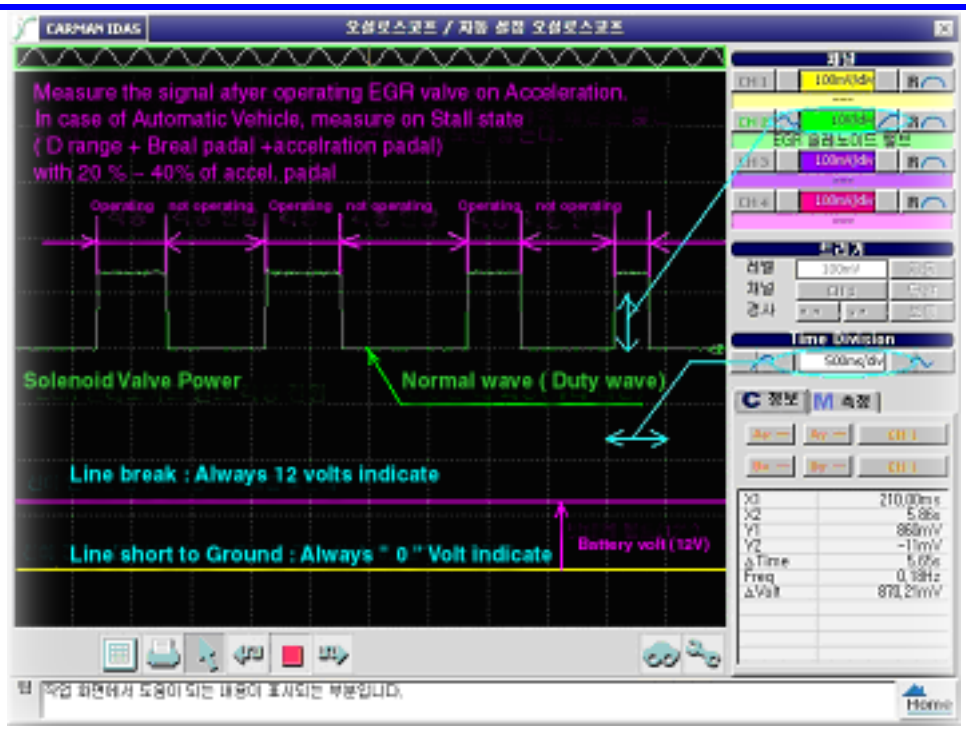
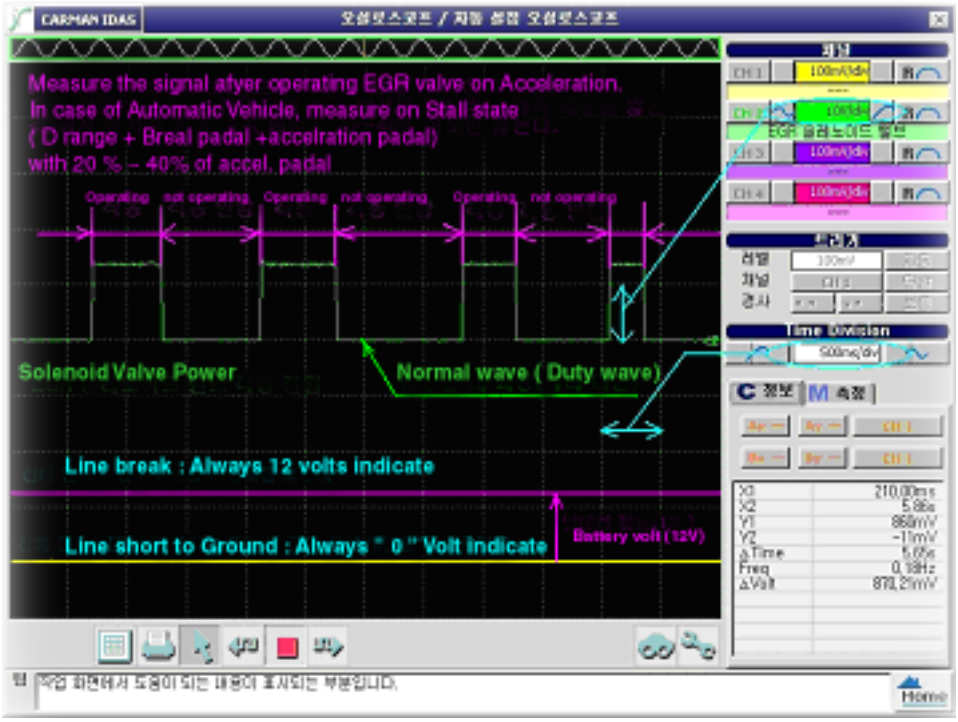
14. The signal check of EGR valve

1. Troubles

1. Power supply line break of the EGR solenoid valve	
Cause of trouble	1.1 Power supply line break 1.2 Duty control line break in ECU 1.3 Abnormal EGR solenoid valve
Counter action	1.1 Repair power supply line 1.2 Repair duty control line in ECU 1.3 Replace EGR solenoid valve
Engine state	In EGR operating area(Part load), actually EGR gas is not supplied into combustion chamber but ECU recognize as it is supplied. Thus ignition is controlled with EGR operating and it may result in knocking. Fuel control is lean before O2 sensor feedback and it make rich correction with feedback. If it is continued, injection time adaptation is too much toward negative direction.
Signal measurement	 <Reference> The signal voltage is always 12[volt] when EGR valve is not operated. If it is ON/OFF type, signal voltage is always 0[volt] with EGR valve operating. EGR valve is not worked in idle. Therefore, check whether it is 0[volt] in idle or not. If it is 0[volt] in idle, it is short to ground.

