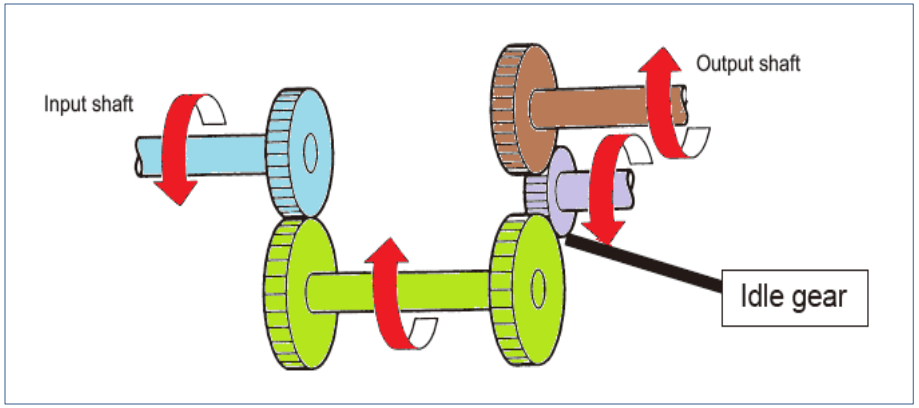
Manual transmission & transaxle



SUZUKI TRAINING ACADEMY

Manual transmission & transaxle
Course code: TR02

Student training manual
Suzuki Online Training

Foreword

In this training manual, we will study the fundamental principles of automotive transmissions, transaxle and the clutch. This course offers the fundamentals and must be used in conjunction with Suzuki service manuals for product specific information and specifications.

Smart manuals

Some sections of this training manual contain videos with detailed information on the topics you are studying. If you are studying this training manual on a PC, look out for the "green play video" symbol on any photo or picture in this manual, click on the green button to watch a video providing you with detailed information on that topic. Note: Internet connection required.

This document is intended solely for training purposes only. All vehicle repairs and adjustments must be carried out according to the procedures stipulated in current service manuals and technical bulletins.

Suzuki Technician curriculum

This training manual is part of the Non Suzuki Technician to Suzuki Technician curriculum. The curriculum consists of the following modules:

1. GE01 Suzuki Introduction
2. GE02 Electrical / Electronics
3. GE03 Diagnostics
4. EN02 Engine Mechanical part I
5. EN03 Engine Mechanical part II
6. EN04 Engine Mechanical part III
7. EN05 Engine Auxiliary systems
8. DS01 Driveshaft/Axle
9. DS02 Driveshaft/Axle - transfer case
10. BR02 Brake control systems
11. TR02 Manual transmission / transaxle
12. CS02 Control system / body electrical
13. CS03 Communication / bus systems

You are currently studying TR02 Manual Transmission/transaxle. This module consists of the following courses:

- TR02 Manual transmission & transaxle
- TR02 Practical Activities

Table of contents

Lesson 1:

Manual transmission fundamentals

Objectives

At the end of this lesson, you will be able to:

- Describe gear operating principles
- Explain the functions of the transmission.
- Describe the operating principles of the transmission.
- Describe the different types of gear shift mechanisms.
- Explain the function of synchromesh mechanism.
- Describe the operating principles of the different mechanisms for safe driving.
- Explain the operating principle of the IBS.

1.1 Overview

When a vehicle starts off, a large driving force is required even through the engine rotation speed is low. When a vehicle is driven at high speed, a high engine rotation speed is required even though the driving force is low. The transmission enables the vehicle to meet these different requirements.

A vehicle must also operate smoothly across many driving conditions. For example, driving at high speed or slow speed, climbing up or going down hills, repeatedly stopping and starting off and reversing. The transmission coverts engine rotation speed and engine torque in accordance with these driving conditions and transmits them to the drive wheels.

1.2 Transmission functions

(i) The transmission transmits force by meshing gears together.

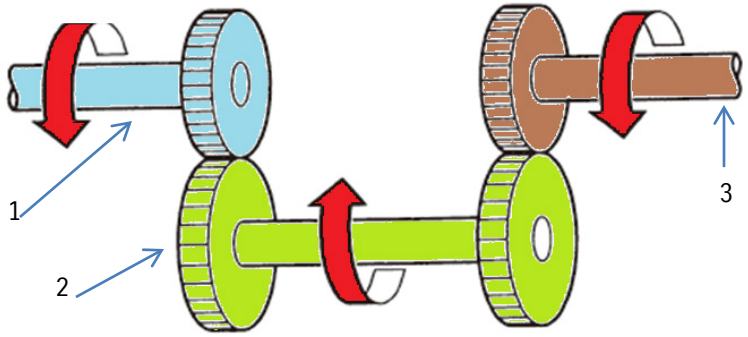


Figure 1: Power transmission

Figure 1
[1] Input shaft
[2] Counter shaft
[3] Output shaft

(ii) Increasing torque and increasing engine rotation speed

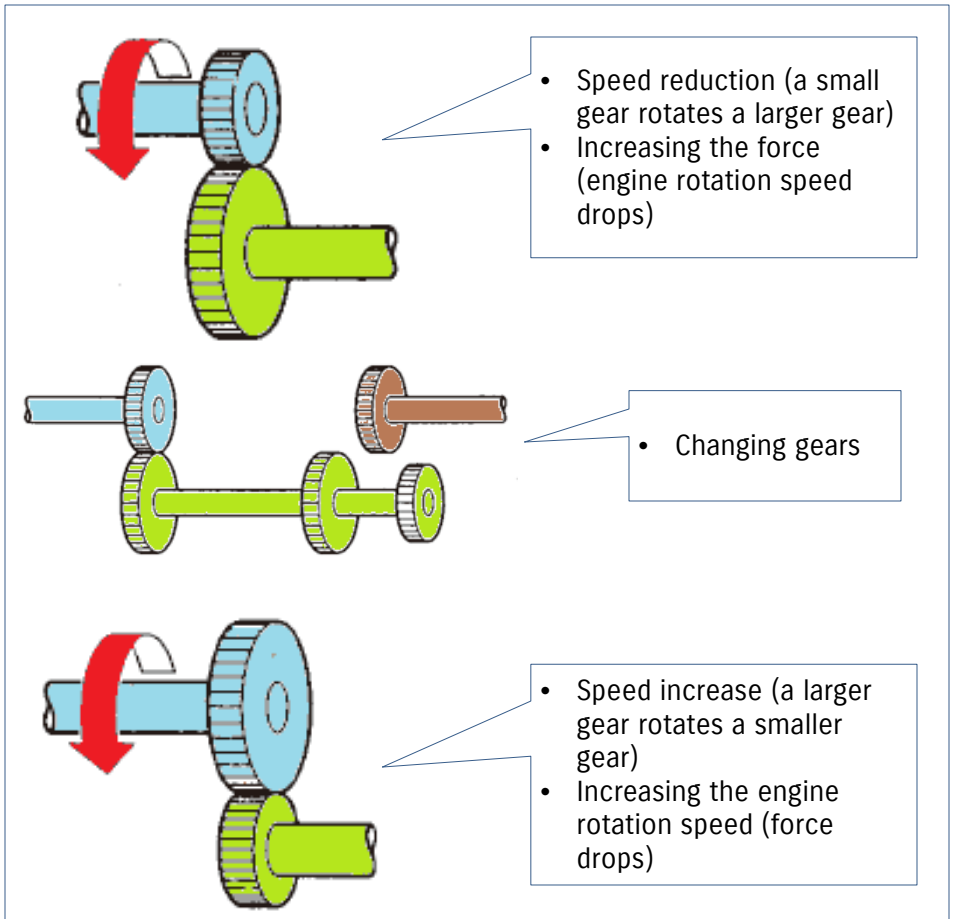


Figure 2: Increasing torque and increasing engine rotation speed

(iii) A gear is added to change the rotation direction.

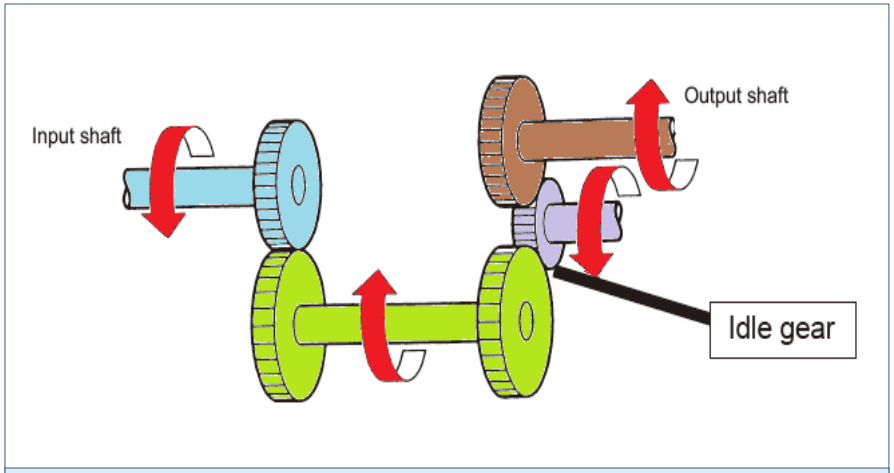


Figure 3: Reverse rotation

(iv) The transmission cuts off the power transmission by disconnecting the gear meshing.

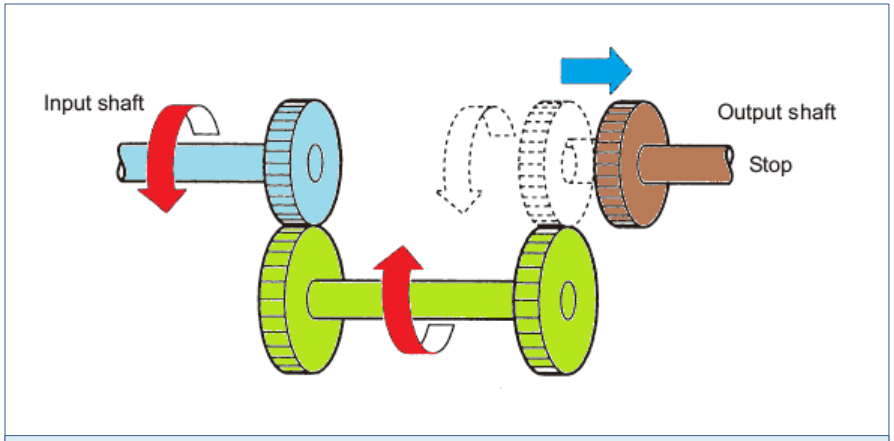


Figure 4: Power disconnection

1.3 Structure and operation

1.3.1 Power transmission

A vehicle requires a large driving force when starting off, and a high engine rotation speed when driving at high speed.

To achieve this, the transmission varies the engine rotation speed and torque by changing the gear combinations (gear ratio).

The engine power is transmitted to the transmission input shaft via the clutch. The rotation of the input shaft is transmitted to the output shaft gear via the countershaft gears. An output gear meshes to the output shaft through synchro-mechanisms.

The rotation from the countershaft is transmitted to the output shaft. In other words, the gear ratio is changed when the sleeve moves in accordance with the shift lever position and changes the gears on the output shaft.

1.3.2 Neutral position

When none of the gears on the output shaft mesh with the gears on the counter shaft, the transmission is in the neutral condition. This means that when the vehicle is stopped and the engine is idling, the engine power rotates the input shaft, countershaft and the gears on the output shaft, but the output shaft does not rotate.

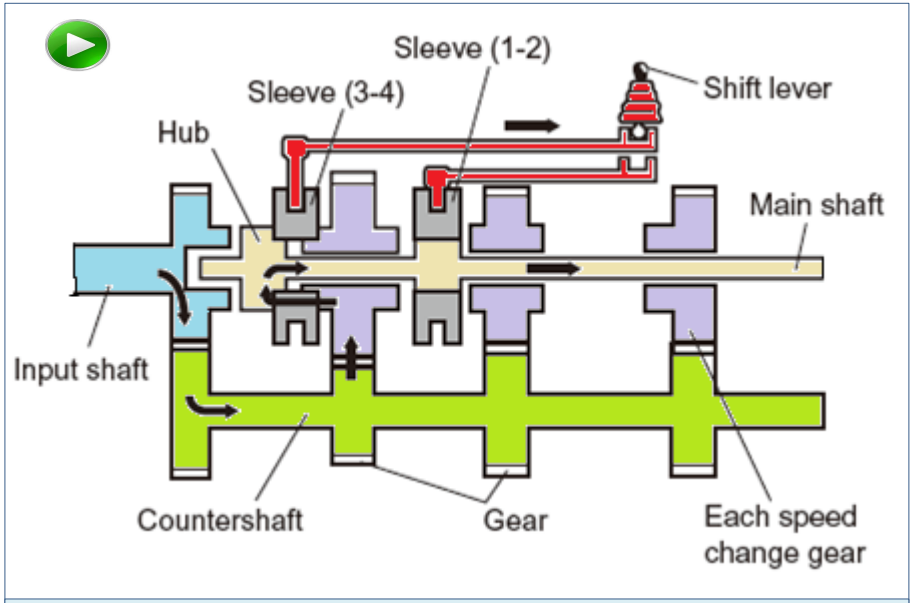


Figure 5: Power transmission

1.3.3 Gear change

- 1st , 2nd and 3rd gear - Speed reduction (small gear rotates a large gear)
- 4th gear - Direct connection (rotation is transmitted unchanged)
- 5th gear - Speed increase (large gear rotates a small gear)
- Reverse gear - Reverse rotation (gear is added)

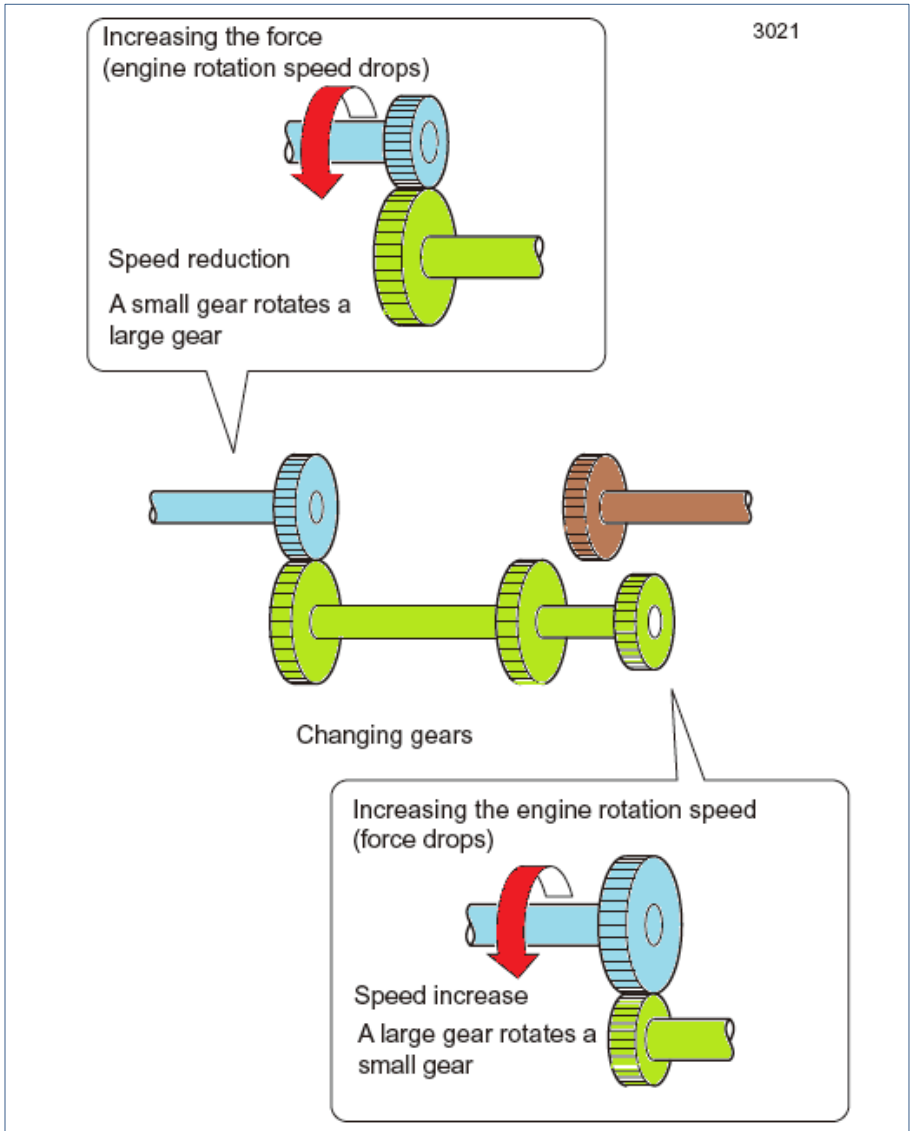


Figure 6: Gear change

1.3.4 Gear ratio

The gear ratio is the ratio between the input gear and output gear rotation speeds. The gear ratio changes as the transmission reduces or increases the engine rotation speed with different gear combinations.

$$\text{Gear ratio} = \frac{\text{No. of output gears}}{\text{No. of input gears}} = \frac{\text{Input gear RPM}}{\text{Output gear RPM}}$$

$$= \frac{\text{Output shaft torque}}{\text{Input shaft torque}}$$

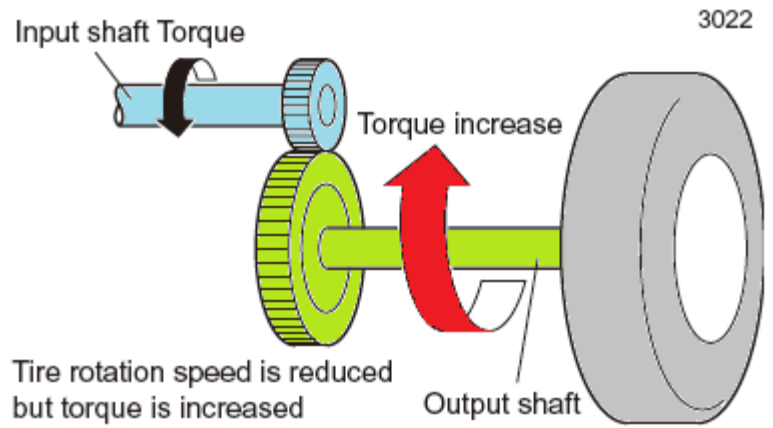


Figure 7: Gear ratios

For example, when the engine operates at a constant torque and a constant speed, if the gear ratio is high (a small gear rotates a large gear), then a high torque but a low engine rotation speed are transmitted to the tires. If the gear ratio is low, a low torque and a high engine rotation speed are transmitted to the tires.

In this way, the relationship between the transmitted torque and engine rotation speed is determined by the ratio of meshed gear teeth. This means that the torque and the engine rotation speed can be expressed as follows.

Engine torque X gear ratio = output shaft torque

$$\frac{\text{Engine rotation speed}}{\text{Gear ratio}} = \text{Output shaft rotation speed}$$

Key Points

In the time that a large gear with 20 teeth rotates once, a small gear with 10 teeth rotates twice. In other words, the small gear rotates at twice the speed of the large gear, but transmits only half the force.

A gear is added to reverse the direction of rotation.

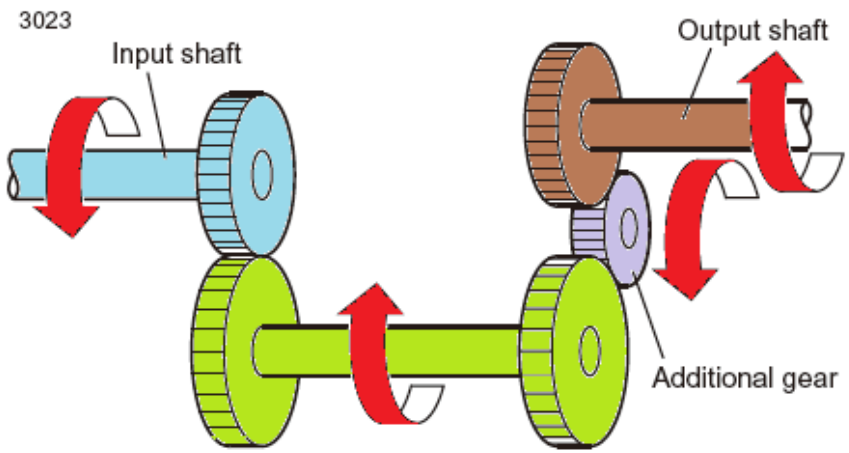


Figure 8: Reverse gear

Examples of gear ratios

Suzuki Kizashi A6B424 6MT

	Number of teeth	Gear ratio	V1000 (km/h)		
			215/60R16	215/55R17	235/45R18
1st	47/13	3.615	8.08	8.09	8.23
2nd	43/21	2.047	14.27	14.29	14.54
3rd	40/29	1.379	21.18	21.22	21.58
4th	35/34	1.029	28.39	28.43	28.92
5th	31/37	0.837	34.90	34.95	35.56
6th	29/41	0.707	41.32	41.38	42.09
Rev	(44/13) x (36/35)	3.481	8.40	8.41	8.55

Suzuki SX4 RW420 J20B 6MT

	Number of teeth	Gear ratio	V1000 (km/h)		
			205/60R16	195/65R15	205/50R17
1st	47/13	3.615	8.00	7.80	7.88
2nd	43/21	2.047	14.14	13.78	13.91
3rd	40/29	1.379	20.98	20.45	20.65
4th	35/34	1.029	28.12	27.41	27.68
5th	31/37	0.837	34.57	33.70	34.02
6th	29/41	0.707	40.93	39.89	40.28
Rev	(44/13) x (36/35)	3.481	8.32	8.11	8.19

1.3.5 Shift lever

The shift lever can be moved horizontally to select the gear row (select movement), forward and back to move the gears (shift movement).

