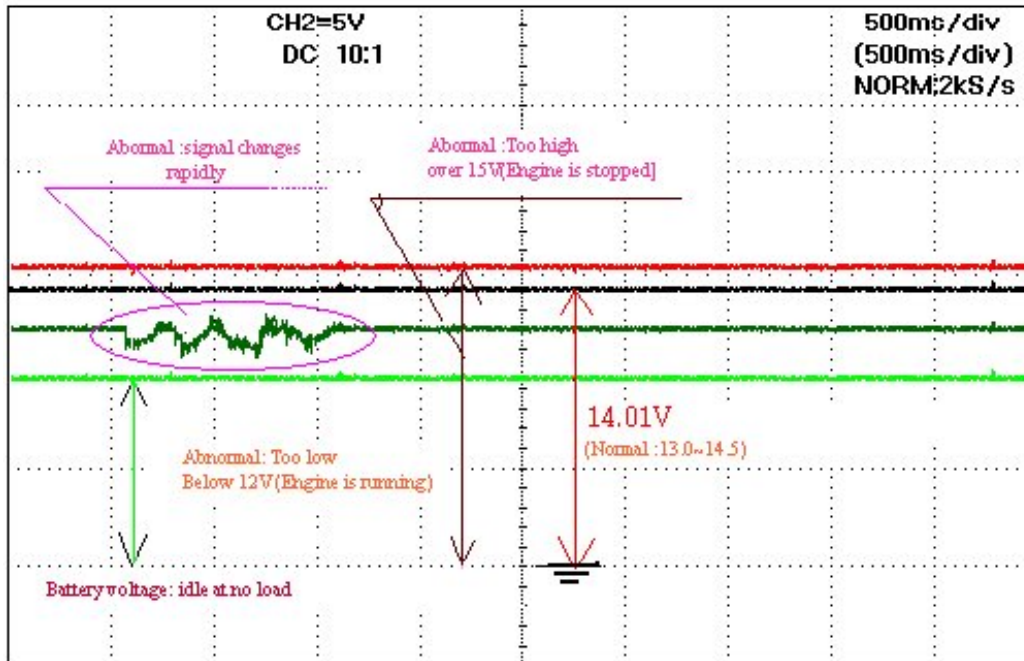


11. The signal check of Battery Voltage

1. Troubles

1. Battery voltage is too low : Below 12[volt] with engine running	
Cause of trouble	1.1 Battery charging is not enough. 1.2 Malfunction of alternator
Counter action	1.1 Charge enough battery and check. Nevertheless if battery voltage is low, replace battery. 1.2 Replace alternator if new battery is rapidly discharged. (Alternator is normal if engine is not stalled after removing battery with engine running)
Engine state	Engine is hard to start and cranking RPM is low. All of lamp is faint.
Signal measurement	

2. Battery voltage is too high : Above 15[volt] with engine running	
Cause of trouble	2.1 Over-charging by alternator
Counter action	2.2 Inspect regulator of alternator and if it is not normal, repair or replace it.
Engine state	There is no problem in engine operation but durability of electric part is bad.
Signal measurement	Refer to cause of trouble 1

