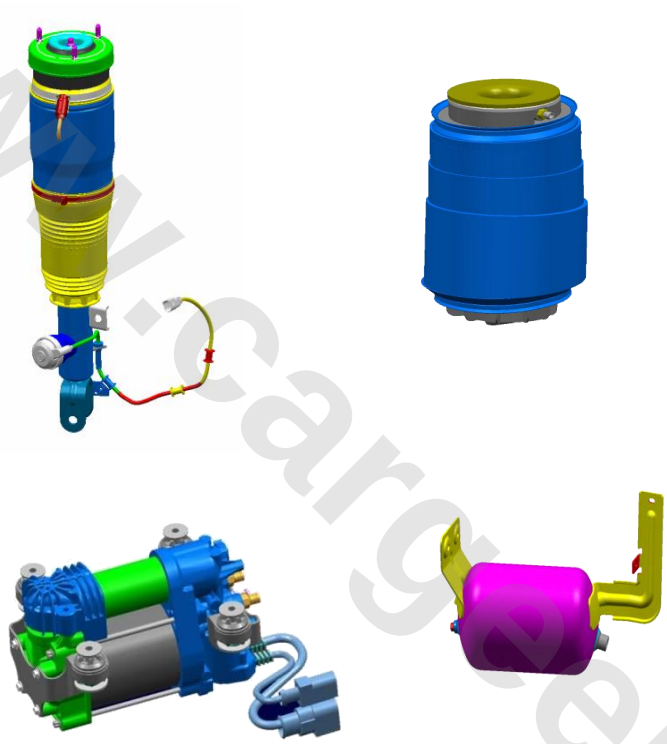
سیستم تعلیق با کنترل الکترونیکی

Electronically Controlled Suspension

AMC-T13-V00



تدوین:

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واحد آموزش آسان موتور

زمستان ۱۳۹۱

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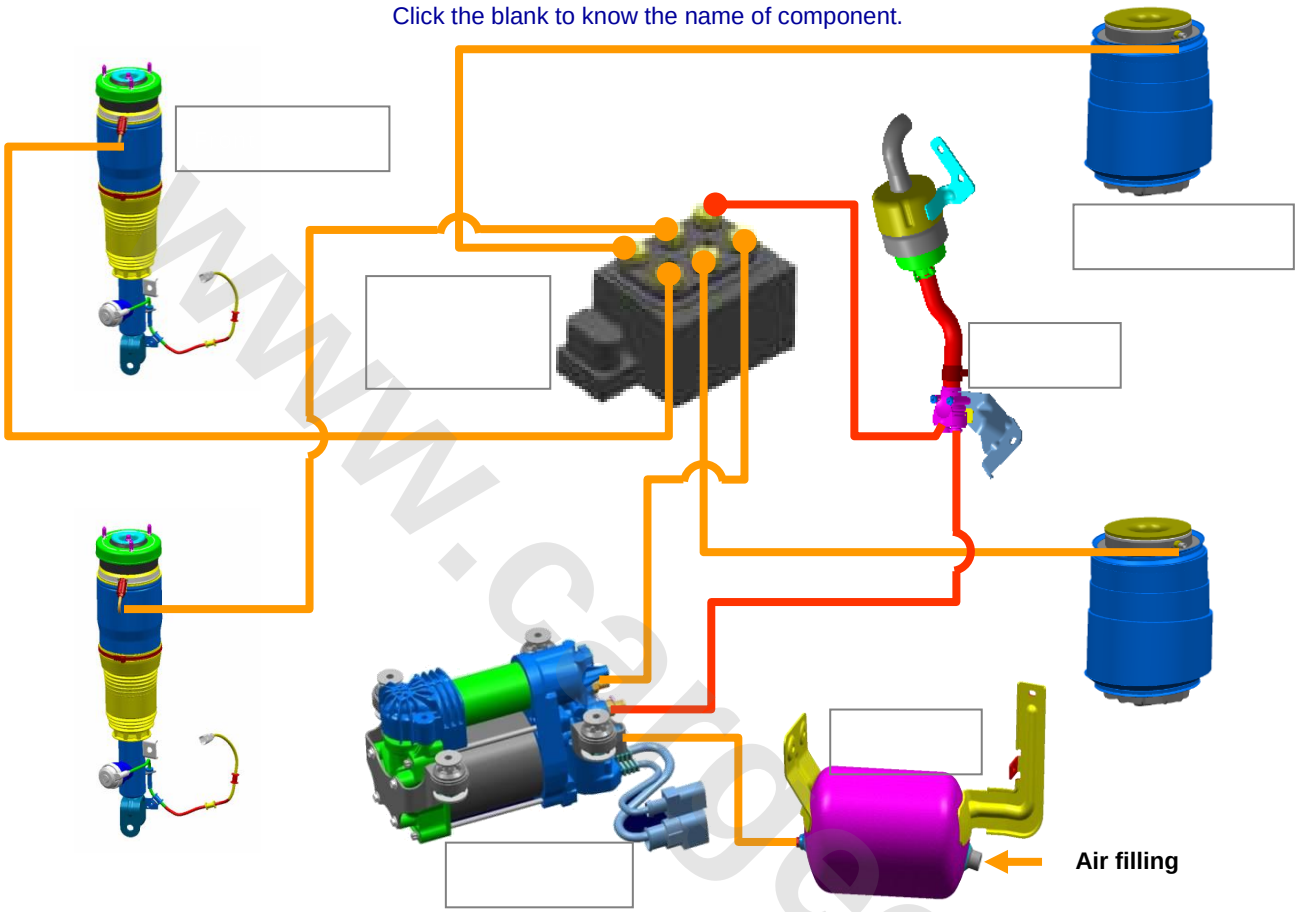
لوله کشی هوا

Air tube connection



This picture has been prepared to help understanding how the pneumatic components are connected in closed type ECS system.

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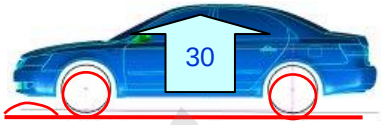
کنترل ارتفاع

Leveling control

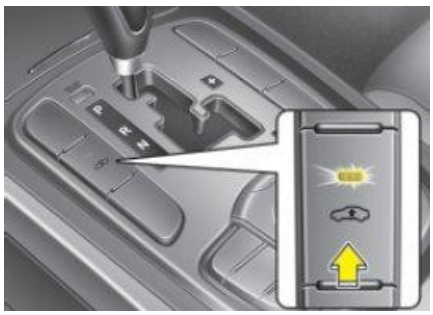


High level
(Off-road level)

Normal level

Low level
(Highway level)

Level	Front	Rear
High level (Off-road level)	+ 30mm	+ 30mm
Normal level	0mm (D.H:394)	0mm (D.H:387)
Low level (Highway level)	-15mm	-15mm



※ D.H: Design Height (the height from the wheel center to the top edge of wheel housing)

High level:
In order to minimize the interference between the vehicle body and the road surface, the vehicle level is controlled by following two features.
Manual – As long as the vehicle speed is lower than 70kph, possible to lift from normal to high level. Opposite manual operation (from high to normal) has no restriction for the vehicle speed.
Automatic – If the vehicle speed exceeds 70kph with high level, it will be alternated into normal level automatically after 10sec for the safety.

Normal level:
This is the basic level for normal driving condition. As same as high level, there are two features.
Manual – Refer to the above 'High level'.
Automatic – If the vehicle speed exceeds 120kph with normal level, it will be alternated into low level after 10sec for the safety and better fuel consumption.
Low level:
No manual operation is supported.

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Automatic – If the vehicle speed is lower than 80kph for more than 5sec, it will be alternated into normal mode automatically, however if it is lower than 40kph, it will be normal level immediately regardless of the time.

Whenever the level is changed, there is a time delay between front and rear wheel for the safety. For lift, rear side will be advanced and front side will be lifted later on. For lowering, it is opposite. (because of this operating sequence, there may be a noise if the brake (AVH, EPB) is being engaged while level control)

Component

اجزاء کمک فنر جلو

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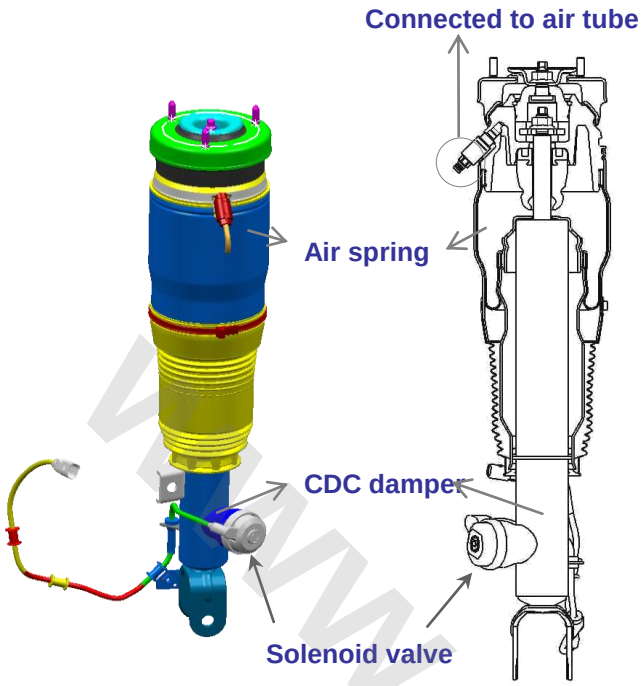
Front Air strut



- Consists of
  Air spring, CDC damper

- Function
  - Air spring
    Controls the vehicle height in real time
  - CDC damper
    Controls damping force depending on the road condition

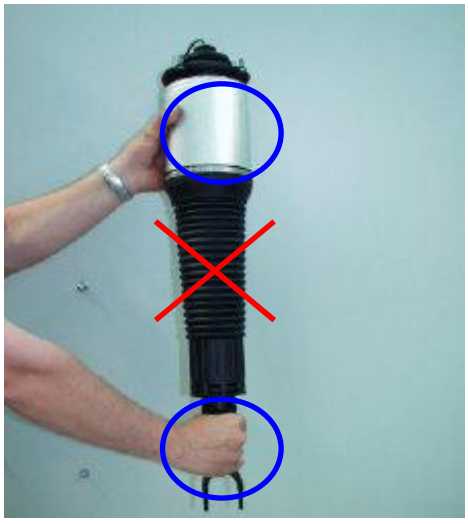
Front Air Strut

The air spring & damper is one unit so that it is not possible to make separation.

The average pressure of front air spring is around 7.5 bar.

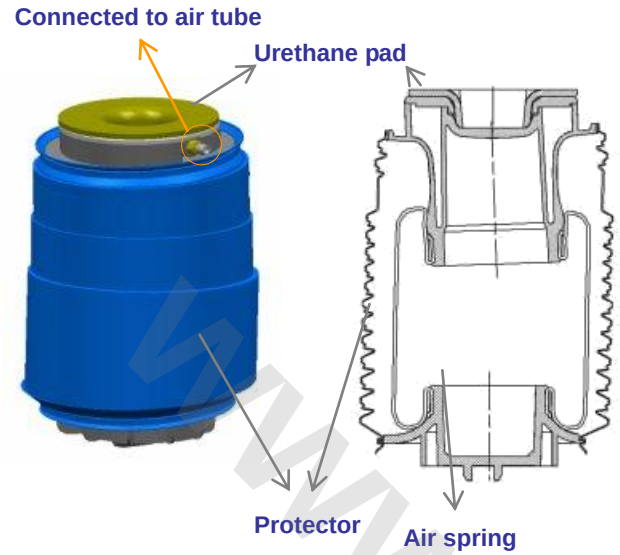
When the front air spring is delivered as service spare part, the air is filled with the pressure of 3 bar. (Therefore, the filling air pressure should be higher than 3 bar to open the inlet valve on the front air spring)

When handle the front air strut, hold the top and lowest portion of the part as shown in the picture below, do not hold the rubber portion then it may damage on the internal components.



فنر بادی عقب

Rear Air spring



- Consists of

  Air spring, Urethane pad to absorb the shock and Protector to isolate the foreign materials.

- Function

  Controls the vehicle height in real time (Air spring)

- Principle – Air spring

  Controls the vehicle height filling or discharging the air via tube.