These movements move the internal parts of the transmission to change gear.

1.3.5.1 Remote control type

In remote control type, a rod or cable connects the shift lever to the transmission. This type minimizes vibration and noise because its use of anti-vibration rubber makes it difficult for engine vibration to be transmitted.

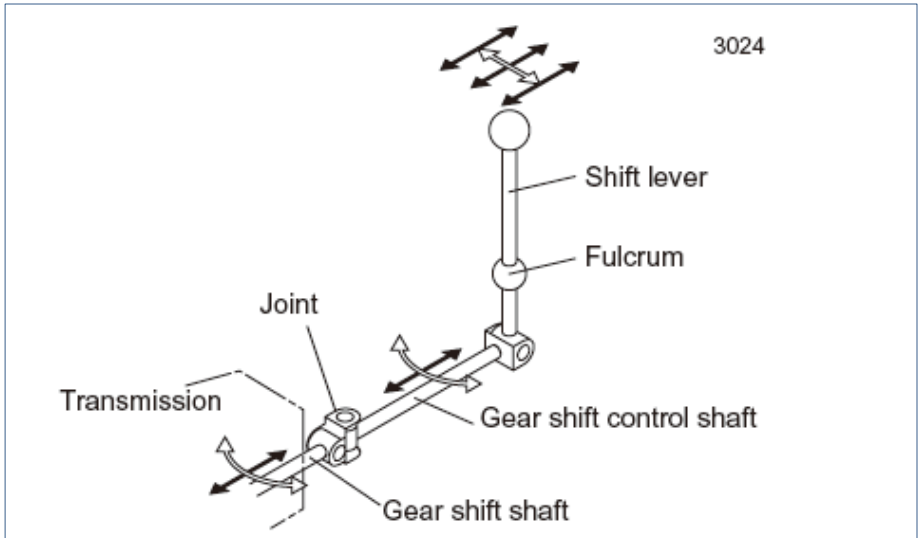


Figure 9: Rod type shift mechanism

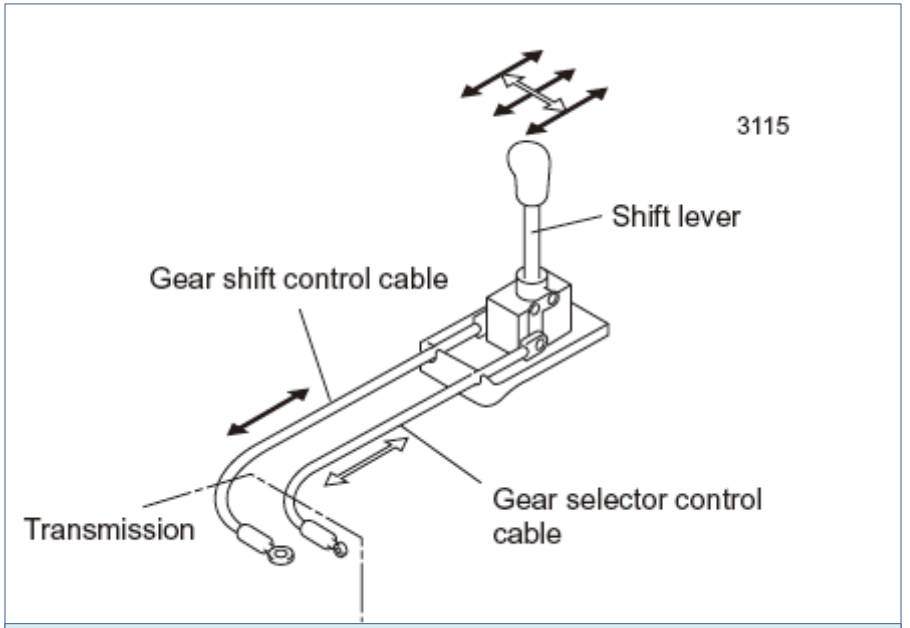


Figure 10: Cable type shift mechanism.

1.3.5.2 Direct shift type

In direct shift type, the shift lever is directly connected to the transmission. Most rear wheel drive vehicles use this system because it delivers fast shift operations and feels good to operate.

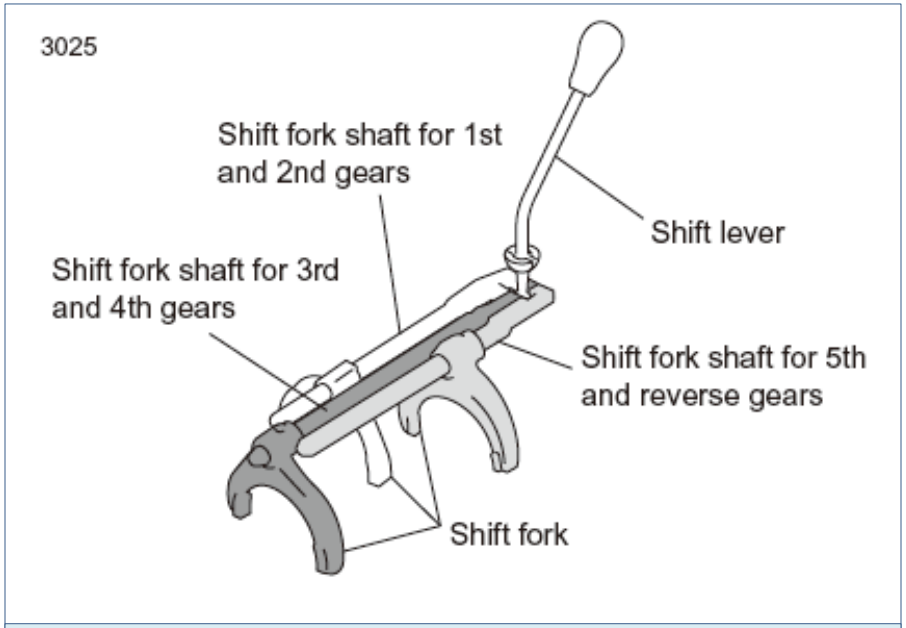


Figure 10: Direct shift mechanism.

1.4 Transmission operation

1.4.1 Gear change

The movement of the shift lever is transmitted unchanged to the gear shift selector lever inside the transmission. When the gear shift selector lever moves in the vertical direction shown in the figure to select and rotate a gear, it moves the synchronizer hub and meshes the gear with the main shaft.

1.4.2 What is the synchromesh mechanism?

The synchromesh mechanism selects the gear to mesh with the main shaft by moving the synchronizer sleeve. When in neutral, the gears on the main shaft rotate at a speed that is a multiple of the teeth ratio (reduction ratio) of the gears that oppose the rotation speed of the countershaft.

This means that the output shaft rotation speed and the rotation speeds of the gears on the output shaft are different. When the gears are changed, the synchromesh mechanism absorbs this rotation difference to ensure a smooth change.

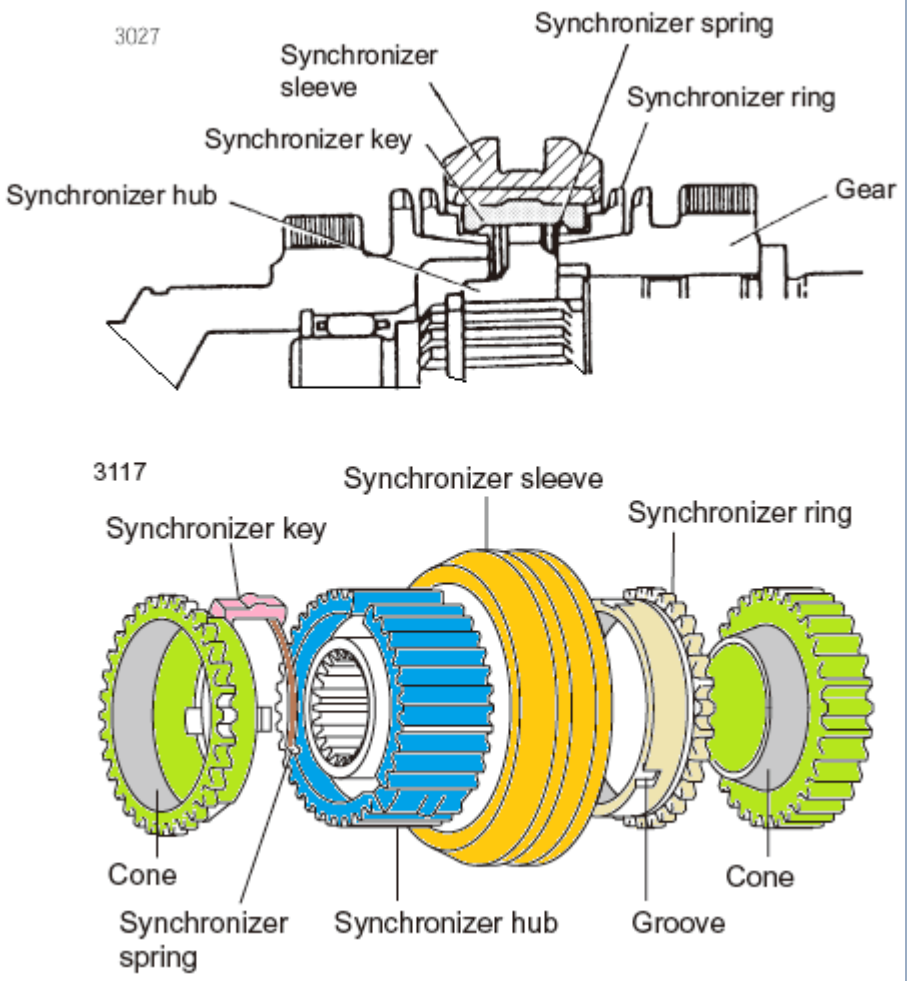


Figure 11: Synchronizer mechanism

1.4.3 Synchromesh mechanism operation

1st stage synchronization action

1. When the shift fork moves the synchronizer sleeve (referred to as “sleeve” from now on), the sleeve and the meshed key move together to the right.
2. The end of the key pushes the ring against the cone. This frictional force transmits the rotation force of the sleeve to the gear.
3. At this time, the difference between the rotation speeds of the ring and gear and the friction with the cone shifts the rotation direction of the gear just by the difference between the key groove width and the key width. As such, when seen from above, the splines on the inside of the sleeve and the ends of the ring splines face each other in different positions as shown in Figure 12.

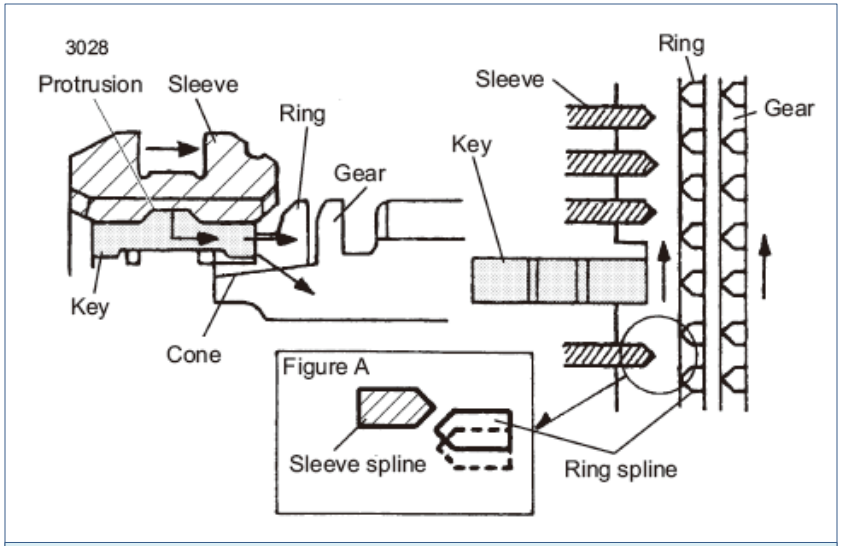


Figure 12: Synchronizer mechanism operation

2nd stage synchronization action

1. As the shift lever is moved, the force acting on the sleeve overcomes the spring. The sleeve goes over the key protrusion and moves forward (moves to the right in the figure).
2. The splines on the inside of the sleeve and the ring splines hit against each other.
3. The force applied to the sleeve is transmitted via the splines that continue to hit and contact each other, and strongly pushes the ring into the gear cone. This frictional force performs a strong synchronization action.

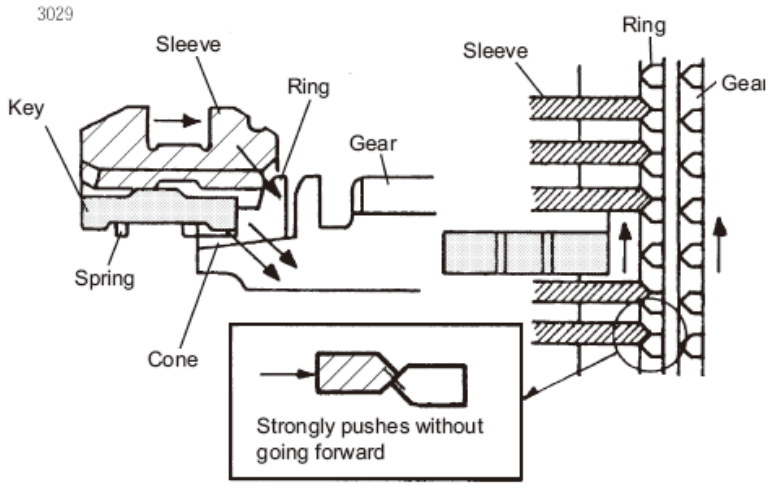


Figure 13: Synchronizer mechanism operation

3rd stage synchronization meshing

1. The sleeve and gear rotation speeds are equalized, and the ring is freed in the rotation direction.
2. As shown in the figure below, the splines on the inside of the sleeve push away the ring splines and move smoothly to mesh with the gear splines.
3. If there is a rotation difference between the ring or gear and the sleeve, the frictional force of the ring and the gear cone stops the forward movement of the sleeve. It only allows forward movement after synchronization is completed. However, when the synchronization action (frictional force) is weak, there is a gear noise when meshing with the gear and gear shifting is difficult.

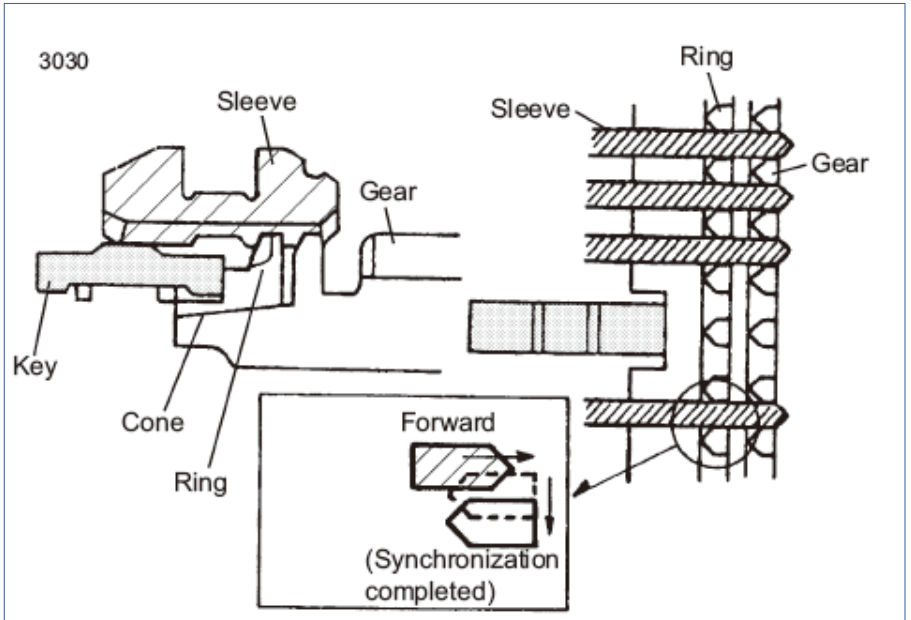


Figure 14: Synchronizer mechanism operation

1.4.4 Mechanisms for safe driving

A manual transmission has various mechanisms for safe driving. These include a mechanism for preventing a meshed gear from jumping out while driving, a mechanism for preventing more than one gear from meshing to the main shaft at the same time, and a mechanism for preventing the vehicle from being mistakenly put into reverse while driving.

1.4.4.1 Gear jump mechanism

"Gear jump out" is when a gear jumps out without a shift operation. It often occurs because of changes in vibration or load while driving, such as during sudden acceleration or deceleration. If the gear jumps out, the transmission goes into neutral.

Gear jump out is often caused by gears meshing in a defective way at the moment of shifting or by a shift in the positional relationship between the sleeve and gear while driving due to wear on the splines between the synchronizer sleeve and the gear resulting in an excessive thrust clearance.

(i) Chamfer

The sleeve and gear spline fittings have tapered teeth surfaces. During rotation, the gear spline is driven by the tapered surface, which makes it difficult for the gear to jump out.

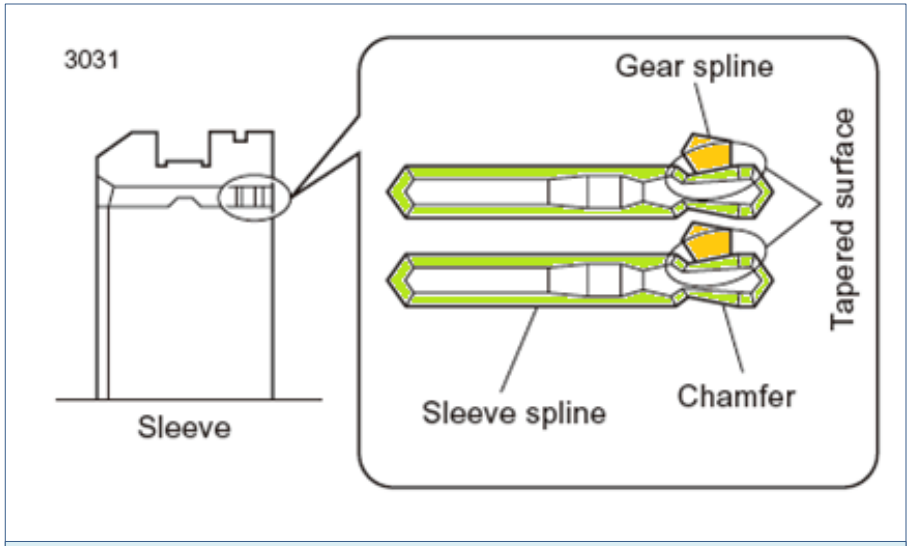


Figure 15: Chamfer method to prevent gear jump

(ii) Detent ball

The detent ball is pushed into the ball groove on the shift fork shaft by the spring. This prevents gear jump out and gives a good operating feel when shifting.

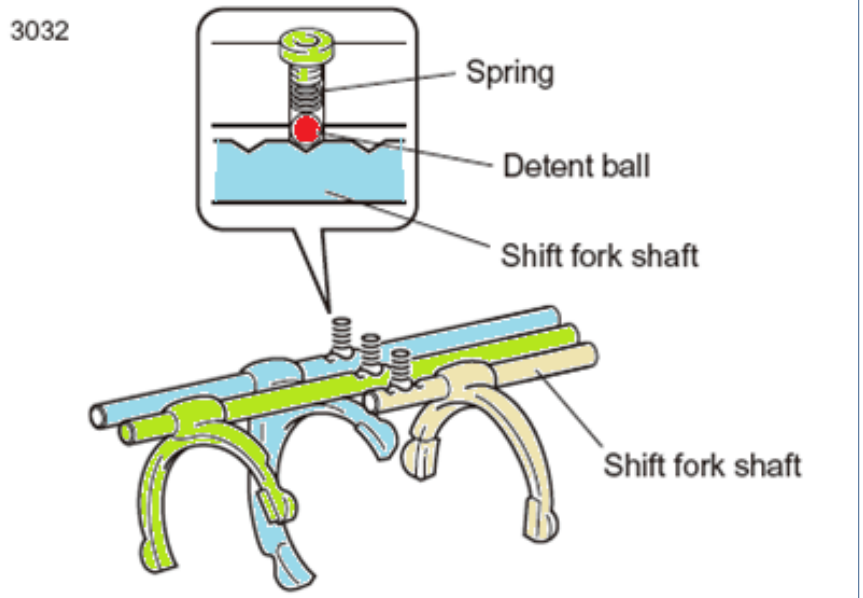


Figure 16: Detent ball method to prevent gear jump

1.4.4.2 Reverse gear shift lever 1-way movement mechanism

In a manual transmission, the shift lever is operated to move the various shift fork shafts. The gear shift forks that are integrated with the shift fork shafts move to change the gears.