3. Abnormal battery voltage fluctuation : Battery voltage fluctuation is out of ± 3.0 [volt] with

Cause of trouble

3.1 Resistance (or ampere) variation of wiring (ECU pin V8) reading battery voltage in ECU is too frequent.

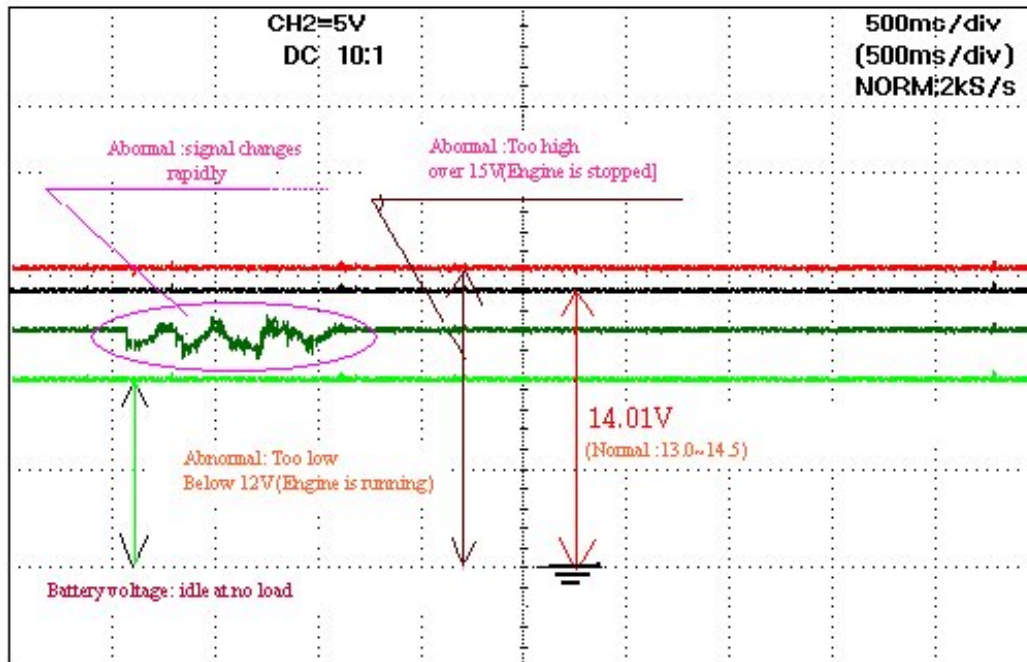
Counter action

Remove a factor which give resistance variation in wiring (ECU pin V8) reading battery voltage in ECU
 3.1 ECU pin number V8 connect directly to battery plus (+) terminal.
 3.2 If there is independent wiring harness (ex: High performance audio, Special lamp etc...) non-related to ECU, return it originally.
 3.3 Inspect output line to use big power and repair if it is not normal : Air conditioner, Cooling fan, Blower, Fuel pump etc ...

Engine state

The engine speed is rough and in case of knocking sensor equipped vehicle, ignition is too much retarded by heavy knocking detection. It led to bad fuel economy and performance.

Signal measurement



Reference :

The battery line may be more than 2. Abnormal check by fast battery voltage change is done in line that recognizes battery voltage.

2. Field example

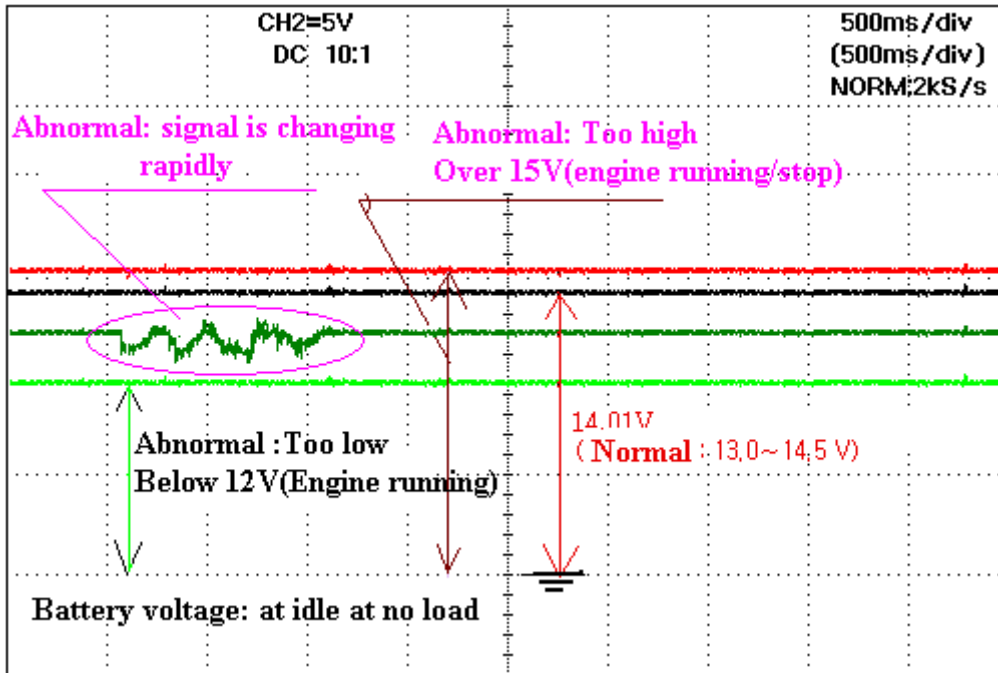
< Example 1 > Fast battery voltage change

Vehicle : Rio, Odometer : 2,400Km

Problem description : Engine vibration is severe and knocking detection is frequent. Surging is occurred during driving.

Cause : Fast voltage variation is happened in line reading battery power in ECU. ECU calculates dwell time with this irregular voltage and it led to unstable combustion.

