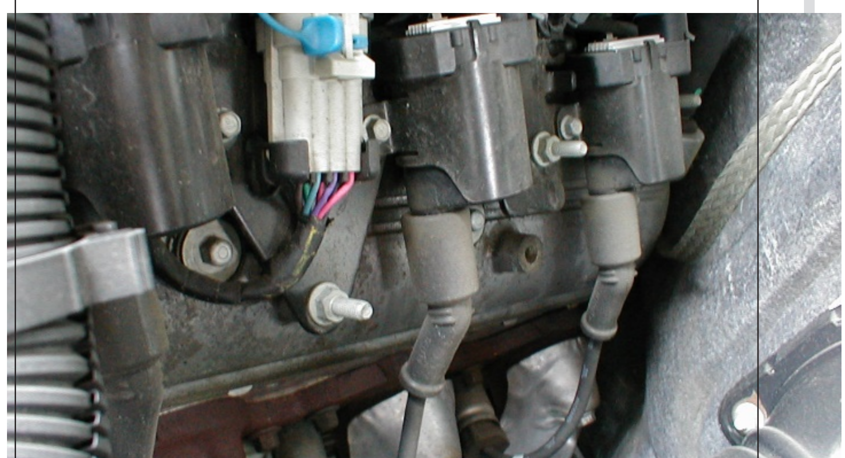
At idle the current ramp shows 3 pulses to charge the coil and fire it 3 times. This pattern is at idle. Once the engine is above about 1000 RPM the pattern shows (on right) that the coil is being charged once and discharged once. This is done for emissions which are typically higher at idle. A multi spark discharge tends to get more of the A/F ratio burning.



Some coils that are in the DIS category will have a heat sink showing. It allows the module which is contained within the coil to keep cool. The picture is from a GM vehicle. The silver finned object on top of the coil is the heat sink.

Coil Near Plug (CNP)

Some vehicles have a short plug wire leading from the coil to the plug on CNP systems. This will allow secondary voltage to be measured by an inductive pick-up that some DSO's have.



As you teach ignition systems and their diagnosis ask the students the same questions for all systems no matter how different they appear to be:

1. How long is saturation time (should be >2.0 mS);
2. How much current does the coil draw (varies);
3. What is burn time (should be 0.8 – 2.0 mS);
4. What is the firing voltage (or relative voltage if measured with a paddle probe) (6 k – 12 kV).

Ignition Testing Using a Scanner

The use of a scanner is limited, and student/technicians need to understand this. Many technicians rely on their scanner for diagnosis and it does give tremendous information. However, the PID's (parameter identifications) are limited to as little as RPM and ignition timing. The information can be used to show that timing does advance (occur earlier) with increases in engine speed. There currently is no vehicle that gives burn time, saturation time, or firing voltage as a PID or line on the scanner. Students/technicians need to understand that they must rely on the DSO to get the necessary information.

Teach the basics of the DSO.