In recent Suzuki vehicles, changing to reverse has been performed not by the sleeve movement, but by the movement of the reverse idler gear.

Longitudinal manual transmissions use a reverse gear shift lever 1-way movement mechanism. When a shift operation is made that involves a movement in the direction of the 5th gear side and the reverse side of the 5th-reverse shift fork, the reverse gear shift lever 1-way movement mechanism is activated only when the reverse gear shift lever is operated to one side (reverse side). This mechanism moves the reverse idler gear.

(i) When in neutral

When in neutral, because the pin of the 5th-reverse gear shift fork restricts the rotation of the reverse gear shift lever, the reverse idler gear does not move.

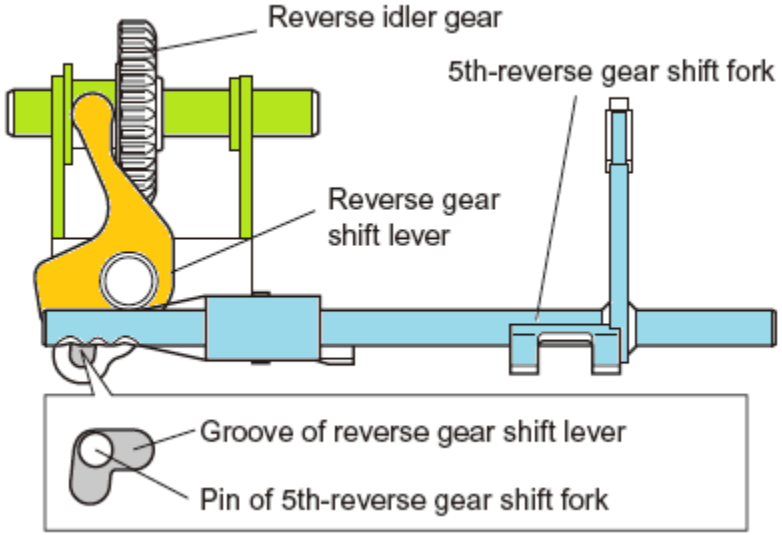


Figure 17: Neutral position

(ii) Reversing

When shifting from neutral to reverse, the pin of the 5th-reverse shift fork moves along the groove of the reverse gear shift lever, applying force to the reverse gear shift lever in the clockwise direction.

The clockwise rotation of the reverse gear shift lever moves the reverse idler gear and fits it into the input shaft.

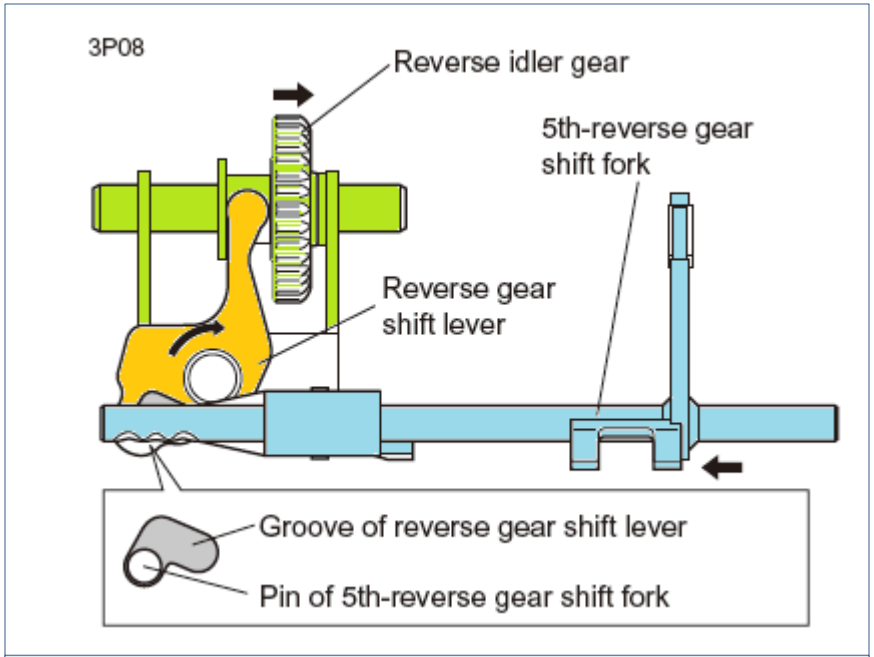


Figure 18: Neutral position

(iii) When in the 5th speed

When shifting from neutral to the 5th gear, the pin of the 5th-reverse gear shift fork moves inside the groove of the reverse gear shift lever, but because rotation force is not applied to the reverse gear shift lever, the reverse idler gear does not move.

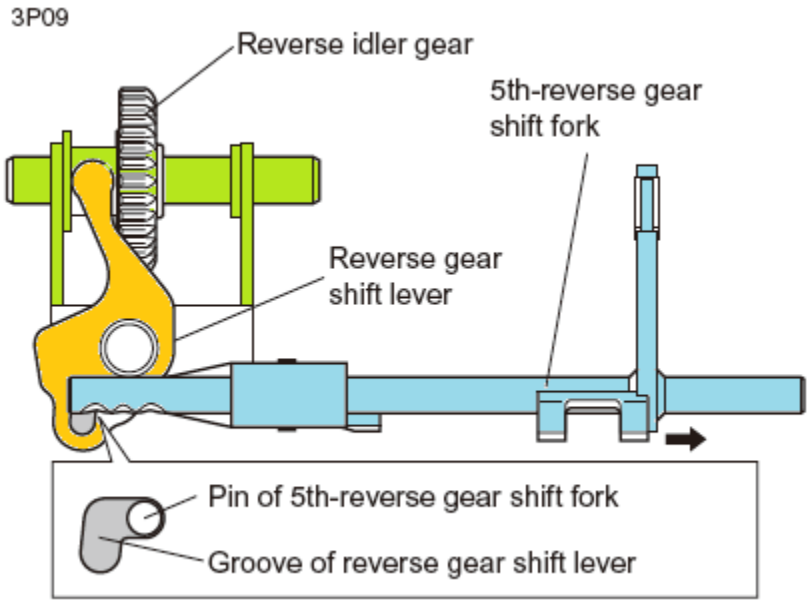


Figure 18: Neutral position

1.4.4.3 Double meshing prevention mechanism (interlock mechanism)

If 2 adjacent shift forks move at the same time, there is a risk of 2 gears meshing. To prevent this, a double meshing prevention mechanism (interlock mechanism) is used.

(i) Transverse manual transmission

When shifting to 1st or 2nd gear, locking ball A that is pushed out by the low speed shift shaft moves the pin and locking ball B. The balls enter the grooves of the high speed shift shaft and the 5th shift shaft to regulate the movement of these shift shafts.

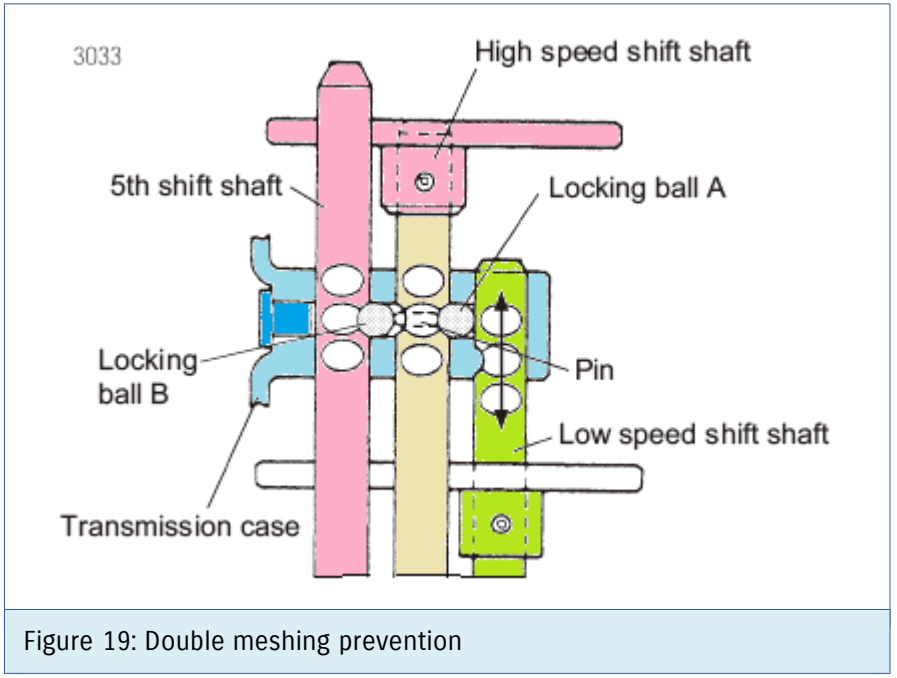


Figure 19: Double meshing prevention

When shifting to 3rd or 4th gear, the high speed shift shaft moves locking balls A and B, which enter the grooves of the low speed shift shaft and the 5th shift shaft to regulate the movement in the shift direction.

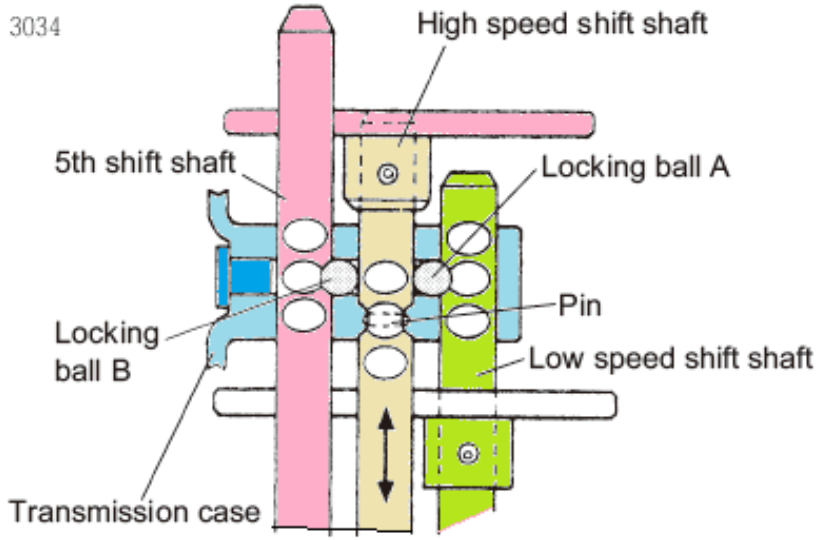


Figure 19: Double meshing prevention

When shifting to 5th or reverse gear, locking ball B that is pushed out by the 5th shift shaft moves the pin and locking ball A. The balls enter the grooves of the low speed shift shaft and the high speed shift shaft to regulate the movement in the shift direction.

1.4.4.4 Inadvertent reverse operation prevention mechanism

An inadvertent reverse gear operation is when the gear jumps out from 5th gear, and through its own momentum, enters the reverse gear. To prevent this, the mechanism is designed so that a shift to reverse gear cannot be made without first returning the shift lever to neutral.

Transverse manual transmission

1. When the shift lever is moved to the 5th gear, the gear shift selector shaft is pushed in the gear shift guide case direction. At this time, the movement of the 5th-reverse interlock plate is regulated by the guide bolt, and the low select spring and the cam guide return spring are compressed.

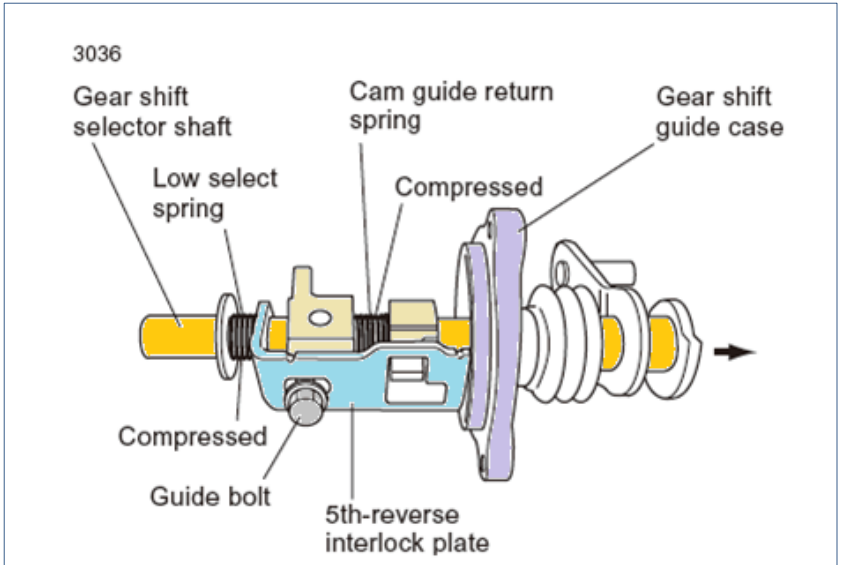


Figure 20: Inadvertent reverse operation prevention mechanism

2. The 5th-reverse gear shift cam that shifts to 5th gear rotates, and the reaction force of the cam guide return spring moves the 5th-reverse interlock plate one step to the rear.

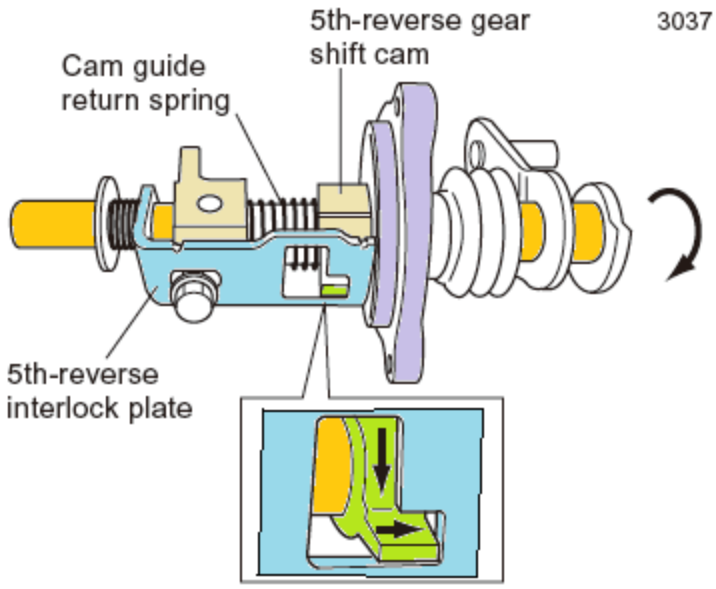


Figure 21: Inadvertent reverse operation prevention mechanism

3. If shifting to reverse is performed in this condition, the gear shift selector shaft rotates, and the 5th-reverse gear shift cam continues to be pushed by the 5th-reverse interlock plate. This means that the shifting cannot be performed.

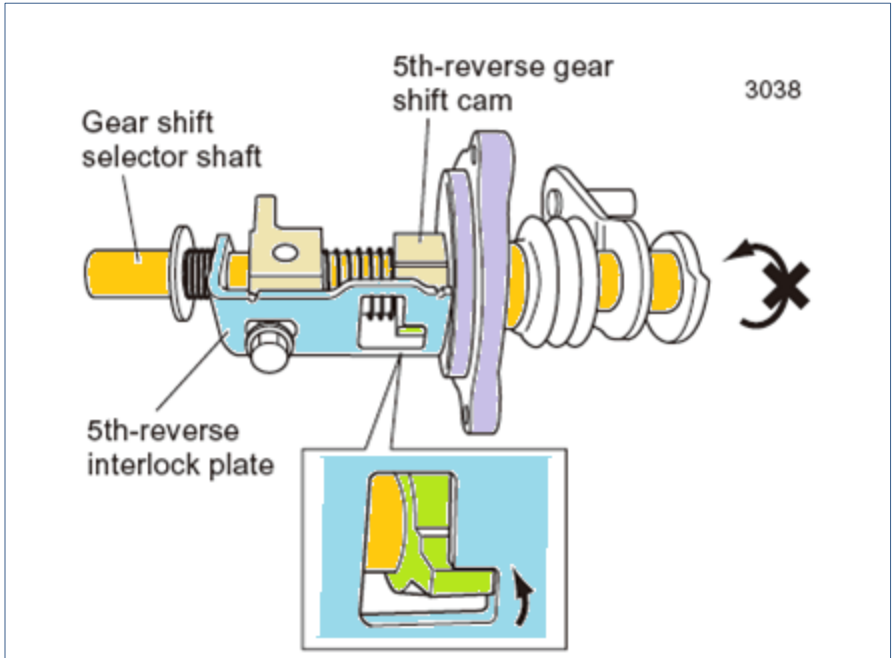


Figure 22: Inadvertent reverse operation prevention mechanism

4. When the shift lever is returned to the neutral position, the reaction force of the low select spring returns the 5th-reverse interlock plate to its normal position, which allows shifting to reverse.

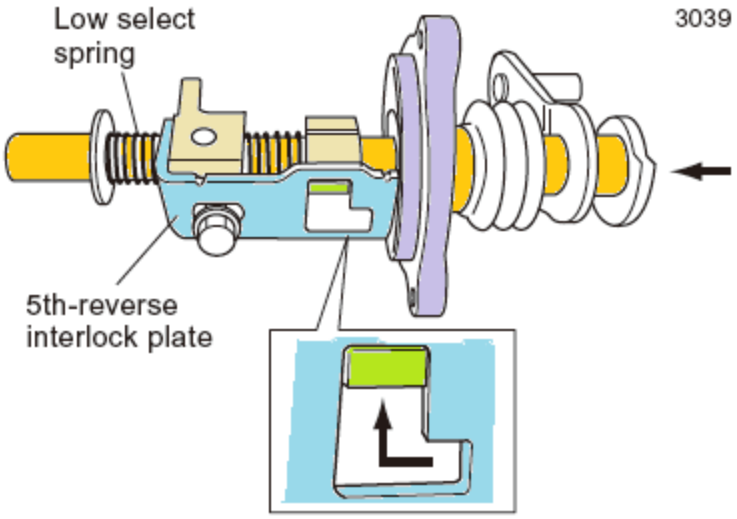


Figure 23: Inadvertent reverse operation prevention mechanism

1.4.4.5 Input shaft brake system (IBS)

When shifting into reverse, even if you step on the clutch to cut off the power from the engine, inertial force continues to rotate the input shaft. This means that when shifting into reverse, the reverse gear of the input shaft that continues to rotate and the reverse idler gear that is stationary are not synchronized. This results in poor shifting into reverse gear and a gear noise. To minimize this effect, the IBS applies a brake to the input shaft with the 5th speed synchronizer ring to reduce the rotation speed and ensure a smooth shift into reverse.

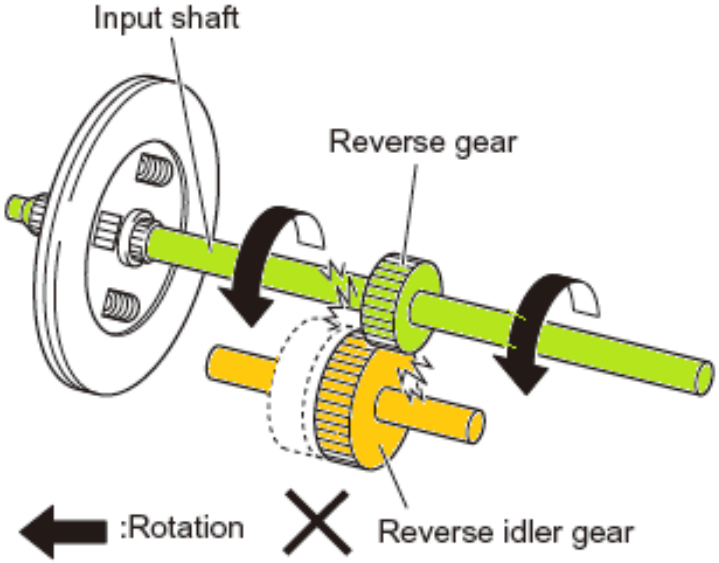


Figure 24: Without IBS (poor shifting and gear noise)

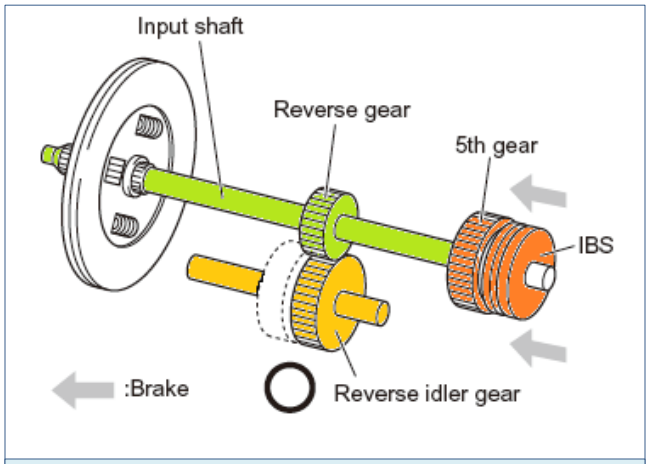


Figure 25: With IBS (improved shifting , reduced gear noise)

(i) IBS structure

The IBS is made up of a 5th speed synchronizer sleeve, 5th speed synchronizer hub, 5th speed synchronizer

lever, 5th speed synchronizer ring and input shaft 5th gear.

