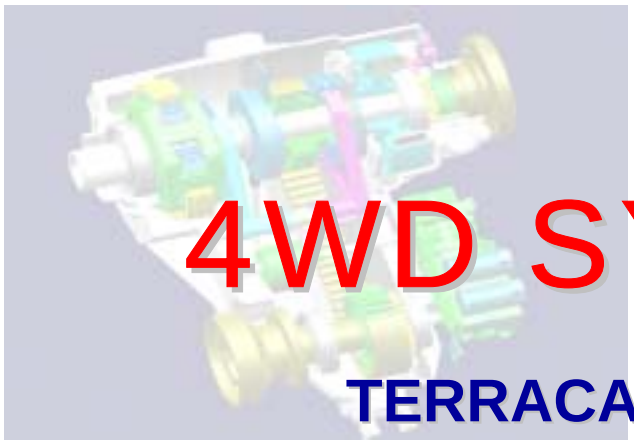


4WD SYSTEM

TERRACAN 4WD

SANTA-FE 4WD

GALLOPER 4WD

CONTENTS

PART TIME 4WD (EST) SYSTEM
EST(Electronic Shift Transfer)

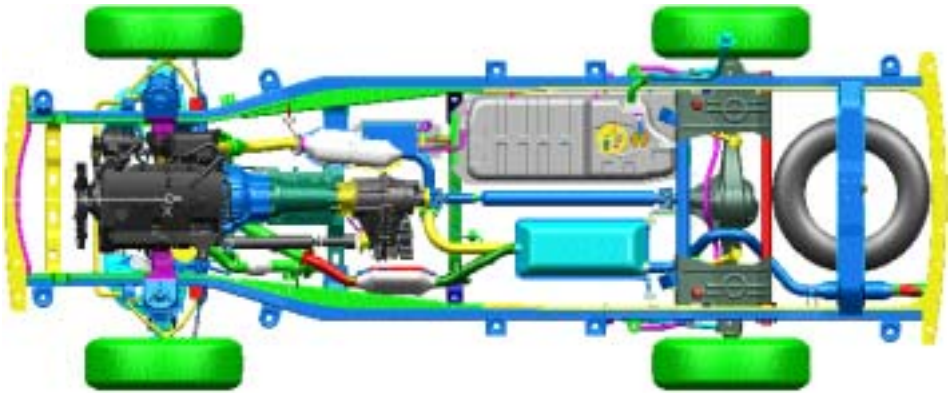
Santa-Fe D-VGT
Electronically Controlled On-Demand 4WD System

FULL TIME 4WD
SYSTEM of Santa-Fe (Center Diff+Viscous)

GALLOPER 4WD SYSTEM

PART TIME 4WD (EST) SYSTEM

EST (Electronic Shift Transfer) -Terracan



BASIC THEORY OF 4WD

1.1 2WD AND 4WD

Engine power enables a vehicle to get moving and to continue moving. To transfer the engine power into moving force an equal amount of traction is needed.

Traction is the resistance or friction happening between each tire and the ground surface. In 2WD the traction of only two wheels is used. The other two tires have traction as well, but they are just rolling along, in rear wheel drive vehicles they are used to steer the vehicle.

If more torque is applied than there is traction available, the 2 tires will lose its grip and start spinning. So, if in need of more power/torque to move more weight or to go faster more traction is needed. That can be achieved by mounting larger tires with a larger footprint or sending some of the torque to the other two wheels (4WD) and using their traction as well.

So, in 2WD power is divided towards 2 tires and the traction of those two tires has the burden of supporting the engine's power - each powered tire has deal with 50% of the available torque. In 4WD power is divided towards 4 tires. In 4WD the traction at each powered tire has to deal only with 25% of the torque created by engine, transmission, transfer case, and axle. Since each tire in 4WD has to carry a much smaller torque load (25% instead of 50%), it is much less likely for the tires to lose its grip. That is why a 4WD can climb much steeper grades than a 2WD. Because much more torque is needed to move the vehicle up a steep grade, and only when the torque load is spread out over 4 tires instead of 2 tires it is supported by sufficient traction.

All this is true with all 4 tires on the same surface and each wheel loaded down with 25% of the vehicle's weight. The very moment one tire gets onto a surface with less friction (resulting in less traction) than the other wheels - at least one differential will start acting up. The very moment one tire, due to rolling into a small rut for example, gets to carry less than 25% of the vehicle's weight (also resulting in less traction).

The wheel with less traction will receive more than 25% of the torque (power is always following the path of least resistance) the wheel with more traction will get less torque. The opposite wheel will get little or no torque and cannot keep the vehicle moving. 4WD was invented to use the traction of all 4 tires to either move more weight or drive on surfaces with marginal traction, or both.

Differential locks and traction control are invented to counteract the "stupid" differential's intention of wasting torque on wheels with little or no traction. All driven axles have to have a differential to make it possible in turns to send more rpm and more torque to the outside wheel and less rpm and less torque to the inside wheel of a turn.

In general:

- 4WD is helpful to get moving and supports directional stability.
- 4WD is not helpful to go faster.
- 4WD is not helpful to stop the vehicle.

1.2 FULL TIME 4 WHEEL DRIVE VS. ALL WHEEL DRIVE (AWD)

Full time four wheel drive (not part time 4WD) is a system that powers all four wheels at all times. Each tire gets about 25% of the available torque. Driver has a choice of a "4-high" and "4-low".

When "4-low" is selected the wheels receive substantially more (on Terracan of HMC and Sorento of KMC, its 2.48 times more) power than in "4-high", at the same time the vehicle moves at substantially slower speeds (2.48 times slower).

The low setting is an advantage for drivers who need to tow and maneuver a heavy trailer etc and for drivers who at one point or another may want to negotiate difficult off-road terrain.

All wheel drive is a system that powers all four wheels of a vehicle at all times as well. Difference to full time 4WD is that "4-low" is not available. Due to the lack of "low range" AWD vehicle are much less capable than 4WD vehicles.

1) All Wheel Drive (AWD)

- Only mode is 4WD full time, - No 2WD available, - No 4WD "low" available,
- Center differential locks automatically (Torsen diff, viscous coupling),
- Almost useless beyond pavement, - No transfer case

2) Full Time 4WD

- Main mode is 4WD. 4WD is used full time.
- No 2WD mode available.
- All four wheels are powered at all times. Operates well on dry pavement due to a center differential or equivalent device (viscous coupling, planetary gears).
- Part Time 4WD does not have a center differential. A center differential is essential for on-road use but can be detrimental for off-pavement use. When leaving pavement the center differential needs to be disabled (locked). It either locks automatically or it has to be locked (disabled) manually.
- Normal setting for on-road use and light duty off-road use is 4WD "high"
- For more torque 4WD "low", also called low range, is available. Low range substantially provides more torque to the wheels and allows slower speeds than in high range. 4 low does not provide more traction. It only provides more torque.

3) Part Time 4 Wheel Drive

- Main mode is 2 wheel drive for everyday pavement use. Only rear wheels are powered. (In some cases front wheels are powered instead)
- When needed (usually beyond pavement) 4WD can be engaged. (4WD is used part time)
- When 4WD is engaged front wheels are powered as well.
- There are two different settings for 4WD "high" and "low"
- 4WD "high", called high range, cannot be used on dry pavement with a "part time " system.
- For extreme situations 4WD "low" is available, it cannot be used on dry pavement either. 4WD "low", also called low range does not provide more traction. However, it provides two to three times more torque at about half or a third of the speeds in high range.

1.3 ADVANTAGES AND DISADVANTAGES OF 4WD

1) **Traction and Grip :**
   Apparently, 4-wheel drive brings traction and grip to higher level because the tractive effort is shared by 4 wheels instead of two. This enable higher cornering limit, especially in rough roads and wet condition. Since it was introduced in 1980 to rally cars, 4WD proved its superiority in this aspect.

2) **Weight penalty and power loss :**
   Because the driving mechanism of the additional wheels has frictional loss, 4WD consumes a little bit more power than 2WD cars. Anyway, this is still a fraction compare with the increased weight. Most 4WD systems weigh 50kg-100kg more than a 2WD system, thus deteriorate acceleration as well as fuel consumption.

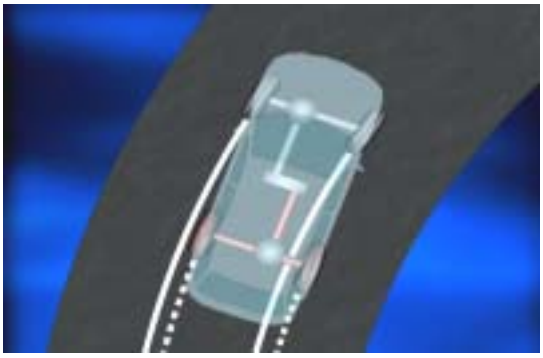
3) **Steering tendency :**
   As mentioned in our study of handling, in theory, permanent 4WD cars generate neutral steering tendency, thanks to the tractive force sharing by all 4 wheels. However, in reality this become much more complicated. Steering tendency can also be corrected by weight distribution, the adjustment of camber and castor, the choice of different size tires in front and rear etc. Moreover, it is widely agreed that a slight oversteering, if could be accurately controlled by throttle and steering, is even more satisfying than neutral steering. In contrast, most 50:50 permanent 4WD cars can hardly enable oversteering, unless in really slippery surface.

4) **Steering feel :**
   Depends on tuning, some 4WD cars deliver less steering feel, since the presence of torque in the front wheels may generate slightly torque steer. However, most modern 4WD cars overcame this problem.

1.4 BASIC LAYOUT OF 4WD

A modern 4-wheel drive system must has 3 differentials - one in the front axle to distribute torque between the left and right front wheels, one in the rear axle again responsible for torque distribution, the third one, calls Center Differential, distributes torque between front and rear axles.

We all know the objective of differential. During cornering, the outside wheels have to travel faster than the inside wheels, therefore we need a differential to distribute different torque to the wheels. For a 4WD car, we in addition need the Center Differential because the front wheels have to travel faster than the rear wheels. The following diagram illustrates this:



If without the center differential, the non-conformance of front and rear wheel speed will lead to tire slip as well as energy losses, tire roar, wear of tires etc. Therefore center differential is a must for modern cars.

1.5 LSD OF 4WD

However, just the 3-differential layout alone cannot cope with the basic requirement for 4WD - provides superior grip in the worst roads. In real world driving, for instance, when pushing the car over its limit in corner, or running on slippery surface, tire slip is inevitable. When a wheel loses traction, a normal differential will transfer nearly all the driving torque to that wheel. As a result, the spinning wheel will spin even wilder, but the wheel that having traction will never share driving torque, therefore the car will be difficult to get out of the trouble. This problem occurs in all kinds of car, no matter 2-wheel drive or 4WD, but it is relatively more important to 4WD because 4WD cars are designed to run in worse roads or cornering harder.

Therefore 4WD cars (or even many latest 2WD sports cars) need Limited Slip Differential (LSD). A LSD lock up both drive shafts whenever tire slip occurs, thus helps the car get out of trouble quickly. The result is enhanced stability and even higher cornering limit.

In fact, LSD is the core of 4WD technology. There are several types of LSD: Torsion LSD, Viscous Coupling LSD, VC differential lock and Active LSD. They have different effectiveness, characteristic and cost so that car makers choose them according to their needs.

Regarding 4WD vehicle such as Santa-Fe(for rear diff.) of Hyundai motors and Sportage, Sorento of Kia motors, Carbon Disc LSD is adapted for the rear as an option.

2. TERRACAN 4WD SYSTEM

2.1 4WD SPECIFICATION

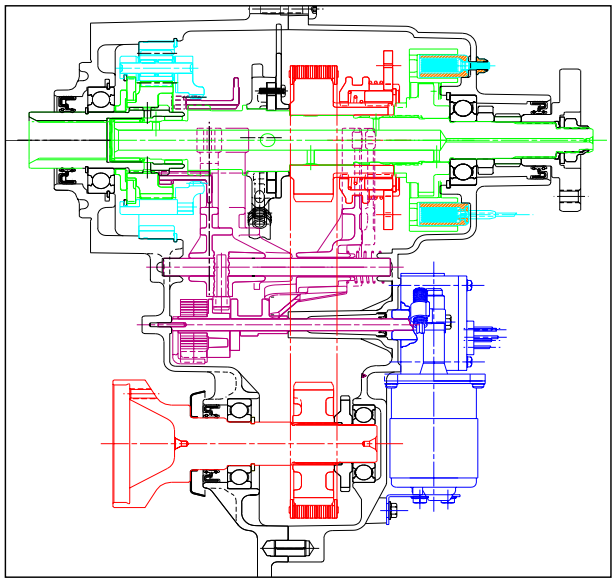
EST: Electrical Shift Transfer is standard on all models and trims for part-time 4WD, allowing drivers to “shift on the fly” between two- and four-wheel-drive modes at speeds up to 80 km/h.

ATT: Active Torque Transfer (or “Torque-on-Demand”) electronically transfers power and torque from the rear to the front as required, enhancing off-road traction, handling agility and steering precision.

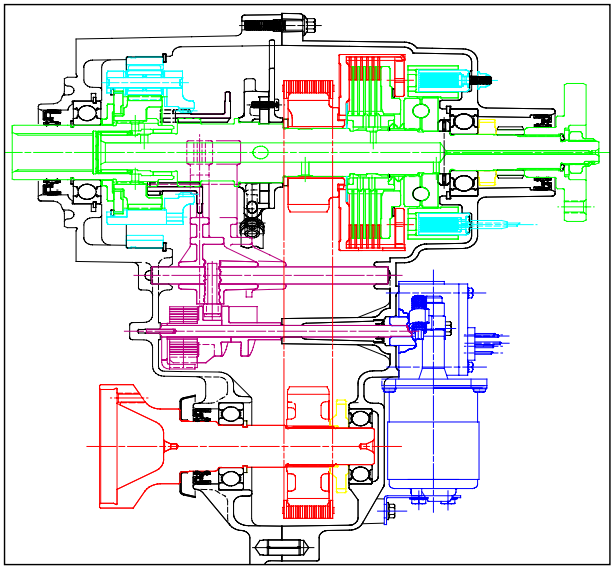
[Comparison between the Part Time 4WD and the Full Time 4WD]

Items	Parts time	Full time
Engine	DSL 2.5, 2.9 GSL 3.5	
Type	Electronic shift transfer	Active torque transfer
Model	BWA 44-24 ESOF	BWA 44-24 TOD
FRT axle connection	CADS	No CADS (Full time connection)
Weight (Kg), Length(mm)	35, 351	37.3, 351
Gear ratio (HIGH)	1 : 1	
Gear ratio (LOW)	2.48 : 1	
FRT driving type	Chain	
Lubricant	DEXRON Ⅲ (Permanent use : No replacement)	
Lub. Quantity (L)	1.42	
CADS solenoid valve	○	×
Front speed sensor	×	Hall IC effect type
Rear speed sensor	Pulse generator	Hall IC effect type
Vehicle speed sensor	Hall IC effect type	Hall IC effect type

2.2 SYSTEM CONSTRUCTION (EST, TOD) & OPERATING CONDITION



[EST]



[TOD]

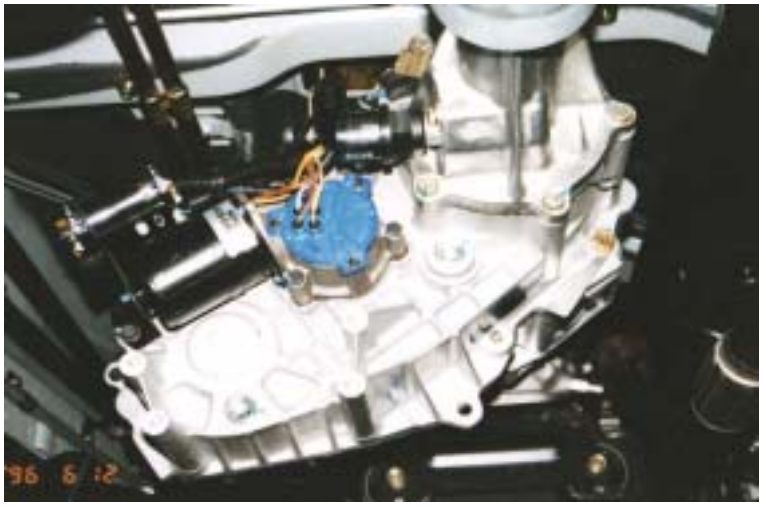
Drive type	Drive item	Drive mode	Drive status	Useful condition
Electric Shift Transfer (EST type)	Drive mode	2H	2WD, Rear wheel drive	Use on the roadway.
		4H	4WD HIGH	* Use on the off-road or snowy and rainy road having slippery road surface. * When turning on the roadway at low speed, vibration and noise happens by tight corner braking.
		4L	4WD LOW	Use in the condition which driving force is required like escaping from rough way and towing.
	Transfer	2H ↔ 4H	2WD ↔ 4WD	Possible to transfer 2WD into 4WD and vice versa at 80kph or below during driving.
		4H ↔ 4WD(L)	4WD(H) ↔ 4WD(L)	* Necessary to stop the vehicle for transfer - M/T vehicle : Transfer after pressing the clutch pedal. - A/T vehicle: Transfer after positioning the A/T lever to “N”. * All vehicles with 4L mode should stop the vehicle for transfer.
Active Torque Transfer (ATT type)	Drive mode	AUTO	2WD ↔ 4WD	* Use on the various road surfaces including roadway, off-road, or snowy and rainy road surface. * Using multiple clutch, control the revolution difference between front and rear wheels electronically. So this mode can correspond to the various road surfaces by controlling the ATT unit automatically.
		LOW	4WD LOW	Refer to 4L of part time.
	Transfer	AUTO ↔ LOW	4WD(H) ↔ 4WD(L)	* Necessary to stop the vehicle for transfer M/T vehicle: Transfer after pressing the clutch pedal. A/T vehicle: Transfer after positioning the A/T lever to “N”. * All vehicles with 4L mode should stop the vehicle for transfer.

3. EST (ELECTRONIC SHIFT TRANSFER)

3.1 INTRODUCTION

EST system is a kind of part time 4wheel drive system and its full name is ‘Electric shift transfer. Instead of previous free wheel hub, CADS (center axle disconnect system) was adopted and this one is for SOTF(shift on the fly) while vehicle driving. When the vehicle runs with 2WD again, the front axle will be rotated idly due to the vehicle speed and this makes the noise and vibration on the propeller shaft and ring gear set. Therefore CADS will prevent this phenomena to get a driving stability, efficiency and improved NVH.

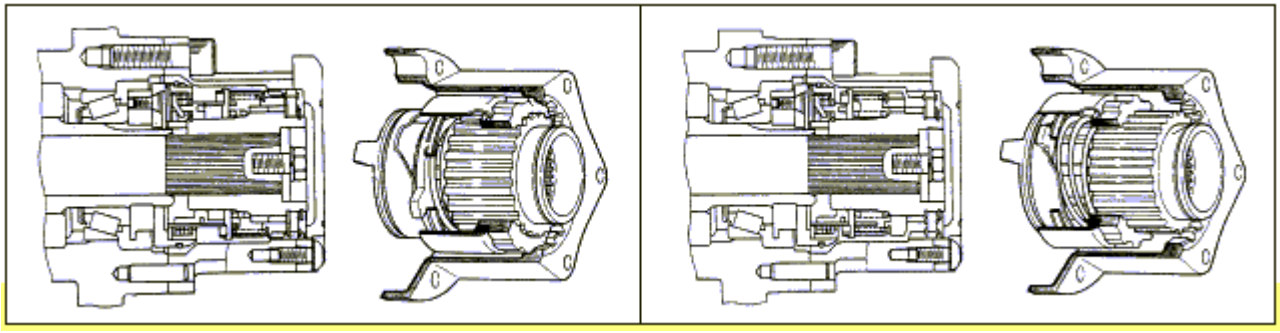
When 2WD is selected by driver, the shift fork is moved due to the spring force of actuator and pressure difference of solenoid valve. Then the sleeve is moved and it results disconnection between axle shaft and differential shaft. Oppositely, if 4WD is selected by driver, the axle shaft and differential shaft is connected so as to be driven by 4WD.



[EST Transfer Case]

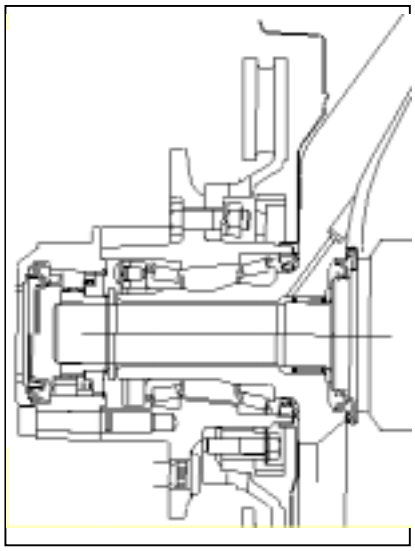
3.2 KINDS OF SOTF SYSTEM IN PART TIME 4WD

1) CAM type auto free wheel hub



2) Vacuum type free wheel hub

- Application vehicles: HMC H-1, KMC Sportage
- SOTF is activated in condition of 40km/h or less.
- In respect of durability, it is difficult to prevent the air leakage on the wheel end side.



3) FRRD(Free Running Differential)

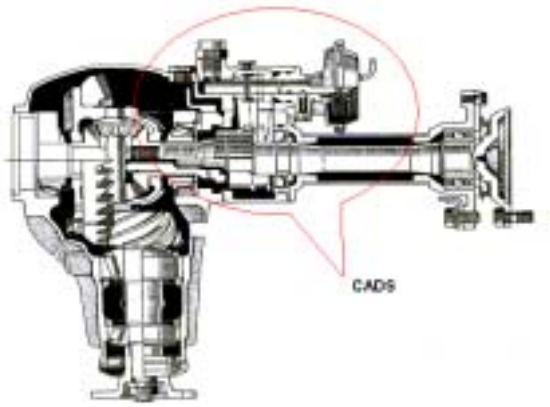
SOTF(Shift On The Fly) system for KIA Sorento is a FRRD type. Sportage, previous KIA 4WD model, has incorporated two types of SOTF system one is a CAM type auto free wheel hub system used till 1999 model, the other type is a Vacuum type free wheel hub system.
A vacuum type has made better performance than a CAM type. But it still has a problem like an air leaking in a hub which is exposed all the time.

FRRD is installed in the front axle. A driver selects 4WD mode, air pump motor is energized and a dog clutch is engaged connecting a front propeller shaft and a front drive shaft. If a drive selects 2WD mode on driving, the dog clutch is disengaged disconnecting the drive force to a drive shaft.

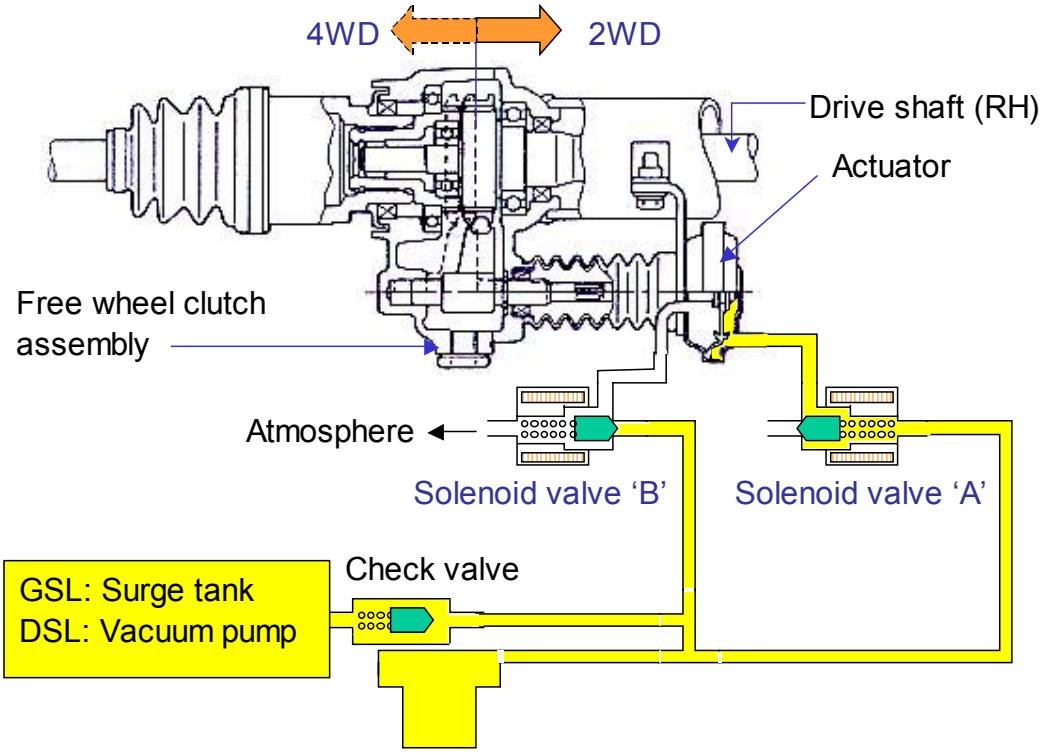
[FRRD case]

[FRRD outer case]

3.3 CADS (Center axle disconnect system) type

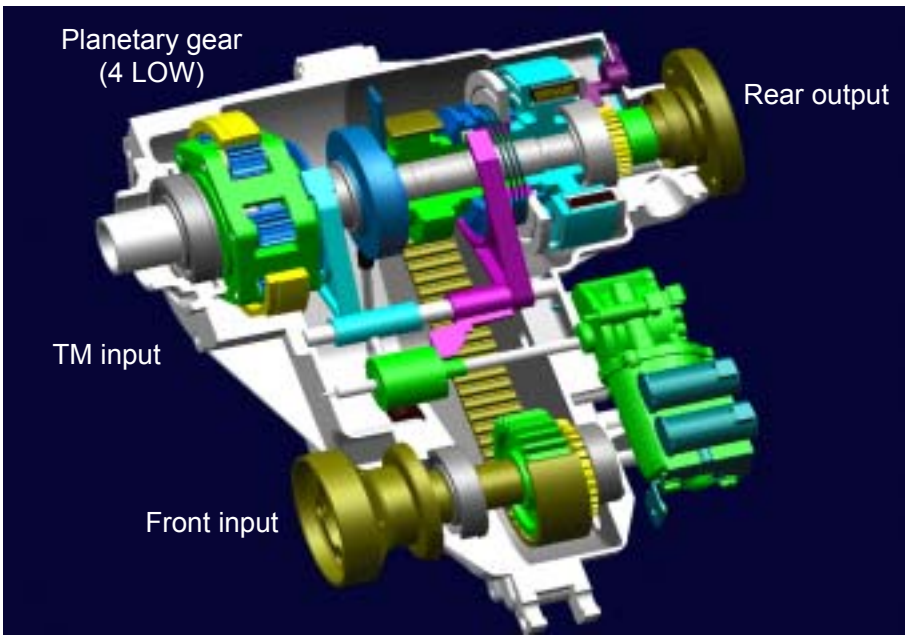


- CADS is activated at 80km/h or less.
- Application vehicles : HMC Terracan, MMC Pajero, Challe



When 2WD is selected by driver, the shift fork of the CADS moves by the pressure difference of each side of the diaphragm inside actuator. It results disconnection between axle shaft and differential shaft. Oppositely, if 4WD is selected by driver, the axle shaft and differential shaft is connected so as to be driven by 4WD.

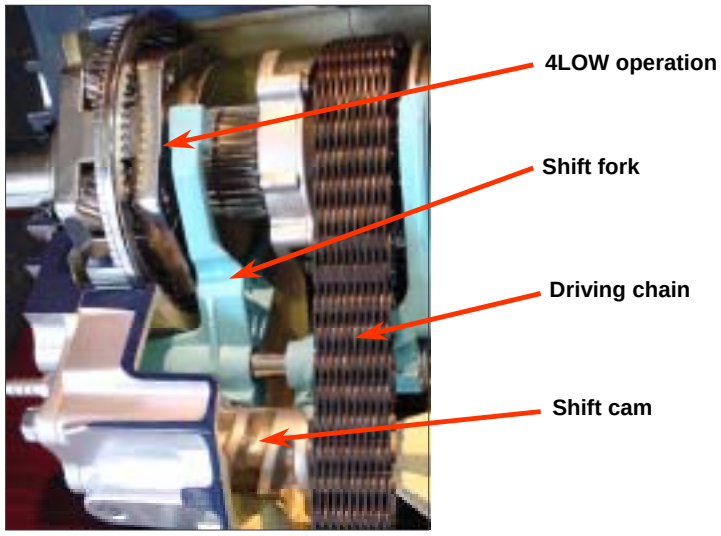
3.4 COMPONENTS

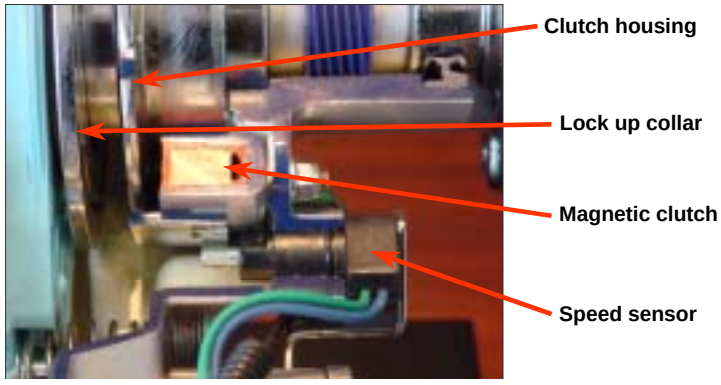


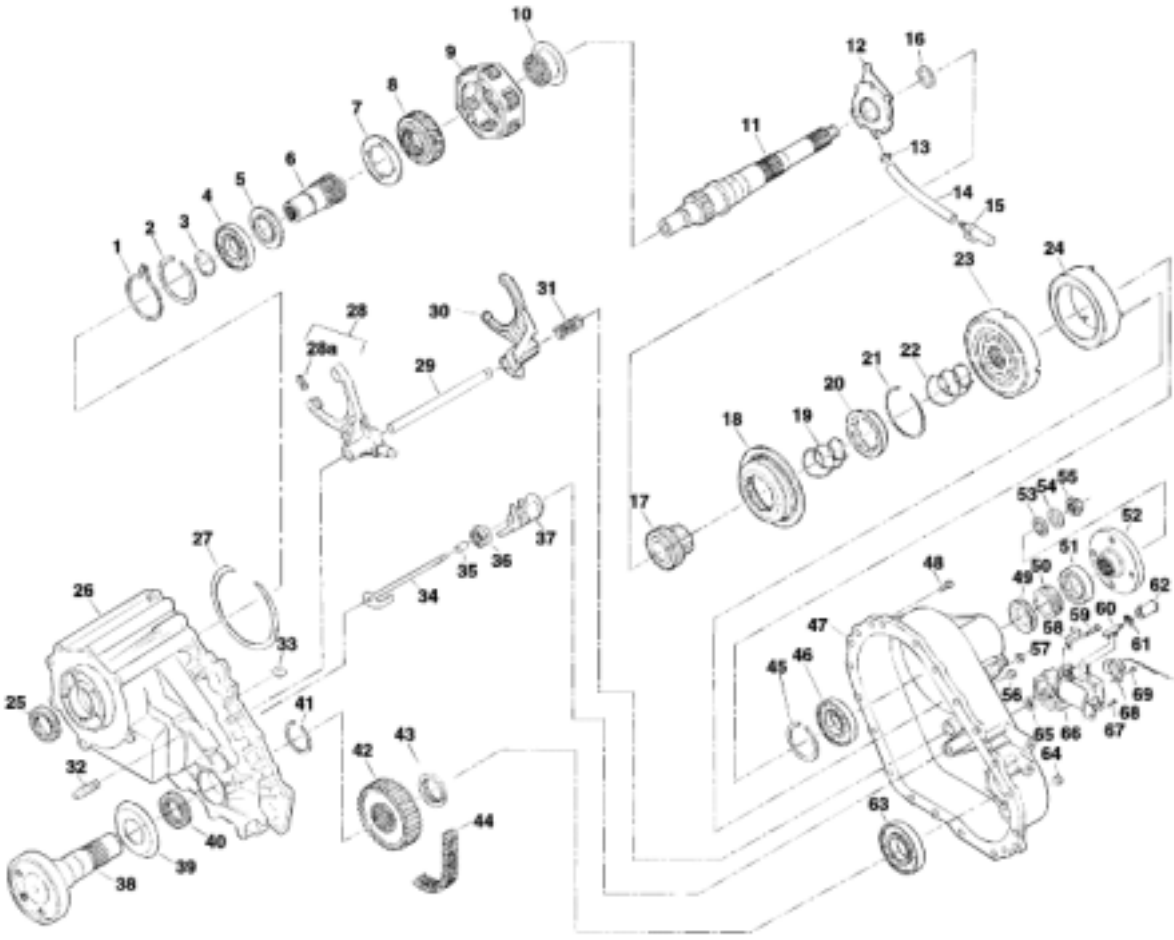
EST case and TOD case looks almost same. But inside it, EST and TOD has some different part for a part time or a full time mechanism.

In case of EST, a lock-up fork and a lock-up collar is added for a part time mechanism. And EST only has a rear output speed sensor differently from a TOD transfer case which has a front output speed sensor as well.

A 4 low mode transfer part which has a planetary gear set to make an output gear ratio of 2.48:1 is the same as that of TOD.

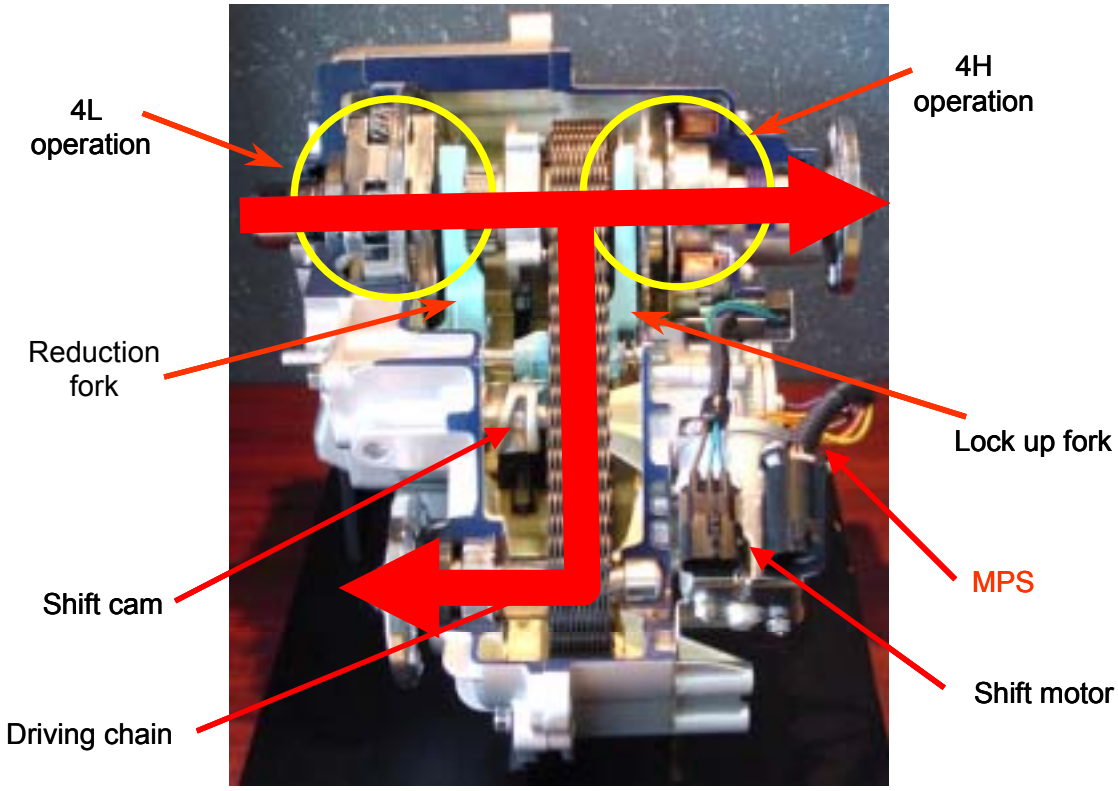






1. Snap ring
2. Snap ring
3. Snap ring
4. Bearing
5. Hub
6. Input shaft
7. Thrust plate
8. Sun gear
9. Carrier
10. Reduction hub
11. Main shaft
12. Rotor pump
13. Hose clamp
14. Hose
15. Filter
16. Thrust washer
17. Upper sprocket
18. Lock-up collar
19. Sleeve return spring
20. Lock-up hub
21. Snap ring
22. Spring
23. Clutch housing
24. Electric coil
25. Oil seal
26. Transfer case
27. Retaining ring
28. Shift fork
28a. Shift fork pad
29. Shift rail
30. Lock-up fork
31. Return spring
32. Breather
33. Magnet
34. Shift shaft
35. Spacer
36. Torsion spring
37. Shift cam
38. Output shaft
39. Dust defector
40. Oil seal
41. Snap ring
42. Lower sprocket
43. Spacer
44. Chain
45. Retaining ring
46. Bearing
47. Cover
48. Nut
49. Tone wheel
50. Speedo gear
51. Oil seal
52. Companion flange
53. Oil seal
54. Washer
55. Nut
56. Pipe plug
57. Nut
58. 'J' clip
59. Bolt
60. Clip
61. Connector lock
62. Connector
63. Bearing
64. Plug
65. Oil seal
66. Electric motor
67. Bolt
68. Speed sensor
69. Bolt

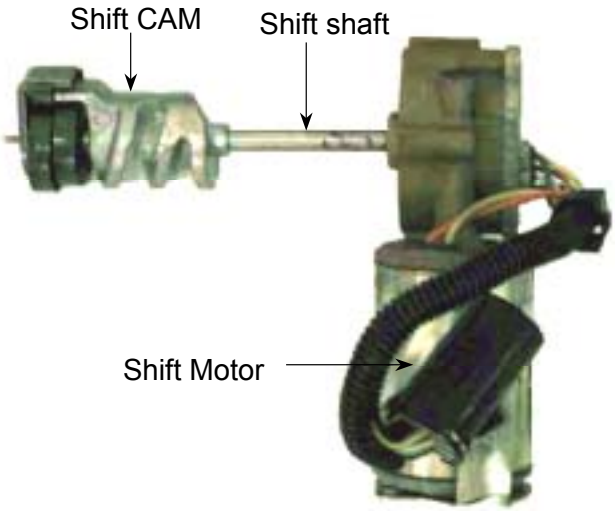
3.5 POWER FLOW



LOCK-UP SHIFT FORK

Comparing with the TOD transfer, EST has one more shift fork for engaging 2WD and 4WD. That is a 'Lock up shift fork'.