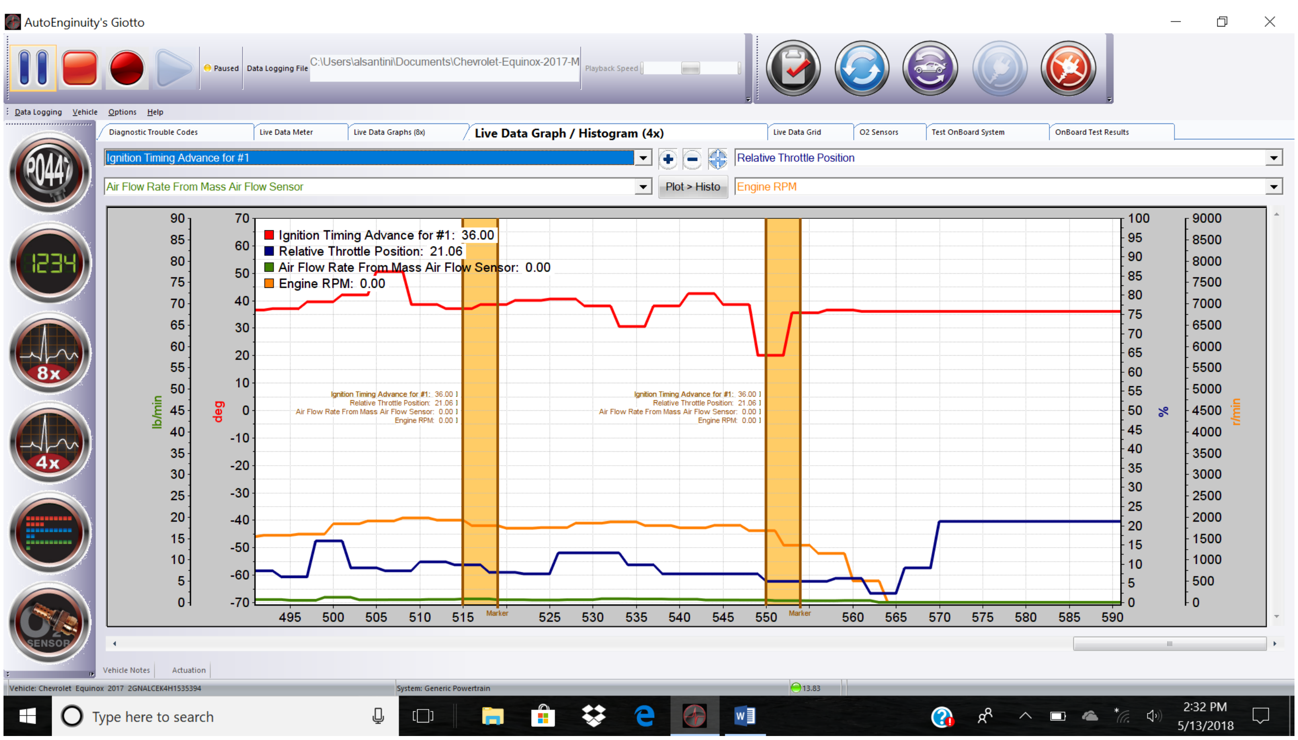
Use it to have students "see" how the primary circuit functions:

- Burn time;
- Saturation time;
- B+ and ground voltages;
- Current ramping.

Look at secondary circuit to see the spark – not measure it.

Look at input sensors.

Use the scanner as the last tool not the first tool.



Ignition System Primary Pattern Analysis

Lab #___

Objective: To increase understanding of how the primary circuit functions by measure various voltages and time using a DSO and cursors.

Procedure: During this lab you will capture and save a primary ignition signal. Cursors will be used to give values for the questions. Note: not all vehicles have a primary signal available. Your instructor will assign a vehicle or engine bench that will allow you to capture a primary pattern.

1. Connect the positive lead of the DSO to the negative of the ignition coil.
2. Connect the negative lead of the DSO to engine ground.
3. Make sure everyone in your group is clear of the engine and start it – idle speed.
4. Set V/Div so the pattern fills the screen.
5. Set T/Div so the pattern fills the screen.
6. Use the trigger function to lock the pattern onto the screen. Move trigger so the entire pattern is on the screen.
7. Press hold.
8. Save the pattern to the DSO's memory, if it has one.
9. Print a copy of the pattern for everyone in your group.
10. Use the voltage cursors to fill in the following answers.
    - A. Applied Voltage _______________V Is this good ___ or bad ___?
    - B. Ground voltage _________V Is this good ___ or bad ___?
    - C. Highest induced voltage (inductive kick) ________V. Is this good ___ or bad ___?
11. Use the time cursors to fill in the following answer
    - A. How long was saturation time? ___________mS. Is this good ___ or bad ___?
12. Why did current flow through the coil primary?

____

____

13. What happened during the coil during saturation time?

____

____

Ignition System Primary Pattern Analysis

14. If the ratio between Primary and Secondary windings was 1000 to 1, How many volts could be generated in the secondary windings? ____________V

15. Be prepared to discuss your answers with your instructor.

16. Staple this sheet to your primary DSO pattern print out and turn in to your instructor.

Name ____________________________________

Instructor Signature____________________________

Date __________________ **Class** ________________________

ConsuLab is proud to have brought you this presentation and hope that you can use the information. We truly believe in our motto:

HELPING YOU TEACH TECHNOLOGY

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