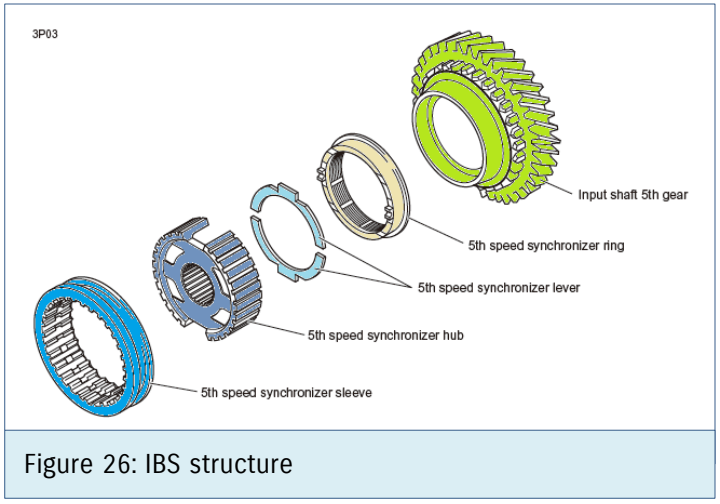


Figure 26: IBS structure

(II) IBS operation

- When in neutral

When the input shaft is rotating due to inertial force, the 5th speed synchronizer sleeve and 5th speed synchronizer lever also rotate. As such, the 5th speed synchronizer lever pushes out toward the circumference due to centrifugal force. This meshes the flange of the 5th speed synchronizer lever with the groove of the 5th speed synchronizer sleeve.

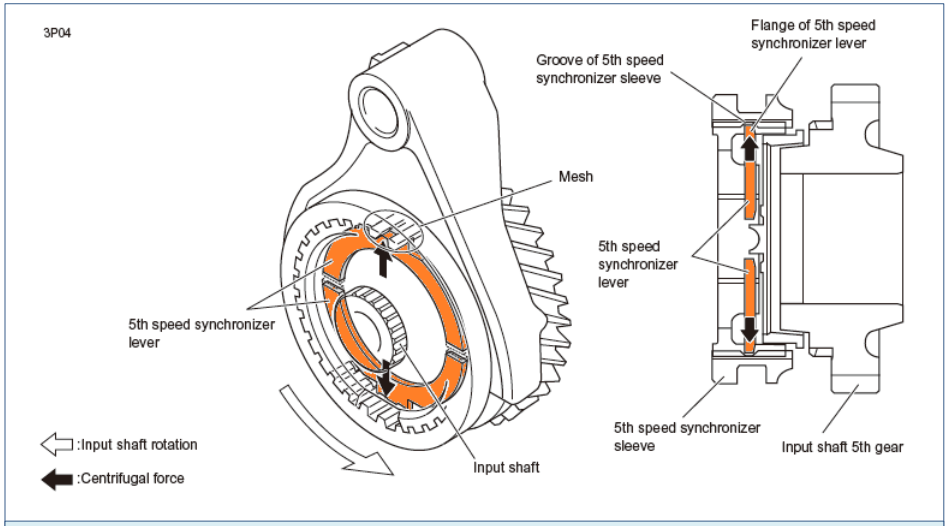


Figure 26: IBS operation: neutral position

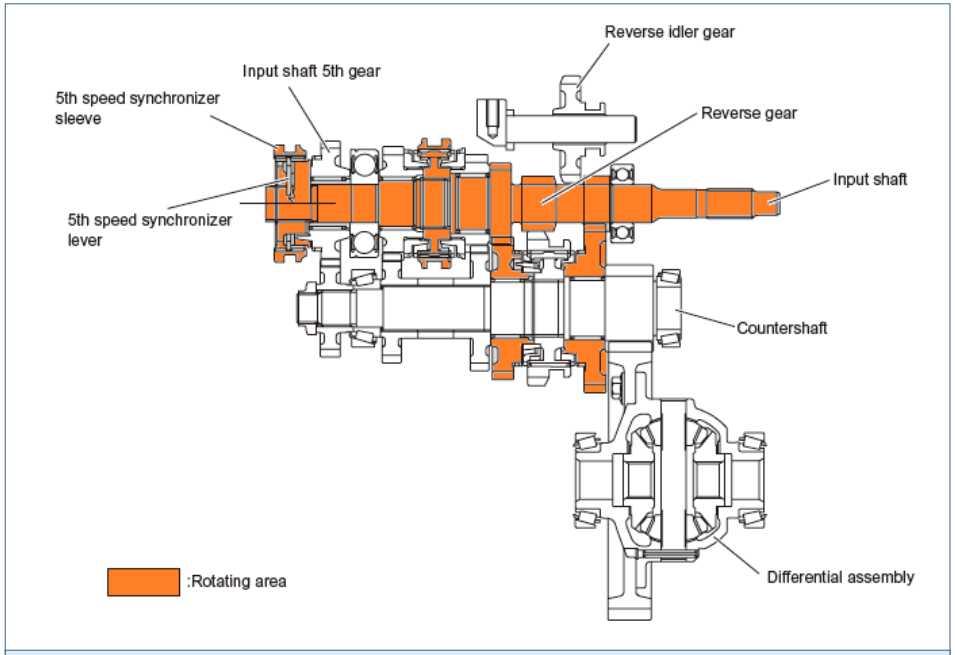


Figure 27: IBS operation: neutral position: rotating components

- Start of synchronization

When shifting into reverse, the 5th gear shift fork moves the 5th speed synchronizer sleeve in the direction, of arrow A. At this time, the 5th speed synchronizer lever moves the flange of the 5th speed synchronizer lever in the direction of arrow B (figure 28), with the 5th speed synchronizer hub as the fulcrum because the 5th speed synchronizer hub is fixed to the input shaft. This means that the 5th speed synchronizer lever pushes the 5th speed synchronizer ring, so that the 5th speed synchronizer ring and the cone surface of the input shaft 5th gear make contact. This applies a brake to the input shaft, reducing its speed. As such, it is easier for the reverse idler gear and the input shaft reverse gear to mesh, enabling a smooth shift into reverse.

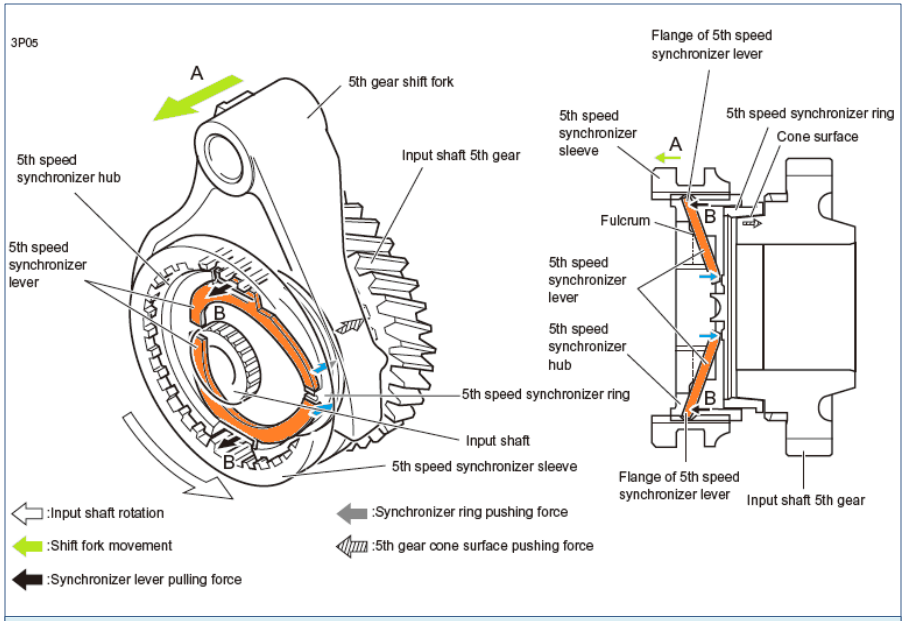


Figure 28: IBS operation: start of synchronization

- Gear change completion

When the 5th speed synchronizer sleeve moves further in the direction of arrow A, the 5th speed synchronizer lever is pushed in the direction of arrow C. This eliminates the force of the 5th speed synchronizer lever pushing against the 5th speed synchronizer ring. At this time, the 5th speed synchronizer ring and the cone surface of the input shaft 5th gear separate, which releases the brake that was applied to the input shaft. This means that after the gear change is completed, the input shaft can rotate again.

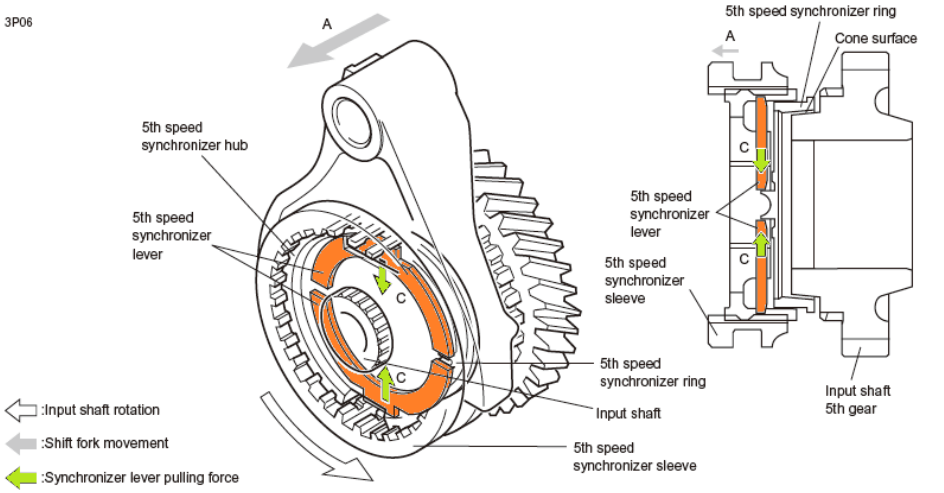


Figure 29: Gear change completion

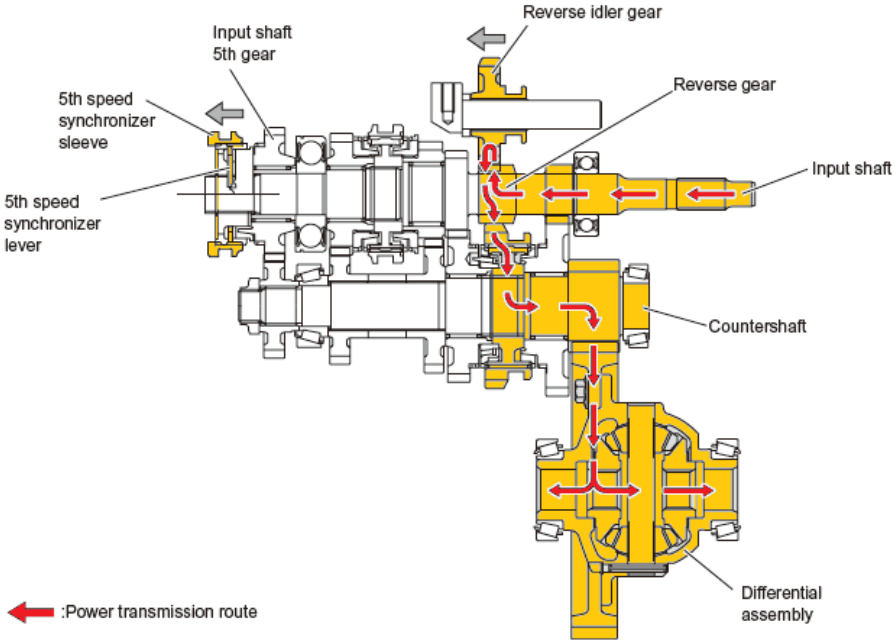


Figure 30: Power transmission route

Lesson 2:

Suzuki manual transmissions & transaxle

Objectives

At the end of this lesson, you will be able to:

- Explain the construction of the transmissions or transaxles used in Suzuki vehicles.
- Identify the different components of the transmissions or transaxles.
- Explain the operation of the gear change mechanisms used in the different models.

2.1 Suzuki Alto AMF310 transaxle overview

2.1.1 Construction

The transaxle provides five forward speeds and one reverse speed by means of three synchromesh devices and three shafts-input shaft, countershaft and reverse gear shaft. All forward gears are in constant mesh and reverse uses a sliding idler gear arrangement.

The low speed synchronizer sleeve & hub is mounted on countershaft and engaged with countershaft 1st gear or 2nd gear, while the high speed synchronizer sleeve & hub is done on input shaft and engaged with input shaft 3rd gear or 4th gear. The 5th speed synchronizer sleeve & hub on input shaft is engaged with input shaft fifth gear mounted on the input shaft. A double cone synchronizing mechanism is provided to 2nd gear synchromesh device for high performance of shifting to 2nd gear. The countershaft turns the final gear and differential assembly, thereby turning the front drive shafts which are attached to the front wheels.

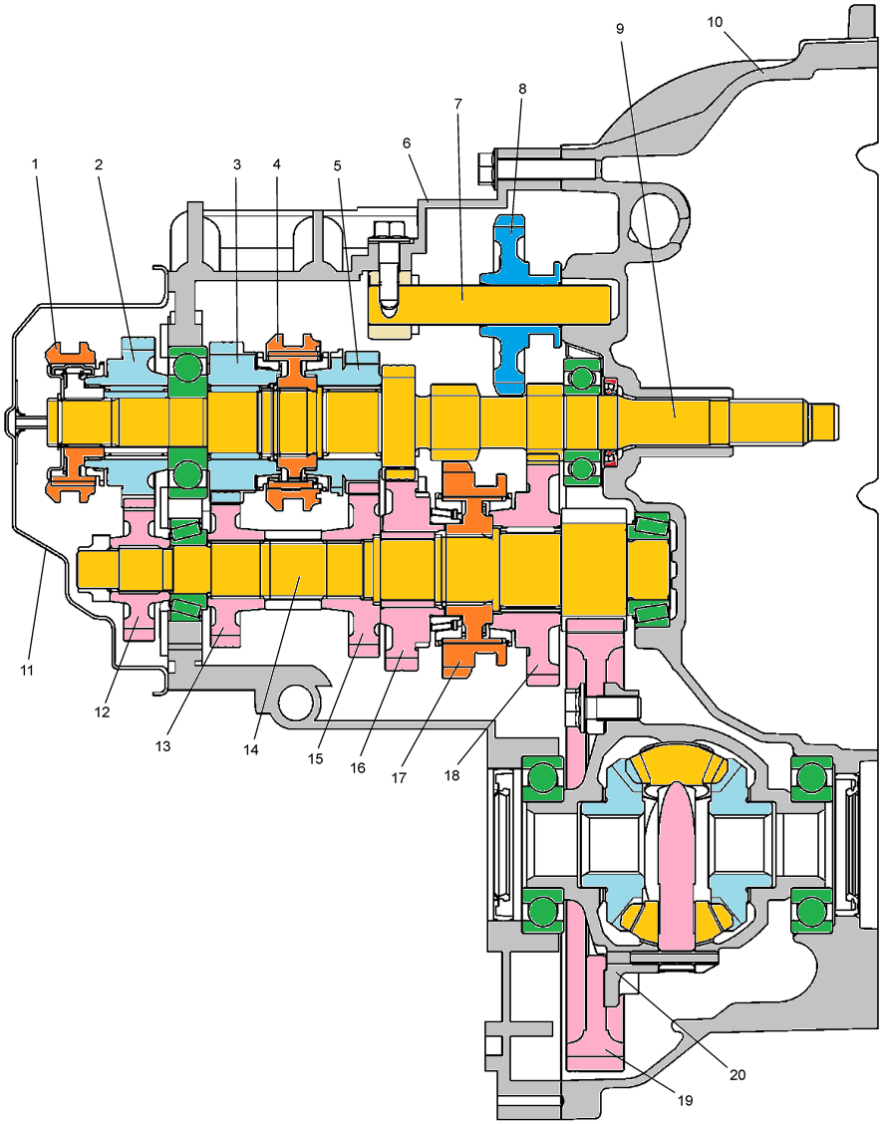


Figure 1: Manual transaxle (Alto AMF310)

Figure 1

[1] 5th speed synchronizer sleeve & hub
[2] Input shaft 5th gear
[3] Input shaft 4th gear
[4] High speed synchronizer sleeve and hub
[5] Input shaft 3rd gear
[6] Left case
[7] Reverse gear shaft
[8] Reverse idler gear
[9] Input shaft
[10] Right case
[11] Side cover
[12] Countershaft 5th gear
[13] Countershaft 4th gear
[14] Countershaft
[15] Countershaft 3rd gear
[16] Countershaft 2nd gear
[17] Low speed synchronizer speed & hub
[18] Countershaft 1st gear
[19] Final gear
[20] Differential case

2.1.2 Gear Shift Mechanism

The gear shifting control system consists of the following main parts. Movement of gear shift control lever assembly (16) is transmitted to gear shift & select shaft assembly (10) through gear shift control cable (1) and gear select control cable (2).

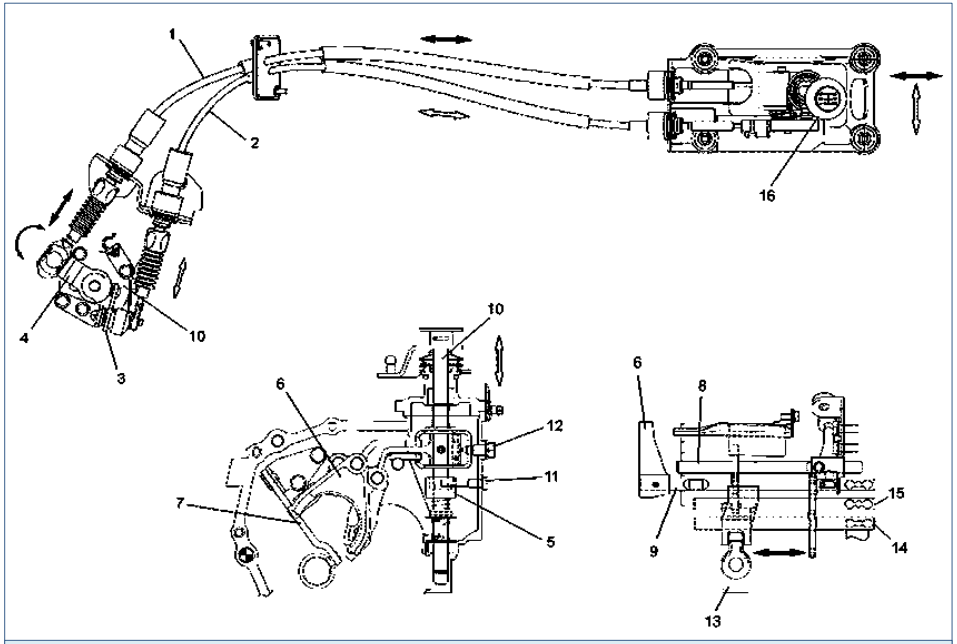


Figure 2: Gear shift mechanism (Alto AMF310)

[1] Gear shift control cable
[2] Gear select control cable
[3] Select cable lever
[4] Shift cable lever
[5] 5th & reverse gear shift cam
[6] 5th gear shift fork
[7] Reverse gear shift lever
[8] 5th & reverse gear shift guide shaft
[9] 5th & reverse gear shift shaft
[10] Gear shift & select shift assembly
[11] 5th to reverse interlock guide bolt
[12] Gear shift interlock bolt
[13] Gear shift & select lever
[14] Low speed gear shift shaft
[15] High speed gear shift shaft
[16] Gear shift control lever assembly

2.1.3 5th & Reverse Gear Shift Cam

5th & reverse gear shift cam, cam guide return spring and 5th to reverse interlock guide bolt are provided to prevent the gear from being directly shifted from 5th to reverse.

