

# Case studies on analysis of light-duty vehicle Exhaust gas control signal in Korea



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National Institute of Environmental Research  
Transportation Pollution Research Center



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# 01 Motivation



## Development in Diesel Engine

Mechanical FIS

Electrical Control System FIS

FIS(Fuel Injection System)

Euro- I

Euro-II

Euro-III

Euro-IV

Euro-V

Euro-VI

Mechanical type of Fuel system

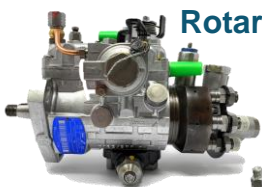
Mechanical electronic Fuel system

CRDI Fuel System

❖ Injection pump

❖ Electronic Injection pump

Rotary type



Tandem type

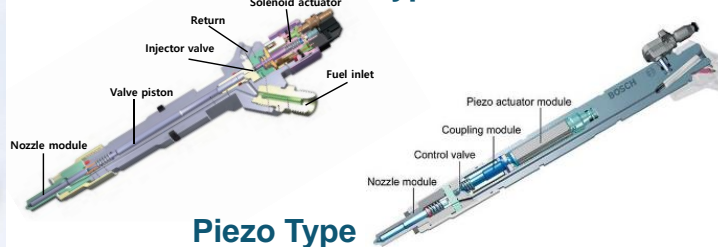
❖ Injection nozzle

Mechanical Type



❖ Injector

Solenoid Type



Piezo Type

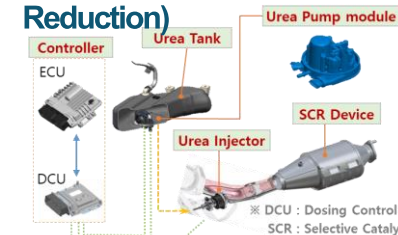
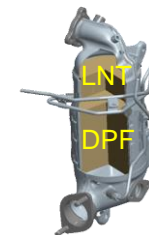
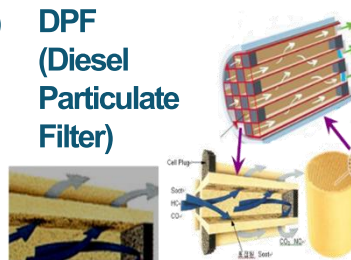
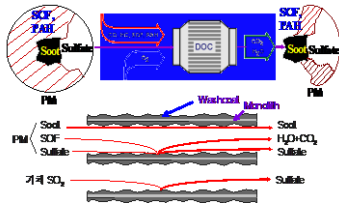
Exhaust Gas After treatment system

DOC(Diesel Oxidation Catalyst)

DPF (Diesel Particulate Filter)

LNT(Lean NOx Trap)

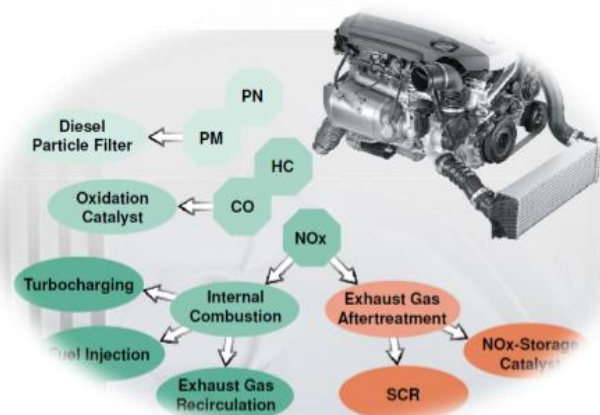
SCR (Selective Catalytic Reduction)



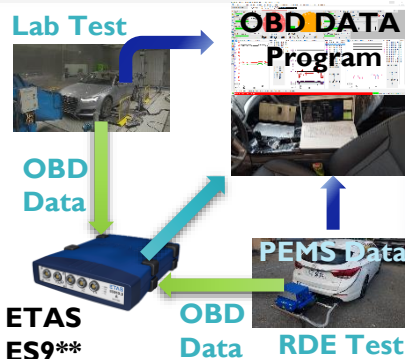
## Background

- EURO-VI Vehicle use a combination of EGR System & Exhaust after treatment devices (LNT, SCR etc.)
- Study of the Exhaust emission level and engine control characteristics

