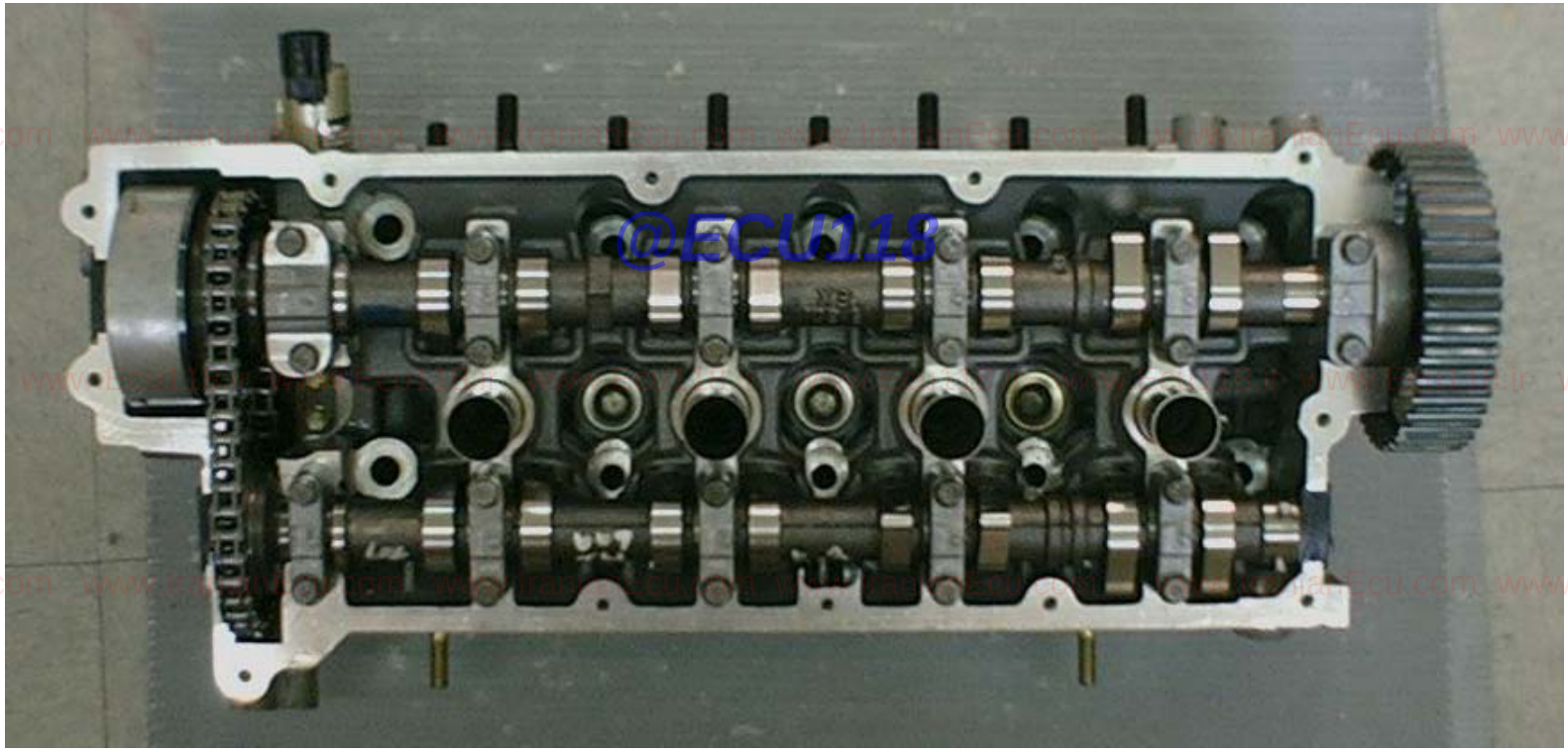
CVVT System

(Continuously Variable Valve Timing)



KIA MOTORS

CONTENTS

CVVT(Continuously Variable Valve Timing) System

The CVVT, which is installed on the exhaust camshaft controls intake valve open and close timing in order to improve engine performance.
The intake valve timing is optimized by CVVT system depending on engine rpm.

Advantages of CVVT

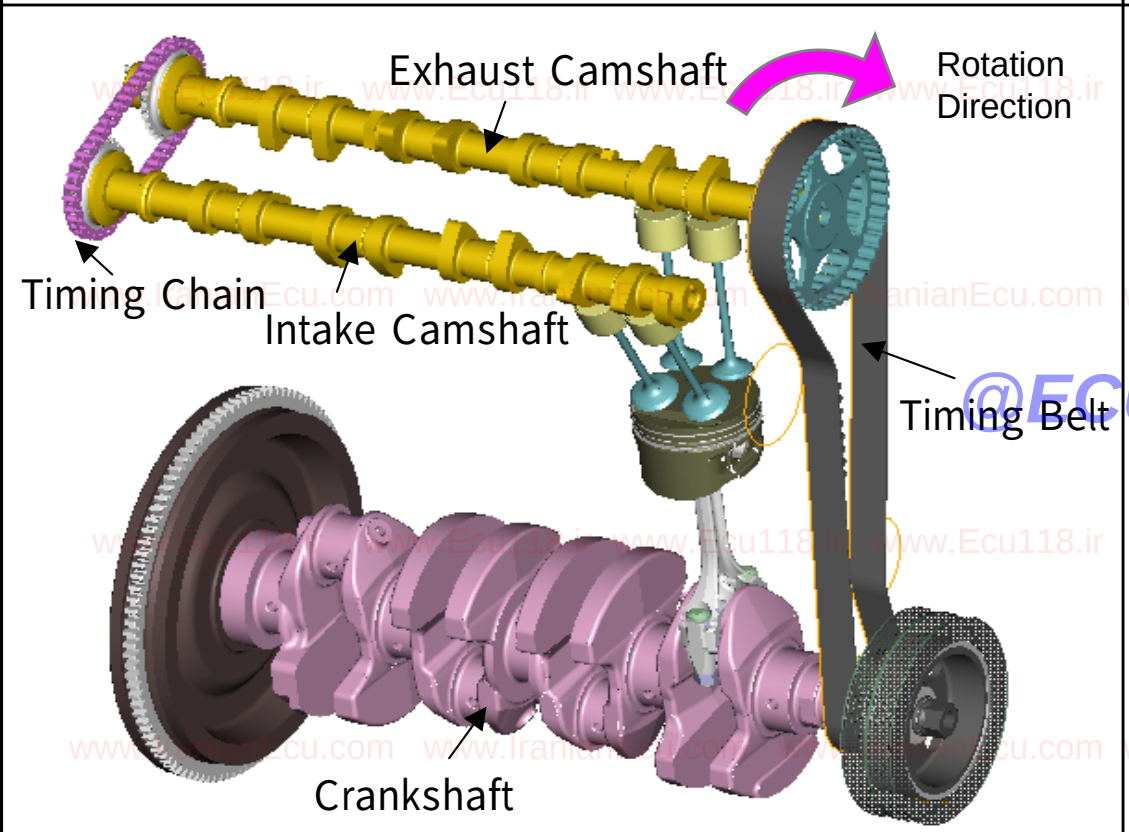
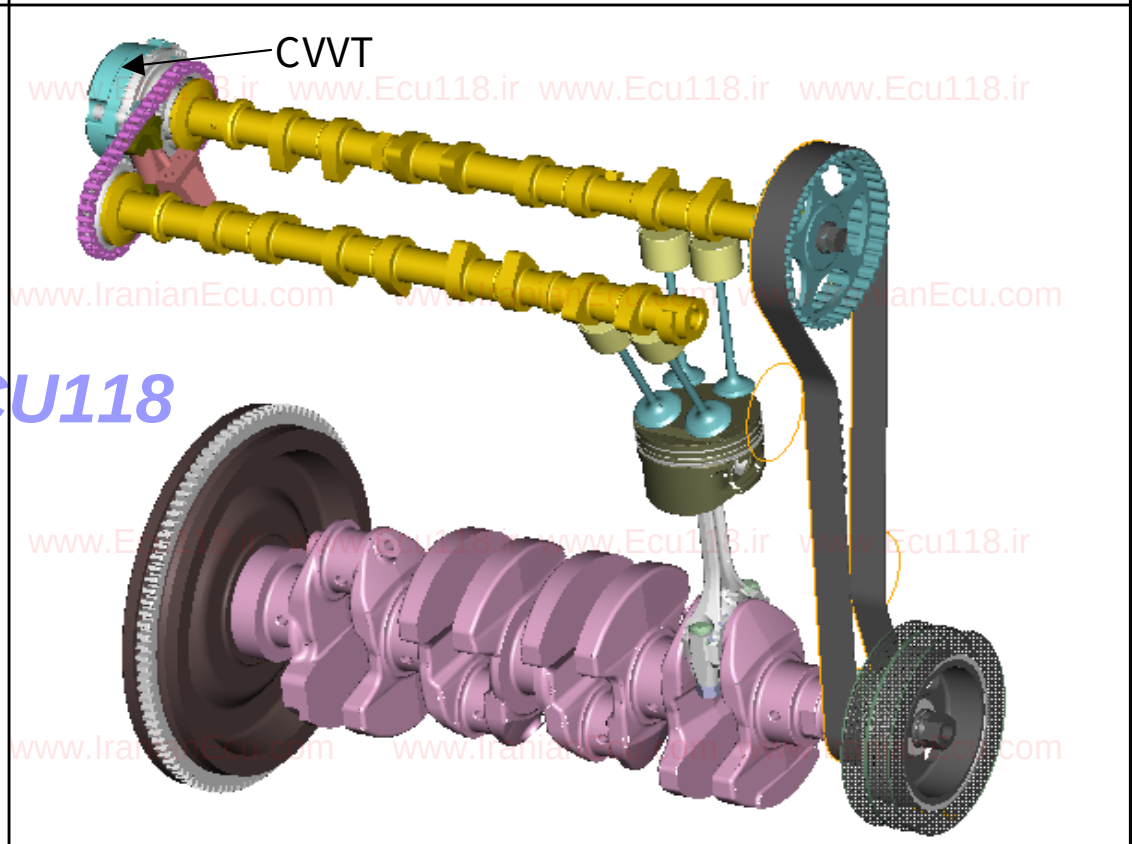
- **Reduced Fuel Consumption** :
  - Reduce Pumping loss because of increasing valve overlap

- **Reduced emission** :
  - Reduce NOx by EGR effect because of valve overlap optimization

- **Improved performance and increased torque at low speed** :
  - Improved volumetric and thermodynamic efficiency by variable valve timing

Introduction of the CVVT System

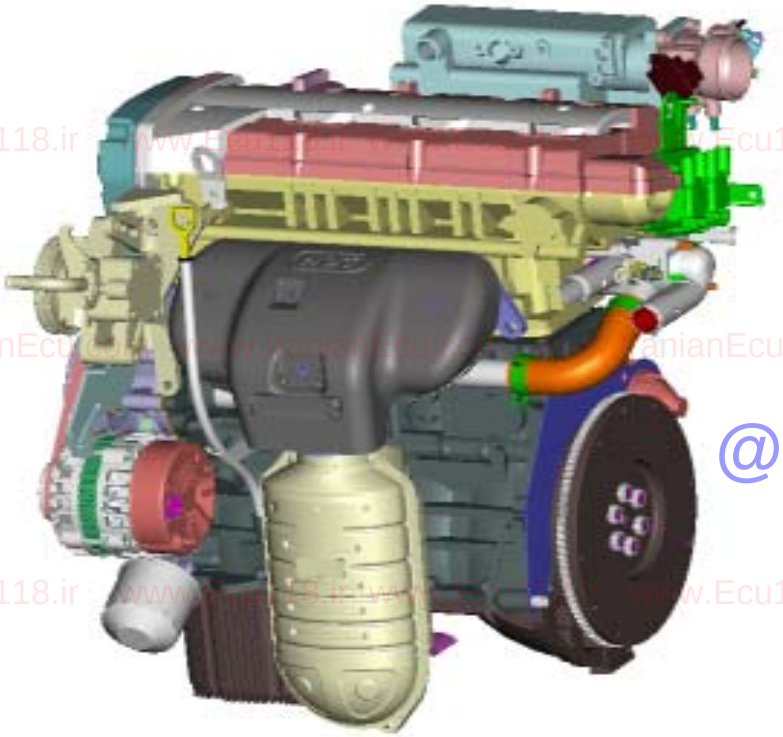
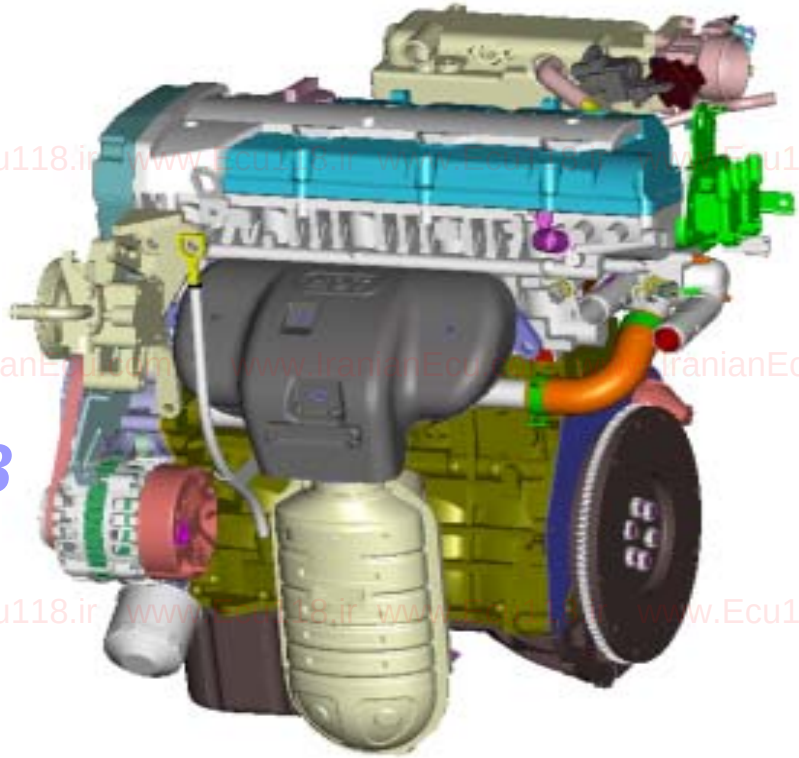
Camshaft Driven Mechanism

Beta Engine	Beta Engine with CVVT
	

① Rotation force of crankshaft is transmitted to exhaust camshaft by timing belt.

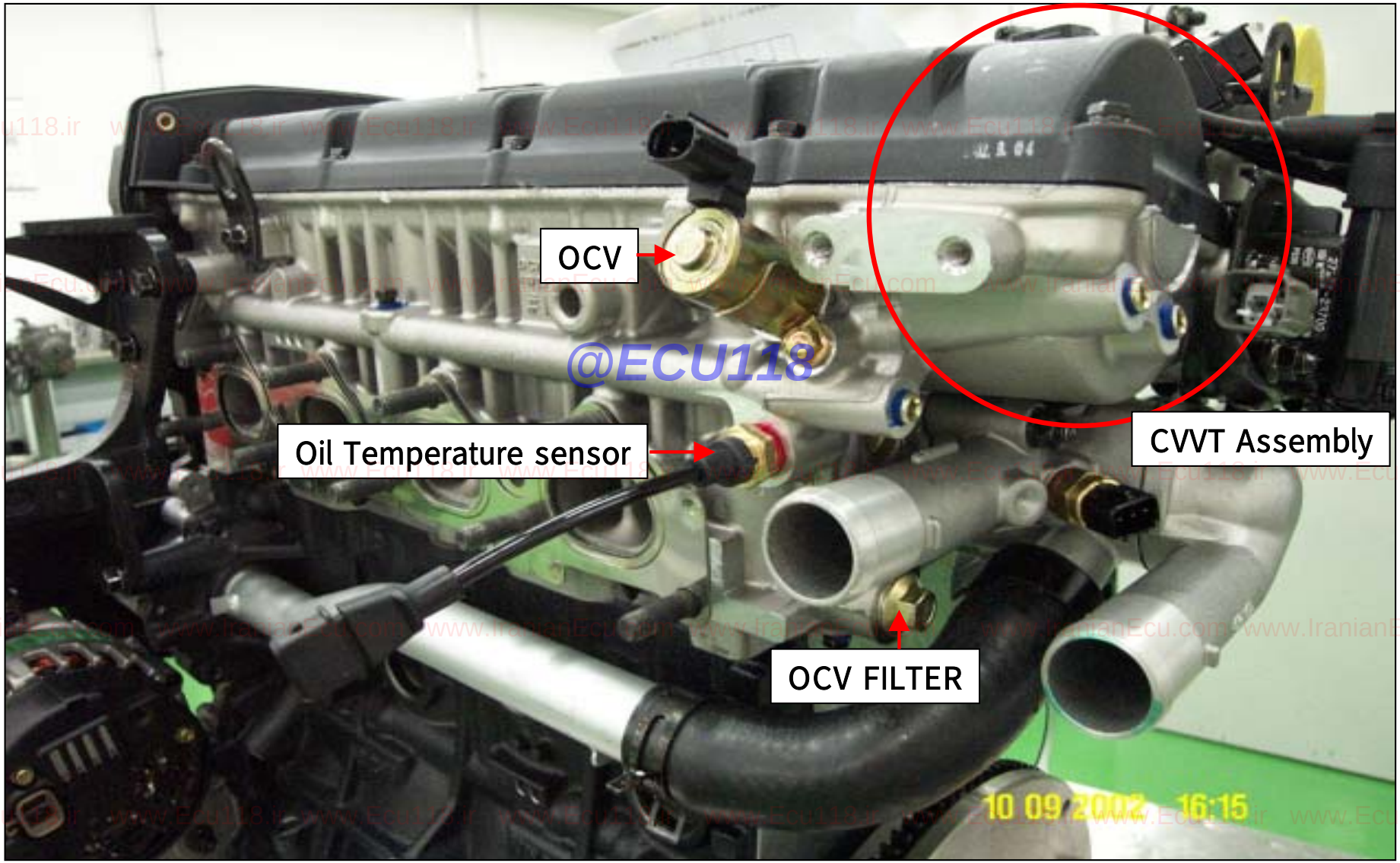
② Rotation force of exhaust camshaft is transmitted to intake camshaft by timing chain.

