Direct Shift Gear Transmission

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ABSTRACT

The Direct Shift Gear Transmission (DSG) also known as Dual Clutch Transmission(DCT) or twin-clutch transmission, is an automated transmission that can change gears faster than any other geared transmission. Dual clutch transmissions deliver more power and better control than a traditional automatic transmission and faster performance than a manual transmission.Modern DSG automatic gearboxes use a pair of clutches in place of a single unit to help you change gear faster than a traditional manual or automatic alternative. Cars with DSG gearboxes don't feature a clutch pedal and are controlled in exactly the same way as a conventional automatic. Direct Shift Gear transmission (DSG) also called as Dual Clutch Transmissions (DCTs) are providing the full shift comfort of traditional step automatics but offer significantly improved full efficiency and performance. Fuel efficiency increased by 15% compared to planetary-ATs, the DCTs are the first automatics to provide better values than manual transmissions. Higher top speed and, more important in everyday driving, better acceleration compared to planetary-ATs and CVTs are additional benefits.

Keywords: ***Dual Clutch, inner shaft, outer shaft, mechatronics system.***

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1. INTRODUCTION

Most people know that cars come with two basic transmission types: manuals, which require that the driver change gears by depressing a clutch pedal and using a stick shift, and automatics, which do all of the shifting work for drivers using clutches, a torque converter and sets of planetary gears.But there's also something in between that offers the best of both worlds -- the dual-clutch transmission, also called the semi-automatic transmission, the automated manual transmission. Despite the incredible development and investment costs required to launch a new automatic transmission, it is the unit in the powertrain that has gone through the most design innovations in recent years. An important aim was to significantly reduce fuel consumption in automatic vehicles.

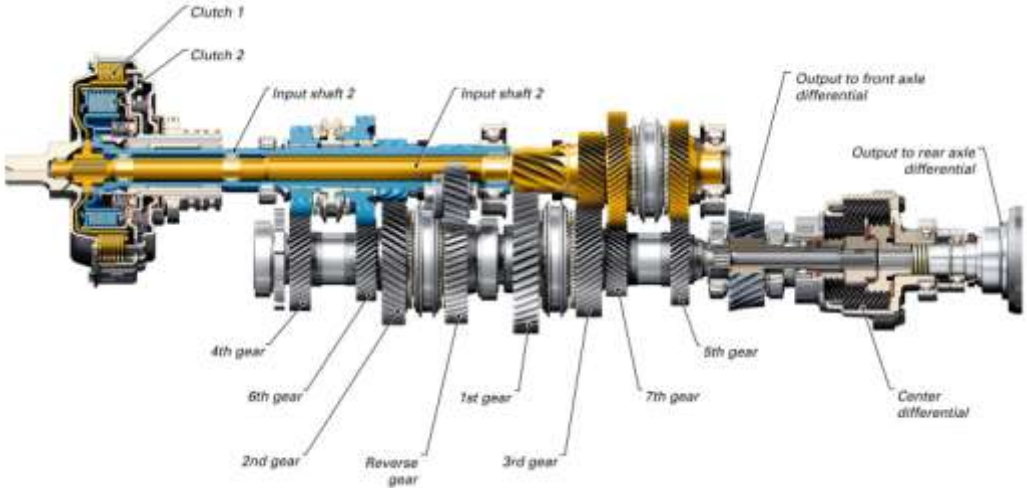

Fig-1:DSG Transmission

2. WORKING OF DSG TRANSMISSION

The internal combustion engine drives two clutch packs. The outer clutch pack drives gears 1, 3, 5 and 7— the outer clutch pack has a larger diameter compared to the inner clutch, and can therefore handle greater torque loadings. The inner clutch pack drives gears 2, 4, and 6 and reverse. Due to space constraints, the two clutch assemblies are concentric, and the shafts within the gearbox

are hollow and also concentric. Because the alternate clutch pack's gear-sets can be pre-selected (predictive shifts enabled via the unloaded section of the gearbox), un-powered time while shifting is avoided because the transmission of torque is simply switched from one clutch-pack to the other.
When we start the vehicle, the 1st gear on the inner shaft and reverse gear on the outer shaft is selected. The gear between 1 and reverse is selected based on whether we put vehicle in drive mode or reverse mode. In DCT transmission a mechatronics system is used to preselect the next gear according to our driving condition. If the vehicle is on 4th gear and is accelerated, the mechatronics system selects 5th gear and if the vehicle is decelerated, the mechatronics system selects 3rd gear. In this way the mechatronics system helps to preselect the gear and gives the working of automatic transmission with benefits of manual transmission.

2.1DSG Controls

The direct-shift gearbox uses a floor-mounted transmission shift lever, very similar to that of a conventional automatic transmission. The lever is operated in a straight before and after plane, and uses an additional button to help prevent an inadvertent selection of an inappropriate shift lever position.