Rear Air Strut

Because of the design layout, the air spring and the shock absorber (damper) is separated. The average (target) pressure of rear air spring for normal operation is around 8.5 bar.
When the rear air spring is delivered as service spare part, no air is filled so that the intensive care is required to handle. It will be explained more detail in the section of 'Caution of handling'.
Due to the stopper inside of spring, the upper end and lower end do not contact (gap exists around 10mm) each other even if the air is totally discharged.

Take care to handle the rear air spring. Don't pull the air spring intentionally, it may very difficult to restore to the original shape. If it was extended untended, a small amount of air pressure inside spring will help you pushing the spring to the original position.

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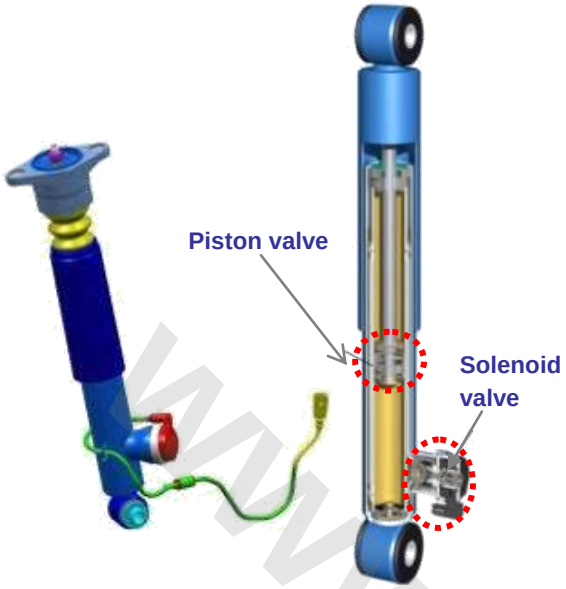
CDC damper



❑ Function

Controls the damping force depending on the road condition (CDC damper)

❑ Principle

A slider inside solenoid valve moves depending on the input current.

Controlling the oil flows the solenoid valve, adjusts the damping force.

CDC Damper

While CDC damping control, 4 corner will be controlled by same damping force (hard, soft). The system controls all required factors which is necessary for all driving conditions such as pitch, roll, ride and sky hook. The solenoid only cannot be replaced, that is the air damper assembly should be replaced if the solenoid valve is failed. The damping force will be the maximum (hard damper), if the current of solenoid valve is not supplied.

Caution:

Be sure that the air spring does not function for the damping control, but only for vehicle level control.

مقایسه سیکل پنوماتیک (باز و بسته)

Comparison of pneumatic circuit

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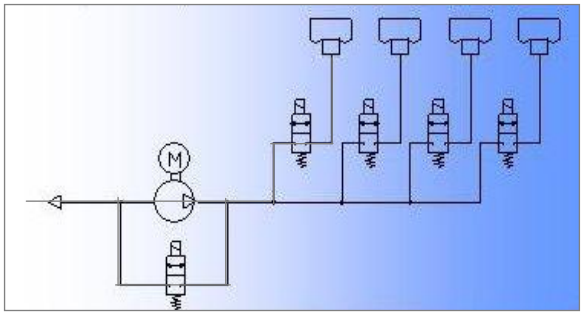
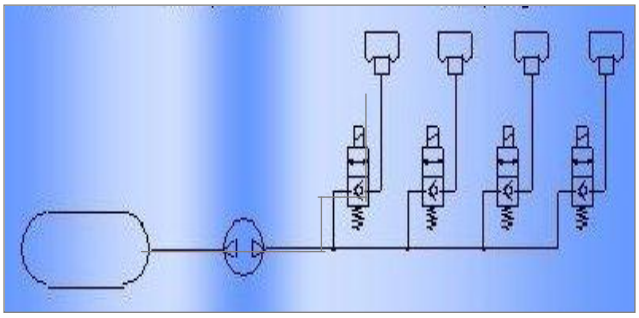


[Open Loop system]

- Intake & Exhaust the air in every cycle
- Use low / high air pressure
- Low leveling control speed
- Low energy efficiency



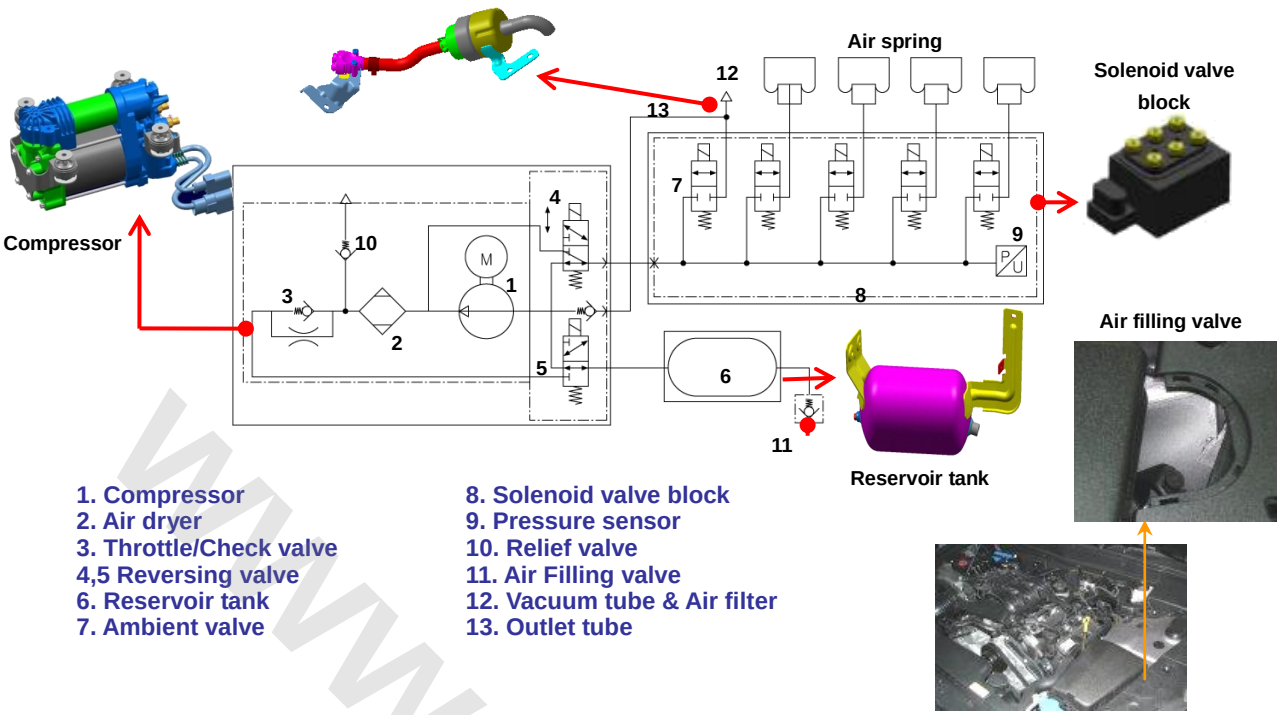
[Closed Loop system]

- Intake & Exhaust the air supplementary (Leakage, etc..)
- Use high pressure
- High leveling control speed
- High energy efficiency
  (Higher than open loop type by 20 ~ 30%)
- Reduced compressor operating time and volume

As it is explained in the section of system layout, the close loop has some merit comparing the existing open loop type applied in Centennial.
In case of open loop type, system intakes the air from atmosphere and compresses it whenever necessary, therefore the system response time (leveling control time) is long. Even Lexus takes several minutes for controlling the vehicle level.
However in case of close loop type, the high pressure is stored in the reservoir tank in ordinary time and used whenever necessary, therefore the response time reduces dramatically. Of course even close loop system also does intake and exhaust for the supplementary filling of air, dryer regeneration accordingly but the actual air amount is very low.

اجزاء سازنده مدار پنوماتیک

Pneumatic components



Pneumatic components

Air filter:

Air filter is a maintenance free (permanent use)

Reservoir (Air tank):

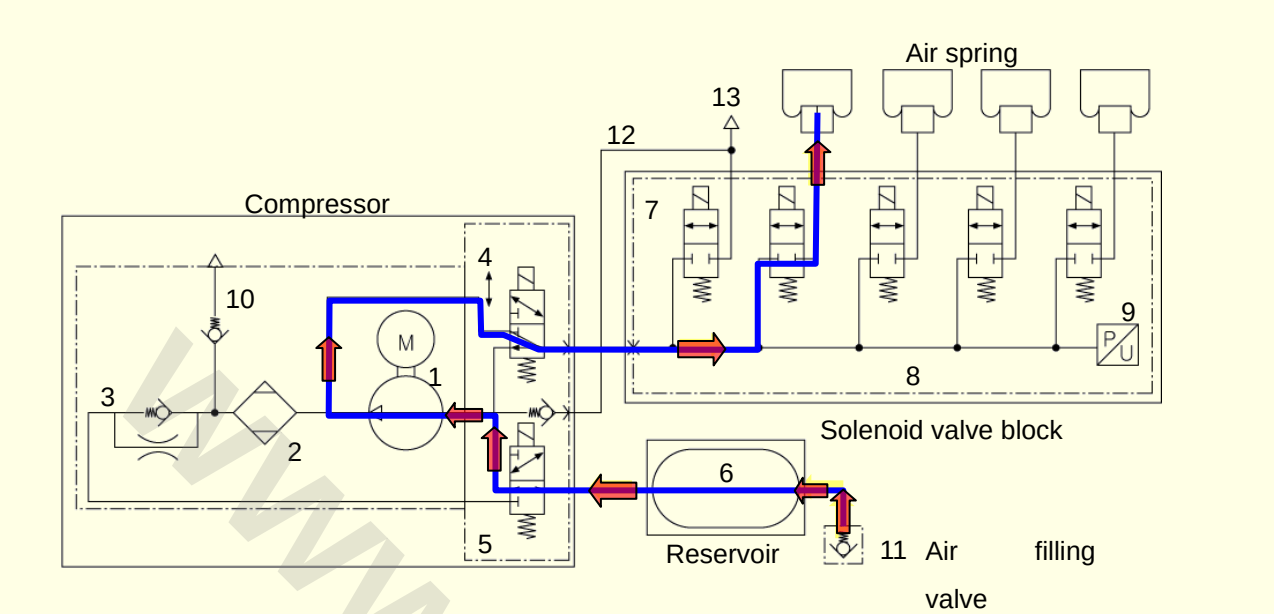
The volume is 5.2 liter and the maximum operation pressure is 16bar. (bursting pressure: 40bar)
The pressure of reservoir tank is monitored every 30 min while driving.

Compressor:

The air dryer and electrical motor are built in the compressor. In addition two solenoid valves (reverse valve) are embedded. Both are normal off with 3-way solenoid valve and the vehicle is lifted or lowered depending on the on, off combination. For example, while lifting, one is off and the other one is off so that both left and right air springs are expanded at the same time.

مدار پنوماتی – سیستم air filling

Pneumatic circuit – System air filling



11. Air filling valve ➔ 6. Reservoir ➔ 5. Reversing valve ➔ 1. Compressor ➔ 4. Reversing valve ➔ 8. Solenoid valve block ➔ Air spring

Pneumatic circuit – System air filling

This job should be done whenever the system components were replaced with new one (except the electrical sensor or control module). Using air filling machine, supply the air to the air filling valve offered in the LH side of engine room. Air will flow to reservoir tank, compressor and will arrive in the air springs.

- Due to the length of air tube and location, at first the front air spring is fulfilled and the rear air spring will be completed later on.
- The vehicle has to be lifted up. (the air spring (rubber) may be bent if the air spring was empty when starts the system filling)
- IG ON and the particular mode in the scanner are required but engine starting is not necessary. (Refer to the section of 'System air filling procedure' for more detail information)
- While the system air filling, the compressor (built in vehicle) does not operate.
- There are two kinds of air filling;

  System air filling: the external air pressure is supplied at the factory or workshop (1 time) The vehicle compressor does not operate. It is not possible to do this filling by vehicle compressor. Because the overload of compressor must be avoided and furthermore the vehicle compressor will not operate if the air pressure (volume) is too low. (less than 80 ~ 120 bar-liter)

  Garage air filling (Supplementary filling): whenever the supplemental air is required in the system, the air is filled by the vehicle compressor.

Depending on the capacity and the pressure of the air filling machine, the whole time to complete differs but mostly it takes around 50 sec.