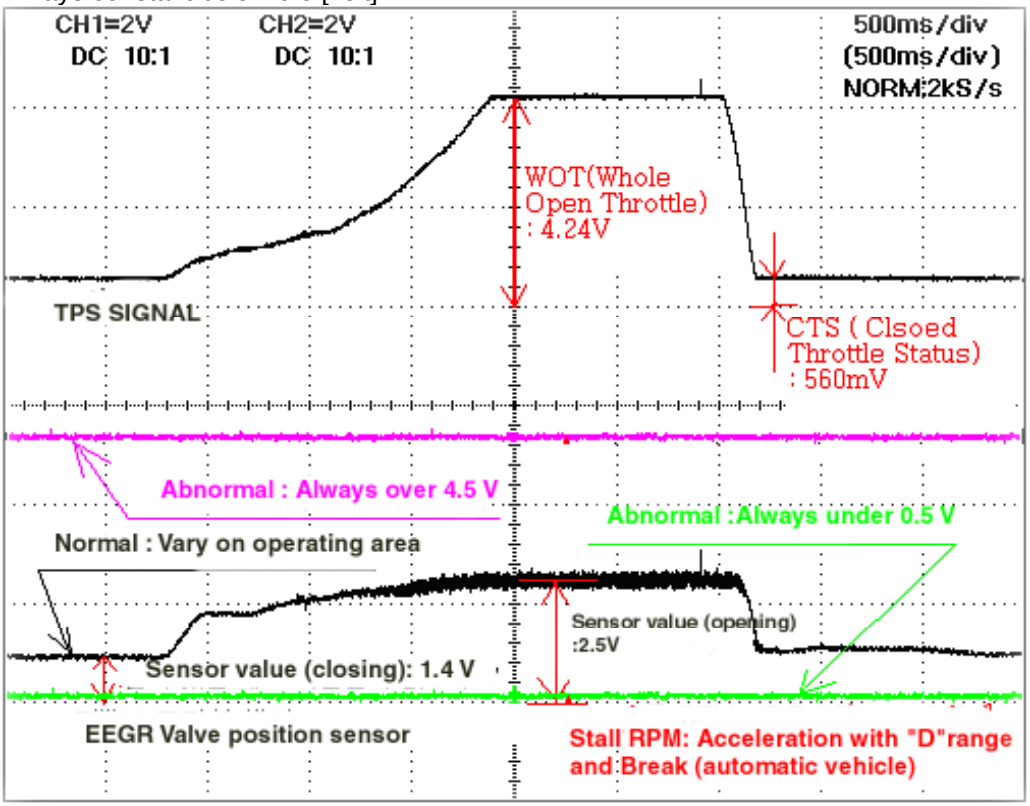
2. EGR solenoid valve duty is always open	
Cause of trouble	2.1 Duty control line in ECU is shorted to ground 2.2 Abnormal EGR solenoid valve
Counter action	2.1 Improvement of duty control line in ECU 2.2 Replace EGR solenoid valve
Engine state	In non-EGR operating area(Part load), actually EGR gas is supplied into combustion chamber and misfire is occurred. It lead to RPM cycling and engine stall in idle. Fuel control is lean before O2 sensor feedback and it make rich correction with feedback. If it is continued, injection time adaptation is too much toward negative direction.
Signal measurement	 <Reference> The signal voltage is always 12[volt] when EGR valve is not operated. If it is ON/OFF type, signal voltage is always 0[volt] with EGR valve operating. EGR valve is not worked in idle. Therefore, check whether it is 0[volt] in idle or not. If it is 0[volt] in idle, it is short to ground.

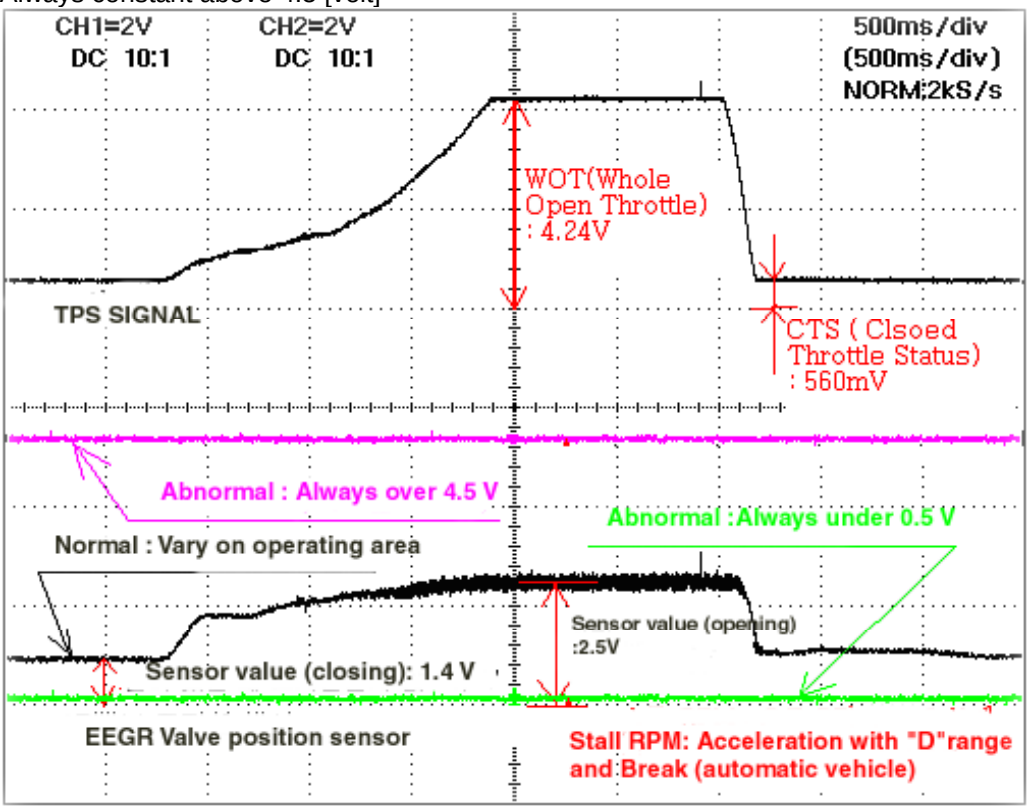
3. EGR solenoid valve opening stuck	
Cause of trouble	EGR valve is stuck because mechanical heating regardless of solenoid valve operation (vacuum) increases resistance.
Counter action	It is very difficult to improve this problem because the improvement of pintle shape must be done by part maker, but it may be opened by hitting the EGR valve.
Engine state	In non-EGR operating area(Part load), actually EGR gas is supplied into combustion chamber and misfire is occurred. It lead to RPM cycling and engine stall in idle. Fuel control is lean before O2 sensor feedback and it make rich correction with feedback. If it is continued, injection time adaptation is too much toward negative direction. < Reference > EGR valve stuck can be detected with EGR valve temperature sensor.
Signal measurement	The signal is not measured < Reference > If you want to check this problem, check EGR valve opening stuck from O2 sensor signal switching. And if injection time adaptation value via scanner is negative , check whether EGR gas is abnormally opened or not.