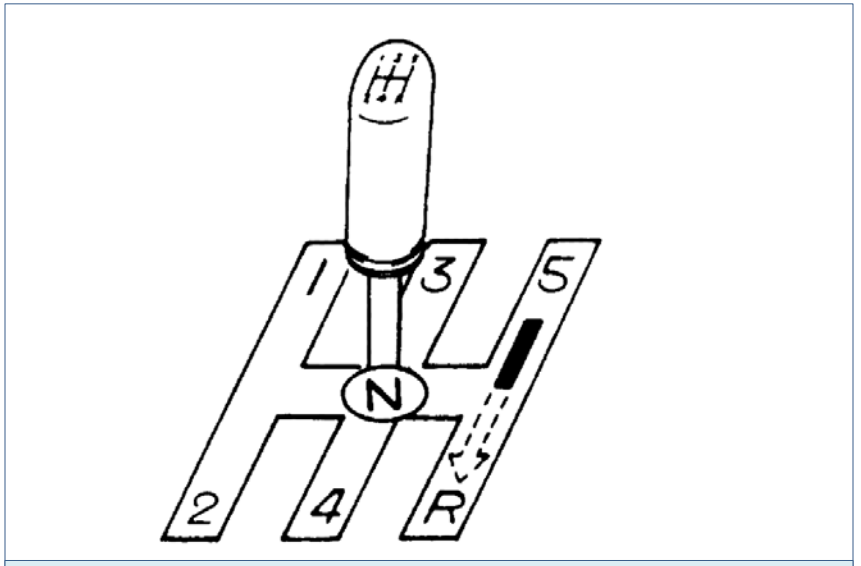


Figure 3: Gear shift cam

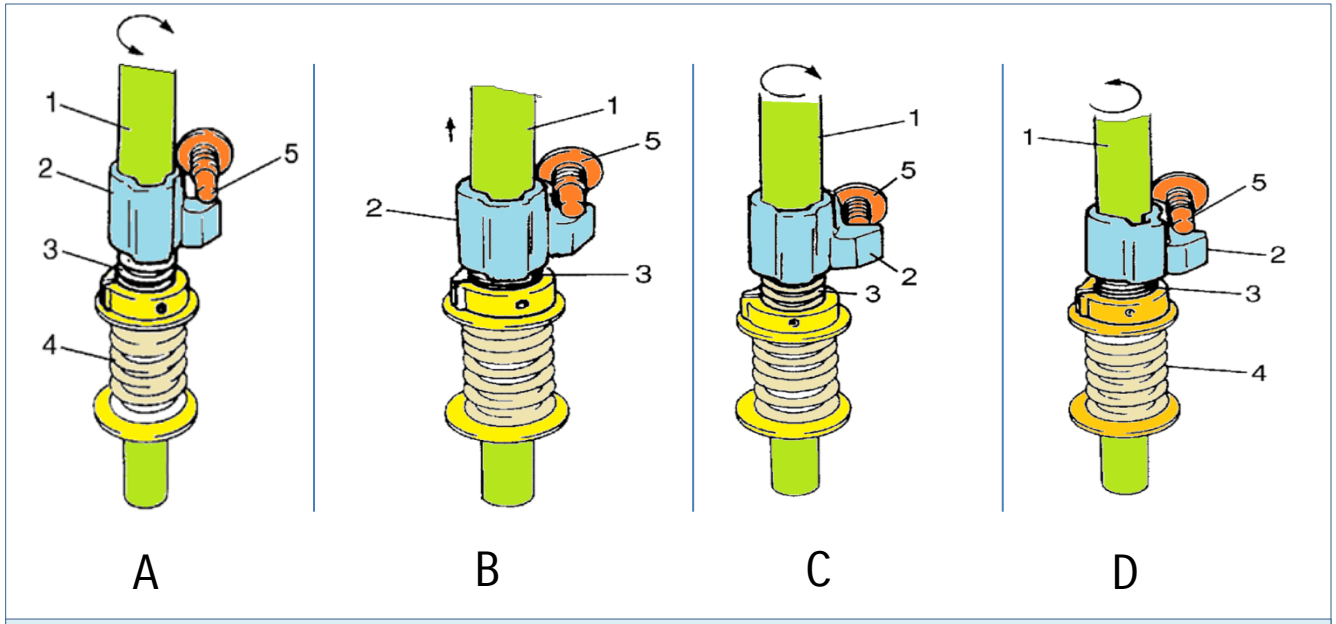


Figure 4: 5th and reverse gear shift cam

1. Figure 4 (A)

When shift lever is at neutral position between 3rd and 4th gear, 5th & reverse gear shift cam (2) is under 5th to reverse interlock guide bolt (5) and can turn freely clockwise (to 3rd gear) and counterclockwise (to 4th gear).

2. Figure 4(B)

When shift lever is shifted toward right from neutral position, gear shift & select shaft (1) moves up but 5th & reverse gear shift cam (2) is restricted by 5th to reverse interlock guide bolt (5) and cam guide return spring (3) is contracted.

[1] Gear shift & select shaft
[3] Cam guide return spring (expanded)
[4] 1st & 2nd select spring (expanded)

3. Figure 4 (C)

When shift lever is shifted to 5th gear, gear shift & select shaft (1) turns clockwise letting 5th & reverse gear shift cam (2) off from 5th to reverse interlock guide bolt and pushed up by cam gear return spring (3). In this state, movement of shift cam is restricted by 5th to reverse interlock guide bolt (5) and therefore, gearshift to reverse is not attainable.

3. Figure 4 (D)

When shift lever is shifted from neutral position between 3rd-4th gear to 5th & reverse gear position, gear shift & select shaft (1) moves up but 5th & reverse gear shift cam (2) is restricted to move up by 5th to reverse interlock guide bolt (5). In this position, shift & select shaft can turn both clockwise (to 5th gear) and counterclockwise (to reverse gear).

[3] Cam guide return spring (contracted)

[4] 1st and 2nd select spring (contracted)

2.2 Suzuki Swift (AZH model) transaxle overview

2.2.1 Description

The transaxle provides five forward speeds and one reverse speed by means of three synchromesh devices and three shafts,

- Input shaft,
- Countershaft and
- Reverse gear shaft.

All forward gears are in constant mesh, and reverse uses a sliding idler gear arrangement.

The low speed sleeve & hub is mounted on countershaft and engaged with countershaft 1st gear or 2nd gear, while the high speed sleeve & hub is mounted on input shaft and engaged with input shaft 3rd gear or 4th gear. The 5th speed sleeve & hub on input shaft is engaged with input shaft 5th gear mounted on the input shaft.

To prevent the cracking noise from the reverse gear when shifting transaxle gear into the reverse gear, the reverse shift braking device is used. This device utilizes the 5th synchromesh, which is the lever synchro type, to apply the brake on the input shaft rotation.

The double cone synchronizing mechanism is provided to 2nd gear synchromesh device for high performance of shifting to 2nd gear.

For servicing, it is necessary to use genuine sealant or its equivalent on mating surfaces of transaxle case which is made of aluminum. The case fastening bolts must be tightened to specified torque by means of torque wrench. It is also important that all parts are thoroughly cleaned with cleaning fluid and air dried before reassembling.

Further, care must be taken to adjust preload of countershaft taper roller bearings. New synchronizer rings are prohibited from being lapped with respective gear cones by using lapping compound before they are assembled

2.2.1 Gear shift mechanism

The gear shifting control system consists of the main parts shown in figure 5. Movement of gear shift control lever is transmitted to gear shift & select shaft through gear shift and gear select cables.

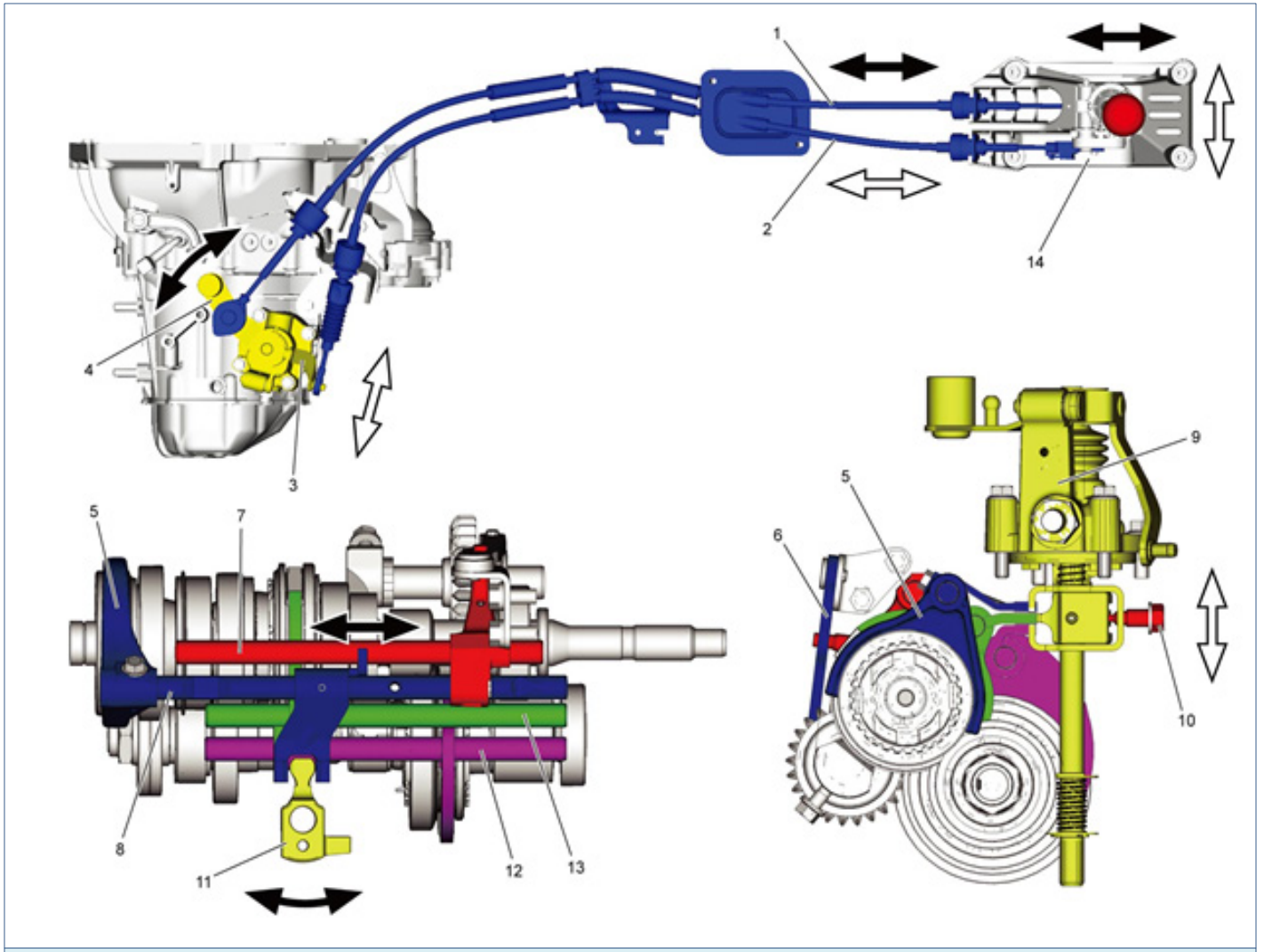


Figure 5: Gear shift mechanism – Suzuki Swift AZH414

Figure 5
[1] Gear shift control cable
[2] Gear selector control cable
[3] Select cable lever
[4] Shift cable lever
[5] 5th gear shift fork
[6] Reverse gear shift lever
[7] 5th & reverse gear shift guide shaft
[8] 5th & reverse gear shift shaft
[9] Gear shift & select shaft assembly
[10] Gear shift interlock bolt
[11] Gear shift and select lever
[12] Low speed gear shift shaft
[13] High speed gear shift shaft
[14] Gear shift control lever assembly

2.2.2 Reverse Shift Prevention Mechanism

Construction

In the gear shift lever case, the reverse shift limit yoke (2) which turns around reverse shift limit yoke (2) retainer is provided.

This reverse shift limit yoke (2) restricts the movement of gear shift & select lever (1) to prevent erroneous reverse shifting.

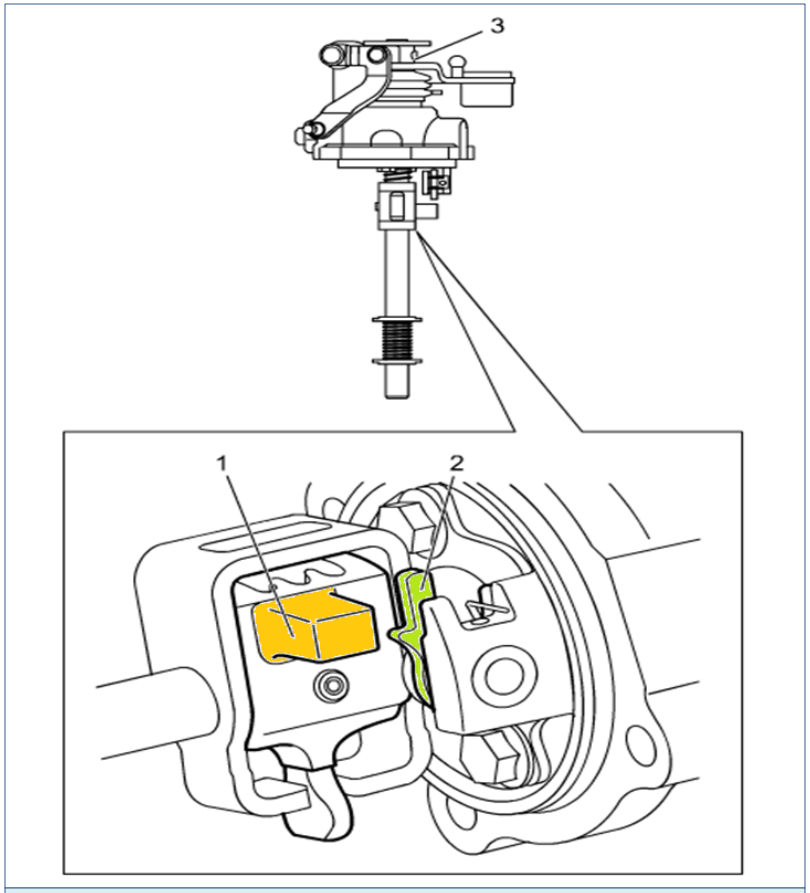


Figure 6: Gear shift & select shaft assembly

Operation

1. If shifting directly from 5th [a] to reverse [b] is attempted, the cubic part of the gear shift & select lever (1) is blocked by the projection of the reverse shift limit yoke (2).

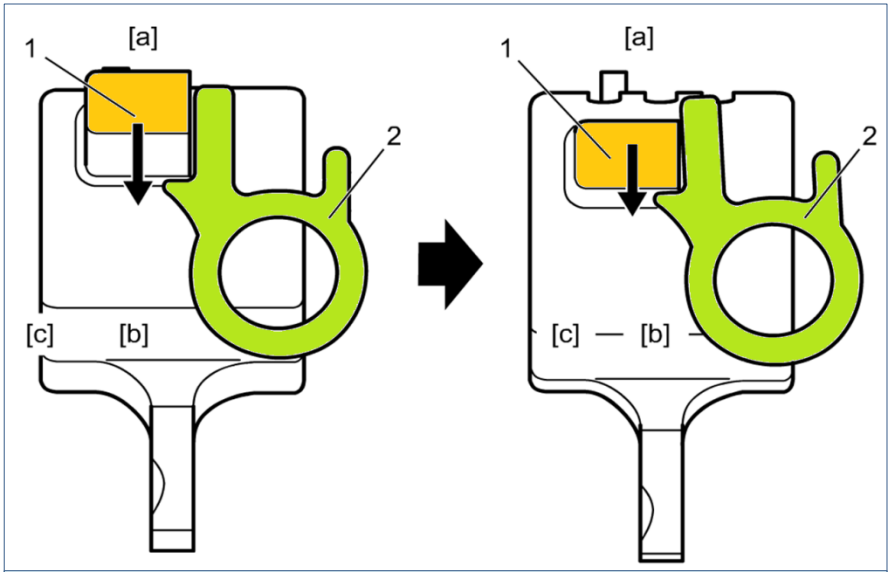


Figure 7: Reverse shift prevention mechanism operation

[c] 4th

2. Then the cubic part of the gear shift & select lever (1) pushes the projection of the reverse shift limit yoke (2). The reverse shift limit yoke (2) rotates and pushes the gear shift & select lever (1) toward the neutral position.

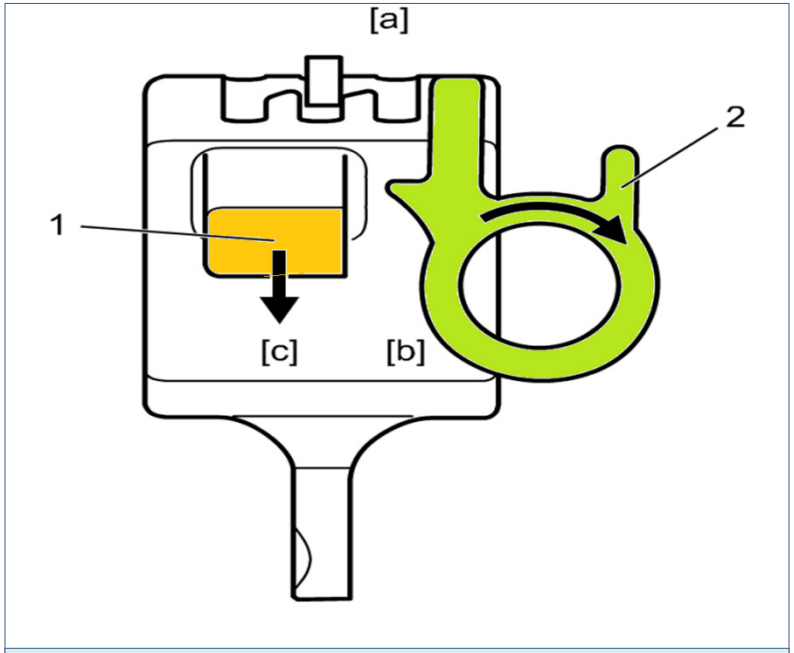


Figure 8: Reverse shift prevention mechanism operation

[a] 5th
[b] Reverse
[c] 4th

3. If the reverse shifting force is still applied to the shift lever, the cubic part of the gear shift & select lever (1) rides over the projection of the reverse shift limit yoke (2), and the gear is shifted into the 4th. The reverse shift limit yoke (2) returns to its original position.