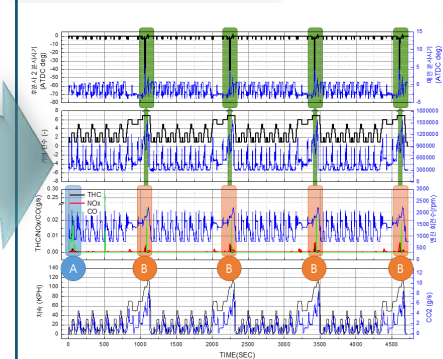
## Inspection method



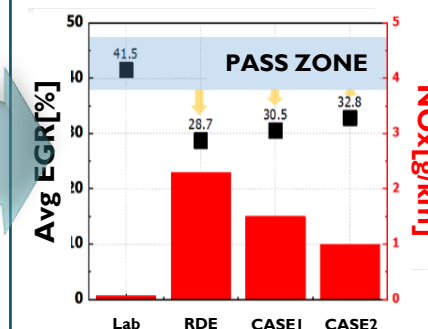
### Signal measurement



### Measurement Data Analysis



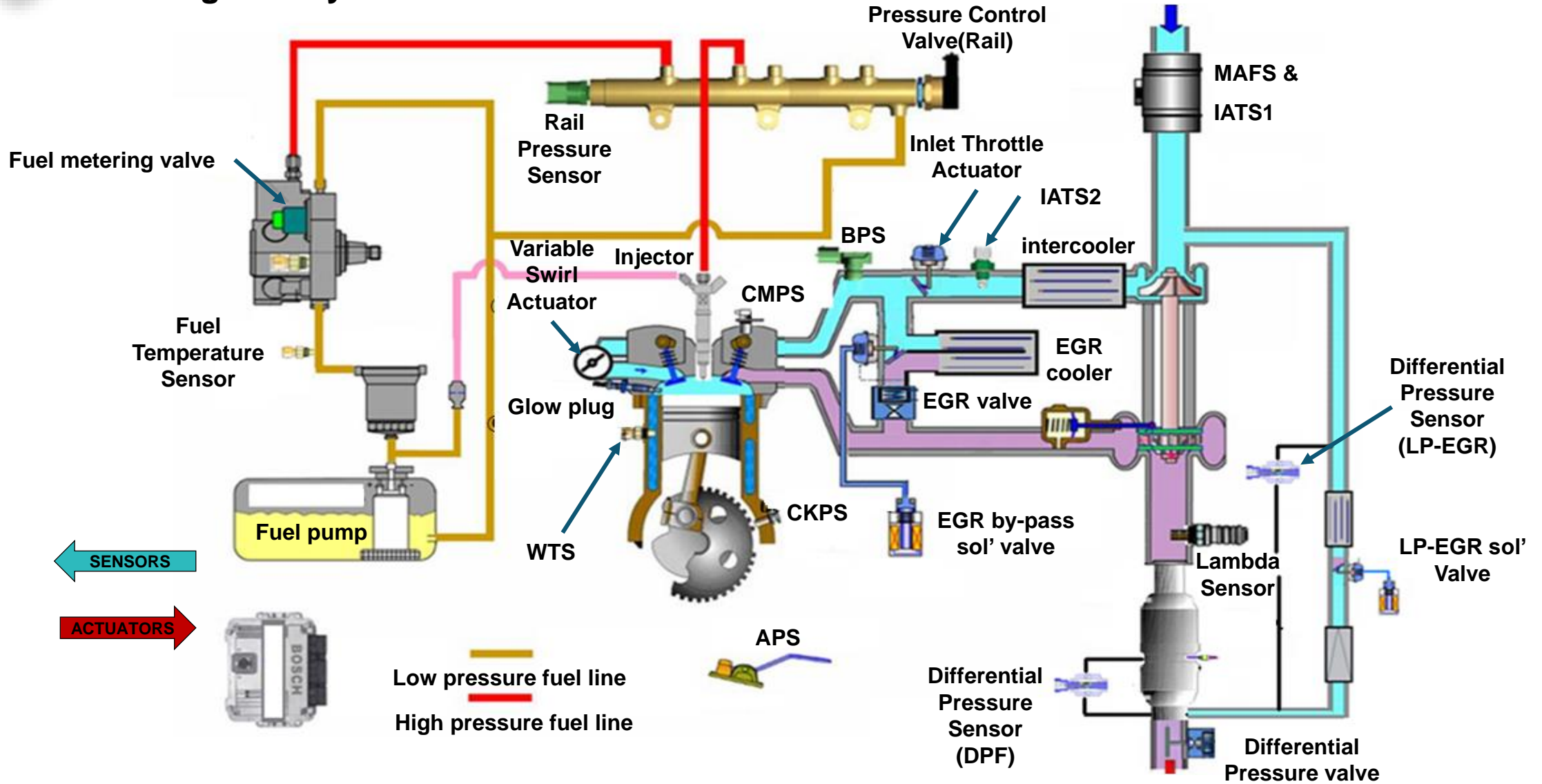
### Assessment



# 02 Experimental Method



## In-out signal analysis



## Test mode

Test cycle	Emission bench	PEMS	Emission item	OBD in-out signal data															
NEDC cold mode	O		(CO, CO2, THC, NOx, CH4)	338 item measure															
NEDC hot mode	O			<table border="1"> <tr> <th>AS Desc. ENG</th> <th>AS Desc. ENG</th> </tr> <tr> <td>A/C Compressor Relay</td> <td rowspan="2">Actuator Test Identifier for Urea Dosing Valve</td> </tr> <tr> <td>Accel pedal is pressed</td> </tr> <tr> <td>Accelerator Pedal Position Sensor</td> <td rowspan="2">After Treatment 1 Exhaust Gas Temperature1</td> </tr> <tr> <td>Accelerator Pedal Position Sensor -1 Voltage</td> </tr> <tr> <td>Actual Engine Torque - Crankshaft Torque</td> <td>Battery Voltage</td> </tr> <tr> <td>Actual Vehicle Acceleration</td> <td>Boost Pressure</td> </tr> <tr> <td>Air Conditioner Pressure Sensor</td> <td rowspan="2">DCU Temperature</td> </tr> <tr> <td>Air Mass per Cylinder</td> </tr> </table>	AS Desc. ENG	AS Desc. ENG	A/C Compressor Relay	Actuator Test Identifier for Urea Dosing Valve	Accel pedal is pressed	Accelerator Pedal Position Sensor	After Treatment 1 Exhaust Gas Temperature1	Accelerator Pedal Position Sensor -1 Voltage	Actual Engine Torque - Crankshaft Torque	Battery Voltage	Actual Vehicle Acceleration	Boost Pressure	Air Conditioner Pressure Sensor	DCU Temperature	Air Mass per Cylinder
AS Desc. ENG	AS Desc. ENG																		
A/C Compressor Relay	Actuator Test Identifier for Urea Dosing Valve																		
Accel pedal is pressed																			
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Accelerator Pedal Position Sensor -1 Voltage																			
Actual Engine Torque - Crankshaft Torque	Battery Voltage																		
Actual Vehicle Acceleration	Boost Pressure																		
Air Conditioner Pressure Sensor	DCU Temperature																		
Air Mass per Cylinder																			
NEDC 4 replicates mode	O																		
WLTP mode	O	O																	
RDE mode		O																	