4. EGR solenoid valve closing stuck	
Cause of trouble	EGR valve is stuck because mechanical heating regardless of solenoid valve operation (vacuum) increases resistance.
Counter action	It is very difficult to improve this problem because the improvement of pintle shape must be done by part maker, but it may be opened by hitting the EGR valve.
Engine state	In EGR operating area(Part load), actually EGR gas is not supplied into combustion chamber but ECU recognize as it is supplied. Thus ignition is controlled with EGR operating and it may result in knocking. Fuel control is lean before O2 sensor feedback and it make rich correction with feedback. If it is continued, injection time adaptation is too much toward negative direction. < Reference > EGR valve stuck can be detected with EGR valve temperature sensor.
Signal measurement	The signal is not measured < Reference > If injection time adaptation value via scanner is negative, check whether EGR gas is abnormally opened or not.

5. Too small output signal of the EEGR(Electrical) position sensor

Cause of trouble	1.1 Signal line open or short to ground 1.2 The connection of signal line connector is bad 1.3 Abnormal sensing part
Counter action	1.3 Repair signal line 1.4 Repair signal line connector 1.3 Replace sensor
Engine state	In EGR operating area(Part load), actually EGR gas is not supplied into combustion chamber but ECU recognize as it is supplied. Thus ignition is controlled with EGR operating and it may result in knocking. Fuel control is lean before O2 sensor feedback and it make rich correction with feedback. If it is continued, injection time adaptation is too much toward negative direction.
Signal measurement	Always constant below 0.5 [volt]



6. Too big EEGR(Electrical) position sensor output signal	
Cause of trouble	2.1 Short to power line with signal reference line 2.2 Abnormal signal sensing part
Counter action	2.1 Improvement of signal line 2.2 Replace sensor
Engine state	In non-EGR operating area(Part load), actually EGR gas is supplied into combustion chamber and misfire is occurred. It lead to RPM cycling and engine stall in idle. Fuel control is lean before O2 sensor feedback and it make rich correction with feedback. If it is continued, injection time adaptation is too much toward positive direction.
Signal measurement	Always constant above 4.5 [volt] 

7. Constant EEGR position sensor signal	
Cause of trouble	3.1 Stuck of EGR valve. <Reference> This phenomenon is occurred frequently, thus if fuel compensation by oxygen sensor is small or if much positive fuel adaptation is done during normal driving (acceleration pedal is pressed), this phenomenon must be checked.
Counter action	3.1 Clean the carbon within the EGR valve
Engine state	Same as cause of trouble 3(Open stuck), 4(Close stuck)
Signal measurement	Same as cause of trouble 3(Open stuck), 4(Close stuck)

2. Field example

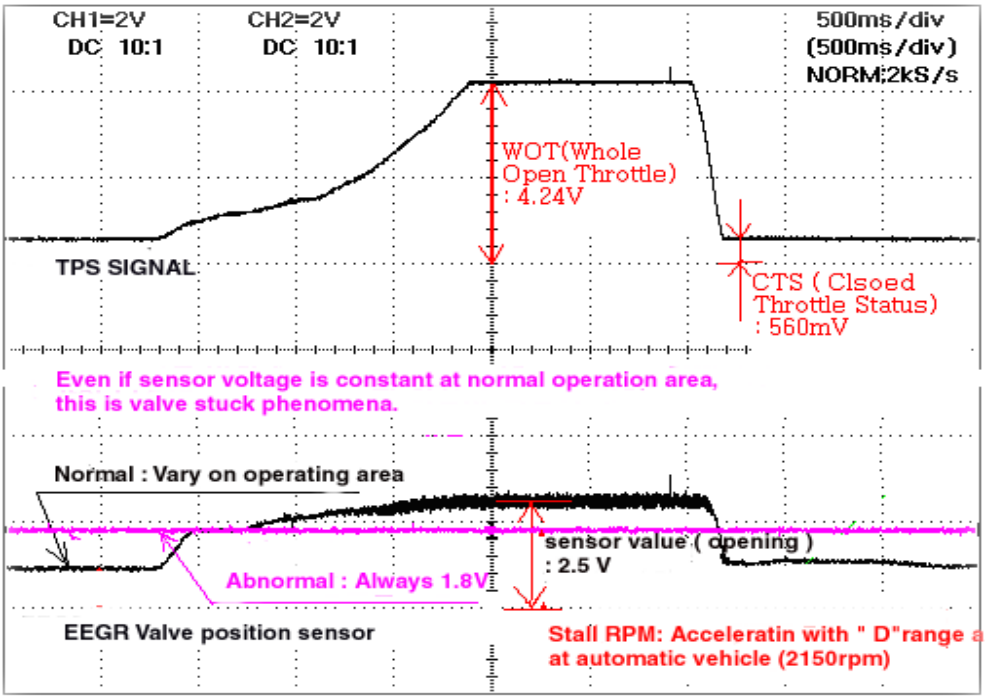
< Example 1 >

Vehicle : Sephia II 1.5L DOHC, Odometer : 24,000Km

Problem description : Severe engine vibration is occurred in idle and driving is impossible due to engine stall.