Introduction of the CVVT System

Beta Engine	Beta with CVVT
	
-	CVVT, OCV(Oil Control Valve)
-	OCV FILTER
-	Oil Temperature Sensor
MAP Sensor	Air Flow Sensor (HOT Film Type)

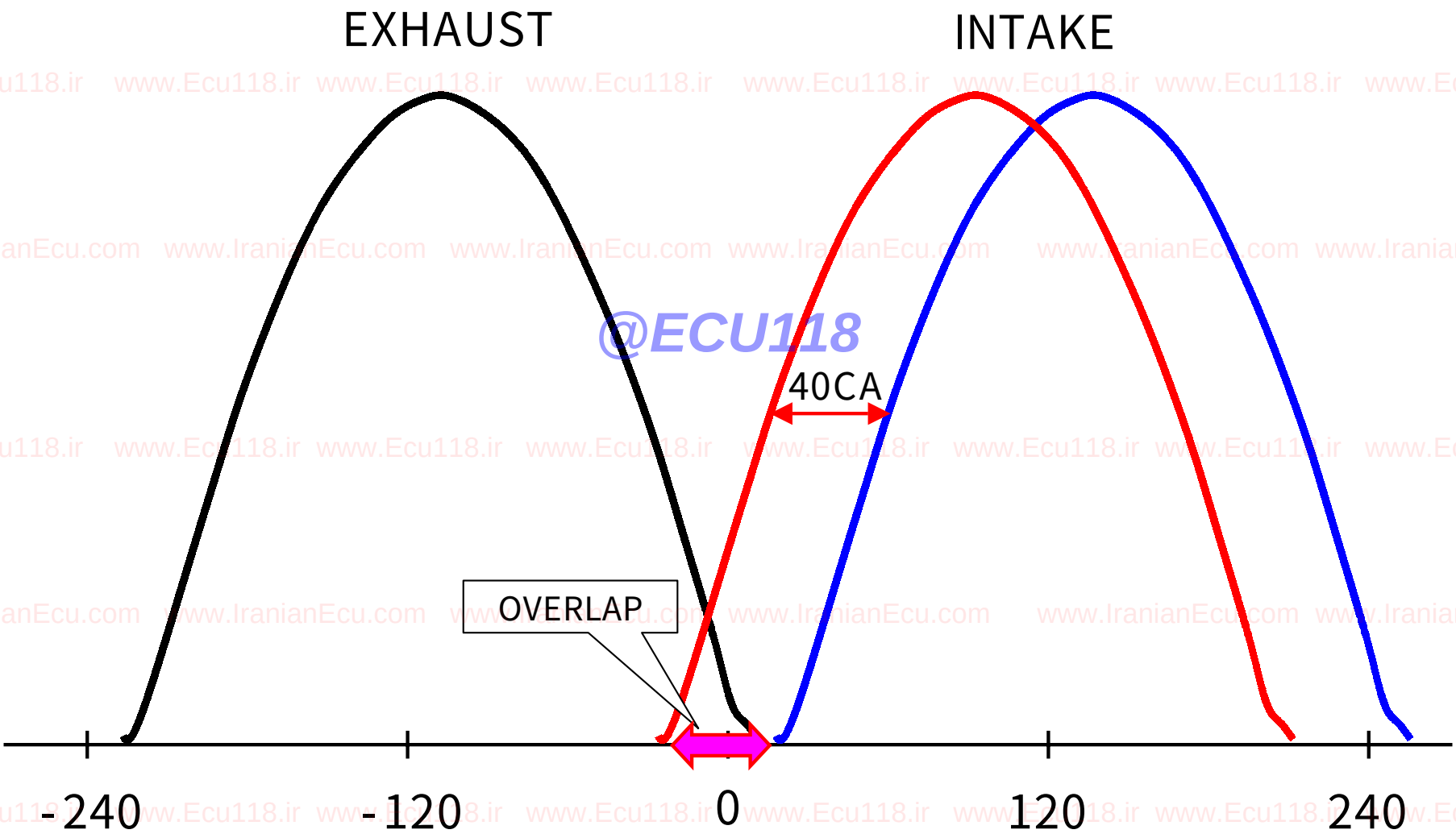
Introduction of the CVVT System

CVVT Parts Location

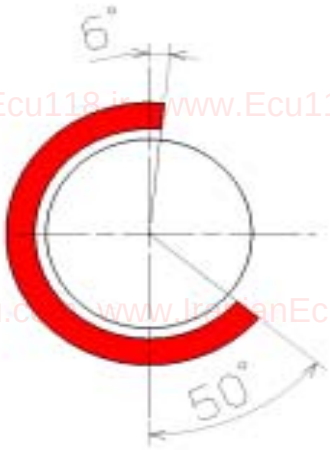
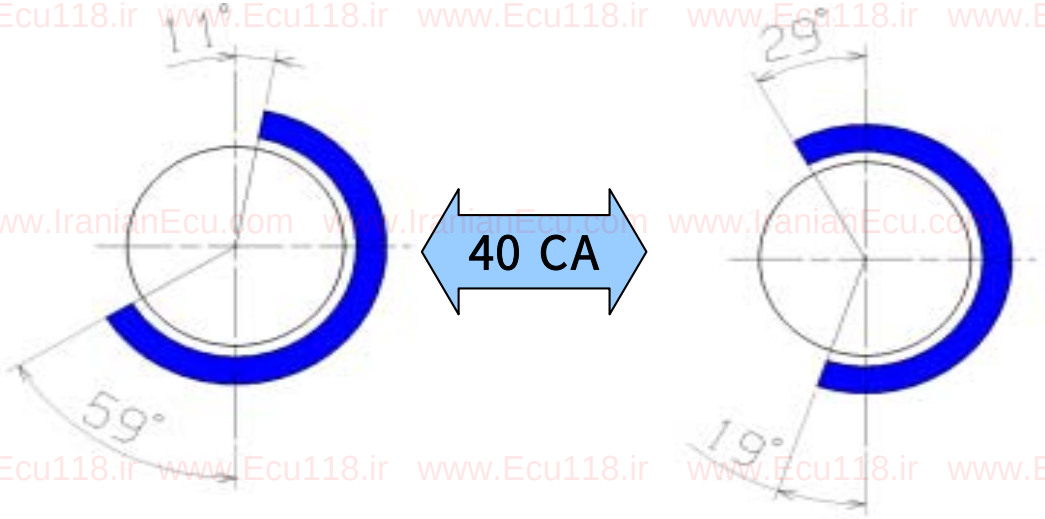


Introduction of the CVVT System

Valve timing variation

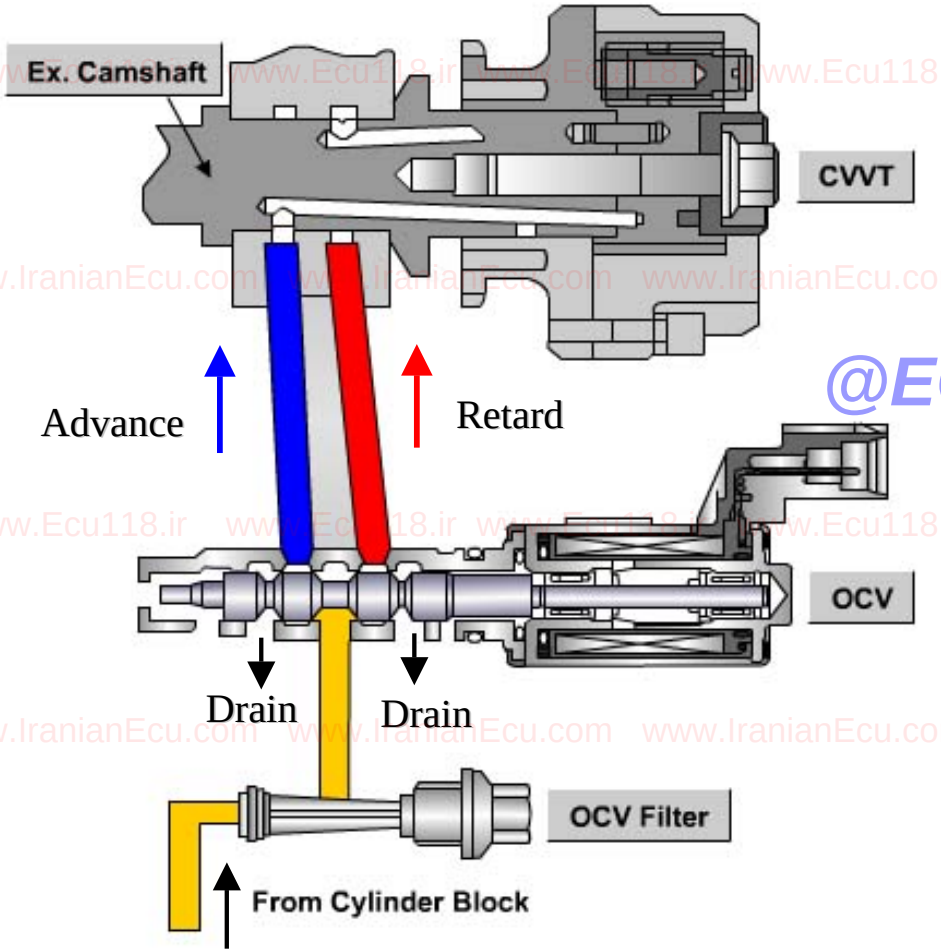


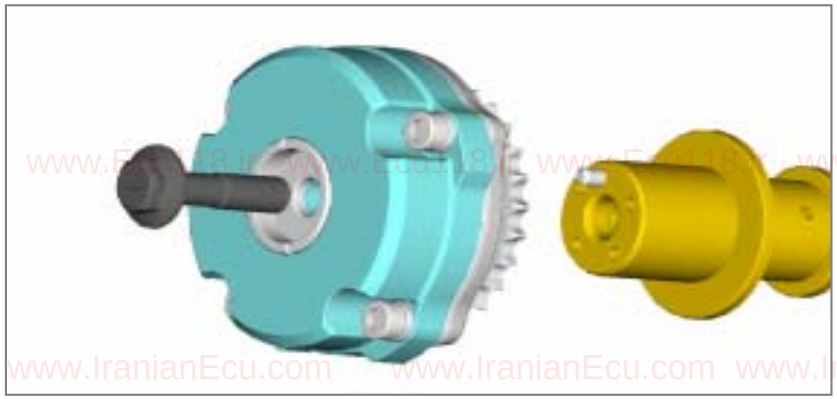
Introduction of the CVVT System

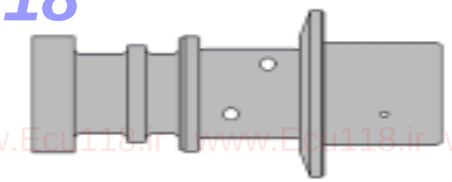
	Intake Valve Timing	Exhaust Valve Timing
Beta Engine		
Beta Engine with CVVT		

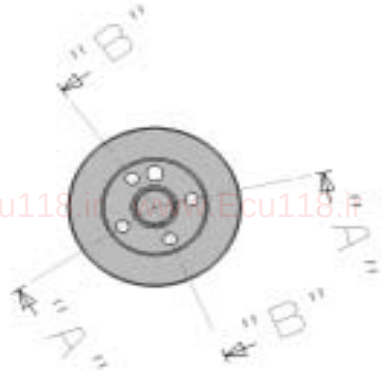
Introduction of the CVVT System

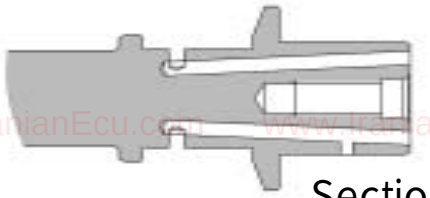
CVVT Oil Passage



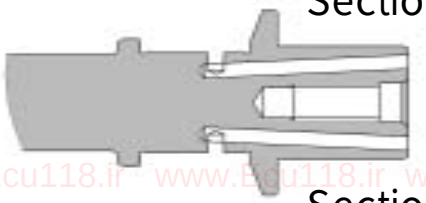






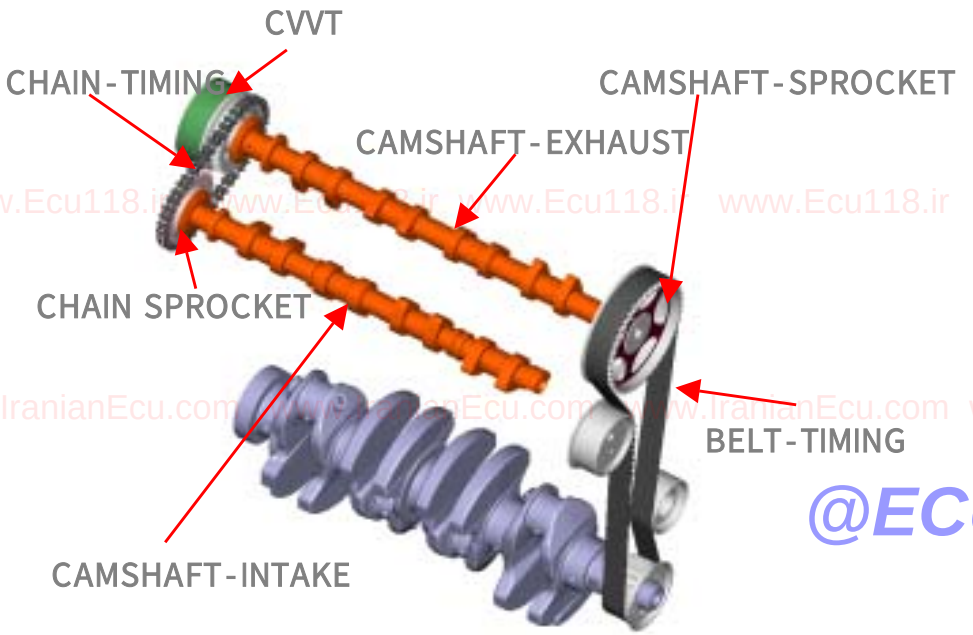


Section A - A

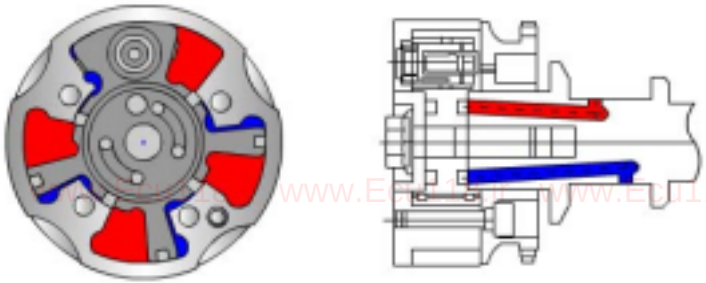


Section B - B

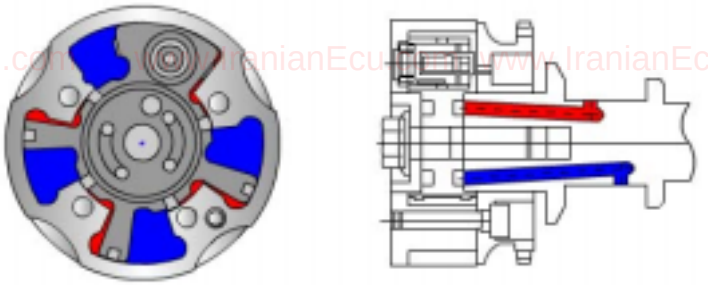
Introduction of The CVVT System

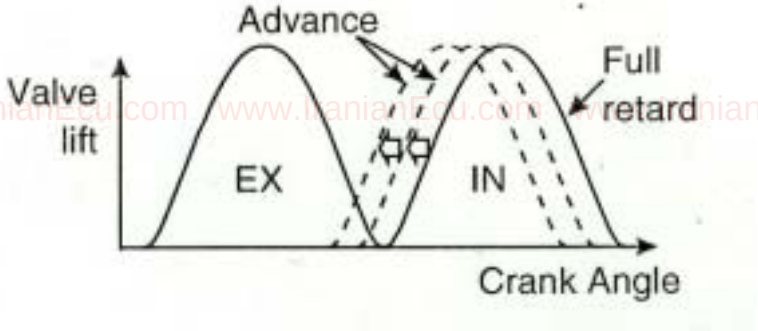


Retard



Advance

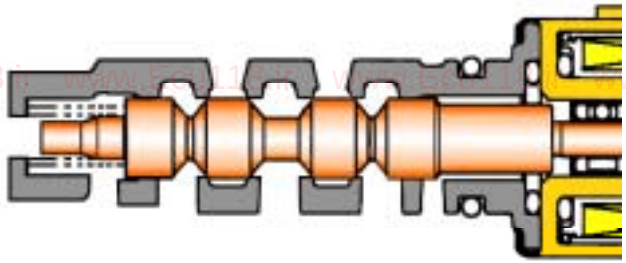




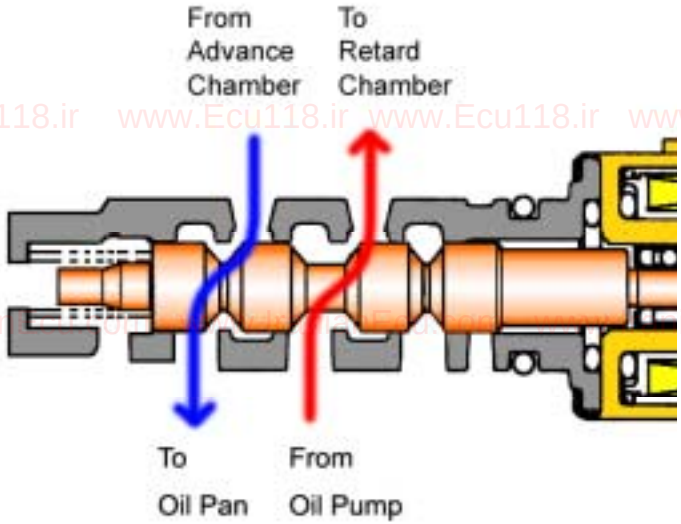
Driving condition	Intake V/Timing	Efficiency
At low load	Retard	Stable combustion
At high load, high speed	Retard	Improved performance
At high load, low speed	Advance	Improved Torque
At middle condition	Advance	Reduced fuel consumption