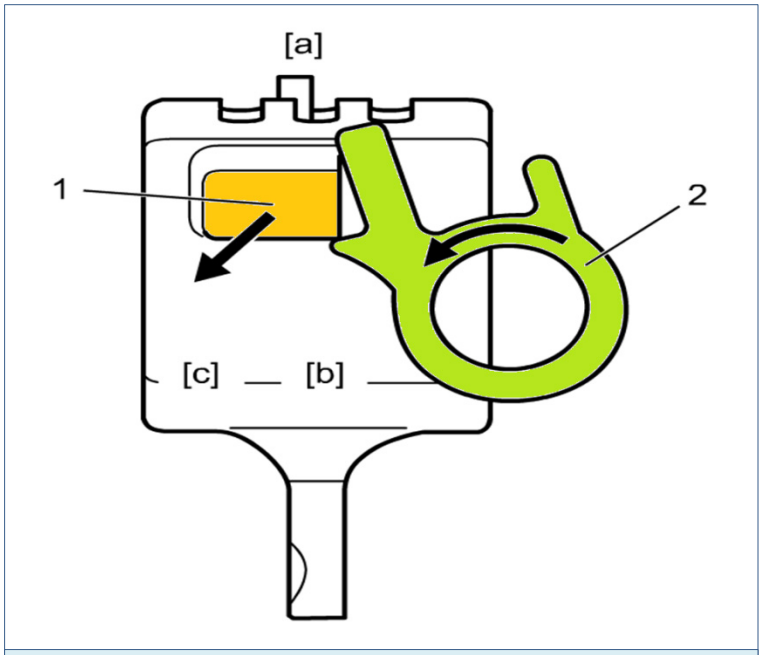


Figure 9: Reverse shift prevention mechanism operation

[a] 5th
[b] Reverse
[c] 4th

2.3 Suzuki Grand Vitara (JB424) manual transmission

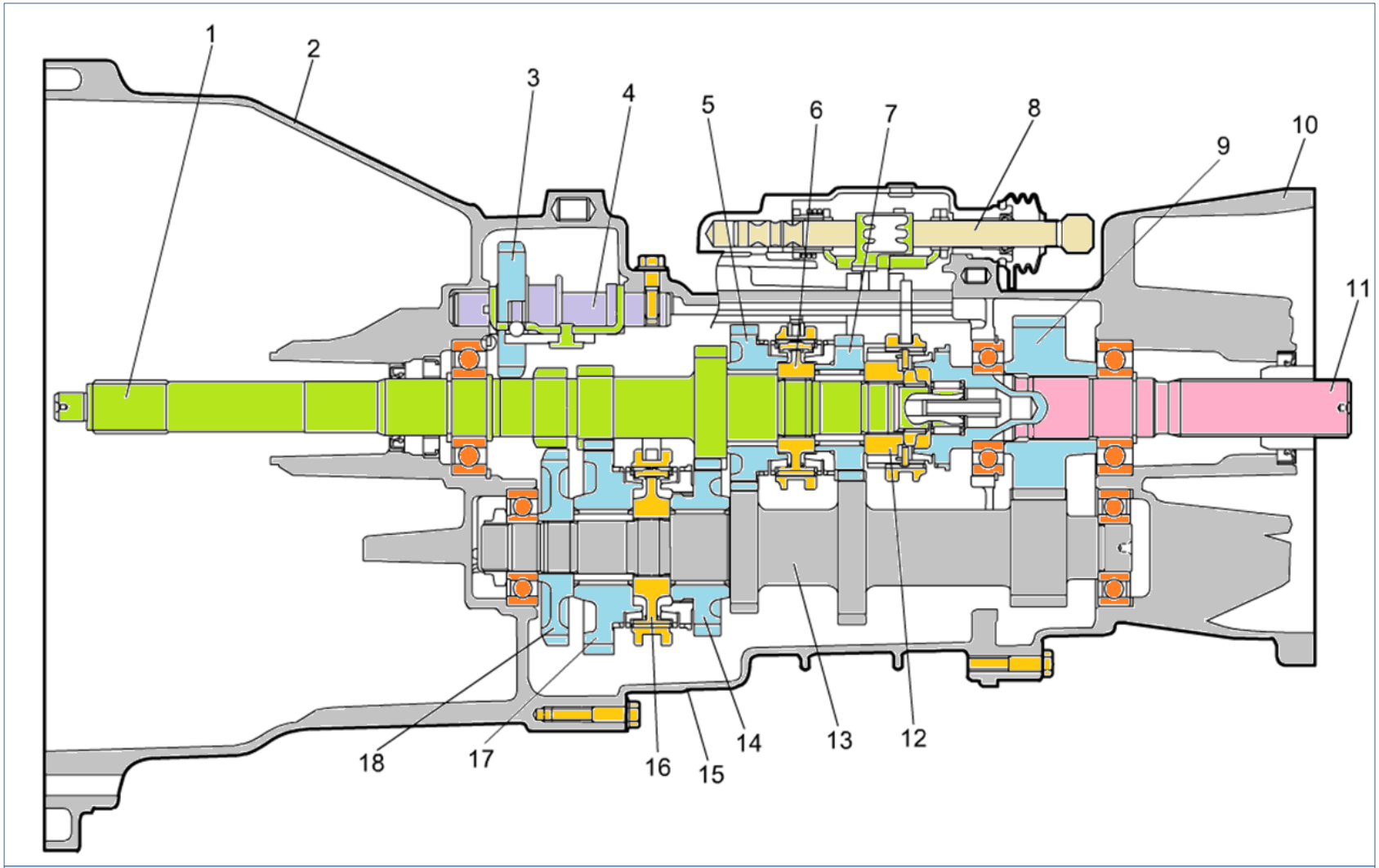
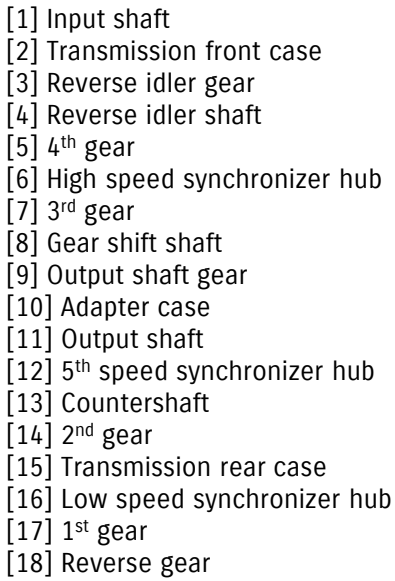


Figure 10: Manual transmission – JB424

Figure 10



[1] Input shaft
[2] Transmission front case
[3] Reverse idler gear
[4] Reverse idler shaft
[5] 4th gear
[6] High speed synchronizer hub
[7] 3rd gear
[8] Gear shift shaft
[9] Output shaft gear
[10] Adapter case
[11] Output shaft
[12] 5th speed synchronizer hub
[13] Countershaft
[14] 2nd gear
[15] Transmission rear case
[16] Low speed synchronizer hub
[17] 1st gear
[18] Reverse gear

Overview

The manual transmission consists of the input shaft, output shaft, countershaft and reverse shaft which are installed in the die-cast aluminum alloy case. This transmission provides five forward speeds and one reverse speed.

The 1st, 2nd, 3rd and 4th speeds are for speed reduction drive, 5th speed is for direct drive. The low speed (1st and 2nd) synchronizer is mounted on the countershaft and engaged with the countershaft 1st or 2nd gear. The high speed (3rd and 4th) synchronizer is mounted on the input shaft and engaged with the input shaft 3rd and 4th gear.

The 5th speed synchronizer is mounted on the input shaft and engaged with the output shaft. The gear shift lever case is located at the upper behind the transmission case and has a cam which prevents direct gear shifting from the 5th speed gear into the reverse gear.

As the die-cast aluminum alloy case are sealed with liquid type gasket, it is necessary to use genuine sealant or its equivalent on its mating surface when reassembling them. Also, the case fastening bolts must be tightened to specified torque by means of the torque wrench and tightening over or below the specified torque should be avoided.

2.4 Suzuki SX4 (RW420) & Kizashi A6B424 6 speed manual transaxle overview

The transaxle provides six forward speeds and one reverse speed by means of four synchromesh device (seven synchromesh devices in the A6B424) and three shafts

- input shaft,
- counter shaft and
- reverse gear shaft.

The low speed sleeve & hub is mounted on counter shaft and engaged with counter shaft 1st gear or 2nd gear, while the high speed sleeve & hub is done on input shaft and engaged with input shaft 3rd gear or 4th gear. The 5th & 6th speed sleeve & hub is mounted on input shaft and engaged with input shaft 5th gear or 6th gear. The reverse gear sleeve & hub mounted on reverse gear shaft and engaged with reverse idler left gear or reverse idler right gear.

The triple cone synchronizing mechanism is provided to 1st and 2nd gear synchromesh devices for high performance of shifting to 2nd gear.

The double cone synchronizing mechanism is provided to 3rd gear synchromesh device for high performance of shifting.

For servicing, it is necessary to use genuine sealant or its equivalent on mating surfaces of transaxle case. It is also important that all parts are thoroughly cleaned with cleaning fluid and air dried before reassembling.

Further, care must be taken to adjust between case and shaft to thrust clearance of input shaft and counter shaft. Synchronizer rings are prohibited from being lapped with respective gear cones using lapping compound before they are assembled

2.4.1 Gear Shift Mechanism

The gear shifting control system consists of the following main parts (shown in figure 11). Movement of gear shift control lever is transmitted to gear shift & select shaft through gear shift and gear select cables

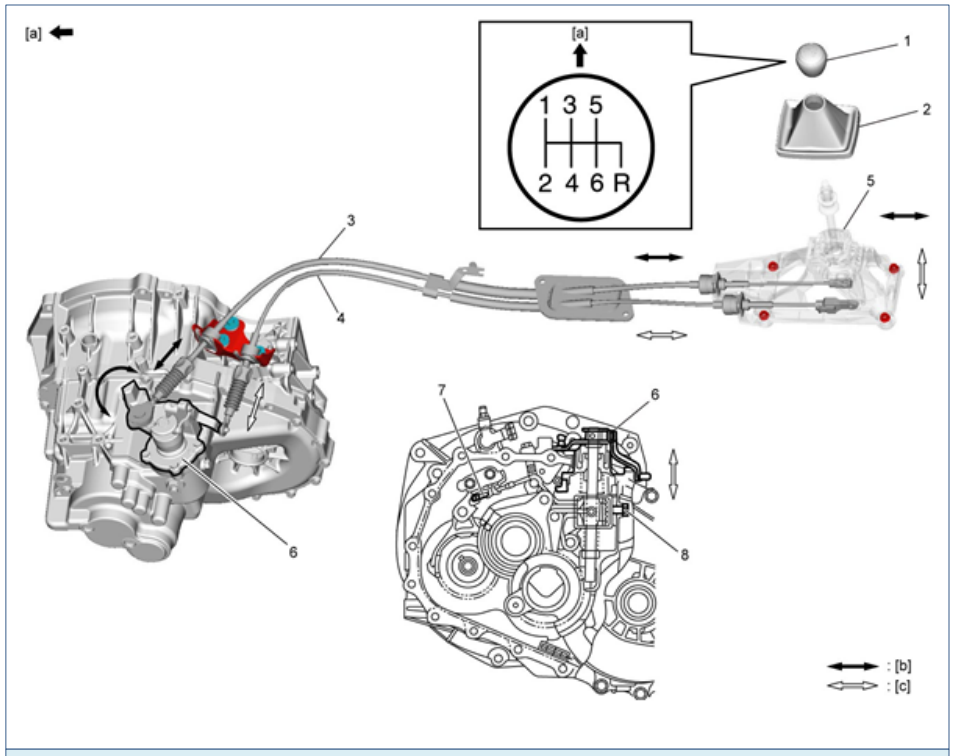
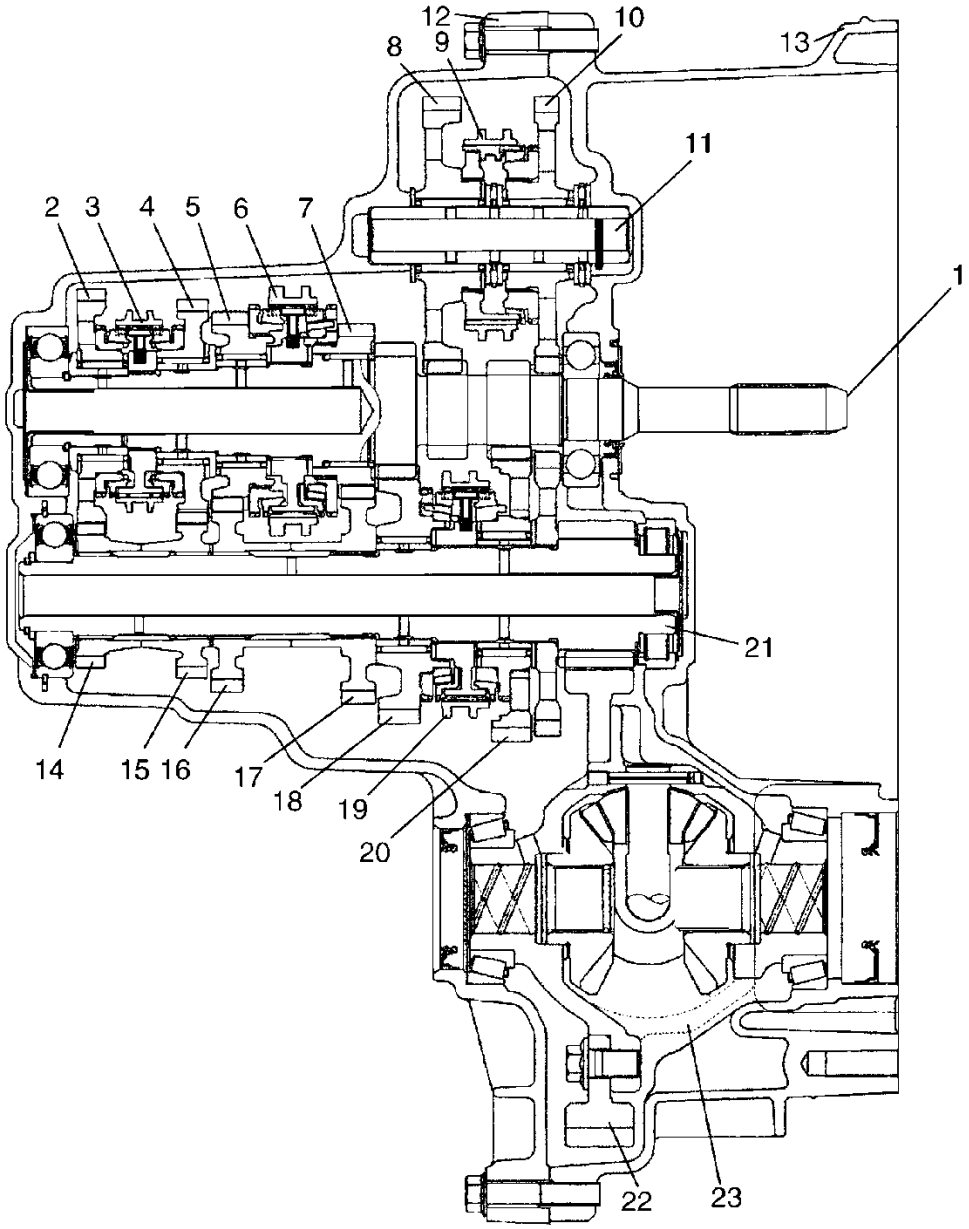


Figure 11: Gear shift mechanism – A6B424

[a] Vehicle forward
[b] Direction of gear shift
[c] Direction of gear select
[1] Gear shift control lever knob
[2] Gear shift control lever boot
[3] Gear shift control cable
[4] Gear select control lever
[5] Gear shift control lever assembly
[6] Gear shift & select shaft assembly
[7] Reverse gear shift lever
[8] Gear shift interlock bolt

2.4.2 Transaxle components



1. Input shaft
2. Input shaft 6th gear
3. 5th & 6th gear sleeve & hub
4. Input shaft 5th gear
5. Input shaft 4th gear
6. High speed sleeve & hub
7. Input shaft 3rd gear
8. Left reverse idler gear
9. Reverse gear sleeve
10. Right reverse idler gear
11. Reverse gear shaft
12. Left case
13. Right case
14. Countershaft 6th gear
15. Countershaft 5th gear
16. Countershaft 4th gear
17. Countershaft 3rd gear
18. Countershaft 2nd gear
19. Low speed sleeve & hub
20. Countershaft 1st gear
21. Countershaft
22. Final gear
23. Differential case

Lesson 3:

Overhaul

Objectives

At the end of this lesson, you will be able to:

- Explain the important points that must be considered during disassembly.
- Describe the different checks for internal transmission parts.
- Explain the important points that must be considered during transmission assembly.
- Explain the different types of possible causes for different transmission malfunctions.

3.1 Important points for disassembly

There may be various reasons for disassembling the transmission, such as abnormal noise or stiff shifting. But before performing the disassembly, you must first check for possible causes in locations other than the transmission unit.

For example, if the shift operation is stiff, if you disconnect the gear shift control cable on the transmission side and check the shift lever movement, you can judge whether or not the cause is on the transmission side. With some transmission types, actual parts can be moved to identify the cause while only one side of the case is disconnected (before disassembling the transmission). These include the condition of the gear backlash and gear meshing, the chattering of each shaft, and the smoothness of the rotation of each gear and shaft.

During disassembly, arrange the disassembled parts so that you remember to which system they belong. Be especially careful of transmission internal parts, because many of these parts have a specific assembly direction. Make sure that you remember the correct assembly method by taking notes or marking the parts.

3.2 Checks of internal transmission parts

3.2.1 Transmission case check

Check mainly for cracks and that the breather plug functions properly. If the plug is clogged, clean it.

3.2.2 Gear teeth surface check

Check the gear teeth surfaces for excessive wear or damage. If a gear is worn or damaged, replace it because it may cause abnormal noise.

3.2.3 Bearing check

Clean the ball bearings and roller bearings and then rotate them. Check that they operate smoothly and do not catch. Also check the parts equivalent to the outer race and inner race in the taper roller bearing, and replace them as a set if there are any problems.

Check the bushes for wear, streaks and cracks, and replace them as a set if there are any problems.

3.2.4 Synchromesh mechanism check

i. If the clearance is equal to or below the specified value when the synchronizer ring and its partner gear are pushed together, replace the synchronizer ring. Also, if there is major wear on the gear cone, replace as a set.

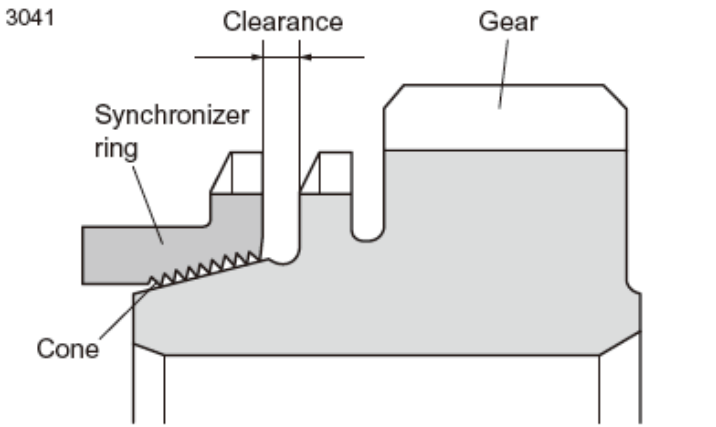


Figure 1: Synchromesh mechanism check

ii. Replace if there is significant wear on the synchronizer key protrusion. Check for wear on the synchronizer sleeve that covers the protrusion

iii. Replace if there is any breaking or attenuation on the key spring.

3.2.5 Shift lever check

Check for wear on the ball on the end of the shift lever, and replace if there are any problems.

3.2.6 Shift fork check

Measure the thickness of each shift fork claw and the width of the synchronizer sleeve groove, and replace if their values deviate from the standard.

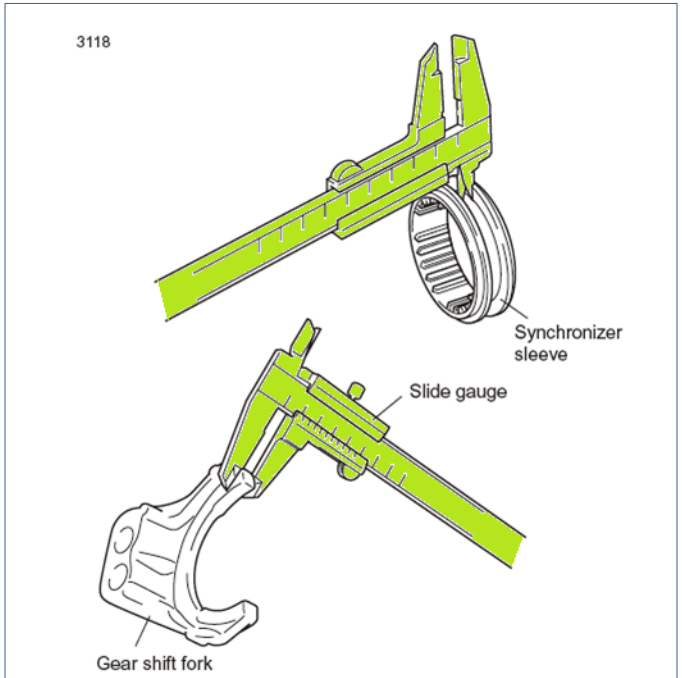


Figure 2: Shift fork check

3.2.7 Check of parts in the interlock mechanism and gear jump out prevention mechanism

Check parts such as the interlock pin, spring and locking balls, and replace if there are any problems such as damage, attenuation or wear.

3.3 Important points for assembly

The important points for assembly are to make sure that the correct parts are installed in the correct areas, in the correct direction and in the correct position. Information such as the allowance of each part before disassembly and the force required for operations must be noted down in advance. By performing this check in every stage, you can prevent maintenance mistakes, such as discovering after reassembly that the gears are too stiff to shift.

3.4 Failure diagnosis

The transmission is connected to the engine, and its rotation speed changes in proportion to the vehicle speed and together with the differential and tires. As such, if a problem occurs, the cause is not necessarily in the transmission.

When performing failure diagnosis for the transmission, first the conditions and phenomena under which the problems occur must be checked and the structure understood. The possible locations must then be narrowed down to find the cause.

3.4.1 Abnormal noise

Most of the parts inside the transmission are sliding parts, such as gears, bearings and the synchro-mechanism. If all parts in the transmission are covered by an oil film they will not wear. But if wearing occurs, chattering will occur in the sliding parts, resulting in abnormal noise.

So in general, the conditions under which the abnormal noise occurs must be identified, and the operating parts that are related to these conditions must be checked. Sometimes abnormal noise occurs only when driving with certain gears or only when shifting to certain gears above can be used to identify the problem. But if the problem occurs across all driving ranges, the cause may be in many different locations, such as the differential, wheel hub, clutch, propeller shaft and drive shaft.

3.4.2 Gear engagement and disengagement problems

Likely gear shift operation problems are (1) shift lever to gear shift control cable, and (2) shift shaft to shift fork to synchro-mechanism. When the transmission side of the gear shift control cable is disconnected and the shift lever is operated, if the movement is stiff, the problem is likely to be in system (1) above. If the movement is light, the problem is likely to be in system (2).

During normal shift operation, the driver steps on the clutch and the engine power is not transmitted to the transmission. For this reason, the same problems occur if the clutch is not fully disengaged.

3.4.3 Gear jump out

Gear jump out may occur more easily during a sudden forward movement. Gear jump out may occur because of changes in vibration or load after the gears meshed in a defective way at the moment of shifting. Or it may occur because part wearing caused a shift in the positional relationship between the synchronizer sleeve and gear. To make a final identification of the cause, the transmission must be disassembled.

