

AT or DCT? MCT – The best of both worlds!

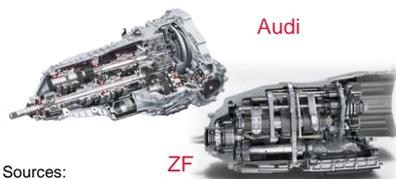
Multi-clutch transmission with more than two disc clutches and synchronized dog clutches

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AT vs. DCT

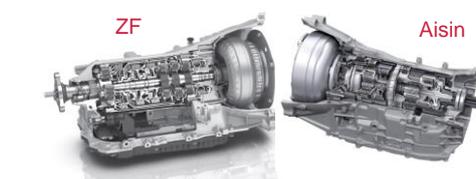
Automatic transmissions (AT) generally consist of a start-up element, multiple planetary gear stages and Load Shift Elements (LSE). All gears are power shifted. An advantage of this design is the high power density, mainly due to the multiple use of planetary gear stages and their internal power split.

Dual-clutch transmissions, also known as double-clutch transmissions (DCT), normally consist of two multi-disc friction clutches which are actuated alternately to switch gears. Synchronized dog clutches set up the power flow of the next gear parallel to that of the actual gear. The different gears are represented by cylindrical gear pairs with different ratios. The specific advantages are listed up in the following figure.



Sources:

<http://www.porsche.com/germany/models/panamera/panamera/drive-chassis/porsche-doppelkupplung-pdk/>



<https://www.auto-medienportal.net/artikel/detail/30776>

Main advantages of DCT

- High shift dynamic due to optimized controlling and cooling for only 2 Load Shift Elements (LSE)
- High efficiency
- Max. 1 open LSE, if kinematical under-determined no open LSE (drag torque)
- 1 closed LSE (actuating power)
- Speed resistant (usually no planetaries)

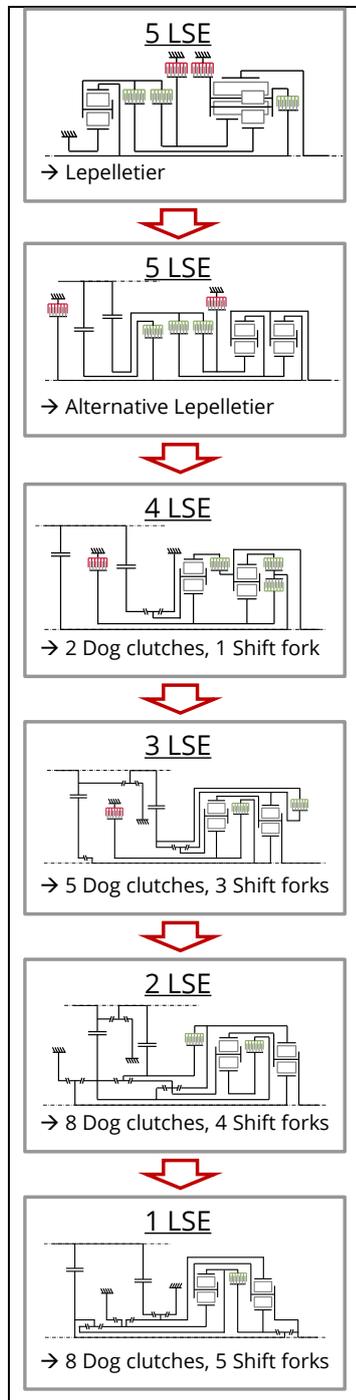
Main advantages of AT

- High power density
- Planetary stages with multiple use in more than 1 gear
- Power distributing planetary gears
- High comfort
- Mostly combined with hydrodynamic clutch (torque converter)
- No noise during shifting due to friction clutches

PlanGear – Gear Synthesis Program

The synthesis program „PlanGear“, developed by ZG GmbH, is now able to generate mixed forms of automatic and dual-clutch transmissions, so called multi-clutch transmissions (“MCT”). PlanGear is able to generate topologies of MCT that may consist of planetary gears (also complex compound planetaries), cylindrical gears, any number of disc clutches and

brakes, and any number of synchronized dog clutches. Any hybridization can be considered directly in the synthesis process. Although the transmission contains a certain number of dog clutches, PlanGear is able to check for power shiftable e-gears while having standstill of the ICE.



Example of generating MCT

The aim of MCT is the combination of the specific advantages of AT and DCT. The presentation explains the derivation of MCT by an example based on a 6-speed Lepelletier topology. Coming from an inline orientation of the Lepelletier gear set the orientation is at first changed into a structure with two cylindrical stages and 2 standard planetary gear sets. The gear ratios are kept identical.

In separate steps derivatives of MCT are determined with a consequently reduced number of load shift elements (LSE) that leads to an increasing amount of synchronized dog clutches. Their reachability with shift forks is checked via graph theory.

The necessary shifts of dog clutches are analyzed in the preselection phase for the power flow of the consecutive gears. The functionality of the resulting structures is compared regarding:

- Shift matrix and power shiftability
- Efficiency and speed dependent drag losses in open LSE
- Complexity (number of LSE, dog clutches, shift forks, ...)

MCT with only 1 LSE

It is remarkable that it is possible to realize sequential power shifts with only one single LSE. By loading the LSE the dog clutch to be opened will get unloaded. After speed synchronization the power flow over the LSE is switched without changing the ratio in order to prepare the LSE for the power shift of the next gear change.

Hybridization of MCT

A hybrid example is examined to show some of PlanGear's functionalities regarding two power inputs. Based on the MCT structure with 3 LSE an additional electric motor is integrated. Three additional gears for pure electric driving are generated without changing the number and type of load shift elements.