CVVT System Components, Function

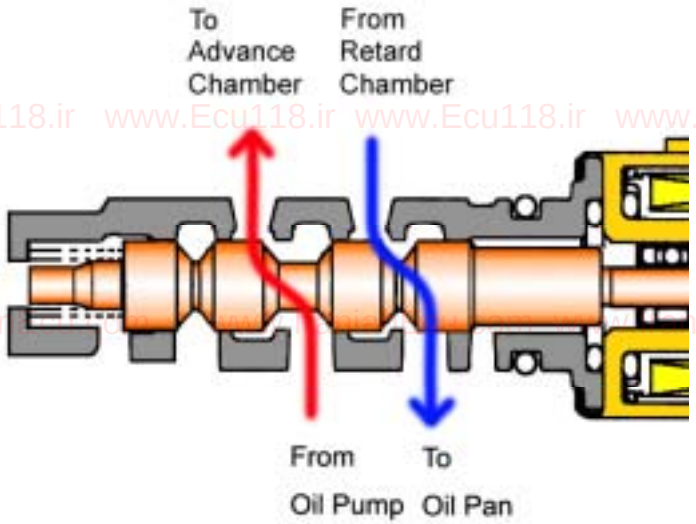
Hold



Retard

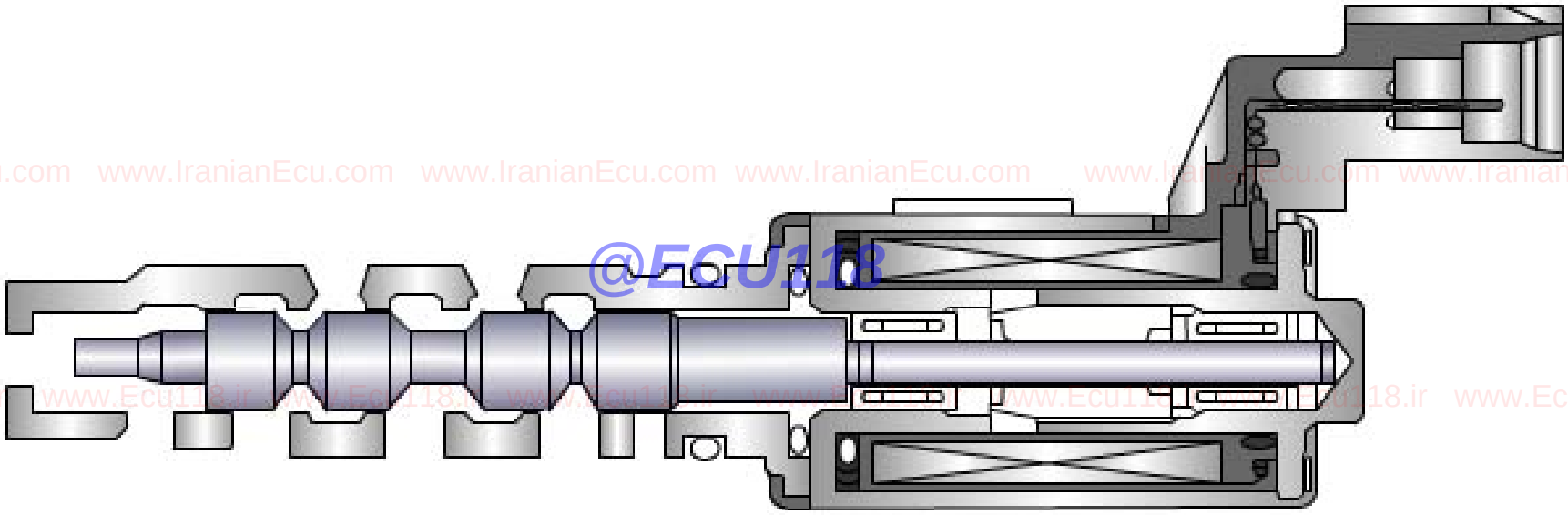


Advance



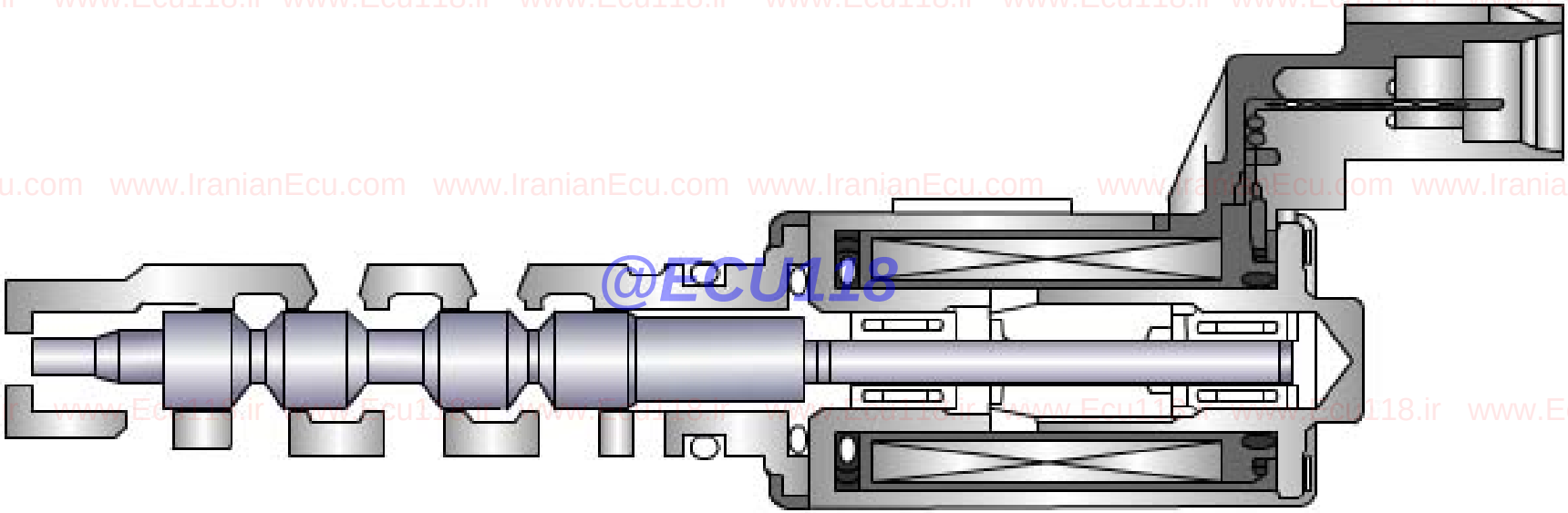
CVVT System Components, Function

Retard



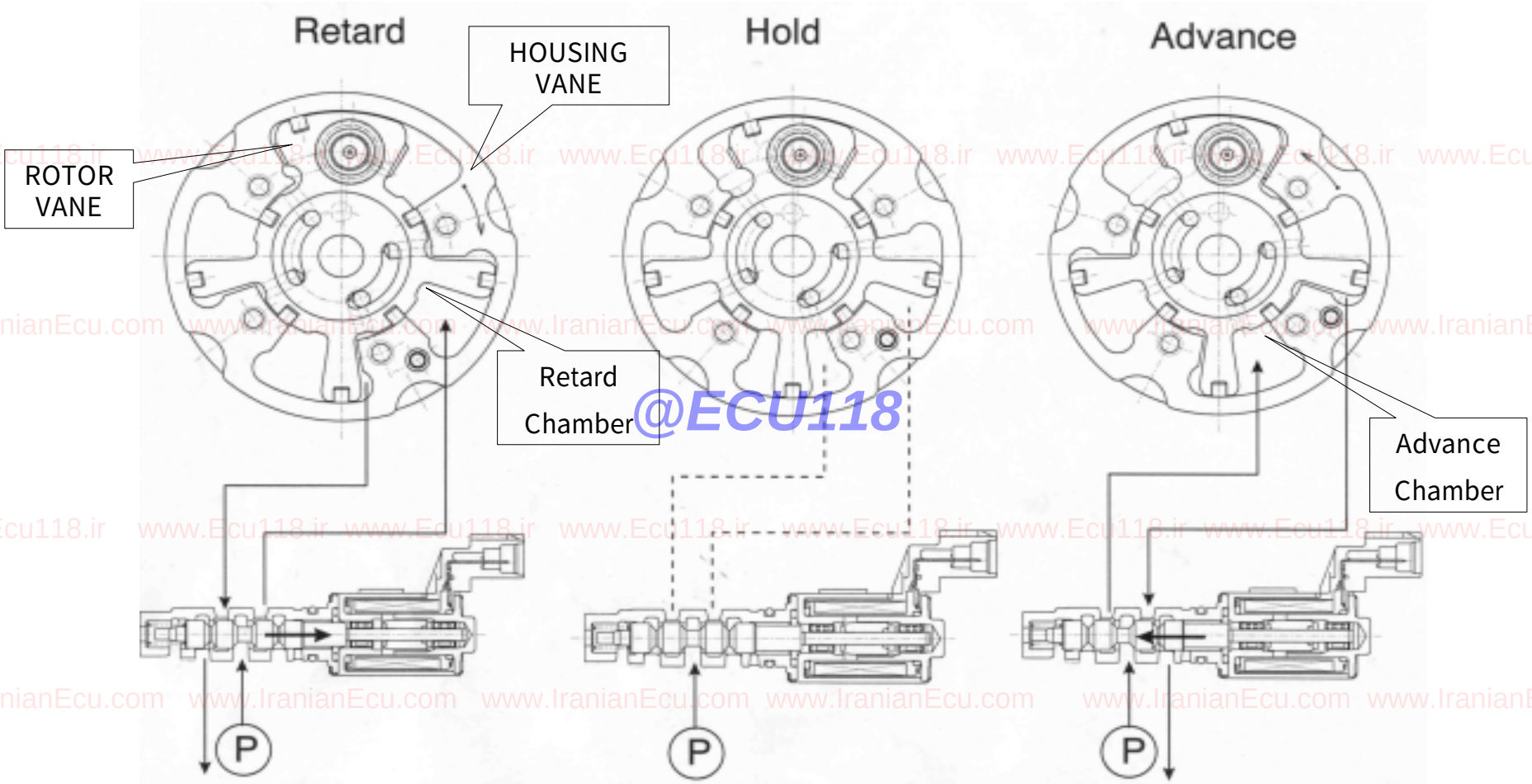
CVVT System Components, Function

Advance



Introduction of The CVVT System

OCV and CVVT Operation Mechanism

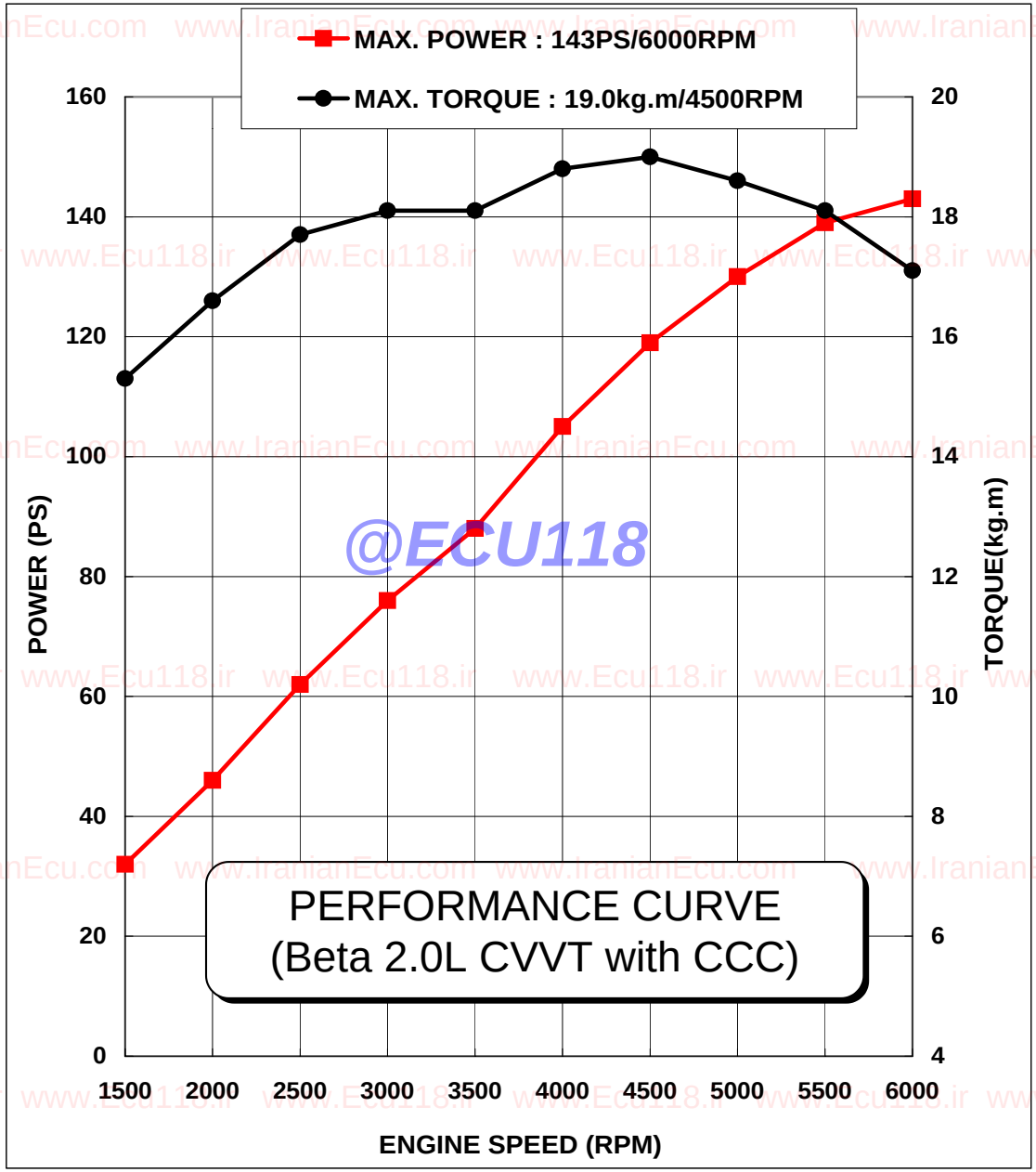


※ The Oil is supplied to the retard chamber and advance chamber by OCV control.