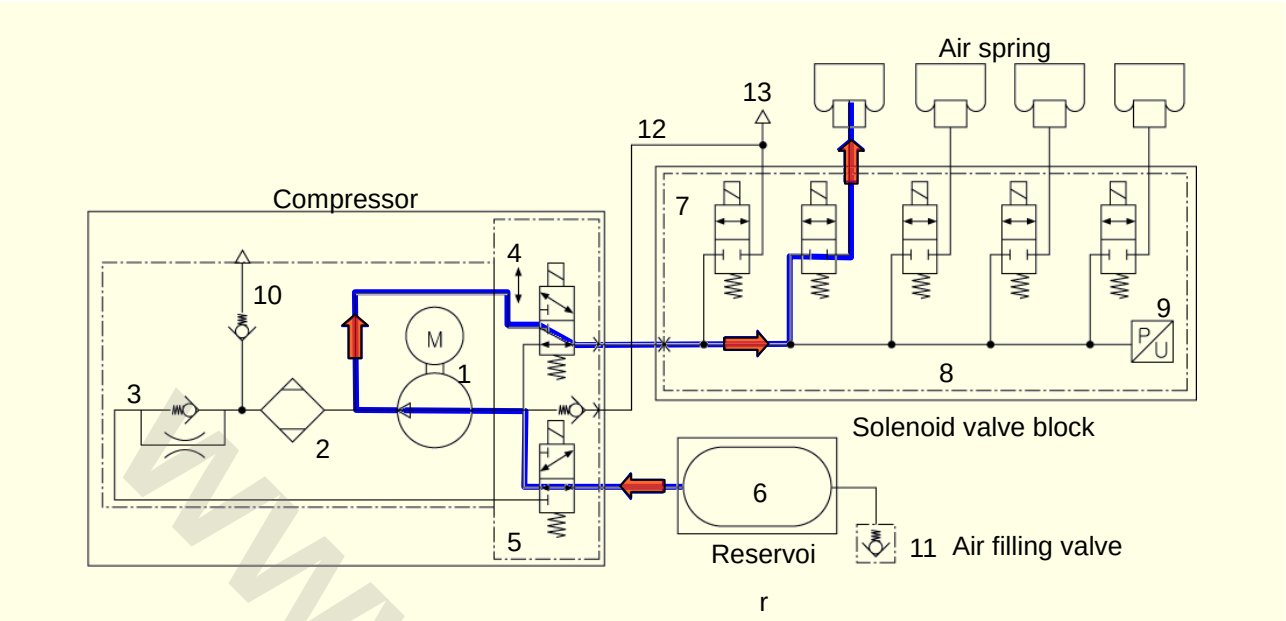
The target air pressure level at each component is;

- Front air spring: around 7.5bar, Rear air spring: around 8.5bar, Reservoir: around 9~10bar.

However, it may change with a little amount in the case of air spring depending on the weight of vehicle (passenger & baggage)

مدار پنوماتیک– بالا رفتن

Pneumatic circuit – Lifting level



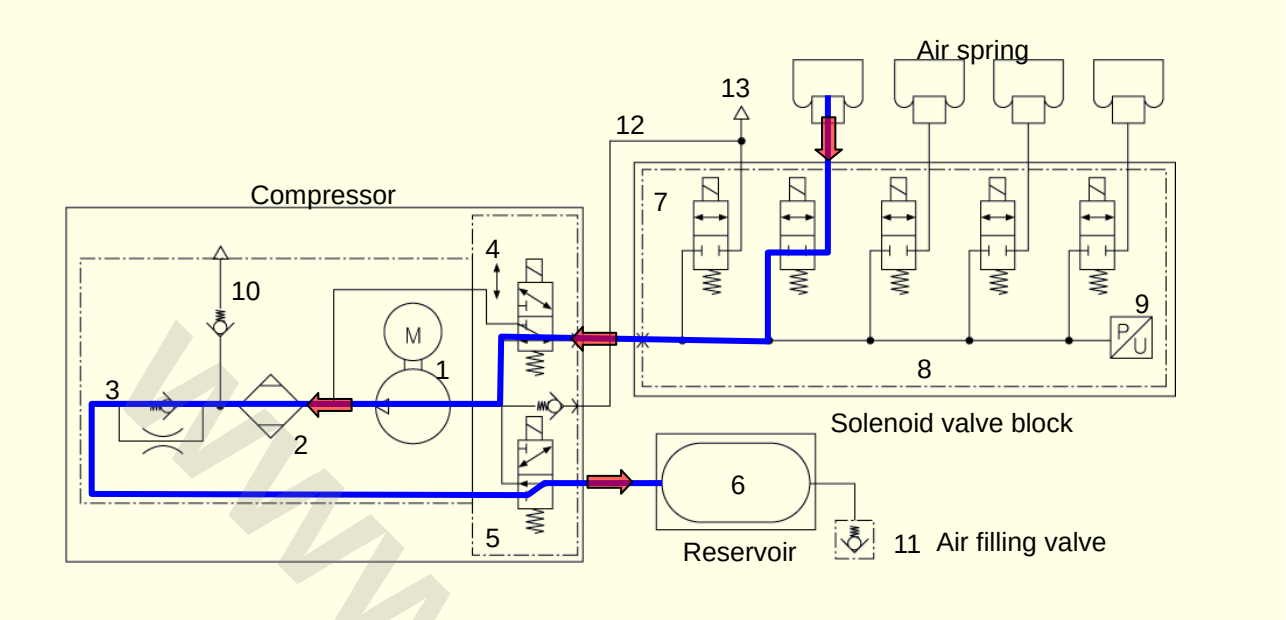
6. Reservoir ➔ 5.Reversing valve ➔ 1. Compressor ➔ 4. Reversing valve ➔ 8. Solenoid valve block ➔ Air spring

Pneumatic circuit

Operating the compressor, the compressed air inside reservoir tank moves to the air spring via solenoid valve block in order to lift up the vehicle height. During lifting mode, the air does not pass the dryer as shown in the picture. The front rear springs are lifted at first and then front springs are followed when lift the vehicle. The reason is to reduce the air resistance while driving and avoid to give an excessive headlamp beam to the driver in opposite direction lane on the road for the safety.

مدار پنوماتیک– پایین رفتن

Pneumatic circuit – Lowering level



Air spring ➔ 4. Reversing valve ➔ 1. Compressor ➔ 2. Air dryer ➔ 3. Check valve ➔ 5. Reversing valve ➔ 6. Reservoir

Pneumatic circuit – Lowering

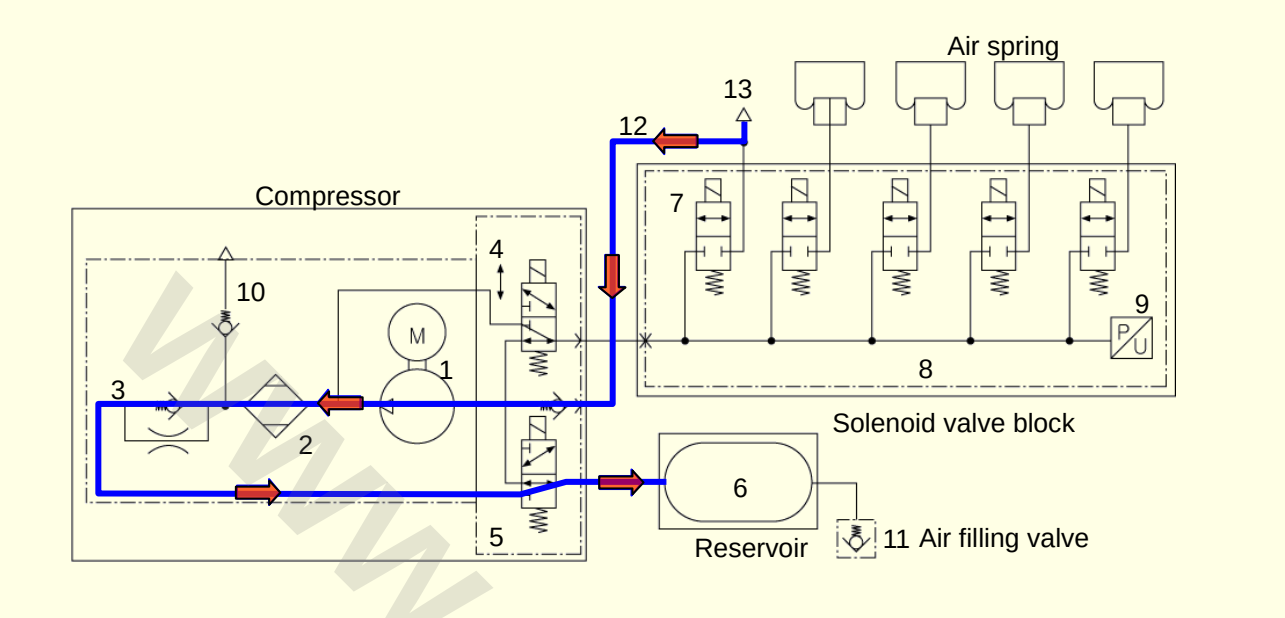
Whenever lowering the vehicle, the dryness is accomplished flowing the air through dryer as shown in the slide. The reverse valve and air spring valves are open so that the compressed air comes out from the air spring. At the same time, the compressor is operated so that the air passes through the dryer in order to store dried air into the reservoir tank. Be sure that even during the process of lowering, the compressor will operate in normal condition (as long as the compressor and compressor relay is normal).

Of course, if the compressor or compressor relay is failed, the lowering (down-leveling) is available by operating the ambient valve (No. 7 in the picture) only like a process of ‘air discharge’ but this is done only in case of emergency condition.

For example, the vehicle is running with high level and the compressor (or relay) failure is detected, if the vehicle speed is higher than 70kph for 10sec or more, the vehicle height should be lowered to normal level by ambient valve for the safety and lower fuel consumption.

مدار پنوماتیک – تزریق فشار هوا

Pneumatic circuit – Air filling (Supplementary)



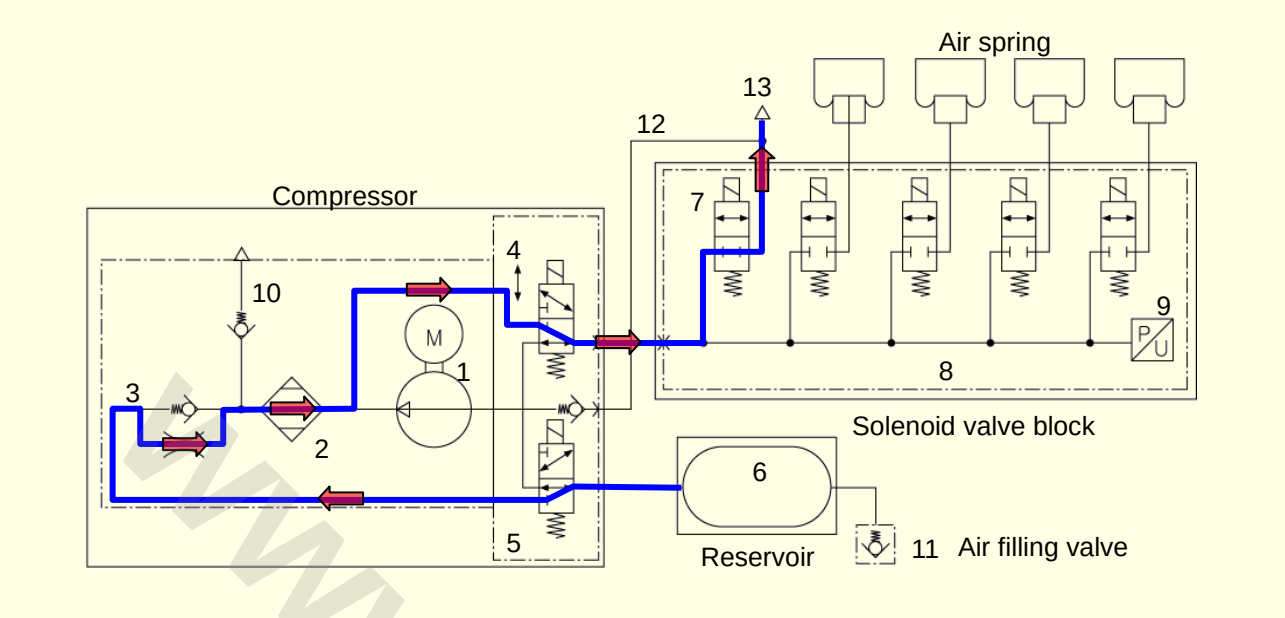
13. Air filter ➔ 1. Compressor ➔ 2. Air Dryer
➔ 3. Check valve ➔ 5. Reversing valve ➔ 6. Reservoir

Pneumatic circuit

If the air mass inside the system is less than 93 bar-liter (refer to the concept of ‘bar-liter’ in the last slide in this syllabus), the air is added by the compressor in the vehicle. At this time the air passes through the dryer as shown in the picture so that the dry air can be supplied into the system. Mostly this may happen in case of long time parking.