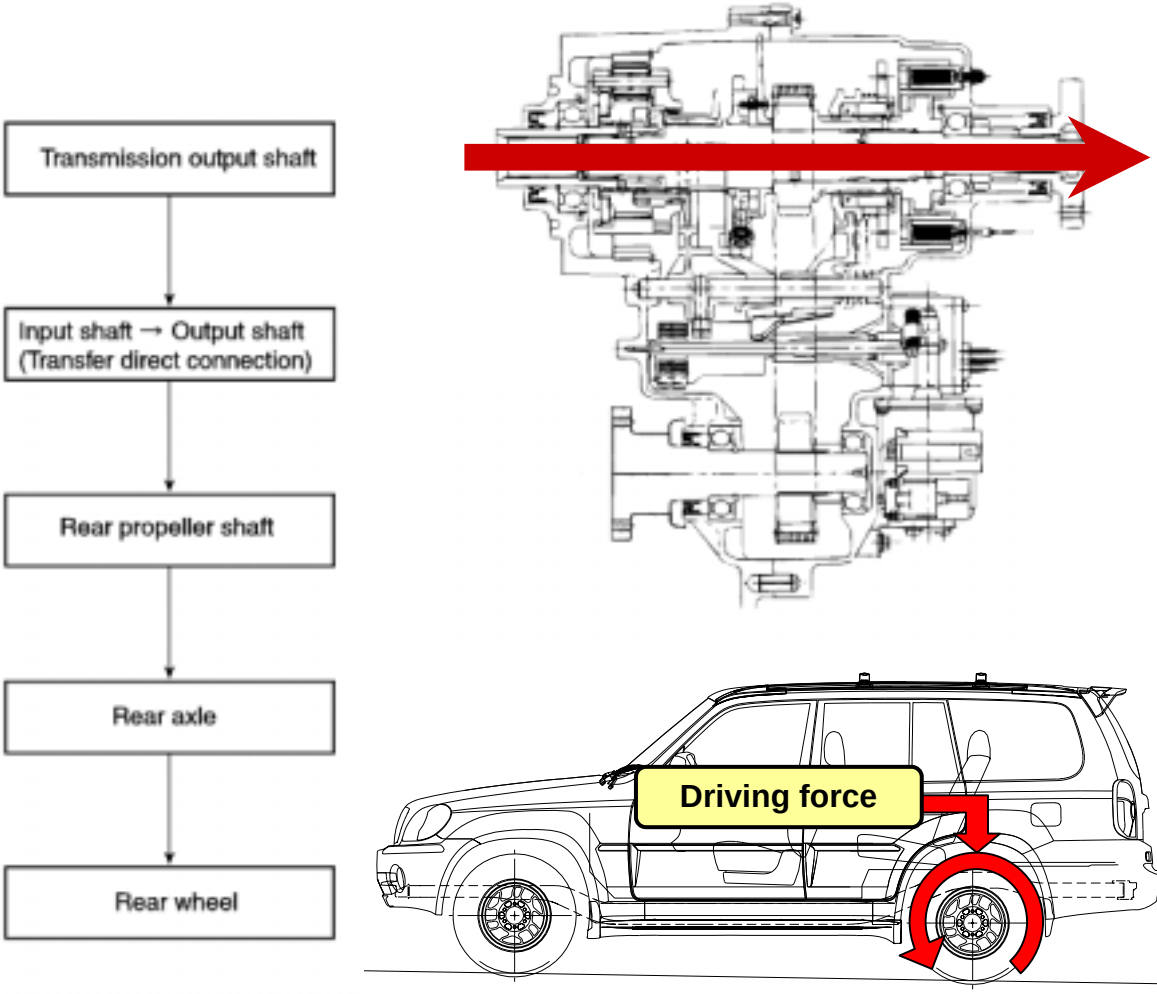
	EST	TOD
Reduction shift fork	Yes	Yes
Lock up shift fork	Yes	No



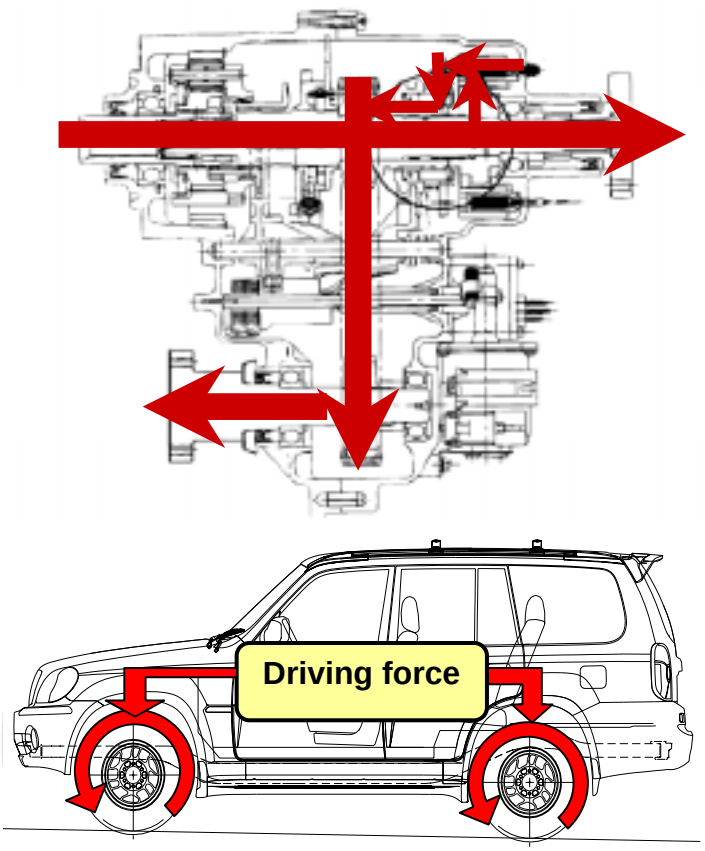
1) POWER FLOW: 2H Mode (Rear Wheel Drive)

At 2H mode, driving force coming from a transmission output shaft directly delivered to the rear output shaft. A shift motor does not operate making a lock-up shift fork remain still.

However, driving chain that transfers the rear output speed to the front output shaft can rotate because of the front wheel rotation while driving. The front wheel rotation is transferred into the transfer case rotating a drive chain. To prevent this, front drive shaft and front propeller shaft connected with a transfer case should be disconnected at 2H mode. FRRD(Free Running Differential) is a kind of center axle disconnect system for that purpose.



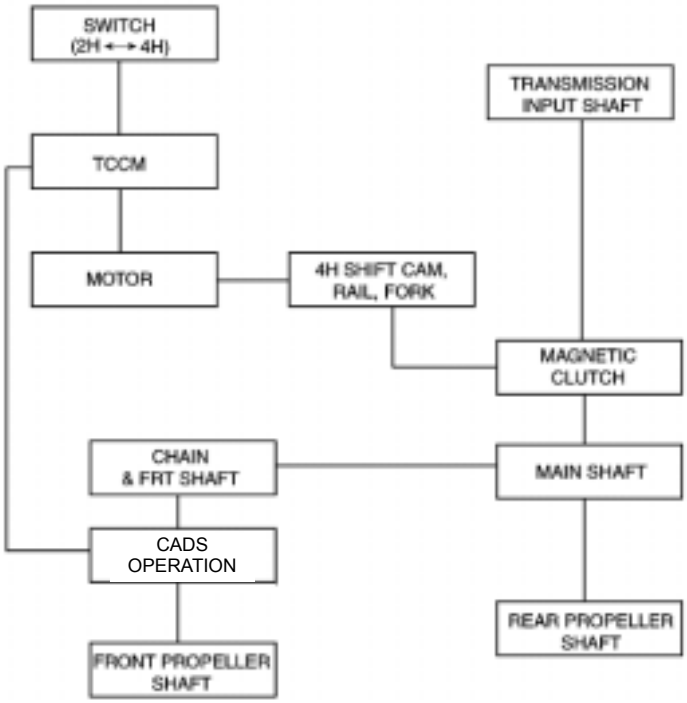
2) POWER FLOW: 4H Mode



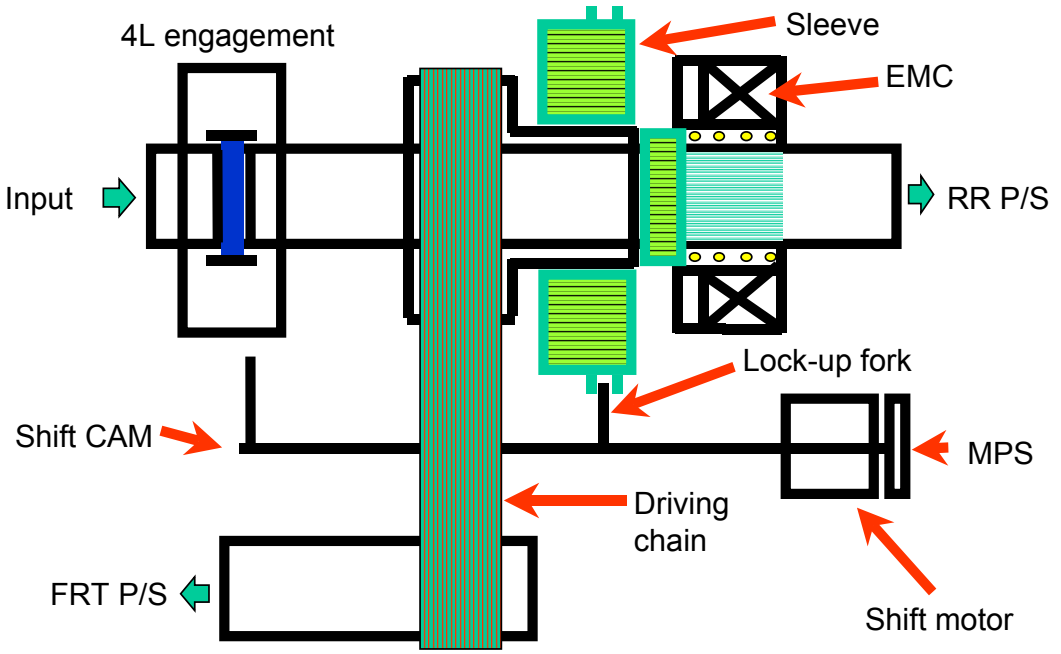
At 4H mode, TCCM(Transfer Case Control Module) sends a signal to the shift motor to rotate. Shift motor rotation slides up a lock-up shift fork which is connected a lock-up shift collar.

The Shift collar is engaged an upper sprocket that drives a drive chain delivering a drive force to the front shaft as soon as a magnetic clutch is on.

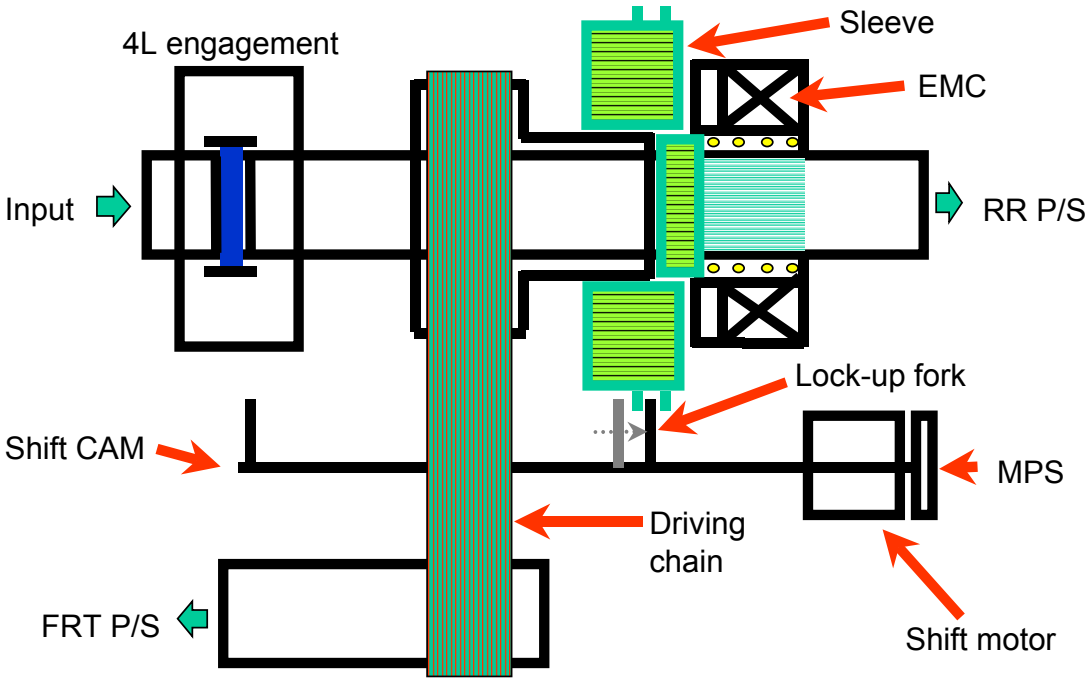
At the moment, TCCM also send a signal to the FRRD air pump motor in order to connect a center axle.



*** 2WD engagement**



*** 4WD engagement**



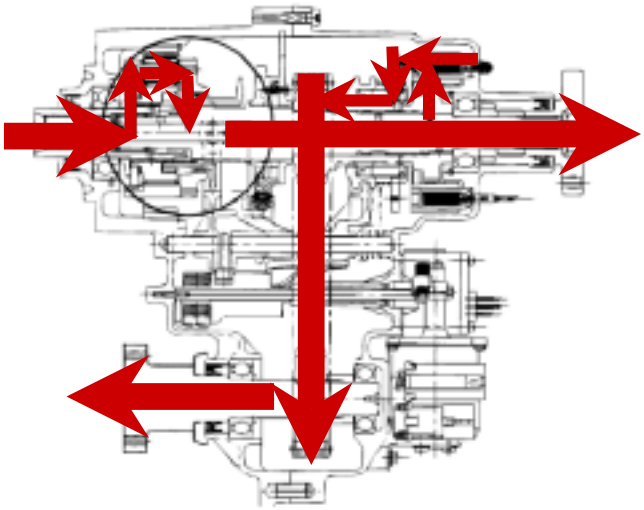
3) POWER FLOW: 4L Mode

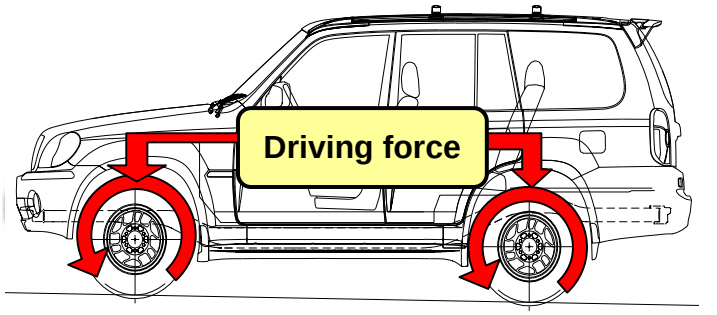
At 4L mode, TCCM (Transfer Case Control Module) sends a signal to the shift motor to rotate. Shift fork as well as a lock-up shift fork which is connected a lock-up shift collar slides up by shift motor rotation.

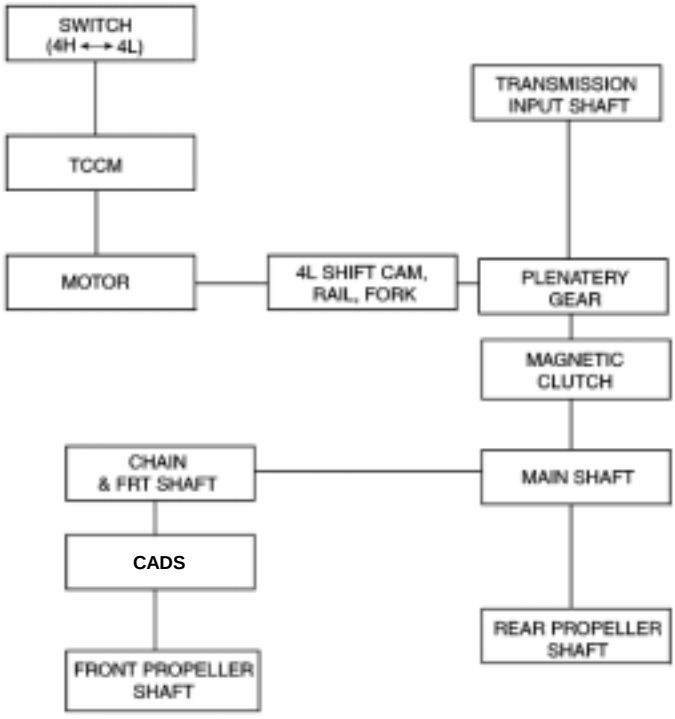
A reduction hub slide outward along the shift fork and a planetary gear is engaged making a lower speed. The output gear ratio is 2.48:1 and the vehicle can get more driving torque than it is in a 4H mode.

A lock-up shift collar slide outward along the lock-up shift fork and it is engaged with an upper sprocket that drives a drive chain delivering a drive force to the front shaft as soon as a magnetic clutch is on.

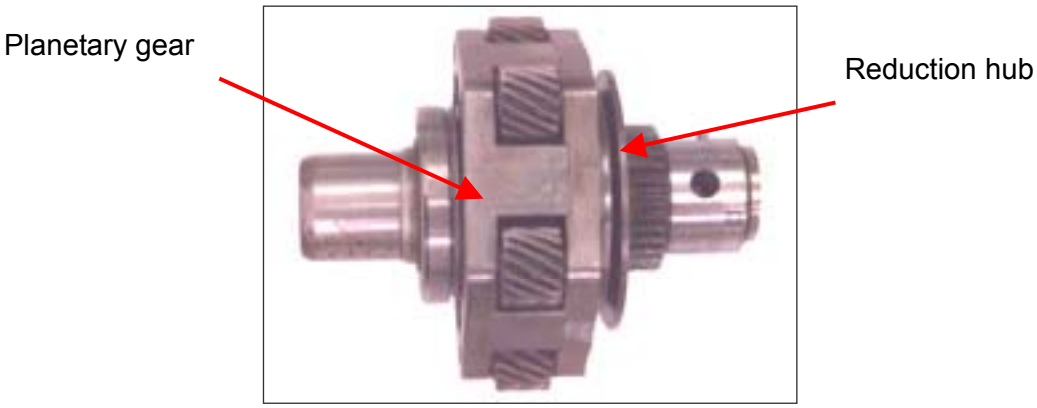
At the moment, TCCM also send a signal to the FRRD air pump motor in order to connect a center axle connection. If a 4L mode is selected from a 4H mode, then the FRRD air pump motor keeps ON and center axle connection remains engaged.



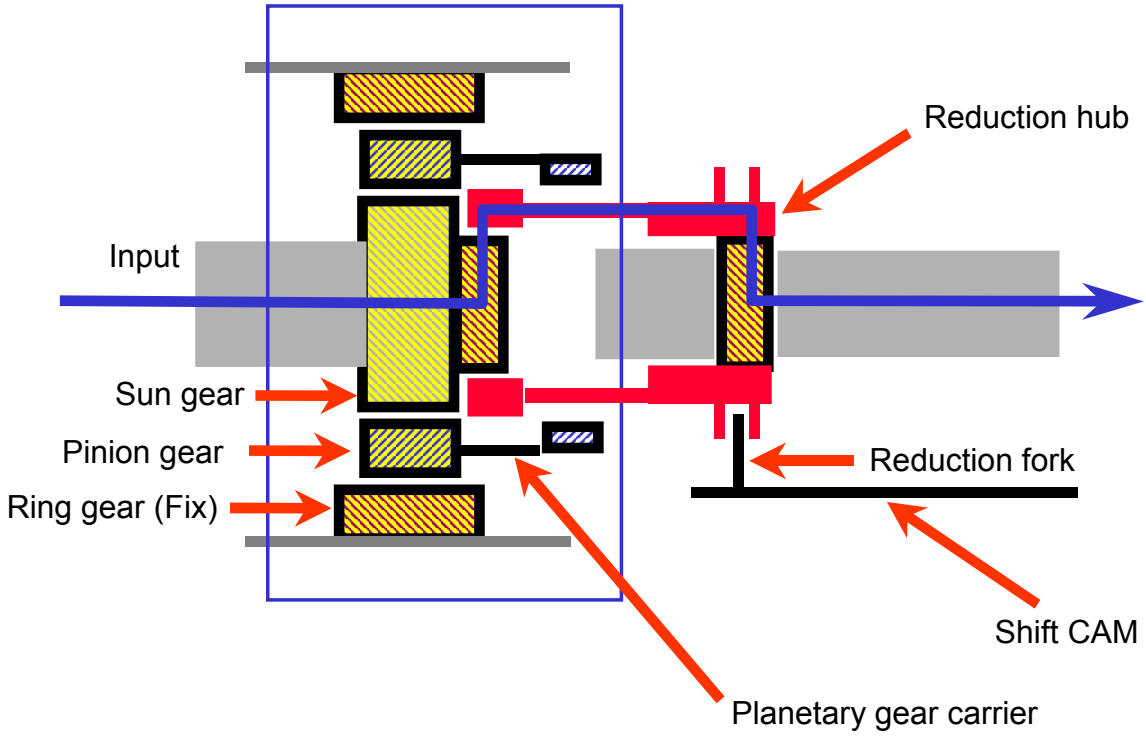




*** Planetary gear engagement (1:1 connection – 2H, 4H)**

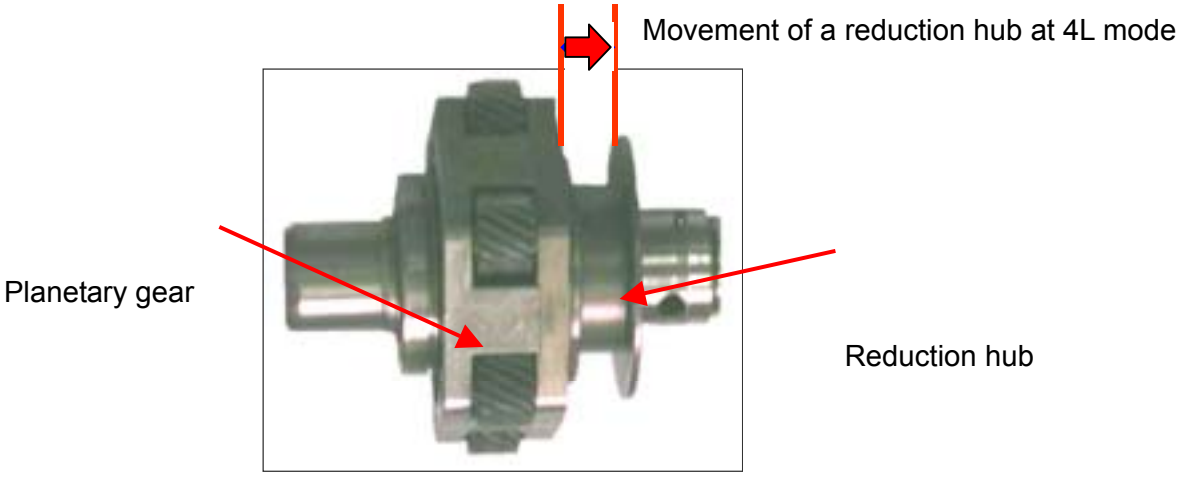


[1:1 connection (2H, 4H)]

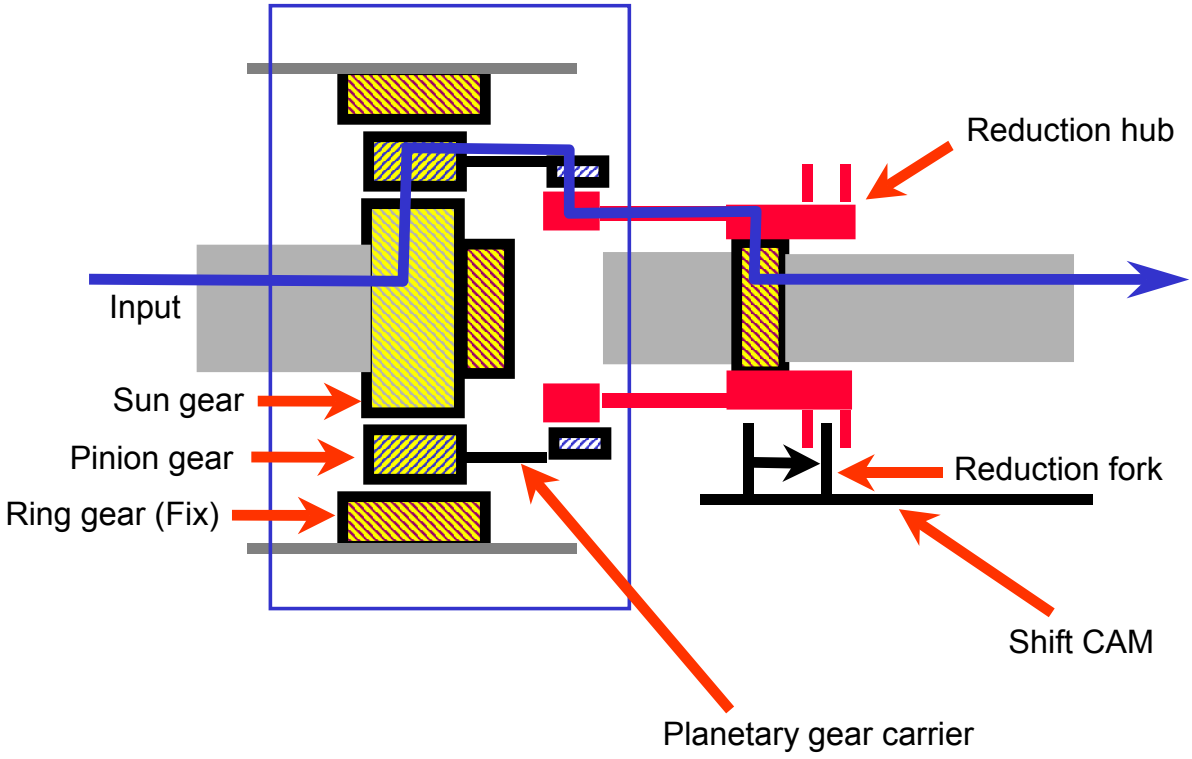


TM output comes into the input shaft of the transfer. At 2H or 4H mode, the planetary gear is not involved because the reduction hub, when it moves inward the planetary gear, is not connected with a planetary pinion gear carrier. Therefore input shaft is directly coupled with the rear output shaft allowing the same revolution speed of the both shafts.

*** Planetary gear engagement (4L mode)**



[4-Low mode → gear ratio 2.48:1]



TM output comes into the input shaft of the transfer. At 4L mode, the planetary gear is involved because the reduction hub, when it moves outward the planetary gear, is connected with a planetary pinion gear carrier. Therefore input shaft is coupled with the planetary gear and then is delivered to the rear output shaft allowing 2:48:1 revolution speed difference between the input shaft speed and the rear output shaft speed.

3.6 COMPONENTS

1) Mode selection switch

- 2H mode: Rear wheel drive mode

- 4H mode: Transferring from 2WD to 4WD can be achieved even while vehicle driving. (SOTF: Shift On The Fly). At this time, the vehicle speed should not be over than 80km/h. If the shift is successfully finished, the 4WD High lamp will be turned on.

- 4L mode: The vehicle should be stopped (3km/h or less). At the moment a shift lever should be positioned “N” position(A/T) or a “Clutch” pedal should be ON before selecting a 4L mode.

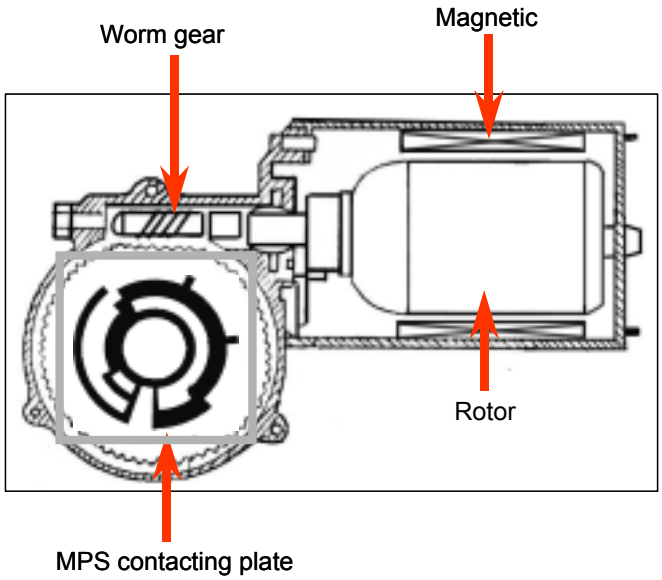
After a mode change is successfully finished, the 4L lamp will be turned on.

2) Shift motor & Motor position sensor

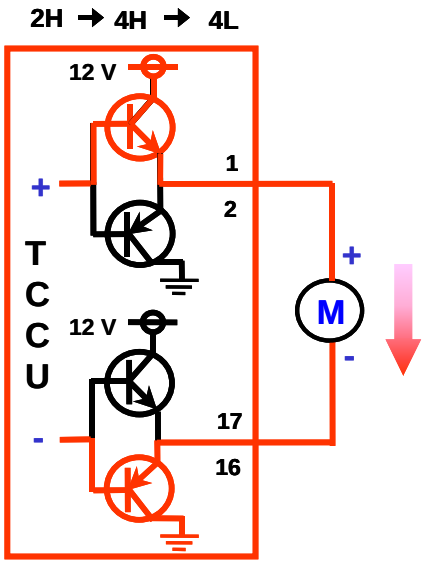
When a driver selects a driving mode, a mode signal comes to a TCCM. Then the TCCM operates a shift motor.

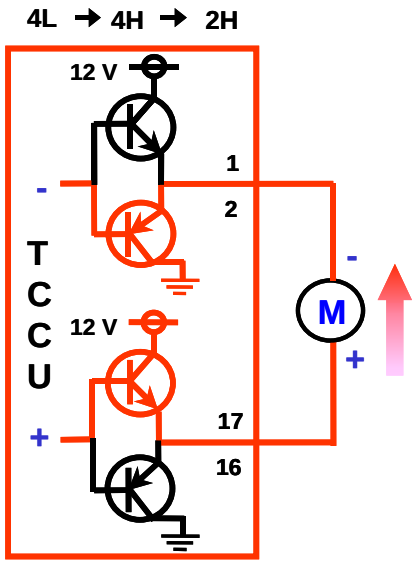
There is a MPS(Motor Position Sensor) inside the motor contacting a position plate which sends a motor position signal to the TCCM. TCCM can get a feedback of a driving mode position.

If the MPS sends to the TCCM different position signals from a mode switch position, a relevant failure code is memorized.

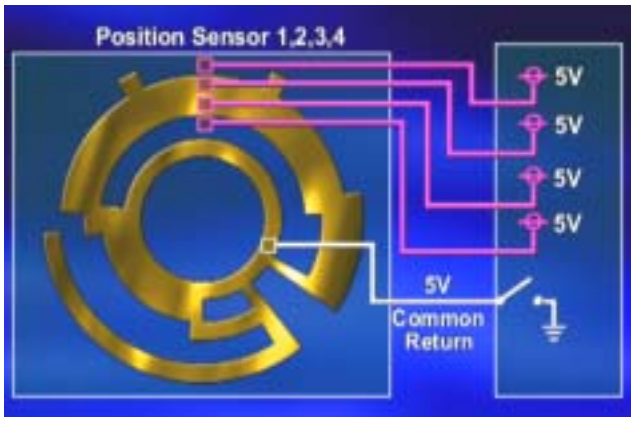


[Shift motor operation while shifting]

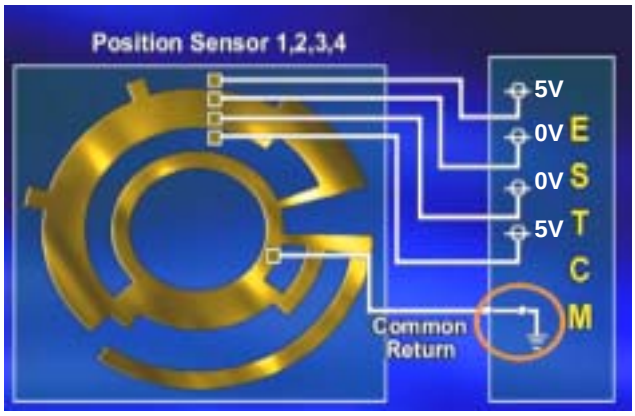




*** Motor position sensor**

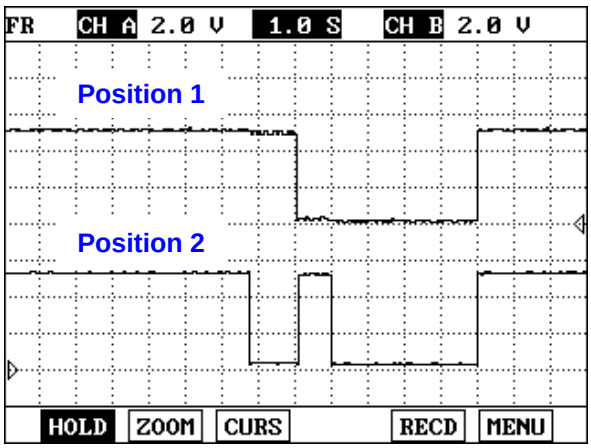


[Sensor output voltage at 2H/4H/4L mode]
The common return terminal is off-grounded. The output voltage of position sensor 1,2,3,4 keeps 5 volts.

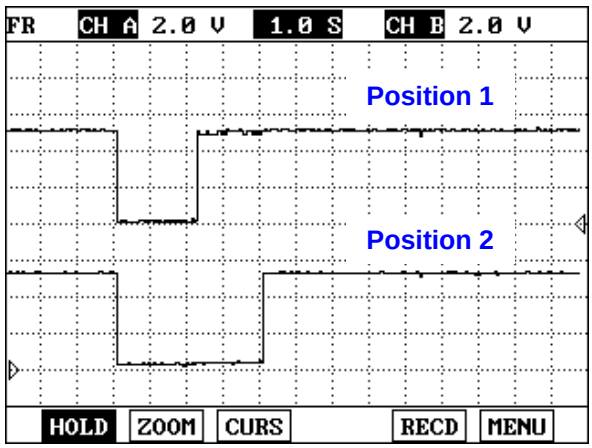


[Sensor output voltage while being shifted]
The common return terminal is grounded for 7 seconds. The output voltage of sensor which contacts the steel plate drops 0 volts.