Cause : Misfire is happened due to overflow of EGR gas with EGR valve open stuck.

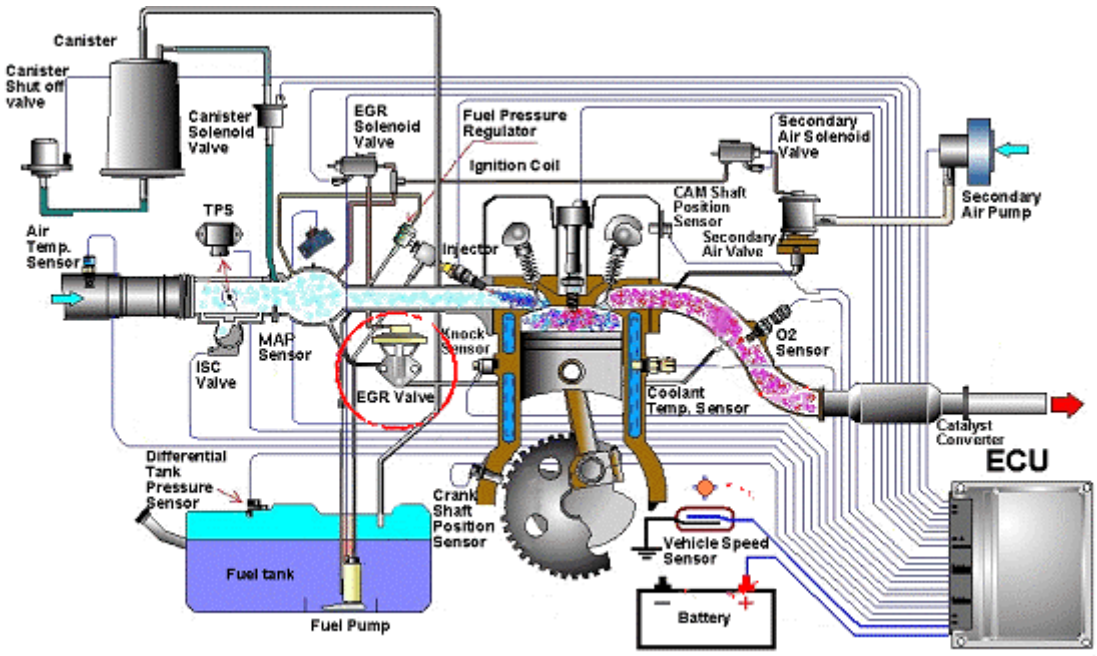
Signal measurement : EGR position sensor voltage remain 1.8[volt] after working acceleration pedal.



Explanation : EGR valve stuck is often occurred. U.S export vehicle is equipped with temperature. If low temperature is maintained with EGR operating range, ECU recognizes closing stuck. In the contrary if high temperature is maintained with non-operating range, ECU recognize opening stuck.

Enlargement of application : Ignition timing and fuel injection is calculated with considering EGR quantity in EGR operating range. Thus, if EGR is not come into operating range, they have difference. Oppositely, if EGR gas is come with non operated EGR, ignition has big difference.

3. Location of EGR valve



< Fig. : EGRvalve : electric(left) / mechanical(right) >

4. Check method

Explain the Method and Diagnosis of checking the trouble..

Preparation

1. Oscilloscope (Multimeter should be not used for duty or EEGR type)
2. Wiring diagram of EGR
3. Scanner
4. Multimeter : Only in case of ON/OFF type EGR

1. Find and connect the signal and ground line with referencing the wiring diagram..
2. Look at the voltage through the Oscilloscope.
3. Check the EGR type (On/Off, Duty, EEGR) through wiring diagram.

< Reference >

It prefers not to use Multimeter in case of Duty control (continuous ON/OFF type).

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Comparing Method: After measuring the signal, compare the measured signal with Normal signal.

(1) Compare the opening value (Duty when the voltage is '0') with the frequency from normally measured signal.

(2)) It would be better check the EGR operating state with connecting the Scanner..

(3) Check the EGR position sensor value.

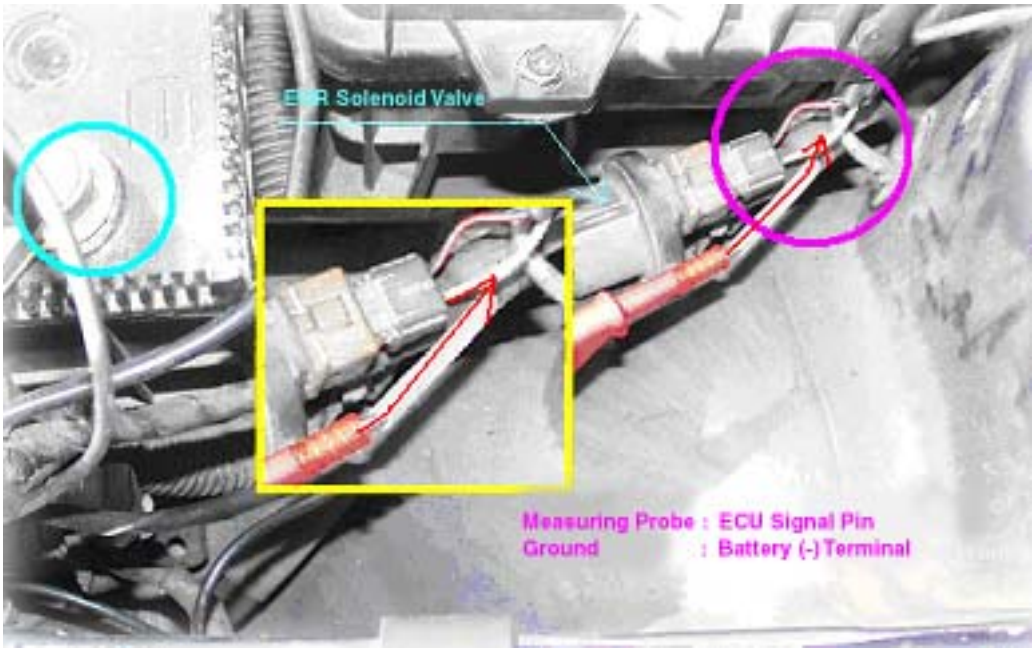
< Check items >

(1) Is the Frequency right?