Introduction of The CVVT System

1. Rotor vane is installed on exhaust-camshaft by bolt
2. Camshaft-intake and housing of CVVT is connected by chain
   (Sprocket is attached on housing. So, phase difference occurs between Housing and Rotor Vane of CVVT).
3. Rotor vane is fixed on housing by stopper pin at the position of the maximum retard
4. If the oil is supplied to advance chamber, Housing will be advanced and stopper pin is unlocked.
5. Timing of intake-camshaft is advanced.
6. Engine off condition. The oil is drained from the advance chamber, the housing returned to retard position and fixed by pin due to lock of position

Introduction of the CVVT System



KIA MOTORS

Components – CVVT Assembly

1. CVVT Assembly

- Location : End of the exhaust camshaft
- Type of CVVT : vane type
- Operation range : 40±2° Crank angle (20±1° Camshaft angle)

- Operation Condition

① Oil Temperature range : -40 ~ +130°C

② Oil Pressure range : 0 ~ 1000kPa

③ Engine speed range : 650 ~ 6000 rpm

- Stopper Pin Release Pressure

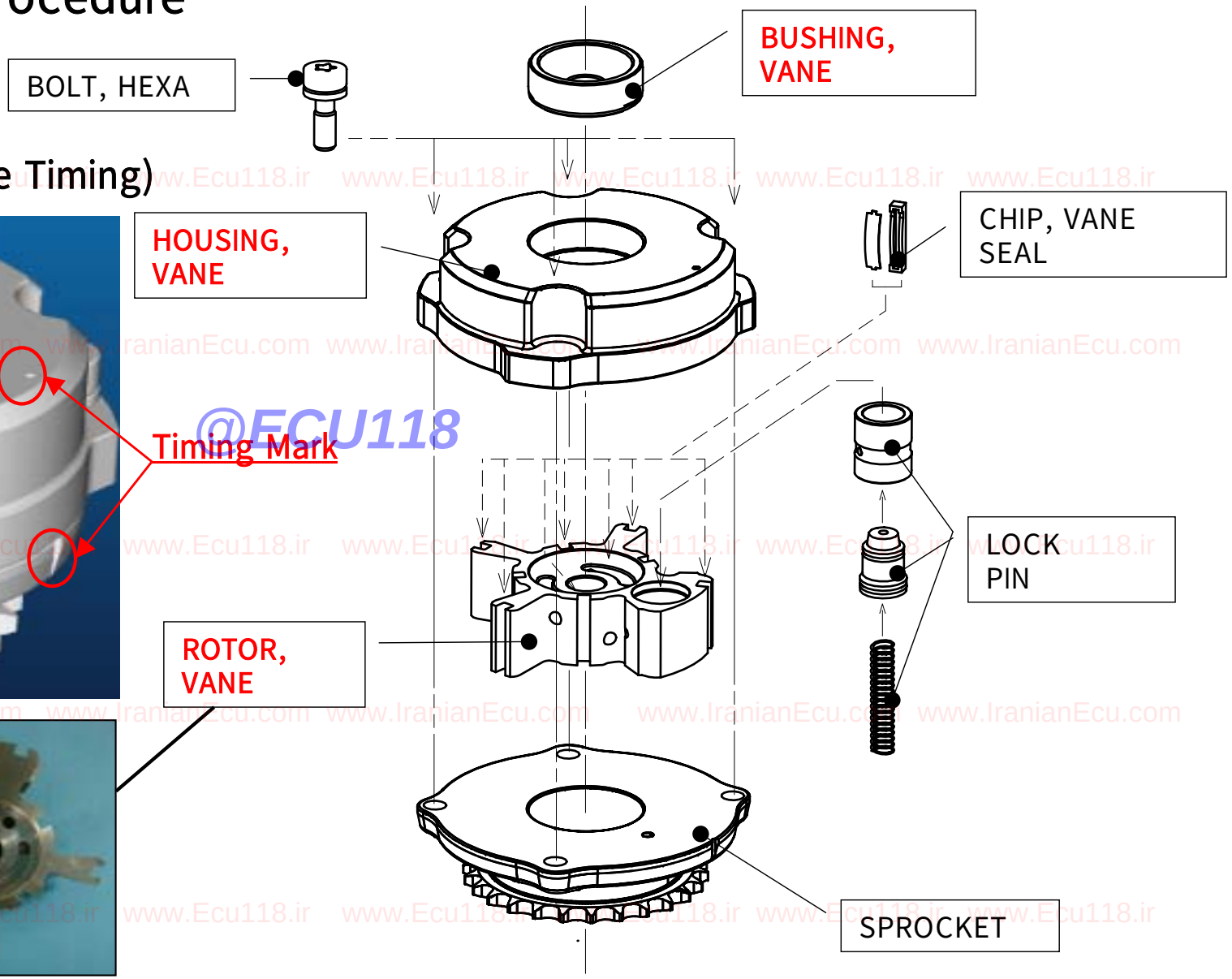
Minimum Release	54kPa
Fully Release	191kPa

Components – CVVT Assembly

β-CVVT Engine Service Procedure

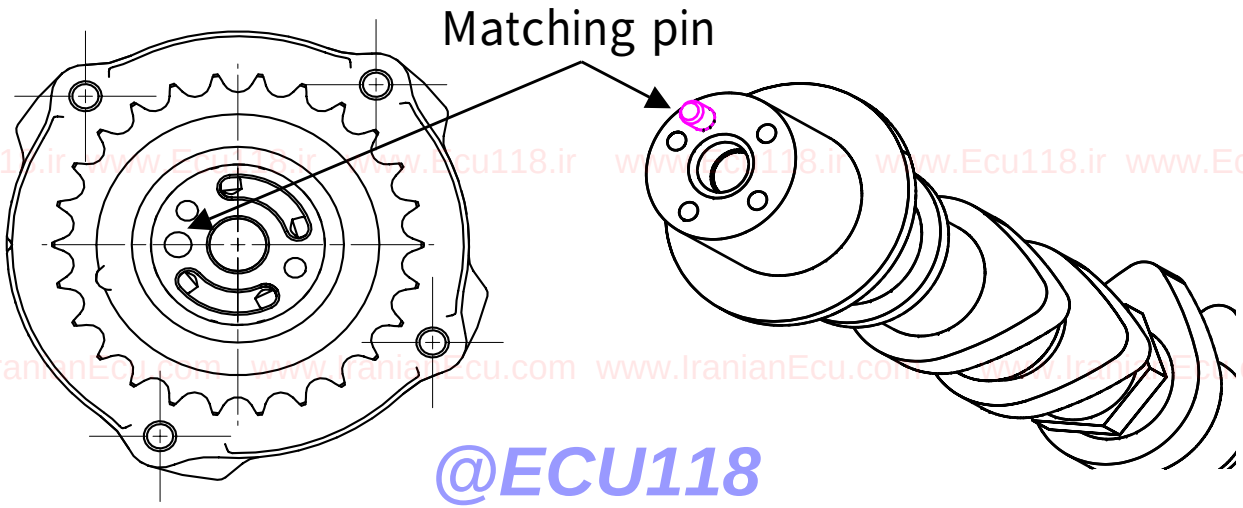
1. Handling caution

1) CVVT
(Continuously Variable Valve Timing)



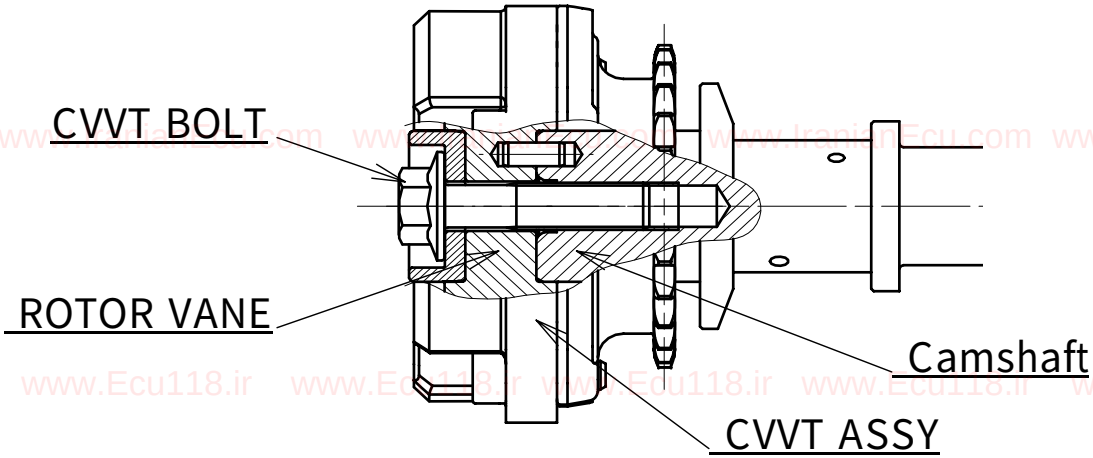
Components – CVVT Assembly

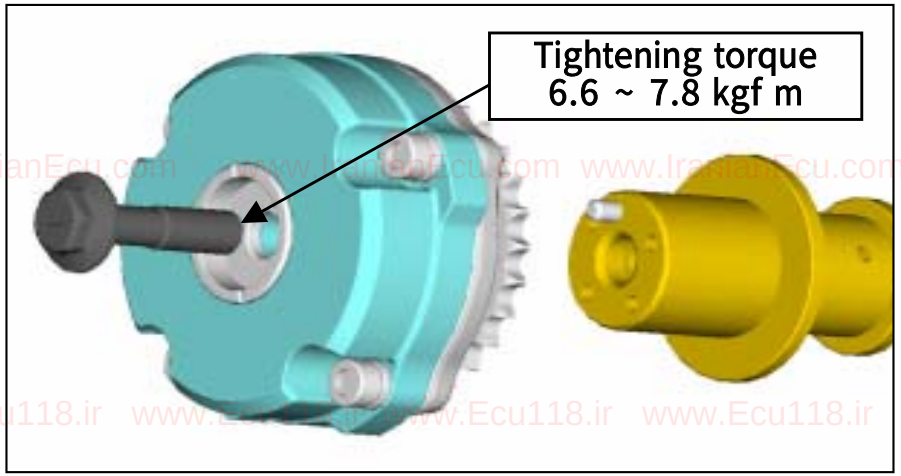
① This pin on the camshaft should be smoothly inserted and assembled with the hole on CVVT.



② Tighten the bolt to Assemble the CVVT and the Camshaft.

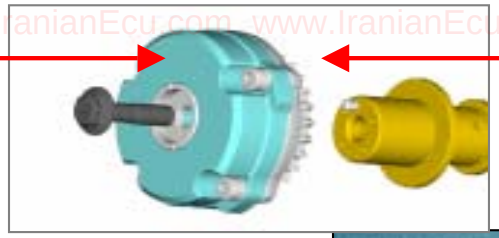
(Apply the oil on the bolt before tightening it.)

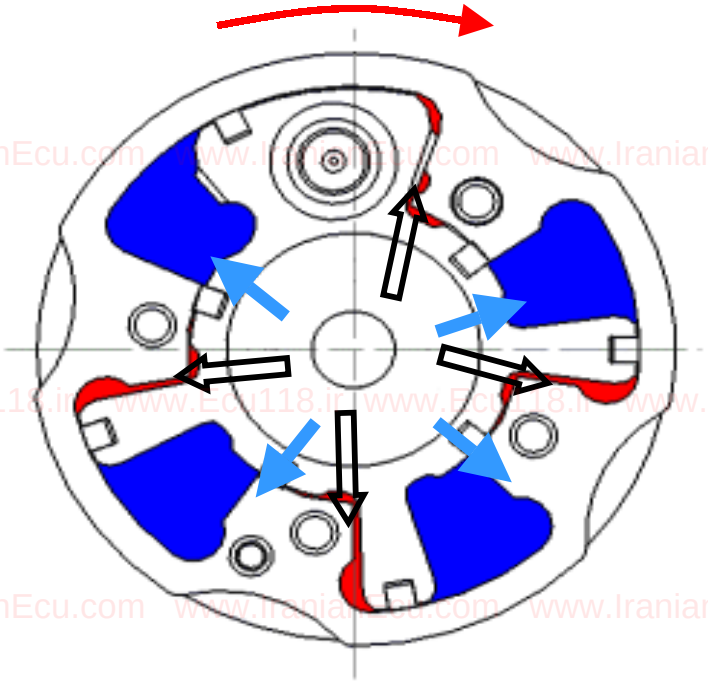


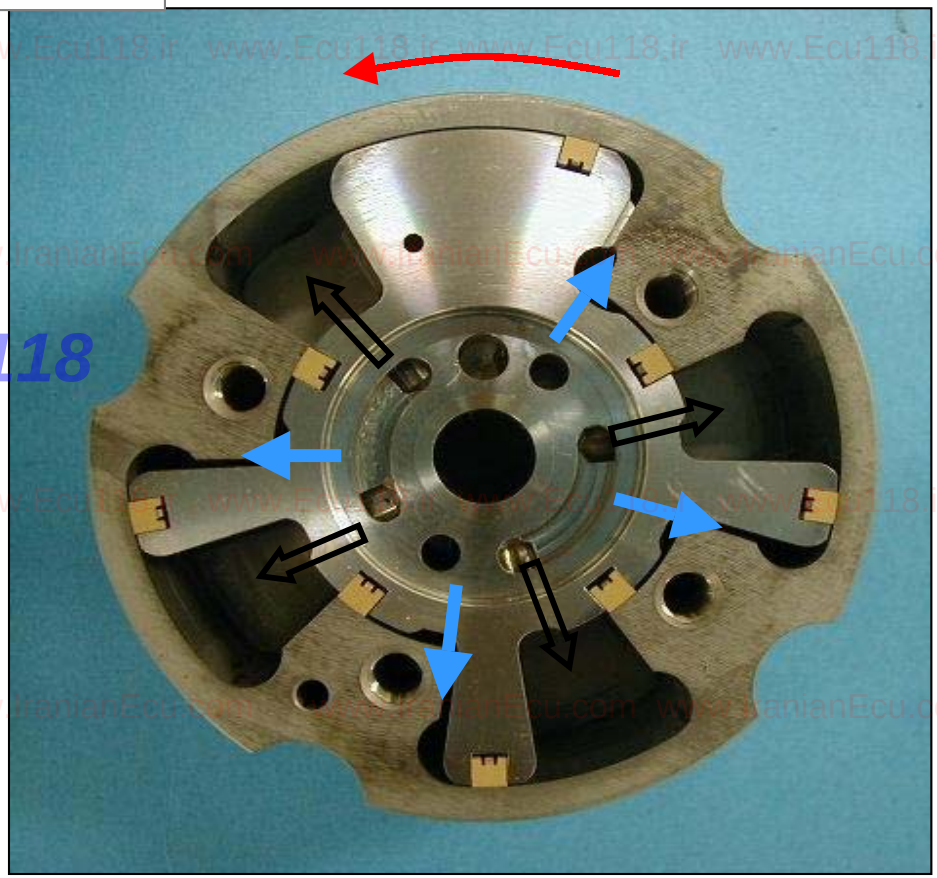


Components – CVVT Assembly

CVVT side view → ← Camshaft side view



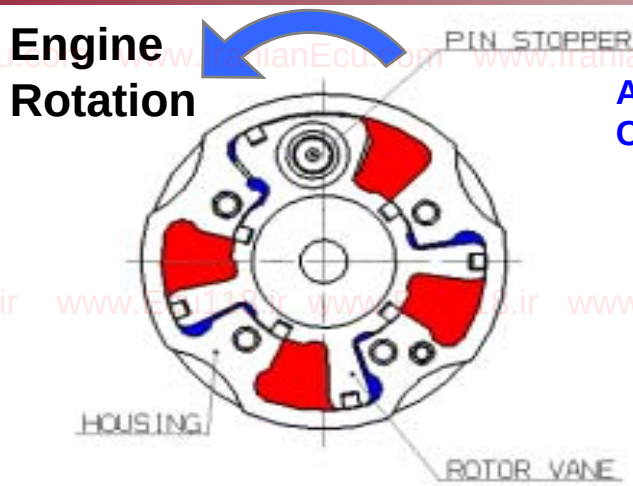


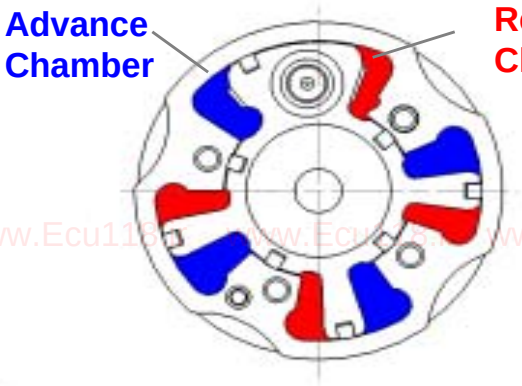


Oil Supply for Retard Chamber ⇨

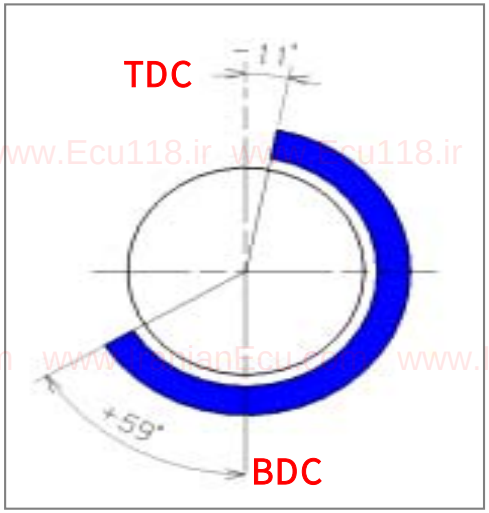
Oil Supply for Advance Chamber →

Components – CVVT Assembly





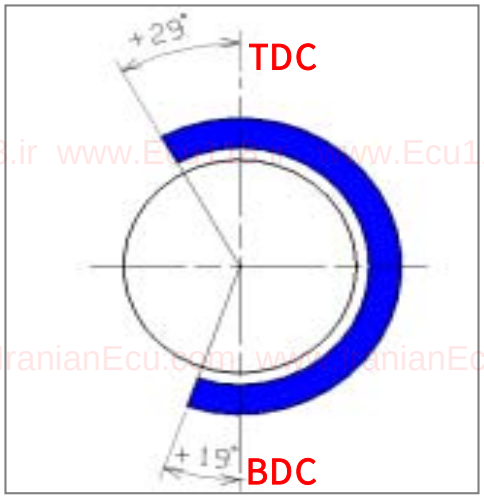
Maximum Retard



Middle

Positioned between ATDC 11 and BTDC29 (Maximum operation angle of CVVT is 40 degree of crank angle)

Maximum Advance



The opening timing of intake valve will be advanced, if the housing is rotated to engine rotation direction. (The intake valve is opened at ATDC 11 in maximum retard position, the intake valve is opened at BTDC 29 in maximum advance position)

Components – CVVT Assembly

Handling caution

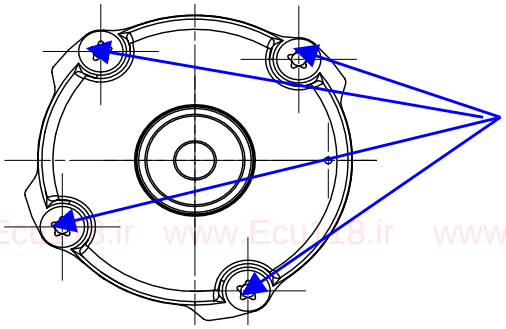
① Dropped one cannot be reused – CVVT may not be operated due to the external impact.