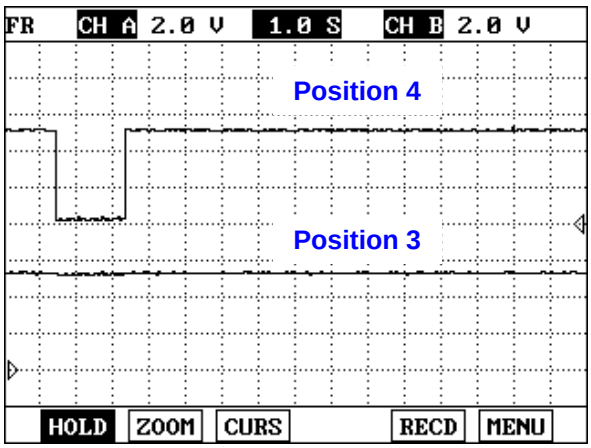
MPS output signal (2H→ 4H)



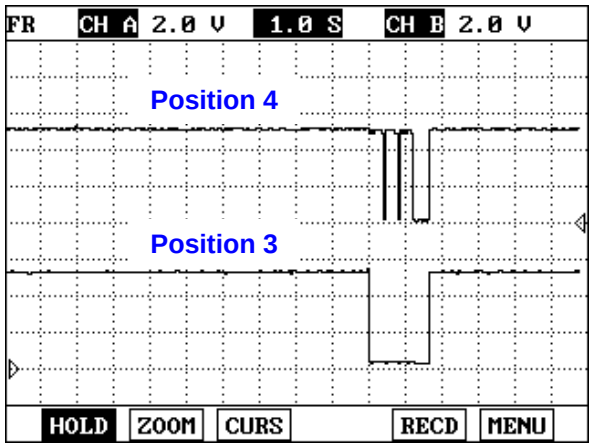
MPS output signal (4H→ 4L)



MPS output signal (2H→ 4H)

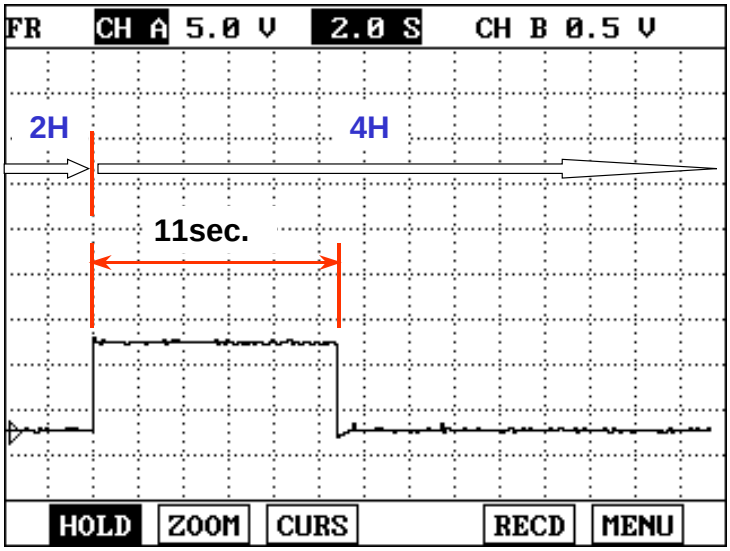


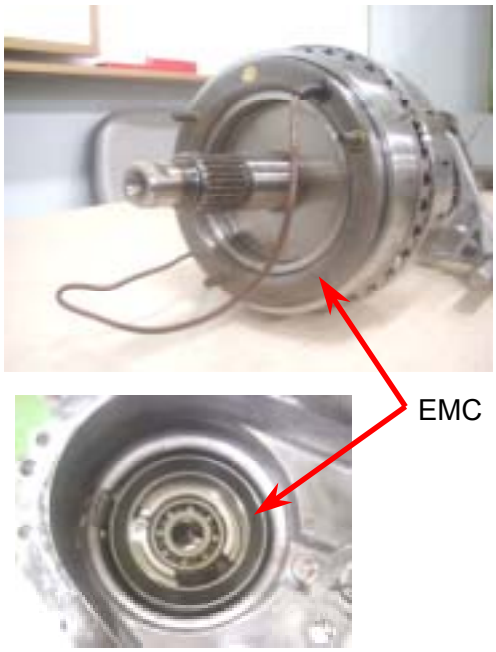
MPS output signal (4H→ 4L)



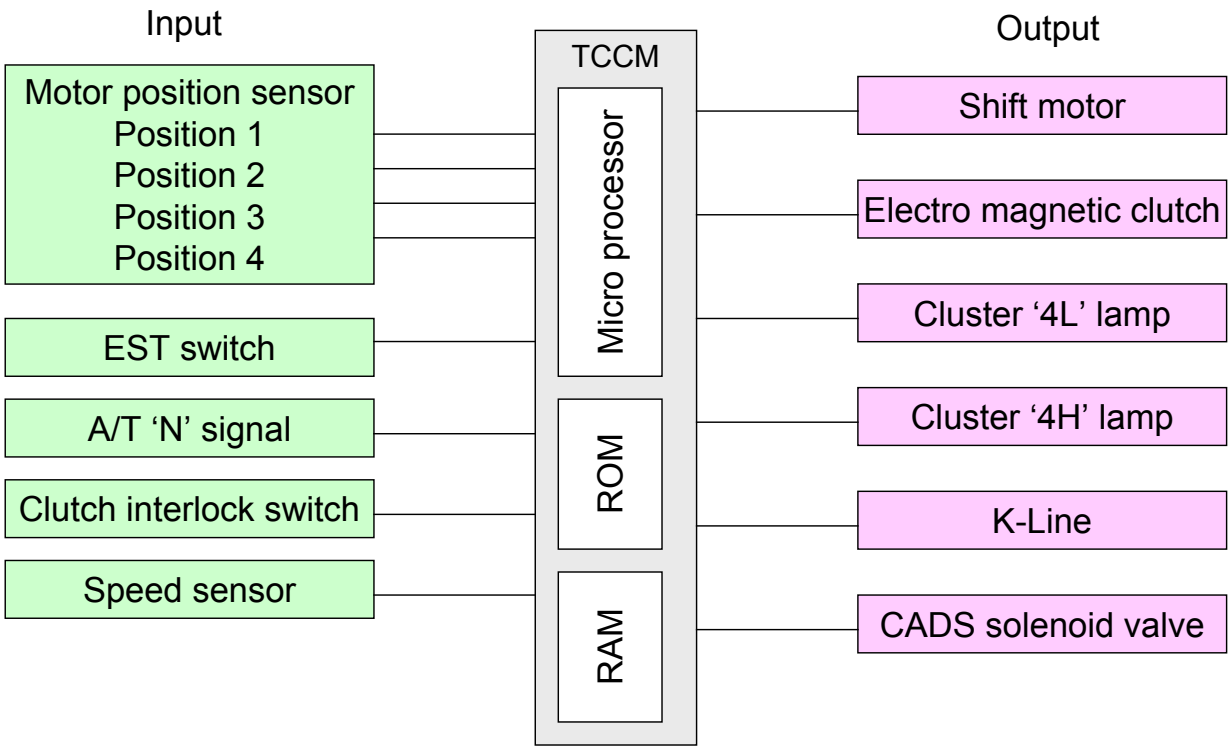
3) EMC(Electronic Magnetic Clutch) signal

EMC is energized to pull the lock-up shift fork to make 4H mode.





3.7 INPUT AND OUTPUT



3.8 DIAGNOSIS

1) DLC location

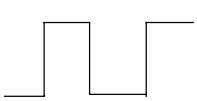
2) DTC

There is no P-code for EST system. DTC is supported with binary code. The binary fault code shall be displayed if a corresponding input or output part is failed.

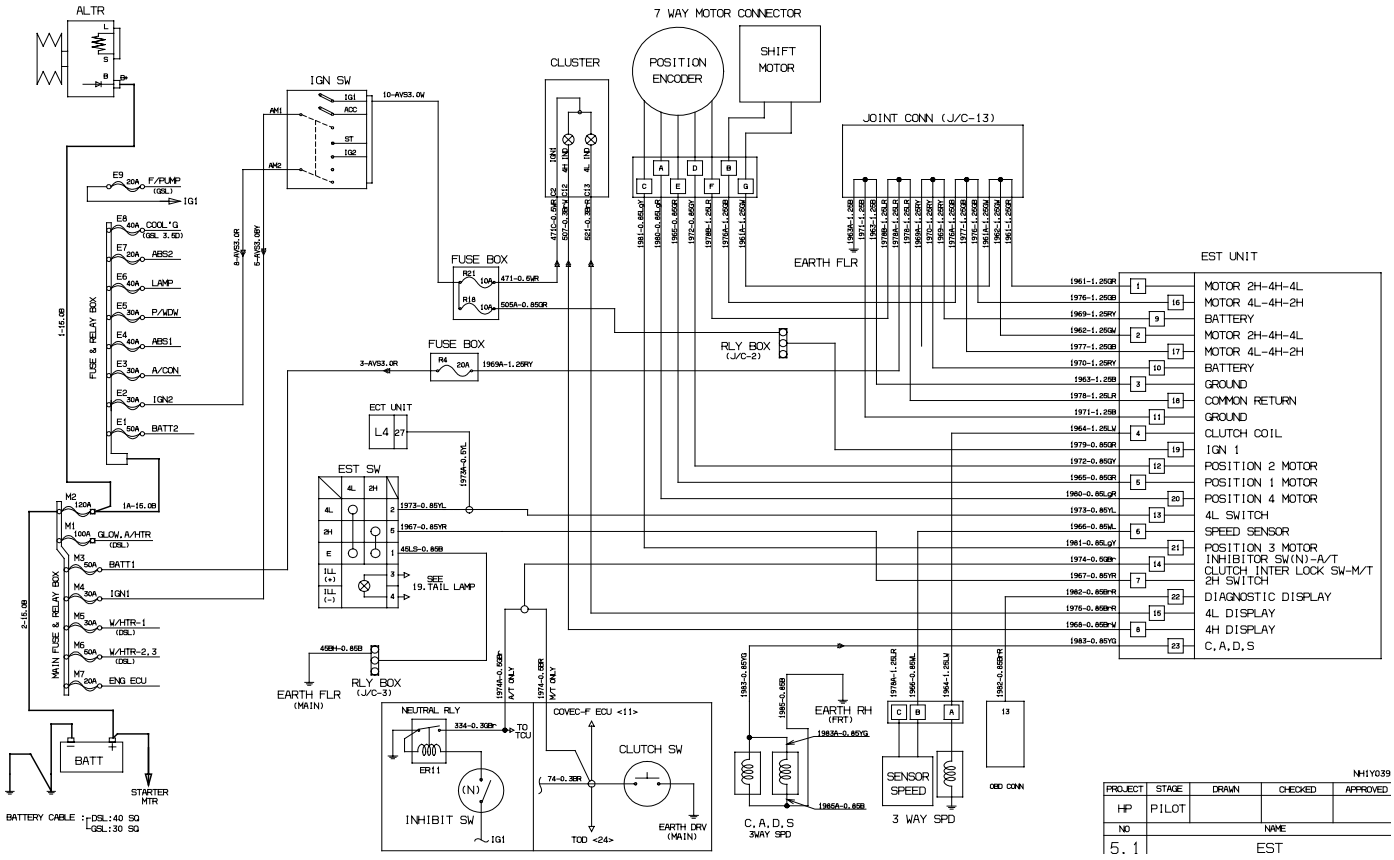
Decimal	Binary	Fault
1	001	TCCM (Tansfer case control module)
2	010	Shift motor
3	011	EMC (Electro magnetic clutch)
4	100	Speed sensor
5	101	CADS solenoid valve
6	110	2H-4H-4L switch
7	111	MPS (Motor position sensor)

3) EST standard input and output value in TCCM

No		Items	Condition	Signal		Remarks
				Type	Level	
1	A1	MOTOR OUTPUT (2H-4H-4L)	IDLE("N")	DC	Vbatt	* Current : INRUSH(+) : 4.64A INRUSH(-) : 4.4A Operation : 0.6A
				↑	0V	
2	A2	MOTOR OUTPUT (2H-4H-4L)	IDLE("N")	DC	Vbatt	
				↑	0V	
3	A3	GND				
4	A4	CLUTCH COIL	IDLE (2H →4H →4L)	DC	Vbatt	* Current : 4.28A
				↑	0V	
5	A5	POSITION 1 MTR	IDLE (P/R/N/D/2/L)	2H 2H →4H 4H →4L	CODE : 1010 CODE : 0011 CODE : 1100 LOGIC HI(1) : 5V LOGIC LO(0) : 0.5V or less	* MTR POS. CODE : 1/2/3/4 = XXXX (1 = 5V dc) (0 ≤0.5V dc)
6	A6	SPEED SNSR	IDLE	PULSE	 135Hz at 60KPH	* VSS of 60KPH : HI : 16.4V LO : -6.4V
7	A7	2H SW	SW OFF	DC	4.5 5.5V	
			SW ON	↑	0.5V or less	
8	A8	4H DISPLAY	SW OFF	DC	Vbatt	
			SW ON	↑	0.5V or less	
9	A9	BATT	IGN OFF	DC	Vbatt	
			IGN ON	↑	Vbatt	
10	A10	BATT	IGN OFF	DC	Vbatt	
			IGN ON	↑	Vbatt	
11	A11	GND				
12	A12	POSITION 2 MTR	IDLE (P/R/N/D/2/L)	2H 2H →4H 4H →4L	CODE : 1010 CODE : 0011 CODE : 1100 LOGIC HI(1) : 5V LOGIC LO(0) : 0.5V or less	* MTR POS. CODE : 1/2/3/4 = XXXX (1 = 5V dc) (0 ≤0.5V dc)

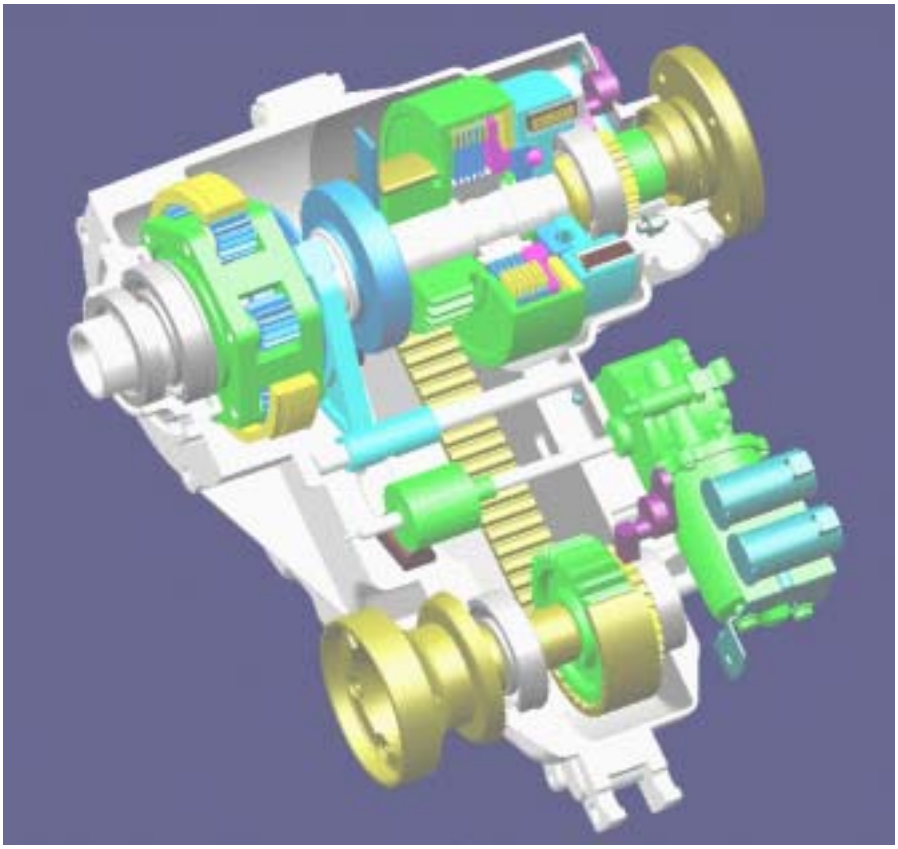
No		Items	Condition	Signal		Remarks
				Type	Level	
13	A13	4L SW	SW OFF	DC	4.5 5.5V	
			SW ON	↑	0.5V or less	
14	A14	INHIBITOR SW(AT	N	DC	0V	
		CLUTCH INTERLC	P/R/D/2/L	↑	5V	
		SW(MT)				
15	A15	4L DISPLAY	IDLE("N")	DC	Vbatt	
				↑	0V	
16	A16	MOTOR OUTPUT	IDLE("N")	DC	Vbatt	
		(4L-4H-2H)		↑	0V	
17	A17	MOTOR OUTPUT	IDLE("N")	DC	Vbatt	
		(4L-4H-2H)		↑	0V	
18	A18	COMMON RETUR	IGN OFF	DC	0.9V or less	
			IGN ON	↑	4.75 5.25V	
19	A19	IGN 1	IGN OFF	DC	0V	
			IGN ON	↑	Vbatt	
20	A20	POSITION 4 MTR	IDLE (P/R/N/D/2/L)	2H 2H →4H 4H →4L	CODE : 1010 CODE : 0011 CODE : 1100 LOGIC HI(1) : 5V LOGIC LO(0) : 0.5V or less	* MTR POS. CODE : 1/2/3/4 = XXXX (1 = 5V dc) (0 ≤0.5V dc)
21	A21	POSITION 3 MTR	IDLE (P/R/N/D/2/L)	2H 2H →4H 4H →4L	CODE : 1010 CODE : 0011 CODE : 1100 LOGIC HI(1) : 5V LOGIC LO(0) : 0.5V or less	* MTR POS. CODE : 1/2/3/4 = XXXX (1 = 5V dc) (0 ≤0.5V dc)
22	A22	DIA. DISPLAY	In comm.	PULSE	 4V or more 0 0.9V	
23	A23	C.A.D.S	IDLE	OFF	Vbatt	
			(2H →4H)	ON	0.5V or less	

4) Wiring diagram



FULL TIME 4WD (TOD) SYSTEM

TOD (Torque On Demand) -Terracan



4 TOD INTRODUCTION

4WD on demand: A 4WD system that supplies power most of the time to just the rear wheels in a vehicle that is basically rear-wheel drive (RWD) or to just the front wheels in a vehicle that is basically front-wheel drive (FWD). The transfer case, or its equivalent, sends power to the other set of wheel when the basic driving wheels start to slip. The 4WD operates "on demand." Most AWD systems really provide 4WD only on demand, not all the time. That's also true of many "Full time 4WD" systems. There are performance and handling advantages if a vehicle operates with power to all 4 wheels all the time.

TOD(Torque On Demand) system is a kind of full time 4wheel drive system and its full name is 'Torque on demand'. This is a trademark of Borg Warner in USA. The optimum engine torque distribution ratio between front and rear is controlled by TOD transfer case. This transfer case is controlled and operated by independent control module, that is, TCCM (Transfer case control module) and it is located under the crash pad on passenger side.

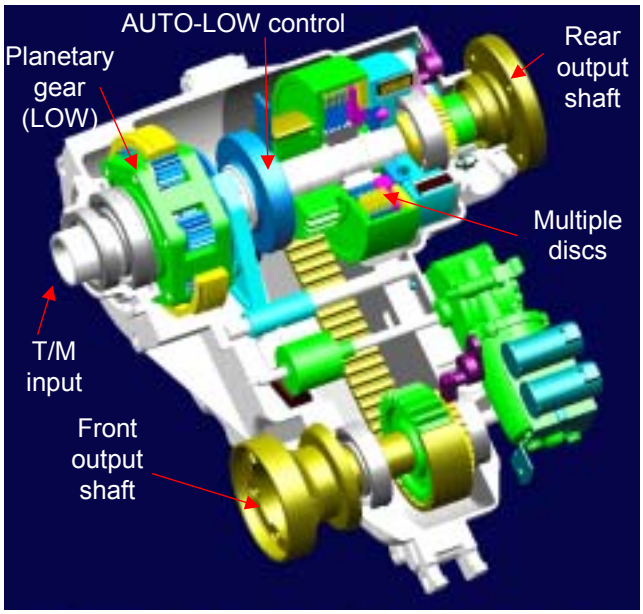
The torque transmission ratio to front and rear side is not fixed and it is changed and controlled continuously depends on the road and vehicle driving condition.

Basically the torque split ratio will be 0:100 (that is 'FR' situation) on road driving with low and medium vehicle speed. If there is any amount of slip on the rear wheel, the optimum amount of torque will be distributed to front wheel to get a stable driving performance.

The range of torque split ratio is from 0:100 to 50:50. It means the maximum torque amount of front wheel cannot be higher than rear wheel in any kind of road or vehicle condition.

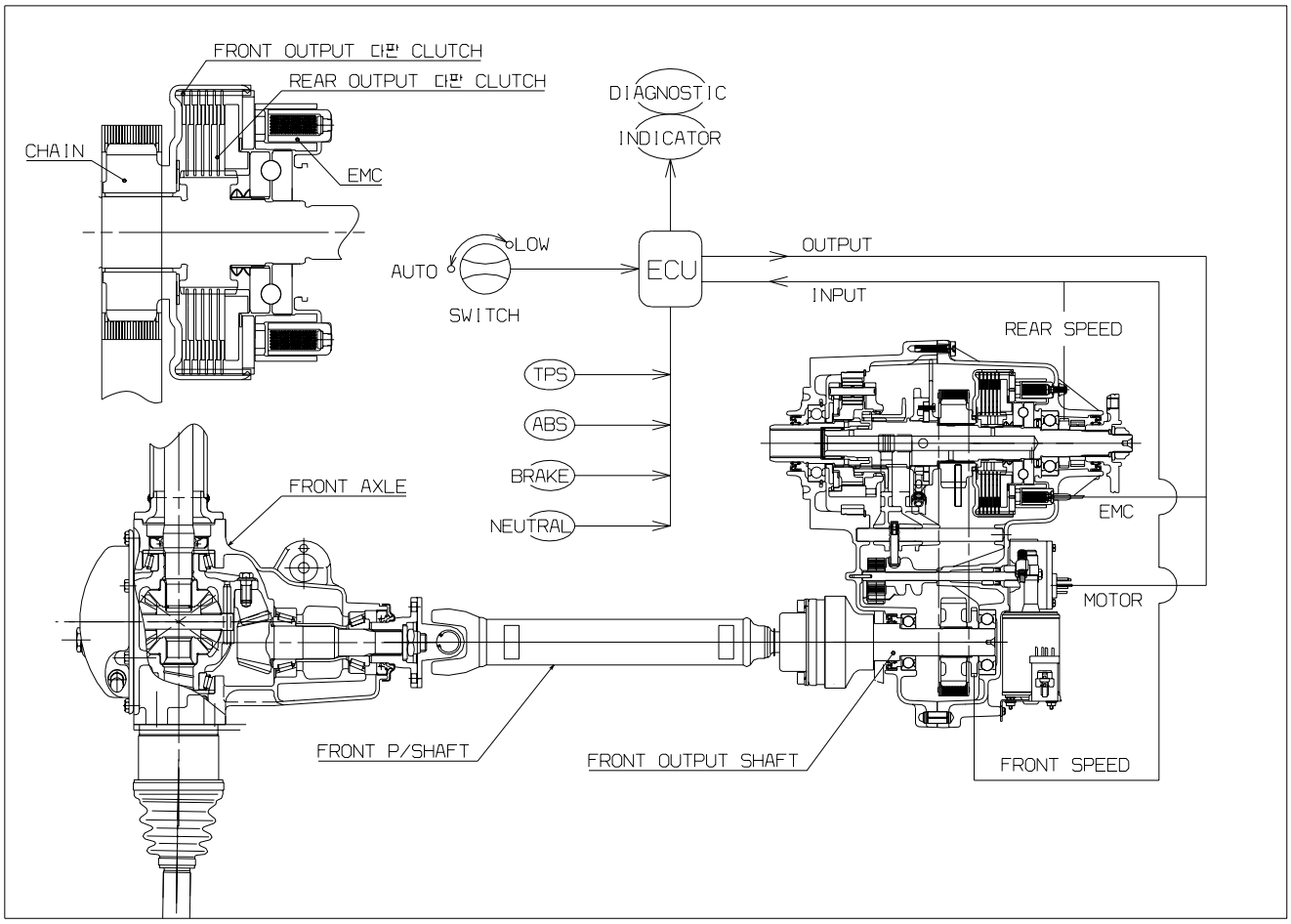
According to the speed signal of front and rear wheel from each sensor, the engine torque information from engine ECM, EMC (Electro magnetic clutch) will be activated and it will result the change of depressing force to the multiple disc clutch. If the force is high, more engine torque will be transmitted to front wheel.

Oppositely, if it becomes low, the torque to front side also will be decreased. It means the slip inside of multiple disc clutch will be increased also. Therefore the oil pump for lubrication of clutch is installed and very important for the overall system durability.



TOD or ATT (Active torque transfer)

5 TOD SYSTEM CONSTRUCTION



Merits and Characteristics

1. The fuel consumption is improved while driving in 4WD due to the optimum and proper engine torque distribution between front and rear wheel.
2. The maximum adhering force of tire into road can be acquired due to the electronic control depends on the road condition.
3. Light weight comparing with another kind of systems.
4. Simple internal structure.
5. Driving performance and steering stability on the off-road and on-road is very excellent.
6. It is easy to handle and control due to the electronic control system.
7. The efficiency of ABS operation is improved due to the easy system configuration with ABS system.
8. The center differential ‘free’ and ‘locking’ is controlled by TCCM so the center differential is not necessary and a tight corner braking development can be prevented.

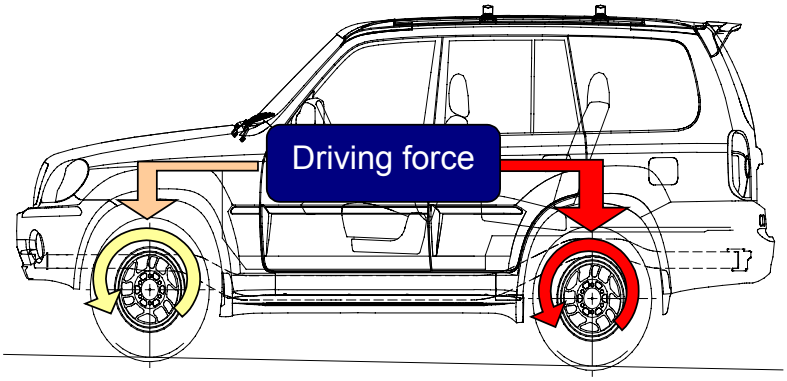
6 TOD SELECTION MODE (AUTO/LOW)

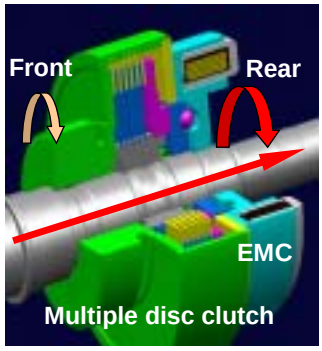
- Auto mode

In Auto mode, TOD system controls the clutch mechanism by detecting the rotating speed of front and rear propeller shaft. If its difference is out of mapping data, the EMC is activated and the engine torque is transmitted to front wheel.

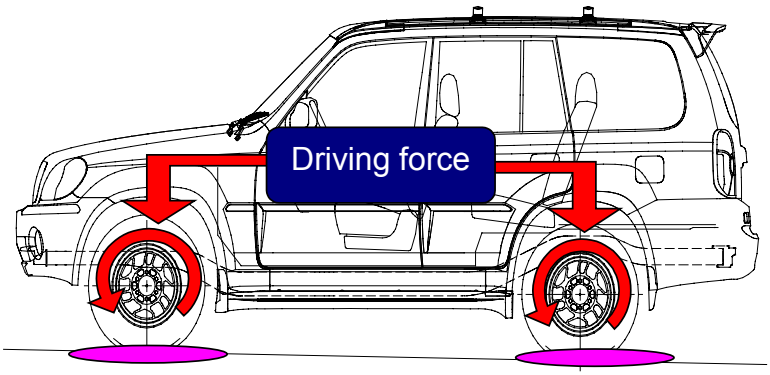
In this time, the gear ratio becomes 1:1 because the output shaft is connected to input shaft through not planetary carrier but sun gear.

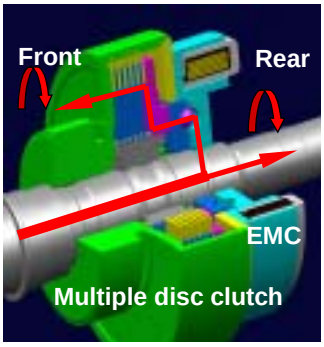
[Rear wheel driving]





[All wheel driving]





- Low mode

In Low mode, the driving system becomes a 4 wheel drive mode with a low speed. To transmit the maximum engine torque to front wheel, the multiple disc clutch with EMC (Electro magnetic clutch) will be “Lock” and the shift motor is activated toward ‘LOW’ position. Through the cam mechanism, the output shaft is connected to carrier of planetary gear set. At this time, the gear ratio is changed from 1:1 to 2.48:1.

- Shifting from ‘Auto mode’ to ‘Low mode’

To select ‘Low mode’ from ‘Auto mode’ driving, the vehicle should be stopped.

→ The rotating speed of both front speed sensor and rear speed sensor should be 87rpm (2,580 pulses per minute) or less.

* With A/T: Move the shift lever to ‘N’ position for 2 seconds or more and select the ‘Low mode’ switch.

* With M/T: Depress the clutch pedal and select the ‘Low mode’ switch.

If the above conditions are not satisfied, shifting from ‘Auto mode’ to ‘Low mode’ will be inhibited (shift ‘default mode’ by TCCM) and the ‘Low’ lamp on the cluster will be blink.

If a shift from ‘Auto mode’ to ‘Low mode’ is successfully finished, the blinking of ‘Low’ lamp will be stopped and the lamp will be turned on continuously.

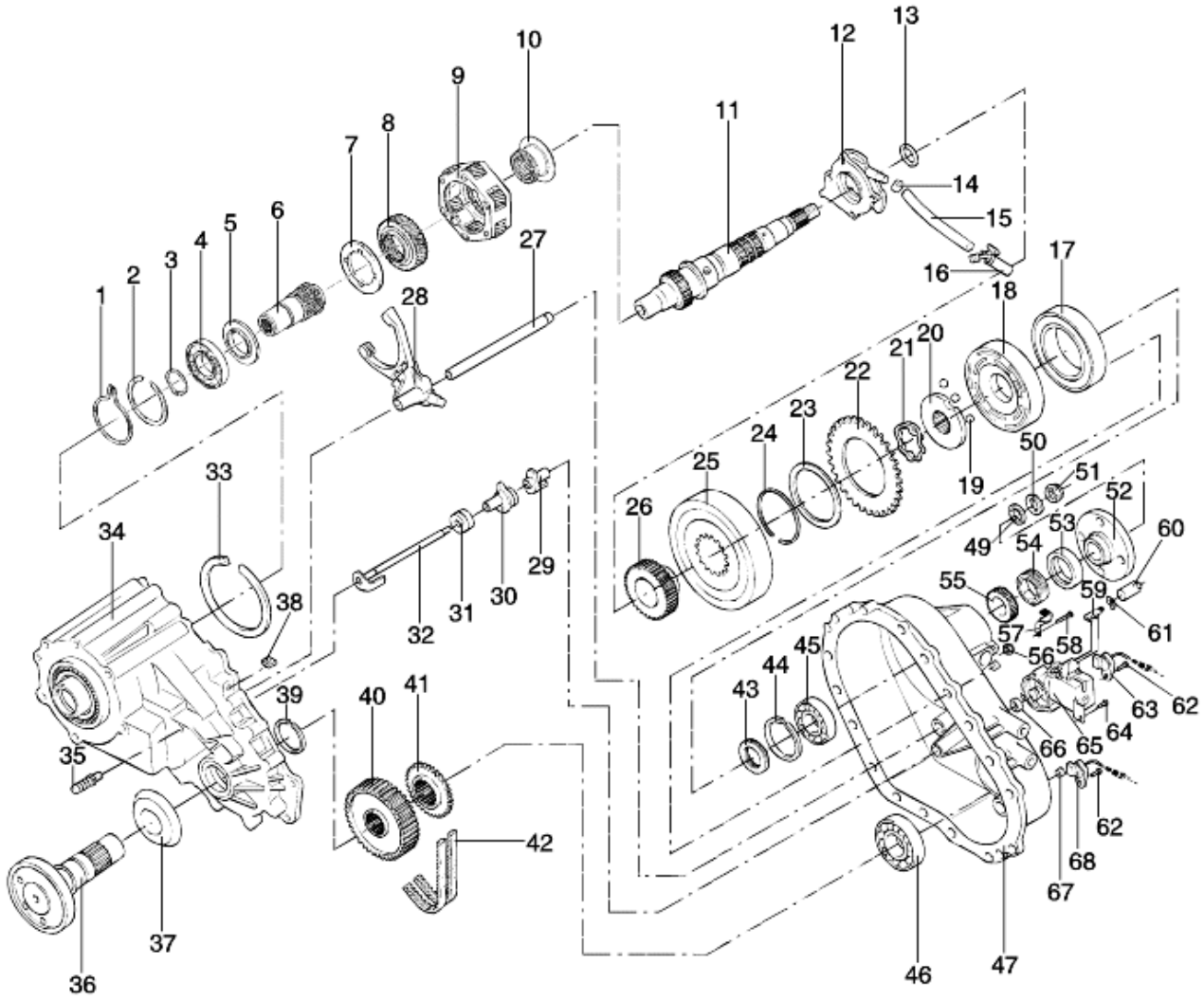
7 TORQUE DISTRIBUTION DEPENDS ON THE DRIVING CONDITION

No.	Items	Condition	Torque distribution	Decision by
1	Fast start	When vehicle starts abruptly to get a enough driving power	50:50	TPS Vehicle speed DIFF.(FRT-RR speed)
2	Normal driving	When vehicle drives at straight road for stable driving and fuel consumption	0:100 30:70	↑
3	Acceleration	When vehicle catch up with another vehicle to get more power and stable driving	30:70 50:50	↑
4	Normal steering	When vehicle steers for stable steering performance	20:80 30:70	↑
5	Driving and steering at slippery road	When vehicle drives or steers at slippery road to minimize wheel slip and get a stability	30:70 40:60	↑

No.	Items	Condition	Torque distribution	Decision by
6	Parking control	When vehicle steers and starts in vehicle stopping condition	5:95 20:80	↑
7	Braking control	When vehicle stops for stable braking and reduce a braking distance	0:100 10:90	Vehicle speed DIFF.(FRT-RR speed)
8	ABS control	When ABS is operated to get a stable braking performance	30:70	ABS operation signal DIFF.(FRT-RR speed)
9	Off-road, Steep slope road	To get a enough driving power	50:50	LOW signal Vehicle speed
10	Fail-safe	1. AUTO mode	0:100	
		2. LOW mode	50:50	

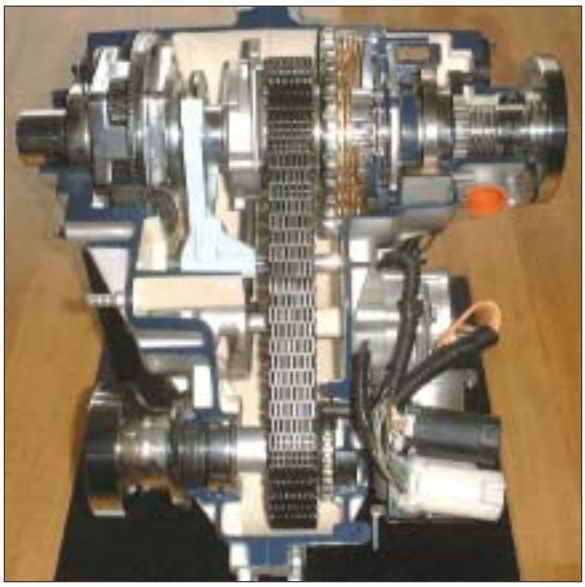
※ DIFF. (FRT-RR speed) :The difference of rotating speed between front and rear propeller shaft.

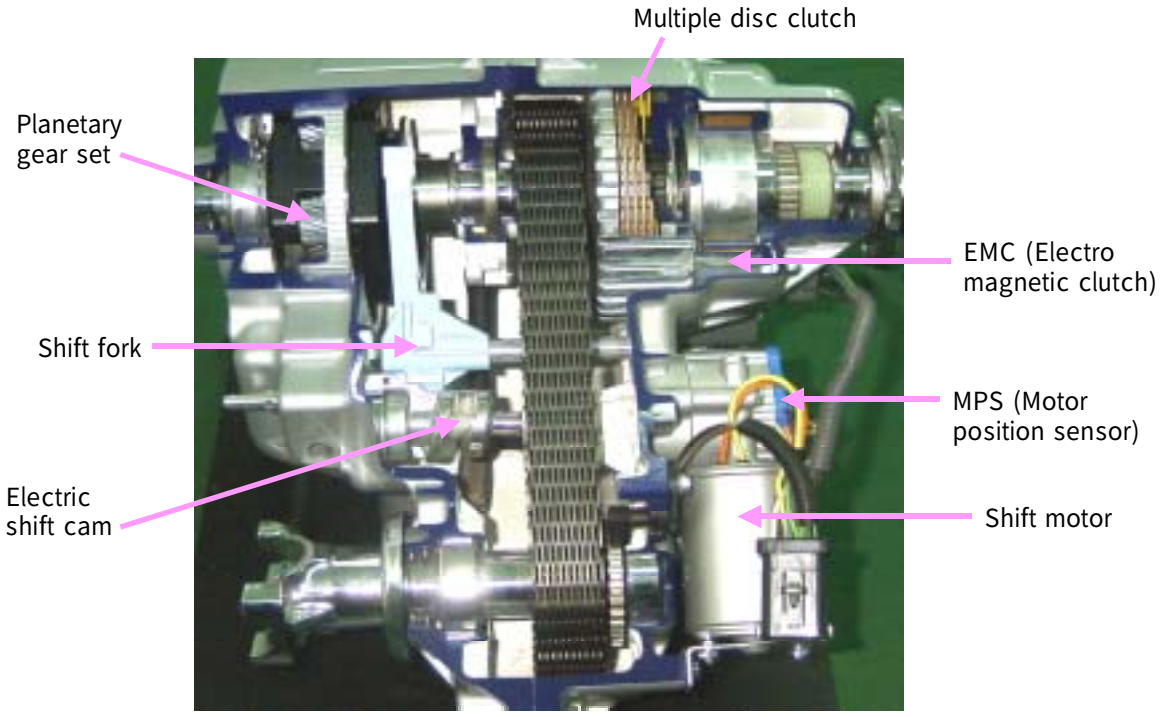
8 TOD COMPONENTS



1. Snap ring
2. Snap ring
3. Snap ring
4. Bearing
5. Circula hub
6. Input shaft
7. Thrust plate
8. Sun gear
9. Carrier
10. Reduction hub
11. Main shaft
12. Pump
13. Thrust washer
14. Hose clamp
15. Hose
16. Filter
17. Electric coil
18. Cam coil housing
19. Ball
20. Cam apply
21. Wave spring
22. Amateur
23. Insulator washer
24. Retaining ring
25. Clutch pack
26. Drive sprocket
27. Shift rail
28. Shift fork
29. Electric shift cam
30. Electric shift cam
31. Torsion spring
32. Shift shaft
33. Retaining ring
34. Transfer case
35. Breather
36. Output shaft
37. Dust deflector
38. Magnet
39. Snap ring
40. Lower socket
41. Lower tone wheel
42. Chain
43. Bearing thrust
44. Retaining ring
45. Bearing
46. Bearing
47. Cover
48. Metric bolt
49. Oil seal
50. Washer
51. Metric nut
52. Companion flange
53. Oil seal
54. Speedo gear
55. Upper tone wheel
56. Metric nut
57. J-clip
58. Hex head bolt
59. Clip
60. Connector
61. Connector lock
62. Hex head bolt
63. Upper speed sensor
64. Hex head cap screw
65. Electric motor
66. Oil seal
67. Pipe plug
68. Lower speed sensor

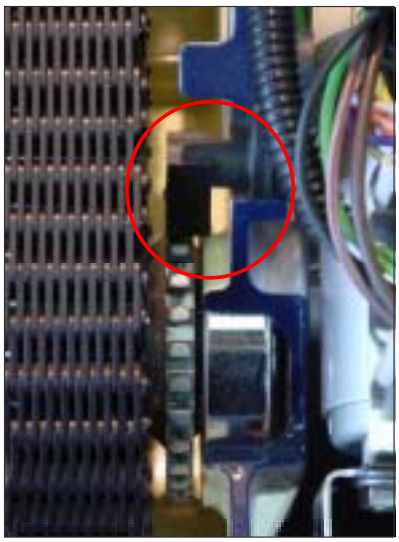
1) COMPONENTS - TOD CUTAWAY



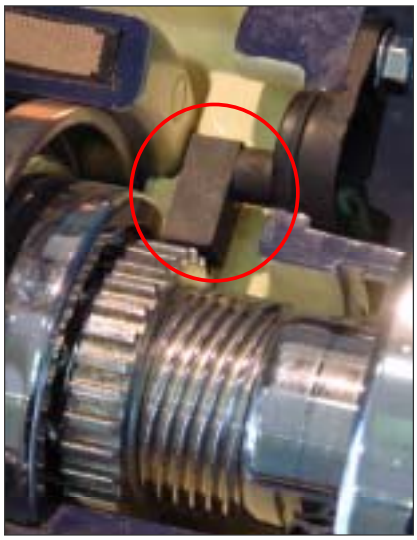


2) COMPONENTS - SPEED SENSORS

The information from the front shaft speed sensor and the rear output shaft speed sensor is very important for a TOD control module in order to perform an Active Torque Control.
According to driving conditions and vehicle load, TOD control module controls the supplying current to the EMC resulting in different torque distribution to the front propeller shaft.
After controlling the current for an optimum torque distribution, TODCM monitors the front speed and the rear speed and compares the speed differences. This is a feedback process by the TODCM.