(2) Check whether the EGR valve is not opening even though operating or opening even though not operating

(3) Is there any sensor operating voltage / Ground line broken?.

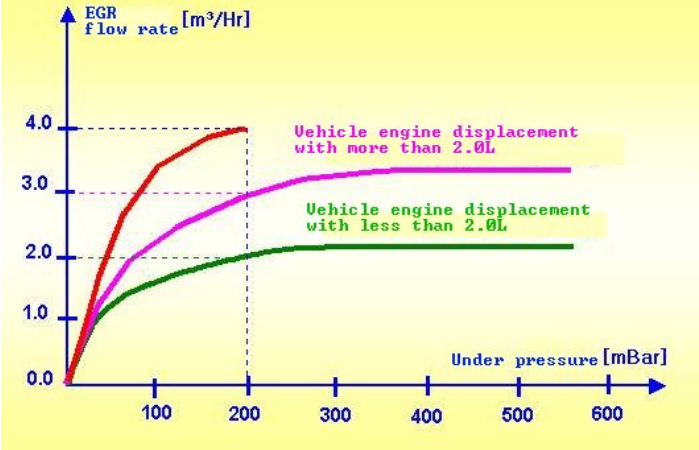
< Measuring tool connection >



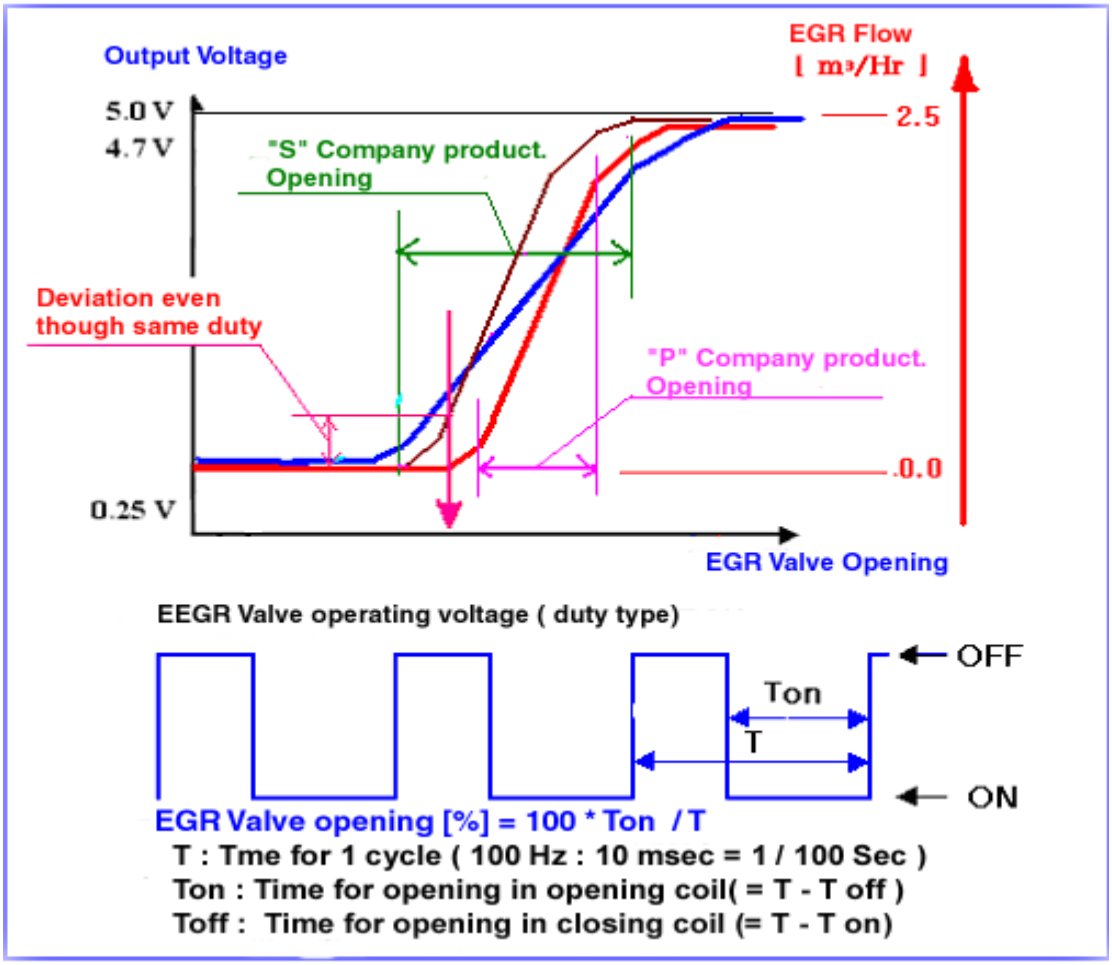
5.Wave analysis

EGR valve characteristic is as followings:

1. Mechanical EGR valve



2) Electrical EGR valve



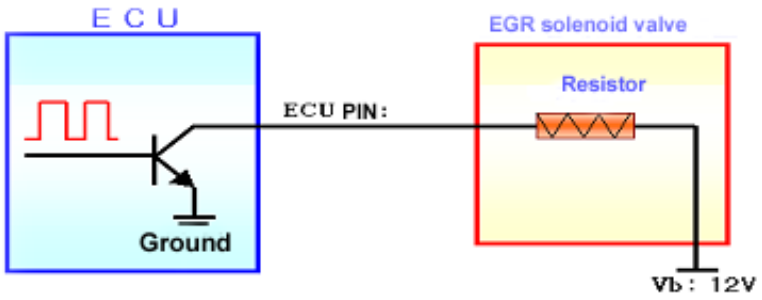
6. General

1. Because nitric oxide (NOx) within exhaust gas is increased at high temperature, some of exhaust gas is recirculated into engine through EGR valve to reduce nitric oxide (NOx) and to decrease exhaust temperature

.