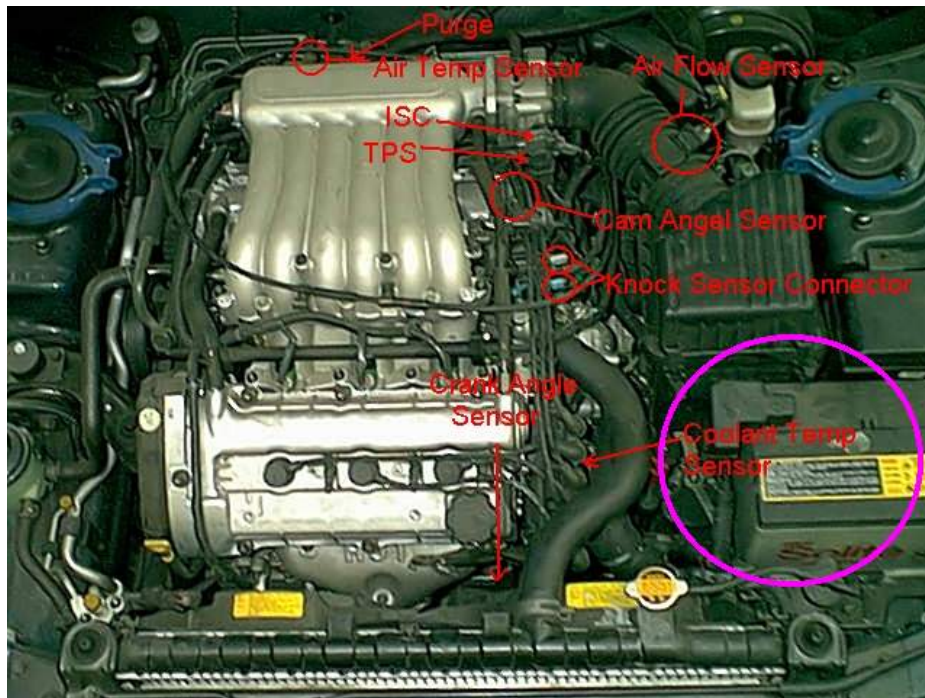
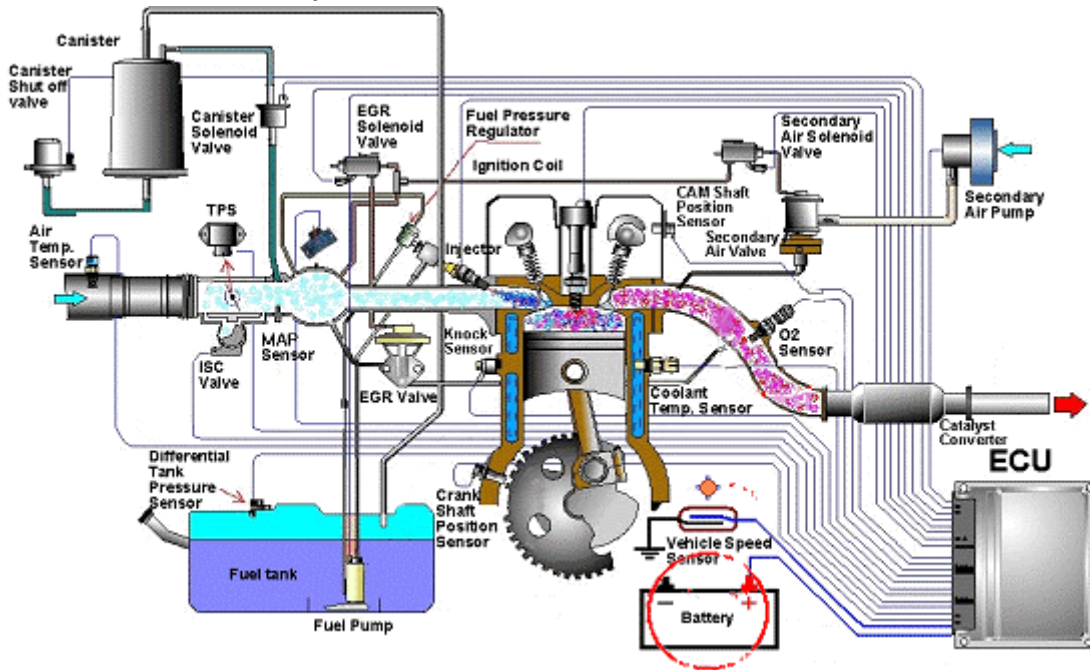
Signal measurement :



Explanation : In case of rapidly current increment by dwell time of ignition coil, combustion in each cylinder is unstable. The vibration that is occurred at this time is detected as knocking and it results in bad fuel economy and performance.