[Front Speed Sensor]

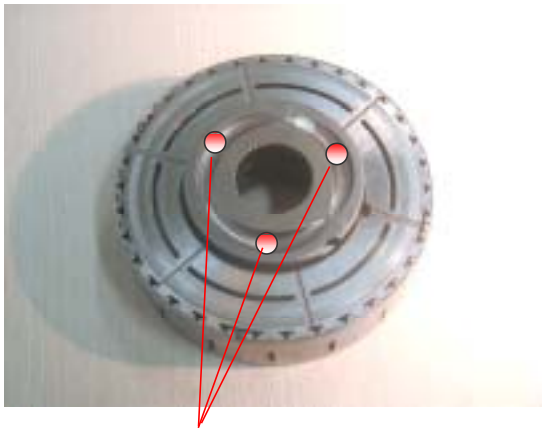


[Rear Speed Sensor]

3) COMPONENTS - MULTIPLE DISC CLUTCH

To transmit a driving force to the front propeller shaft, part time transfer, EST, used a lock-up shift fork and a lock-up collar to connect a rear shaft and a front shaft. According to the driver's selection, 2-wheel drive or 4-wheel drive is alternatively changed.

In case of TOD, driving toque to the rear shaft is transmitted to the front shaft by way of a multiple disc clutch. Output torque through the disc clutch is changeable by the amount of the applied current to the EMC(Electronic Magnetic Clutch). There is a cam with 3 balls Between a multiple disc clutch and a EMC housing. If higher current is applied to the EMC, more magnetic pressure pushes disc clutch via a cam. As a result, more frictional force is generated in a disc clutch assembly allowing a higher torque transmission.



3 steel balls (Ball ramp mechanism) is installed to be controlled by EMC.

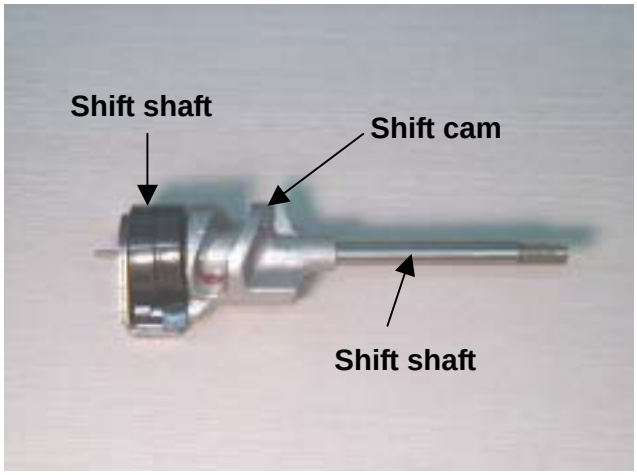
Ball ramp is for changing the rotational movement into reciprocating movement to compress the clutch.

Totall 11 clutch discs were installed.

4) COMPONENTS - SHIFT CAM

A shift cam is to engage a low mode (4 low mode). It is adapted a TOD as well as a EST. but the appearance is a little different. Shift cam for EST has a longer cam size because of the slot for a lock-up shift fork.

A driver selects a LOW mode, a shift motor operates and the connected shift cam rotates together. Shift fork slides side along the slot of shift cam, according to the location of the shift fork, AUTO mode or LOW mode is engaged.

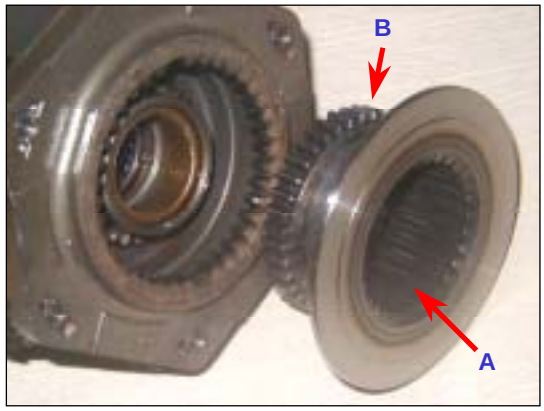


5) COMPONENTS - PLANETARY GEAR SET

To make a 4LOW gear ratio (2.48:1), the planetary gear set was installed and controlled by electronic shift fork. The connecting point 'A' and 'B' is shifted depends on the moving direction of shift fork.

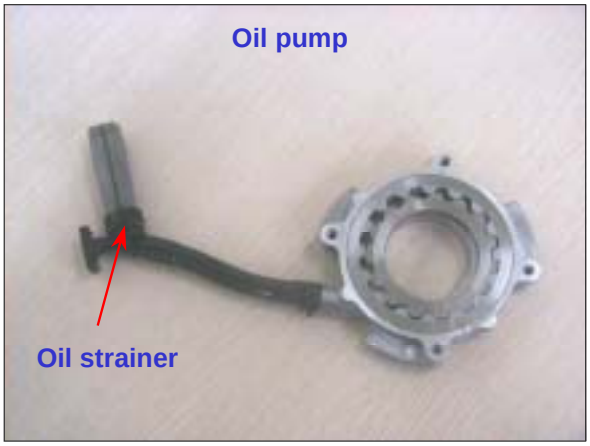
In case of point 'A' connection : Planetary sun gear → 1:1

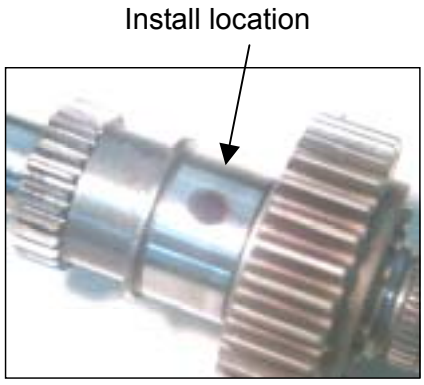
In case of point 'B' connection : Planetary carrier → 2.48:1 (4LOW)



6) COMPONENTS - OIL PUMP

The oil pump for lubrication of multiple disc clutch as well as other parts in the transfer case was installed.

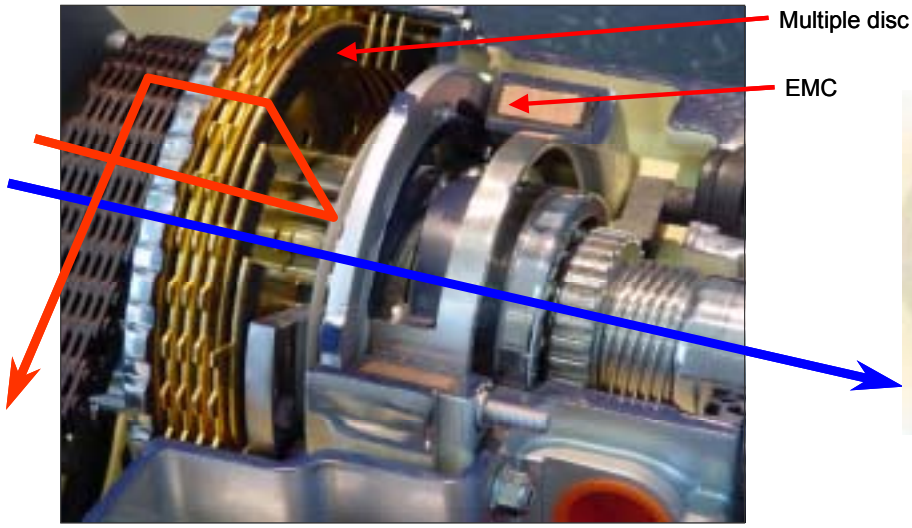




9. POWER FLOW

Power flow of the TOD system is almost the same as the EST system except that a multiple disc clutch is replaced instead of a lock-up shift fork and a Lock-up collar.

Driving force from the TM case comes into the input shaft. In AUTO mode, the input shaft is directly coupled with a rear output shaft making a 1:1 connection. The rear output shaft torque is delivered to the front shaft through the multiple disc clutch. In LOW mode, planetary gear is engaged making the gear ratio 2.48:1. And the next flow is the same as that in AUTO mode.



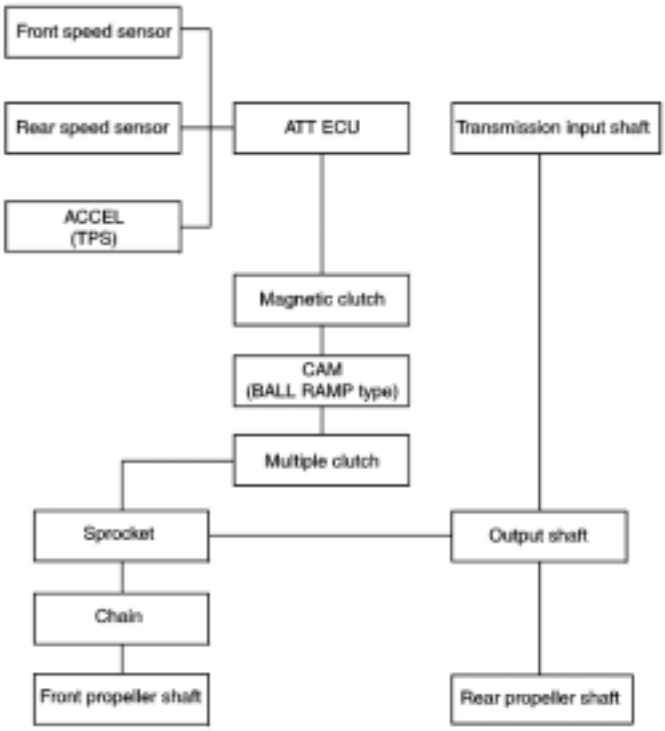
[Cam & balls]

1) POWER FLOW (AUTO MODE)

A driver select an AUTO mode, TODCM(or ATTCM) uses the information of front speed sensor signal, rear speed sensor signal and TPS(APS: Accelerator Position Sensor) signal for torque distribution to the front shaft.

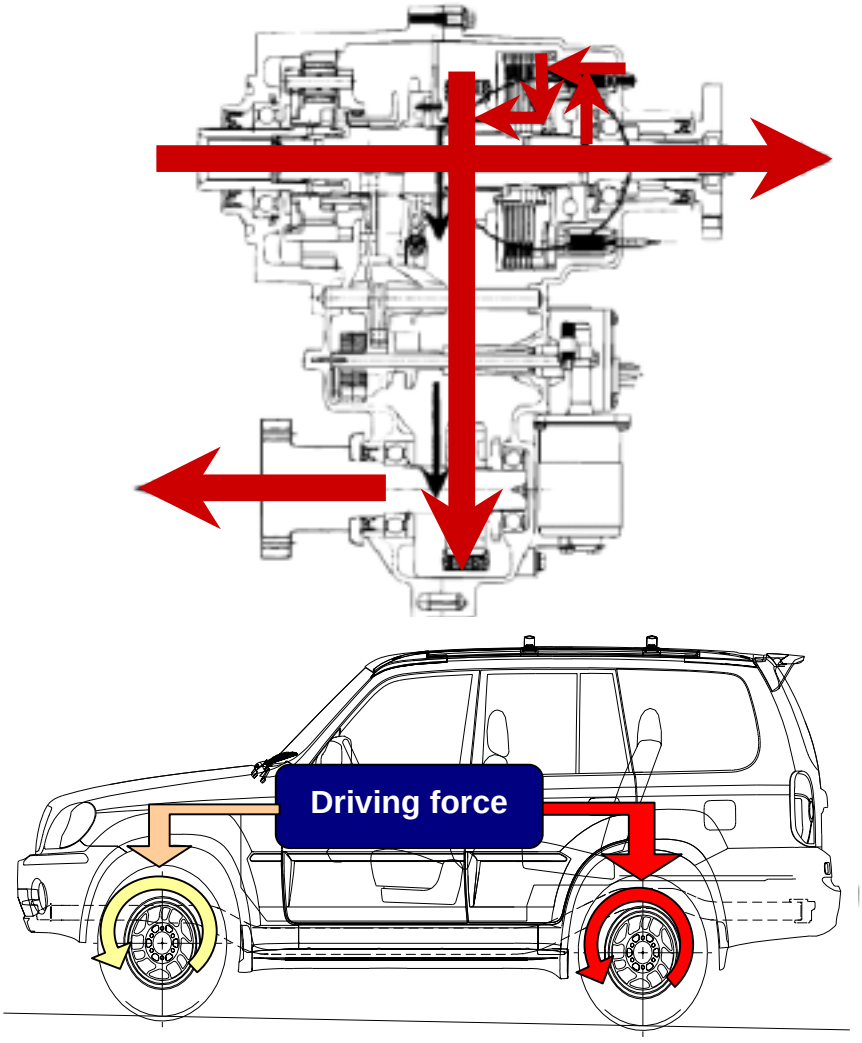
In AUTO mode, planetary gear set is not engaged. Input shaft is directly coupled with rear output shaft making a same speed.

According to the amount of current of EMC from TODCM, different torque through a multiple disc clutch is transmitted to the front shaft.



There is a cam with three balls between the EMC and a disc clutch. The balls have their seats on the center of the slot of the cam and they keep its position unless a rotational moment occurs on the contact surface with balls. If the contact surface is twisted because of the driving force, that is rotation moment, the balls roll out from their seats. The slot shape on the cam is tapered to the edge. The three slots on the cam have the biggest depth on their center. The depth is smaller on its edge. That is why the ball rolls more over the slot to the edge in proportional to the magnetic force from the EMC coil.

The more the ball moves side, the more pressure a multi-disc clutch is applied generating more driving force to the front shaft.

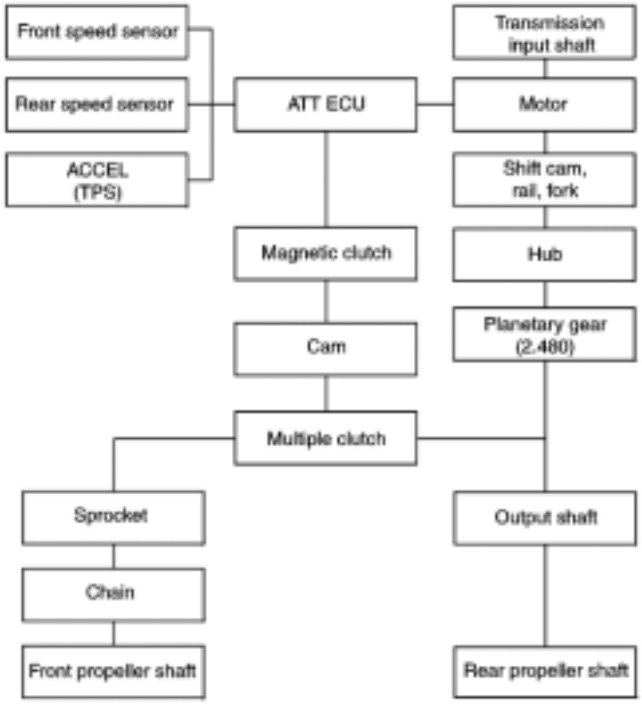


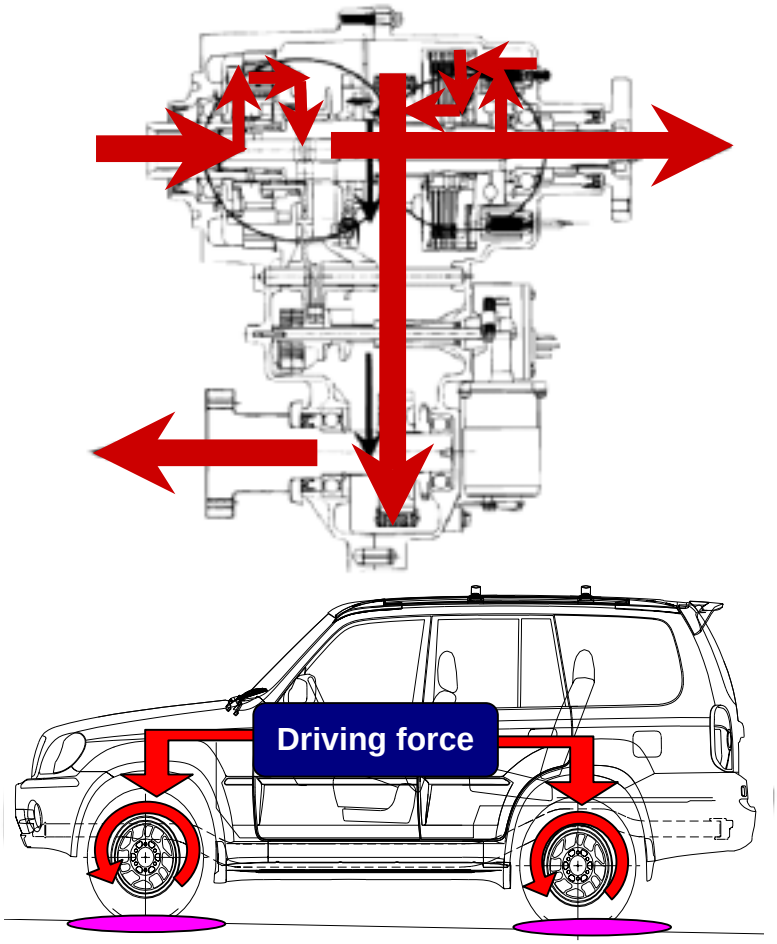
2) POWER FLOW (LOW MODE)

In LOW mode, planetary gear is engaged. That means input force is delivered to the output shaft via planetary gear making a gear ratio of 2.48:1. so, driver can get more driving torque in this mode.

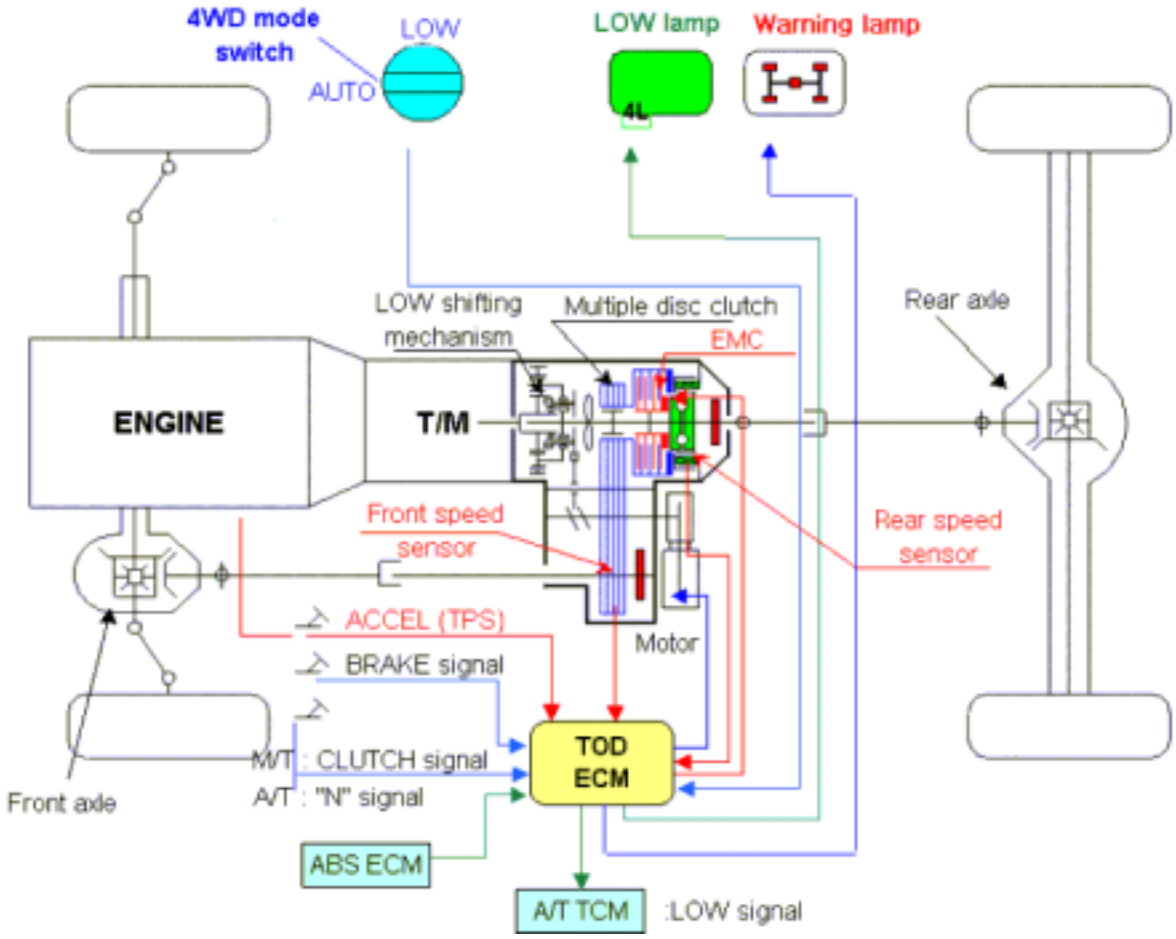
LOW mode is selected, TODCM operates a shift motor and a shift cam. When the shift cam rotates, shift fork slides along the slot on the cam and the reduction hub coupled with a shift fork also moves. According to the location of reduction hub, planetary gear can be involved or not.

Power flow in this mode, most things are same as AUTO mode except planetary engagement.

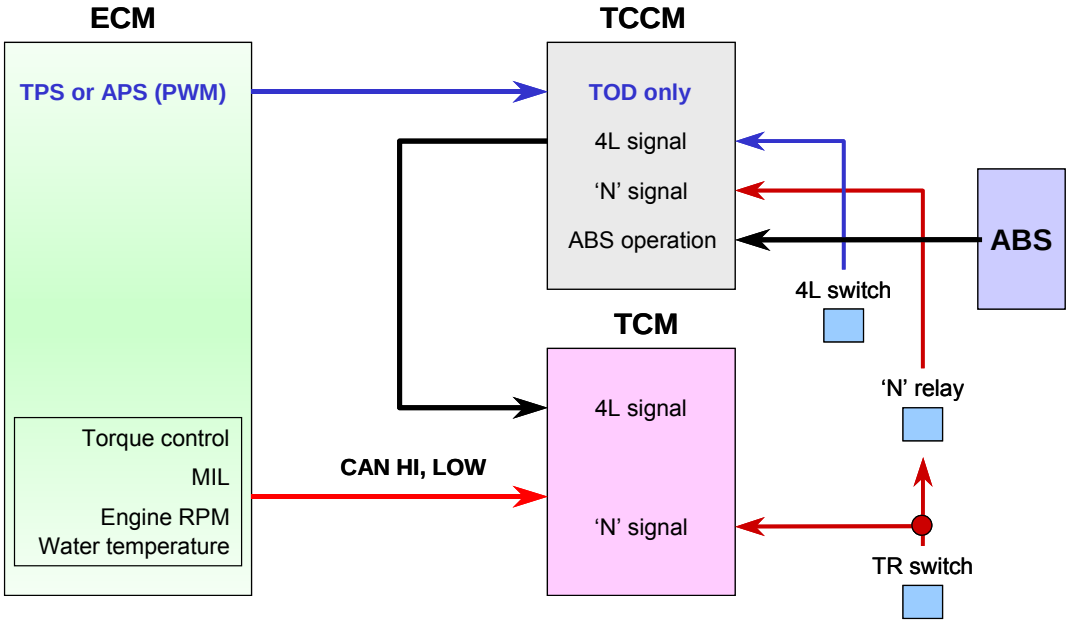




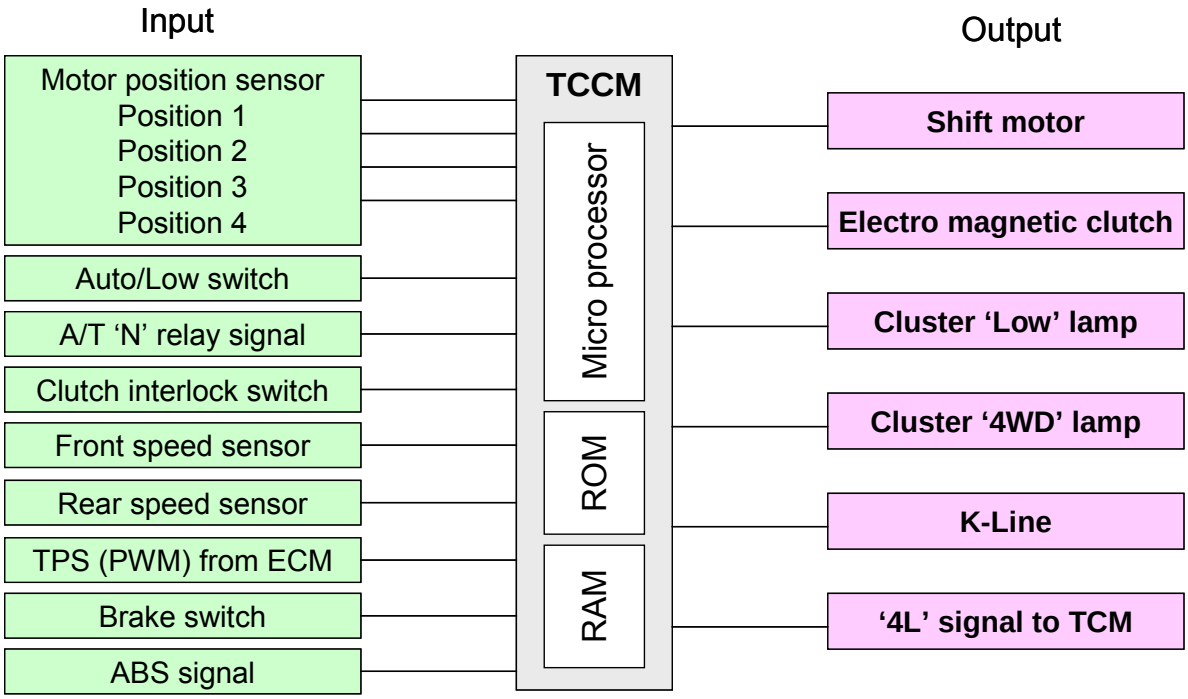
10. SYSTEM LAYOUT



* PIN TO PIN COMMUNICATIONS

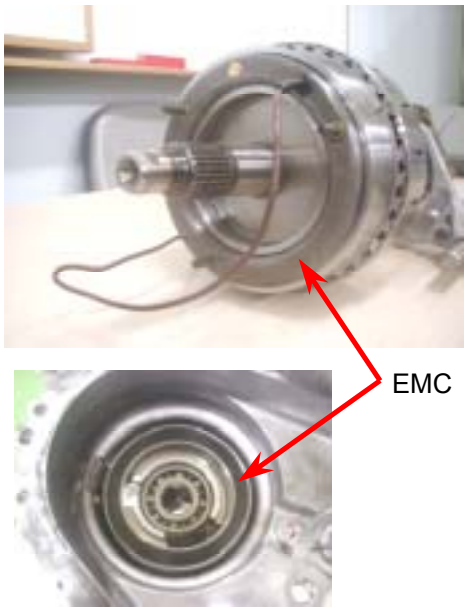


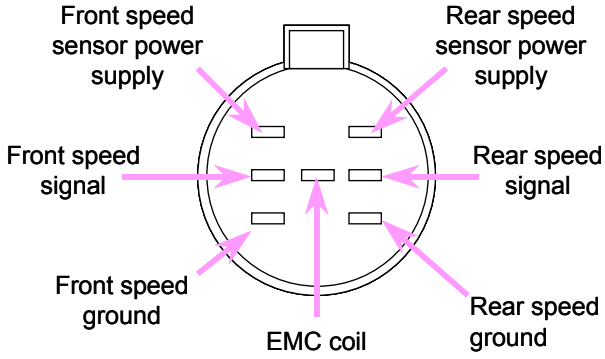
11. TOD SYSTEM INPUT AND OUTPUT

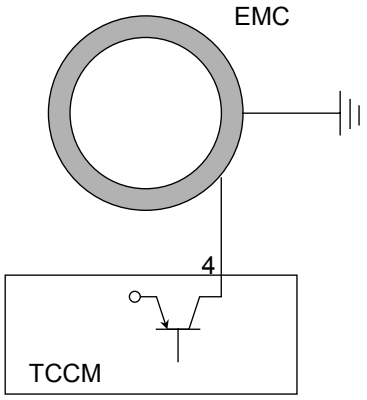


1) EMC (ELECTRO MAGNETIC CLUTCH)

If EMC is energized, the multiple disc clutch is engaged so the torque is transmitted to front wheel. Depends on EMC duty ratio, the amount of transmitted torque to front side is changed.





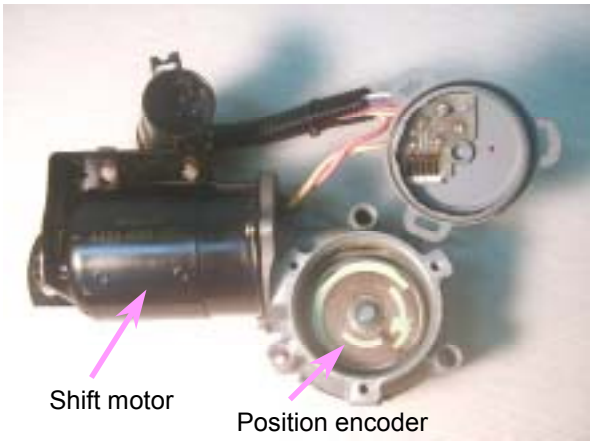


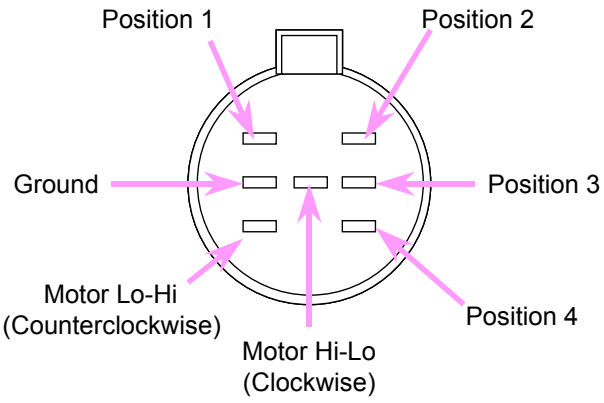
2) SHIFT MOTOR AND MPS(MOTOR POSITION SENSOR)

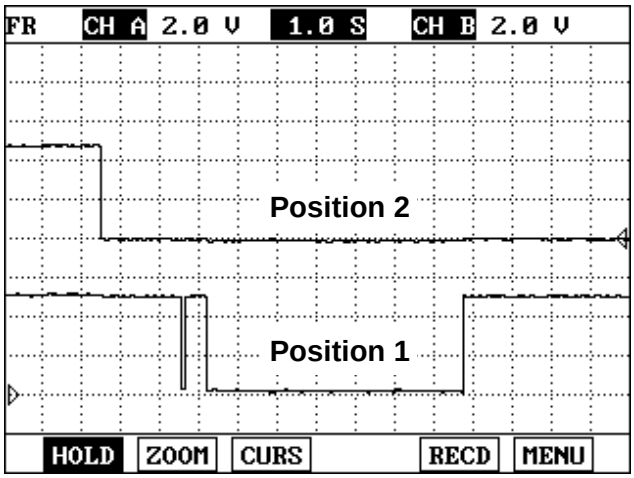
This shift motor is DC motor and controlled by TCCM. Its function is to shift into 4LOW for higher gear ratio. If shift motor is overhauled, the MPS signal is changed and cannot be reused. Therefore shift motor should not be overhauled.

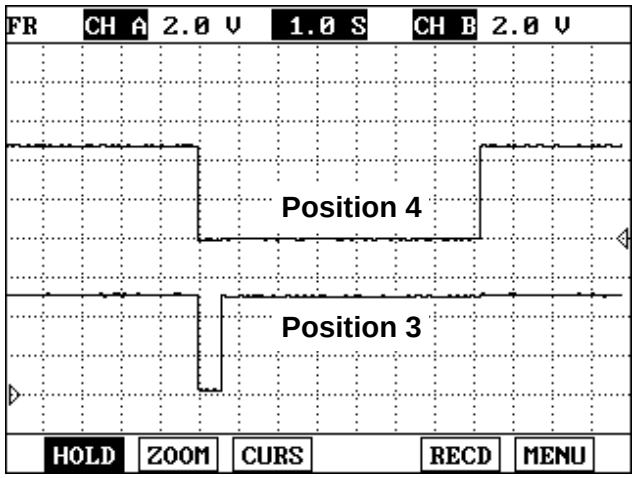
Coil resistance value : 0.78 ± 0.078Ω

* The shift motor for TOD cannot be replaced with one for EST.





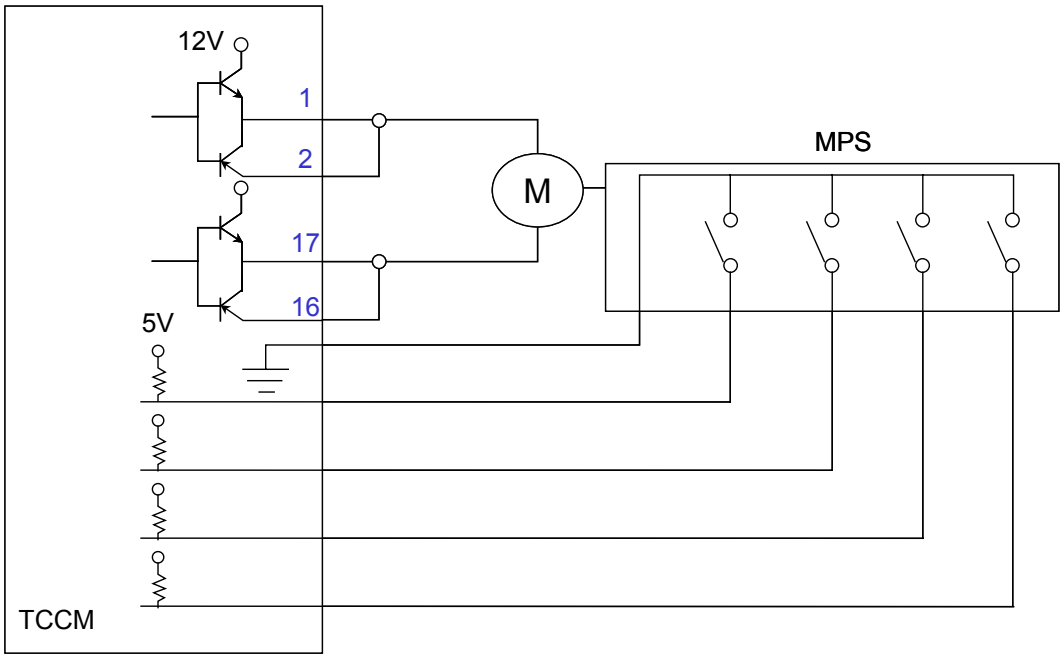




Output signal is changed depends on the shift motor position. There are 9 valid codes for the position to be detected by TCCM.

Motor position	Position 1	Position 2	Position 3	Position 4	Reamrks
Left stop	OFF	OFF	OFF	ON	ON : 0.8V or less OFF : 4.5V or more
Left of high	OFF	ON	OFF	ON	
High	ON	ON	OFF	ON	
Right of high	ON	ON	ON	ON	
Zone 1	OFF	OFF	OFF	OFF	
Neutral	OFF	ON	ON	OFF	
Zone 2	ON	ON	ON	OFF	
Low	ON	OFF	ON	OFF	
Right stop	ON	OFF	ON	ON	

SHIFT MOTOR AND MPS DIAGRAM

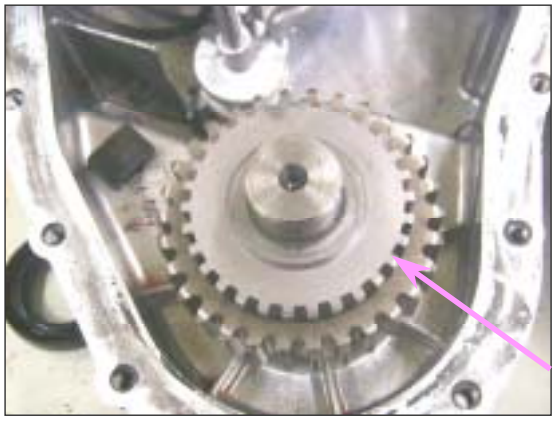


Clockwise rotation (Hi →Lo): Terminal 1,2 is B+ (12V), terminal 16,17 is earth.

Counterclockwise (Lo →Hi): Terminal 1,2 is earth, terminal 16,17 is B+ (12V).

3) FRONT AND REAR SPEED SENSOR

Front speed sensors and rear speed sensor signals is very important information for the TODCM to decide a torque distribution rate between the rear shaft and the front shaft. If one of the both is failed, mode change between the AUTO and the LOW is not available.