2. Additionaly, this valve is also used to improve fuel consumption because needed suction air is reduced caused by suction exhaust gas.

Mechanical EGR valve: If EGR solenoid valve is opened, exhaust gas is sucked into intake manifold and ventilated to engine through this valve by negative pressure of intake manifold. It is called mechanical EGR (Exhaust gas recirculation) valve.



< EGR Valve wiring : Duty type >

Electrical EGR valve : Electric EGR (Electric Exhaust recirculation) valve is opened by electromagnetic force induced by electricity and it is called EEGR (Electric Exhaust Gas Recirculation) valve. And EGR position sensor that senses valve position is also equipped with this EEGR valve to determine right opening

7. Principle (Algorithm) introduction

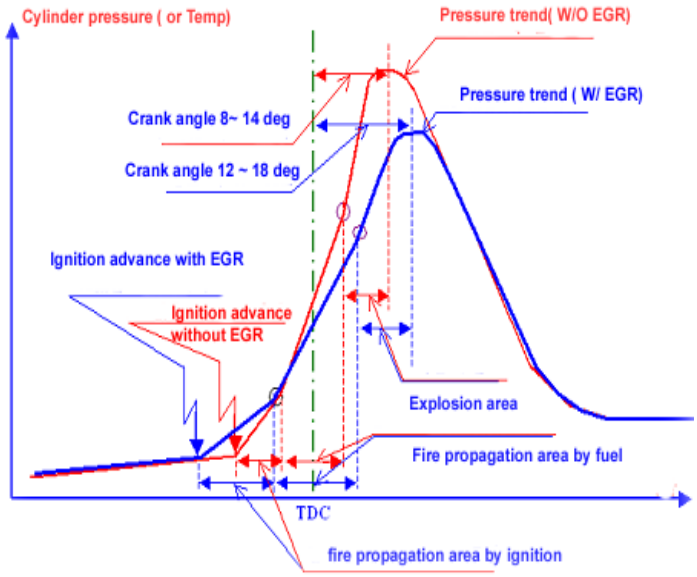
What kind of problem can be happened with EGR valve?

Basically, the problems caused by EGR valve can be found out by technician, but there are some fundamental problems that a few people know it.

As this problem can be solved easily when we know the principle, I'd like to introduce principle first and then follow up related problems.

1. If EGR gas is supplied to the cylinder, additional spark time is needed due to ignition delay.

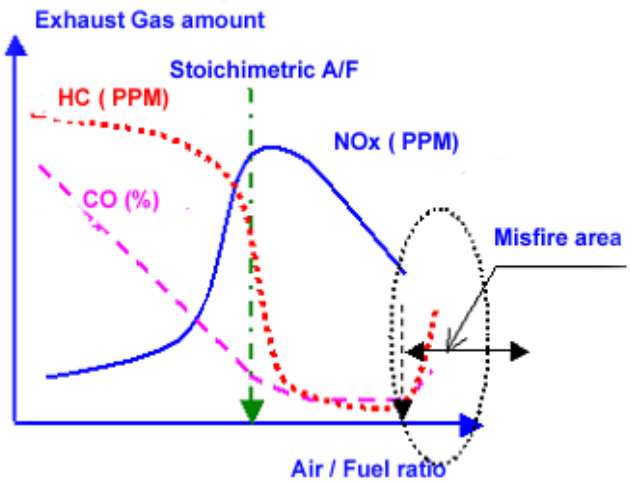
EGR gas which have already combusted disturbs flame propagation and this reduces not only peak combustion pressure but also temperature.



High combustion temperature (it depends on compression ratio and air quantity but normally 1000 - 1400°C) produce nitrous-oxide emissions(NO, NO2, N2O2) by oxidizing the nitrogen(N2) in the air. These nitrous-oxide emission is more produced with high temperature.

< Reference >

The reason why LPG fuel produces about 70 – 80% of nitrous-oxide emissions compared to gasoline is that combustion temperature is lower than gasoline due to slow combustion speed.



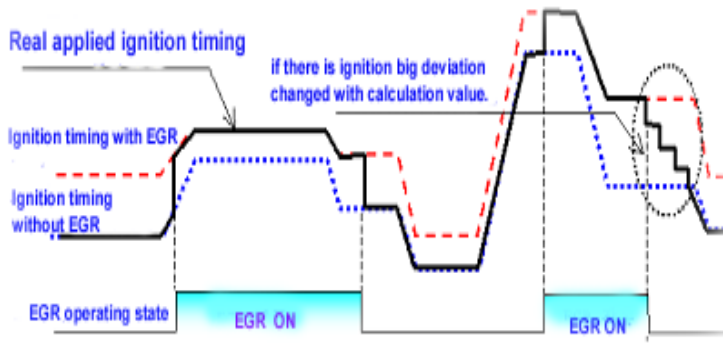
And nitrous-oxide emission is also depending on air fuel ratio and it is generated well with lean mixture (lambda = 1.1). So, nitrous-oxide emission should be considered seriously with current car, which uses stoichiometric air fuel ratio by oxygen sensor feedback control.

< Reference>

Lean-burn engine that supplies smaller fuel than stoichiometric air fuel ratio without misfire must

be lean more than 10% to reduce nitrous oxides. But more important point during development is to find out misfire area instead of to reduce nitrous-oxide emission.