مدار پنوماتیک – خالی کردن هوا از مدار

Pneumatic circuit – Air discharge (dryness)



6. Reservoir ➔ 5. Reversing valve ➔ 3. Throttle ➔ 2. Air dryer ➔ 4. Reversing valve ➔ 7. Ambient valve ➔ 13. Air filter

Pneumatic circuit – Air discharge (dryness)

The purpose of doing air discharge is only to regenerate the air dryer built in the compressor. The discharged air amount is very small.

The independent logic to perform air discharge is implemented to decide the regeneration period based on the following factors. (not performed every ignition cycle)

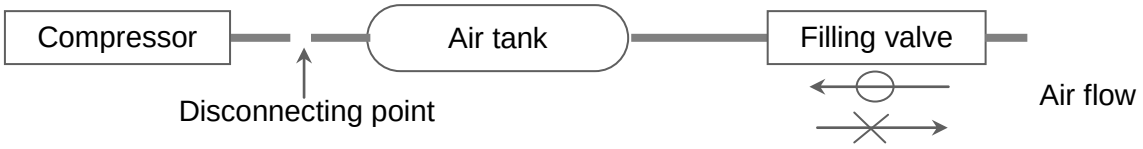
- Air pressure sensor (built in the compressor) signal
- Height sensor signal
- Engine room temperature

Not only for dryer regeneration but also for other reason, sometimes it is necessary to discharge the air from the system. Scanner offers the ‘Air discharge mode’ to cope with this time, and just enter to the above mode and perform the air discharge. Sometimes, air discharging is required to inspect the noise from the rear chassis frame or front suspension. Scanner will control the reverse valve and five solenoid valves in the solenoid block in order to discharge the air electrically.

Be sure that this menu in the scanner does not offer the discharge of air in the reservoir tank as follows.

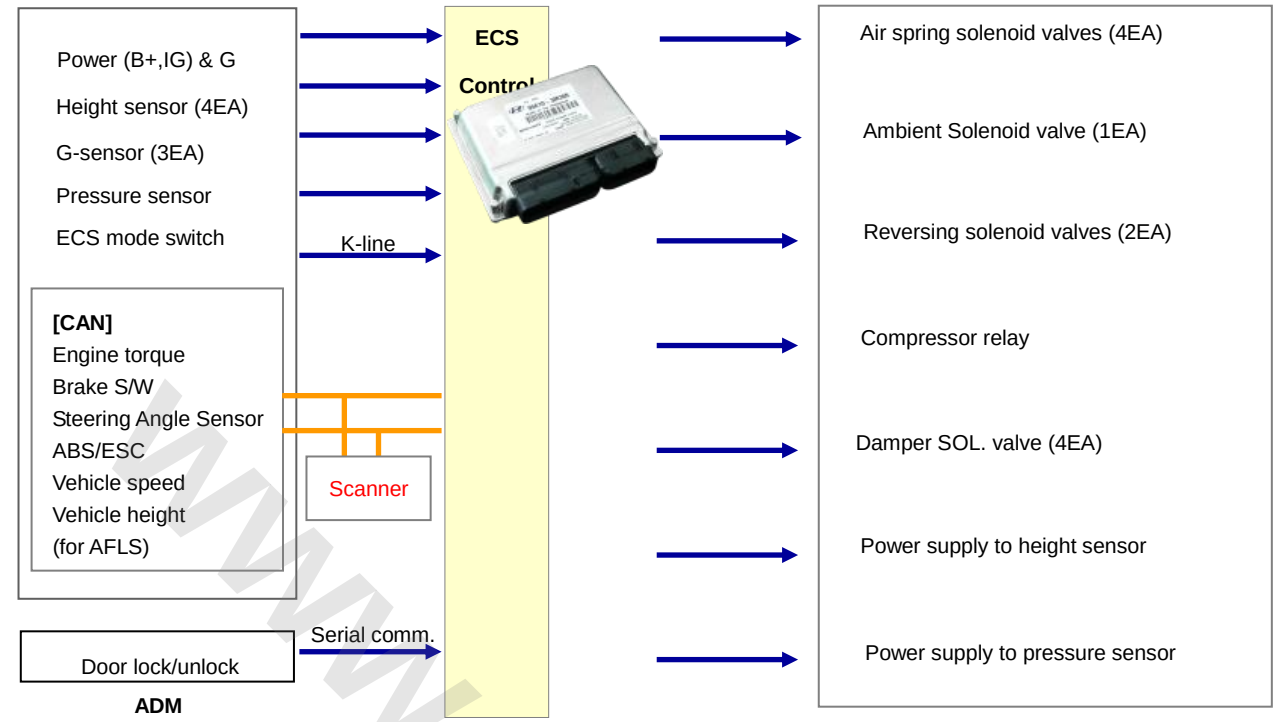
1) From air filter to solenoid valve block (mostly air in the air springs):
   the air in this area can be discharged by the scanner (electrically)
2) Air in the reservoir cannot be discharged by electrical driving of solenoid valve in the scanner. Instead, you can disconnect the air tube between the compressor and reservoir tank manually. Then only the air in the tank will be discharged as long as the air in the air springs are clogged by the solenoid valves. This means that the vehicle will not be rapidly lowered even if the mentioned tube is disconnected. However, disconnect the tube gently because the air will

come out rapidly.



ورود و خروج اطلاعات به ECS

Inputs & Outputs



* ADM: Assistant door module

Door Lock / Unlock signal from ADM:

- This signal is used to shift the ECS mode such as ‘Sleep mode’ and ‘Wake-up’ & ‘Pre-run mode’. This signal is sent to ECS via not CAN but the independent serial communication line as shown in the picture.

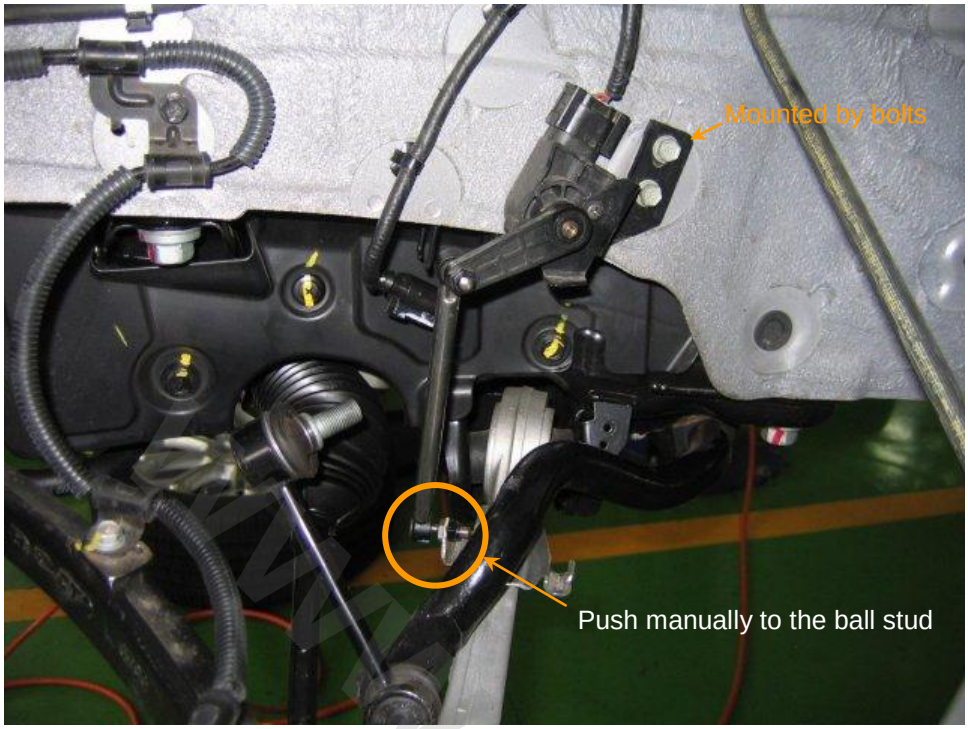
Height Sensor

- Height sensor detects not only the vehicle height but also vehicle bouncing acceleration, so that it is also used for CDC damping control as well as air spring control. Therefore, if height sensor is failed, CDC current is fixed by 600mA for the failsafe.
- The height sensor values are shared with AFLS control module via CAN.

CAN signals

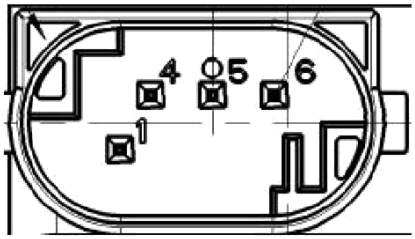
- If CAN bus off or CAN timeout is detected in the system, the vehicle level will be shifted to normal level immediately and the manual or automatic level control at normal level will not be available anymore. And the CDC damper is controlled by zero ampere so that the damping feeling will be hard.

Height sensor



Height Sensor (Front side)

[Connector layout]



PIN	Description
1	GND
4	Not used
5	+5V
6	PWM signal

Function

- Detects the level (for vehicle level control) and the bouncing acceleration (for damping force control).

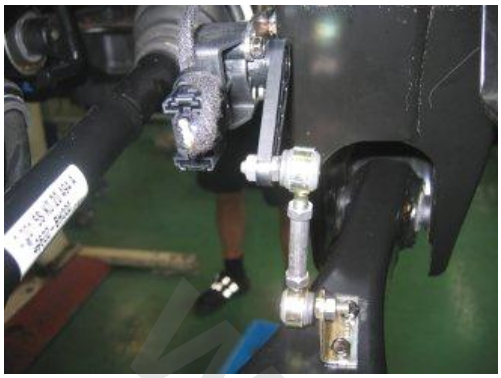
Applying Hall IC, it detects the level and the bouncing acceleration of vehicle. Installed at each suspension(4EA). Even if the sensor bracket is different, 4 sensors in each corner can be interchangeable. Receiving these values, control module controls not only vehicle level but also damping force for the CDC damper. This signal is the main for vehicle level control.

Refer to the followings for the specification of height sensor.

- Sensor power: 5V
- PWM frequency: 800Hz
- Range: 5% (-54°) ~ 95% (+54°)

While service for this sensor, any shock should be avoided. Especially inspect that any foreign

materials are attaching on the sensor body because the rod portion of sensor rotates in relation to the vehicle body as shown in the picture.