**Emission bench**



**PEMS**

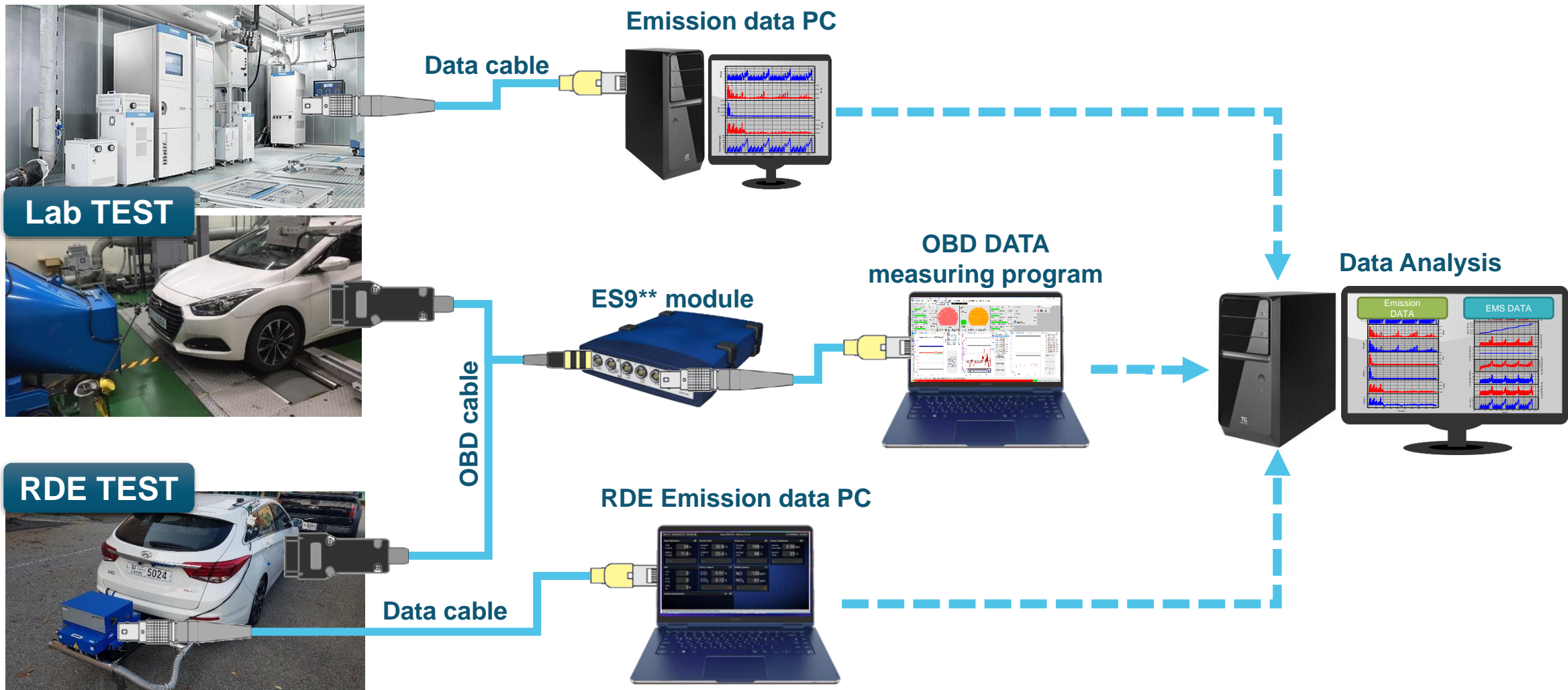


**ETAS**





## ECU/DCU In-out signal & Exhaust Emission measurement



## Data analysis based on factors such as Time, Temperature and pressure

### ➤ ECU/DCU data analysis according to the engine symptom and conditions

OBD Item name			Description	Variable name	Symptom and Conditions							Importance	비고		
No	Korean Name	English Name	English Description	Variable Name	I40(V/F)	LNT/DPE	Smoke	EGR monitoring (Air control monitoring)	Turbocharger monitoring	Torque monitoring	순위 (중요도)	Sample rate	통신 Channel	통신 Protocol	비고
1	에어컨클래셔작동상태	AC Compressor Status	Air condition Compressor status		0	X	X	0	X	0	4	B	CAN	CCP	
2	공기량 측정값	Air Mass Flow per Cylinder	Filtered air mass per cylinder		0	0	0	0	0	0	1	B	CAN	CCP	
3	흡기 표준값	ratio of normalized airmass/time to measured airmass/time			X	X	X	0	0	0	3	B	CAN	CCP	
4	인터쿨러 출구온도	Charged air temperature down stream	Temperature down stream of charged air cooler		0	0	0	0	0	X	2	B	CAN	CCP	
5	블로어 MAX ON(AMS)	Blower Max Switch	AMS Stop Reason - Blower Max Switch(AMS)		0	X	X	X	X	X	6	B	CAN	CCP	Blower state
6	에어컨 콤프레셔 작동 상태	A/C Compressor Control Status	Final digital output to the power stage of AC compressor actuator		0	X	X	0	X	0	4	B	CAN	CCP	
7	에어컨 스위치 작동 상태	A/C Main Switch Underbounced Raw Value	Raw value of AC-switch read from the sensor		0	X	X	0	X	0	4	B	CAN	CCP	A/C SW의 ON/OFF 상태 1.A/CON 스위치를 ON 하면 에어컨 콘트롤러가 실내온도를 감지하여 내부 설정치 이상으로 온도가 올라갈때 에어컨 컴프레셔를 작동시키고 압력센서의 신호에 따라 엔진 ECU는 연료 보정을 함.
8	에어컨압력센서	Air Conditioner Pressure Sensor	The raw voltage value from the ADC for AC coolant pressure		0	X	X	0	X	0	4	B	CAN	CCP	
9	공기량 목표	Desired air mass	Desired air mass		0	0	0	0	0	0	1	B	CAN	CCP	
10	EGR 제어 편차량	Control Deviation of the Exhaust-Gas Recirculation Control	Governor deviation [mg/Hub]		0	X	X	0	X	X	5	B	CAN	CCP	
11	공기량 제어 상태	Status of the exhaust-gas recirculation control	Status of the switch-off events of the exhaust-gas recirculation control, monitoring		0	0	0	0	0	X	2	B	CAN	CCP	
12	재생 배기는 제어에 의한 공기량 제어상태	Status byte of the Regeneration Intervention	Status of the transition to another operating mode		0	0	X	X	X	X	5	B	CAN	CCP	
13	발전기 제어전압(AMS)	Duty Cycle from Alternator PWM Signal(AMS)	Duty Cycle from Alternator PWM Signal (DF Signal)		0	X	X	X	X	X	6	B	CAN	CCP	Raw load on the Alternator
14	발전기 목표전압(AMS)	Desired Alternator Voltage Duty Cycle(AMS)	Desired Alternator Voltage Duty cycle		0	X	X	X	X	X	6	B	CAN	CCP	Output duty cycle to power stage
15	엑셀페달	Accel Pedal	Standardized accelerator pedal position		0	0	0	0	0	0	1	B	CAN	CCP	ETS용 APS의 출력값(백분율) 1.엔진 ECU는 APS1,APS2출력값을 내부 연산로직에 활용하기 위해 백분율로 환산하여 운전자의 가속의지를 판단하고, 적절한 토크량을 산출한다음 ETS 모터를 구동하여 스로틀을 개방한다. 2.TPS1과 TPS2는 스로틀개도가 ECU가 요구한 양만큼 열렸는지를 검출하기 위하여 사용 3.TPS의 출력전압값도 ECU가 내부에서 백분율로 환산하여 나타낸다.
16	엑셀 페달	eleration pedal position	Acceleration pedal position filtered value		0	0	0	0	0	0	1	B	CAN	CCP	
17	엑셀 페달	Acceleration pedal position			0	0	0	0	0	0	1	B	CAN	CCP	Acceleration pedal position filtered value
18	엑셀페달과 브레이크신호 상태	Status of Plausibility APP/Brk	State of plausibility APP with brake		0	X	X	X	X	X	6	B	CAN	CCP	
19	엑셀 페달 센서 1 전압	Accelerator Pedal Position Sensor-1 Voltage	Acceleration pedal sensor1 raw value		0	X	X	X	X	X	6	B	CAN	CCP	Acceleration Pedal Position D
20	엑셀 페달 센서 2 전압	Accelerator Pedal Position Sensor-2 Voltage	Acceleration pedal sensor2 raw value		0	X	X	X	X	X	6	B	CAN	CCP	Acceleration Pedal Position E
21	서지애퍼 dc 토크	ASD disturbance compensator torque output	Torque Demand Disturbance Control		0	X	X	X	X	0	5	B	CAN	CCP	
22	서지애퍼 r 토크	ASD reference filter torque output	ASD reference filter torque output		0	X	X	X	X	0	5	B	CAN	CCP	
23	배기 유량	exhaust-gas volume flow	Calculated exhaust-gas volume flow in the particulate filter		0	0	X	0	X	X	4	B	CAN	CCP	
24	CPF 표면 온도	Surface temperature of oxicat	Surface temperature of oxicat		0	0	X	X	X	X	5	B	CAN	CCP	
25	배터리 전압	Battery Voltage	Battery Voltage		0	0	0	0	0	0	1	B	CAN	CCP	

Data analysis based on factors such as Time, Temperature and pressure

➤ ECU/DCU data analysis according to the engine symptom and conditions

- Turbocharger monitoring
- DPF/SCR
- Smoke
- Excessive fuel consumption
- Torque monitoring
- Air control monitoring
- Excessive Combustion noise
- Poor acceleration
- Poor power
- Hesitation
- Fuel pressure monitoring
- Engine stalling
- Engine hesitation
- Hard starting
- Delayed starting

NO	Parameter	English Signal Name
2		Air Mass Flow per Cylinder
12		Status byte of the Regeneration Intervention
15		Acceleration pedal position
176		Desired Injection Quantity of MI1
177		Desired Injection Quantity of PI1
178		Desired Injection Quantity of PI2
179		Desired Injection Quantity of PO1
180		Desired Injection Quantity of PO2

NO	Parameter	English Signal Name
2		Air Mass Flow per Cylinder
4		Charged air temperature down stream
9		Desired air mass
11		Status of the exhaust-gas recirculation control
242		Actuator position (VSA)
243		VSA Valve First Learnt Value
244		VSA Valve Last Learnt Value
245		Duty cycle to power stage (VSA)

## Acquisition data

ECU DATA					
Parameter	Sample	Unit	Parameter	Sample	Unit
Accelerator Pedal Position Sensor	0	%	Idle Stop or Engine Stall	ON	
Pressure Control Valve(Rail)	0.31	%	AMS Stop Reason - Blower Max Switch(AMS)	NO	
Air Mass per Cylinder	224	mg/hub	Gearbox Neutral Position Status Signal	YES	
Barometric Pressure Sensor	1002	hpa	Starter ON Signal	NO	
Clutch Switch (MT only)	on		Starter Request by Key	NO	
A/C ON Signal Switch	off		Clutch is Pushed more than 40%	NO	
Gear is on Neutral Position	on		Idle Stop request by Drivers demand(ISG)	NO	
Brake Switch 2	off		Driver's Seat Belt	unbelted	
Brake Switch 1	off		Driver's Door	OPEN	
A/C Compressor Relay	off		Hood Switch	CLOSED	
Blower Switch	on		State of Charge of Battery(AMS)	82	%
Ignition Switch	on		State of Health of Battery(AMS)	80	%
Accelerator Pedal Position Sensor-1 Voltage	0.75	V	State of Function of Battery(AMS)	8.4	V
Accelerator Pedal Position Sensor-2 Voltage	0.35	V	ISG Status(ISG)	OFF	
MIL Status Indicator(MIL by DTC)	off		Brake Boost Vacuum Pressure	984.984	hpa
GRU(Glow Relay Unit) Control Unit	6	%	Brake Boost Vacuum Pressure Voltage(ISG)	4.474	V
Fuel Quantity	5	mm3	Nominal Capacity(AMS)	90	Ah
Voltage of Battery	14.2	V	Flag Status of Battery Charge(AMS)	NO	
Vehicle Speed	0	km/h	Flag Status of Battery Health(Aging) (AMS)	NO	
Engine Cooling Fan-Low	10	%	Flag Status of Battery Function to Crank the Engine(AMS)	NO	
Engine Cooling Fan-High	off	off	Flag Status of Quiescent Current(AMS)	NO	
Elec. Fuel Pump Relay	on	on	Invalid Condition of Battery Sensor(AMS)	NO	
Boost Pressure Actuator	74	%	Response Error Flag from Battery Sensor(AMS)	NO	
Fuel Temperature Sensor	28.43	°C	AMS Stop Reason - Head Lamp(AMS)	NO	
Synchronizing Status	full syne complete		AMS Stop Reason - Wiper(AMS)	NO	
Engine Status	running		Lambda Sensor #2	0	
PTC Heater Realy	off	off	Battery Current(AMS)	6.9A	A
Immobilizer Status Lamp	off	off	Voltage of Battery	14.31V	V
Fuel Pressure Set Point Value	313726	hpa	Temperature of Battery	36	°C
Output of Fuel Metering Unit(MPROP)	41	%	Engine ON Time	1770222	sec
Air Conditioner Pressure Sensor Voltage	1.31	V	Kilometer Count with MIL ON	0	km
Air Conditioner Pressure Sensor	92.59	psi	Final stop enable signal	NO	
Raw Voltage of Exhaust Temperature Sensor 1(Upstream of the Oxidation Catalyst) (CPF OPT)	1.1	V	Final stop Request signal	OFF	
Raw Voltage of Temperature at Upstream of the DPF	1.06	V	Final start Enable signal	NO	
Raw Voltage of Differential Pressure Sensor (DPF OPT)	1	V	Final start Request signal	OFF	
Oxygen Sensor Subtraction Voltage	0	V	Water Temperature of Engine	70	°C
Lambda Sensor	0	0	Barometric Pressure Sensor	1010	hpa
Oxygen Sensor Temperature	575°C	575°C	Engine Speed	799.5	rpm
Oxygen Sensor Heater Duty	2	%	Stop enable by brake booster (less than -350hpa)	YES	
Oxygen Sensor State of Adaption	1		Stop enable by safety condition (seat/Door/hood)	NO	
Oil Level - Raw Value(Option)	18	mm	Stop enable by battery (SOC/Battery Temperature)	YES	
Oil Temperature Sensor(Option)	-40	°C	Stop enable by air conditioner	YES	
Oil Level - Last Averaged Value(Option)	18	mm	Stop enable from EMS	YES	
Oil Status(Level)(Option)	NORMAL		Stop enable from OBD	YES	
Active Operation Mode	16781313		Stop enable from SPAS	YES	
Differential Pressure of Particulate Filter (CPF OPT)	0	hpa	Braking system is not operating	YES	
Exhaust Temperature Sensor 1 Value (Upstream of the Oxidation Catalyst) (CPF OPT)	103.71	°C	Stop enable by TCU	NO	
Exhaust Temperature Sensor 2 Value (Upstream of the DPF) (CPF OPT)	99	°C	Stop enable by HAC	YES	
Charge State of the Particle Filter (CPF OPT)	3		Accel pedal is pressed	OFF	