② Keep the tightening torque of CVVT bolt while tightening it. (Specification : 6.6 ~ 7.8 kgf m)

- Lower than specification : Bolt can be loosened and CVVT is separated from the camshaft, it may result in the damage of engine.
- Higher than spec. : CVVT may not be operated due to the plastic deformation.

③ Do not overhaul CVVT even though CVVT is suspected and send defected parts to the parts supplier.

- Because CVVT is assembled by using the unique tool, it may not be operated if it is overhauled and reassembled in the shop. If CVVT was overhauled, it should be replaced with new one.



※ Do not loosen or reassemble this bolt.
If it is overhauled, it should be replaced with new one.

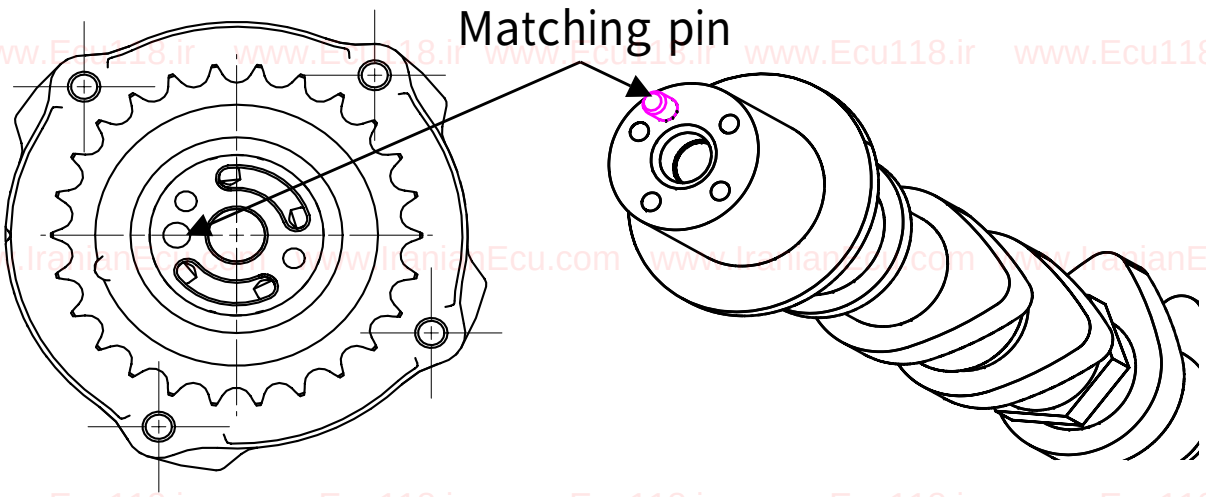
Components – CVVT Assembly

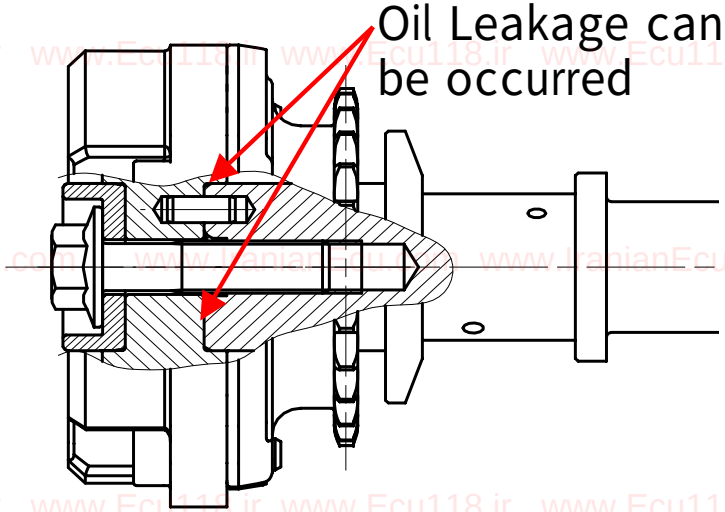
④ Be careful the cleanness of CVVT oil passage on the cylinder head, cylinder block and camshaft.

- To prevent the OCV malfunction by foreign material

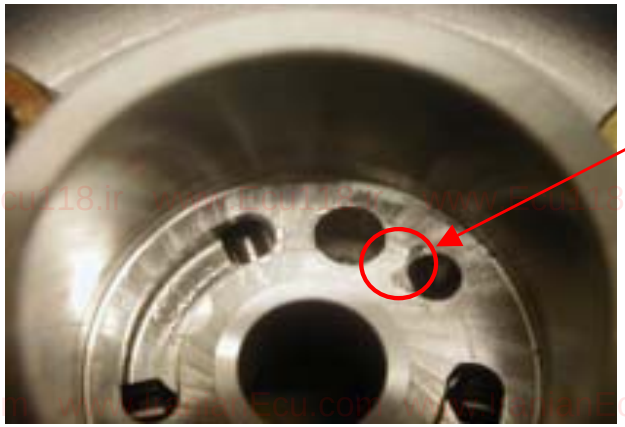
⑤ Avoid the scratch on surface of the rotor vane when the CVVT is installed on the camshaft. (Do not depress CVVT strongly and do not rotate relatively while the pin of the camshaft is not inserted into the hole on CVVT.)

- The response of the CVVT can be decreased by oil leakage because of scratch damage.





Components – CVVT Assembly



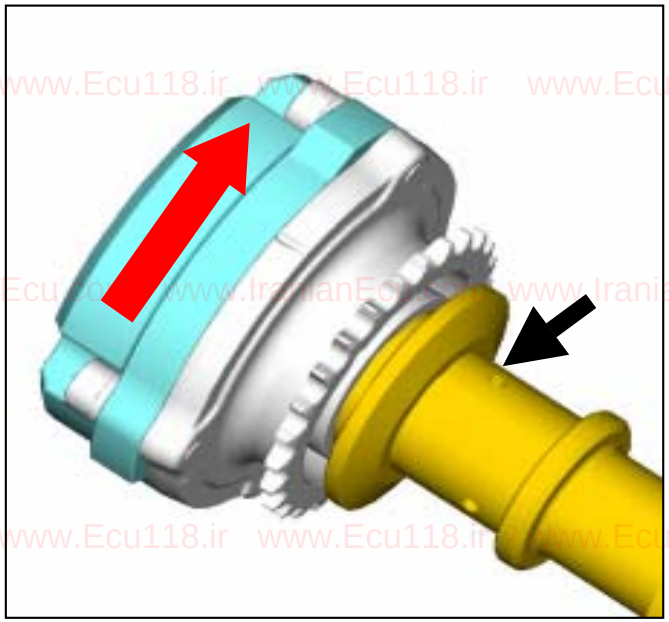
⑥ Do not hold the CVVT assembly but hold the camshaft by the vice when the tighten the mounting bolt of the CVVT.

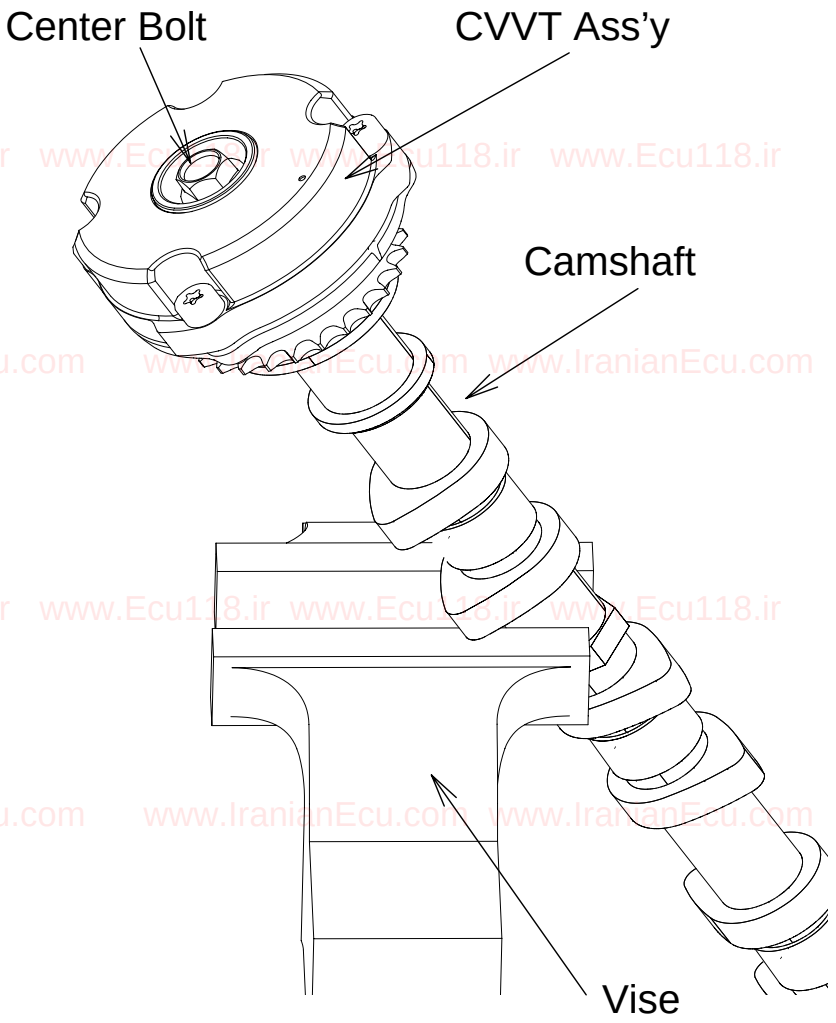
- CVVT may not be operated due to the plastic deformation.

Components – CVVT Assembly

How to check the CVVT itself

1. Fix the camshaft using the vice.
   (Avoid the damage on the cam or journal)
2. Make sure whether CVVT is rotated or not.
   (should not be rotated)
3. Using some tape or other things, clog every holes except one hole (nearest to CVVT) designated by black arrow on the right side figure.





Components – CVVT Assembly

How to check the CVVT itself

4. Apply the air of 100kPa into the hole which is not clogged in procedure ‘3’.
 - This is to release the lock pin inside of CVVT.
 - Even though CVVT is not rotated by hand, it can be rotated naturally depends on the strength of air pressure.
 - The lock pin may not be released if there is a leakage when the air is applied. (Lower than pin releasing pressure)

5. Rotate CVVT by hand in the direction of advance (red arrow on the figure) under the condition ‘4’.
 - CVVT should be rotated smoothly in the direction of advance and retard if the lock pin was released. (However, the air pressure is released and CVVT is returned to maximum retarded position, it cannot be rotated if the lock pin is locked again.)
 - The overall rotating angle of CVVT from maximum retarded to maximum advanced position is 20 degrees.
6. Replace with new one if there is a faulty.
 Rotate CVVT up to maximum retarded position to lock the lock pin if there is no problem.

Components – OCV

2. OCV (Oil-flow Control Valve)

OCV Specification

① Voltage : 12V

② Coil Resistance : 7.4±0.5Ω(at 20℃)

③ Control current : 100 1000 mA

④ Insulation Resistance : over 50MΩ (at 500V)

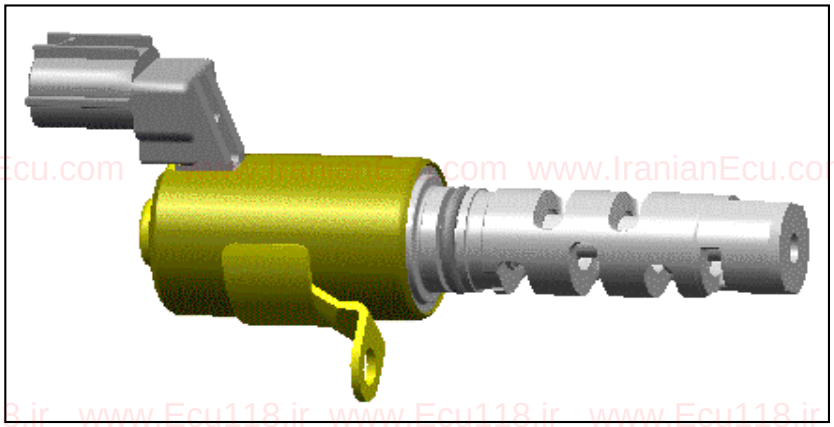
⑤ Assembly air-tightness : Leakage test - Leakage should be less than 1.0㎤/min(Apply air pressure 200 kPa)

Operation condition

OIL Temperature Range : -40 +130℃

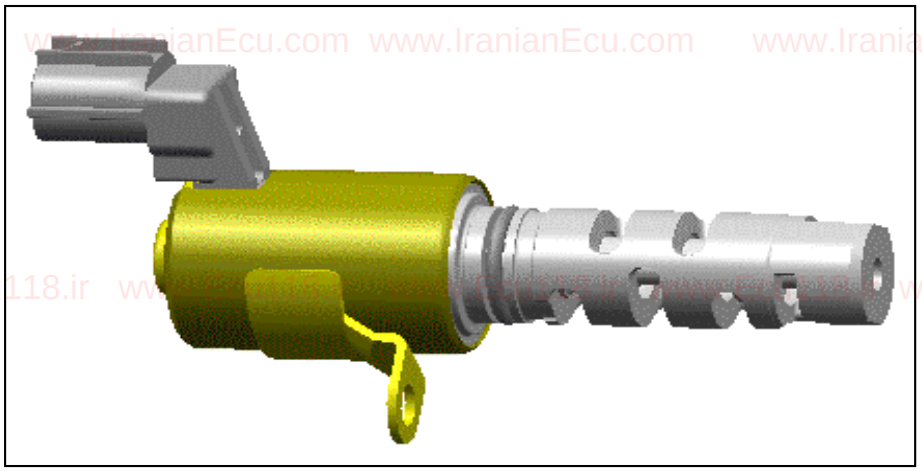
OIL Pressure Range : 0 1000 kPa

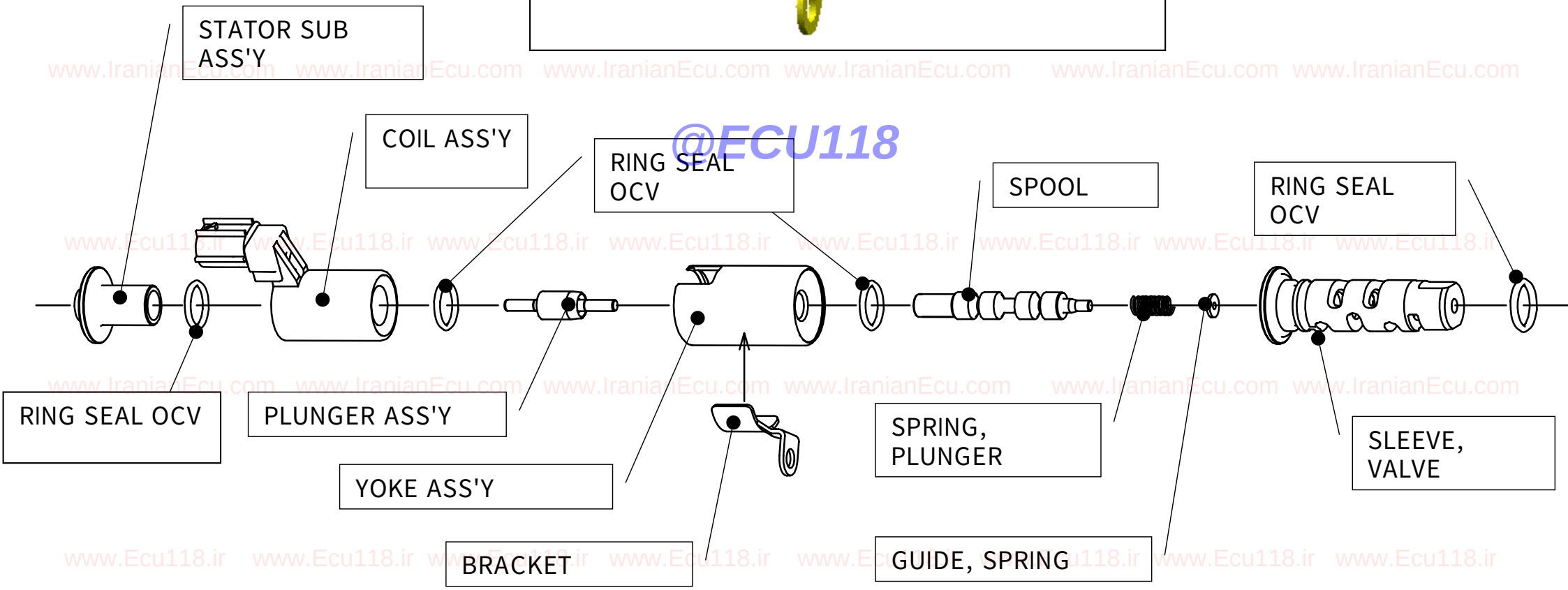
Voltage Range : 10 16 V



Components – OCV

Structure





Components – OCV

Caution

① Dropped one cannot be reused.

- OCV may not be operated, If it was deformed due to the external impact,

② When the OCV is replaced, be careful the cleanness to avoid the inflow of foreign substance in CVVT.

- OCV locking due to the inflow of foreign substance will result in malfunction of CVVT

③ Don't touch the OCV sleeve to prevent that a foreign substance flow in CVVT, When you repair the CVVT.