Hall effect type speed sensor

Sensing tone wheel for front speed (teeth = 30EA)

Sensing tone wheel for rear speed (teeth = 30EA)

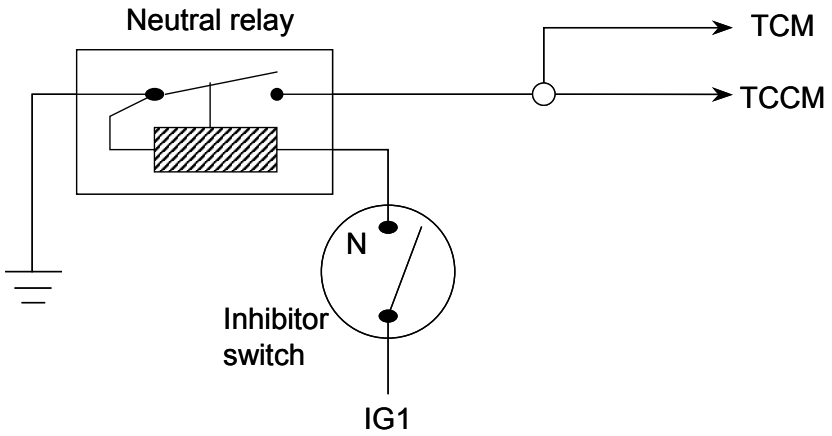
Location : The end of rear propeller shaft

4) INDICATOR

Condition	A/T LEVER	TOD SW mode	INDICATOR		Description
			4LOW	W/Lamp	
IGN ON or IDLE	P/R/D/2/1	AUTO	ON (3sec)	ON (3sec)	ON (3sec) --> OFF at IG. ON
		AUTO→4LOW	Blinking	OFF	'AUTO mode' holding
		4LOW→AUTO	OFF	OFF	'AUTO mode' holding
	N	AUTO	ON (3sec)	ON (3sec)	ON (3sec) --> OFF at IG. ON
		AUTO→4LOW	7 times blinking --> ON	OFF	4LOW indicator : 6 times blinking --> Shift motor ON --> 1 time blinking --> ON
		4LOW→AUTO	7 times blinking --> OFF	OFF	4LOW indicator : 6 times blinking --> Shift motor ON --> 1 time blinking --> OFF

5) AT NEUTRAL RELAY (EST/TOD)

In case of automatic transaxle vehicle, there is a A/T neutral relay to detect the condition that shifts from 'Auto mode' to 'Low mode' (TOD) or '4H' to '4L' mode (EST). Due to the characteristics of TCCM, the 'N' signal (battery 12voltage) from inhibitor switch cannot switched directly. That's why neutral relay was installed. In case of manual transaxle, the clutch lock switch was installed instead of A/T neutral relay so as to prevent the '4LOW' engagement during vehicle driving.



12 WARNING LAMP OPERATING CONDITIONS

Items	Condition	HP		
		INDICATOR		Description
		4LOW	W/Lamp	
TPS	OPEN OR SHORT(GND)	OFF	OFF	1. No warning lamp blink or ON. **2. AUTO ↔ 4LOW shift is possible**
SHIFT MOTOR	OPEN	OFF	Blink	1. Warning lamp blinks after 1 sec. since the fault is occurred. 2. Fail at the 'AUTO mode' : AUTO mode holding : '4LOW' lamp blinks if '4L' is selected 3. Fail at the '4LOW mode' : 4L mode holding : '4L OW lamp blinks if 'AUTO' is selected 4. Even though the fault is repaired, shift prevention is still existed. If IG. ON again, system is operated normally.

Items	Condition	HP		
		INDICATOR		Description
		4LOW	W/Lamp	
SHIFT MOTOR POSITION SENSOR (1), (2), (3), (4), (5)	OPEN Short to battery	OFF	OFF	1. Warning lamp blinks after 1 sec. since the fault is occurred. 2. Fail at the 'AUTO mode' : AUTO mode holding : '4LOW' lamp blinks if '4L' is selected 3. Fail at the '4LOW mode' : 4L mode holding : '4L OW lamp blinks if 'AUTO' is selected 4. Even though the fault is repaired, shift prevention is still existed. If IG. ON again, system is operated normally.
	SHORT(GND)			
FRT SPEED SENSOR	OPEN	OFF	OFF	1. Warning lamp blinks after 0.5 sec. since the fault is occurred. 2. Fail at the 'AUTO mode' : AUTO mode holding : '4LOW' lamp blinks if '4L' is selected 3. Fail at the '4LOW mode' : 4L mode holding : '4L OW lamp blinks if 'AUTO' is selected 4. Even though the fault is repaired, shift prevention is still existed. If IG. ON again, system is operated normally.
RR SPEED SENSOR	OPEN	OFF	OFF	
EMC (ELECTRO-MAGNETIC CLUTCH)	OPEN	OFF	Blink	1. Warning lamp blinks after 0.8 sec. since the fault is occurred. 2. Fail at the 'AUTO mode' : AUTO mode holding : '4LOW' lamp blinks if '4L' is selected 3. Fail at the '4LOW mode' : 4L mode holding : '4L OW lamp blinks if 'AUTO' is selected 4. Even though the fault is repaired, shift prevention is still existed. If IG. ON again, system is operated normally.
	SHORT(GND)	OFF	Blink	

13 DTC LIST AND FAILSAFE

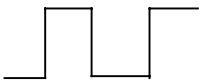
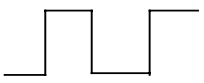
DTC	Content
P1725	TOD CONTROL MODULE(CHECKSUM) ERROR
P1726	THROTTLE POSITION INPUT - LOSS OF SIGNAL
P1727	THROTTLE POSITION INPUT - OUT OF RANGE
P1728	EMC - OPEN/SHORT TO BATTERY
P1729	EMC - SHORT TO GROUND
P1730	FRONT SPEED SENSOR - LOW INPUT
P1731	FRONT SPEED SENSOR - HIGH INPUT
P1732	REAR SPEED SPEED SENSOR - LOW INPUT
P1733	REAR SPEED SPEED SENSOR - HIGH INPUT
P1734	SPEED SENSOR REFERENCE - LOW INPUT
P1735	SPEED SENSOR REFERENCE - HIGH INPUT
P1736	SHIFT MOTOR - OPEN
P1737	SHIFT MOTOR - OPEN/SHORT TO GROUND
P1738	SHIFT SYSTEM TIMEOUT
P1739	GENERAL POSITION ENCODER FAULT
P1740	POSITION 1 - SHORT TO GROUND
P1741	POSITION 2 - SHORT TO GROUND
P1742	POSITION 3 - SHORT TO GROUND
P1743	POSITION 4 - SHORT TO GROUND

No.	Description	P-code	Failure effect	Fail-safe	W/Lamp
1	EEPROM checksum fault	P1725	TOD	Default calibration data	-
2	TPS loss of signal	P1726	TOD (TPS Idle)	TOD Determined by wheel slip only	OFF
3	TPS out of range	P1727	TOD (TPS Idle)	TOD Determined by wheel slip only	OFF
4	EMC open/shorted to battery	P1728	TOD Halted (2WD)	None	**Blink**
5	EMC shorted to ground	P1729	TOD Halted (2WD)	None	**Blink**
6	Front speed sensor voltage Low	P1730	TOD	4H mode fail, Rear speed sensor, EMC Touch off level fixing. 4L Mode fail, EMC Maximum level fixing.	OFF
7	Front speed sensor voltage High	P1731	TOD		OFF

No.	Description	P-code	Failure effect	Fail-safe	W/Lamp
8	Rear speed sensor voltage Low	P1732	TOD	4H mode fail, Front speed sensor, EMC Touch off level fixing. 4L Mode fail, EMC Maximum level fixing.	OFF
9	Rear Speed sensor voltage High	P1733	TOD		OFF
10	Vehicle speed sensor reference Voltage Low	P1734	TOD	4H mode fail, Zero speed sensor, EMC Touch off level fixing. 4L Mode fail, EMC Maximum level fixing.	OFF
11	Vehicle speed sensor reference Voltage High	P1735	TOD		OFF
12	Shift motor open/shorted to Battery	P1736	Electric motor shifting(4H-4L-4H)	No Shifts	**Blink**
13	Shift motor open/shorted to Ground	P1737	Electric motor shifting(4H-4L-4H)	No Shifts	**Blink**

No.	Description	P-code	Failure effect	Fail-safe	W/Lamp
14	Shift system timeout	P1738	Electric motor shifting(4H-4L-4H)	No Shifts	**Blink**
15	General position encoder Fault	P1739	Electric motor shifting(4H-4L-4H)	No Shifts	OFF
16	Position 1 shorted to Ground	P1740	Electric motor shifting(4H-4L-4H)	No Shifts	OFF
17	Position 2 shorted to Ground		Electric motor shifting(4H-4L-4H)	No Shifts	
18	Position 3 shorted to Ground		Electric motor shifting(4H-4L-4H)	No Shifts	
19	Position 4 shorted to Ground		Electric motor shifting(4H-4L-4H)	No Shifts	

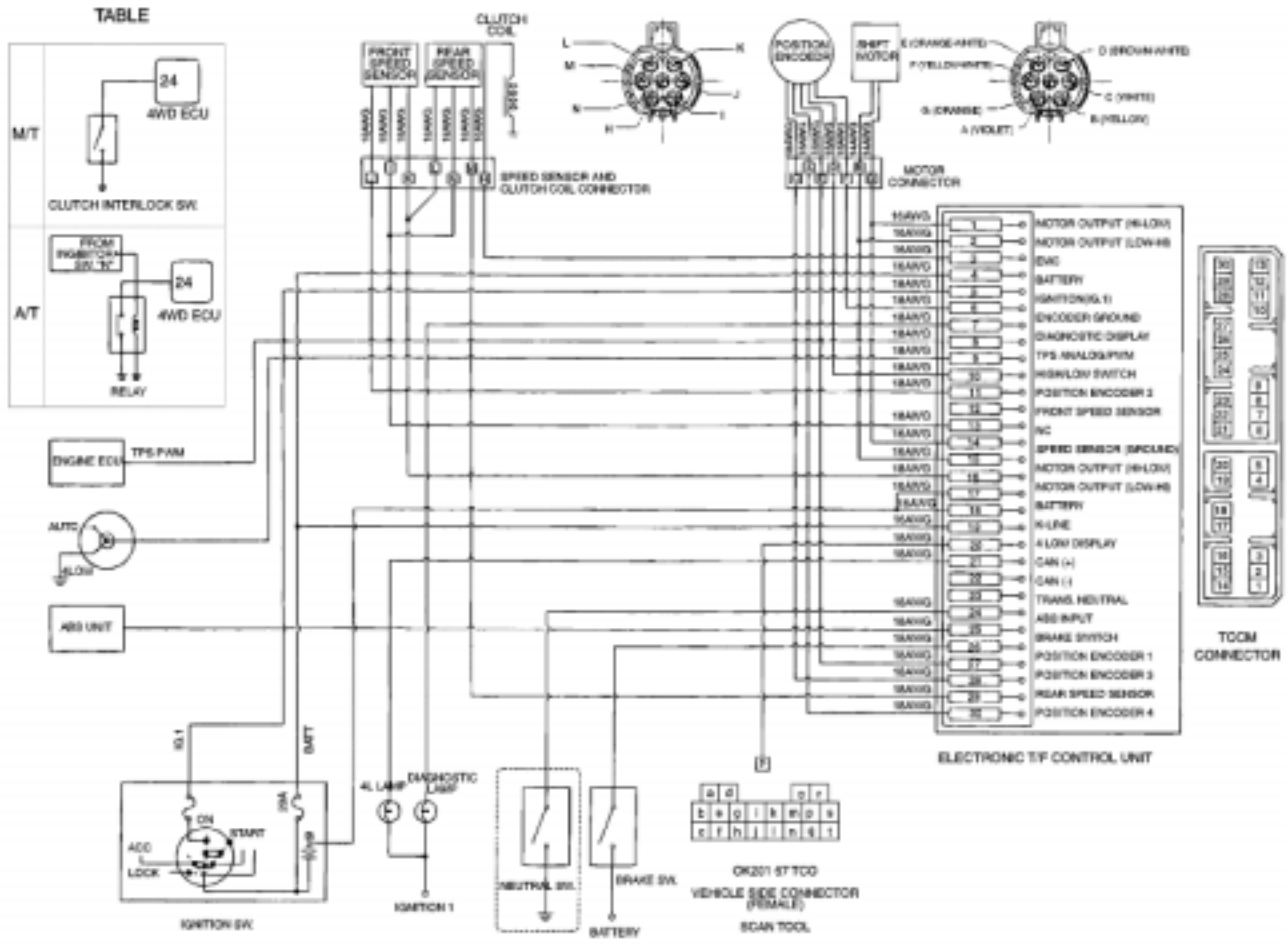
14 STANDARD INPUT AND OUTPUT VALUE IN TODCM

No		Items	Condition	Signal		Remarks
				Type	Level	
1	A1	MOTOR OUTPUT (HI-LOW)	IIDLE (A/T LEVER "N")	DC	Vbatt	
				↑	0V	
2	A2	MOTOR OUTPUT (LOW-HI)	IDLE (A/T LEVER "N")	DC	Vbatt	
				↑	0V	
3	A3	EMC	Vehicle driving	PULSE (PWM)	 Vbatt 0V FREQ. : 50Hz DUTY(-) : 0 88%	* 4LOW DUTY(-): 88.72%
4	A4	BATT	IGN OFF	DC	Vbatt	
			IGN ON	↑	Vbatt	
5	A5	IGN 1	IGN OFF	DC	0V	
			IGN ON	↑	Vbatt	
6	B1	ENCODER GND				
7	B2	DIAGNOSTIC DISPLAY	LAMP OFF	DC	Vbatt	
			LAMP ON	↑	0.5V or less	
8	B3	TPS(PWM)	ACCEL C.T & W.O.T	PWM	HI : 4V MIN LO : 0.9V MAX FREQ. : 100Hz DUTY(-) : C.T - 10% W.O.T - 83%	
9	B4	AUTO/LOW SW	IDLE (A/T LEVER "N")	AUTO LOW	4V or more 0.9V or less (AUTO mode : 4V or more)	
10	B5	SHIFT MOTOR POSITION 2	IDLE (A/T LEVER "N")	→AUTO →LOW	CODE : 0010 →0000 CODE : 0101 →0000 LOGIC HI(1) : 4.5V or more LOGIC LO(0) : 0.5V or less	* MTR POS. CODE: 1/2/3/4 = XXXX
11	B6	FRT SPEED SNSR	Vehicle driving	PULSE	 4V or more 0 0.9V 30PULSE/PROPSHAFT REV. DUTY(-) : 50%	* VSS 60KPH : 985Hz

No		Items	Condition	Signal		Remarks
				Type	Level	
12	B7	N.A				
13	B8	SPEED SNSR GND				
14	A6	MOTOR OUTPUT (HI-LOW)	IDLE("N")	DC	Vbatt	
				↑	0V	
15	A7	MOTOR OUTPUT (LOW-HI)	IDLE("N")	DC	Vbatt	
				↑	0V	
16	A8	SPEED REFERENCE	IGN OFF	DC	0.9V or less	
			IGN ON	↑	4.75 5.25V	
17	A9	GND FOR ECU				
18	A10	GND FOR ECU				
19	A11	BATT	IGN OFF	DC	Vbatt	
			IGN ON	↑	Vbatt	
20	A12	K-LINE	In comm. (10.4Kbps)	PULSE	LOGIC "0" : Vbatt 20% or less LOGIC "1" : Vbatt 80% or more	
21	B9	4LOW DISPLAY	SW OFF	DC	Vbatt	* IGN ON : Turned on for 3sec.
			SW ON	↑	0.5V or less	
22	B10	N.A				
23	B11	N.A				
24	B12	TRANS. NEUTRAL	N	DC	0.9V or less	
			P/R/D/2/L	↑	4.5 5.5V	
25	B13	ABS INPUT	ABS OFF	DC	4.5 5.5V	
			ABS ON	↑	0.9V or less	
26	B14	BRAKE SW	SW OFF	DC	0.9V or less	
			SW ON	↑	Vbatt	
27	B15	SHIFT MOTOR POSITION 1	IDLE (A/T LEVER "N")	→AUTO →LOW	CODE : 0010 →0000 CODE : 0101 →0000 LOGIC HI(1) : 4.5V or more LOGIC LO(0) : 0.5V or less	* MTR POS. CODE: 1/2/3/4 = XXXX

No		Items	Condition	Signal		Remarks
				Type	Level	
28	B16	SHIFT MOTOR POSITION 3	IDLE (A/T LEVER "N")	→AUTO →LOW	CODE : 0010 →0000 CODE : 0101 →0000 LOGIC HI(1) : 4.5V or more LOGIC LO(0) : 0.5V or less	* MTR POS. CODE: 1/2/3/4 = XXXX
29	B17	RR SPEED SNSR	Vehicle driving	PULSE	4V or more 0 0.9V 30PULSE/PROPSHAFT REV. DUTY(-) : 50%	* VSS 60KPH : 966Hz
30	B18	SHIFT MOTOR POSITION 4	IDLE (A/T LEVER "N")	→AUTO →LOW	CODE : 0010 →0000 CODE : 0101 →0000 LOGIC HI(1) : 4.5V or more LOGIC LO(0) : 0.5V or less	* MTR POS. CODE: 1/2/3/4 = XXXX

15 TOD WIRING DIAGRAM



16. TRANSFER OVERHAUL

16.1 DISASSEMBLY

* Prepare an EST unit on a table with proper tools.

1. Before overhaul, remove an EMC coil wire carefully from the connector.

* After removing the pin, correct the stopper of the pin using a driver.

2. Remove the shift motor assembly.

* After removing the shift motor assembly.

3. Remove the vehicle speed sensor.

4. Remove the lock nut.

5. Remove the companion flange and the oil seal.

6. Remove the rear speed sensor.

7. Remove the cover bolts.

8. Remove the EMC coil nuts.

* Check the rubber bush and extension housing.

9. Remove the oil seal.

* After removing the oil seal.

10. Remove the speedo gear.

11. Remove the tone wheel.

12. Remove the case upper cover.

13. Remove the EMC coil and the coil housing.

* EMC coil and housing

* EMC housing (bottom)

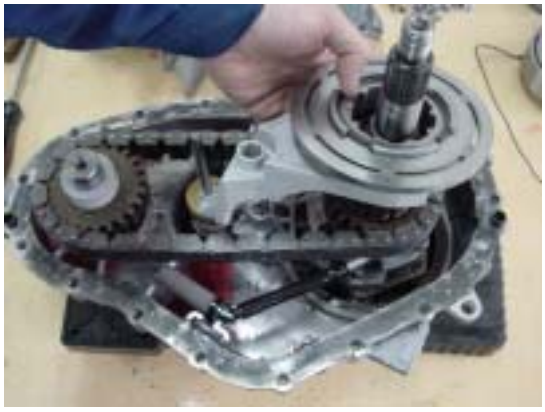
* EMC coil

14. Remove the 4H mode return spring.

15. Check the proper function of the lock-up assembly by pressing the lock-up hub.

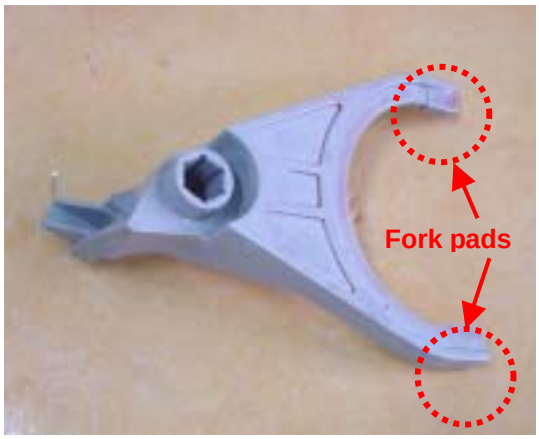
* Examine the wear on the face.

16. Remove the lock-up assembly and the shift-fork together.



* Lock-up assembly and the shift-fork

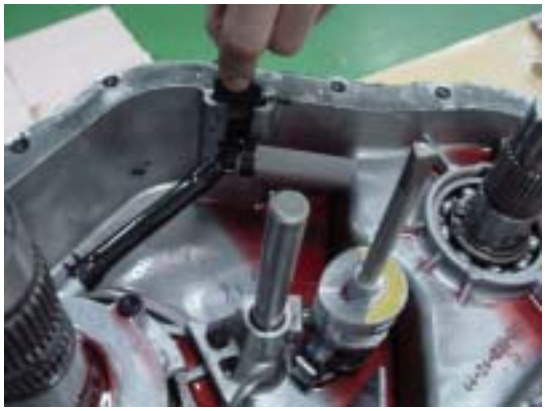
17. Inspect the 4H shift-fork and wear of fork pads.



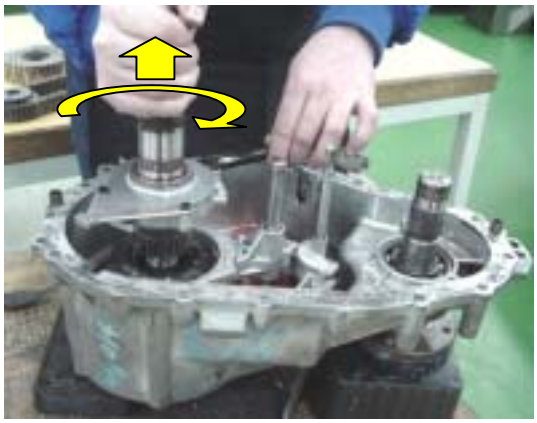
* After removing the lock-up assembly and the shift-fork

18. Remove the chain and sprocket together

19. Remove the magnet before removing the pump from the output shaft.



20. Rotate the output shaft to rotate inner pump gear and remove the pump assembly and the shaft together.



21. Remove the spacer.

22. Lift pump of the shaft.

* Pump assembly is not a serviceable item and should be replaced as an assembly.

23. Inspection of the upper output shaft.

* Check the spline teeth for brakes, chipping, crack.

* Check journals for excessive wear or discoloration.

* After removing the output shaft

24. Remove the shift rail.

25. Remove a shift cam.

26. Remove a reduction fork.

* Inspect the reduction fork. Check the fork pad for wear or discoloration from heat.

27. Remove a reduction hub.

* Check the reduction hub teeth for wear, brakes, chipping, crack.

* Snap ring

28. Ply open the snap ring and pull out the planetary carrier assembly from the cover.

* After removal

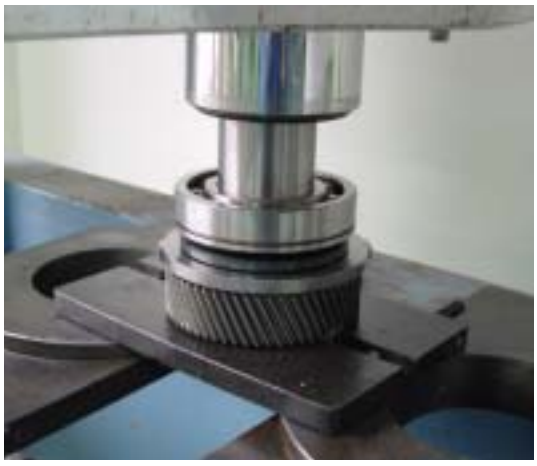
* Planetary carrier assembly

29. Remove a snap ring.

30. Remove a snap ring.

31. Remove the input gear assembly from the carrier assembly.

32. Disassemble the input gear assembly using a press.

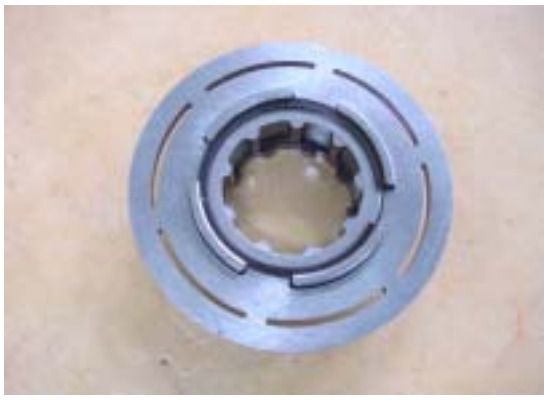


* Input shaft assembly

* Shift cam assembly

33. Disassemble shift cam assembly

* 4H lock-up assembly



34. Disassemble the 4H lock-up assembly by removing a snap ring between the cowl and lock-up hub

* 4H lock-up assembly

16.2 ASSEMBLY

1. Reassemble the sun gear to the input gear.

   And install new input bearing snap ring.

After installation

2. Install the input assembly into the carrier assembly and then install the snap ring.

3. Insert the shift cam assembly.

4. Place the reduction hub and the shift fork together into the carrier.

* After installation

5. Slide the pump onto the shaft and align the drive pin on the slot in the pump.

6. Insert the output shaft into the input and reduction hub.

7. Insert the magnet into the case.

8. Install a spacer over the shaft onto the pump.

* Location of the spacer.

9. Place the chain and sprocket on the shaft.

* After installation

10. Locate blue chain link which is always on the top side of chain facing up.

11. Place the lock-up assembly and 4H shift fork on the sprocket aligning the lock-up collar teeth with the sprocket teeth.

* After installation

12. Place the coil housing on the shaft.

13. Install the shift fork return spring.

14. Insert the coil in the case.

15. Install the EMC coil nuts.

16. Install cover bolts.

17. Install the speed sensor.

18. Insert the coil pin to the connector.

19. Apply sealant to the shift motor seat on the case.

20. Install the shift motor on the case.

21. Attach wire retainer to the connector.

* After installation

Santa-Fe D-VGT

Electronically Controlled On-Demand 4WD System

17. APPLICATION

◈ : Mechanical ★ : Electronic

Line-up		Korea	North America	Europe	General	Aus.	Japan
SIR-II 2.4	M/T	-	-	◈	◈	◈	-
DELTA2.7	A/T	◈	◈	◈	◈	◈	◈
D-2.0 VGT	M/T	★	-	★	★	-	-
	A/T	★	-	★	★	-	-
SIGMA3.5	A/T	-	★	-	-	-	-

Widely Used for Passenger car / SUV / Light Commercial Vehicles in the World(FF Base)

- **Volkswagen** : Golf 4-Motion, Bora 4-Motion, Beetle Rsi
- **Audi** : A3/S3 Quattro, TT Quattro
- **Volvo** : S60
- **Skoda** : Octavia
- **Seat** : Leon
- **Toyota** : Nadia / Ipsum / Gaia / Estima
- **General Motors** : Aztek, Rendezvous
- **Nissan** : X-Trail
- **Honda** : Acura MDX

18. ADVANTAGES

In Control, Regardless the Driving Situation

Controllability of the vehicle in all driving situations is becoming an important promotional factor for All-Wheel-Drive. An AWD vehicle has better road handling and is safer in all driving situations.
Answering these requirements, the new Electronically Controlled On-Demand 4WD System of Santa-Fe D-VGT offers fully controllable torque transfer characteristics and extremely rapid activation and deactivation automatically.
Maximum performance and safety are achieved in all driving situations, as shown here:

Enhanced Vehicle Traction

- Torque transfer up to 1,200 Nm
- Full function in reverse
- Instant activation on differential speed

Enhanced Vehicle Dynamics

- Improved dynamics during acceleration and deceleration
- Rapid activation and deactivation
- Fully controllable torque transfer characteristics

Enhanced Occupant and Vehicle Safety

- Full integration with brake systems (like ABS) and stability systems (like ESP).
  On demand, the system can be deactivated in less than 60 ms.

Enhanced Vehicle System Compatibility

- Fully compatible with ABS, ESP and TCS without freewheel or additional clutch
- On-line communication with the CAN system

Enhanced Vehicle Driving Comfort and Transparency

- No wind-up during tight cornering and parking
- Optimal traction during acceleration

Enhanced Optimization of Weight and Fuel Consumption

- The fully controllable torque transfer characteristic decreases the design requirements of the complete AWD drive line, resulting in reduced weight and reduced fuel consumption

Parking

Low or zero torque transfer needed for easy and comfortable maneuverability

Acceleration

High torque transfer for maximum traction on all four wheels

High speed driving

Reduced torque transfer, to minimum, still adding dynamic stability

Driving on slippery/wet roads

Swift activation of the coupling for maximum traction and safety depending on the slip of the wheels. The coupling is in on-line communication with other safety systems in the vehicle

Braking/ABS

Immediate deactivation on ABS signal to ensure full function of ABS system

ESP/TCS

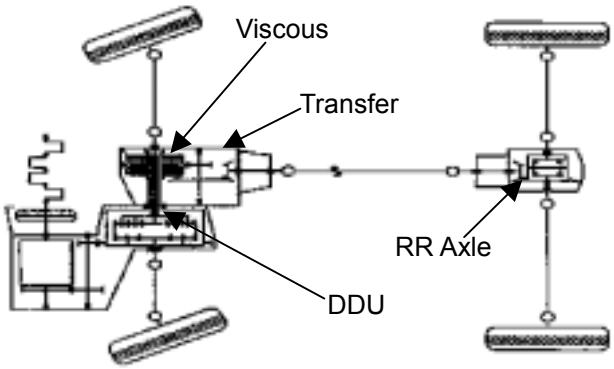
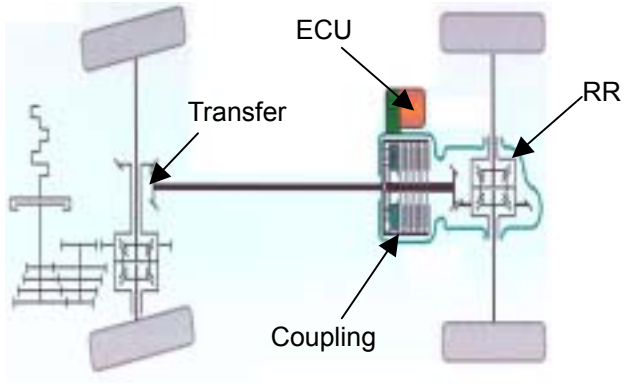
Immediate deactivation on ESP/TCS signal to ensure full function of ESP/TCS system. Alternative is to communicate with the ESP/TCS system for adding the control possibility of the new ON-Demand 4WD System to the ESP/TCS System

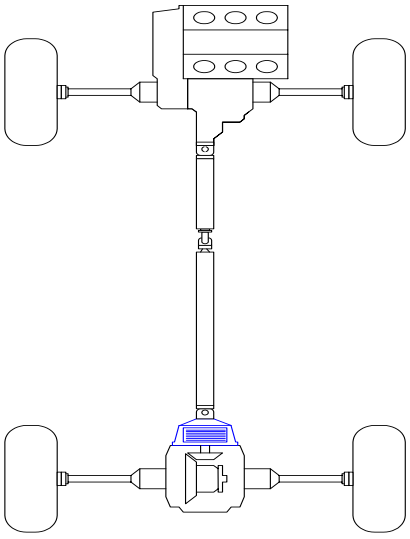
Off-road

Rapid activation with high torque transfer for maximum traction

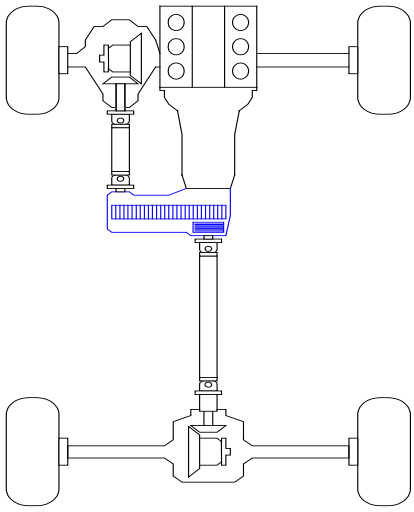
19. SCHEMATICS

New On-Demand vs. Center Diff.+Viscous

Santa-Fe WGT **(Center Diff+Viscous)**	**Santa-Fe VGT** **(New On-Demand)**
	
- Torque Distribution: made by DDU - No Sensors (Pure Mechanical)	- Torque Distribution: made by Coupling & ECU - With Sensors (Electronically Controlled) · Throttle Position · Steering Wheel Angle · Four Wheel Speed



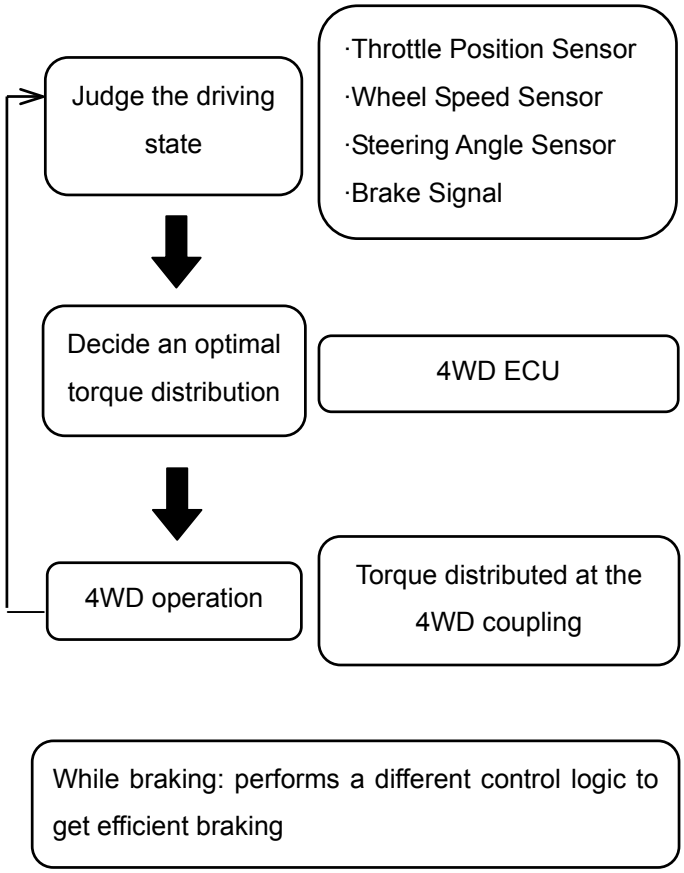
[ITM (FF car: Santa-Fe)]



[TOD & EST (FR car: Terracan)]

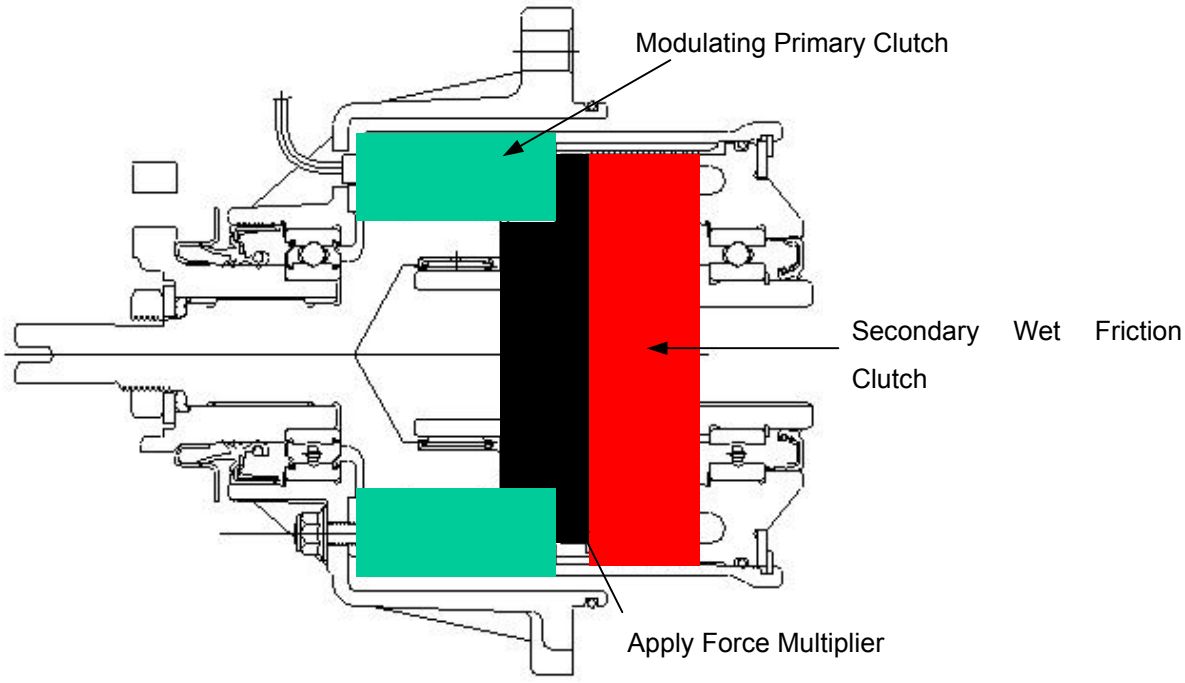
*ITM : Interactive Torque Management

20. **OPERATING PRINCIPLE**

Mechanical type **(Center diff. Type)**	**Electronic type** **(On-Demand type)**
■ Constant speed drive: Toque distribution between the front and the rear 6:4 in the center differential ■ Speed difference between the front and the rear: viscous coupling operates distributing a proper torque to the front and the rear.	■ Constant speed drive: almost 2WD state ■ Torque distribution changes according to the driving state (ex: sudden start, turning, at low-mu surface) by the ECU logic.  While braking: performs a different control logic to get efficient braking