Height sensor attached on rear axle

Height sensor signal

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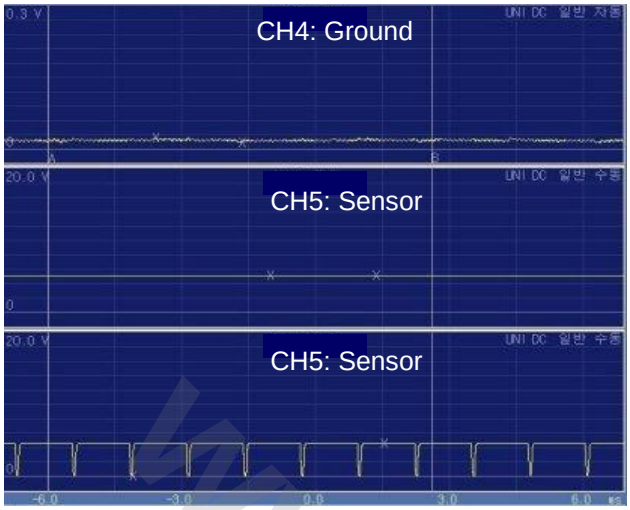
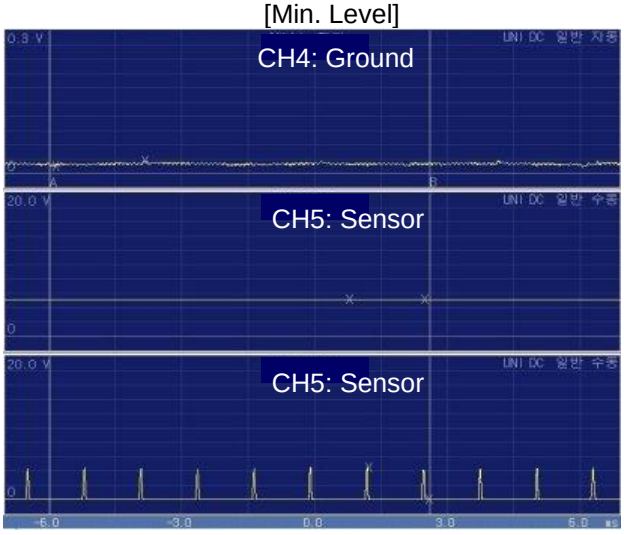


[Max. Level]

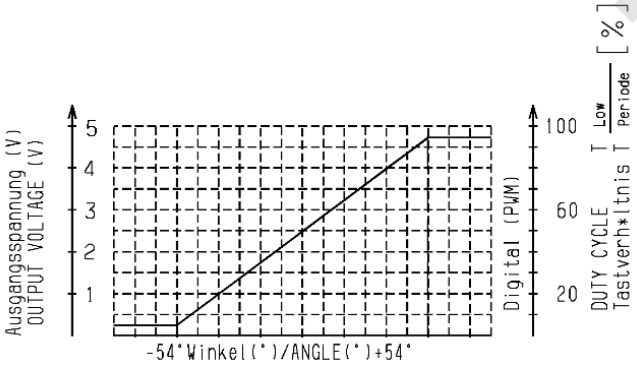
Duty(-): 6%
Frequency: 783Hz
Max.: 4.63V
Min.: 0.06V

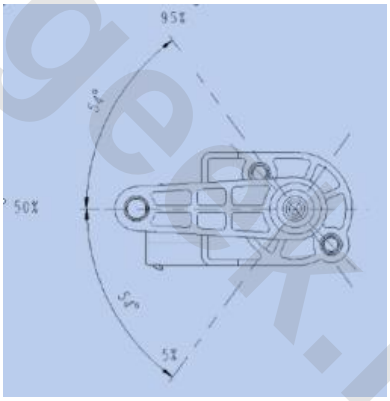
Duty(-): 97%
Frequency: 785Hz
Max.: 4.49V
Min.: 0.06V

[Min. Level]



As shown in the picture, it outputs PWM duty waveform for each level. Total 120 degree (maximum capable angle allowed in this sensor) is divided into 256 detection ranges and it outputs ‘128’ in the scanner in case of 0 mm level (design height).





Applying the bracket for front and rear side, it offers full-proof to avoid wrong installation of sensor to the vehicle body.

If a height sensor is failed, vehicle level is controlled based on the data from the other 3 sensors. If two sensors are failed, vehicle level control will stop. For more detail features for failsafe of height sensor, please refer to the section of ‘Air spring failsafe’ in this slide

کالیبره کردن Height sensor

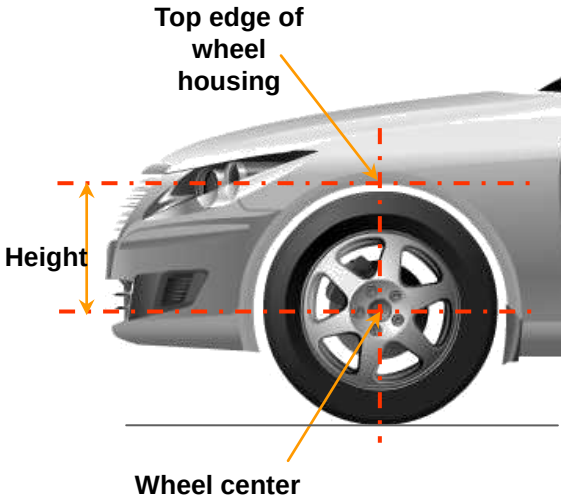
Height sensor calibration

❑ Height sensor calibration

- When? ☞After air filling, height sensor or ECS control module replaced.

❑ Calibration procedure

- IG ON (engine off or on) and keep 'Normal level'.
- Measure the height described in the right side picture.
- Input the measured value to the scanner.
  ※Order: FL, FR, RL, RR
- After calibration, confirm that the value is within the specification measuring the height again.

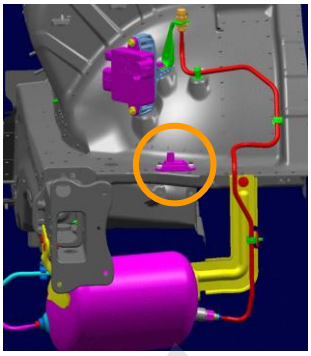


After filling the air, the actual vehicle level has to be renewed into ECS control module for more accurate control as well as after height sensor or control module replacement.
Just follow the procedure in below.

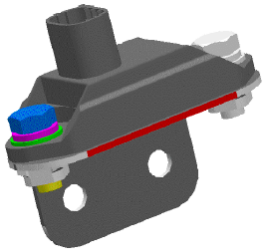
1) IG ON (engine running or stall doesn't matter). Keep the 'Normal level'.
   - Avoid doing on the lifter ! It should be done on the ground.
2) Connect the scanner and move to the relevant menu.
3) Follow the instruction and order (FL, FR…) in the scanner.
4) Measure the height using the tape ruler described in the slide and input the value in the scanner.
5) After calibration, measure again the height is within the specification or not.
   Front: 394±5mm, Rear: 387±5mm.

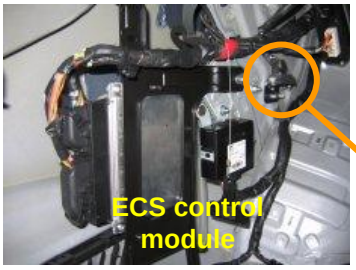
After completing this calibration, the memorized data is stored in ROM so that the height value will not be erased even if the vehicle battery is removed. If the height sensor calibration is not completed, DTC (C1620) is stored and warning lamp turns on. However, the air spring control and CDC damping control is available.
In case of replacement of ECS control module, the variant coding also is required. That is, the variant code should be done in advance to calibrate the height sensor.

G-sensor



G-sensor (FL)





Inside trunk

❑ Function
- It detects the bouncing acceleration of vehicle and installed at the front area (2EA) and rear area (1EA).

- Receiving G-sensor output value, control module controls the solenoid valve in the CDC damper.

Because this sensor signal is a main input for the CDC damping control, it is referred to as CDC sensor. The sensor power supply is 5V and output from 0.5 to 4.5V under normal driving condition. In case of vehicle stationary, it outputs 2.5V.
Totally 3 sensors are installed, one for rear left side (inside of trunk, nearby ECS control module) and other two sensors are for front side (left and right accordingly).
There is no other particular reason except for lower cost to have only one sensor in case of rear side. However, in case of front side, much more changes occurs comparing with the rear side so that two independent sensors are required. Three sensors have same part number so that it is interchangeable each other.

Failsafe for G-Sensor:
As it is explained this sensor is only for CDC damping control and there is no relation for air spring control. Therefore, if this sensor has a problem (any possible failures such as electrical short, open, invalid signal and out of range), the CDC damper will be controlled by fixing value of 600mA current flows in damper solenoid valve. As it is learned previously, the current flows in the damper solenoid valve varies from zero to 1.6A, therefore, 600mA means that the amount of stiffness of damper will be around half. However, don't forget that the air spring is operated normally even if G-sensor is failed.

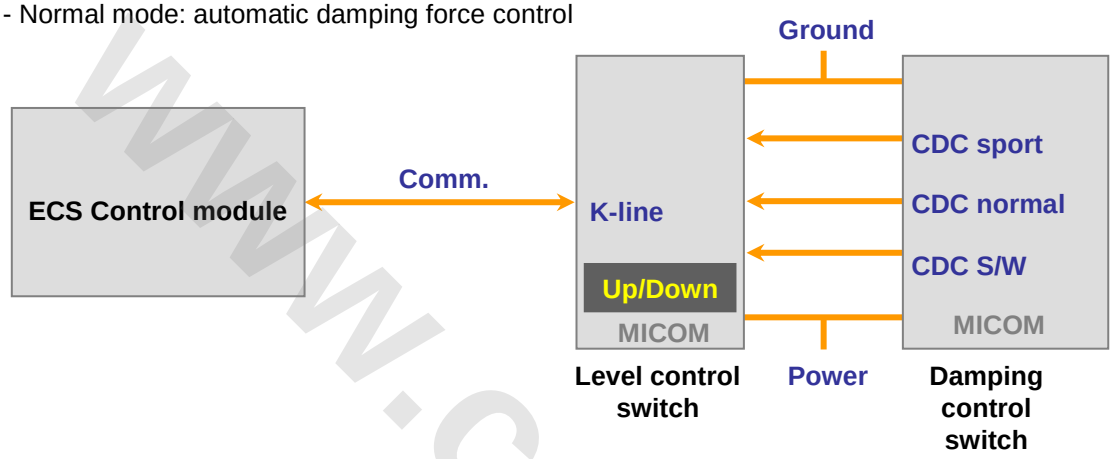
ECS switch

❑ Level control switch

- Manual Up: Normal → High
- Manual Down: High → Normal

❑ Damping control switch

- Sport mode: high damping force (hard)
- Normal mode: automatic damping force control



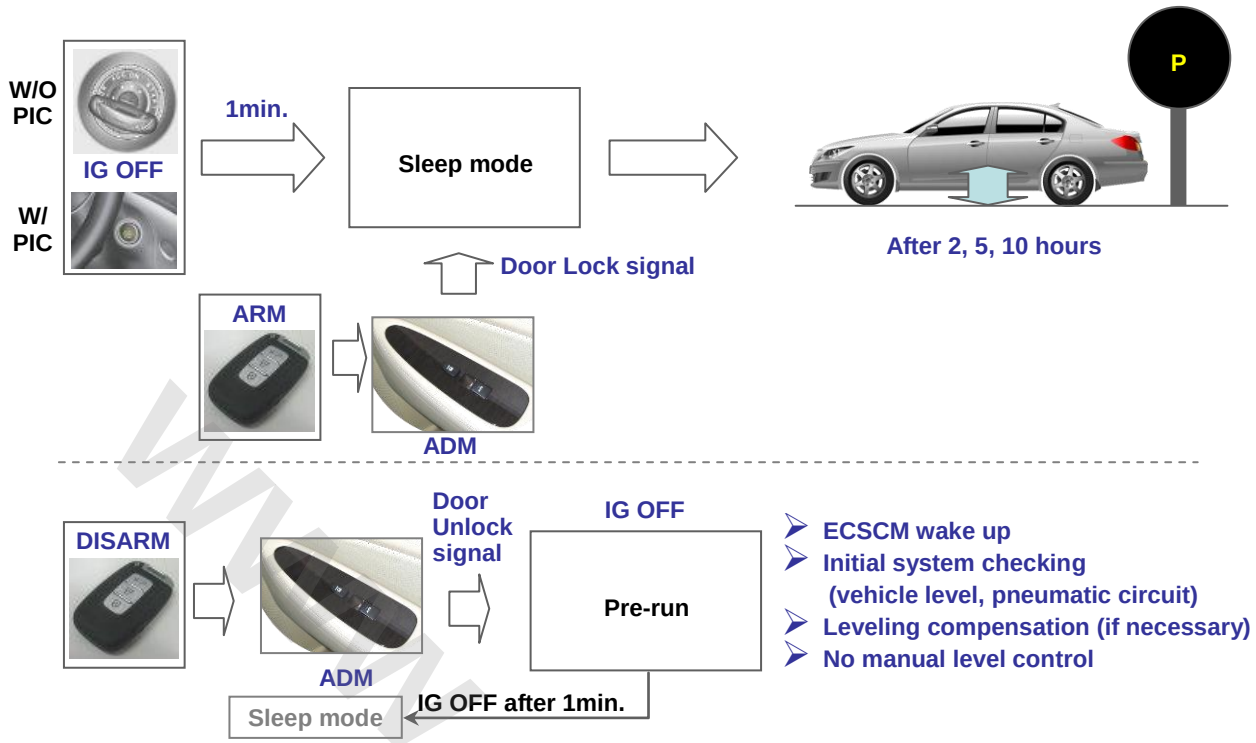
Two manual switches are applied in ECS switch. One is ‘level control switch’ in order to change the vehicle level manually. Be sure that there is particular condition to perform the level change successfully. As the high level is selected, the lamp will turn on.