Enlargement of application : Unstable vehicle wiring prevent stable power supply and sensor signal.

3. Location of Battery



4. Check method

Explain the checking Method and Diagnosis of trouble.

Preparation

1. Oscilloscope (It prefers not to use Multimeter)
2. Wiring Diagram for Battery voltage (Voltage recognized in the ECU)
3. Scanner

1. Find and connect the Signal and Ground line referencing the wiring diagram.
2. Check How is the Signal voltage with connecting the scanner.
3. After connecting the Hi-scan, Check that HI-scan detected the Idling state without stepping on the accelerator pedal.

< Reference >

In case of connecting the Multimeter, It is difficult to measure the variation of voltage varying short and fast. It prefers not to use Multimeter to checking if there is that rapid variation of voltage.

< Reference >

In case of connecting the Auto-scanner, we can get the reference as analyzing and diagnosing the rapid voltage variation automatically.

Connecting Method: To get more exact voltage, it must be measured on not battery side but closest position to ECU (within 30 mm)

Connection part:

- (1) Battery voltage: Reference to Wiring diagram, Ground part: Battery(-)
- (2) Oxygen sensor signal: if there is Checking items "(2)"phenomenon.
- (3) Ignition, Injector opening : If there is Checking items"(3)"phenomenon.

Comparing Method:

After measuring the signal, Compare the measured signal with **Normal signal**.

- (1) After checking in IDLE state, Measuring the signal at WOT (Whole Open Throttle) as stepping on the accelerator pedal.

- (2) It prefers to check the Battery voltage with connecting the Scanner in the same time.

< Checking items >

- (1) Is the measured value same as that of displaying through Scanner?
- (2) Is there a battery voltage variation each time?
- (3) Check if Oxygen sensor signal switching (signal UP and Down) is too fast or signal shape is not clear When above "(2)"phenomenon appeared.: In this phenomenon, we assumed that injector opening or ignition dwell time is unstable as voltage recognized at ECU varying.

Check method



5. General

Battery makes electricity and consists in electrolyte (Sulfuric acid : H_2SO_4), lead (The surface is coated by cadmium, calcium ...) at which electricity (electron) is made and separators. When electron is made from this separators and move to another opposite separators through electrolyte, electricity is made. 2 voltages are generated from one separator, and total generated voltage is 12V from battery (There are 6 separators in the battery). When engine is running, battery come to be charged. During battery is used for a long time and is repeated charging and discharging, the coated material (cadmium or calcium) in which electron is made is separated and generated electron is reduced, battery come to be damaged

It supplies needed electricity for the vehicle components (sensor, actuator etc). Especially, for the good working of injector and for more enough ignition energy this battery charge stage is very important.

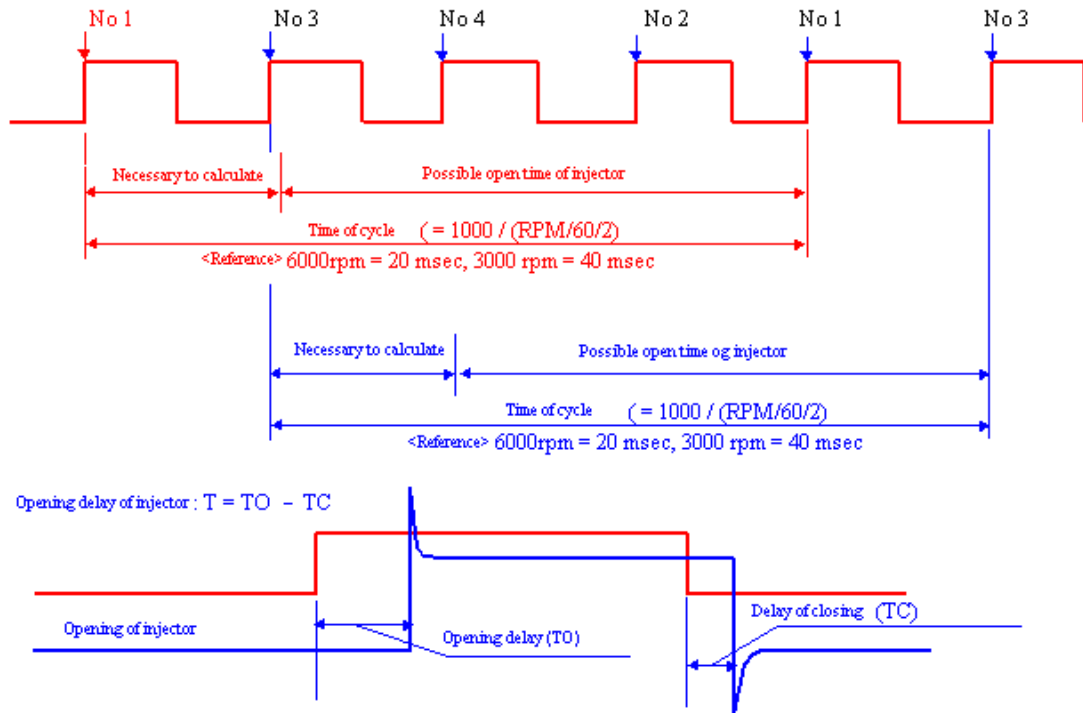
Normally battery capacity is called " AH" or "CCA",