④ When OCV is installed to engine,

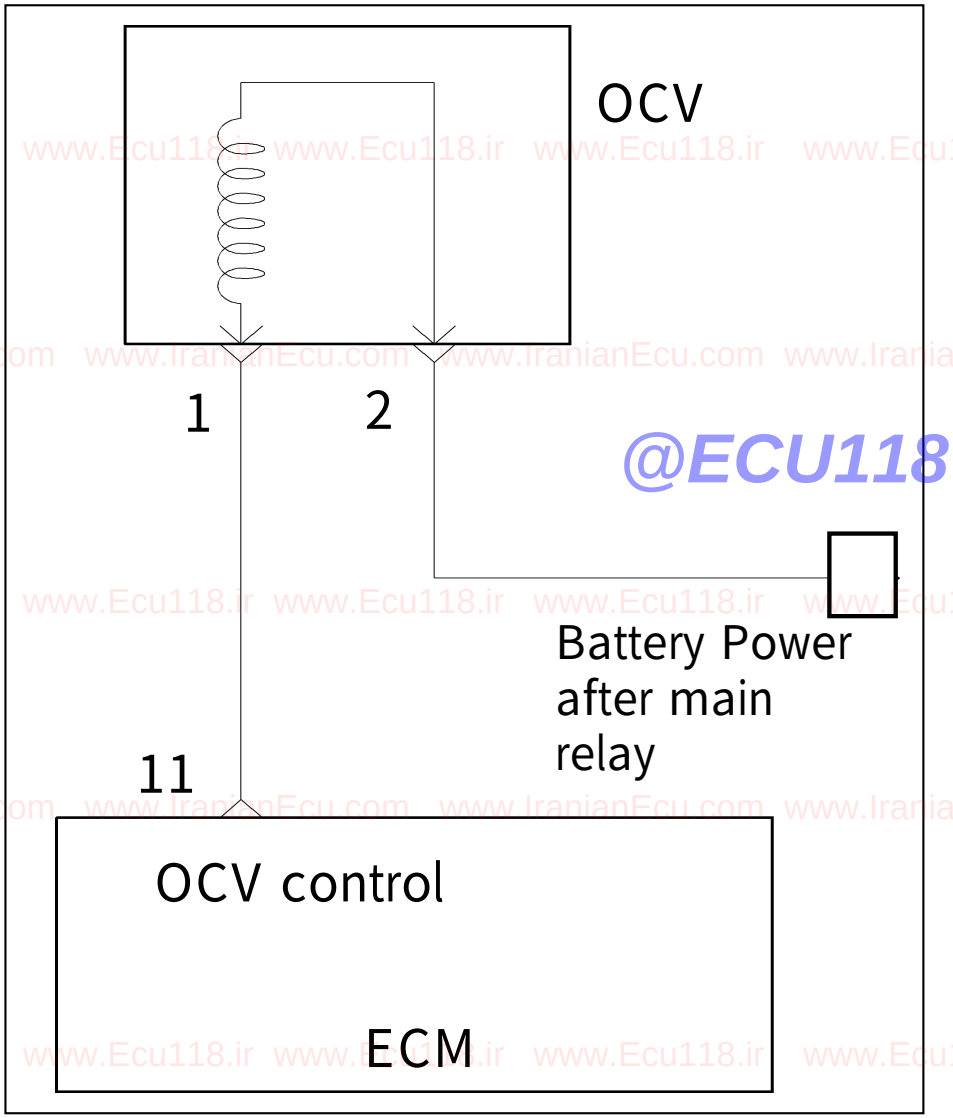
- Don't use a OCV yoke as a handle or hook when the engine is moved.

- To prevent the deformation of OCV.

⑤ If OCV is stuck with a foreign substance, you must replace with new OCV.
(even thought you remove a foreign substance, don't reused OCV.)

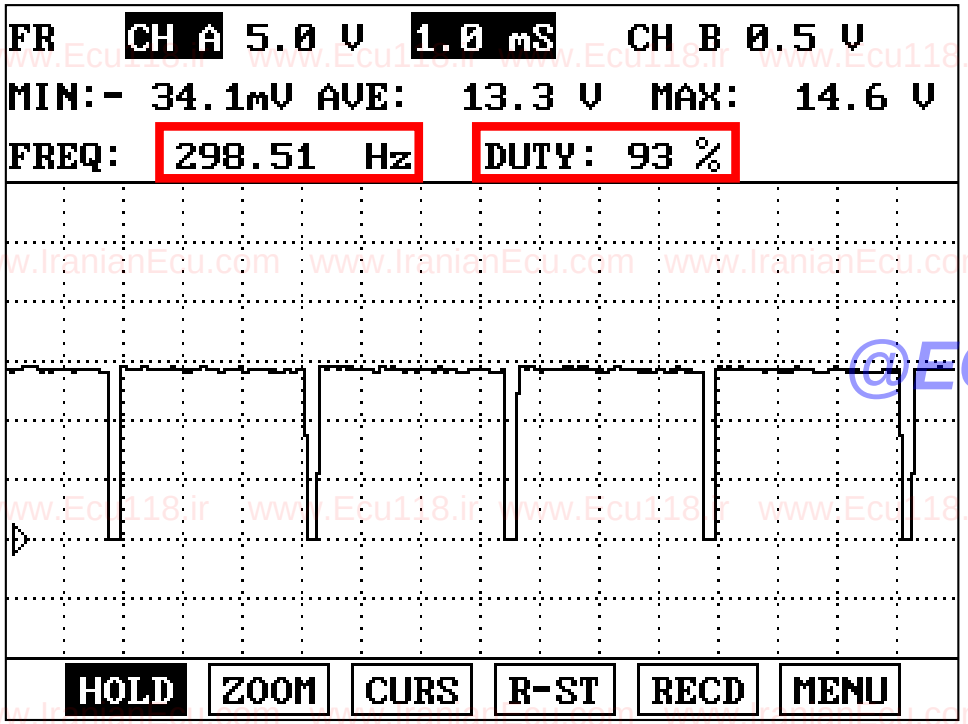
Components – OCV

OCV Circuit

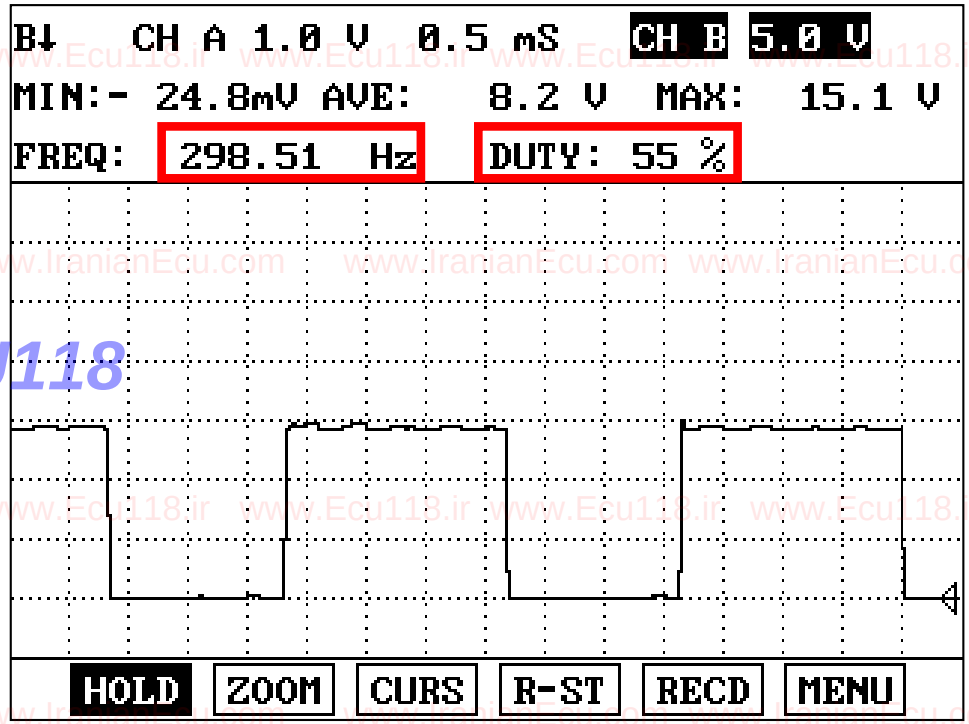


Components – OCV

OCV Waveform



Idle condition



2000rpm full load condition

93% duty at oscilloscope function is equals to 7% duty at current data.
Oscilloscope : (+) duty, Current data : (-) duty

KIA MOTORS

Components – OCV

Checking OCV

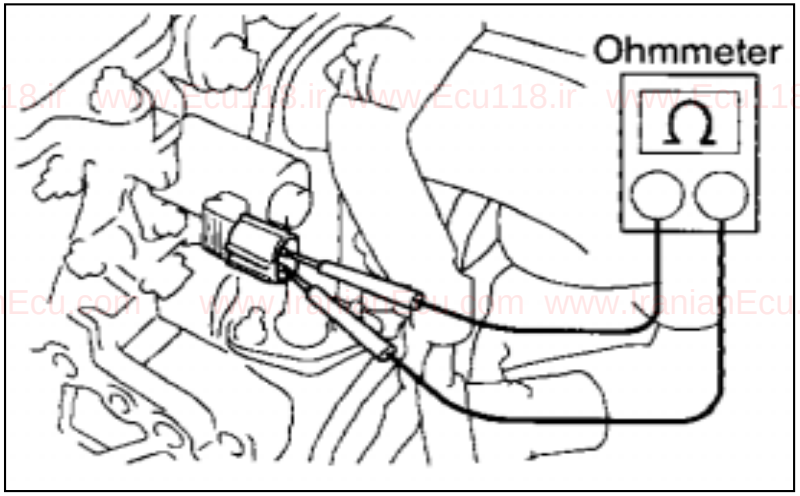
Check resistance of OCV

① Disconnect OCV connector.

② Measure resistance of OCV

- Specification : 6.9 ~ 7.9 Ω (20℃)

③ If out of range, replace with new one.



Check the operation of OCV

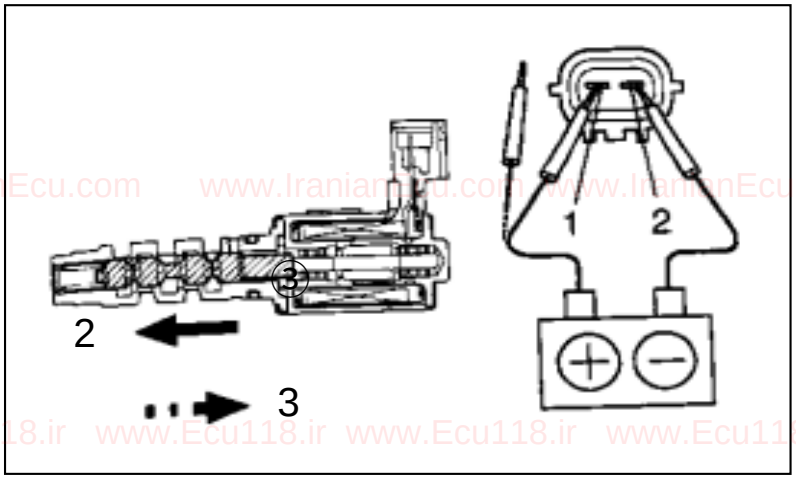
① Disassemble OCV from cylinder head.

② Connect the Battery.

- Check that SPOOL is moved toward (#2 direction)

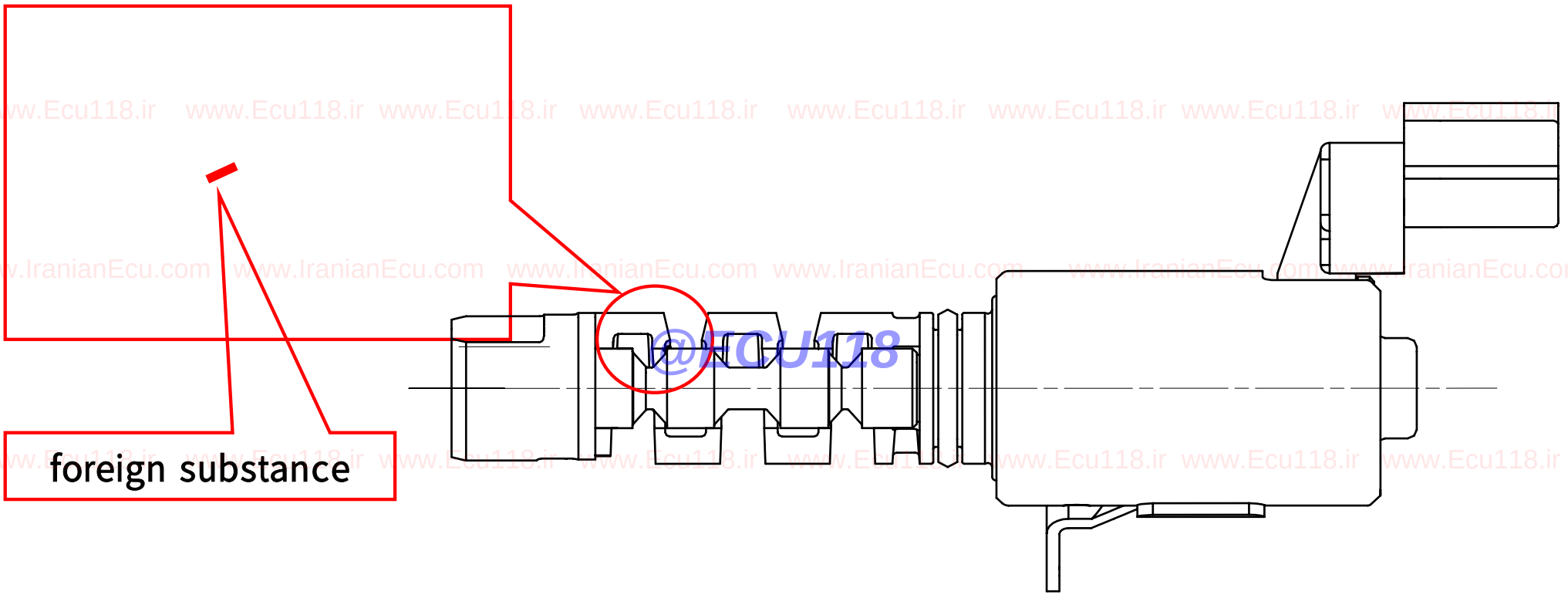
③ Disconnect to Battery

- Check that SPOOL is returned (#3 direction)



Components – OCV

1) CVVT may not be operated when the foreign substance clogs the OCV.



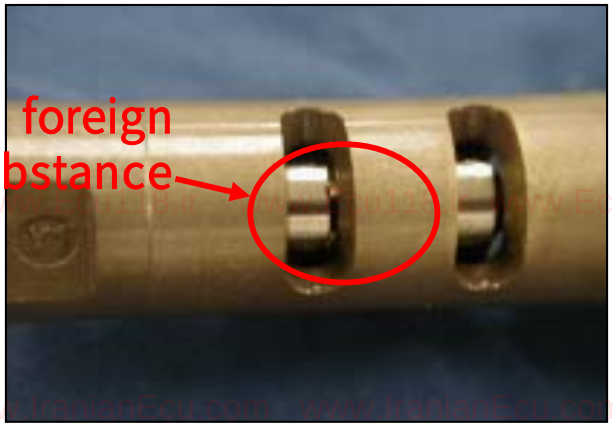
① OCV spool is locked when the foreign substance clogged between OCV sleeve and spool.

② If the CVVT is not operated. The camshaft's real position and target position is not matched.

③ If it is fixed at advanced position. The engine vibration and engine stop occurred at the engine idle condition.

Components – OCV

2) A case study for the foreign substance clogs the OCV.



3) Specification

Relate Parts		**Foreign substance quantity** (Max)	**Size**
Parts	CVVT	2 mg	Max 0.4 mm
	OCV	1 mg	
	OCV Filter	0.1 mg	
Oil path	Oil Filter ~ OCV	2 mg	
	Entrance of oil path (OCV ~ Camshaft)	1 mg	
	Camshaft inside oil path	1 mg	
TOTAL		7.1 mg	

Components – OCV

4) NOTICE

① Be careful not to inflow the foreign substance while remove or install the CVVT related parts.

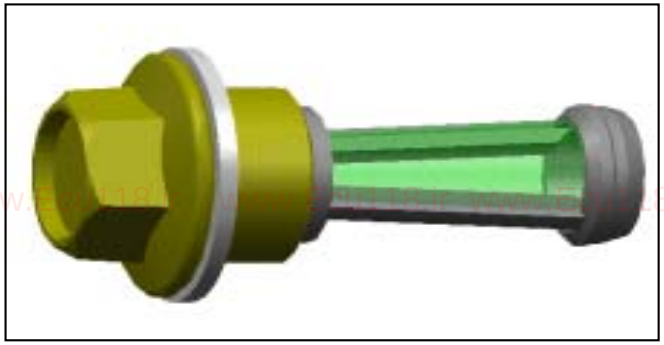
- CVVT ASS'Y
- OCV ASS,Y
- OCV Filter
- OTS(Oil Temperature Sensor)
- Camshaft ASS'Y
- HEAD BOLT etc.