Therefore, exhaust gas is supplied to the cylinder to reduce combustion temperature. And then, MAF(Mass Air Flow) sensor can measure air flow only while EGR is supplied, but MAP sensor can not distinguish the manifold pressure with and without EGR.



So, separate spark time is applied when EGR is operating. Then, how much does spark must be retarded with EGR?

This is very different according to engine speed and air mass and amount of EGR. But simply, 6 - 10° are normal value.

Reference 1 : If EGR is stuck when ECU is recognizing that EGR is working and retard the spark time with EGR working, then what will be happened?

Result is two.

First, oxygen sensor correction value is increased due to lean mixture.

Because fuel is reduced as much as EGR gas and oxygen sensor feedback provides additional fuel to compensate reduced fuel. Without oxygen sensor feedback, mixture would be lean.

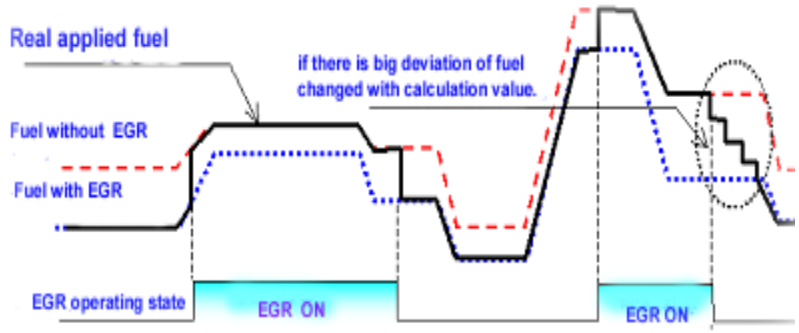
Second, Spark time is advanced about 6～10° and knocking possibility is increased.

This is well happened in the field. If there is knocking in the EGR equipped vehicle, then check EGR valve stick. Simply it works again by beating the EGR valve.

In case of mechanical type, if the line to operate solenoid valve by ECU is breoken then same phenomenon will happen.

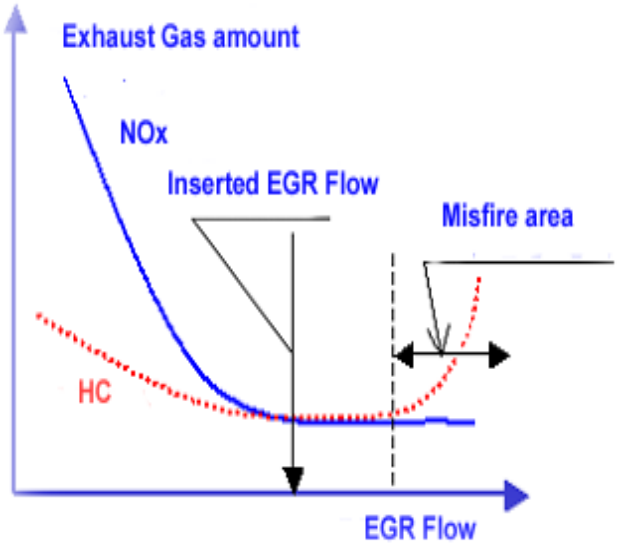
2. Different injection time with EGR gas.

If EGR opens then incombustible exhaust gas is inducted to surge tank and mixed with air. ECU can not detect it. So, different injection time calculation is performed with EGR valve operation.



3. How to decide EGR valve opening (in case of duty type or EEGR valve)

As soon as EGR valve is open, exhaust gas is coming into the cylinder and this exhaust gas disturbs flame propagation. If it disturbs too much flame propagation, misfire will happen. Therefore valve opening is decided not to get misfire. In case of mechanical type EGR valve , valve opening is controlled by adjusting solenoid valve which is connected to surge tank to deliver under pressure to EGR, while Electrical type is directly control EGR valve opening.



Reference 2 : What if EGR valve is fixed with opening position?

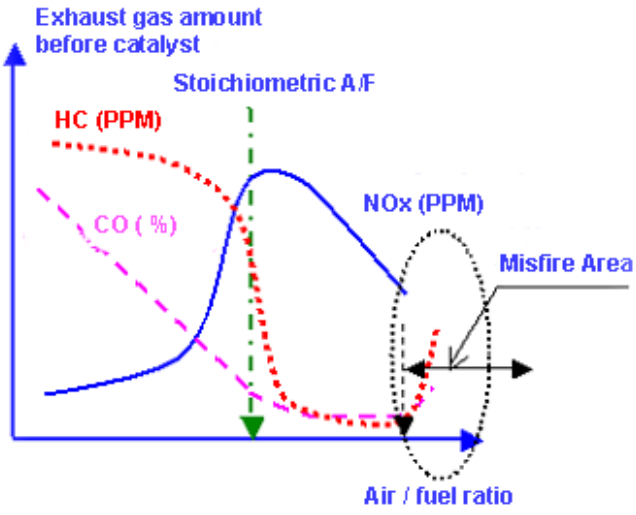
Engine speed will be very unstable and engine can be stall in idle due to EGR gas in the cylinder. This case can be found easily by technician.

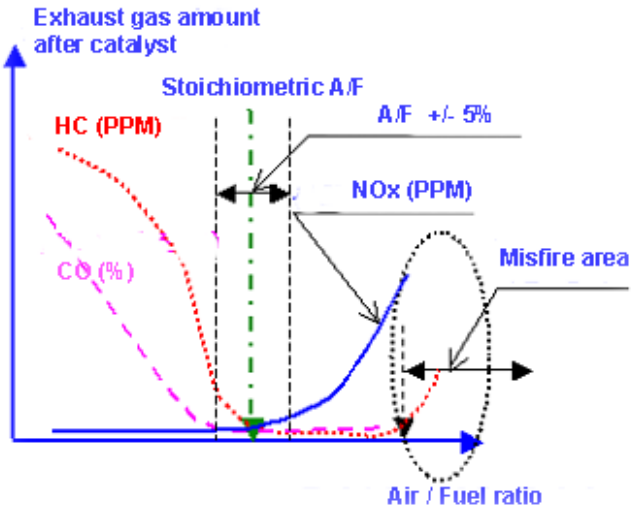
But what if opening is small?