To check, shift to the gear that has the problem and make sure it is properly meshed. Repeatedly perform sudden acceleration and deceleration to generate sudden forward movements, and check the gear jump out phenomenon. Also carefully check the shift feeling (operation feel, weight) while operating the shift.

3.4.4 Oil leaks

Clean the location where you suspect there is an oil leak. Perform a driving test and check the oil leak location. Be aware that breather clogging and overfilling may cause oil leaks.

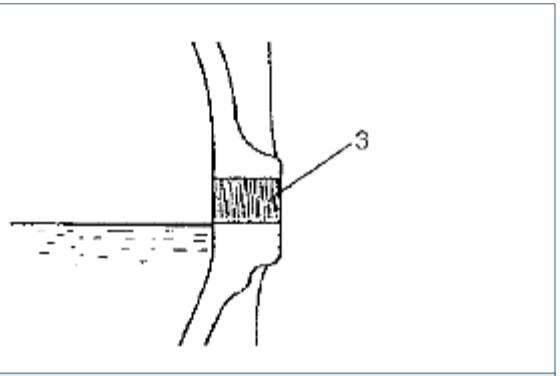


Figure 3: Oil level [3] oil filler hole

3.4.5 Manual transaxle symptom diagnosis

Condition	Possible cause
Gears slipping out of mesh	Worn shift fork shaft
	Worn shift fork or synchronizer sleeve
	Wear or damaged locating springs
	Worn bearings on input shaft or countershaft
	Worn chamfered tooth on sleeve and gear
Hard shifting	Inadequate lubricant
	Improper clutch pedal free travel
	Distorted or broken clutch disk
	Damaged clutch pressure plate
	Worn synchronizer ring
	Worn chamfered tooth on sleeve and gear
	Worn gear shift control shaft joint bushing
	Distorted shift shaft
	Broken gear shift/select control cables
Noise	Inadequate or insufficient lubricant
	Damaged or worn bearings
	Damaged or worn gears
	Damaged or worn synchronizer parts

Lesson 4:

Clutch

Objectives

At the end of this lesson, you will be able to:

- Explain the function of the clutch and its components.
- Describe the basic construction of clutch components.
- Explain the different types of clutch release mechanisms.
- Explain the function and operation of the clutch master cylinder
- Describe how the clutch pedal height inspection is performed.
- Describe how the clutch release margin can be checked.
- Describe how the cylinder push rod play can be checked.
- Describe how the vehicle and be inspected to determine if any clutch malfunction exists.
- Using clutch wear pattern, identify the possible cause of clutch failure.

4.1 Overview

Location

The clutch is positioned between the engine and the transmission.

Function

The clutch connects and disconnect the engine to the manual transmission. When engaged, the clutch transmits the engine power using the frictional force between the clutch disc and plate, and the force that pushes down these parts.

The clutch is made up of an operation mechanism, which transmits the operation force of the driver through a clutch cable or hydraulic pressure, and a clutch unit that receives this force and connects and disconnects the power transmission.

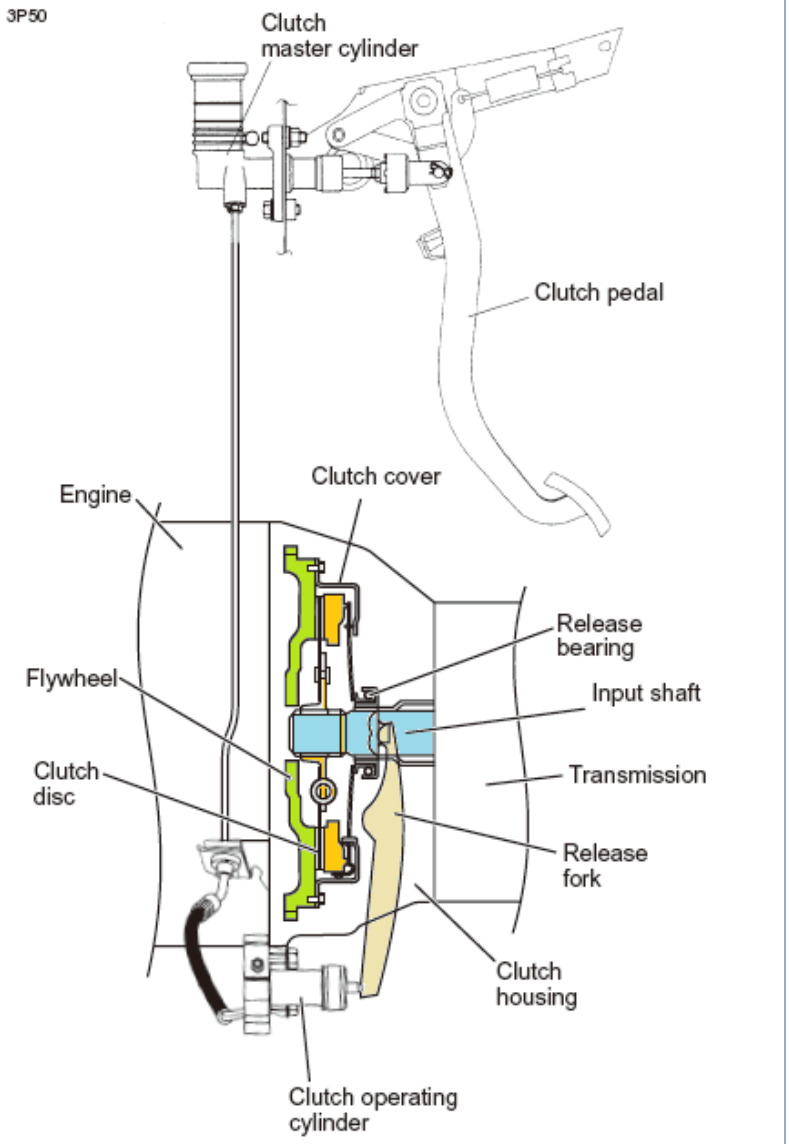


Figure 1: Clutch mechanism

4.2 Structure and operation

4.2.1 Clutch unit

4.2.1.1 Clutch unit structure

The clutch unit components include a clutch disc, clutch cover and release bearing.

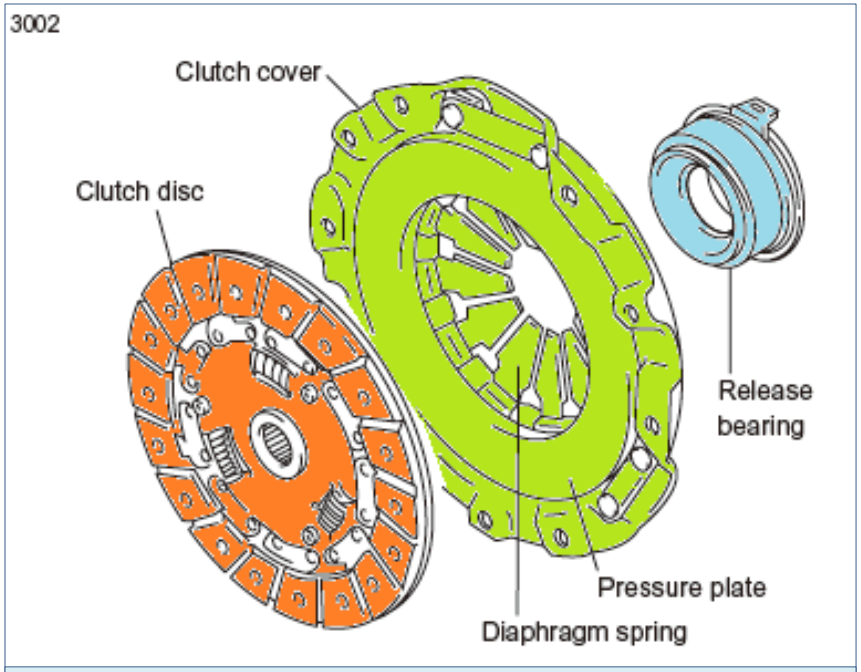


Figure2: Clutch unit components

A diaphragm spring and a pressure plate are assembled to the clutch cover. They are fixed to a flywheel with bolts. The clutch disc is installed between the flywheel and clutch cover (pressure plate), and is fitted into the transmission input shaft and splines.

The clutch disc is press fitted between the flywheel and pressure plate by the spring force of the diaphragm spring. In other words, the engine power is transmitted to the transmission input shaft via the frictional force between the clutch disc, flywheel and pressure plate.

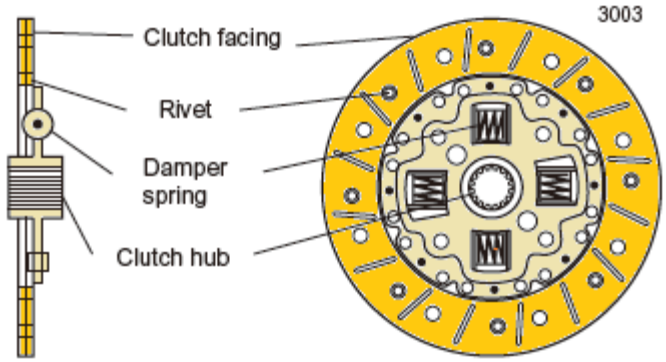
4.2.1.2 Clutch disc structure

- Clutch disc

Clutch facing, which is a frictional material, is riveted to both sides of the clutch disc. There is a clutch hub in the center of the clutch disc into which the transmission's input shaft is inserted. The clutch facing must have an appropriate friction coefficient. Its friction coefficient must not change much with temperature variations.

- Damper spring

The clutch hub is sandwiched between plates to its front and rear, and is constructed so that the clutch can move in a circle (rotation direction) via the damper spring. It absorbs and dampens the rotation impact when the clutch is connected.



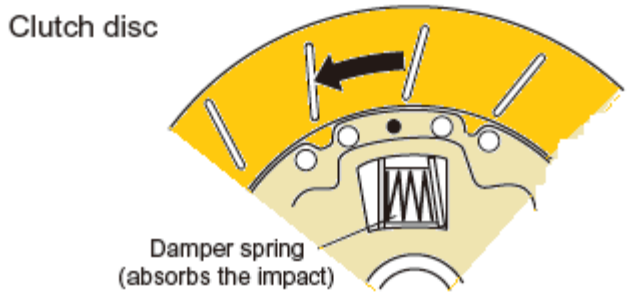
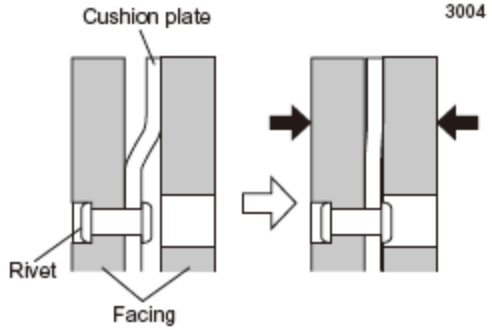


Figure 3: Clutch disc structure

Key Points

Cushion plate

The clutch facing is riveted together while sandwiching a curved cushion plate. When the clutch is connected suddenly, the bending of the cushion plate absorbs the impact, resulting in a smooth power transmission.



4.2.1.3 Diaphragm spring clutch operation

When the clutch is connected, the spring force of the diaphragm spring pushes the clutch disc strongly against the flywheel via the pressure plate. This means that the clutch plate rotates together with the flywheel so that the power from the engine is always transmitted to the transmission. When the driver steps on the clutch pedal to cut off the power, the release fork pushes the release bearing against the end of the diaphragm spring.

At this time, the pivot ring (wire ring) becomes the fulcrum and the diaphragm spring outer circumference bends back. The retracting spring (retainer plate) moves the pressure plate to the right. This creates a gap between the friction surfaces of the clutch disc, the power from the engine is cut off.

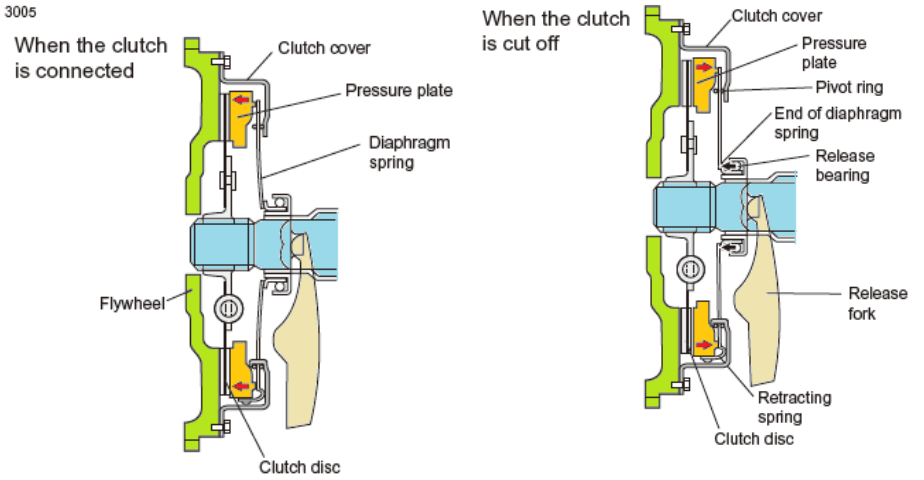


Figure 4: Clutch connection & disconnection

4.3 Clutch operation mechanism

4.3.1 Mechanical operation mechanism

In this system, the clutch pedal and release fork are connected with a clutch cable. When the driver steps on the clutch pedal (1), the clutch cable is pulled (2) (3), and the release fork pushes the release bearing onto the diaphragm spring (4).

When the driver releases the clutch pedal, the spring force of the return spring and diaphragm spring returns the release fork and clutch pedal to their home positions and power is transmitted to the transmission.

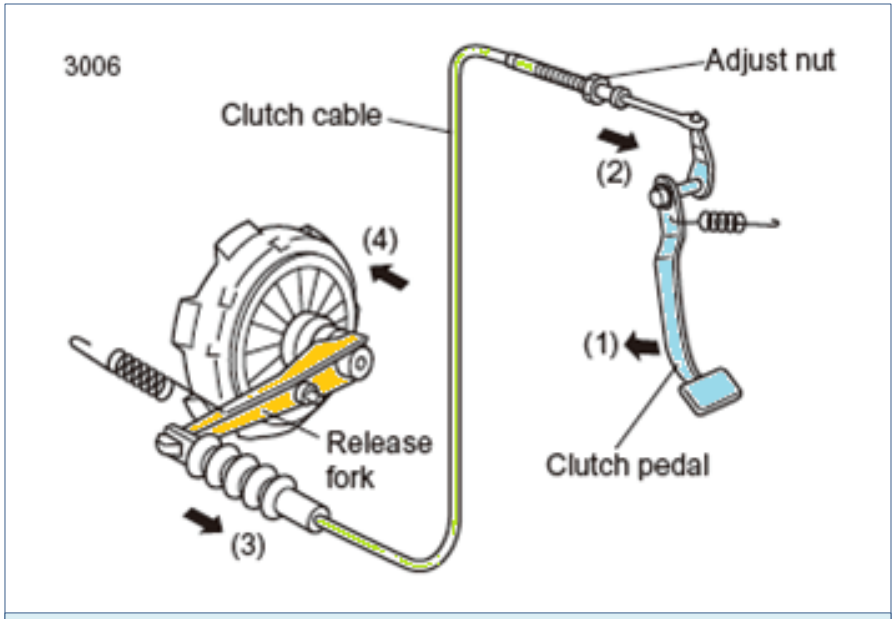


Figure 5: Mechanical clutch mechanism

4.3.2 Hydraulic operation mechanism

The components of this system include a clutch pedal, master cylinder, release cylinder, release fork and pipe. The pedal force (1) (2) is transmitted by hydraulic pressure (3) to the release fork (4).

The hydraulic operation mechanism delivers reliable operation that is light and smooth. However, it has a complex structure, and if air enters the clutch fluid, it results in improper operation in the same way as in the brake hydraulic system (becomes difficult to disengage the clutch). Attention must also be paid to the clutch fluid level.

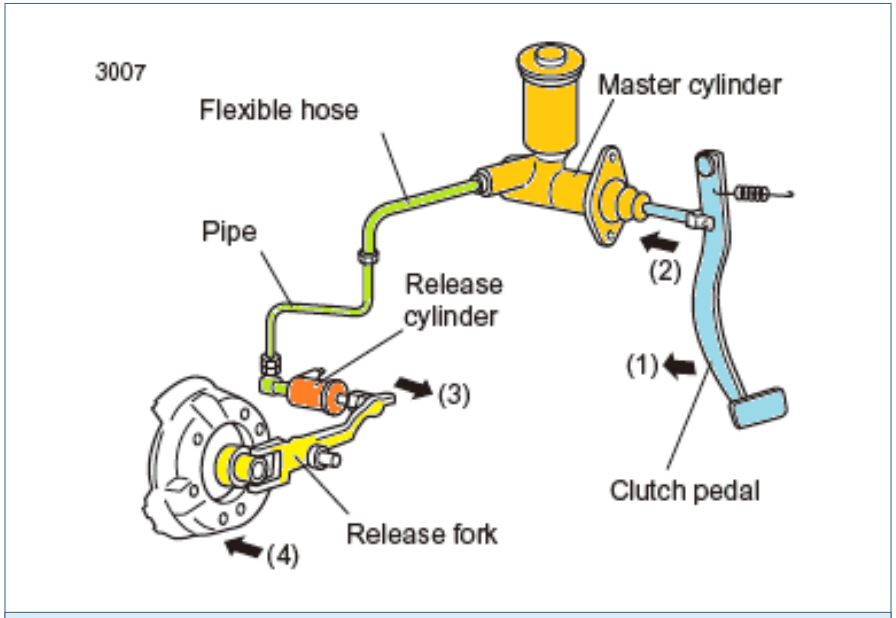


Figure 6: Hydraulic clutch mechanism

4.4 Master cylinder

The master cylinder is made up of a cylinder section in which a piston slides a long distance, and a reservoir tank that stores the clutch fluid. The master cylinder generates the hydraulic pressure for operating the clutch. To generate the hydraulic pressure, when the driver steps a little on the clutch pedal, the piston is pushed and the clutch fluid inside the cylinder is sent to the reservoir tank. When the driver steps more on the clutch pedal, the piston moves and releases the connecting rod, which up to now had been pulled by the spring retainer. The spring force of the small conical spring that is built in to the connecting rod moves the inlet valve to the left and cuts off the inlet return common port.

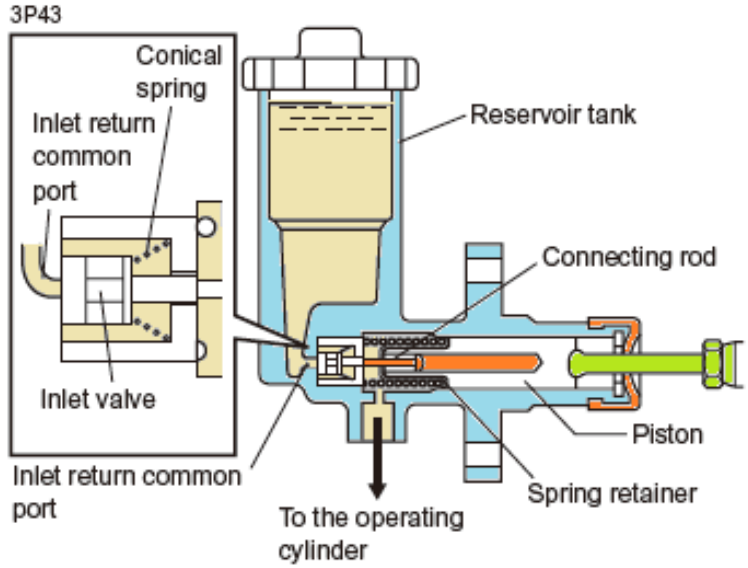


Figure 7: Master cylinder-brake pedal depressed

At the same time, the fluid pressure inside the cylinder rises rapidly. The clutch fluid is sent to the operating cylinder and moves the release piston.

When the driver releases the clutch pedal, the piston is returned by the spring force of the return spring and the hydraulic pressure drops. This makes the clutch fluid return from the operating cylinder side. Also, because the spring retainer pulls the connecting rod, the inlet valve opens the inlet return common port. This connects the reservoir tank with the master cylinder, and the master cylinder is filled with clutch fluid.