AH : How long(H) it can be used with how high current(A)

CCA : Cold Cranking Ampere

6. Principle (Algorithm) Introduction

6.1 Injection time correction



Battery voltage is very important input for the actuators in the electric control unit. Because, in case of injector, injection time is calculated with minimum 4usec of resolution and if the battery voltage that gives a electromagnetic power to open injector is changed then injector opening time is changed. Then there is no meaning of exact injection time control. So, battery voltage is used to compensate injection time.

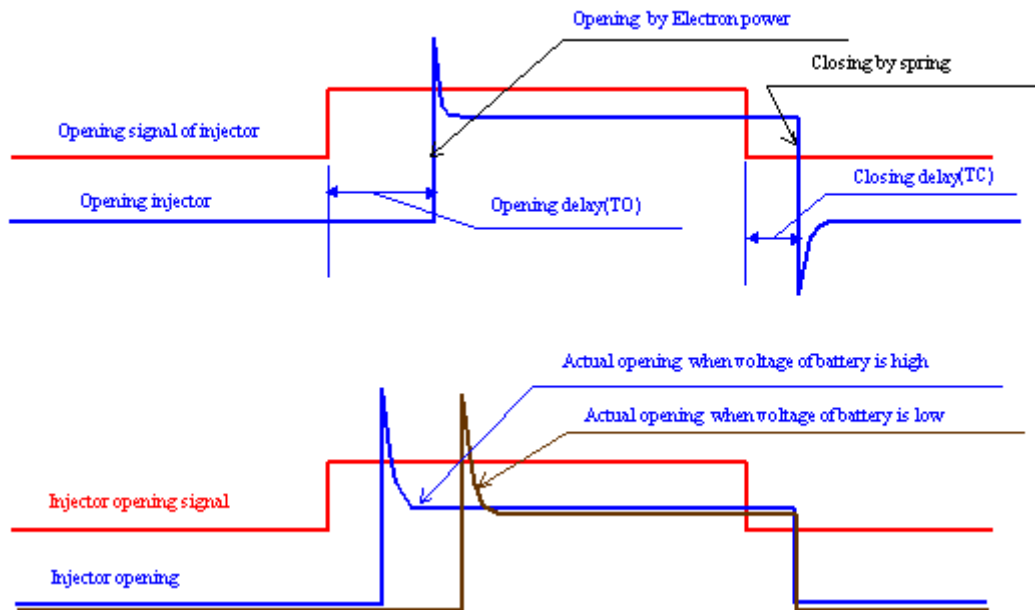
As shown in the picture, there is a delay time to open injector. The delay time depending on battery voltage with 1500CC engine (DOHC, compression ratio :9.3) is as shown below table

Battery voltage	8V	10 V	12V	13V	14V	15V
Delay time	1.44ms	1.05ms	0.82ms	0.75ms	0.67ms	0.67ms

As show above, injector delay time is quite big.

Then, how about closing delay time?

Opening delay of injector : $T = T_O - T_C$



This closing delay time can be different by each injector. In fact, injector is closing by spring force, and delay time can be different depending on this spring force.