Reverse phenomenon of above "Reference 1" will occur. First, fuel is rich because injection time is calculated with the case of no exhaust gas in the cylinder and it is corrected by oxygen sensor feedback control.

Second, power loss is coming because it gives spark retard effect when spark time that have to be advanced to compensate delay of flame propagation is not advanced.

In case of mechanical type, if the line to operate solenoid valve by ECU is short circuit then same phenomenon will happen.





As a reference, about **reduction of emission**;

If more fuel compared to air is provided to cylinder, unburned and incompletely burned fuel remains in the cylinder due to

insufficient air during combustion.

Therefore, much more total Hydrocarbon (THC) and carbon monoxide are generated and on contrary to this, less nitrous oxide is generated. Then, noble metals (Pt :platinum, Pd :palladium (A substituted material for platinum, Currently it is used a lot due to low cost and low light off temperature), Rd :rhodium) in the three way catalyst separates hydrogen and carbon from hydro carbon and carbon monoxide and then oxidize it to water (H2O) and carbon dioxide (CO2) and convert nitrogen to stable nitrogen (N2) is produced.

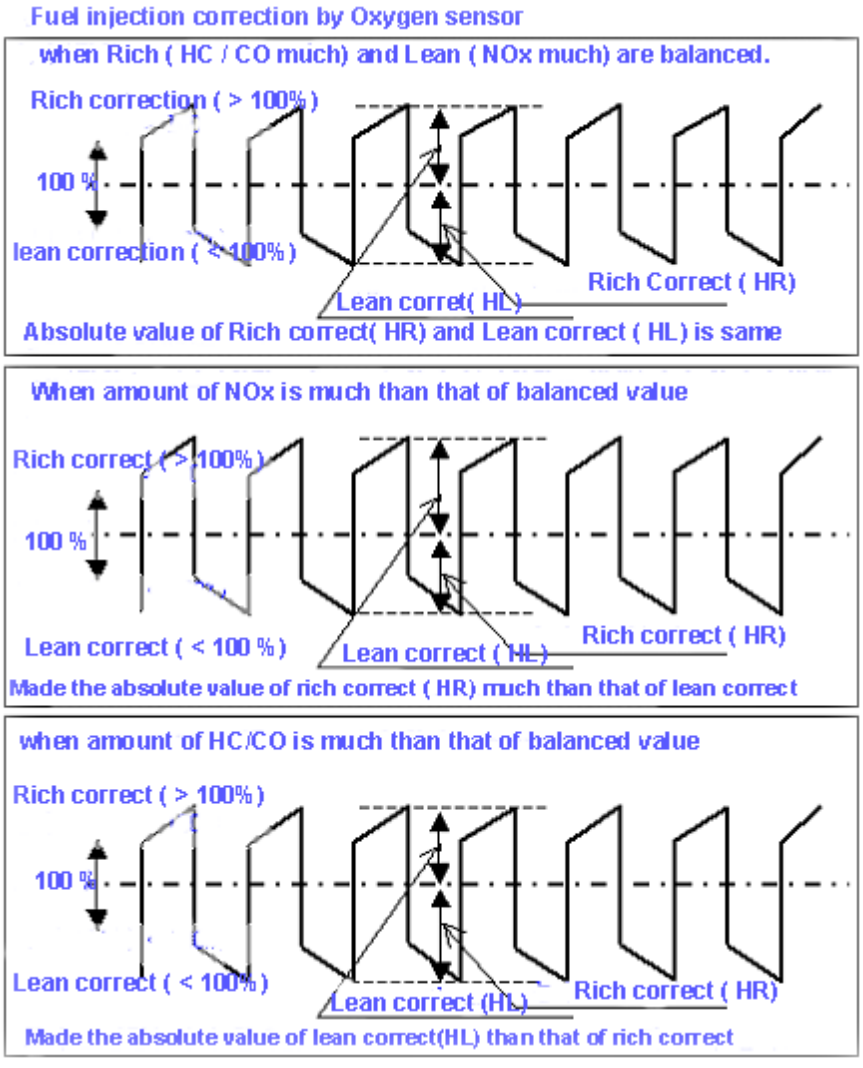
At this moment, fuel and carbon monoxide is remained.

Rich mixture: [CnHm + CO] + NOX (NO, N2O2, N02 …) ⇒ CO2 + H2O + N2 + remained gas(THC + CO)

Next time, lean fuel is provided.

Then, contrary to rich mixture, more nitrous oxides are generated with less hydro carbon and carbon monoxide. These also react on noble metals in the three-way catalyst and generate water (H2O), carbon dioxide (CO2) and stable nitrogen (N2). At this moment, nitrous oxides are remained.

Lean mixture: [CnHm + CO] + NOX (NO, N2O2, N02 …) ⇒ CO2 + H2O + N2 + remained gas(NOX)



These remained nitrous oxides react on hydrocarbon and it converts to non-toxic emission.

Remained gas (THC + CO) + remained gas(NOX) ⇒ H20 + CO2.

But if remained gas with rich mixture is bigger than remained gas with lean mixture, then according to test, more lean mixture is applied until these are well balanced by nitrogen.

On contrary, if remained hydrocarbon and carbon monoxide with rich mixture are smaller than nitrous oxides that

remained after reaction of lean mixture, then according to test, more rich mixture is applied until these are well balanced by hydrocarbon and carbon monoxide.

Doing like this, toxic emission (hydrocarbon, carbon monoxide, nitrous oxides) is converted to non-toxic emission. In case of new vehicle for US export, it produces lower emission than ambient air in the small or middle city.