DCU DATA		
Parameter	Sample	Unit
Engine Intake Airmass Flow Rate in EGF1 CAN Frame	21.6	kg/h
Throttle Valve Duty Cycle (received over CAN)	99.902	%
Temperature Field of the SCR Catalyst	151.06	°C
Estimated Efficiency of the SCR Catalyst	0.518	
Saturation Ratio of the SCR Catalyst	0.912	
Longterm Adaption Factor	1	
Initial Refill Finished Successful	OK	
Signal Test for Urea Pressure Line Heater Actuator	OFF	
Signal Test for Urea Tank Heater Actuator	OFF	
NOx Concentration Value (Front)	65535	ppm
NOx Concentration Value (Rear)	65535	ppm
UREA Concentration		
Relative Urea Pump Module Pressure	6248	hPa
Urea Catalyst Upstream Temperature (Model)	131.96	°C
Urea Catalyst Upstream Temperature	138.96	°C
Urea Tank Temperature	19.96	°C
DCU Temperature	30.96	°C
Battery Voltage	13.04	V
Remaining Quantity of Reducing Agent in [%]	81.506	%
Remaining Quantity of Reducing Agent in [L]	13.2	L
Remaining Quantity of Reducing Agent in [g]	14405	g
Tank Level (Filtered)	87.354	%
Tank filling state valuin mm	5184.5	mm
State of Hydraulic SCR-System	PRESSURE CTL	
Last State of Hydraulic SCR-System	NO PRESSURE CTL	
Substate of Hydraulic SCR-System	METERING CONTROL	
Last Substate of Hydraulic SCR-System	PRESSURE BUILD UP	
Status of Current Tank Level	OK	
State of the Defrosting Check	Unfreeze	
Engine Speed Sent Over CAN	790.5	RPM
Environment Pressure Received Over CAN	1012	hPa
Environment Air Temperature	15.46	°C
After Treatment 1 Exhaust Gas Temperature1	136.96	°C
Heater Enable Status	Available	
Boost Pressure	994	hPa
Exhaust Gas Mass Flow	20.5	kg/h
Model Value for NOx Signal Upstream of the SCR Catalyst	0.001	
Lambda Value	0	
Vehicle Speed	0	km/h
Actuator Test Identifier for Urea Dosing Valve	0	%
Engine Off Time	2	Sec
Number of Warm-Up Cycles After Last Clearing of Error Memory	0	
Output Signal of the Fill Level Height in mm	0	mm

## In-out signal measurement

## ECU IN-OUT Signal 232 Item

AS Desc. ENG	AS Desc. KOR	Unit
A/C Compressor Relay	에어컨 컴프레서 릴레이	
Accel pedal is pressed	엑셀 페달 밟음	
Accelerator Pedal Position Sensor	엑셀포지션 센서	%
Accelerator Pedal Position Sensor-1 Voltage	엑셀 페달 센서 1 전압	V
Actual Engine Torque - Crankshaft Torque	실제 엔진 토크 - 크랭크 샤프트	Nm
Actual Vehicle Acceleration	차량 가속도	m/s <sup>2</sup>
Air Conditioner Pressure Sensor	에어컨압력센서	psi
Air Mass per Cylinder	실린더별 흡입공기량	mg/hub

Engine Cooling Fan-Low	냉각팬-저속	%
Barometric Pressure Sensor	대기압 센서	hPa
Brake master cylinder pressure	브레이크 마스터 실린더 압력	bar
GRU(Glow Relay Unit) Control Unit	글로우 릴레이 유닛 제어 듀티	%
Variable Swirl Actuator Control Duty	가변 스웰 액추에이터 제어 듀티값	%

## ECU IN-OUT Signal 30 Item selection

## DCU IN-OUT Signal 106 Item

AS Desc. ENG	AS Desc. KOR	Unit
Actuator Test Identifier for Urea Dosing Valve	인젝터 테스트 듀티	%
After Treatment 1 Exhaust Gas Temperature1	SCR 전단 온도	deg C
Battery Voltage	배터리 전압	mV
Boost Pressure	부스트 압력	hPa
DCU Temperature	DCU 내부 온도	deg C

Urea Catalyst Upstream Temperature	배기 온도 센서 (SCR전단)	deg C
Urea Catalyst Upstream Temperature (Model)	모델링된 SCR 전단온도	deg C
UREA Concentration	요소수 농도	g/l
Urea Tank Temperature	요소수 탱크 온도	deg C
Vehicle Speed	차속	km/h

## DCU IN-OUT Signal 15 Item selection

## In-out signal measurement

### ECU DATA

### DCU DATA

센서명	센서값(sample)	단위	센서명	센서값(sample)	단위	센서명	센서값(sample)	단위
엑셀포지션 센서	0	%	ISG 작동 상태(ISG)	ON		차속	0	km/h
연료 압력 조절기(레일)	0.31	%	발전제어중지-블로어 MAX ON(AMS)	NO		브레이크 페달 밟음	OFF	
실린더별 흡입공기량	224	mg/hub	기어중립화	YES		브레이크 마스터 실린더 압력	0bar	
대기압 센서	1002	hpa	스타트 구동 신호	NO		자동변속레버-D단	OFF	
클러치 스위치(M/T only)	on		크랭킹 신호(By Key)	NO		자동변속레버-N단	OFF	
에어컨 스위치	off		클러치 페달 스위치(MT only)	NO		엔진 정지 요구-변속레버 D단 시	OFF	
기어 중립화	on		아이들 스톱 신호(ISG)	NO		엔진 정지 요구-변속레버 N단 시	OFF	
브레이크 스위치-2	off		운전석 안전 벨트	unbelted		엔진 시동 가능-ISG 관련 고장 유무 조건 만족	YES	
브레이크 스위치-1	off		운전석 도어	OPEN		엔진 시동 가능-기어 조건 만족	YES	
에어컨 컴프레서 릴레이	off		후드 스위치	CLOSED		엔진 시동 가능-EMS 조건 만족	YES	
플로워 스위치	on		배터리 충전 상태(AMS)	82	%	엔진 시동 가능-엔진벨트,도어,후드 조건 만족	YES	
이그니션 스위치	on		배터리 노화 진행률-신용 100%기준(AMS)	80	%	엔진 시동 가능-TCU 조건 만족	YES	
엑셀 페달 센서 1전압	0.75	V	크랭킹시 배터리 최저 전압(AMS)	8.4W	V	엔진 시동 가능-브레이크 페달 및 기타 조건에 의한 시동	OFF	
엑셀 페달 센서 2전압	0.35	V	ISG 상태	OFF		엔진 시동 가능-ISG OFF바튼 ON에 의한 시동	OFF	
엔진 경고등(DTC에 의한 경고등)	off		브레이크 부스트 배플 압력	984.984	hpa	엔진 시동 가능-OBD 진단기능에 의한 강제 시동	OFF	
클로우 릴레이 유닛 제어 듀티	6	%	브레이크 부스트 배플 센서 전압(ISG)	4.474	V	엔진 시동 가능-EMS에 의한 강제 시동	OFF	
연료 분사량	5	mm <sup>3</sup>	배터리 규격 용량(AMS)	90	Ah	엔진 시동 요구-에어컨에 의한 시동	OFF	
배터리 전압	14.2	V	배터리 충전 불량(AMS)	NO		엔진 시동 요구-배터리 조건에 의한 시동	OFF	
차속	0	km/h	배터리 노화(AMS)	NO		엔진 시동 요구-브레이크 부스터 압력(-350hpa 초과)에 의한 시동	OFF	
냉각팬-저속	10	%	크랭킹 불가능 배터리 상태(AMS)	NO		엔진 시동 요구-차속 발생에 의한 시동	OFF	
냉각팬-고속	off	off	대기(압)전류 비정상(AMS)	NO		엔진 시동 요구-장시간 Auto Stop에 의한 시동(300초)	OFF	
엔진펌프릴레이	on	on	배터리 센서 비정상 상태	NO		엔진 시동 요구-안전 항목 해제에 의한 시동(벨트,도어,후드)	OFF	
부스터압력 액츄에이터	74	%	배터리 센서 LIN 통신 에러	NO		엔진 시동 요구-경사각 과대에 의한 시동(오르막:12%, 내리막:8%)	OFF	
연료온도 센서	28.43	°C	발전제어중지-헤드램프 ON(AMS)	NO		엑셀 페달 이상	OFF	
엔진회전수 동기상태	full syne complete		발전제어중지-외어퍼 ON(AMS)	NO		브레이크 부스터 압력 이상	OFF	
현재 엔진상태	running		람다센서 #2	0		브레이크 실린더 압력 이상	OFF	
보조히터(ptc) 릴레이	off	off	배터리 전류	6.9A	A	브레이크 페달 이상	OFF	
이오빌라이저 켈프	off	off	배터리 전압	14.31V	V	배터리 센서 이상	OFF	
목표 레일 압력	313726	hpa	배터리 온도	36°C	hpa	통신 신호 없음-CNU2	OFF	
연료 압력조절기(펌프)	41	%	엔진ON 경과시간	1770222	sec	통신 신호 없음-DCT1	OFF	
에어컨입력센서 전압	1.31	V	MIL ON 주행거리	0	km	운전석 도어 스위치 이상	OFF	
에어컨입력센서	92.59	psi	엔진 정지 가능 조건 만족	NO		엔진 회전수 이상	OFF	
배기 온도 센서 #1 전압	1.1	V	엔진 정지 요구 신호	OFF		통신 신호 없음-ESP2	OFF	
배기 온도 센서 #2 전압	1.06	V	엔진 시동 가능 조건 만족	NO		키 시동 신호 이상	OFF	
배기 자압 센서 전압	1	V	엔진 시동 요구 신호	OFF		변속레버 이상	OFF	
산소센서 조절 전압	0	V	엔진 냉각수온	70	°C	후드 스위치 이상	OFF	
공기 과잉률	0	0	대기압	1010	hpa	보조오일펌프 이상	OFF	
산소센서 온도	575°C	575°C	엔진 회전수	799.5	rpm	안전벨트 착용 이상	OFF	
산소센서 히터 듀티	2	%	엔진 정지 가능-브레이크 부스터 압력 만족(-350hpa 미만)	YES		Total Sulphur Mass	308.995	mg
산소 센서 온도 조정	1		엔진 정지 가능-엔진벨트,도어,후드 조건 만족	NO		레이 압력	313725.5	hPa
오일 레벨 센서값	18	mm	엔진 정지 가능-배터리 조건 만족(SOC/배터리온도)	YES		EGR 액츄에이터	2	%
오일 온도	-40	°C	엔진 정지 가능-에어컨 조건 만족	YES		냉각수온 센서	70	°C
오일레벨 평균값	18	mm	엔진 정지 가능-EMS 조건 만족	YES		가변 스칼라 액츄에이터	15.3	%
오일레벨 상태	NORMAL		엔진 정지 가능-OBD 조건 만족	YES		스토폴 플럼 액츄에이터	-12.2	%
활성화 명령 모드	16781313		엔진 정지 가능-SPAS 조건 만족	YES		룸기온도센서	35	°C
CPF/DPF 자압발상량	0		엔진 정지 가능-브레이크 조건 만족	YES		차압 센서 신호	-0.784	hPa
배기 온도 센서 #1	103.71	°C	엔진 정지 가능-TCU 조건 만족	NO		배기 유량	16	m <sup>3</sup> /h
배기 온도 센서 #2	99	°C	엔진 정지 가능-HAC 조건 만족	YES		부스터 압력 센서	998	hPa
soot 피착량에 의한 재생요구	3		엑셀 페달 밟음	OFF				