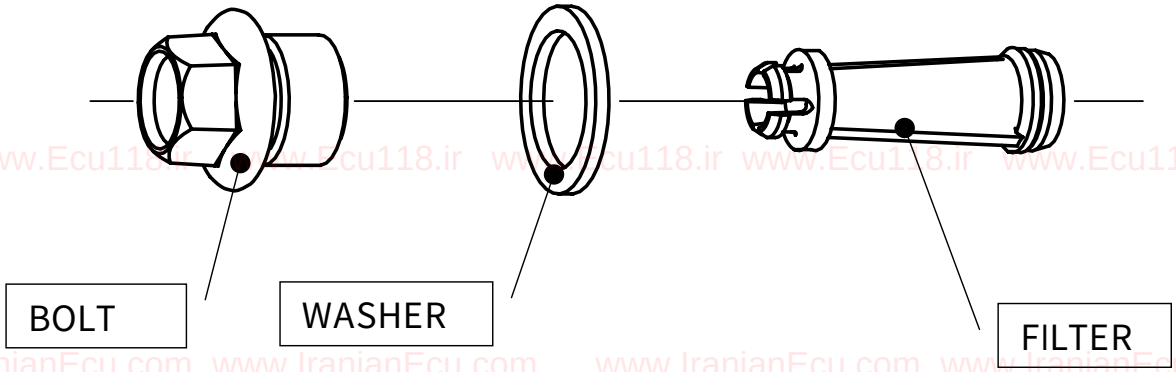
② Before reinstalling, you have to wash the related parts.

③ Wear the coated gloves instead of the cotton gloves.

Components – OCV Filter

3. OCV Filter





Attention

① When OCV Filter was replaced, ensure the cleanliness

- Prevent that OCV LOCK by foreign material

② When OCV Filter reassemble, replace the Washer with new one

- remove the foreign material by Air Gun, and clean up by the ether.

Confirm problem of OCV Filter

Disassemble the OCV Filter and check that foreign materials were trapped.

- If necessary, replace or clean up by Air Gun

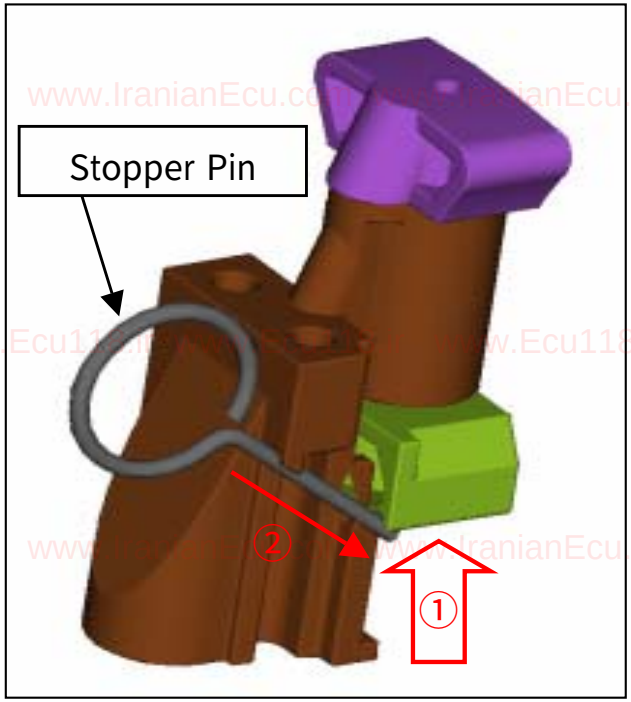
4. Auto Tensioner

Setting auto-tensioner before installation on the cylinder head

① Compress auto tensioner to retract it

② Insert the Stopper Pin

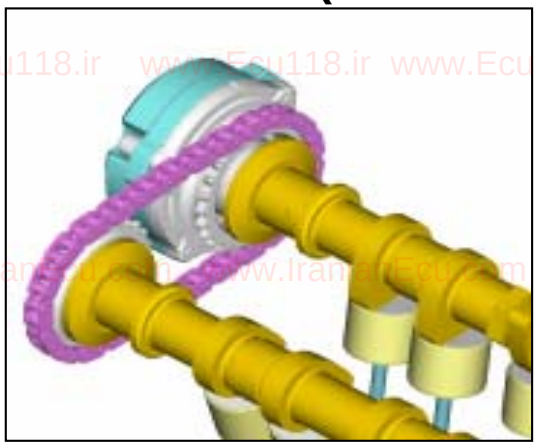
③ Assemble the tensioner to the cylinder head



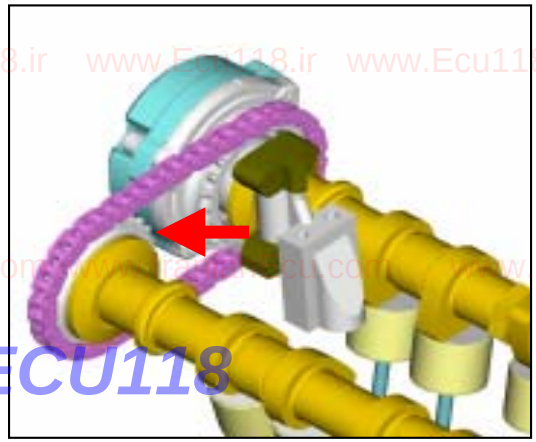
Components – Auto Tensioner

Assemble

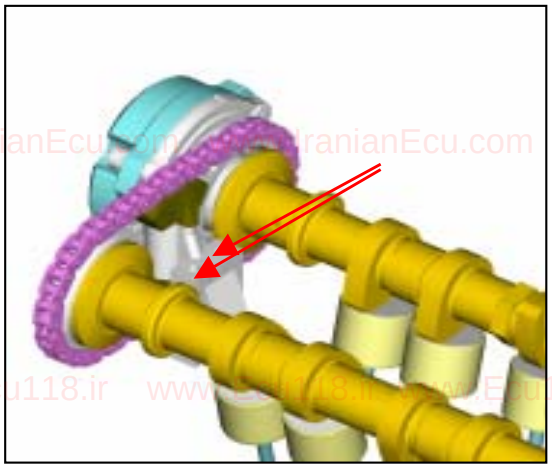
① Assemble camshaft and chain to head (caution : timing)



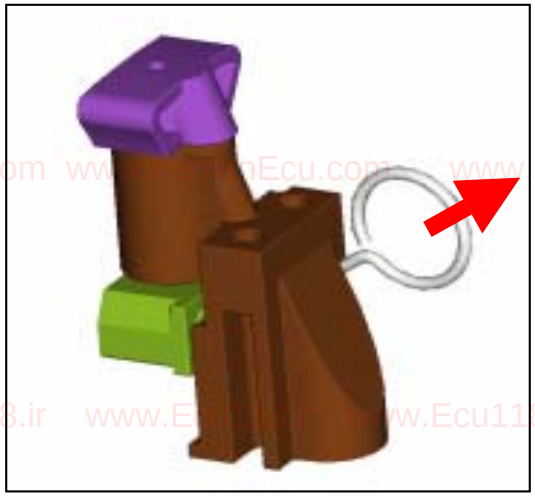
② Install Auto Tensioner as Fig



③ Assemble 2 bolts (Torque 0.8 ~ 1.0 kgf m)



④ Remove Stopper Pin



Attention

① Keep the tightening torque

② Timing

(Match the Timing Mark of the Sprocket and the Timing Chain)

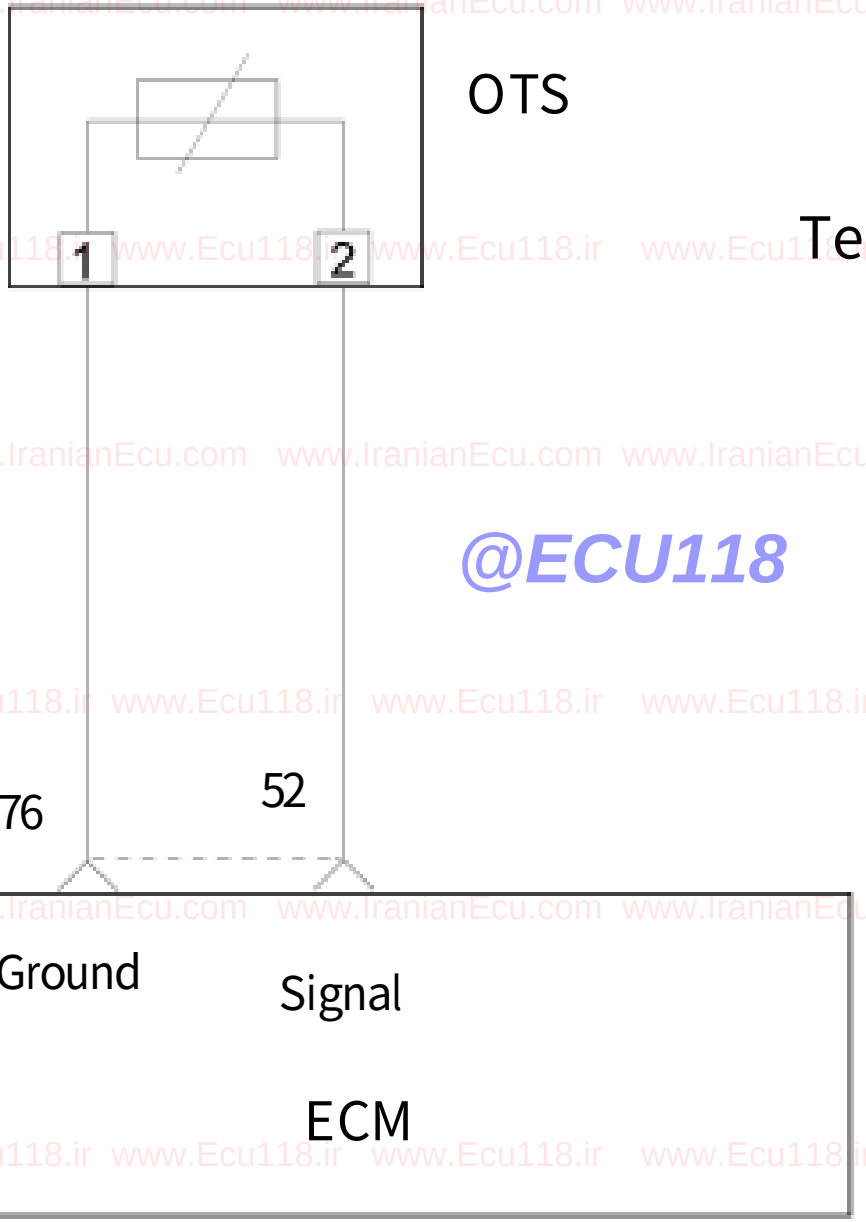
5. OTS (Oil Temperature Sensor)

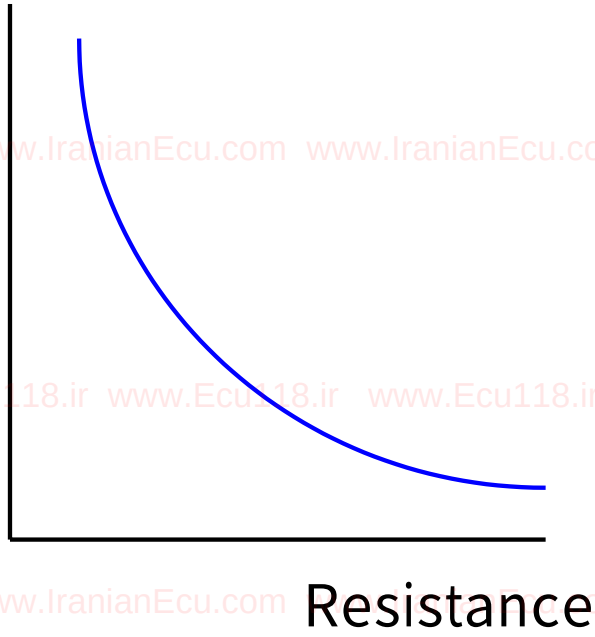
The OTS located on the passage of the engine oil. The CVVT is operated by the engine oil. The oil density is changed according to the its temperature. The control signal of the OCV is compensated by ECM depending on OTS signal.

The OTS is required in order to measure the temperature and it use a NTC type resistor.

Components – Auto Tensioner

OTS Circuit





Components – Auto Tensioner

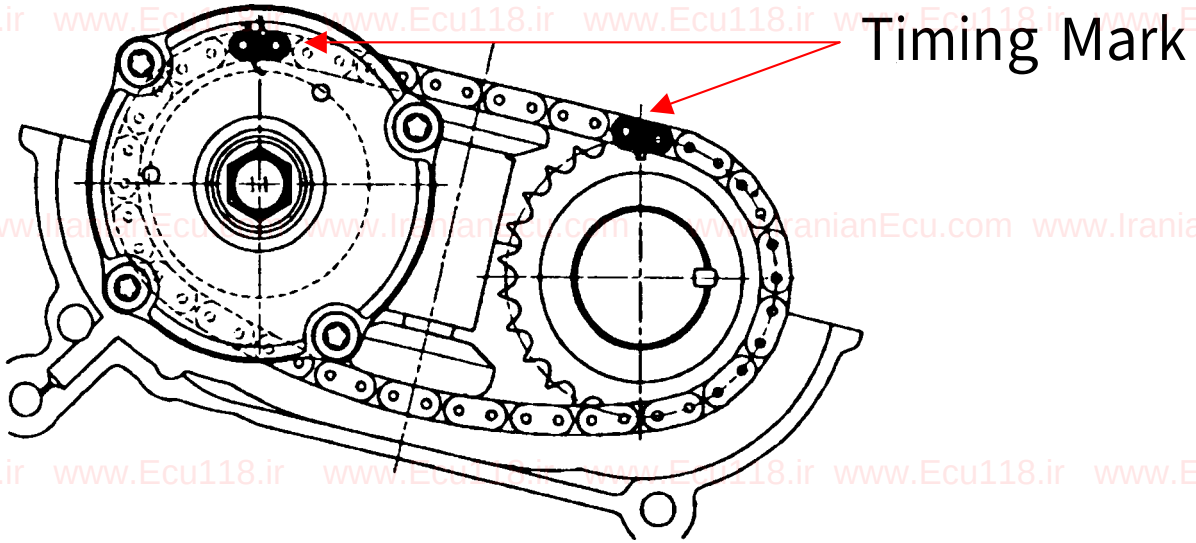
6. Timing Chain

① Align the timing marks

② Install the Timing chain as figure

* The timing chain of CVVT engine is different from current Beta engine which is not equipped CVVT system.

Vendor and chain pitch are different



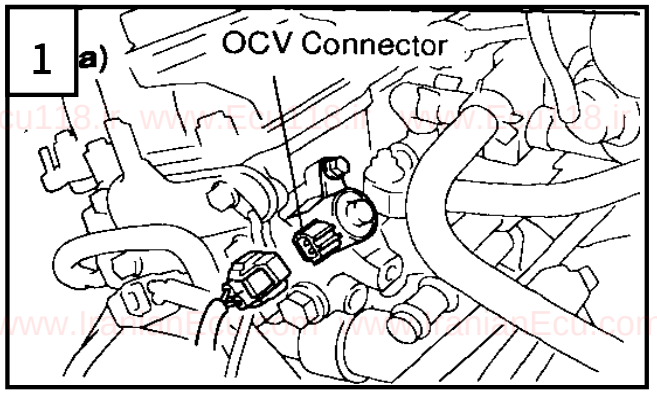
CVVT System Diagnosis

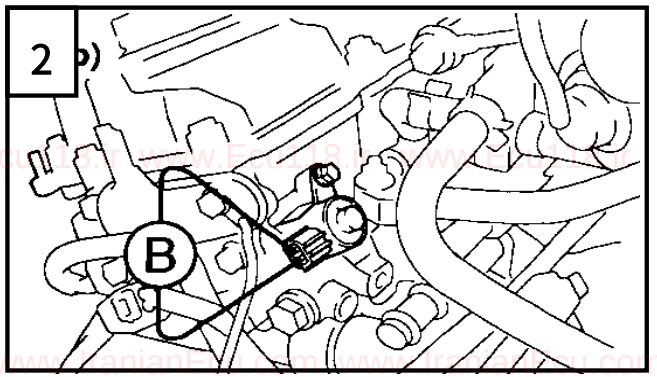
CVVT troubleshooting procedure

1) Start the engine at idle.

2) Test 2 items as shown in the below table at the idle condition.

	Condition	Test	Remark
1	Disconnect the OCV connector.	Check the engine condition.	To check the CVVT position at maximum retarded.
2	Connect battery voltage to the OCV connector.	Check the engine vibration and engine stop at engine idle condition.	To check the CVVT movement to advanced position.