The other one is ‘damping control switch’ in order to select the feeling of shock absorber. If sport mode is selected (lamp turns on), the current flows to the solenoid valves will be around 300-1,000mA so that the shock absorber feeling will be hard.
Oppositely, in case of normal mode (lamp turns off), the current in the solenoid valves is controlled by 800-1,600mA depending on the G-sensor and height sensor signals (road condition).

This switch assembly has a MICOM so that it communicates with ECS control module via K-line as shown in the picture and it is referred to as HMI (Human Machine Interface). All signals including of vehicle level request, CDC damper mode selection will be processed inside switch and will be sent to control module. If ‘K-line’ communication is failed or HMI has a electrical problem such as missing signal or internal error, only manual operation (level control manually, soft/hard control manually) will not be available but other automatic controls are activated normally. The warning lamp does not turn on but corresponding DTC will be stored.

حالت sleep modeو پیش حرکت

Sleep mode & Pre-run mode



Sleep mode:

The control module has a low power consumption (less than 1mA). In this mode no manual level control is possible. The sleep mode will be quit, when the ECM recognizes a change on the ECM wake up status or when the ignition is switched on.

The ECM returns to sleep mode with a delay time (1min) after ignition is switched off. If the vehicle is armed by RKE, sleep mode will start immediately without time delay.

Under sleep mode (mostly while parking), the vehicle level is monitored and compensated automatically by ECS control module up to 3times (after 2, 5, 10hours)

However, the compressor will not be operated if the battery voltage is lower than 10V.

Pre-run mode:

As the vehicle is disarmed, it wakes up the control module and Pre-run mode starts. Pre-run mode lasts for 1min after wake up. While Pre-run mode, the system is initially checked including of pneumatic circuit and the vehicle level is automatically adjusted if necessary. (That is, if the passengers or baggage are heavy weighed, the vehicle level may be compensated automatically even if the ignition switch is off ; while driver is preparing to start)

Don't forget that the manual level change is not allowed in this mode.

However, if the ignition switch still stays in off position after 1min, it will shift into 'Sleep mode'.

Oppositely, as soon as the ignition switch is on, the mode shifts into 'Stand 1'.

Vehicle on the lifter

Fully rebounded wheels on the lifter

Lifting-Platform mode:

For the vehicle to be lifted from normal level to high level, there is only one way; to push ECS button when vehicle speed is lower than 70kph. But what will happen if the vehicle is lifted up by external force without input of ECS switch ? For example, usually when the vehicle is lifted on the lifter, the vehicle level is rapidly increased without pushing of button.

At this time, ECSCM will neglect all the conditions of vehicle level down (70kph, 10s) and try to lower the vehicle discharging the air from the front two air springs. Even if the air comes out from the air springs, the vehicle level is not changed (no change of height sensor value) so that ECS control module will stop the air discharging considering the special vehicle condition. This is referred to as ‘Lifting-Platform Mode’. Under this mode, the manual level control is not available.

As the vehicle lift down and touch on the ground, the vehicle level will be minimum (full rebound) because the air in the front springs already discharged on the lifter, but it will be restored to normal level by control module upon ignition switch ON ◊ OFF or vehicle speed is higher than 10kph for 5sec or more or manual request by switch.

In case of tire replacement at the workshop:

In order to replace the tire, mostly lifter will be used. The best way is that turn the ignition switch off and wait for 1min. Then system will shift into ‘Sleep mode’ automatically so that the wheel does not be rebounded (by system) even if the vehicle is lifted up by lifter. Because, under sleep mode, system will try first adjustment of the vehicle level after 2 hours enough to replace whole tires.

Summary:

Even though we have a lifting platform mode, it may affect to the lifetime of compressor because of unnecessary operation. Therefore we recommend that;

1) To lift up the vehicle, turn ignition key off and lift it after 60 seconds.

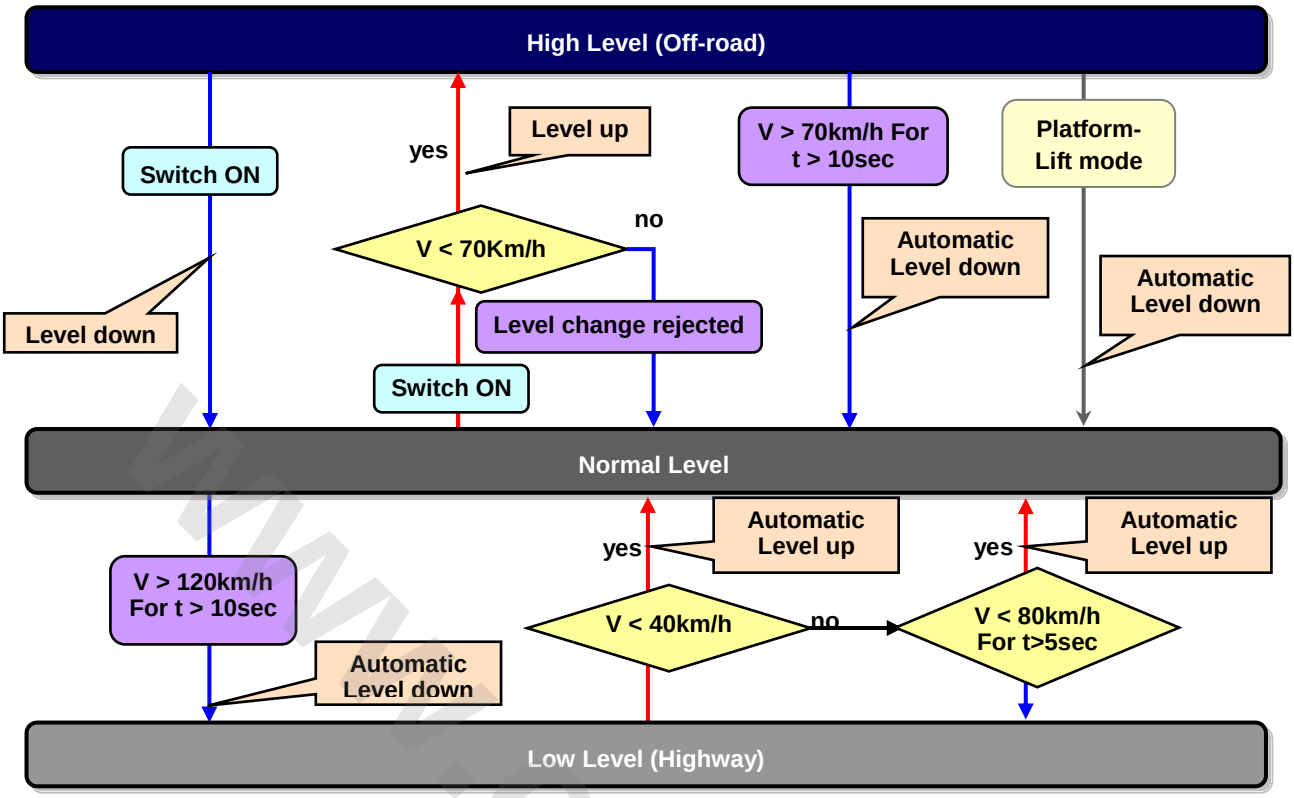
→ Do your job under sleep mode.

2) If you have to lift the vehicle for more than 2 hours (2HR: this is the FIRST timing of level compensation under sleep mode),

→ Remove the fuse of ECS control module or compressor relay.

نحوه تنظیم ارتفاع

Leveling control logic



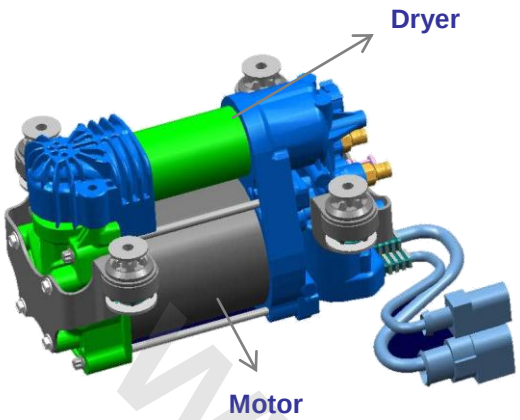
Leveling control logic:

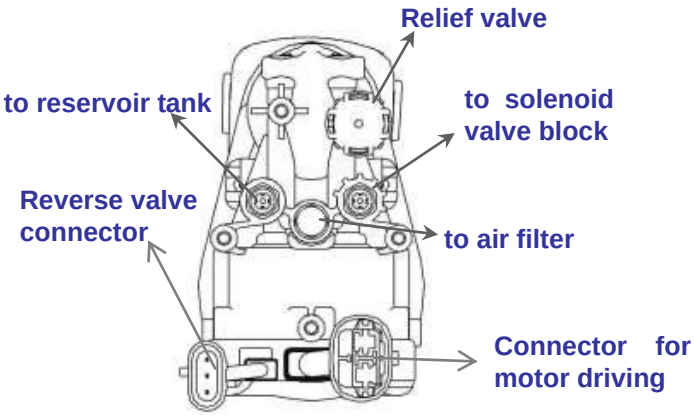
The shown diagram is to explain the overall level control (both manual and automatic) accomplished by air spring. Be sure that the manual operation to low mode is not available as shown in the picture.

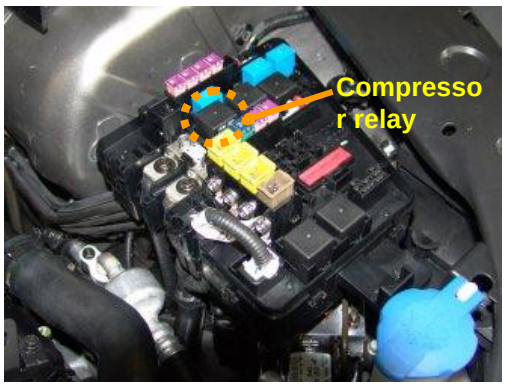
For details, please refer to the section of ‘Leveling control’ in this slide.

کمپرسور

Compressor







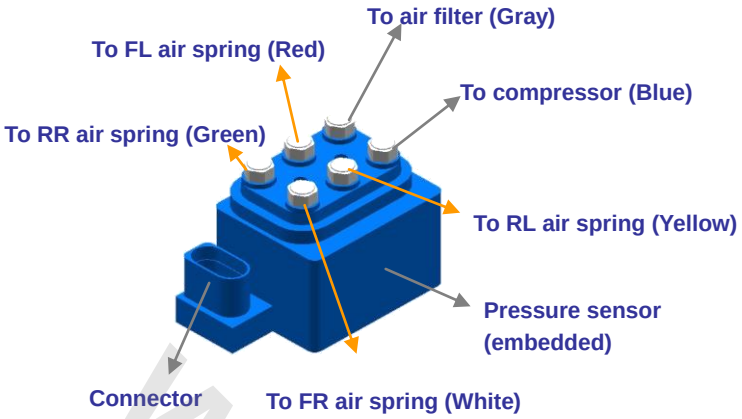
- Components: Motor, Dryer
- Function:
  - Compresses the air in the system
  - Transfers the air
  - Perform the air dryness using the dryer

The compressor operates in all events except the system air filling and two solenoid valves (referred to as reverse valve, on-off control, normal open) are embedded.
Air dryer is maintenance free (permanent use)
The relief valve opens upon the pressure of 20±3bar.
The compressor relay is monitored by control module in order to detect any failure in relay. If the compressor relay is failed (short to battery, short to ground or open circuit), the lifting is prohibited but down leveling is only available. However, the down leveling is done not by compressor but ambient valve.

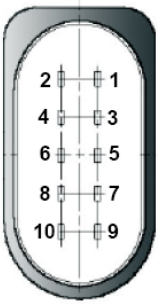
In case of compressor overheating: temperature is higher than 140℃ for more than 10 sec.
→ Level control is prohibited.