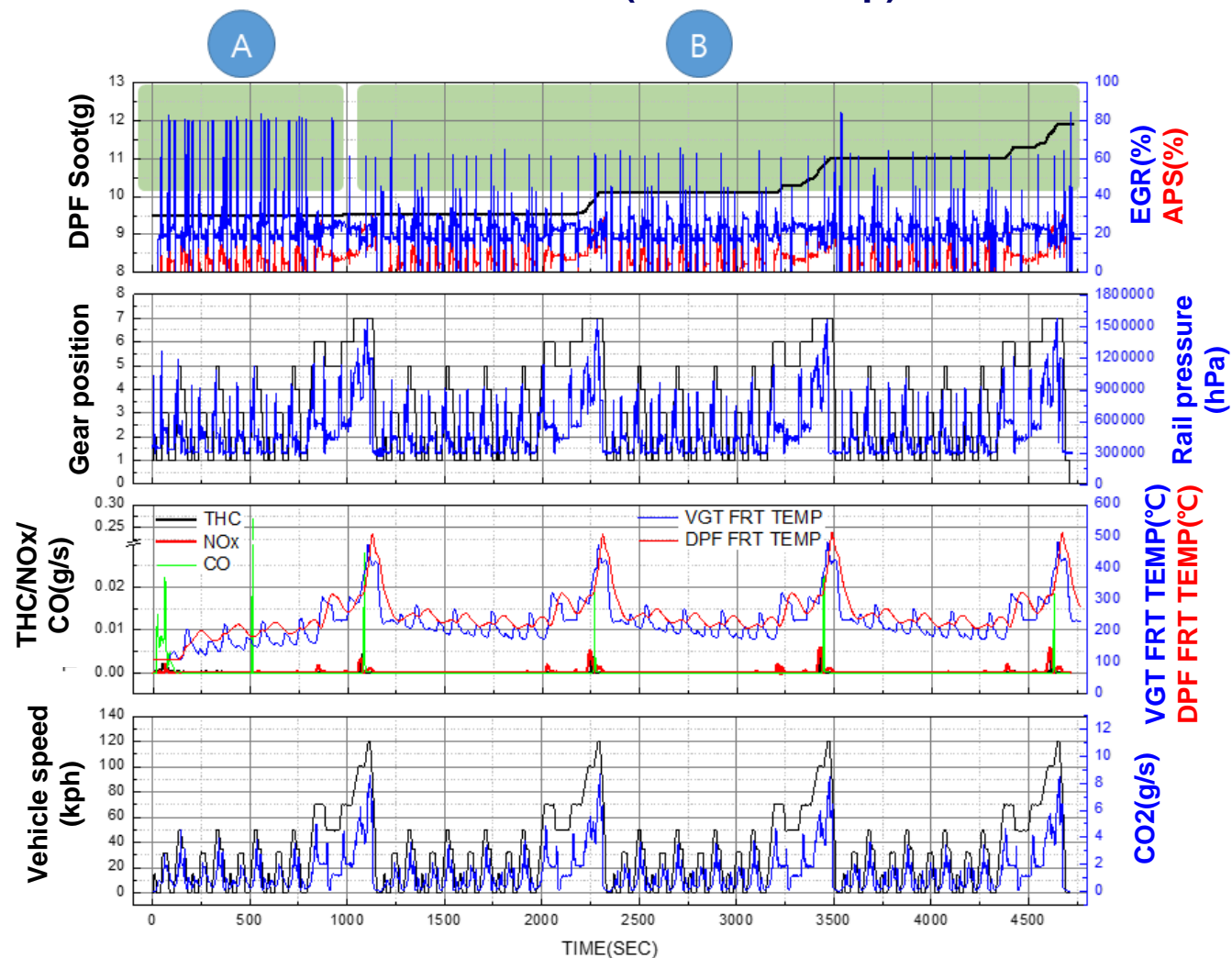
센서명	센서값(sample)	단위
흡입 공기량	21.6	kg/h
쓰로틀 작동 듀티	99.902	%
SCR 온도	151.06	°C
SCR 정화 효율	0.518	-
SCR 알루미나 잔류율	0.912	-
요소수 분사 보정값	1	-
요소수 최초 채움 성공	OK	-
공급 라인 히터 테스트 상태	OFF	-
요소수 탱크 히터 테스트 상태	OFF	-
전단 NOx 값	65535	ppm
후단 NOx 값	65535	ppm
요소수 농도	미지원	-
요소수 라인 압력	6248	hPa
모델링 된 SCR 전단 온도	131.96	°C
배기 온도 센서(SCR 전단)	138.96	°C
요소수 탱크 온도	19.96	°C
DCU 내부 온도	30.96	°C
배터리 전압	13.04	V
요소수 잔류량(%)	81.506	%
요소수 잔류량(L)	13.2	L
요소수 잔류량(g)	14405	g
요소수 잔류량(밀터값)	87.354	mm
Tank filling state valuin mm	5184.5	mm
요소수 압력 계통 상태 (상위)	PRESSURE CTL	-
이전 요소수 압력 계통 상태 (상위)	NO PRESSURE CTL	-
요소수 압력 계통 상태 (하위)	METERING CONTROL	-
이전 요소수 압력 계통 상태 (하위)	PRESSURE BUILD UP	-
요소수 잔류 상태	OK	-
요소수 해당 상태	Unfreeze	-
엔진 회전수	790.5	RPM
대기 압력	1012	hPa
대기 온도	15.46	°C
SCR 전단 온도	136.96	°C
히터 구동 가능 상태	Available	-
부스터 압력	994	hPa
배기 유량	20.5	kg/h
전단 NOx 값 (모델)	0.001	-
공기 과잉률	0	-
차속	0	km/h
인젝터 테스트 듀티	0	%
엔진 Off 시간	2	Sec
고장코드 식재 후 시동 횟수	0	-
요소수 표면 높이	0	mm