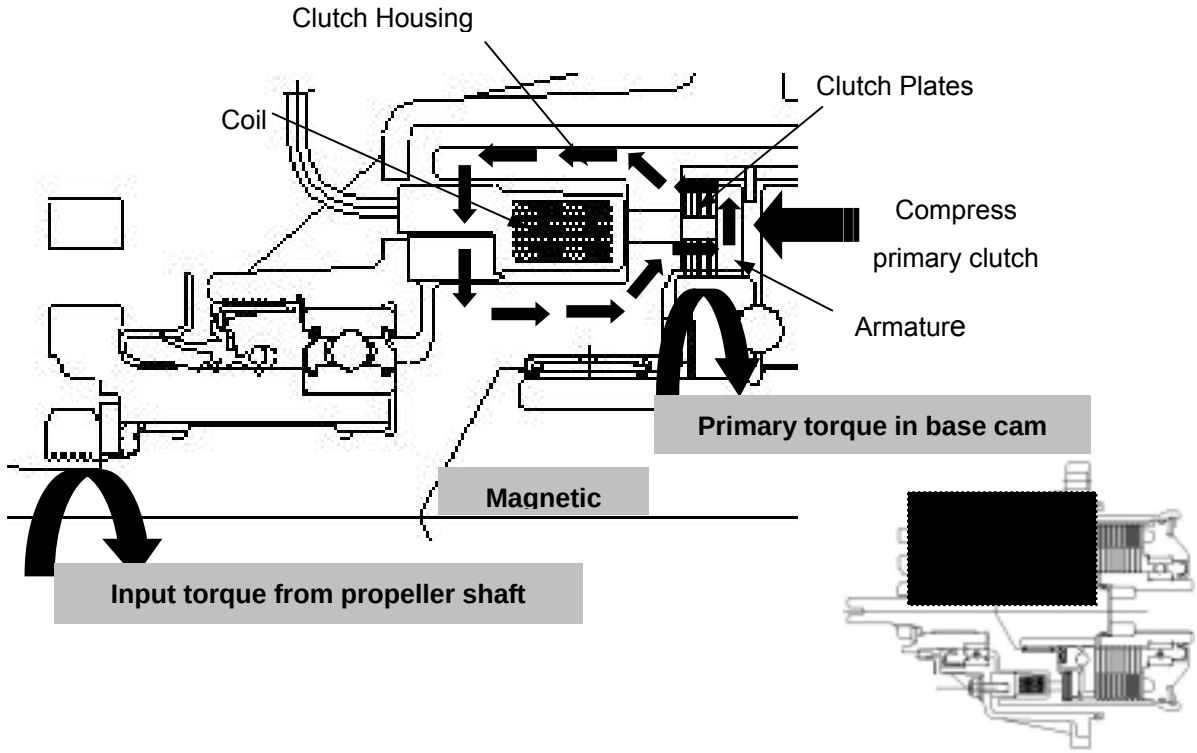
21. STRUCTURE

STRUCTURE-COUPLING

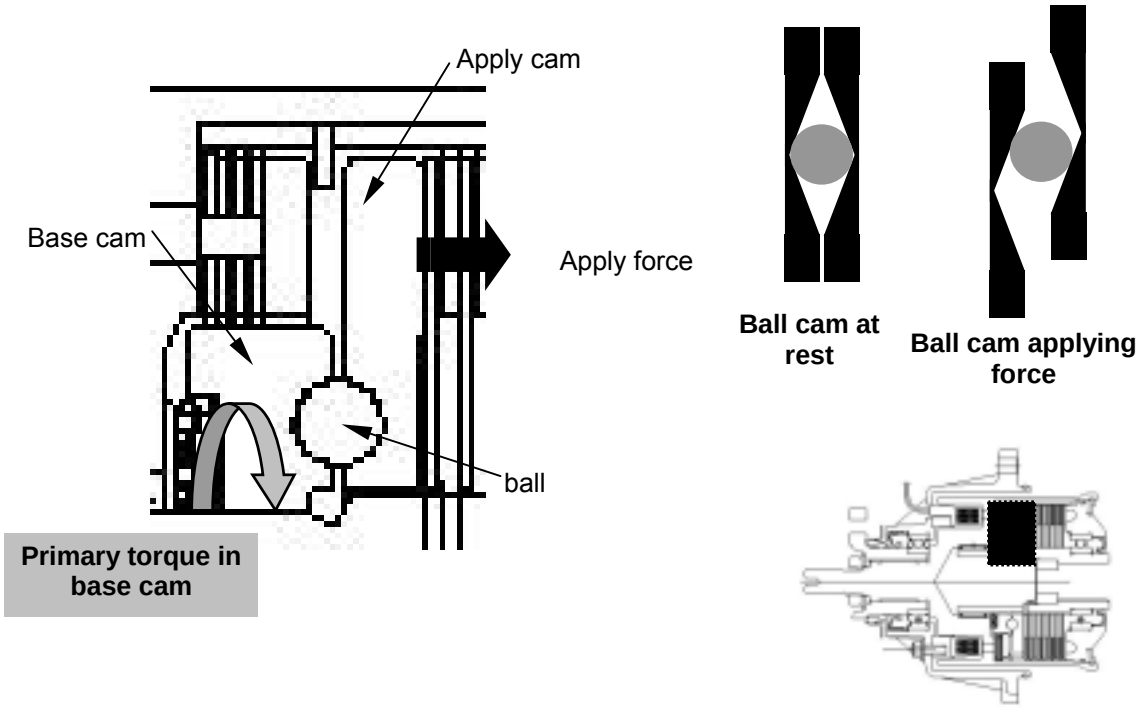


22. OPERATION OF COUPLING

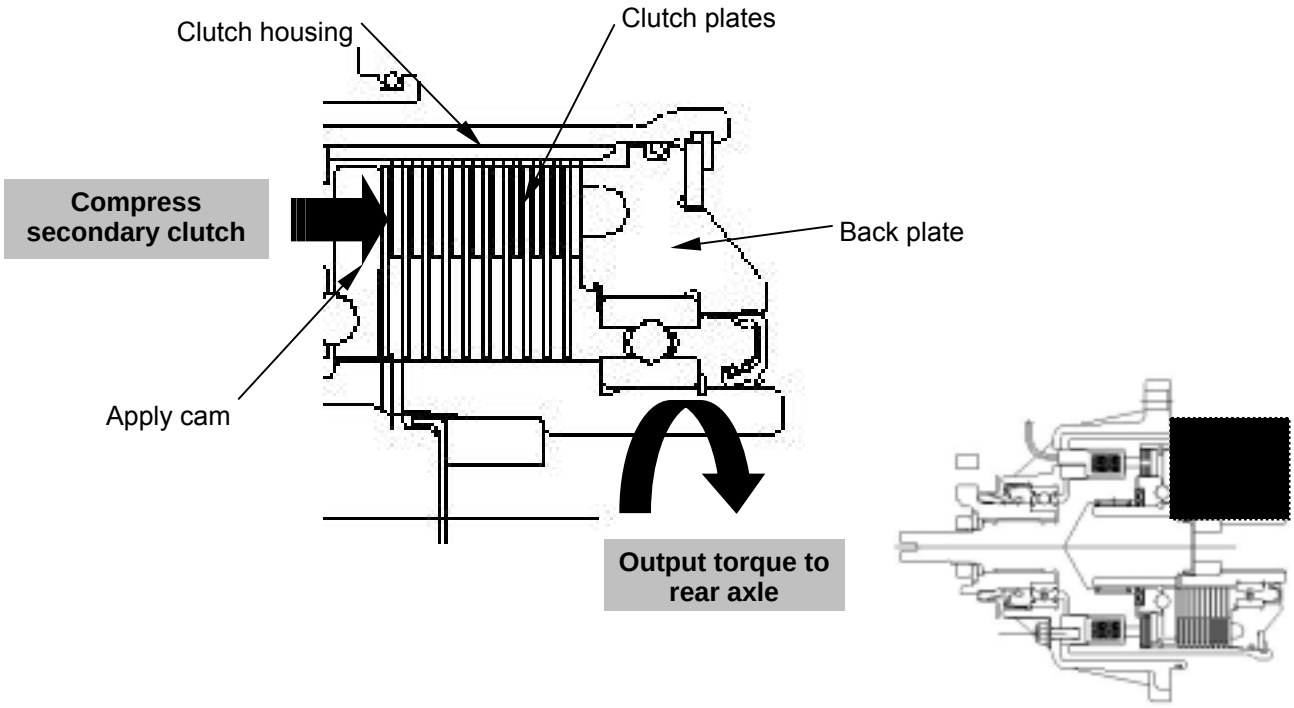
Modulating primary clutch



Apply force amplifier

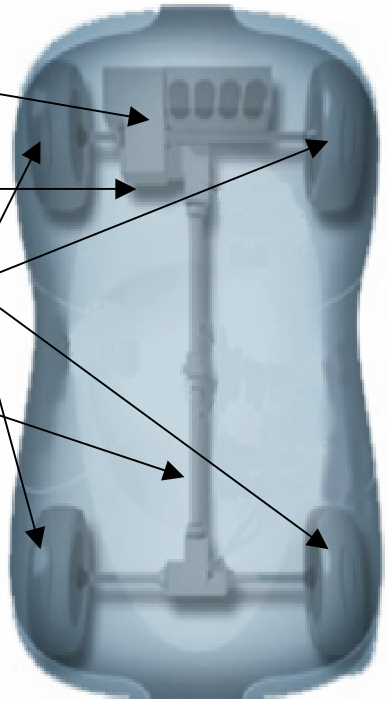


Secondary wet friction clutch



23. INPUT SIGNALS

1. Throttle Position
2. Steering Angle
3. 4 Wheel Speeds
4. Prop-Shaft speed



VehicleModel	Sensors			
	1	2	3	4
Santa-Fe WGT	-	-	-	-
Santa-Fe VGT	●	●	●	-
Terracan	●	-	-	●

24. TORQUE TRANSFER

New On-Demand vs. Center Diff.+Viscous

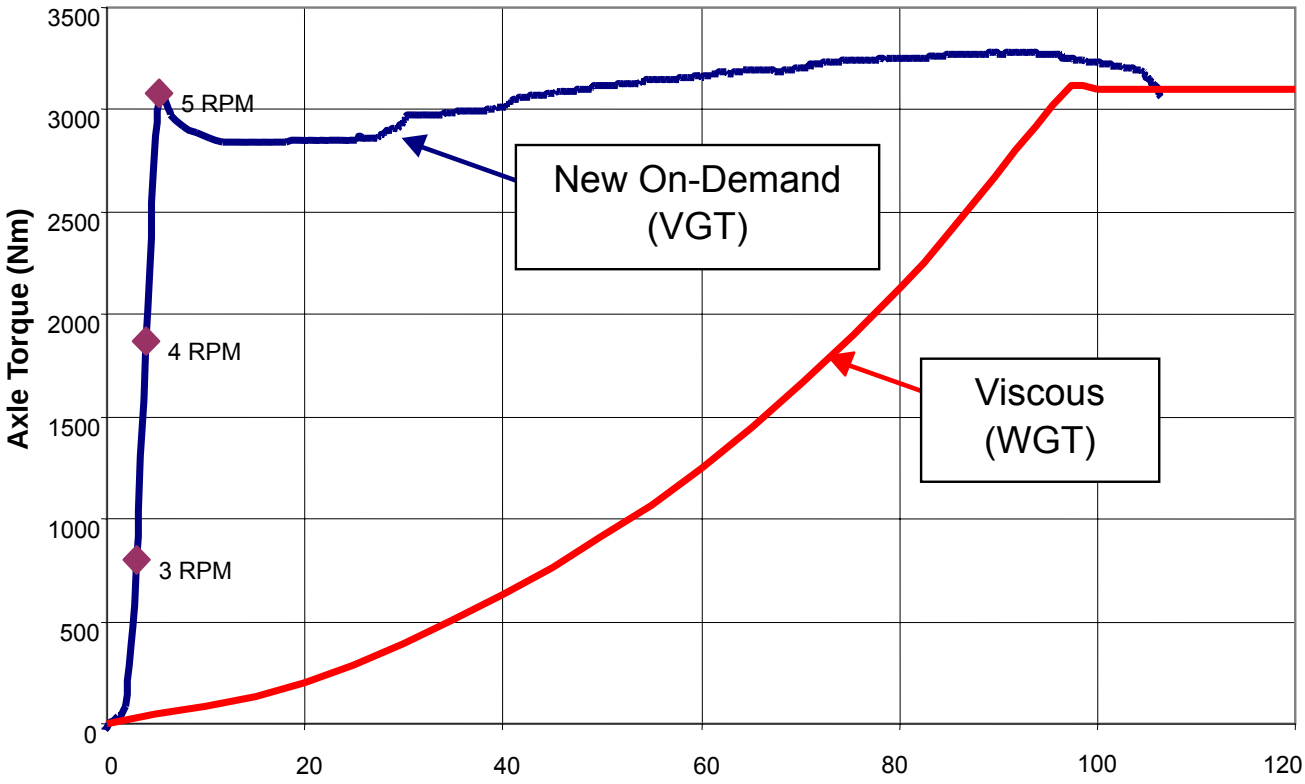
New On-Demand (VGT)

- Torque available at low slip speeds
- Simple control of Torque through electrical current
- Cold Temperatures do not cause start up delays

Center Diff+Viscous (WGT)

- Higher slip speeds required to develop torque
- No Control of torque. Torque is applied whenever there is slip.
- Viscous couplings are temperature sensitive

Axle torque vs. Diff. RPM



25. 4WD SYSTEM WEIGHT COMPARISON

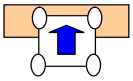
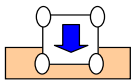
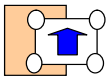
New On-Demand vs. Center Diff.+Viscous

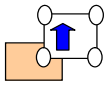
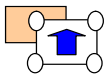
No	Part Name	Weight (kg)		Remark
		Center Diff (WGT)	On-Demand (VGT)	
1	Transfer Assy	23.5	21.0	
2	D.D.U.	8.8		Assembled in T/M
3	Front Diff Assy		5.0	Assembled in T/M
4	4WD Coupling		8.9	
5	Rear Axle Assy	20.0	19.5	
6	4WD ECU		0.3	
Total		52.3	54.7	Net increase: +2.4 kg

Start & Stability on Low-mu Road (Tested by HMC)

: Roll

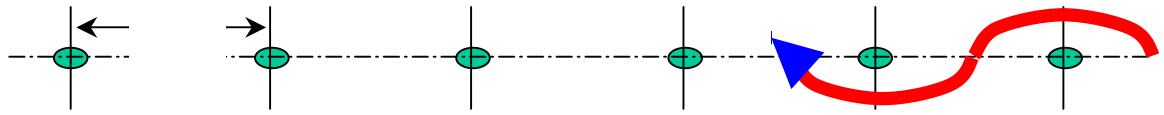
◎:Excellent, ○:Good, △:Slight Dissatisfaction

Road Condition		On-Demand	Center Diff
Starting on Low mu 	START	◎	△
	STABILITY	◎	○
Starting(Rev) on Low mu Road 	START	◎	○
	STABILITY	◎	○
Starting on Split-mu 	START	△	△~○
	STABILITY	△	△~○

Road Condition		On-Demand	Center Diff
Starting on Split-mu 	START	◎	○
	STABILITY	◎	○
Starting on Split-mu 	START	◎	△
	STABILITY	◎	△~○
SLALOM		○~◎	○
TCB (TIGHT CORNER BRAKING)		◎	◎

26. VEHICLE TEST RESULTS

Detail Description of Slalom Test (Tested by HMC)



	WGT (Center Diff+Viscous)	VGT (Electronically Controlled On-Demand)
MAX SPEED	84.8 kph	85.5 kph

Object of Slalom Test

- To See the Vehicle's Steering Characteristics(O/S or U/S) & its Response

Test Summary

- The Maximum Controllable Vehicle Speed becomes faster
- Steering Response has been improved (Subjectively)

Others

- No Customer Complaints about Handling Performance in WGT 2WD (Generally 4WD is better than 2WD in terms of Handling, therefore, there will not be any complaints in VGT 4WD)

27. DIAGNOSIS

While the ECU is actived it periodically monitors its inputs and outputs. If a fault is detected the Diagnostic Bulb is illuminated and flash at a rate of 0.25 seconds “ON”, and 0.25 seconds “OFF”. A fault code will also be stored in the ECU memory.

The first time a fault is detected a DTC is stored in the ECU’s Non-Volatile memory. This DTC will remain in memory until the ECU is instructed to erase DTC's by the diagnostic tester. DTC's will not be erased by disconnecting power to the ECU.

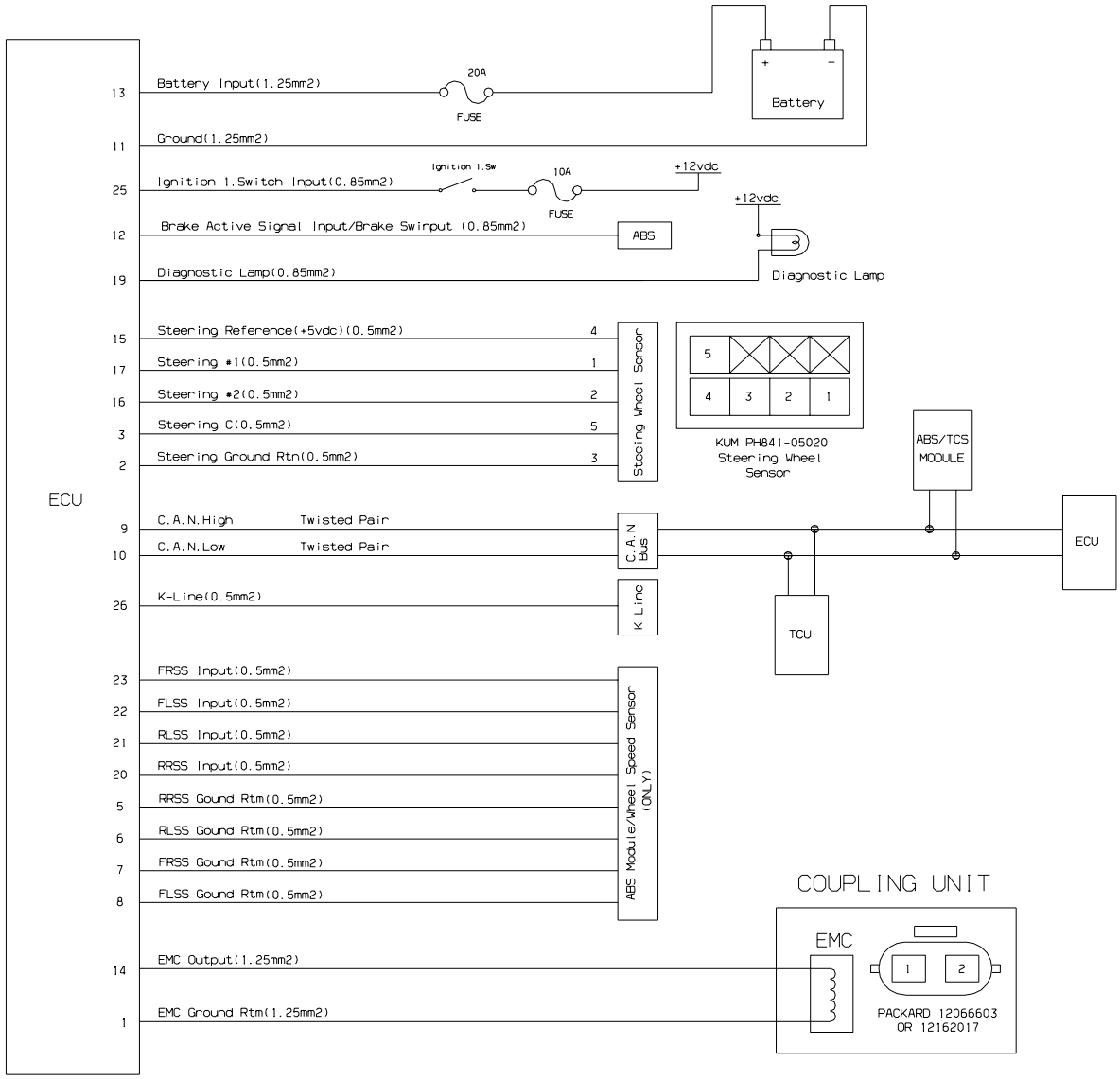
[ITM Control Module]

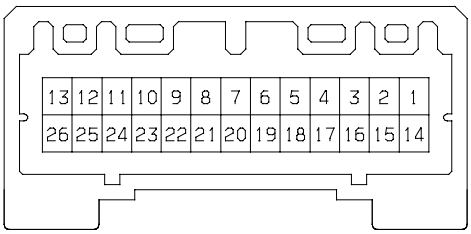
DTCs	ITMES	DESCRIPTIO
P1717	STEER 1	Loss of signal out of range
P1718	STEER 2	Loss of signal out of range
P1719	STEER C	Loss of signal out of range
P1726	TPS INPUT-LOSS OF SIGNAL	Loss of signal out of range
P1728	EMC-OPEN/SORT TO BATTERY	Short/Open to battery
P1729	EMC-SHORT TOGROUND	Short to ground
P1750	FLSS LOSS OF SIGNAL	Malfunction of front & left speed sensor
P1751	FLSS LOSS OF SIGNAL	Malfunction of front & right speed sensor
P1752	RLSS LOSS OF SIGNAL	Malfunction of rear & left speed sensor
P1753	RRSS LOSS OF SIGNAL	Malfunction of rear & right speed sensor
P1764	ECU-ITM CAN COMM.LINE, OR ECU SIDE MAL.	Malfunction of ECU-ITM CAN communication
P1765	TCS-ITM CAN COMM.LINE. OR ECU SIDE MAL.	Malfunction of TCS-ITM CAN communication

Input	Error Description	Diagnostic	Diagnostic Lamp	Clearing Strategy
TPS	Loss of signal Out of range	P1726	Diagnostic Lamp set	Active P-code cleared error is removed after 1 second
Error Strategy	A fault code of FFH from the C .A .N .Bus, Signal lost for 1 sec. Fault code stored in memory			
ECU Action	TPS=0 ITM Controller will not re-act to pre-empt. Pre-empt=0. The ECU will not send current to the clutch coil.			
Steer_1	Loss of signal Out of range	P1717	Diagnostic Lamp set	Active P-code cleared if error is removed after 1 second
Steer_2	Loss of signal Out of range	P1718	Diagnostic Lamp set	Active P-code cleared if error is removed after 1 second
Steer-C	Loss of signal Out of range	P1719	Diagnostic Lamp set	Active P-code cleared if error is removed after 1 second
Error Strategy	Out of Range signal : Voltage >= 4.5 vdc for greater than one (1) second			
ECU Action	Steering Wheel Sensor input=0. The ECU will not send current to the clutch coil.			
FLSS	Loss of signal	P1750 (C1201)	Diagnostic Lamp set	Fault cleared at ignition cycle reset. P-code stored, and erased by K-Line tool
FRSS		P1751 (C1201)		
RLSS		P1752 (C1201)		
RRSS		P1753 (C1201)		
Error Strategy	Measure individual wheel, if speed difference is 30kph for 30 seconds fault code will be set. Ignition cycle reset			
ECU Action	Speed sensor error will turn ITM off. ITM will not have output			

Input	Error Description	DTC	Diagnostic Lamp	Clearing Strategy
C.A.N	ECU-ITM Communication Line, or ECU side malfunction	P1764	Diagnostic Lamp set	Active P-code cleared if error is removed
Error Strategy	Loss of the following signals TPS, Transmission type.			
ECU Action	TPS=0 ITM Controller will not re-act to pre-empt. Pre-empt=0. The ECU will not send current to the clutch coil.			
C.A.N	TCS-ITM Communication Line. Or ECU side malfunction	P1765	Diagnostic Lamp set	Active P-code cleared if error is removed
Error Strategy	Loss of the following signals Wheel Speed No signal for greater than one (1) second, and a fault will be set.			
ECU Action	Speed sensor error will turn ITM off. ITM will not have output			
EMC	Short/Open to Battery	P1728	Set Diagnostic Lamp	Same as Speed sensor fault
	Short to Grid	P1729	Set Diagnostic Lamp	
Error Strategy	25 occurrences in a row mature			
ECU action	EMC Error will turn ITM off. The ECU will not send current to the clutch coil			

28. WIRING DIAGRAM





[CONNECTOR]

FULL TIME 4WD

SYSTEM of Santa-Fe

(Center Diff+Viscous)

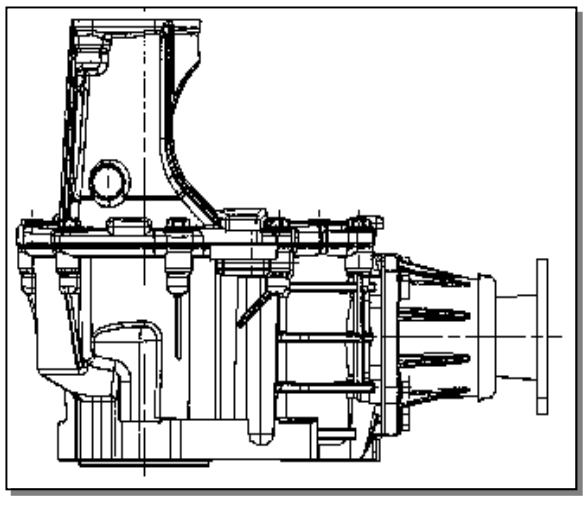
- DDU
- LSD (Front)

29. SYSTEM GENERAL

1) POWER TRAIN LINE-UP

ENG	DRIVE TYPE	North America		Europe		General		Australia	
		2WD	4WD	2WD	4WD	2WD	4WD	2WD	4WD
SIRIUS II - 2.0 DOHC	M/T			★					
	A/T								
SIRIUS II - 2.4 DOHC	M/T	★		★	★	★	★		★
	A/T	★							
δ - 2.7 V6	A/T	★	★		★		★		★
2.0 DSL Tci	M/T			★	★	★	★		
	A/T				★		★		

The full time 4WD system offers safe driving performance at the worst road condition due to the operation of DDU (Double Differential Unit) which distributes the driving power to front and rear wheel with the ratio of 60 and 40 percent, considering optimal vehicle driving condition at the normal road condition.



At the slippery road such as snow or wet asphalt, if the rotating speed is different between front and rear wheel, the driving power is optimally distributed to the front and rear wheel by high viscosity fluid coupling. It offers advanced driving efficiency.

It is more comfortable in respect of driver, because it is not necessary to select or shift 4WD such as part time 4WD system.

2) TORQUE SPLIT OF AWD SYSTEM

Fixed type with viscous coupling similar with Toyota or Subaru system.

But **60:40 front and rear torque split is the unique point of SM system.** Conventional AWD system should split engine torque in 50:50 front and rear due to its gear characteristics, but SM system can split 60:40, which is selected as optimal torque distribution for on-road

traction by simulated test in SFT, owing to the DDU, double differential unit.

In spite of its fixed basic torque split, viscous coupling distribute engine torque to the each axle in optimal ratio by mechanical sensing.

The range of torque split cannot be defined clearly because of the characteristics of viscous coupling unit.

Summary - DDU function

- CENTER + FRONT DIFF
- Power distribution to front/rear wheel and absorbing its rotation difference
- Power distribution to front left/right wheel and absorbing its rotation difference

- Lubrication oil specification :
  SAE80W90 / API GL5 - 0.8Liter
- Conventional manual transaxle :
  SAE75W90 / API GL4

☞ No exchangeability with conventional M/T lubrication oil.

3) THE TYPES OF 4WD SYSTEM AND ITS CHARACTERISTICS

Items	PART TIME 4WD		FULL TIME 4WD							
Type	- GEAR driving - CHAIN driving - Without DIFF. on the FRT/RR		CENTER DIFF type - BEVEL GEAR TYPE - PLANETARY GEAR TYPE			ON-DEMAND 4WD type			TORQUE SPLIT type	
2WD/4WD shifting	Shift after stopping	SOTF	Not necessary (All time : Constant distribution)			Not necessary			Not necessary	
4WD control	Manual shifting	SOTF	MECHANI -CAL LOCK	VISCOUS COUPLING	Etc (TORSEN LSD and so on)	VISCO DRIVE type	HYDRAU-LIC UNIT type	Electronic control MULTI PLATE type	HYDRAU-LIC CONTROL	ELECTRO-MAGNETIC CONTROL
Application	GALLOPER	STAREX 4WD KIA SPORTAGE DAEWOO MUSSO	TOYOTA RAV4 TOYOTA RX-300 BENZ ML320	SM 4WD, MMC, TOYOTA RAV4, RX-300 SUBARU FORESTER	AUDI QUATTRO	CHRYSLER VOYAGER	HONDA CRV HONDA HR-V HONDA ODYSSEY	TOYOTA GAIA, ISUZU BIGHORN, MAZDA ACTI VEHICLE TOYOTA NADIA TOYOTA	TOYOTA CELICA	
	(HEAVY DUTY 4WD OFF ROAD VEHICLE JEEP series)									
Main points	* Changed FRT/RR power distribution from the load condition. * 2WD is needed at the normal road.		* CENTER DIFF distributes the FRT/RR power. * LSD has a function to limit the FRT/RR differential. * Most generally used FULL TIME 4WD system.			* Drivie with 2WD at the normal road. * Select 4WD when the FRT/RR slip occurrs. * Electronic control ON-DEMAND 4WD type is currently increased.			* The function of FRT /RR power distribution and LSD is controlled actively. * It is advanced system in the respect of 4WD function, but the system is complicated and cost is high.	

Items	PART TIME 4WD	FULL TIME 4WD				
Type	- GEAR driving - CHAIN driving - Without DIFF. on the FRT/RR	CENTER DIFF type - BEVEL GEAR TYPE - PLANETARY GEAR TYPE	ON-DEMAND 4WD type			TORQUE SPLIT type
Driving/ Towi-ng power	A	B	B	B	A	A
TIGHT CORNER BRAKING	D (Necessary to select 2WD)	A	B	A	A	A
SYSTEM feature	A	B	A	B	B	C
Easy-driving	C	A	A	A	A	A
Fuel consumption	B	C	B	A	A	C
COST	A	B	A	B	B	C

Remarks) A : Excellent, B : Good, C: Normal, D : Bad

30. SYSTEM CONFIGURATION

1) MAJOR FEATURES

System Configuration

Full Time 4WD System (AWD)

Center Differential + Viscous Coupling

Double Differential Unit (DDU)

- Center differential and front differential designed as an intergrated unit (located in transmission)

Torque Distribution

60% : 40% (Front : Rear Wheel)

Compact Design

VC housing integrated design with helical drive gear

Double differential unit

Seperated Transfer Oil Lubrication

SAE 80W/90, API GL-5 grade (Shell SPIRAX AX equivalent)

Volume : 0.8Liter

2) SYSTEM STRUCTURE

a. T/F assembly :

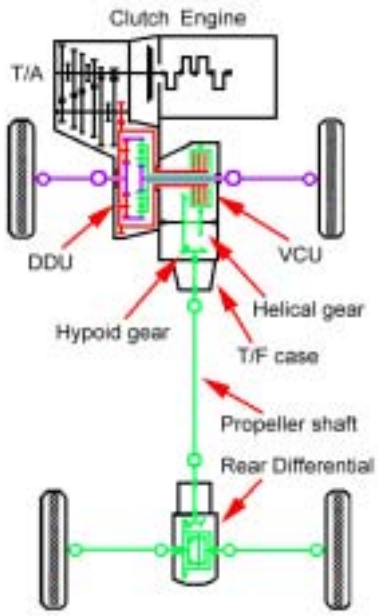
The transfer assembly including of DDU (double differential unit) was developed by 'SFT' (Steyr-Daimler-Puch Fahrzeugtechnik AG&Co.) Graz, Austria. Now it is manufactured by KIA heavy Inc.,

b. Front LSD (2WD only) :

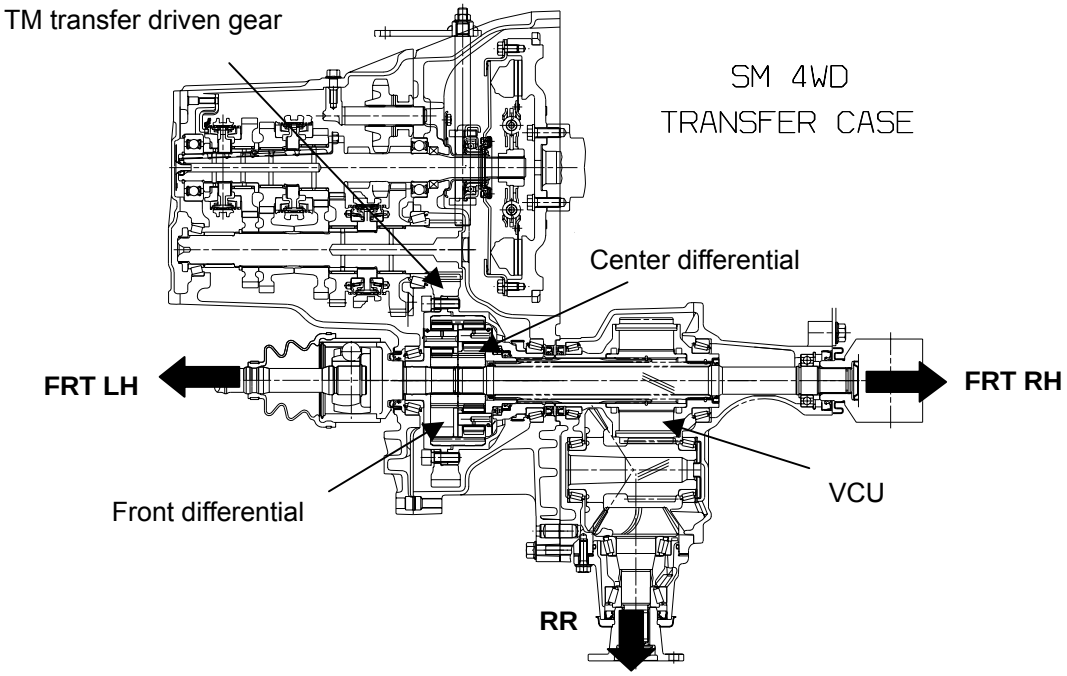
For better performance as a 4X4 vehicle, ZEXEL(Japan) product was adopted.

c. Rear LSD (Optional) :

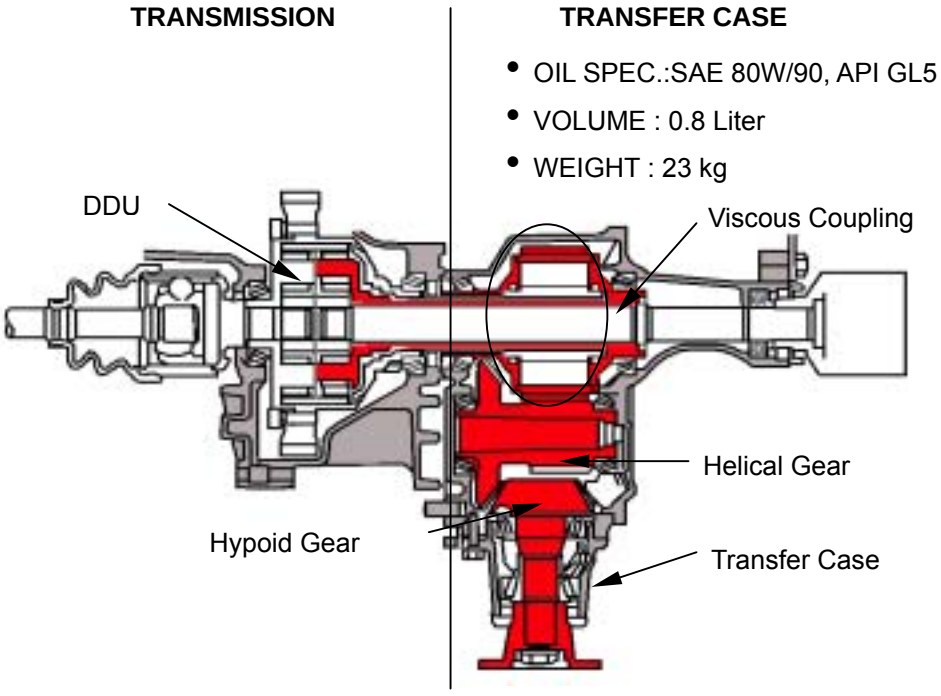
Same model (Eaton product) with one for H-1 was adopted but cannot exchange each other due to the different size.