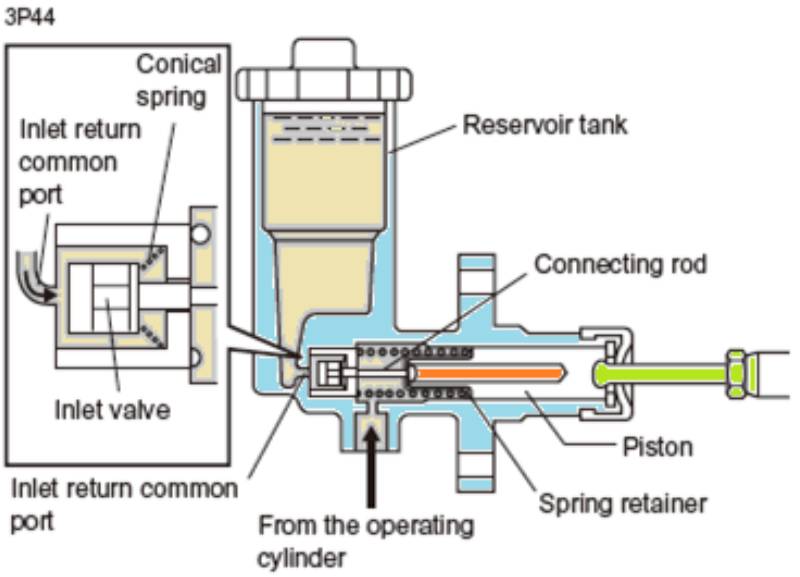


Figure 8: Master cylinder-brake pedal depressed

4.4.1 Operating cylinder

The hydraulic pressure generated by the clutch master cylinder acts on the piston. It acts as a force that moves the piston. Also, together with the tension from the piston spring, it operates the clutch via the push rod and the release fork. The bore of the operating cylinder is larger than the bore of the master cylinder, which reduces the pedal force required when operating the clutch.

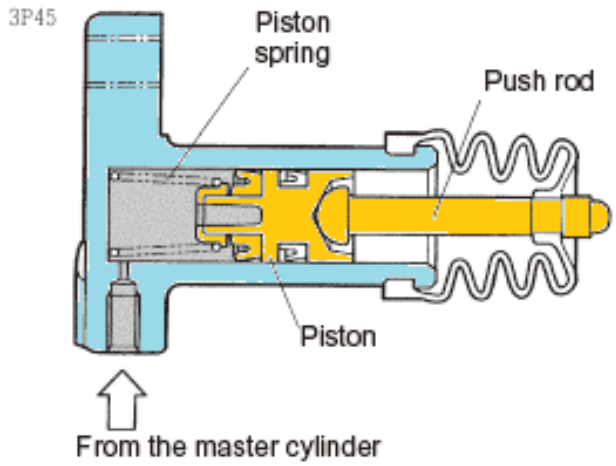
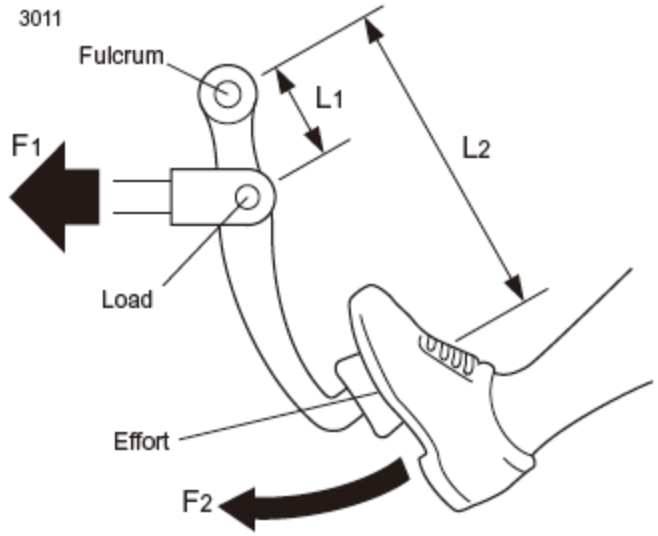


Figure 9: Clutch master cylinder

Key Points

Principle of leverage

The "principle of leverage" is the way that a small force changes to a large force depending on the distance ratio between the fulcrum, effort (point of force) and load (point of operation). This "principle of leverage" applies to the clutch pedal, release fork and diaphragm spring.



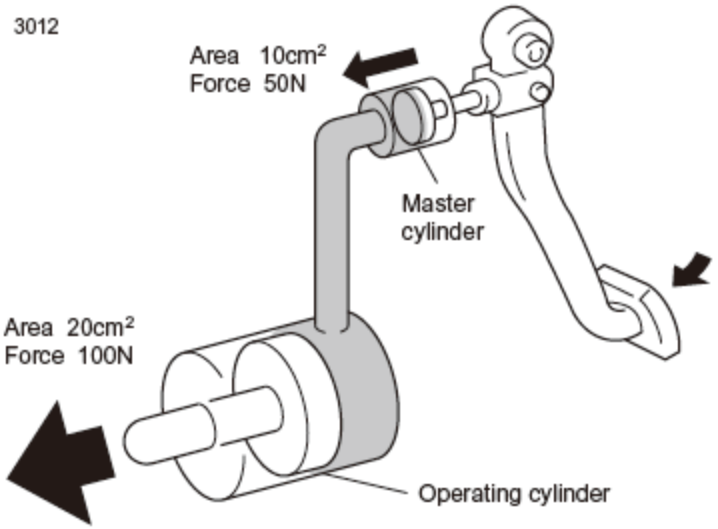
This means that the long but light movement of the clutch pedal can be used to operate the short but heavy movement of the pressure plate.

Pascal's principle

When pressure of a certain force per unit area is applied to one area of a fluid in a sealed container, regardless of its shape, the pressure is transmitted undiminished to all areas of the fluid.

When pressure is applied to a sealed fluid, force of the same strength (force per unit area) is generated in all parts.

Using this "Pascal's principle", the force is increased by making the area of the operating cylinder larger than the master cylinder.



4.5 Checks and maintenance

4.5.1 Clutch pedal inspection

(NB: AZH models used for description)

4.5.1.1 Clutch pedal height inspection

Measure distance between free position (1) and fully depressed position (2) on clutch pedal shown by "a" in figure. If clutch pedal height is out of specification, replace pedal arm and/or clutch master cylinder (3).

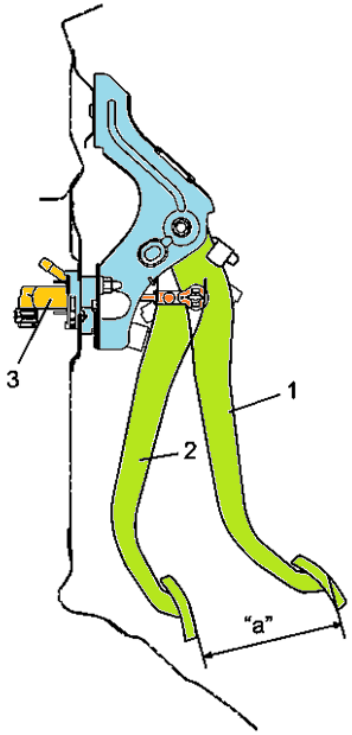


Figure 10: Clutch pedal height inspection

4.5.1.2 Cylinder push rod play

Press clutch pedal (1) gradually with finger, stop when slight increase of resistance is felt and measure how much pedal has moved (shown by “a” in figure).

If “a” is not within specification, replace master cylinder (3) or pedal arm (2).

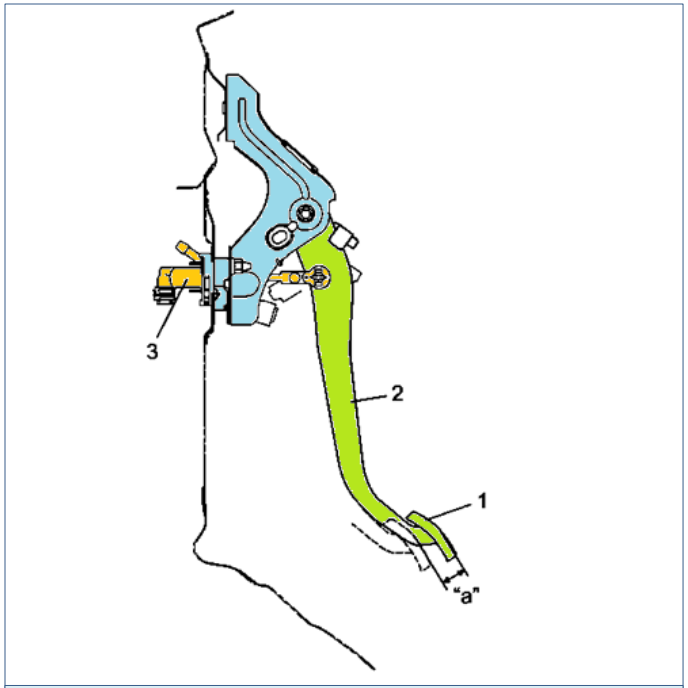


Figure 11: Cylinder push rod play

4.5.1.3 Clutch Pedal Free Travel

Depress clutch pedal (1), stop the moment clutch resistance is felt, and measure how much pedal has moved (shown by “b” in figure). If “b” is not within specification, check pedal arm (2) and master cylinder (3) and replace defective part.

4.5.1.4 Clutch Release Margin

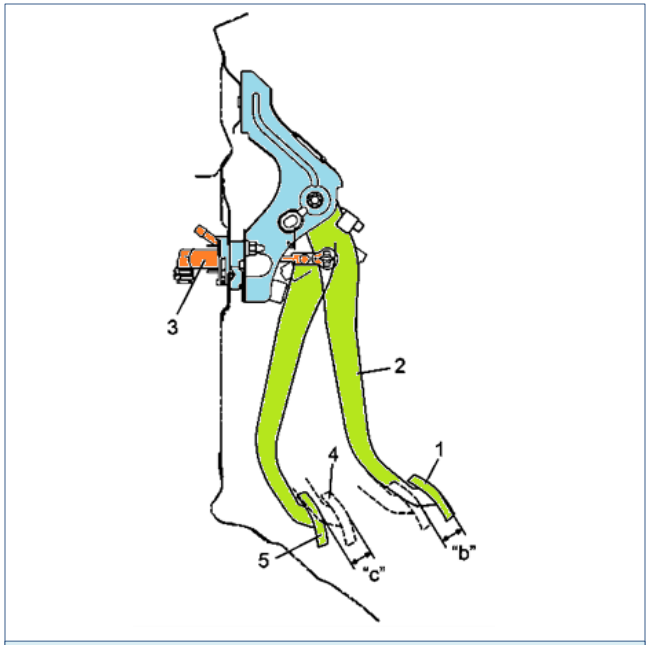


Figure 12: Clutch release margin

1) Apply parking brake fully and block wheels.
2) Start engine and keep engine at idle in neutral position.
3) Without clutch pedal (1) depressed, slightly push the shift lever to reverse position until transaxle emits gear contact noise. Do not shift the lever to reverse position.
4) While listening to gear contact noise, slowly depress clutch pedal (1) and stop it when gear contact noise died (release point).

5) Measure distance between release point (4) and full stroke point (5) on clutch pedal (1) shown by “c” in the figure.
If “c” is not within specification, air may be trapped in clutch system. Bleed air from clutch system.
Upon completion of above inspection, start engine and check clutch for proper operation.

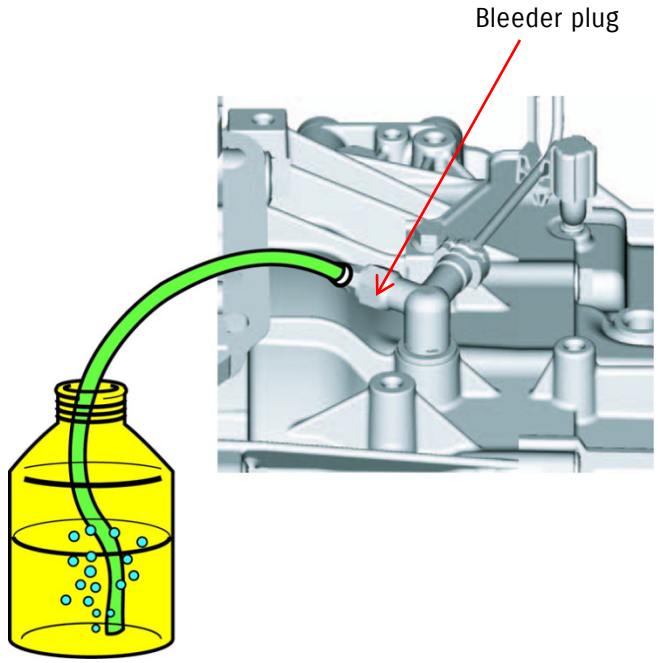
4.5.2.5 Air bleeding of clutch system

CAUTION:

- Brake fluid (Clutch fluid) is extremely damaging to paint. If fluid should accidentally touch painted surface, immediately wipe fluid from paint and clean painted surface.
- When operating the clutch pedal for air bleeding, after releasing the clutch pedal, be sure to wait 1 second or more before depressing it again. Otherwise, the oil seal of operating cylinder will be damaged, resulting in oil leakage.

Perform in the same way as air bleeding for the brake hydraulic system, but also pay attention to the following.

- During the air bleeding operation, make sure that the fluid level does not drop to half or less.
- After bleeding the air, tighten the bleeder plug to the specified torque.



4.6 Failure diagnosis

4.6.1 Engagement defect

To check for engagement defect, first put the transmission into the 1st gear while stepping on the clutch pedal. Next, put the transmission into the neutral position, step on the accelerator pedal to raise the engine rotation speed, and then return the transmission to the 1st gear. At this time, continue stepping down on the clutch pedal. If an abnormal noise (gear noise) occurs during the above operations, you can diagnose the problem as engagement defect. In the engagement defect check, you must determine whether the engagement defect occurs because the movement distance of the pressure plate is too short, or whether the engagement defect is caused by a clutch unit problem where the clutch disc cannot separate from the flywheel and pressure plate.

4.6.2 Slipping

If slipping occurs between the clutch disc and pressure plate, it may impair the transmission of power from the engine to the transmission and cause acceleration problems. For this reason, be careful during diagnosis because this problem is easy to mistake for an engine failure. Check carefully whether the origin of the problem is in the operation mechanism or the clutch unit.

Before performing the check, pull up the parking brake, place wheel blocks around the tires and fully stop the vehicle.

Then, step on the clutch pedal, put the transmission into the 4th gear, and slowly connect the clutch while slowly raising the engine rotation speed. If the engine stops at this time, the clutch is in a good condition. But if the engine does not stop and the vehicle does not move forward, you can conclude that the clutch is slipping.

4.6.3 Unsmooth engagement

Check carefully whether the cause is insufficient smoothness in the operation mechanism, or uneven transmission torque caused by a defect in the clutch unit. Check carefully because this may also cause the engine output to drop or other problems.

To perform the check, start the engine, step on the clutch pedal, put the transmission into the 1st gear and slowly connect the clutch. If there is no uncomfortable vibration at this time, you can conclude that the clutch unit is in a good condition.

4.6.4 Sudden forward movement (jumping out)

Sudden forward movement is a symptom where the vehicle does not start off smoothly. The vehicle may jump forward automatically when the clutch pedal is operated, or the engine may feel like it will stop.

Check carefully whether the cause of the sudden forward movement is insufficient smoothness in the operation mechanism, or uneven transmission torque caused by a defect in the clutch unit.

To perform the check, start the engine, put the transmission into the 1st gear or reverse and slowly connect the clutch. If the vehicle does not start off suddenly, you can conclude that the clutch unit is in a good condition.

4.6.5 Abnormal noise

Continuous abnormal noise may be caused by defects in the pilot bearing, release bearing or input bearing, or in bearings inside the transmission.

While the vehicle is stopped and the engine is operating, if the abnormal noise stops when you step on the clutch pedal, the defect is probably in a bearing inside the transmission. If the abnormal noise does not stop at this time, the defect is probably in the release bearing or the pilot bearing.

Sometimes, a temporary abnormal noise is made during acceleration or deceleration while the clutch is engaged. In such cases, depending on the noise type and the conditions under which it occurs, you must check not only the clutch and transmission, but also parts such as the engine mount and drive belt.

Summary

- The clutch is used to connect and disconnect the engine from the manual transmission
- The clutch disc consists of a splined hub and a round metal plate covered with friction material.
- The release bearing is usually a ball bearing and collar assembly that reduces friction between the pressure plate levers and the clutch fork.
- A clutch release mechanism allows the driver to disconnect the clutch from the engine.
- The release mechanism can use either a cable or hydraulic pressure.
- A worn clutch disc will cause clutch slippage and sometimes damage the flywheel.
- A bad pressure plate can also cause clutch slippage and clutch release problems.
- A worn pilot bearing will allow the transmission input shaft and clutch disc to wobble up and down. This can cause clutch vibration, abnormal noises and damage to the transmission.
- Clutch slippage causes the engine to race (engine speed increases quickly) without an increase in the vehicle's road speed.

The following abbreviations can be used in this training manual

A

A/B	Air Bag
ABDC	After Bottom Dead Center
ABS	Anti-lock Brake System
AC	Alternating Current
A/C	Air Conditioning
A-ELR	Automatic-Emergency Locking Retractor
A/F	Air Fuel Ratio
ALR	Automatic Locking Retractor
API	American Petroleum Institute
APP	Accelerator Pedal Position
A/T	Automatic Transmission, Automatic Transaxle
ATDC	After Top Dead Center
ATF	Automatic Transmission Fluid, Automatic Transaxle Fluid
AWD	All Wheel Drive
API	American Petroleum Industry

B

BARO	Barometric Pressure
BBDC	Before Bottom Dead Center
BCM	Body electrical Control Module
BTDC	Before Top Dead Center
B+	Battery Positive Voltage
BB+	Battery Positive Voltage for Backup

C

CAN	Controller Area Network
CKP	Crankshaft Position
CMP	Camshaft Position
CO	Carbon Monoxide
CO2	Carbon Dioxide
CPP	Clutch Pedal Position
CPU	Central Processing Unit
CVT	Continuously Variable Transmission, Continuously Variable Transaxle

D

DC	Direct Current
D/C	Driving Cycle
DLC	Data Link Connector
DOHC	Double Over Head Camshaft
DOJ	Double Offset Joint
DOT	Department of Transportation
DPF®	Diesel Particulate Filter
DRL	Daytime Running Light
DTC	Diagnostic Trouble Code (Diagnostic Code)
D/C	Driving Cycle

E

EBD	Electronic Brake Force Distribution
ECM	Engine Control Module
ECT	Engine Coolant Temperature
ECU	Electronic Control Unit
EEPROM	Electrically Erasable Programmable Read Only Memory
EFE Heater	Early Fuel Evaporation Heater
EGR	Exhaust Gas Recirculation
EGT	Exhaust Gas Temperature
ELR	Emergency Locking Retractor
ENG A-Stop	Engine Auto Stop Start
EPS	Electronic Power Steering
ESP®	Electronic Stability Program
EVAP	Evaporative Emission

G

GND	Ground
GPS	Global Positioning System
GL	Gear libricant

H

HVAC	Heating, Ventilating and Air Conditioning
HC	Hydrocarbons
HFC	Hydro Fluorocarbon
HI	High
HO2S	Heated Oxygen Sensor

I

IAC	Idle Air Control
IAT	Intake Air Temperature
IMT	Intake Manifold Tuning
ISC	Idle Speed Control
ISO	International Organization for Standardization

J

JIS	Japanese Industrial Standards
J/B	Junction Block
J/C	Junction Connector

L

L	Left
LCD	Liquid Crystal Display LED Light Emitting Diode
LHD	Left Hand Drive vehicle
LIN	Local Interconnect Network
LO	Low
LSPV	Load Sensing Proportioning Valve

M

MAF	Mass Air Flow
MAP	Manifold Absolute Pressure
Max	Maximum
MFI	Multiport Fuel Injection
Min	Minimum
MIL	Malfunction Indicator Lamp (“CHECK ENGINE” Light or “SERVICE ENGINE SOON” Light)
M/T	Manual Transmission, Manual Transaxle

N

NOx	Nitrogen Oxides

O

OBD	On-Board Diagnostic system
OCM	Occupant Classification Module
OCV	Oil Control Valve
O/D	Overdrive
OHC	Over Head Camshaft
O2S	Oxygen Sensor

P

PCM	Powertrain Control Module
PCV	Positive Crankcase Ventilation
PM	Particulate Mater
PNP	Park / Neutral Position
P/S	Power Steering
PSP	Power Steering Pressure

R

R	Right
RAM	Random Access Memory
RHD	Right Hand Drive Vehicle
ROM	Read Only Memory
RPM	Engine Speed

S

SAE	Society of Automotive Engineers
SDM	Sensing and Diagnostic Module (Air Bag Controller, Air bag Control Module)
SDT	Smart Diagnostic Tester
SFI	Sequential Multiport Fuel Injection
SI	System International
SOHC	Single Over Head Camshaft
SRS	Supplemental Restraint System

T

TCC	Torque Converter Clutch
TCM	Transmission Control Module
TCSS	Traction Control Support System
TDC	Top Dead Center
TP	Throttle Position
TPMS	Tire Pressure Monitoring System
TWC	Three-Way Catalytic converter

U

UART	Universal Asynchronous Receiver / Transmitter
USB	Universal Serial Bus

V

VFD	Vacuum Fluorescent Display
VIN	Vehicle Identification Number
VSS	Vehicle Speed Sensor
VVT	Variable Valve Timing

W

WU-OC	Warm Up Oxidation Catalytic converter
WU-TWC	Warm Up Three-Way Catalytic converter

Other

2WD	2-Wheel Drive
4WD	4-Wheel Drive

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