P mode
P position of the floor-mounted gear shift lever means that the transmission is set in parking. Both clutch packs are disengaged, all gear-sets are disengaged, and a solid mechanical transmission lock is applied to the crown wheel of the DSG's internal differential. This position must only be used when the motor vehicle is stationary (parking). Before removing the ignition key, this is the position of shift lever must be set.

N mode
N position of the floor-mounted shift lever means that the transmission is in neutral. Similar to **P** above, both clutch packs and all gear-sets are disengaged, the parking lock is also disengaged.

D mode
When the motor vehicle is stationary and in neutral (**N**), the driver can select **D** for drive (after pressing the foot Brake Pedal)

Fig-2:Stick of DSG Transmission

The transmission's 1st gear is selected on the first shaft, and the outer clutch K1 engages at the start of the bite point. At the same time, on the alternate gear shaft, the reverse gear clutch K2 is also selected (pre-selected), as the gearbox doesn't know whether the driver wants to go forward or reverse. The clutch pack for 1st gear (K1) gets ready to engage. When the driver releases the brake pedal, the K1 clutch pack increases the clamping force, allowing the 1stgear to take up the drive through an increase of the bite point, and thereby transferring the torque from the engine through the transmission to the drive shafts and road wheels, causing the vehicle to move forward. As the vehicle accelerates, the transmission's computer determines when the second gear (which is connected to the second clutch) should be fully used. Depending on the vehicle speed and amount of engine power being requested by the driver (determined by the position of the throttle pedal), the DSG then up-shifts. During this sequence, the DSG disengages the first outer clutch whilst simultaneously engaging the second inner clutch (all power from the engine is now going through the second shaft), thus completing the shift sequence. This sequence happens in 8 milliseconds (aided by pre-selection), and can happen even with full throttle opening, and as a result, there is virtually no power loss.

Once the vehicle has completed the shift to second gear, the first gear is immediately de-selected, and third gear (being on the same shaft as 1st to 7th) is pre-selected, and is pending. Once the time comes to shift into 3rd, the second clutch disengages and the first clutch re-engages. This method of operation continues in the same manner for the remaining forward gears.
Downshifting is similar to up-shifting but in reverse order, and is slower, at 600 milliseconds, due to the engine's Electronic Control Unit, or ECU, needing to 'blip' the throttle so that the engine crankshaft speed can match the appropriate gear shaft speed. The car's computer senses the car slowing down, or more power required (during acceleration), and thus engages a lower gear on the shaft not in use, and then completes the downshift.
The actual shift points are determined by the DSG's transmission ECU, which commands a hydro-mechanical unit. The transmission ECU, which combines with the hydro-mechanical unit, are collectively called a mechatronics unit or module. Because the DSG's ECU uses fuzzy logic, the operation of the DSG is said to be adaptive that is, the DSG will "learn" how the user drives the car, and will progressively tailor the shift points accordingly to suit the habits of the driver.
Under "normal", progressive and linear acceleration and deceleration, the DSG shifts in a sequential manner; i.e., under acceleration: 1st- 2nd -3rd -4th -5th -6th-7th, and the same sequence reversed for deceleration. However, the DSG can also skip the normal sequential method, by missing gears, and shift two or more gears. This is most apparent if the car is being driven at sedate speeds in one of the higher gears with a light throttle opening, and the accelerator pedal is then pressed down, engaging the kick-down function. During kick-down, the DSG will skip gears, shifting directly to the most appropriate gear depending on speed and throttle opening. This kick-down may be engaged by any increased accelerator pedal opening, and is completely independent of the additional resistance to be found when the pedal is pressed fully to the floor, which will activate a similar kick-down function when in Manual operation mode. The seven-speed unit will not automatically shift to 6th gear; rather, it stays at 5th to keep power available at a high RPM while cruising.
When the floor-mounted gear selector lever is in position **D**, the DSG works in fully automatic mode, with importance placed on gear shifts programmed to deliver maximum fuel economy. That means that shifts will change up and down very early in the rev-range

S mode
The floor selector lever also has an **S** position. When **S** is selected, sport mode is activated in the DSG. Sport mode functions as a fully automatic mode,identical in operation to **D** mode, but upshifts and downshifts are made much higher up the engine rev-range. This aids a sportier driving manner, by utilising considerably more of the available engine power, and also making the most of engine braking. However, this mode does have a negative effect on the vehicle fuel consumption, when compared to **D** mode. This mode may not be ideal to use when wanting to drive in a sedate manner; nor when road conditions are very slippery, due to ice, snow or torrential rain — because loss of tire traction may be experienced. On 4motion or Quattro-equipped vehicles this may be partially offset by the drivetrain maintaining full-time engagement of the rear differential in S mode, so power distribution under loss of front-wheel traction may be improved.