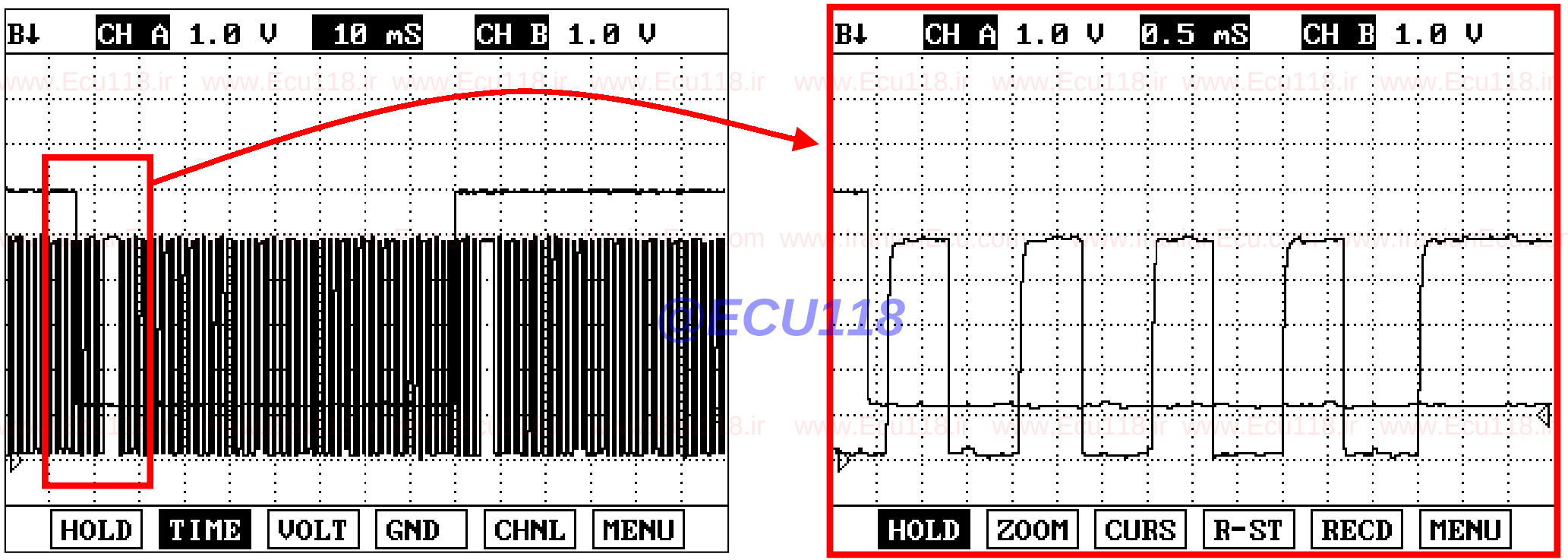
3) If problems are found by above test, Check each parts as following order.

Valve Timing → Sensor, ECU Output signal → CVVT ASS'Y → OCV → OCV Filter

* Refer to the parts inspection method in previous slides

CVVT System Diagnosis

CKP + CMP Waveform

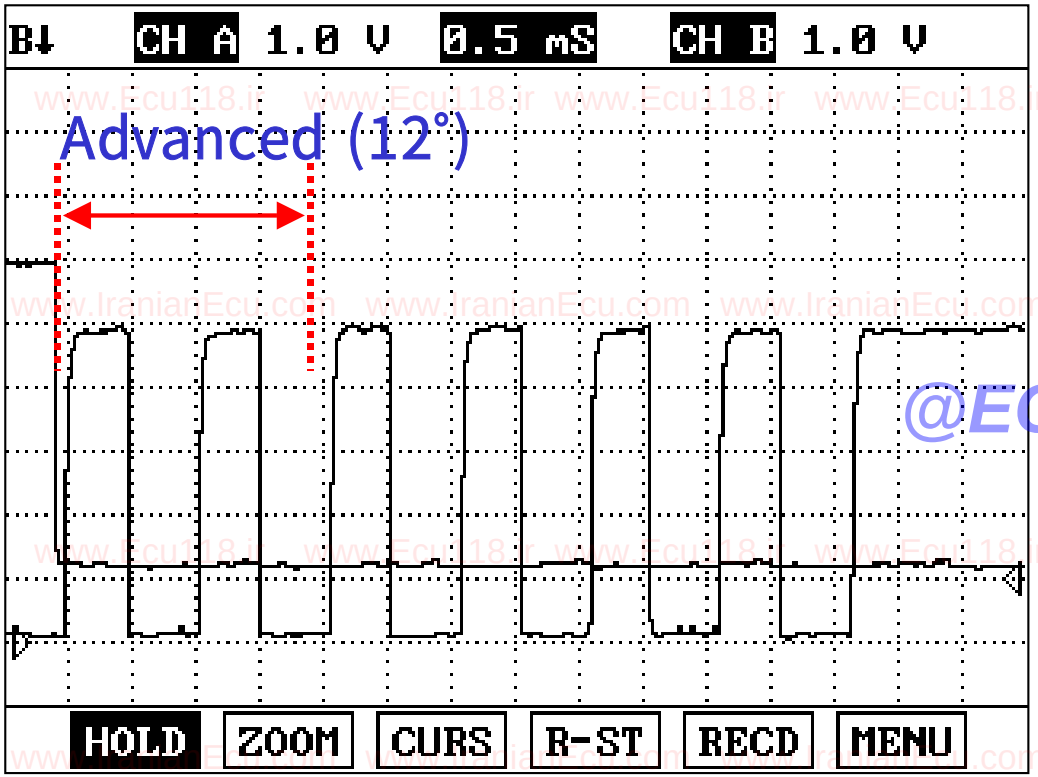


Idle condition, Maximum retarded

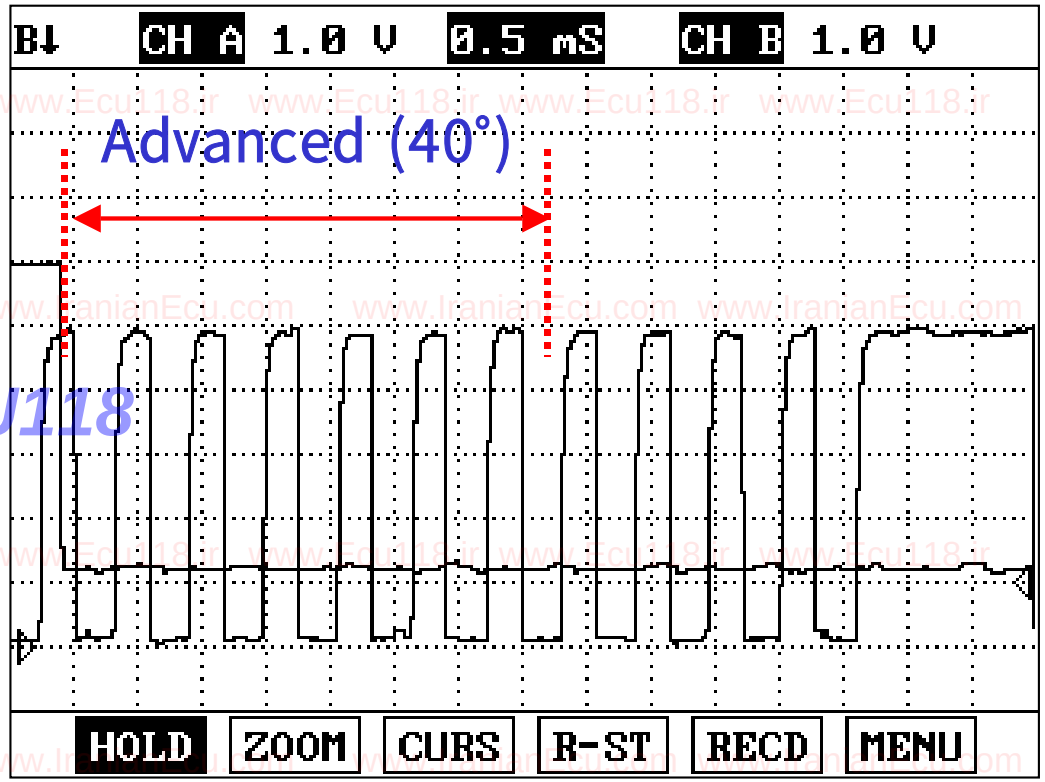
CVVT operation can be checked by waveform which is comparison between CKP and CMP.

CVVT System Diagnosis

CKP + CMP Waveform



1200RPM with load
(Increasing load slowly)



Maximum advanced, Full load condition

* 40° Crankshaft angle =
20° Camshaft angle

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CVVT System Diagnosis

DTC	Descriptions
P0010	Camshaft Position Actuator Circuit
P0075	Intake Valve Control Solenoid Circuit(B1) (OCV)
P0076	Intake Valve Control Solenoid Circuit -Low(B1) (OCV)
P0077	Intake Valve Control Solenoid Circuit -High(B1) (OCV)
P0196	Engine Oil Temperature Sensor Range/Performance
P0197	Engine Oil Temperature Sensor Low Input
P0198	Engine Oil Temperature Sensor High Input
P0341	Camshaft Position Sensor Range

CVVT System Diagnosis

P0010	Camshaft Position Actuator Circuit

Camshaft is mis-aligned exceed 5 degree of CA from target position, when the CVVT is operating.

Example)

1. Insufficient oil flow such as clogging, stuck of OCV, Oil leakage from CVVT assembly.
2. Improper operation of CVVT assembly.

P0341	Camshaft Position Sensor Range

Camshaft position is mis-matched with crankshaft position, when the CVVT is not operating (fully retarded position).

Example)

1. Mis-aligned the timing belt or the timing chain
2. Damaged CMP or CKP sensing teeth,
3. Wrong signal of CMP or CKP sensor

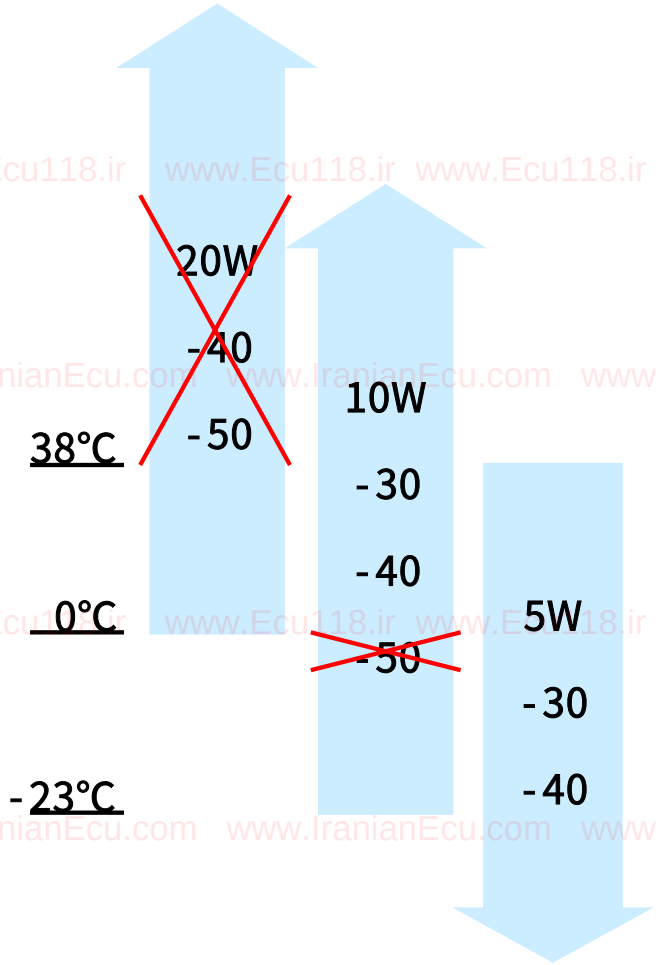
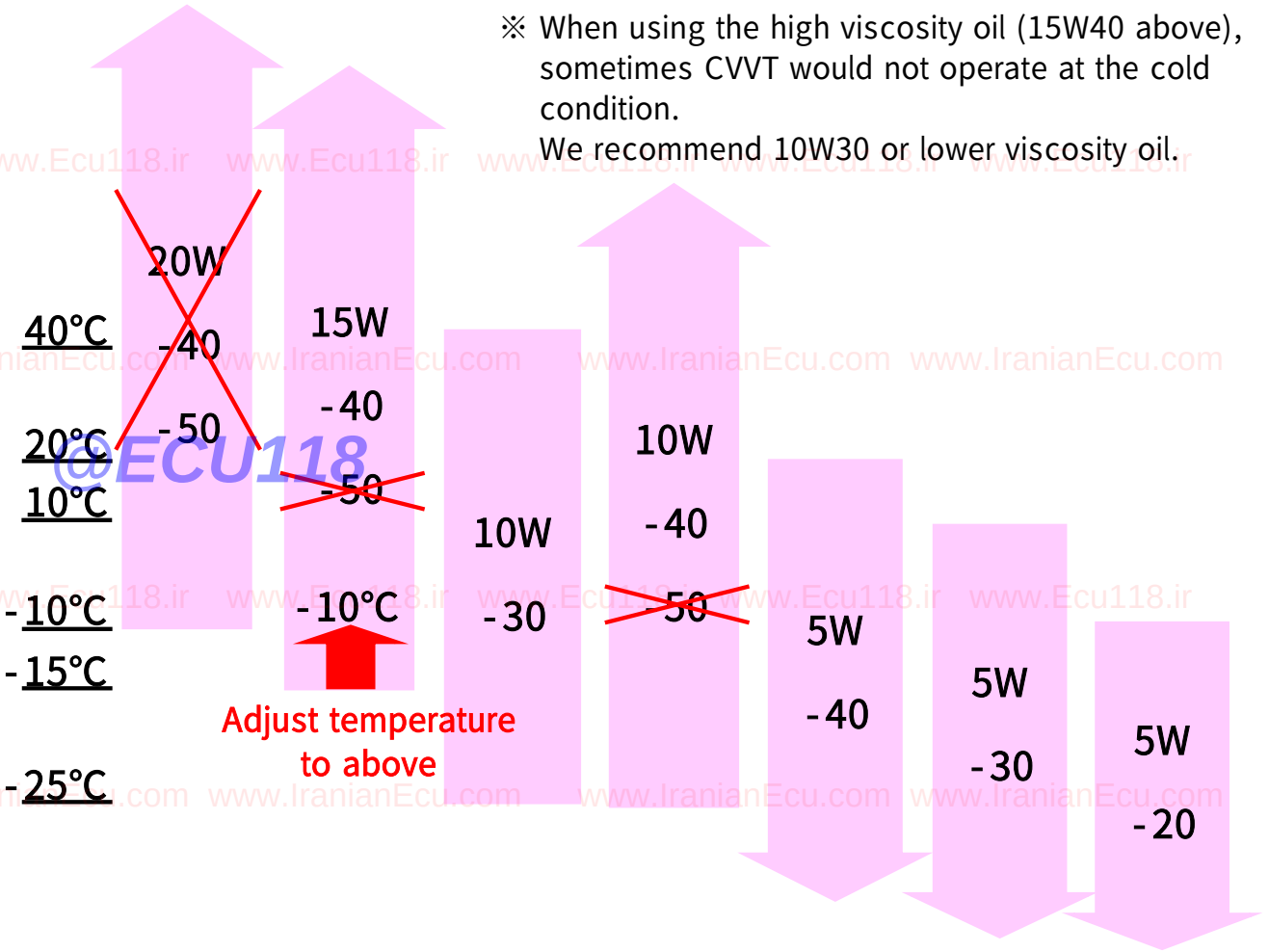
CVVT System Diagnosis

NO.	Item		Application on HI-SCAN (Compare with Hi-scan PRO)
	Description	Unit	
1	BATTERY VOLTAGE	V	
3	COOLANT TEMP. SENSOR	° C	
2	COOLANT TEMP. SENSOR(V)	mV	X
5	OIL TEMP. SENSOR	° C	
4	OIL TEMP. SENSOR(V)	mV	X
7	INT.AIR TEMP.SNSR	° C	
6	INT.AIR TEMP.SNSR(V)	mV	X
9	THROTTLE P.SENSOR	°	
8	THROTTLE P.SENSOR(V)	mV	X
10	ADAPTED THROTTLE	°	X
11	GRANKING SIGNAL	OFF/ON	
12	IDLE STATUS	OFF/ON	
13	PART LOAD STATUS	OFF/ON	X
14	MASS AIR FLOW	Kg/h	
16	VEHICLE SPEED	Km/h	
17	ENGINE SPEED	rpm	
18	TARGET IDLE SPEED	rpm	
19	TRANS.RANGE SW	P,N/DRIVE	
20	A/C SWITCH	OFF/ON	

CVVT System Diagnosis

21	A/C PRESSURE SW	OFF/ON	X
22	A/C COMP.RELAY	OFF/ON	
23	OXYGEN SNSR-B1/S1	mV	
24	OXYGEN SNSR-B1/S2	mV	X
25	IGNITION TIMING	°	
26	INJ.DURATION-B1	mS	
27	A/F CLOSED LOOP		
28	LONE FUEL TRIM-IDLE	mS	
29	LONE FUEL TRIM-P/LOAD	%	
30	O2 SNSR HEAT.DUTY-B1/S1	%	
31	O2 SNSR HEAT.DUTY-B1/S2	%	X
32	IDLE SPEED ACTUATOR DUTY	%	
33	EVAP.PURGE VALVE DUTY	%	
34	IGNITION DWEL TIME	mS	
35	CAMSHAFT POSITION	° CRK	X
36	CAMSHAFT POSITION-TARGET	° CRK	X
38	CVVT STATUS		
39	CVVT ACTUATION STATUS		
46	CVVT DUTY CONTROL STATUS		
43	CVVT VALVE DUTY	%	

Oil specification for Beta CVVT engine

	North America	Domestic/EU/General(Include Middle East)/Australia
SAE		※ When using the high viscosity oil (15W40 above), sometimes CVVT would not operate at the cold condition. We recommend 10W30 or lower viscosity oil. 
ILSAC	GF-I or above	
API	SH or above	

Models with CVVT system

VANE TYPE	TOYOTA	V6 3.0L	LEXUS RX300, ES300 New Previa etc.
		L6 2.0L	LEXUS IS200 etc.
		L6 3.0L/2.5L	CROWN(GDI)
		L4 1.0L	YARIS etc.
	SUBARU	H4 2.0L/2.5L	LEGACY etc.
HELICAL TYPE	TOYOTA	V8 4.0L	LEXUS LS400 etc.
		L4 2.0l	CARINA etc
	JAGUAR	V8 4.0L	XK8 etc