بلوک شیر سلونوئید

Solenoid valve block



Connector layout

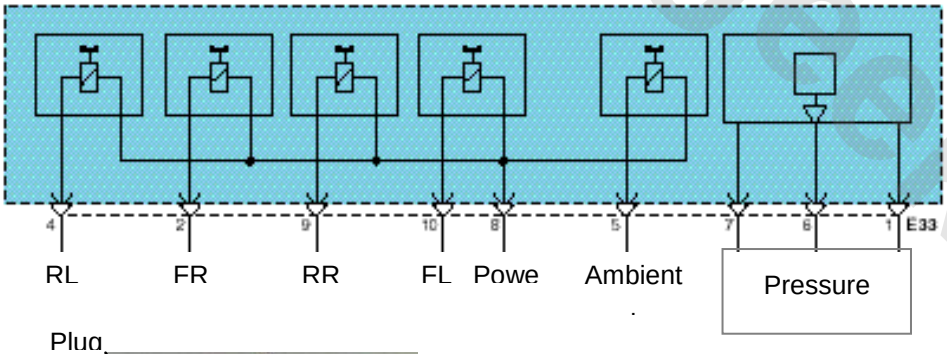


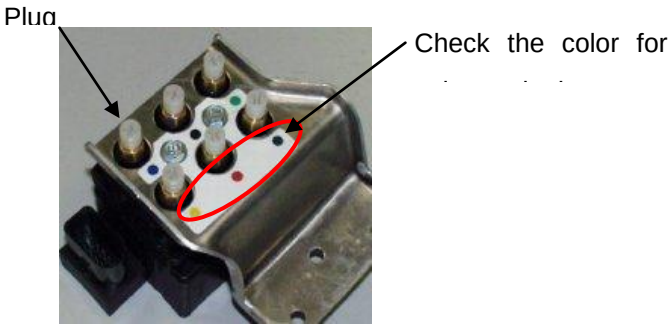
1. FL air spring SOL.
2. Ambient valve
3. RR air spring SOL.
4. RL air spring SOL.
5. Solenoid valve power
6. Solenoid valve power
7. Pressure sensor ground
8. FR air spring SOL.
9. Pressure sensor output
10. Pressure sensor power

- Components
  5 solenoid valves, Pressure sensor, Air port
- Function
  Air port open and close depending on the solenoid valve operation.

Four air spring solenoid valves (‘-’ control) and one ambient solenoid valve are embedded inside this solenoid valve block as shown in the circuit diagram below. When connecting the air tube to the solenoid valve block, carefully check the color dot which is marked on the valve and tube so that all colors should be matched each other.

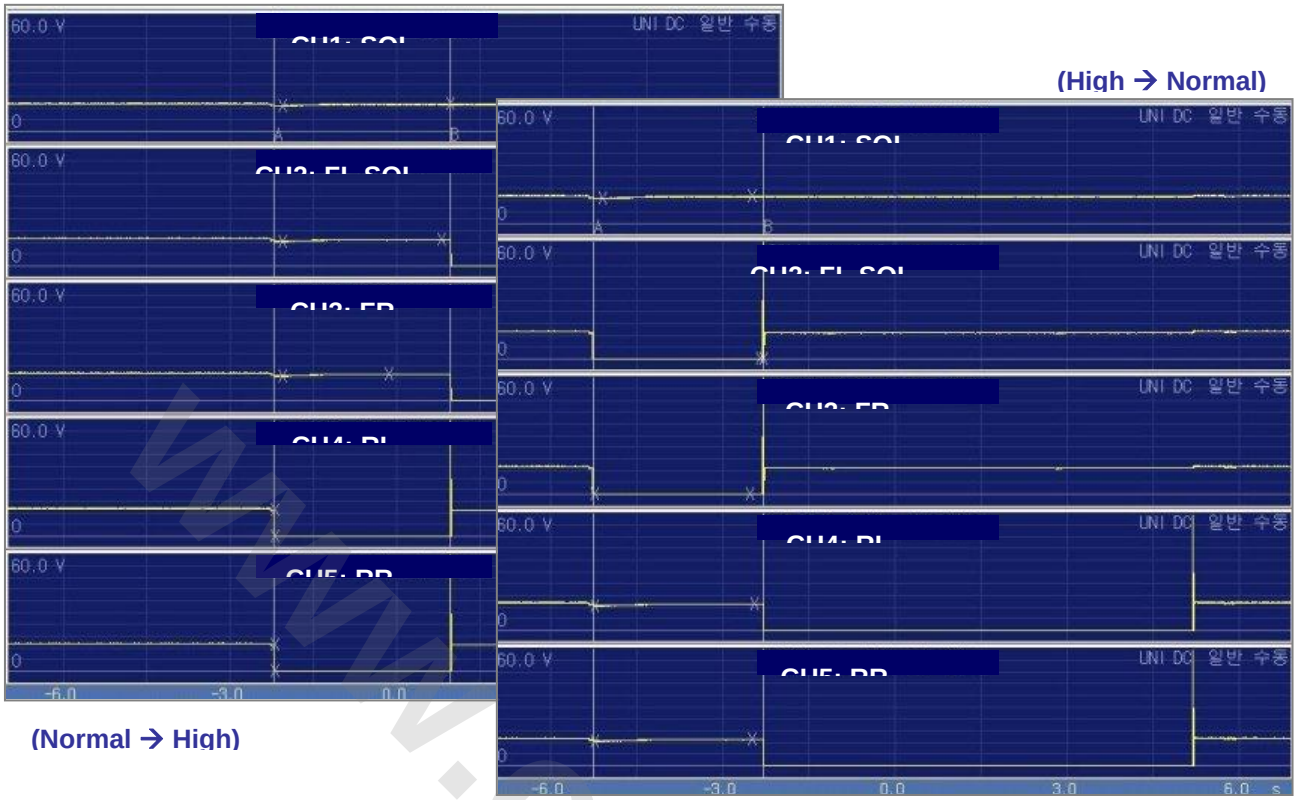
The pressure sensor is built in the solenoid valve block so that it detects the internal pressure when lifting or lowering the vehicle height. Also it senses the pressure of reservoir tank every 30 minutes when the vehicle is running.





If the pressure sensor is failed (lower than 0.2V or higher than 4.8V or no signal for more than 12times), the lifting control is prohibited but the down leveling only is available.

Solenoid valve operation



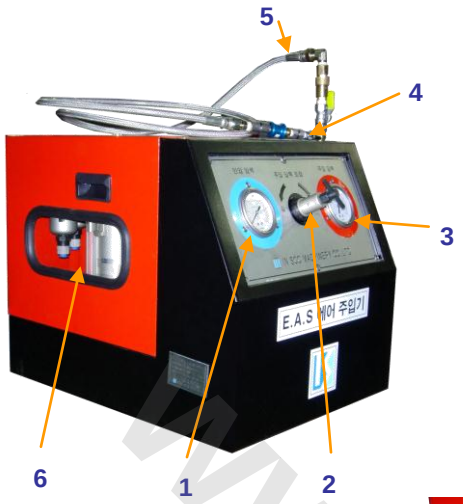
Normal level ◊ High level:

As it is explained previously, during lifting process the rear side air springs are expanded at first and then front side air springs are expanded later on. Therefore, RL and RR solenoid valves are grounded firstly ('-' control type) for around 3sec at the same time and then FL and FR solenoid valves are grounded accordingly. In case of front side, it starts as soon as the rear side is completed and it takes around 2sec as shown in the waveform.

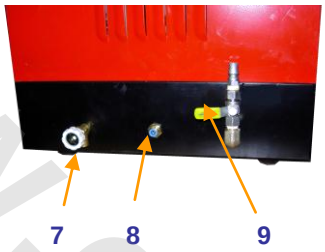
High level ◊ Normal level:

Oppositely, during down-leveling process the front side air springs are expanded at first and then rear side air springs are expanded later on. Therefore, FL and FR solenoid valves are grounded firstly ('-' control type) for around 3sec at the same time and then RL and RR solenoid valves are grounded accordingly. In case of rear side, it starts as soon as the front side is completed and it takes around 7~8sec as shown in the waveform. Comparing with the lifting, the lowering is done mostly under the high vehicle speed so that more careful and slow motion is required to complete the lowering of vehicle level.

System air filling machine



- **Pressure gauge (inlet): around 5~8bar**
- **Pressure adjusting handle (set to 12bar)**
- **Pressure gauge (outlet)**
- **Filling nozzle: connected to the filling valve of vehicle**
- **Filling hose**
- **Air filter**
- **Air tank drain valve**
- **Water outlet (filtered water is automatically drained)**
- **Inlet nozzle: connected to the air supply line in workshop**



This machine is used to fill the system air at the factory or workshop, that is used to do a system air filling by externally. It receives the air from the supply line (5bar) at the factory or workshop and compressed the air into 12bar in order to fill the system line in the vehicle.

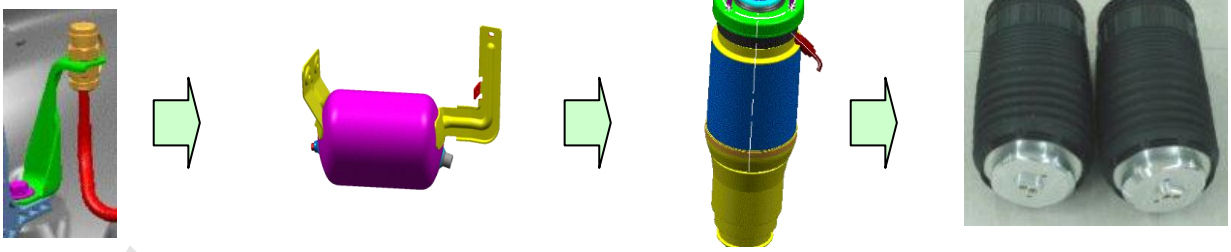
◊ There is no electrical motor and switch for driving the compressor on this machine. The air is compressed by the energy of compressed air (5~8bar) from the air line in workshop.

As the air is supplied to the machine, it starts to compress air automatically with operating noise and it stops automatically until the pressure reaches 12bar (if the pressure adjusting handle is set to 12bar). After that connect the outlet nozzle to the vehicle side then the compressed air will be transferred to the vehicle naturally.

In system air filling procedure, the dry condition of air must be strictly kept, because water in the air will affect the control parameter and result in the poor performance. Furthermore, it may give a damage to the compressor if it frozen in winter. For this reason, the dryer and filter are built in the machine.

System air filling procedure

Filling route



Filling valve | Reservoir | Front air spring | Rear air spring

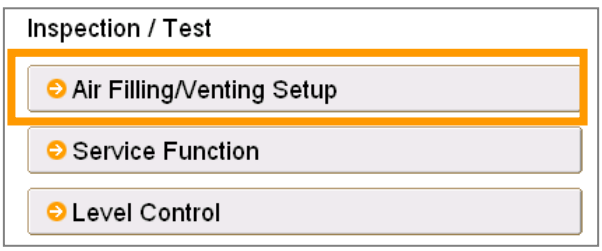
❑ System air filling condition

- The vehicle must be lifted up.
- External air supply pressure (from machine): **12 ± 2 Bar**

System air filling is done at the factory before delivering the vehicle. In case of workshop, it should be done after replacing the related parts or the system air was drained because of other repairing works. Follow the recommended procedure for system air filling.

1) Prepare the compressed air (12bar) using the air filling machine. (refer to the section of 'system air filling machine')
2) Connect the air outlet nozzle in the machine to the air filling valve (RH side of engine room) in the vehicle.
3) Ignition ON (engine off) and connect the scanner.
4) Lift up the vehicle (all wheels must be rebounded)
5) Opening the lever in the machine, starts to fill the air from filling machine to the reservoir tank in the vehicle until the whistle sound stops.
6) Enter the menu of system air filling in the scanner and follow the instruction in the scanner. The compressed air will be transferred to the front air spring and rear air spring accordingly by operating the compressor and solenoid valves.
7) Take down the vehicle after completing the air filling.

It will take around 40~60 seconds to complete this job.