# 03 Test Result



## Data analysis(NEDC mode)

## ➤ EGR control characteristics(Coolant temp)

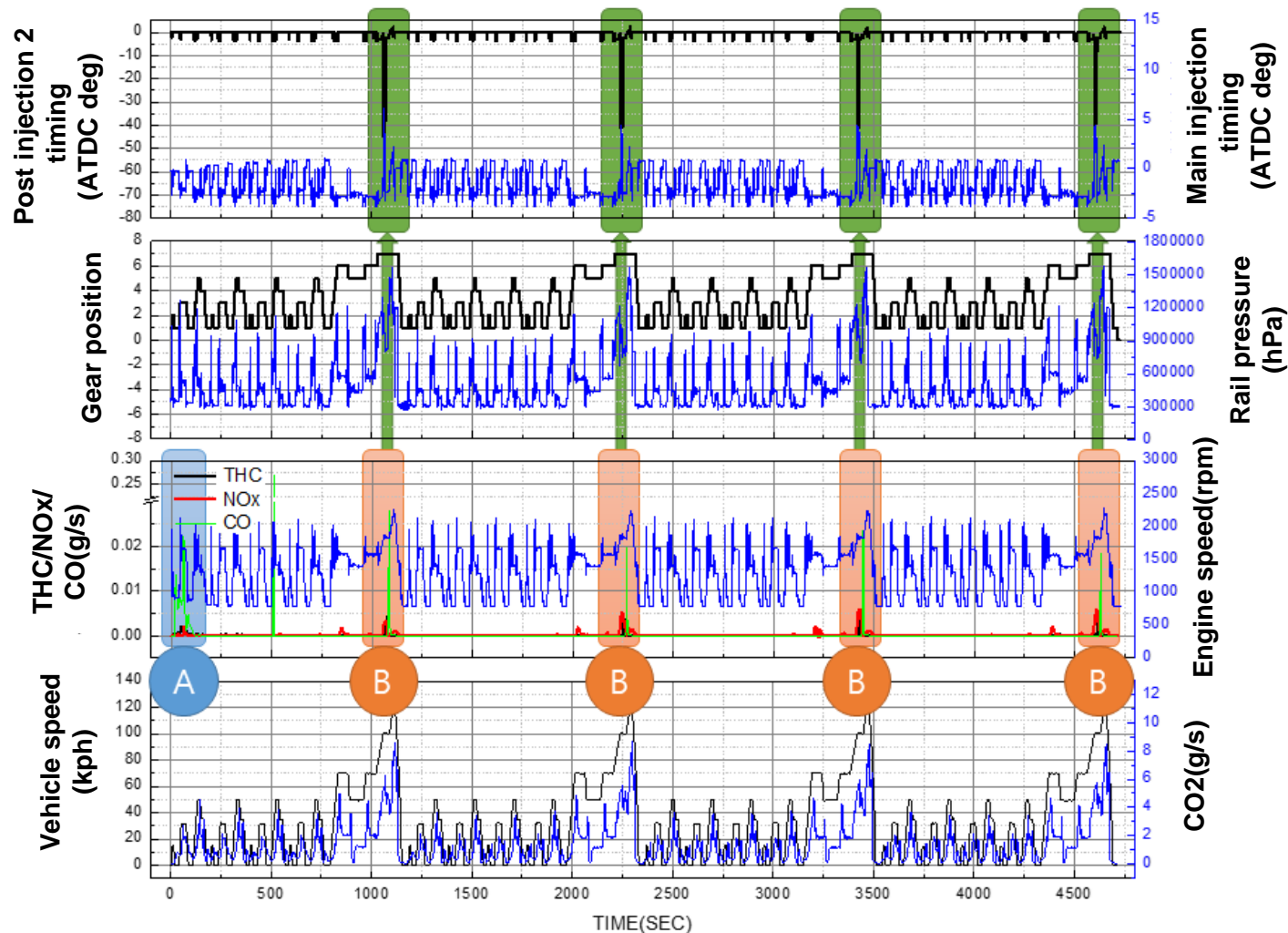


- EGR operation status is different between **cold section A** and **hot section B** where cooling water temperature rises.
- Improves combustion efficiency with EGR gas during cold section A
- Many manufacturers use EGR characteristics.



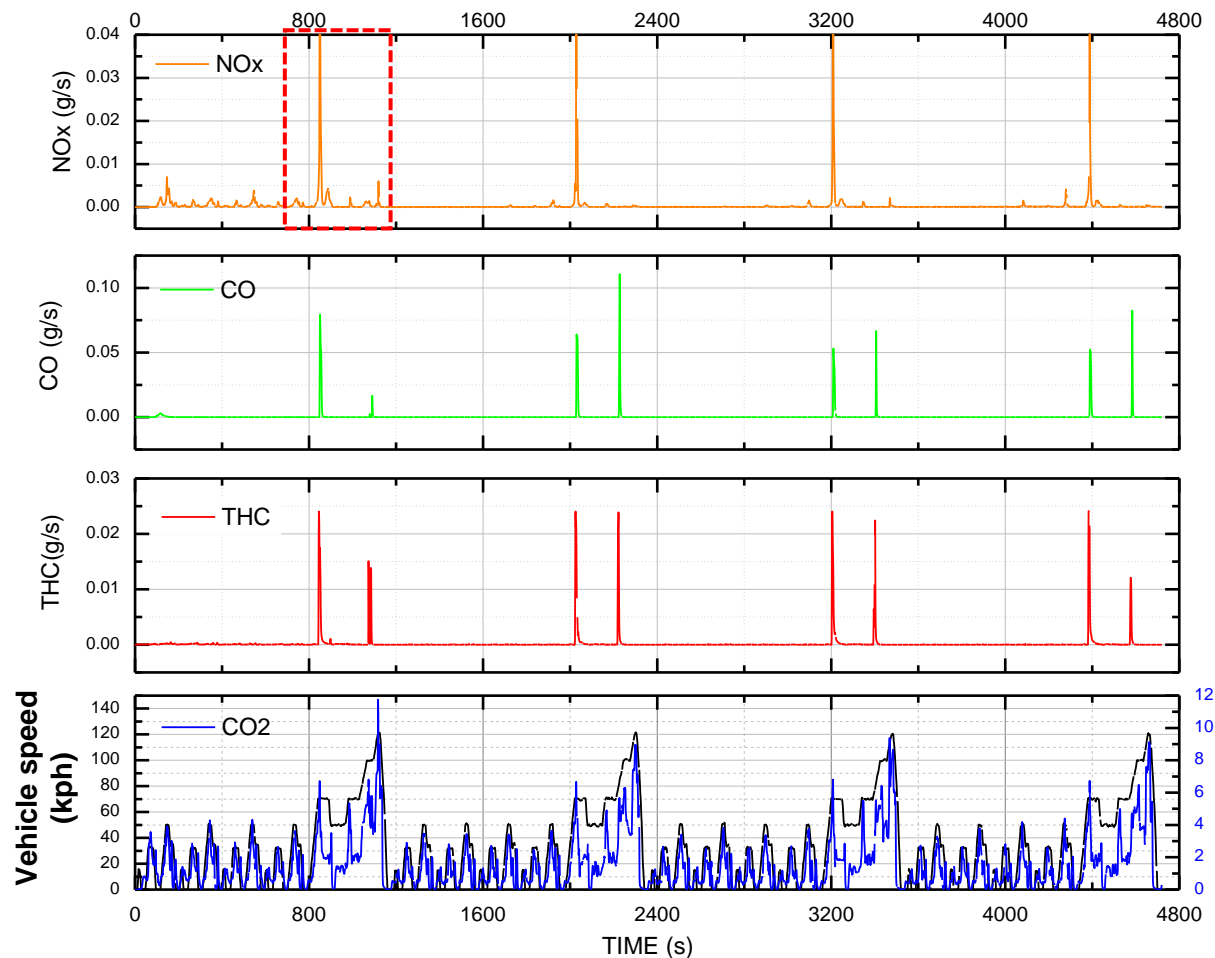
## Data analysis(NEDC mode)

## ➤ Emission Characteristics(Post Injection Timing)



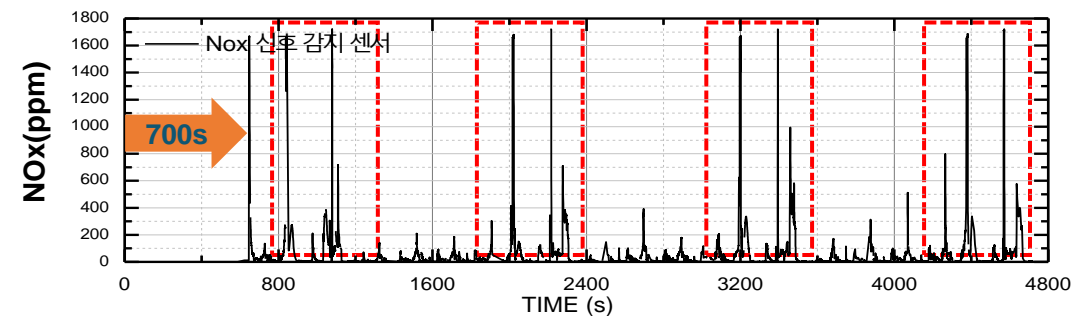
- Control of engine temperature rise and lambda measurement is impossible during cold, Post-injection 2 not controlled (Cold section A)
- Post injection 2 at vehicle speeds above 100KPH and fuel injection for LNT activation In vehicle with LNT (section B)