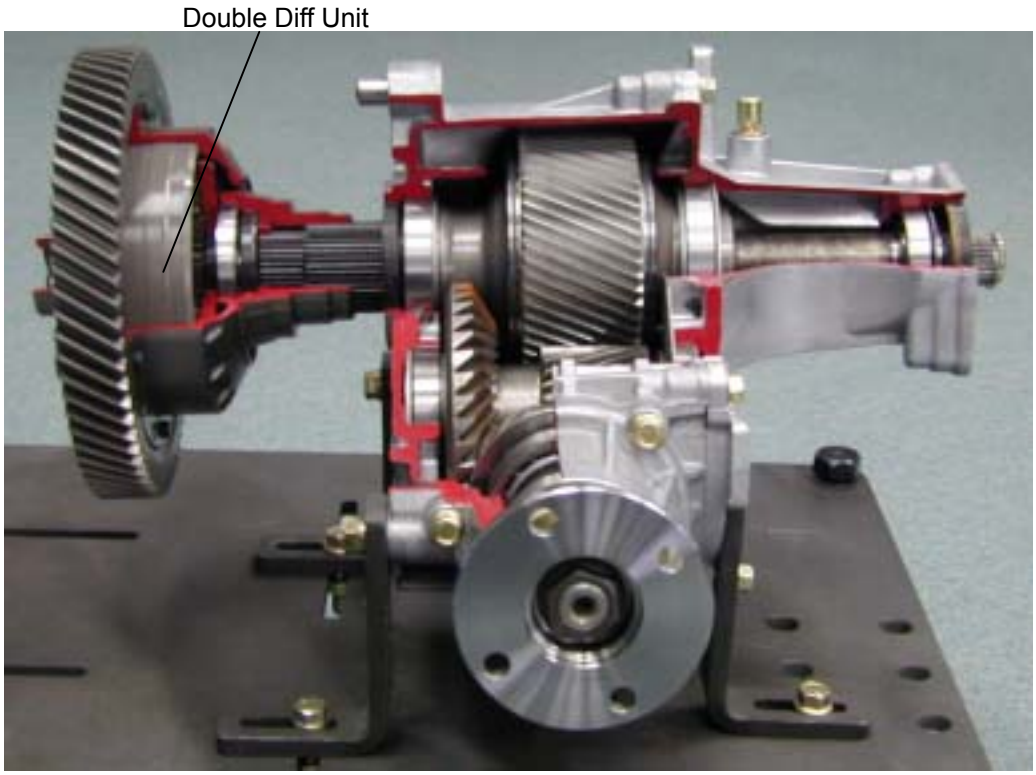
Transfer Overview



Transfer Case

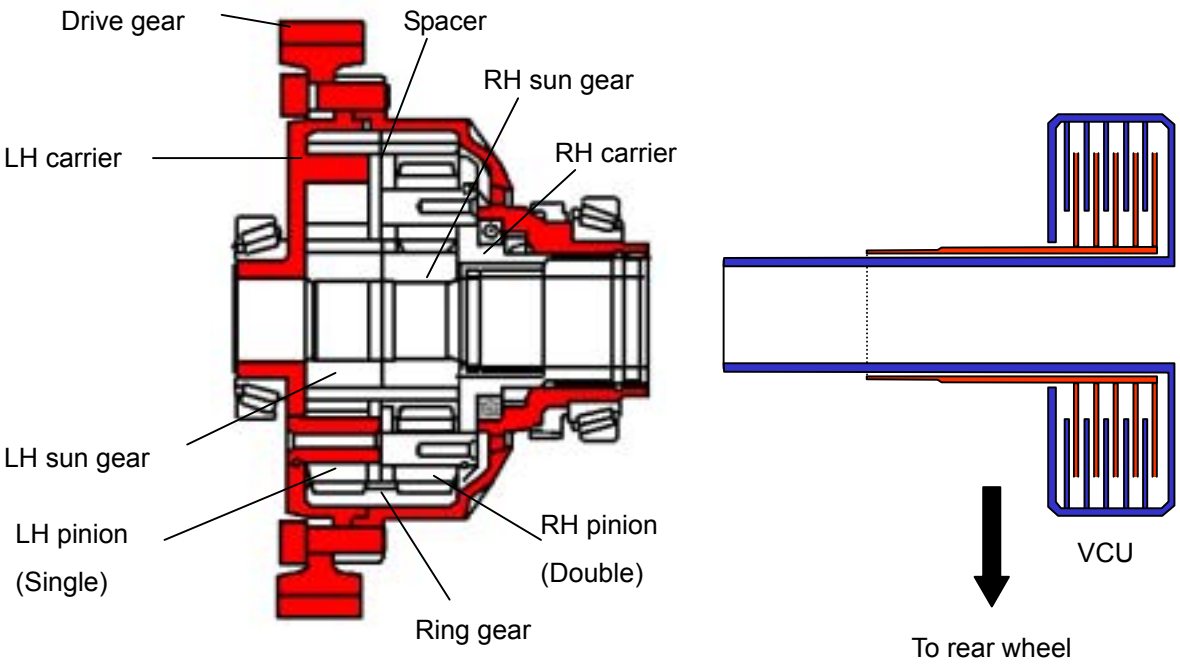


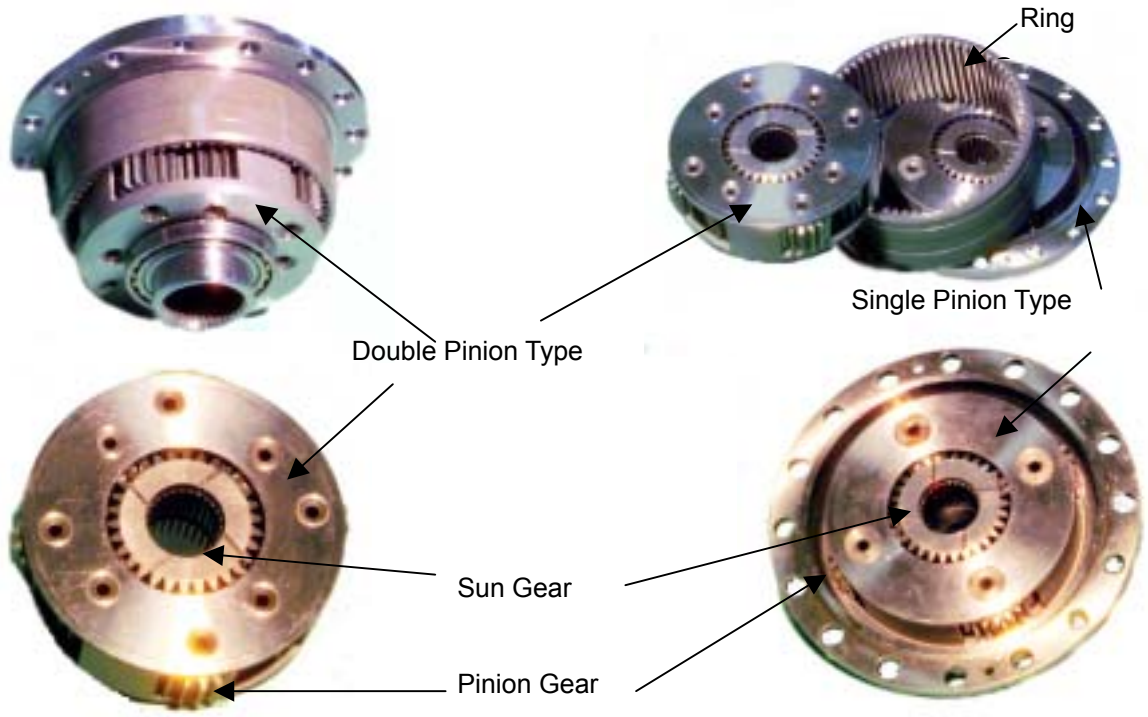
Transfer Case (Cut Away Part)



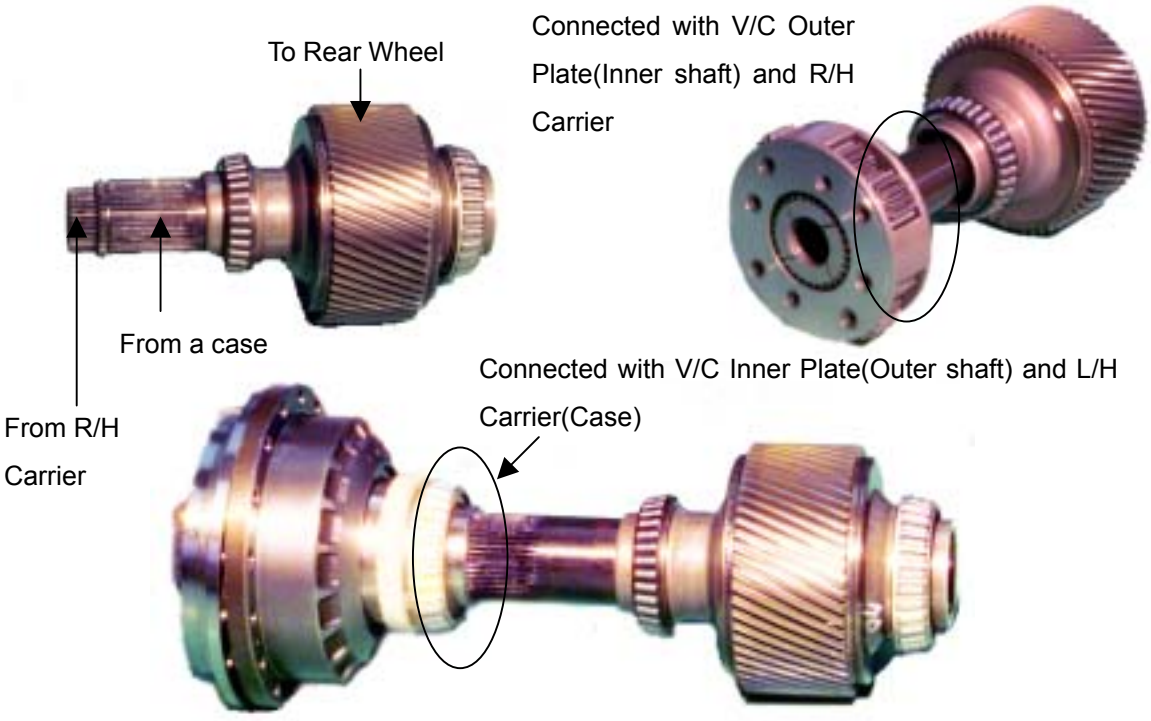
31. DOUBLE DIFFERENTIAL UNIT(DDU)

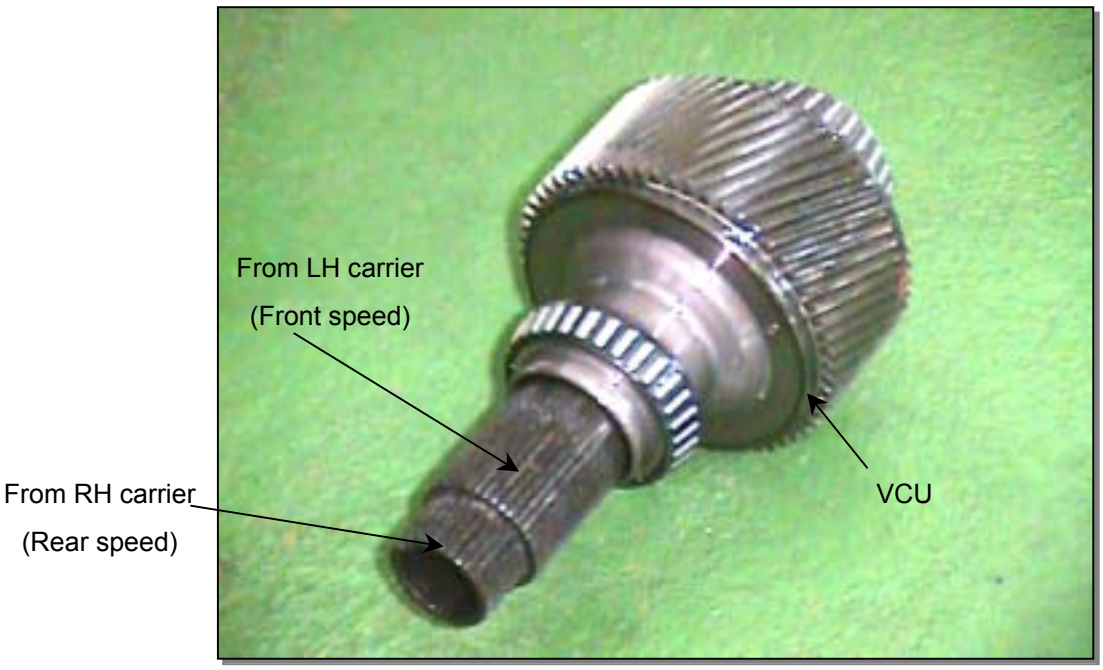
Components of Double Differential Unit



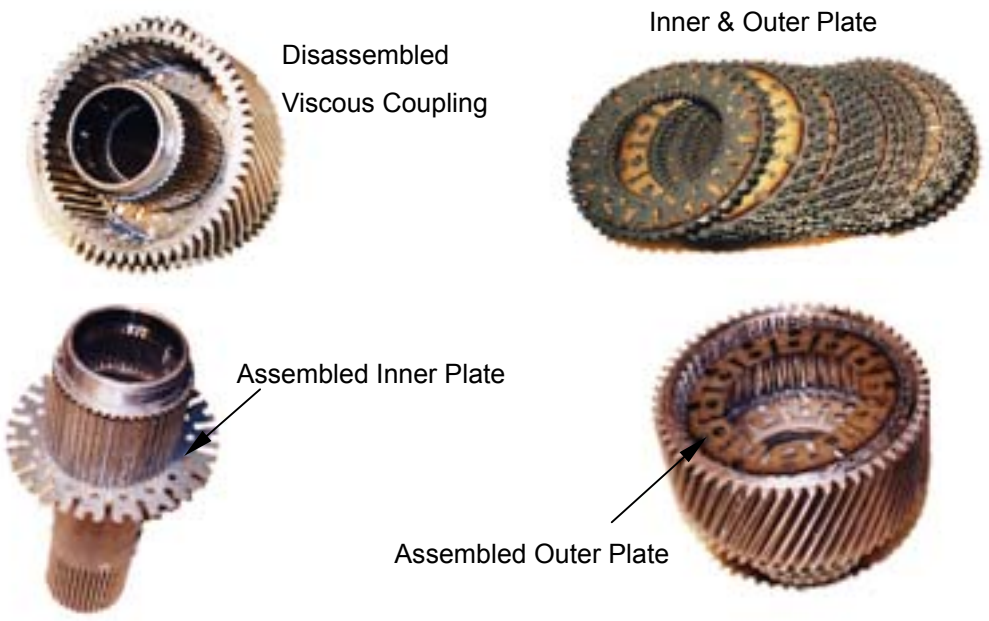


32. VISCOUS COUPLING UNIT

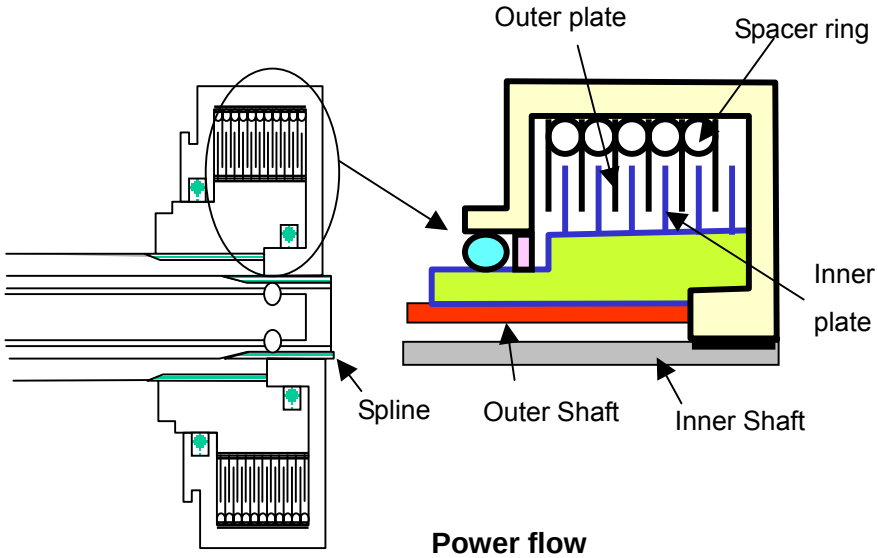




1) COMPONENTS OF THE VISCOUS COUPLING UNIT



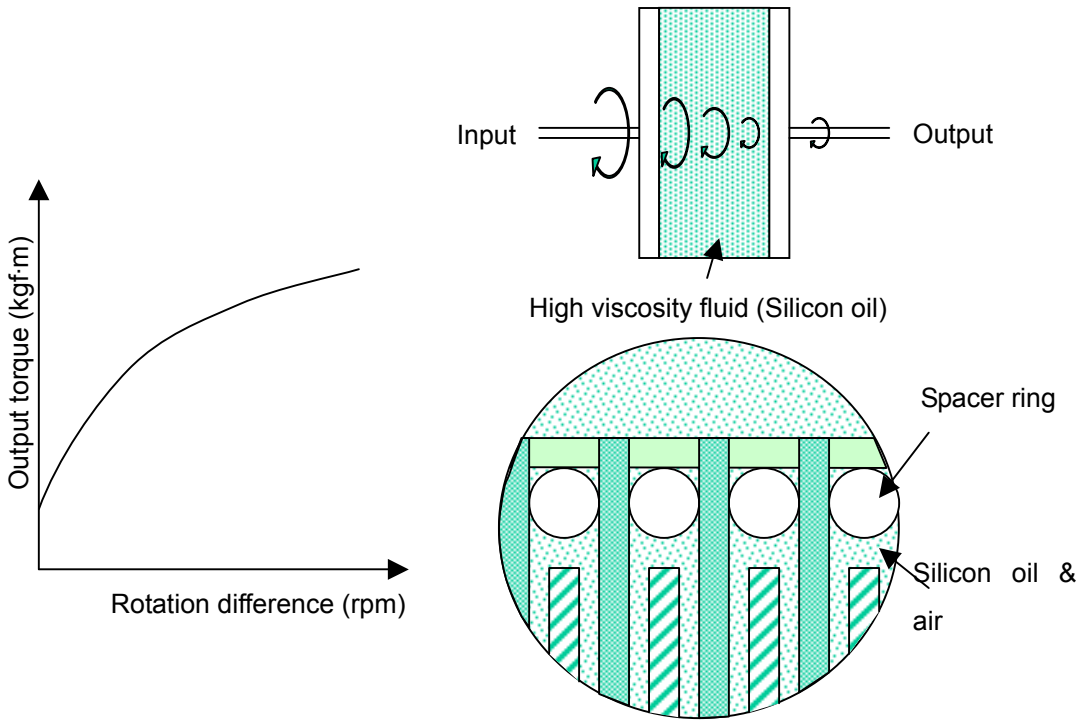
2) VISCOUS COUPLING UNIT – STRUCTURE



Power flow

1. R/H Carrier → Inner Shaft → O/Plate → Helical gear → Rear Wheel
2. L/H Carrier(F/Drive Gear) → Outer Shaft → I/Plate

3) THE PRINCIPLE OF VCU



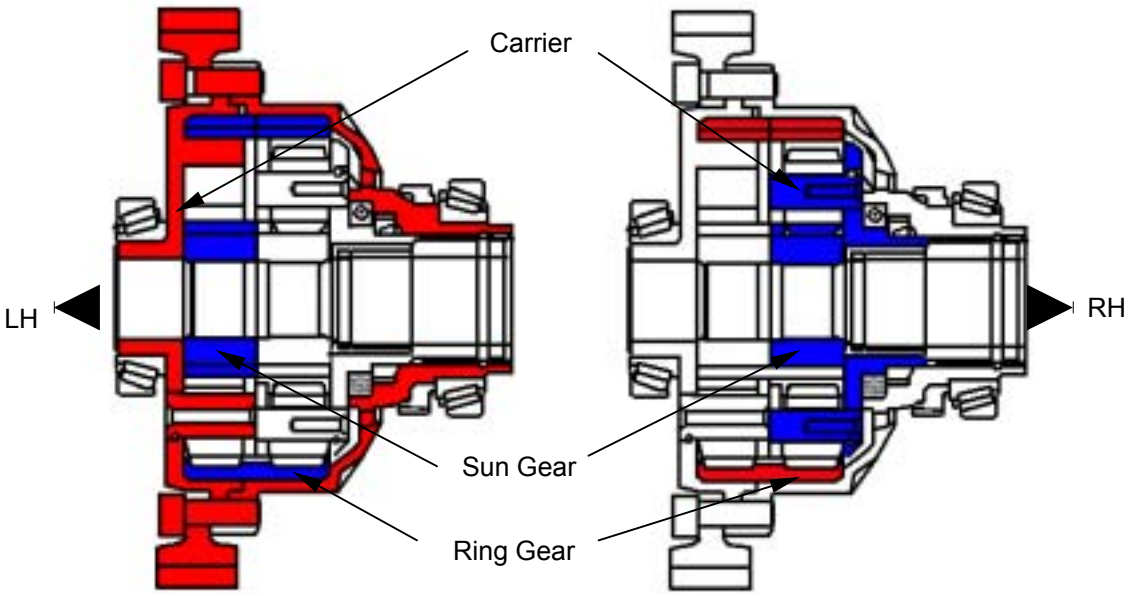
33. POWER FLOW

1) SYSTEM STRUCTURE

- Double Diff Unit : Power Distribution
  - Front / Rear Wheel, Front LH / RH Wheel
- Viscous Coupling : Limited Slip Device
  - Front / Rear Wheel
- Hypoid Gear Set : Direction Change Device
  - To Rear Wheel

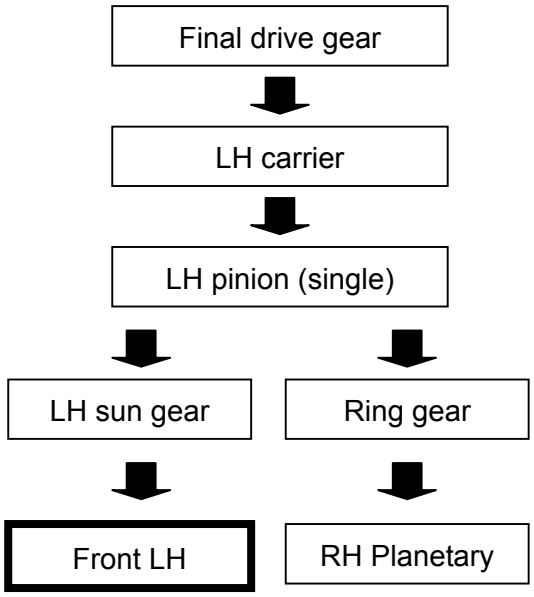
- Front Wheel
  : Output of Transmission → DDU → Front LH/RH Wheel
- Rear Wheel
  : Output of Transmission → DDU → (Viscous Coupling) → Hypoid Gear → Rear LH/RH Wheel

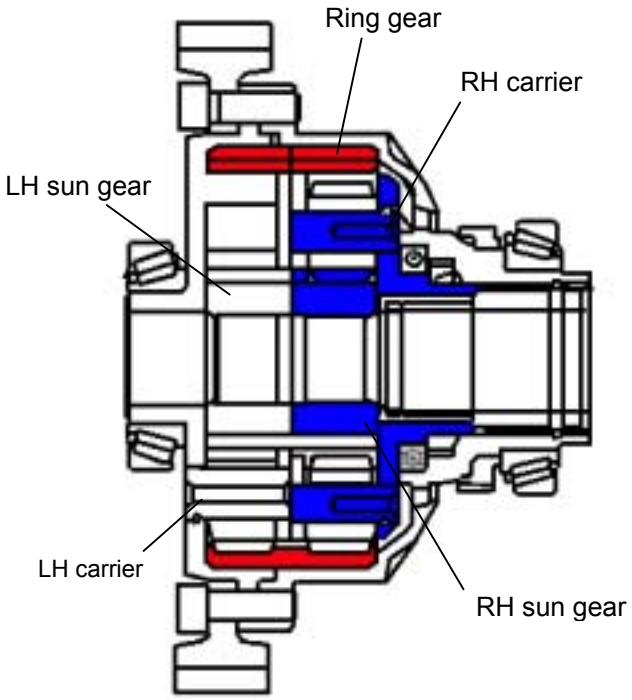
2) DDU (Double Differential Unit)

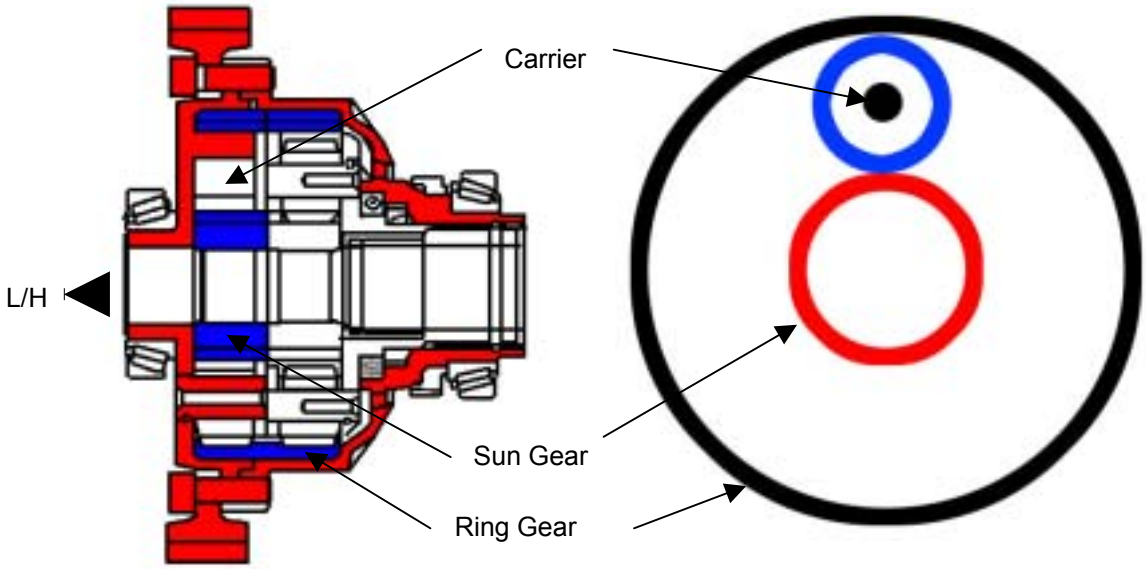


RH Carrier→ Rear Wheel
Ring Gear →RH Sun Gear →Front RH Wheel
LH Carrier →LH Sun Gear →Front LH Wheel

3) LH PLANETARY GEAR SET (SINGLE)

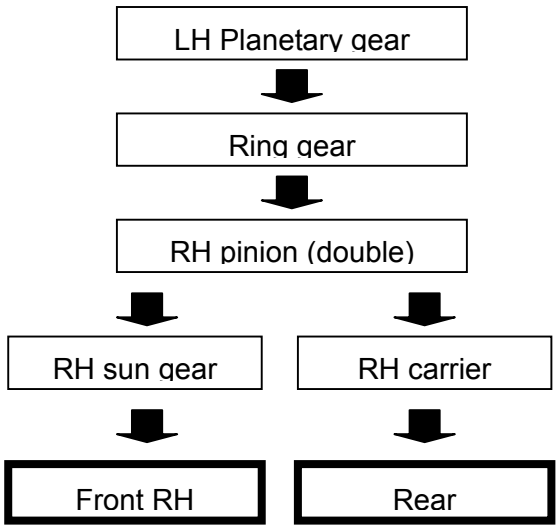


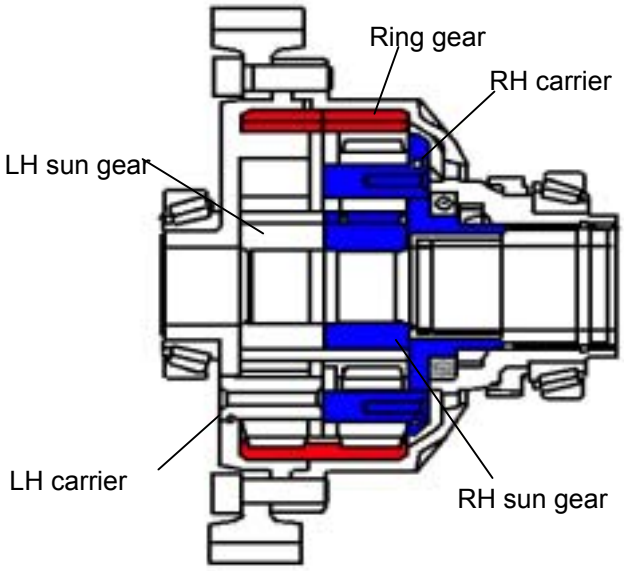


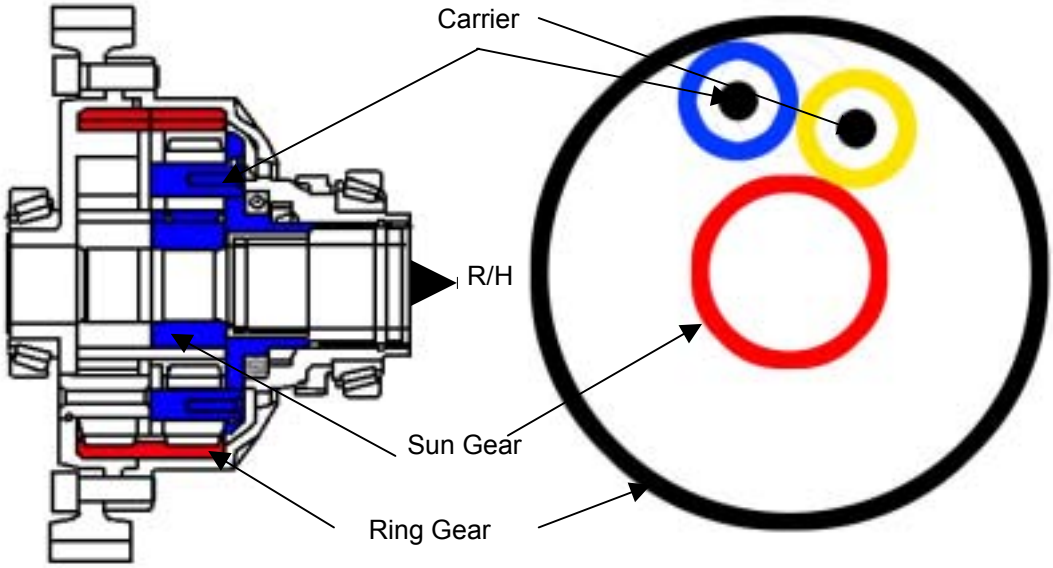


L/H Carrier → Ring Gear → R/H Planetary
L/H Carrier → Sun Gear → L/H Wheel

4) RH PLANETARY GEAR SET (DOUBLE)

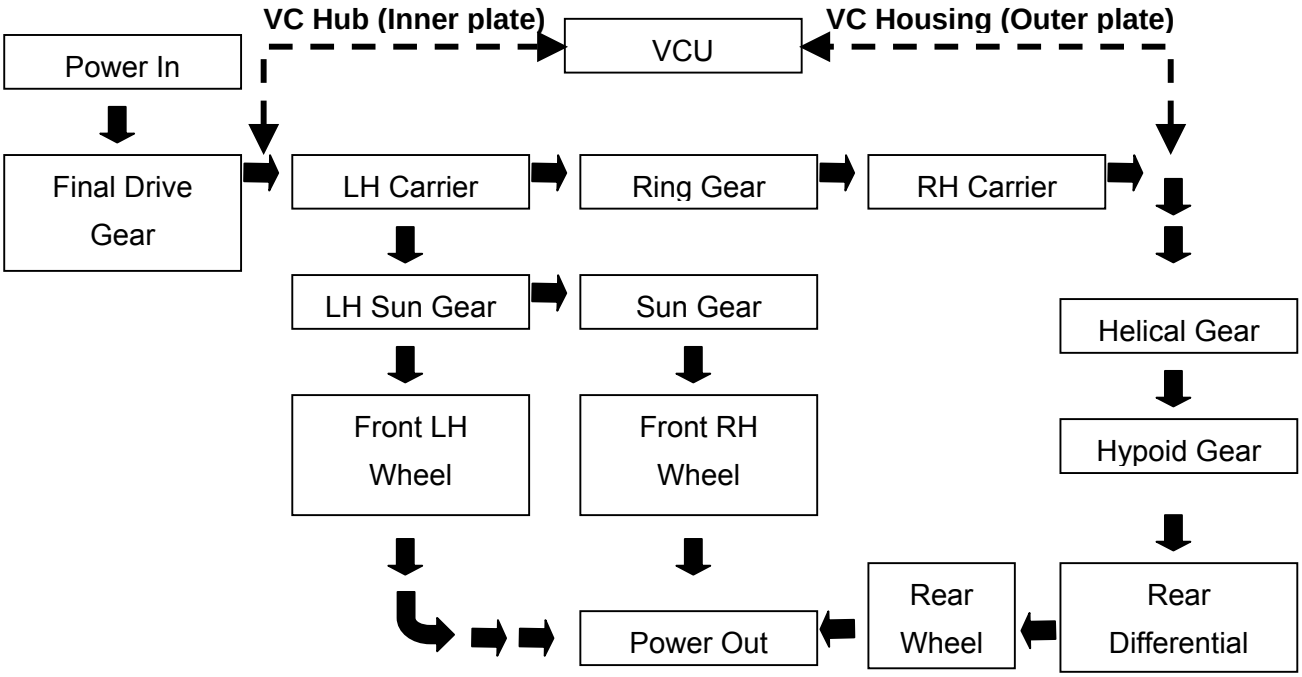






Ring Gear → R/H Carrier → Rear Wheel
Ring Gear → Sun Gear → R/H Wheel

5) POWER FLOW CHART



6) POWER FLOW

A: Front L/H Wheel

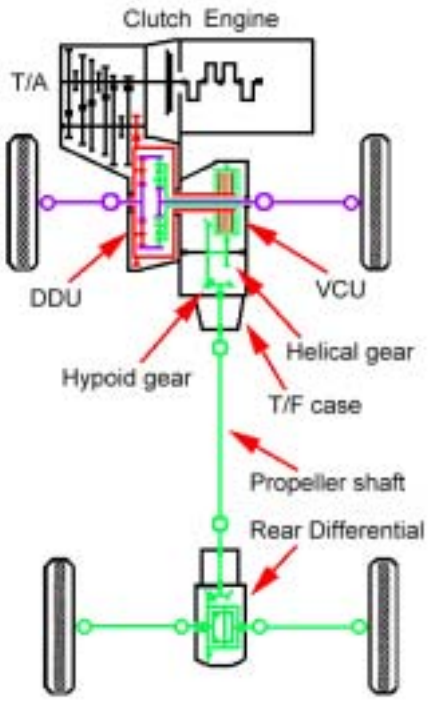
F/Drive Gear → L/H Carrier → L/H Sun Gear→ L/H Wheel

B: Front R/H Wheel

F/Drive Gear → L/H Carrier → Ring Gear → R/H Sun Gear → R/H Wheel

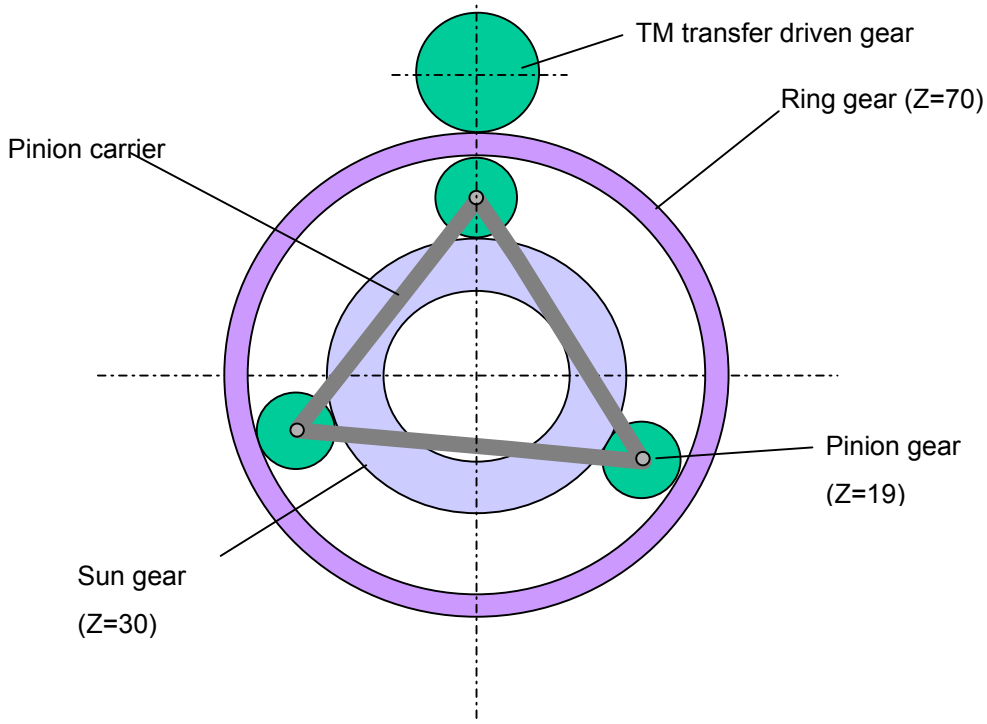
C: Rear Wheel

F/Drive Gear → L/H Carrier → Ring Gear → R/H Carrier → Hollow Shaft → Helical Gear Set → Hypoid Gear → P/Shaft → R/Diff' → Rear Wheel

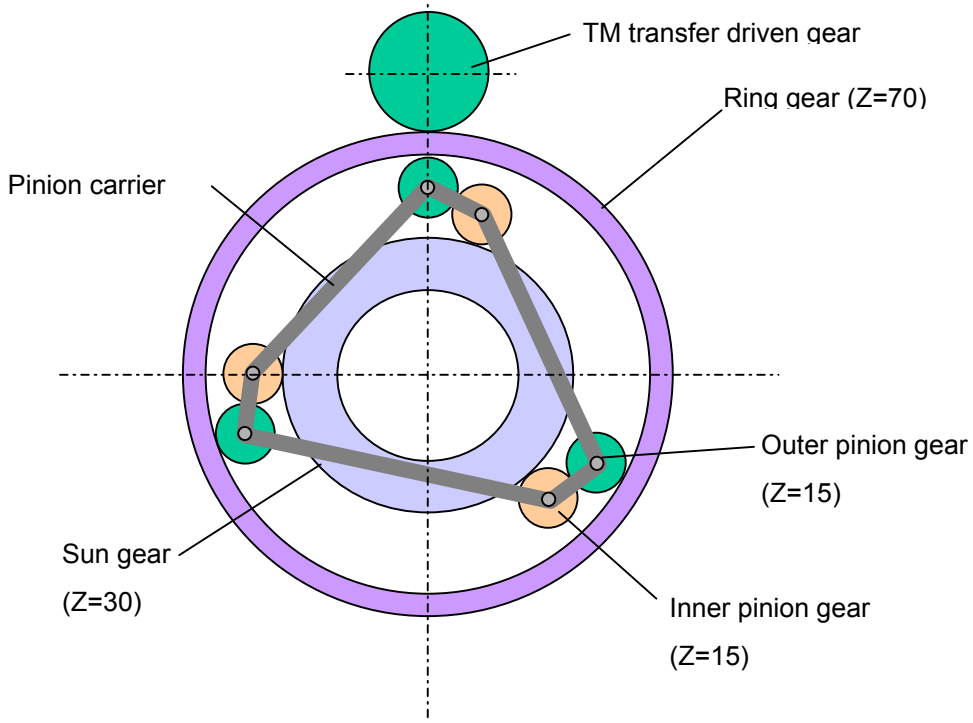


34. PLANETARY GEAR TYPE DIFFERENTIALS

1) FRONT DIFFERENTIAL

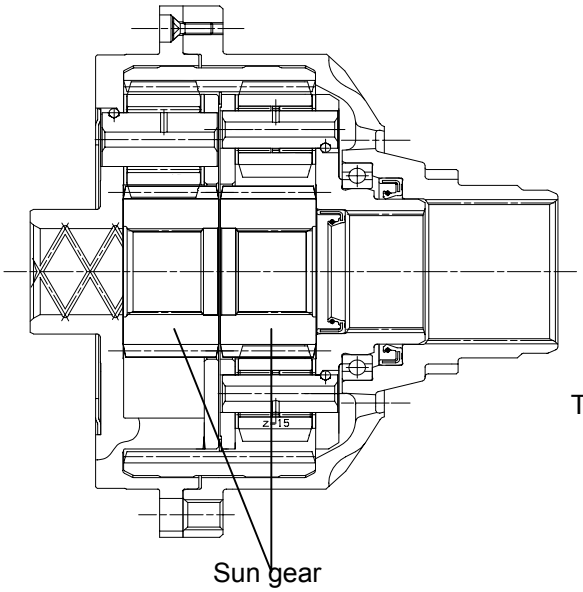


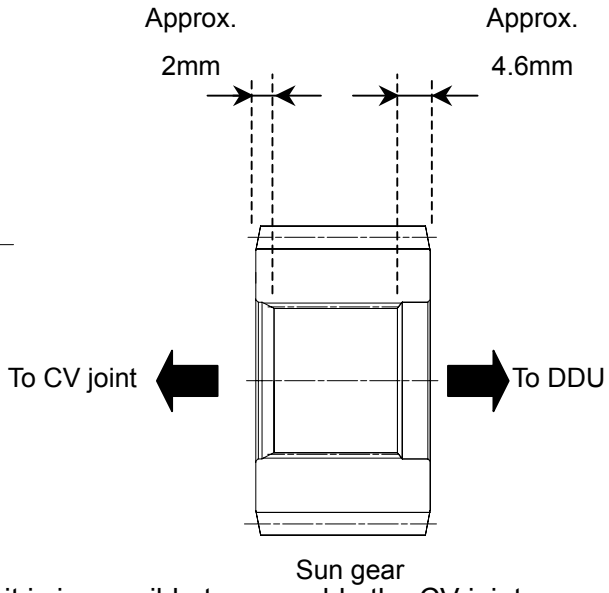
2) CENTER DIFFERENTIAL



3) 60:40 FRONT & REAR TORQUE SPLIT

Installing Direction of Sun Gear

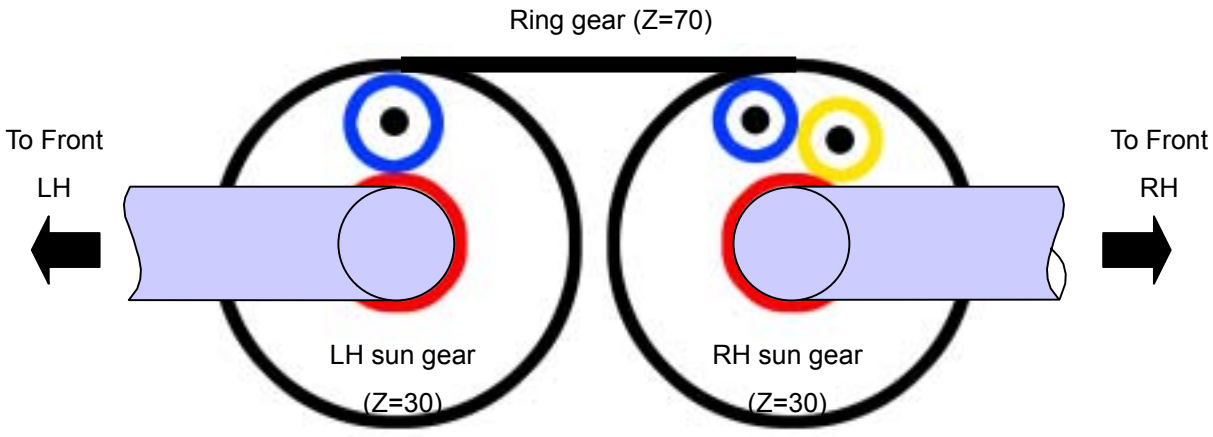




If the sun gear is installed opposite direction, it is impossible to assemble the CV joint.