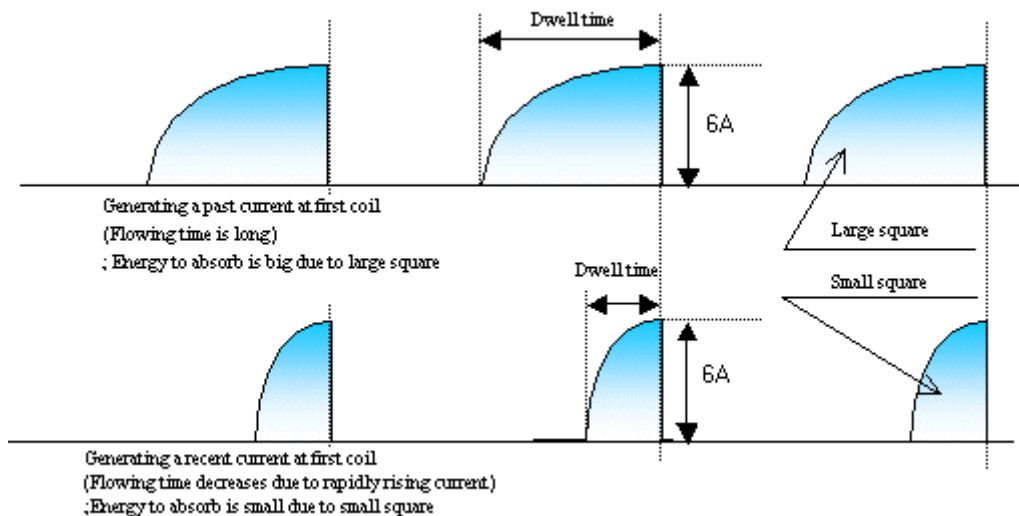
As a reference, closing delay is approximately 0.2~0.4msec and it is always constant so that we don't need to take care about it.

6.2 Dwell time compensation

The dwell time compensation is very depending on battery voltage.

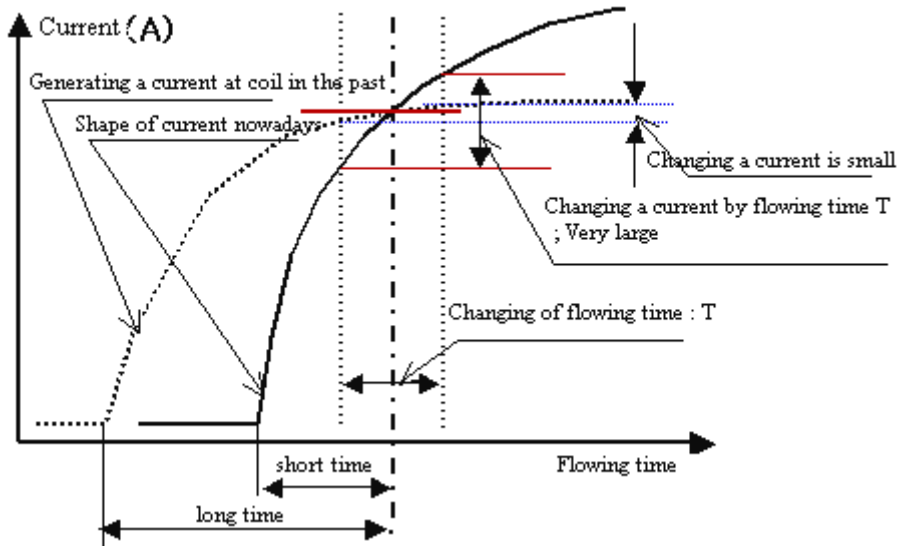
Dwell time is the power charging duration of primary coil. The longer dwell time is the higher current. That means, if this power charging duration of primary coil is long then current is high and ignition energy ($E = VA$) is high so that combustion in the cylinder is stable with strong spark energy. But the problem is that electric energy is increase as current is increase. If it is too big then there will be a problem with endurance of ignition coil. So, with good endurance of ignition coil, we can increase dwell time, which gives high current.

Generating a current by flowing time



But, as it needs more money to increase endurance with current ECU that have power TR inside, current is controlled to a certain value (generally 6A) as fast as possible. Therefore electric current is changed very fast by dwell time and there is big difference of electric current by small dwell time change.