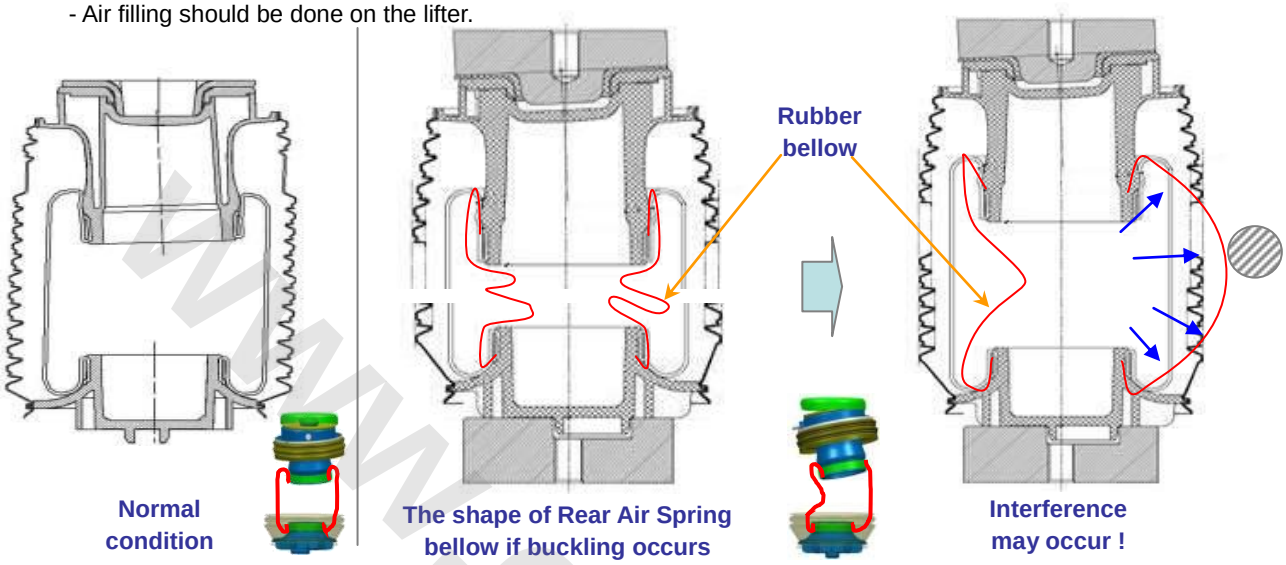


Cautions of handling

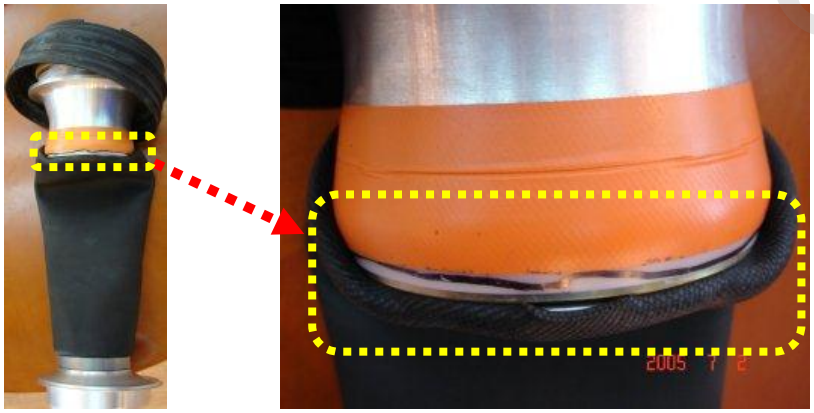
❑ When vehicle is on the ground with fully rebounded wheels.

▸ Cautions for system air filling

- Air filling should be done on the lifter.



If the air is filled when the wheels are fully compressed on the ground, the air spring may be subject to buckling phenomenon as shown in the picture. Therefore it is strongly recommended to use a lifter when fill the air into the ECS system. If it was buckled accidentally, the air spring has to be removed from the vehicle and the buckled rubber bellow should be abstracted manually as well as the inspection of exterior damage on the rubber bellow, but it is not so easy.
Furthermore, buckling may result the third problem as shown in the picture below.



The upper clamping portion of bellows in rear air spring due to the buckling.

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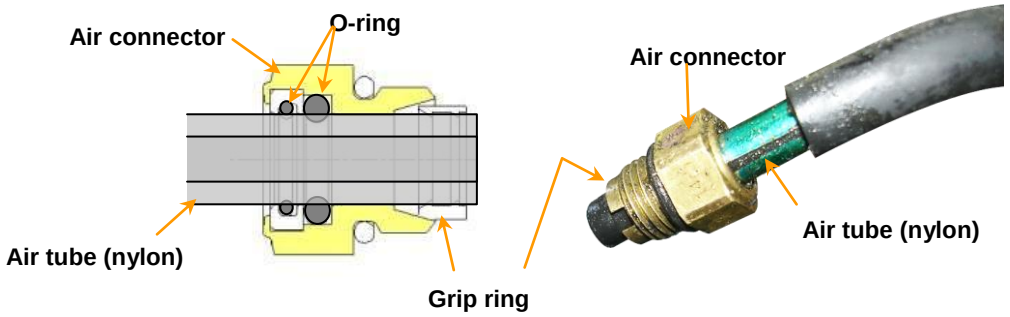
Air tube connection



- It is possible to disconnect the air connector that the tube is connected by rotating the air connector counter clockwise. The air connector will rotate freely due to the O-ring and grip ring.
- Pushing the air tube toward inside, make the grip ring protruded and then expand the grip ring in order to remove the tube from the air connector.

The air connector should not be reused.

- If the end of air tube was damaged, it can be repaired cutting the end of tube by 3mm. At this time, nylon tube must be cut off square. A saw may not be used for this purpose as the possible formation of burrs will affect the sealing capability of connection. For cutting nylon tubing to the correct length, the special cutting pliers which ensure that the tubing is cut squarely and cleanly as shown in the picture. (however, it is not listed in the official SST for BH)
- When tighten the air connector, excessive torque may result in the damage of housing so that tighten by hand carefully. (Torque: about 2.0Nm +/-0.5)
- If the air connector is new one, you may find the cover for connector. The cover should not be removed until the connection is completed in order to prevent the separation of grip ring.
- When you insert the tube at first, try to align the approaching angle with target female or male side, otherwise it may result in the damage of O-ring. Sometimes, the damaged end of tube may cause the damage on the O-ring.
- Insert with enough effort up to the marking which is indexed in the tube and then confirm the proper connection by pulling the tube 2 or 3 times.
- After completing the air tube connection, please check the any leakage by applying some soup liquid on the connecting portion and check that any bubble is generating or not after air filling.

- For more detail information for the cautions of air tube service, please refer to the workshop manual.

Service procedure

Here let's do a summary for the works for each event in ECS system applied in BH.

1) If control module replaced: Variant coding + Height sensor calibration should be done.
   : If the control module is new one, it may have C1702 (variant coding not completed) and C1620 (height sensor not calibrated) already.
2) If height sensor replaced: Height sensor calibration should be done.
3) Air spring replaced: System air filling + Height sensor calibration
4) Compressor replaced: System air filling + Height sensor calibration
5) Reservoir tank replaced: System air filling + Height sensor calibration
6) Solenoid valve block replaced: System air filling + Height sensor calibration
7) Steering angle sensor replaced: Nothing to do in ECS section but sensor has to be calibrated in ESC system. (Steering angle signal for ECS is transferred from ESC via CAN)

Cautions for variant coding:

It is only for distinguish the vehicle model (BH or VI). That is, there is no difference for area, engine volume and wheel size and so on. Because the main purpose for variant coding is to input the vehicle model into ECS control module, it is not possible just only to do the ignition on like other systems. It should be done using the scanner. **If the variant coding is not done properly, the air spring cannot be controlled anymore and CDC damper solenoid valve current will be fixed by zero ampere.**

Warning lamp:

Following picture shows the location of ECS warning lamp. Refer to the workshop manual for more details about warning lamp.

Current data

As for the concept (definition) of ‘bar-liter’. for example 100 bar-liter means that the air with pressure 1bar is confined in the volume of 100 liter so that it is used to express the air mass in ECS system. It shows as an unit of ‘barl’ in the current data of scanner as shown in the picture.

Air Spring Failsafe

Mode	All SOL.	Comp. relay	Height sensor	Level control	Restore condition (if failure repaired)

A	OFF	OFF	OFF	OFF	Cannot be restored
B	OFF	OFF	ON	OFF	Next IG cycle
C	OFF	OFF	ON	OFF	Current IG cycle
D	ON	OFF	ON	Down leveling only (via ambient valve)	Next IG cycle
E	ON	ON	ON	Down leveling only	Current IG cycle
F	ON	ON	ON	Done by 3 height sensors	Current IG cycle
G	ON	ON	ON	Move to Normal level immediately and no more auto/manual level control at normal level	Current IG cycle

As for the failsafe mode of air spring control system, there are several modes depending on the failure type as shown in the table. Mode ‘A’ means a severe problem so that almost control is prohibited. Mode ‘E’ is valid when the most light failure is occurred.

Mode A: Actually mode A is not applied in BH.

Mode B:

- **Height sensor power supply error** (lower than 4V or higher than 6V)
- Air spring solenoid valves error (short to B+ or short to Ground)
- Reverse valves error (short to B+ or short to Ground or internal failure)
- Ambient valve error (short to B+ or short to Ground or invalid operation)
- Level control failure (if lifting or lowering time exceeds 20 sec.)
- Control module hardware error (ROM/RAM/EEPROM, etc)

Mode C:

- Vehicle battery voltage error (lower than 10V, higher than 16V)
- **More than 2 height sensors are failed** (abnormal frequency or invalid signal)
- Ambient valve out of control range
- **Variant coding error**

Mode D:

- Compressor relay error (short to B+ or ground, open circuit)
- Control module hardware failure (internal MICOM comm. error)

Mode E:

- Pressure sensor error (lower than 0.2V or higher than 4.8V or no signal more than 12times)
- Solenoid valve operating time is over. (Air spring sol.: exceeds 3min within 10min, Reverse valve: exceeds 5min within 10min) ◊ to avoid the over heating of solenoid valve.
- Compressor overheating: temperature is higher than 140℃ for more than 10 sec.
  → Exceptionally down leveling also is prohibited.

Mode F:

- One height sensor is failed (abnormal frequency or invalid signal)

Mode G:

- **CAN bus off, CAN timeout (EMS)**
- **CAN message failure (EMS)**
- Lop sided car could not be adjusted (VSS<10kph, left & right deviation of level cannot be corrected after 3 times try)

CDC damper Failsafe

Mode	Level control	Defect item	Restore condition (if failure repaired)
A	CDC Solenoid current: 0mA (Hard control)	- CDC solenoid valve - Control Module	Next IG cycle
B	CDC Solenoid current: 600mA (Fixing midway control)	- Height sensor + volt Low or High - G-Sensor	Next IG cycle
C	CDC Solenoid current: 600mA	- Height sensor + short to ground	Current IG cycle

	(Fixing midway control)		
D	Reserved	Not Used	Reserved
E	Reserved	Not Used	Reserved
F	CDC Solenoid current: 0mA (Hard control)	- Battery voltage too low or high - One of height sensor error - Variant code error - CAN BUS Off DTC - CAN message failure (EMS,ESP or SAS)	Current IG cycle

As for the failsafe mode of CDC damper control system, there are several modes depending on the failure type as shown in the table. Mode ‘A’ and ‘F’ mean a severe problems so that almost control is prohibited. Mode ‘C’ and ‘D’ is valid when lighter failure occurs. Mode ‘D’ and ‘E’ are not used.

Mode A:

- CDC actuator (solenoid valve) failure: High side is shorted to ground.
- Control module hardware failure (internal MICOM comm. error)
- Control module hardware error (ROM/RAM/EEPROM, etc)

Mode B:

- Height sensor power supply error (lower than 4V or higher than 6V)
- G-sensor failure (short to B+ or short to Ground or open circuit or invalid signal or sensor power is less than 4.75 or higher than 5.25V)

Mode C:

- Height sensor failure (short to ground or B+)

Mode D and E:

- It does not used in BH.

Mode F:

- Vehicle battery voltage error (lower than 10V, higher than 16V)
- One height sensor is failed (abnormal frequency)
- **Variant coding error**
- **CAN bus off**
- **CAN timeout (EMS or ABS/ESC or SAS)**
- CAN message failure (EMS or ABS/ESC or SAS)

Sometimes, you may encounter that ESC, ECS, EPB and SCC warning lamps altogether do not disappear after ignition on. At this time, please check that;

1) Check the battery cable or ground is correctly connected or not. If the battery connection is not good, ESC cannot perform to write the offset value of sensors and it may result in the warning lamp on in other systems also even though those systems

have no problem.

2) Next, check ESC at first ! As it is mentioned, ECS shares various info via CAN and the problems from ESC can affect to other systems.