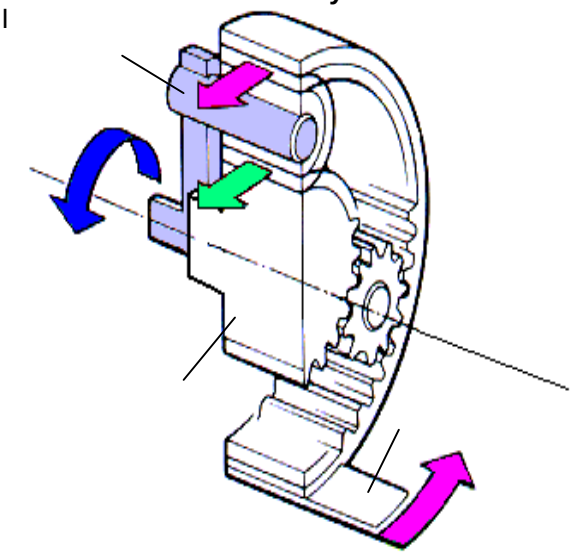
60:40 front and rear torque split

If the input torque from transmission is supplied in amount of '1', the torque for LH and RH will be '3/10' due to the gear ratio between ring gear and both sun gear. So the total torque to front side will be '6/10'. (3/10+3/10) Without considering the torque loss in the DDU unit, the torque for rear side will be '4/10' (1-6/10)



Input torque through carrier : T1
Output torque to RH planetary gear through ring gear : T2
Output torque to front LH wheel through LH sun gear : T3

< LH Planetary Gear >

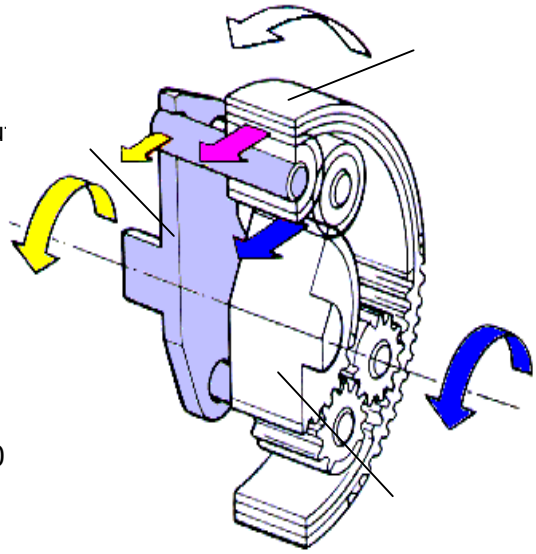


Z2 = Ring gear teeth = 70
Z3 = Sun gear teeth = 30

T2 / T3 = Z2 / Z3
T3 = T1 × Z3 / (Z2+Z3) = T1 × 30/100 = T1 × 3/10
T2 = T1 × Z2 / (Z2+Z3) = T1 × 70/100 = T1 × 7/10
: 30% of input torque is transmitted to front LH wheel.
: 70% of input torque is transmitted to RH planetary gear.

Input torque through ring gear : T1 × 7/10
Output torque to rear differential through RH carrier : T4
Output torque to front RH wheel through RH sun gear : T5

< RH Planetary Gear >



Z4 = Ring gear teeth = 70
Z5 = Sun gear teeth = 30

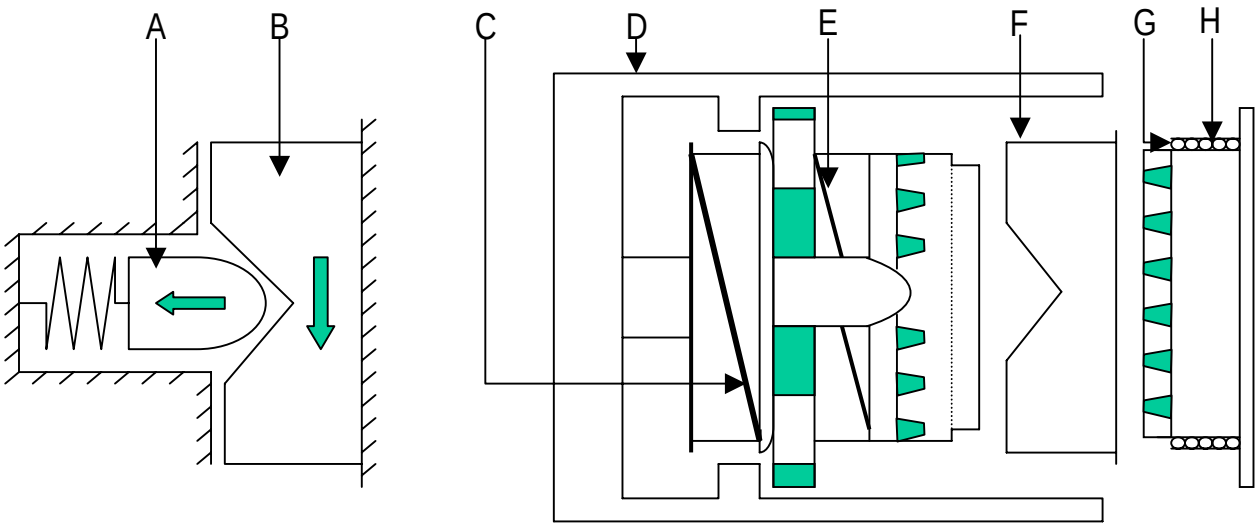
T5 = Input torque×Z5 / Z4 = T1 × 7/10 × 30/70 = T1 × 3/10
T4 = Input - T5 = (T1 × 7/10) - (T1 × 3/10) = T1 × 4/10
: 30% of input torque is transmitted to front RH wheel.
: 40% of input torque is transmitted to rear differential.

GALLOPER
4WD SYSTEM

- **AUTO FREE WHEEL HUB**
- **LSD (Limited Slip Differential)**
- **GALLOPER 4WD SYSTEM**

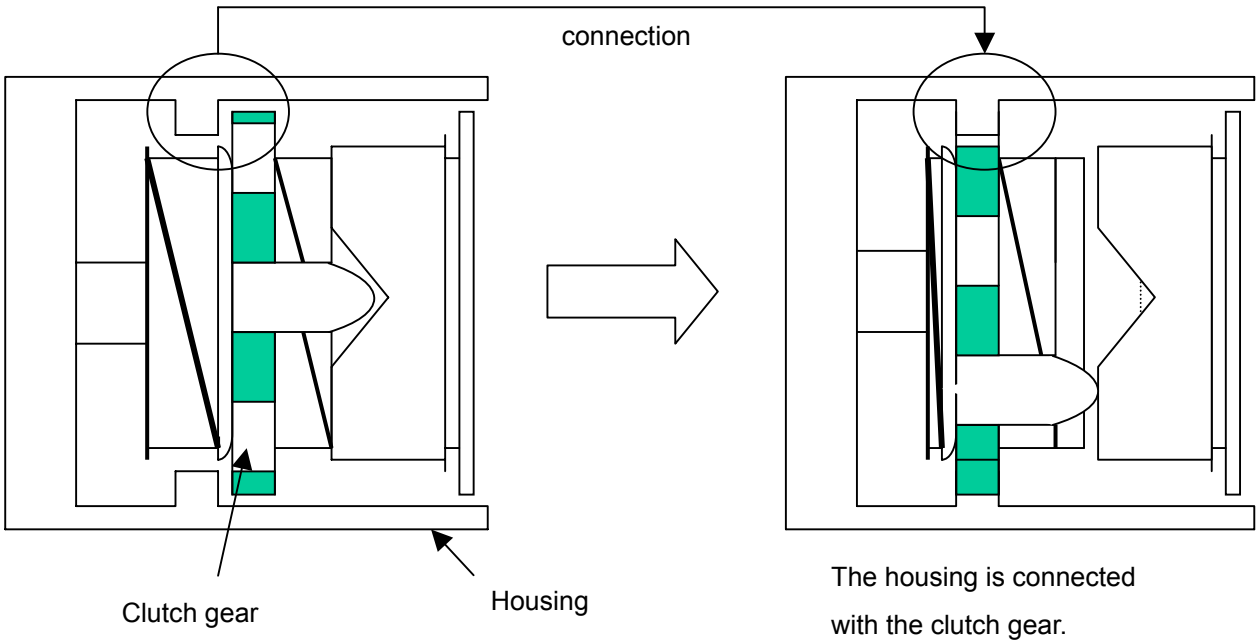
35. AUTO FREE WHEEL HUB

1) CAM TYPE



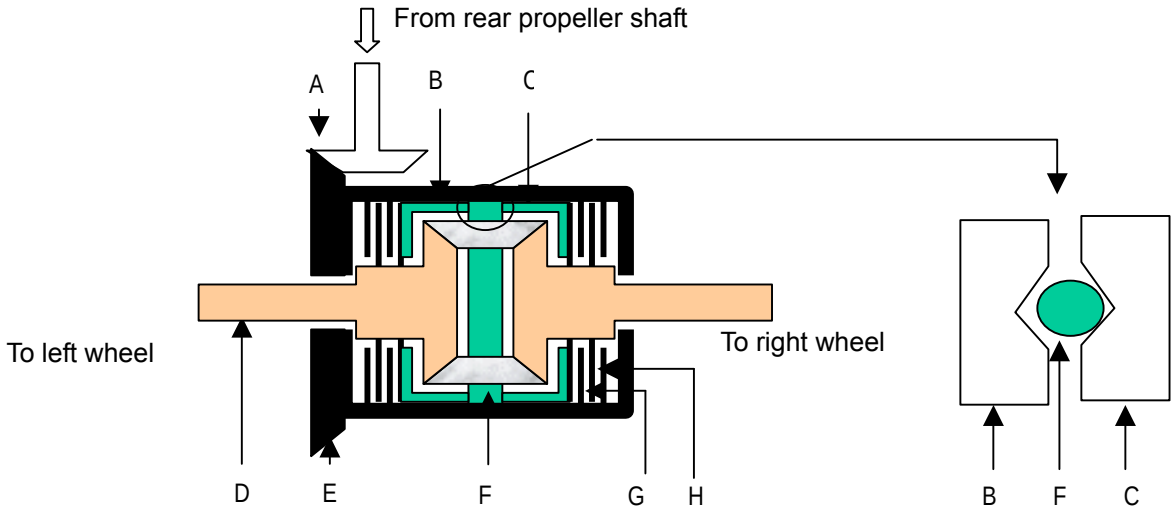
A : cam B : follower E : shift spring F : inner cage
C : return sping D : housing G : brake band H : brake band clip

2) OPERATING PRINCIPLE



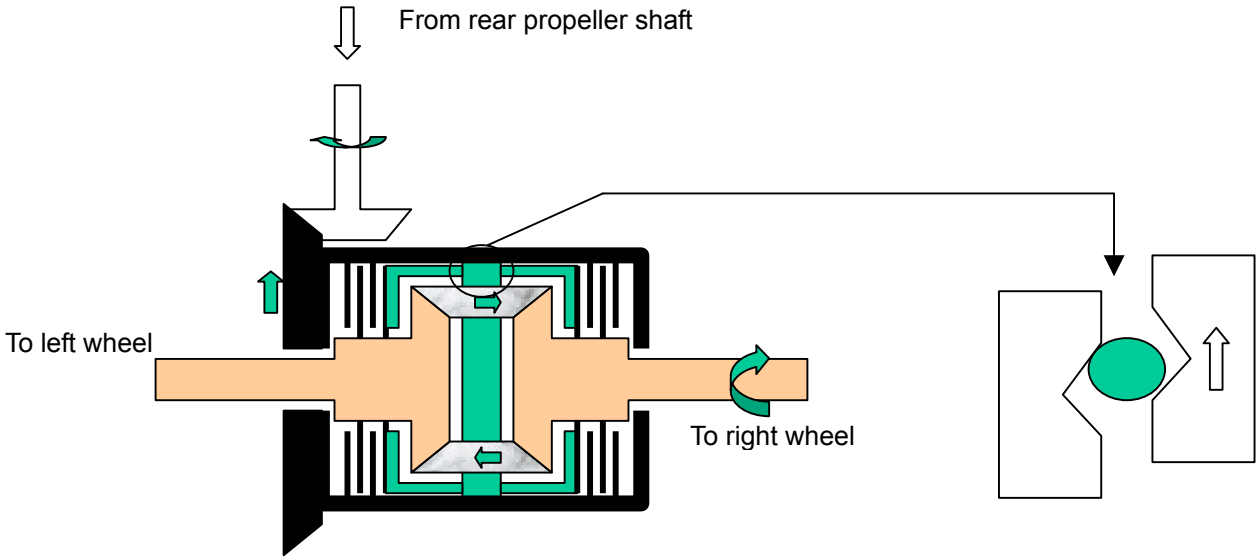
36. LSD (Limited Slip Differential)

1) CONSTRUCTION



A : Drive Pinion
B : Left Pressure Ring
C : Right Pressure Ring
D : Axle Shaft
E : Drive Gear
F : Pinion Shaft
G : Friction Disk
H : Spring Disk & Plate

2) OPERATING PRINCIPLE

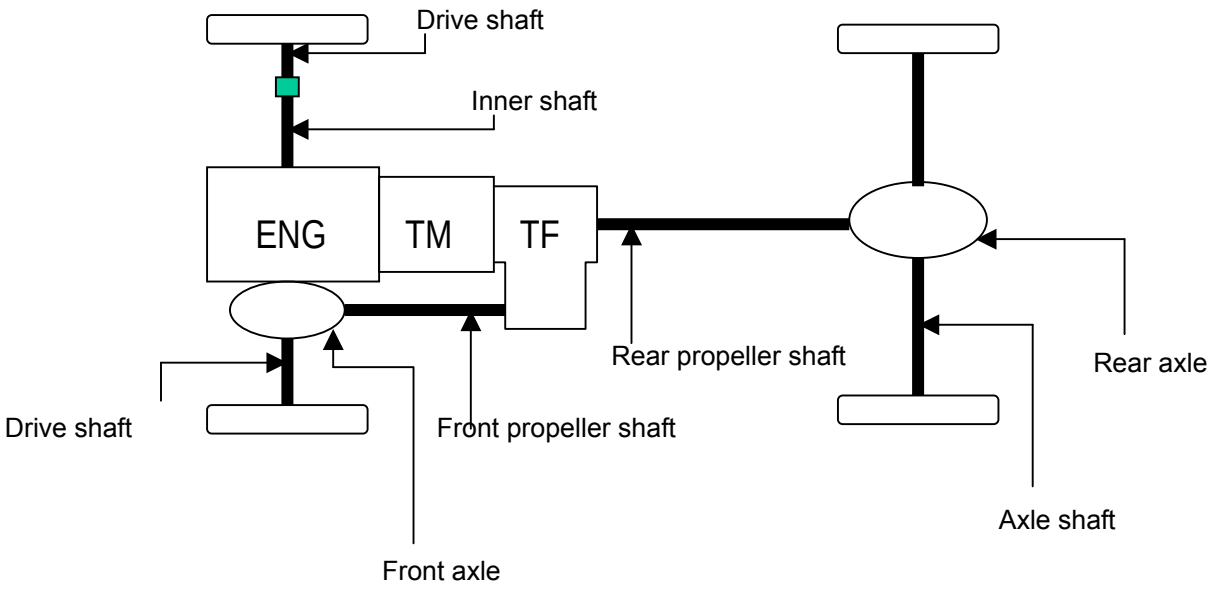


*** Power flow inside LSD:**

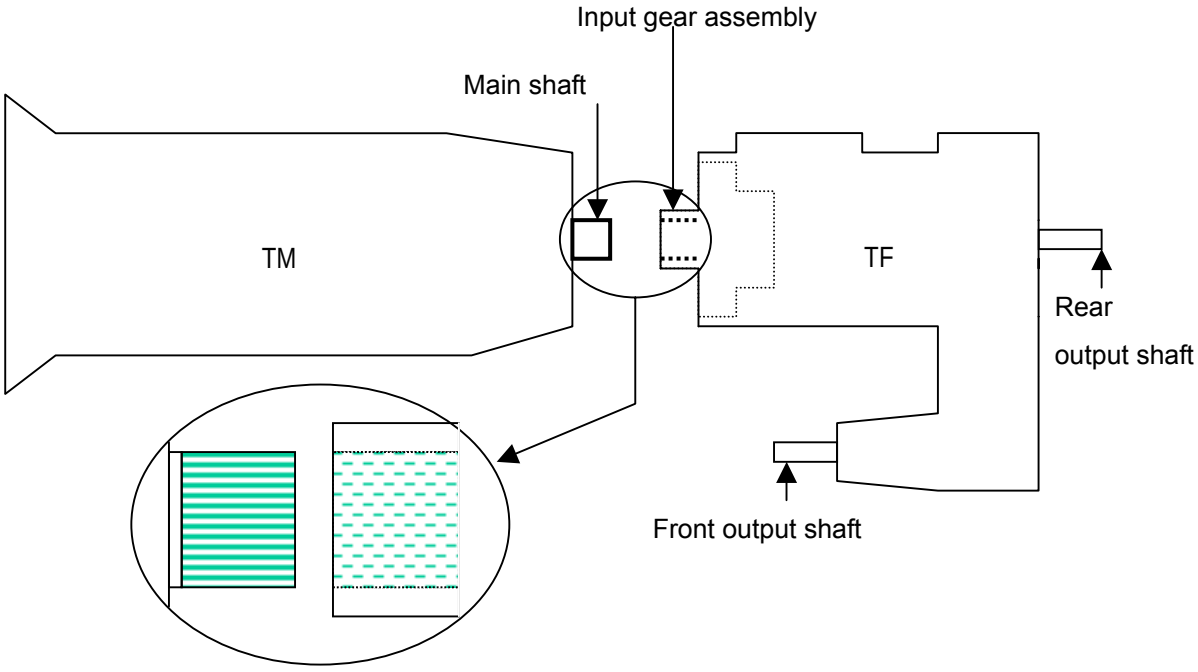
LSD case - pressure ring - pressure ring cam - pinion shaft - pinion gear - side gear - axle shaft

37. GALLOPER 4WD SYSTEM

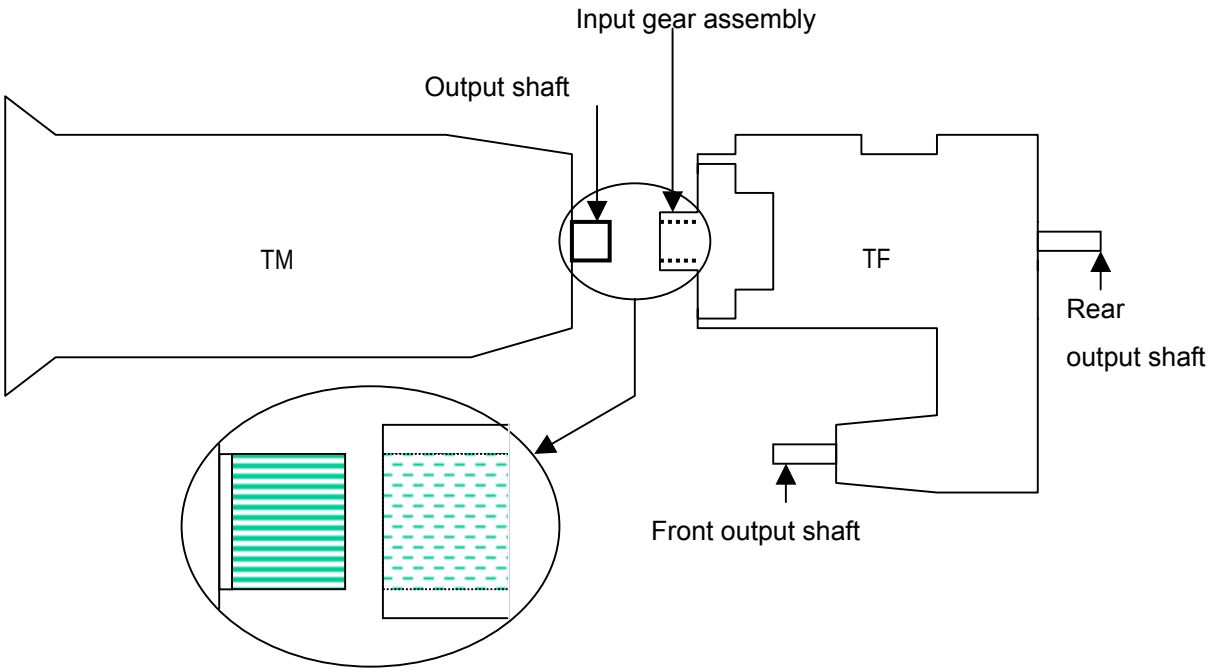
1) COMPONENTS OF 4WD



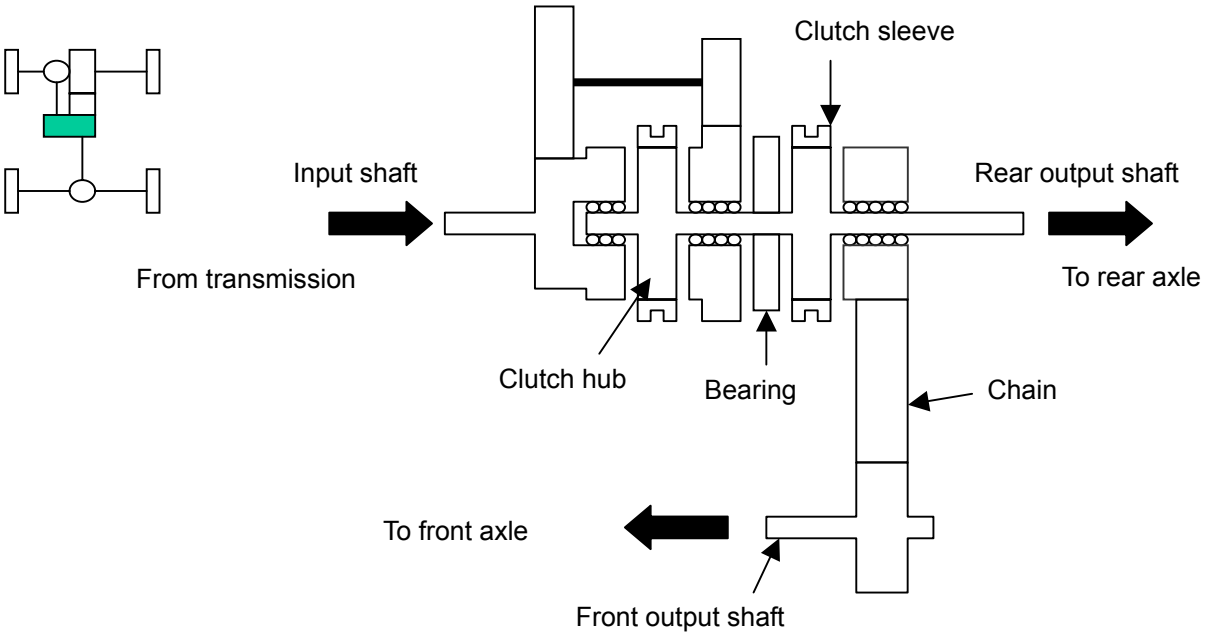
2) CONNECTION BETWEEN MTM AND TF



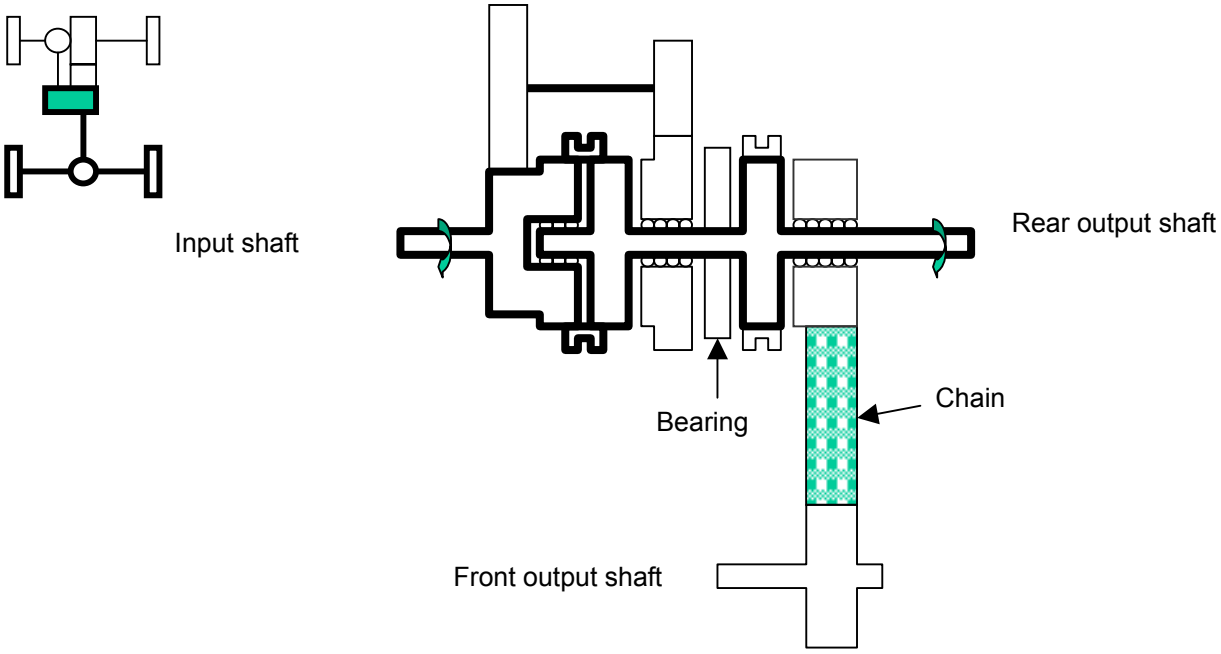
3) CONNECTION BETWEEN ATM AND TF



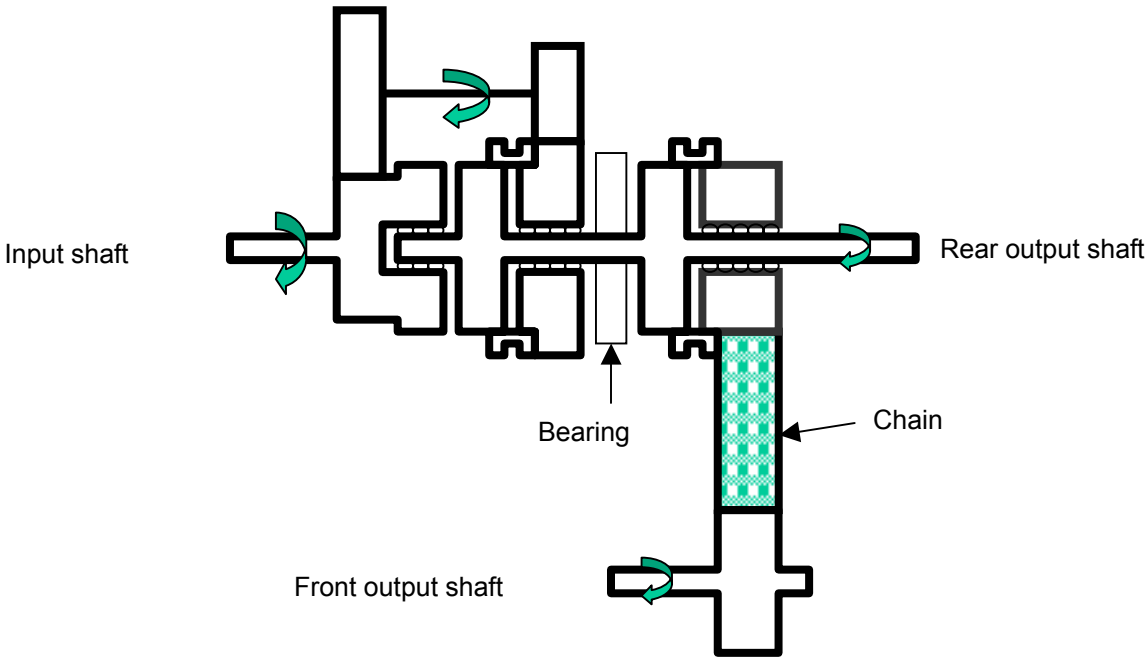
4) TRANSFER – STRUCTURE



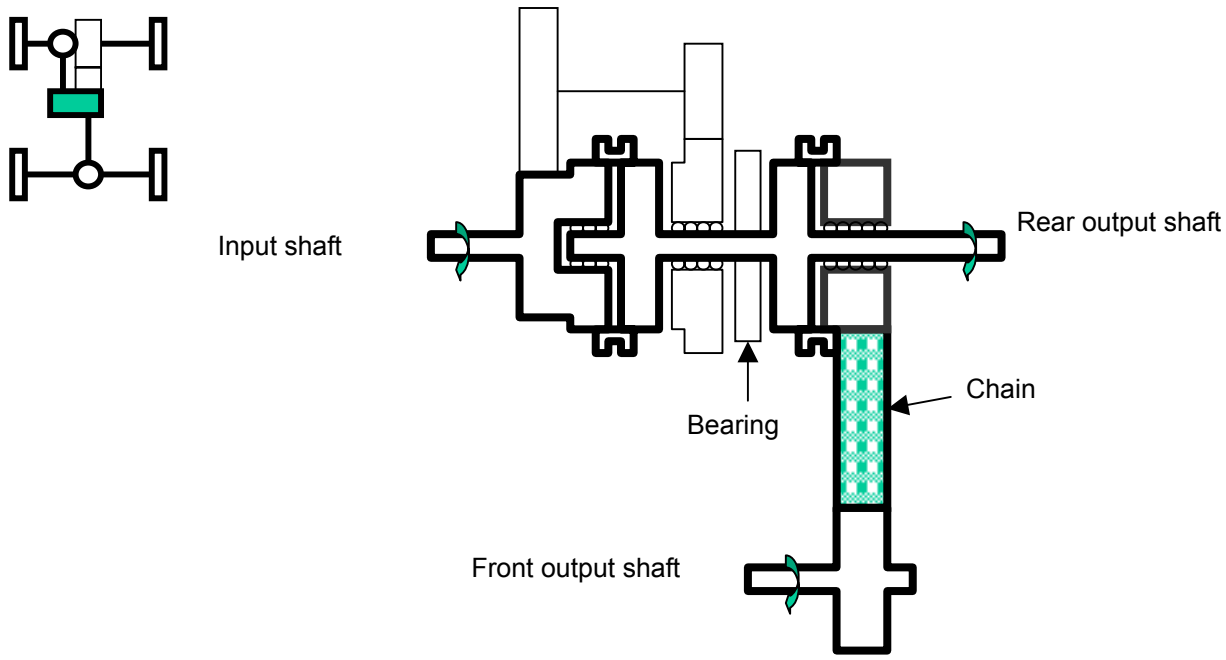
5) TRANSFER - 2WD OPERATING ELEMENTS



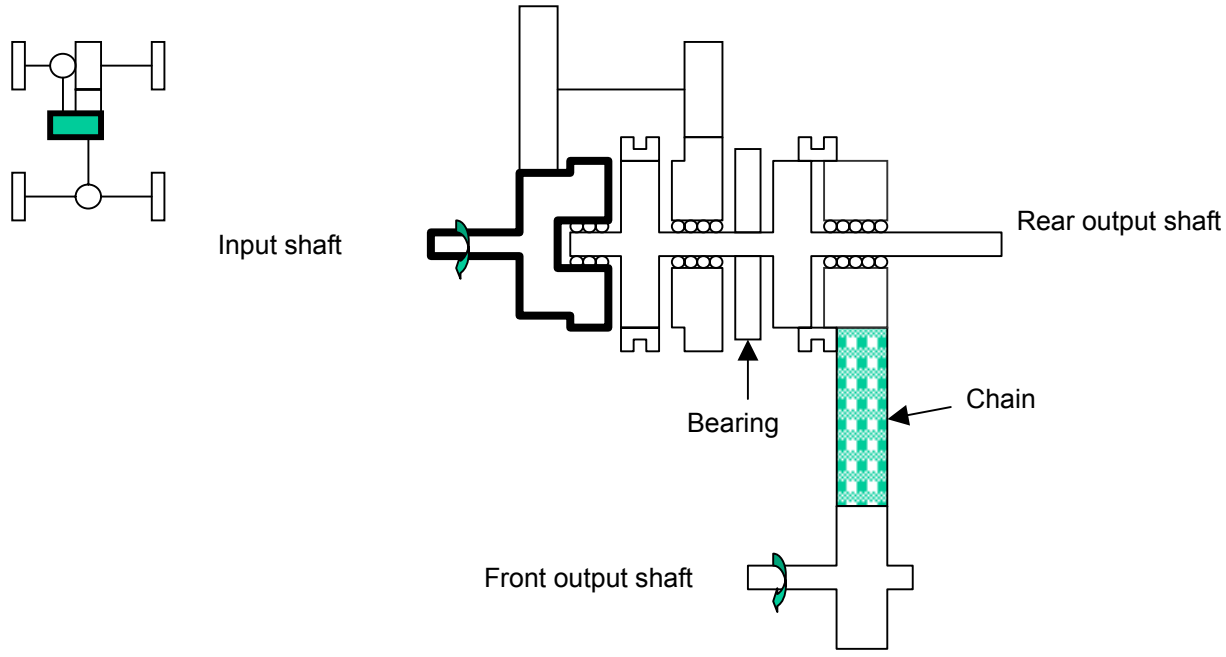
6) TRANSFER - 4WD LOW OPERATING ELEMENTS



7) TRANSFER - 4WD HIGH OPERATING ELEMENTS



8) TRANSFER - NEUTRAL POSITION



9) TRANSFER – TOWING

- For the vehicle with manual transmission, move the gearshift lever to neutral and the transfer shift lever to the “N” position so as to unlock the free-wheeling hubs. For vehicles with automatic transmission, move the selector lever to the “N” position.
- Be sure the towing speed is within the legal limit. Also, vehicles with automatic transmission should never be towed at speeds excess of 30km/h(18mph) or for distance greater than 30km(18miles).
- Turn the ignition switch to “ACC” to unlock the steering wheel. If you will be using the turn signals while being towed, turn the ignition switch to the “ON” position.