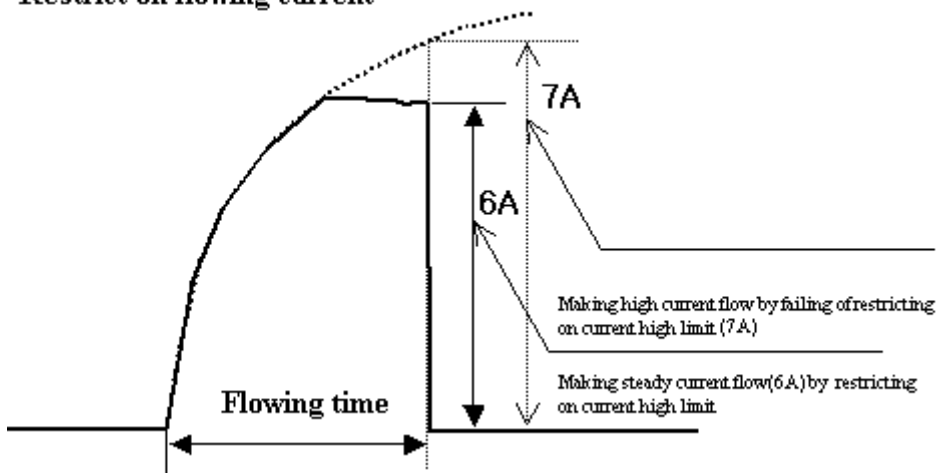
Effect by flowing time depending on rising speed of a current



Then what is a countermeasure of carmaker?

The countermeasure is to prevent over current, but there is no countermeasure for low current.

Restrict on flowing current



Because over current can give damage on ignition coil or power TR while low current does not give big problem with small secondary voltage and small ignition spark.

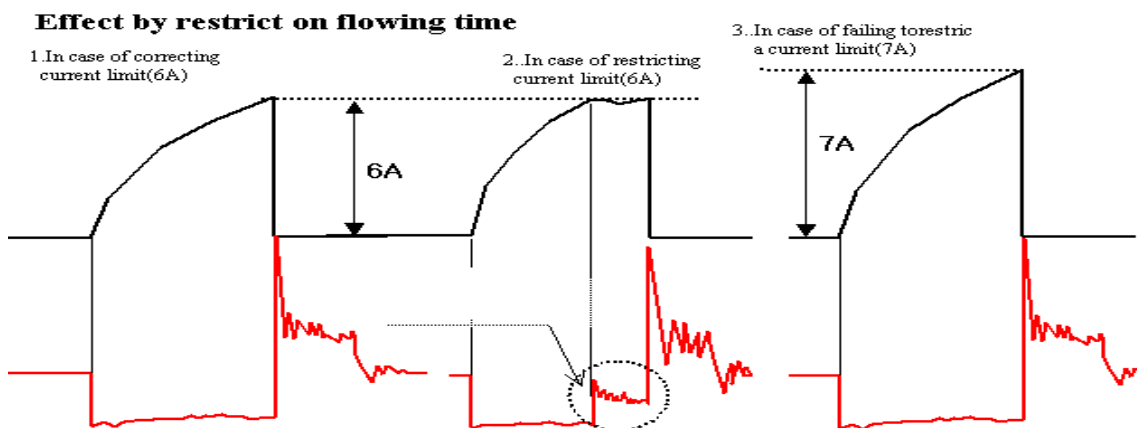
The reason why it is not a big problem is as following.

The secondary voltage signal is almost similar at each engine operating conditions, but generation and destruction of instant high voltage is very various. Especially, it is depending on combustion chamber shape and engine operating conditions (temperature, airflow and

mixture condition) and even with same conditions, it can not be regular. Therefore, in my opinion, to investigate engine condition with secondary voltage signal can give only few information, such as problem of spark plug and coil wiring or decreasing of compression rate. If you want to understand the combustion condition exactly, you have to look at cylinder pressure. Some of electric control unit maker and carmaker's research center use the sensor that equipped inside the spark plug to see cylinder pressure variation.

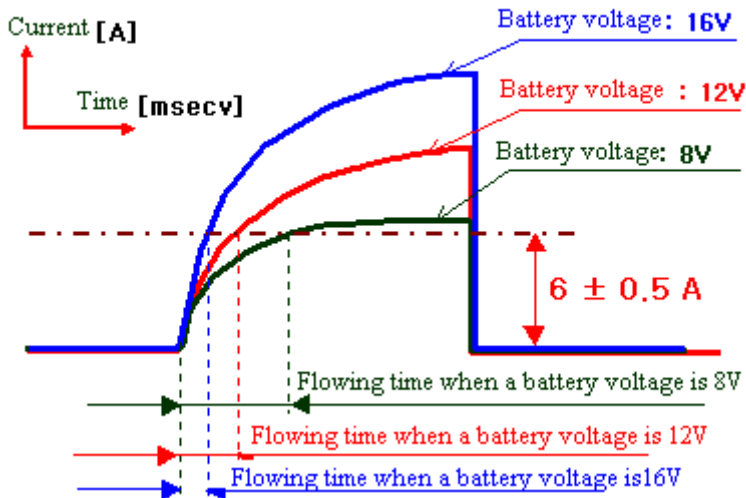
Back to main subject, in fact, to say no problem with small ignition energy is dangerous. To say exact meaning, when engine is in idle at cold state (Coolant below -10°C), energy of approximately 1J is required and energy of approximately 1 – 3mJ is required for warm-up engine with oxygen sensor feedback control. And more energy is required during acceleration or for rich mixture or for lean mixture. But normally required energy for warm-up engine is one-hundredths of cold engine.