## NEDC mode [NOx sensor, SCR actuator]

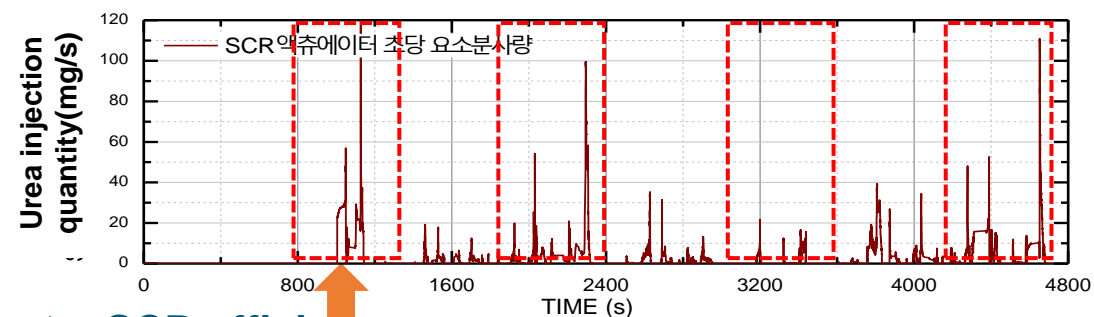


- NOx sensor does not detect signal for about 700 seconds.
- DCU does not spray urea at efficiency below 0.8 even when NOx signal is detected

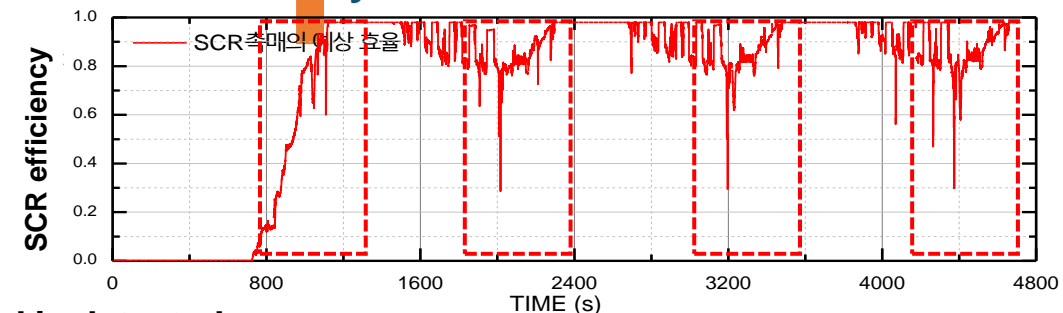
## ➤ NOx sensor



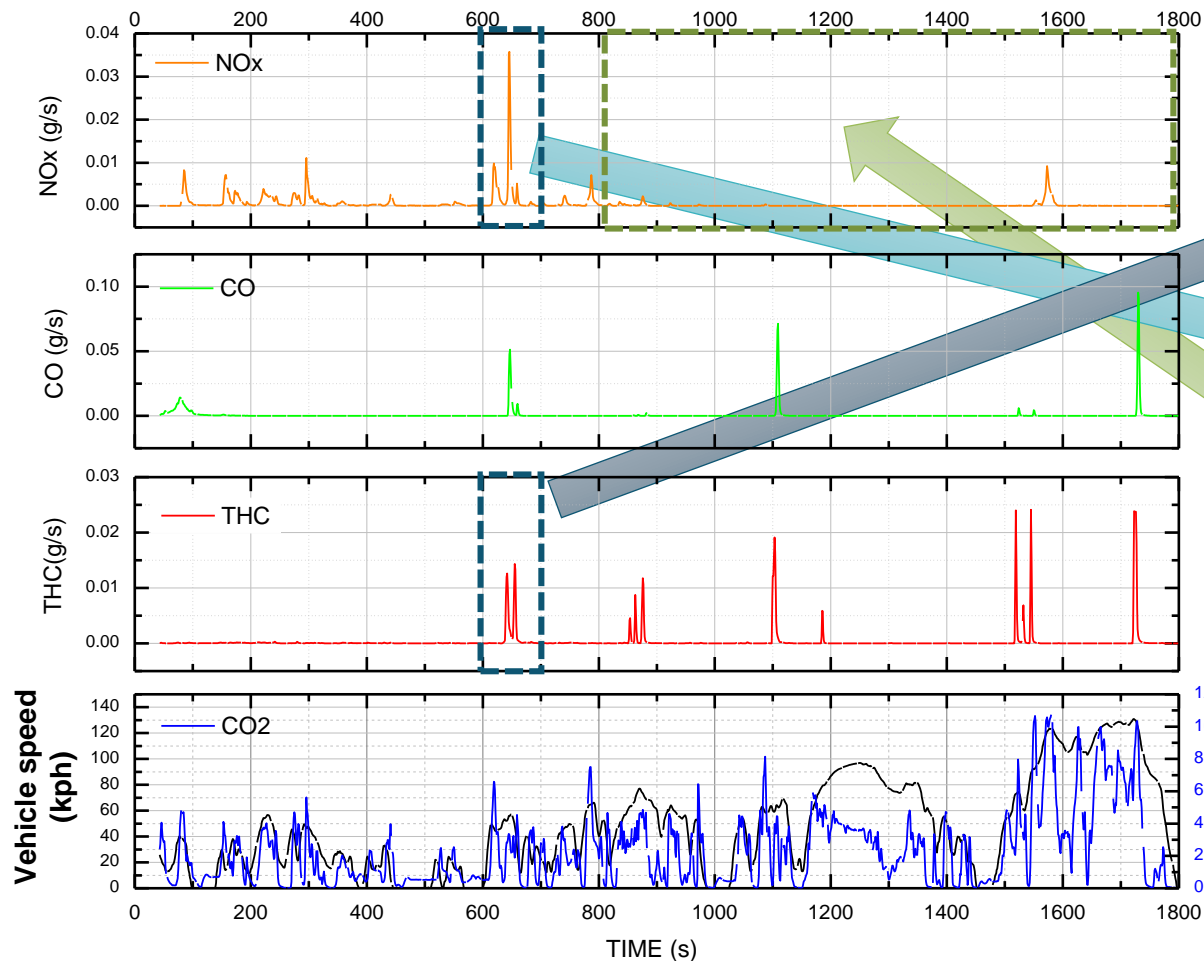
## ➤ SCR actuator



## ➤ SCR efficiency

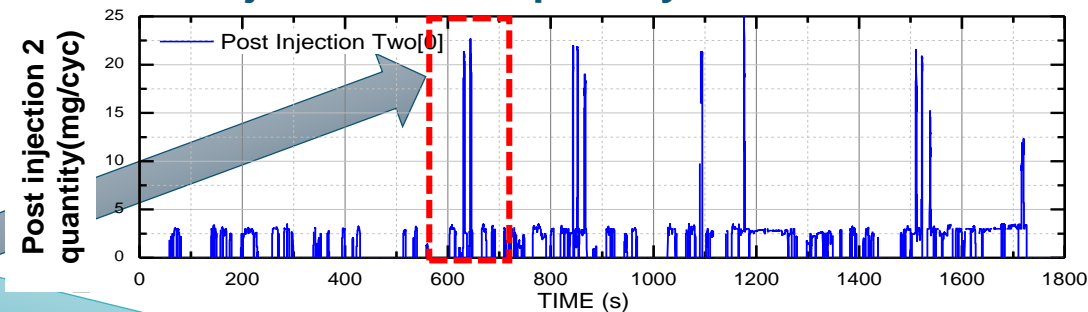


## WLTP mode [Fuel quantity]

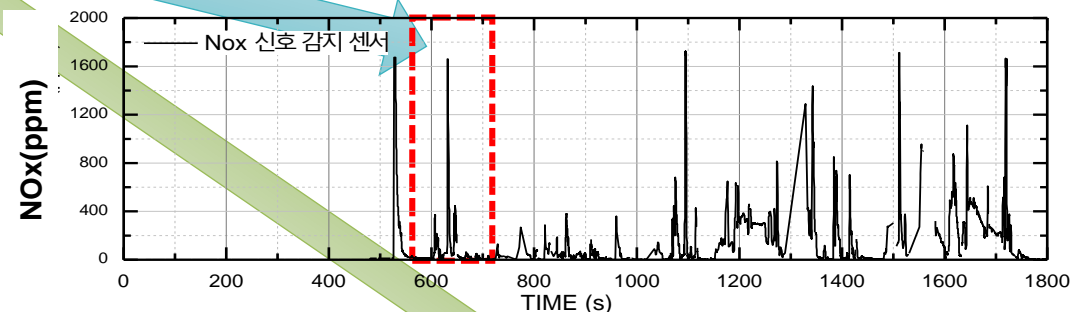


- HC emission gas generation when post injection 2
- NOx emission occurs before SCR activation
- However, NOx emission is not emitted during urea injection