Manual mode
Additionally, the floor shift lever also has another plane of operation, for **manual** mode, with spring-loaded + and − positions. This plane is selected by moving the stick away from the driver (in vehicles with the driver's seat on the right, the lever is pushed to the left, and in left-hand drive cars, the stick is pushed to the right) when in **D** mode only. When this plane is selected, the DSG can now be controlled like a manual gearbox, albeit only under a sequential shift pattern.
In most (VW) applications, the readout in the instrument display changes to **76 5 4 3 2 1**, and just like the automatic modes, the currently used gear ratio is highlighted or emboldened. In other versions the display shows just **M** followed by the gear currently selected; e.g., **M1**, **M2**, etc.
To change up a gear, the lever is pushed forward (against a spring pressure) towards the +, and to change down, the lever is pulled rearward towards the −. The DSG transmission can now be operated with the gear changes being (primarily) determined by the driver. This method of operation is commonly called tiptronic In the interests of engine preservation, when accelerating in Manual/tiptronic mode, the DSG will still automatically change up just before the redline, and when decelerating, it will change down automatically at very low revs, just before the engine idle speed (tick over). Furthermore, if the driver calls for a gear when it is not appropriate (e.g., requesting a downshift when engine speed is near the redline) the DSG will not change to the driver's requested gear.
Current variants of the DSG will still downshift to the lowest possible gear ratio when the kick-down button is activated during full throttle whilst in manual mode. In Manual mode this kick-down is only activated by an additional button at the bottom of the accelerator pedal travel; unless this is pressed the DSG will not downshift, and will simply perform a full-throttle acceleration in whatever gear was previously being utilised.

Paddle Shifters
These operate in an identical manner as the floor mounted shift lever when it is placed across the gate in manual mode. The paddle shifters have two distinct advantages: the driver can safely keep both hands on the steering wheel when using the Manual/tiptronic mode; and the driver can temporarily manually override either of the automatic programmes (**D** or **S**), and gain instant manual control of the DSG transmission.

If the paddle-shift activated manual override of one of the automatic modes (**D** or **S**) is used intermittently the DSG transmission will default back to the previously selected automatic mode after a predetermined duration of inactivity of the paddles, or when the vehicle becomes stationary. Alternatively, should the driver wish to immediately revert to fully automatic control, this can be done by activating and holding the + paddle for at least two seconds.

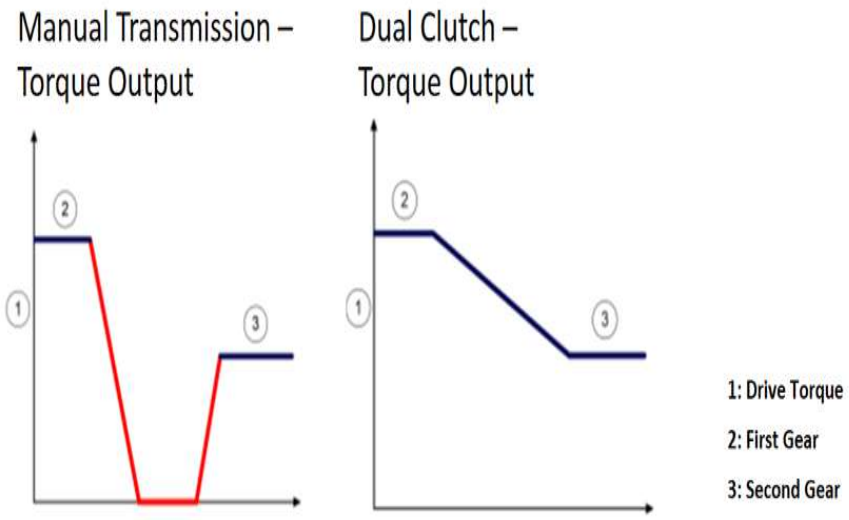

Fig-3: Graph of Manual Transmission vs. DSG Transmission Torque output

3. CONCLUSION

1. Better fuel economy (up to 15% improvement) than conventional planetary geared automatic transmission (due to lower parasitic losses from oil churning) and for some models with manual transmissions.
2. No loss of torque transmission from the engine to the driving wheels during gear shifts.
3. Short up-shift time of 8 milliseconds when shifting to a gear the alternate gear shaft has preselected.
4. Smooth gear-shift operations.
5. Comfortable driving.
6. Marginally worse overall mechanical efficiency compared to a conventional manual transmission, especially on wet-clutch variants (due to electronics and hydraulic systems).
7. Expensive specialist transmission fluids/lubricants with dedicated additives are required, which need regular changes.
8. Relatively expensive to manufacture, and therefore increases new vehicle purchase price.
9. Relatively lengthy shift time when shifting to a gear ratio which the transmission control unit did not anticipate (around 1100 ms, depending on the situation).
10. Torque handling capability constraints perceive a limit on after-market engine tuning modifications (though many tuners and users have now greatly exceeded the official torque limits.) Later variants have been fitted to more powerful cars, such as the 300 bhp/350 Nm VW R36 and the 272 bhp/350 Nm Audi TTS.
11. Heavier than a comparable conventional manual transmission.
12. While the first generation DSG fuel economy was up to 15% worse than a manual, the second generation DSG (current) gets the same fuel economy as the manual transmission.

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