As carmaker make there ignition system to get enough energy at cold state, if there is no trouble with ignition system then there will be no big problem with low current at warm-up engine. Then what is the effect when we limit over current on ignition system?



If we limit the current then we can see that voltage increase by a step. This does not give any influence on engine (combustion condition), but ignition system has to consume more energy by itself. And this current size is depending on battery voltage.

Generating a current by voltage of battery

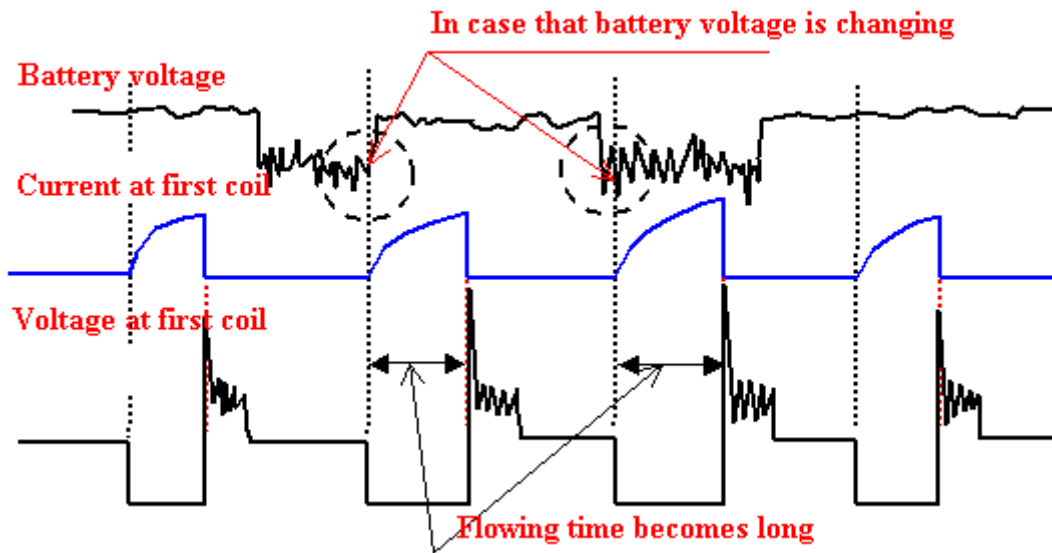


So, according to battery voltage, ECU gives different dwell time. As a reference, ECU has several power supply lines with different purposes and the line for battery voltage recognition is used to compensate battery voltage.

What if battery voltage is changed due to high resistance or noise in the battery voltage line, which is connected to ECU?

Then ignition sparks for each cylinder is irregular due to frequent changing of ignition enrage by irregular dwell time.

In case that battery voltage reconizing at ECU is changing



This phenomenon happens more in hot summer with complex power supply wiring to ECU.

Then what will be influence by this phenomenon? First, engine combustion is unstable due to unstable current flow. And this leads engine vibration.

In case of knock sensor, engine vibration generates knock sensor signal and ECU detect this signal as knocking and retard spark time.

< Reference >

ECU analyzes knock sensor signal frequency to define real knocking frequency (generally 8-13KHz) from the engine. Yet, engine vibration due to different ignition power between each cylinder can be detected as knocking.

How can the technician find out this condition that has very short difference of dwell time? It is difficult. But it can be suspected that dwell time is unstable when battery voltage from the power line that recognized by ECU is irregular. If engine vibration is severe with that condition, connect power line for voltage recognition to the ECU directly with one line.

6.3 ISC (Idle Speed Control) valve battery correction.

There is a correction factor to compensate ISC opening depending on battery voltage. But this is not a important point.

Even if we set all the same data for this, there is no big effect on idle state or compensation for other loads.

One reason is that ISC reaction speed against engine speed is fast enough and another reason is that very short ISC opening by battery noise can not give any big effect on engine speed.