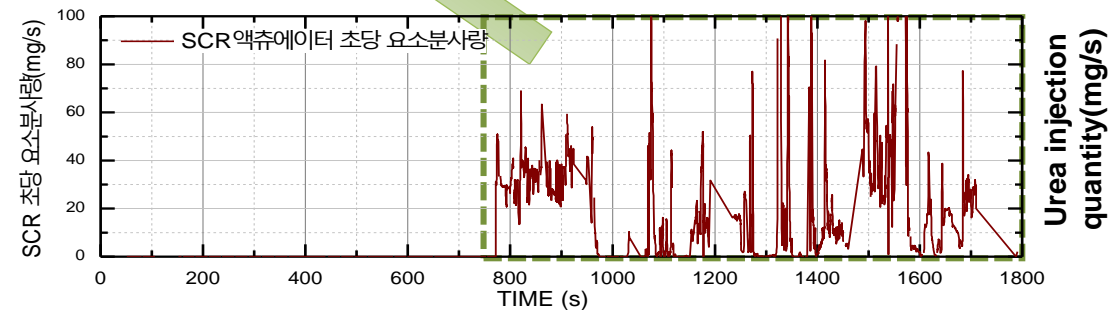
## Post injection 2 fuel quantity



## NOx sensor

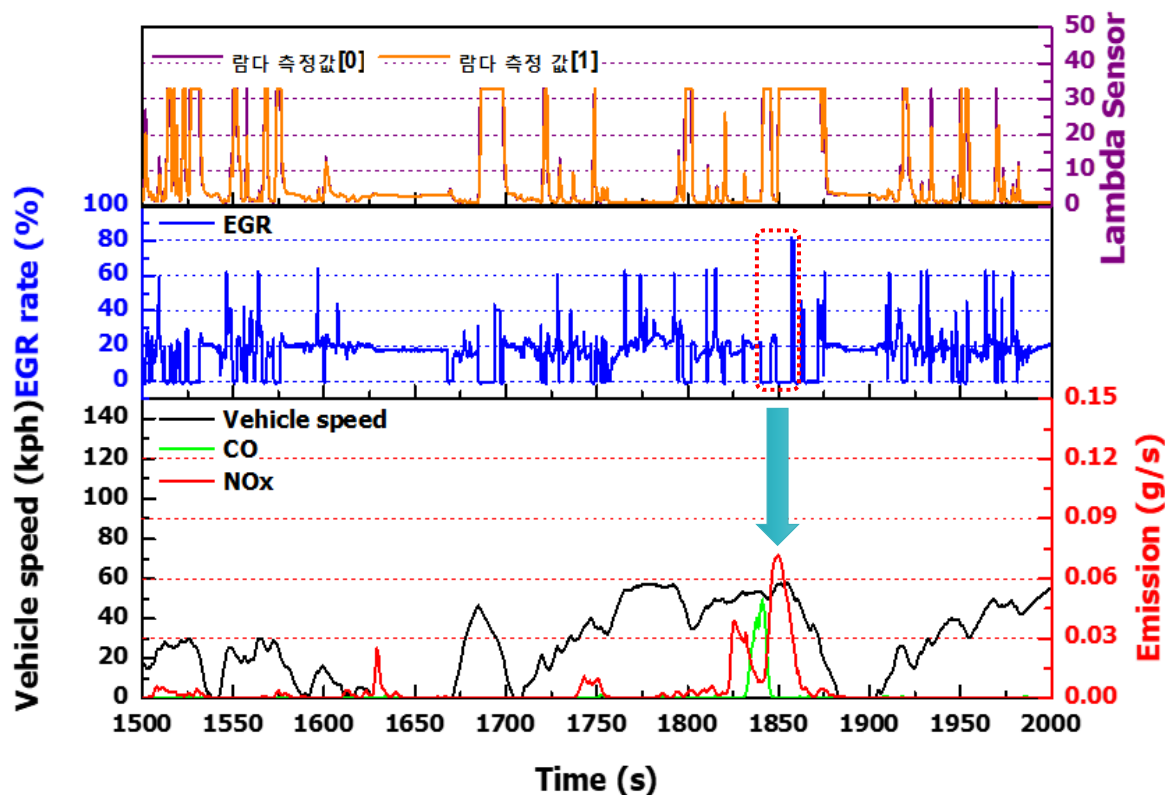


## SCR Urea actuator

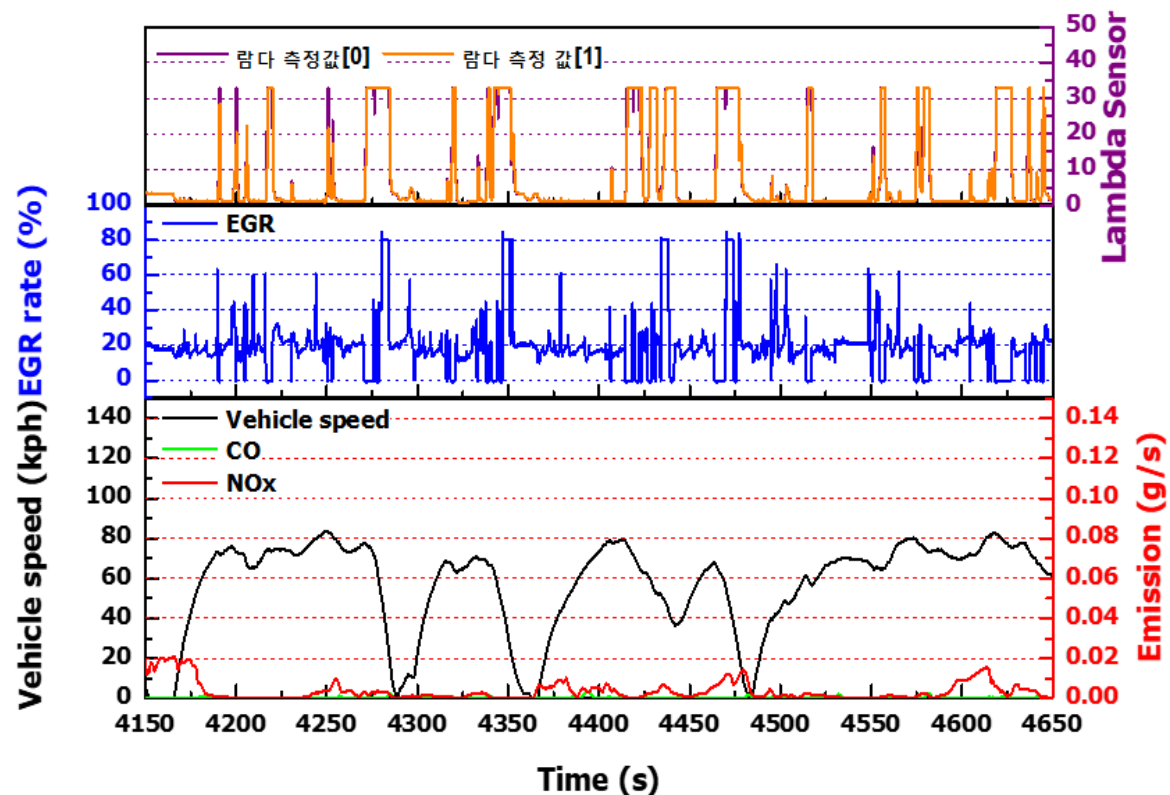


## Data analysis (RDE mode)

## ➤ RDE Urban



## ➤ RDE Rural



- NOx emissions occur at random intervals
- However, NOx emissions when EGR stops for more than 3 seconds

# 04 Future work



Development of program for checking engine emission characteristic

## Automotive Engine Analysis Research Team in Korea

### Objective

- Preventing pollutant discharge through accurate fault diagnosis
- Follow-up management of emissions problems vehicle

### Detail

- **Advanced electronic control system analysis**
  - Exhaust emission after treatment system control variable analysis
  - Developed electronic control system analysis program
- **How to evaluate characteristics**
  - Engine characteristic case DB construction
  - Preparation guidelines for exhaust emission level
- **Advanced FIR(Field Information Report)**

Development of program for checking engine emission characteristic

## 2020: LDV emission and characteristic monitoring

- Accurate calculation of exhaust emission from LDVs

## 2021: Development of program

- Program development using Deep learning and Machine learning
- Artificial Intelligent Monitoring System Development

# Thank you for attention!

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