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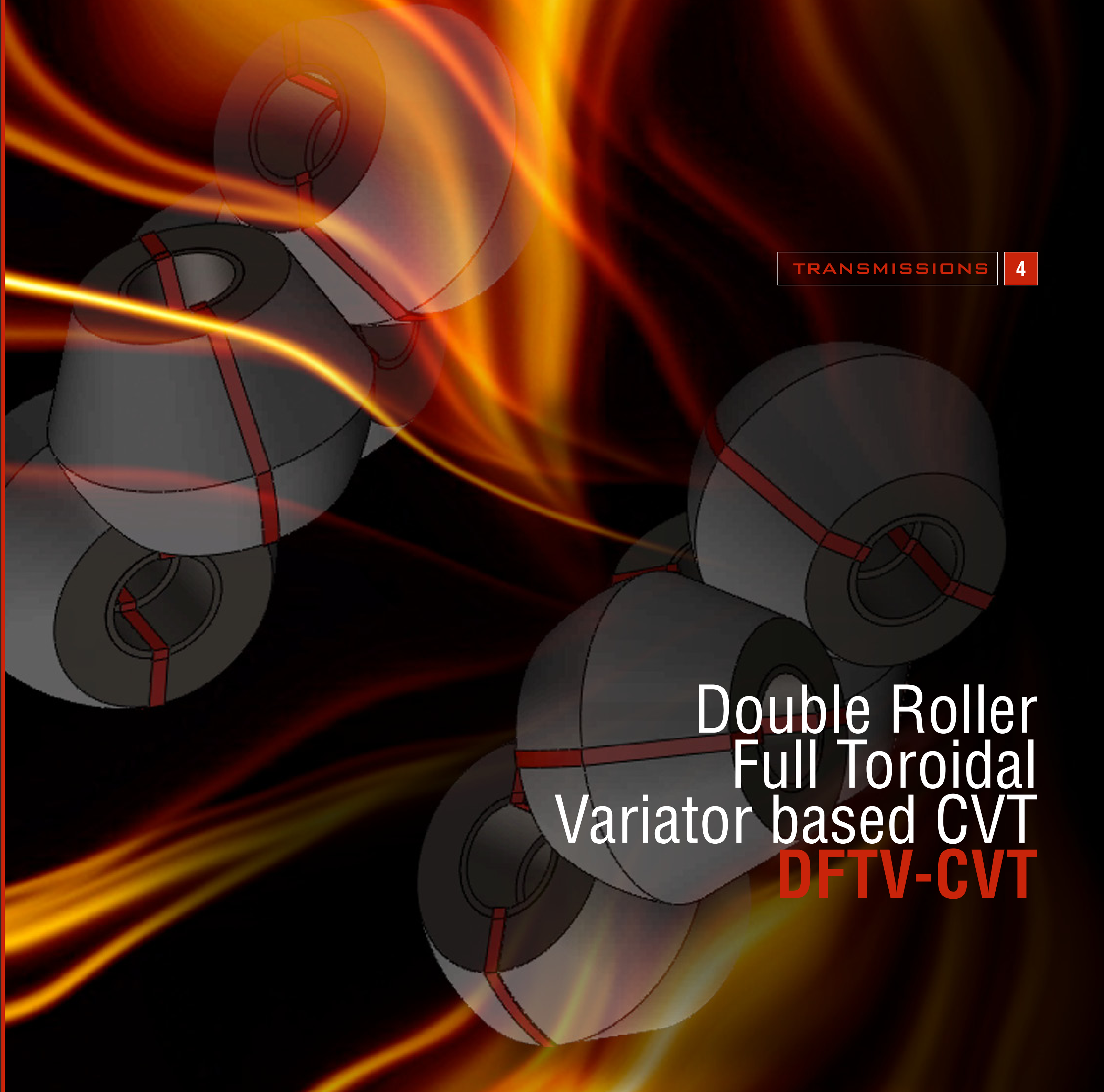

Double Roller Full Toroidal Variator based CVT

DFTV-CVT

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Double Roller Full Toroidal Variator based IVT (DFTV-IVT)

Single Range IVT

The DFTV can be arranged in a single stage Infinitely Variable Transmission for delivery of forward reverse and neutral gear ratios in a very simple manner.

This type of arrangement is very suitable for small machines like scooters, Outdoor Power Equipment, and tractors.

In these applications it is usually sufficient to use a ball ramp loading arrangement (with a conventional thrust bearing) to carry the clamping load, and adopt a manual or semi manual ratio control strategy.

The resulting transmission is extremely simple requiring no electronics or hydraulics.

The efficiencies of theses transmissions is not high because recirculating power is encountered across 100% of the ratio range, although they will typically be above 90%.

The same basic architecture adopted by the Jatco CVT is uses with the torque convertor and forward reverse gears and clutches located between the Variator and the IC engine. The same idler gear and and differential are used.

Dual Range IVT

The DFTV can be used to create a dual range IVT or Infinitely Variable Transmission with geared Neutral.

The IVT concept also allow the transmission to move from reverse to forward through neutral without disconnecting the IC engine from the drive wheels.

By incorporating the dual range the amount of recirculating power is reduced in the Low range with none happening in the high range.

Double Roller Full Toroidal Variator based IVT (DFTV-IVT)

NSK and Torotrak Concepts For IVT

NSK have continued with the development of its Powertoros SHTV incorporating it in a Toyota Lexus. They claim high torque capabilities, good drivability, and similar power to weight to a 6 speed AT. It can be seen in this picture that the SHTV is around double the physical size of the planetary gears and clutches.

NSK now propose a concentric gear arrangement eliminating the secondary lay-shaft shown in the earlier picture on the right.

Torotrak have installed its SFTV based CVT in a Ford Expedition and also claim high torque transfer, excellent drivability, and compact dimensions. They also point out that the no physical disturbance is felt as the transmission moves from low range to high range.

Again the physical size of the variator including the hydraulics and lay-shaft dwarfs the very compact planetary and clutch set. Torotrak claim that their IVT is similar in size to a 6 speed AT of the same capacity.

As far as Ultimate Transmissions is aware Neither Torotrak or NSK have attempted a front wheel drive application of this type of transmission.

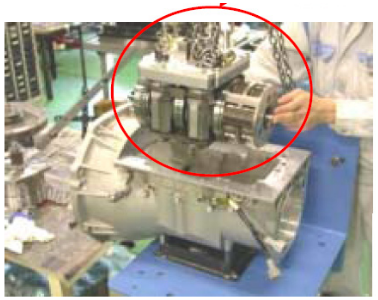


Fig.8 Modularized variator

NSK

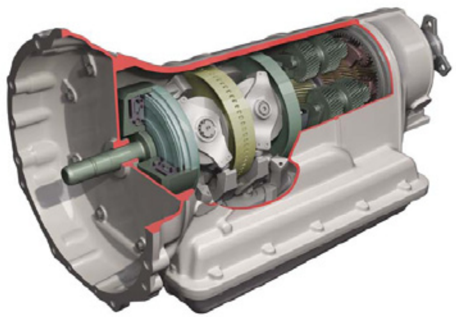


Fig 7 Cross Section of New Coaxial IVT Design

Double Roller Full Toroidal Variator based IVT (DFTV-IVT)

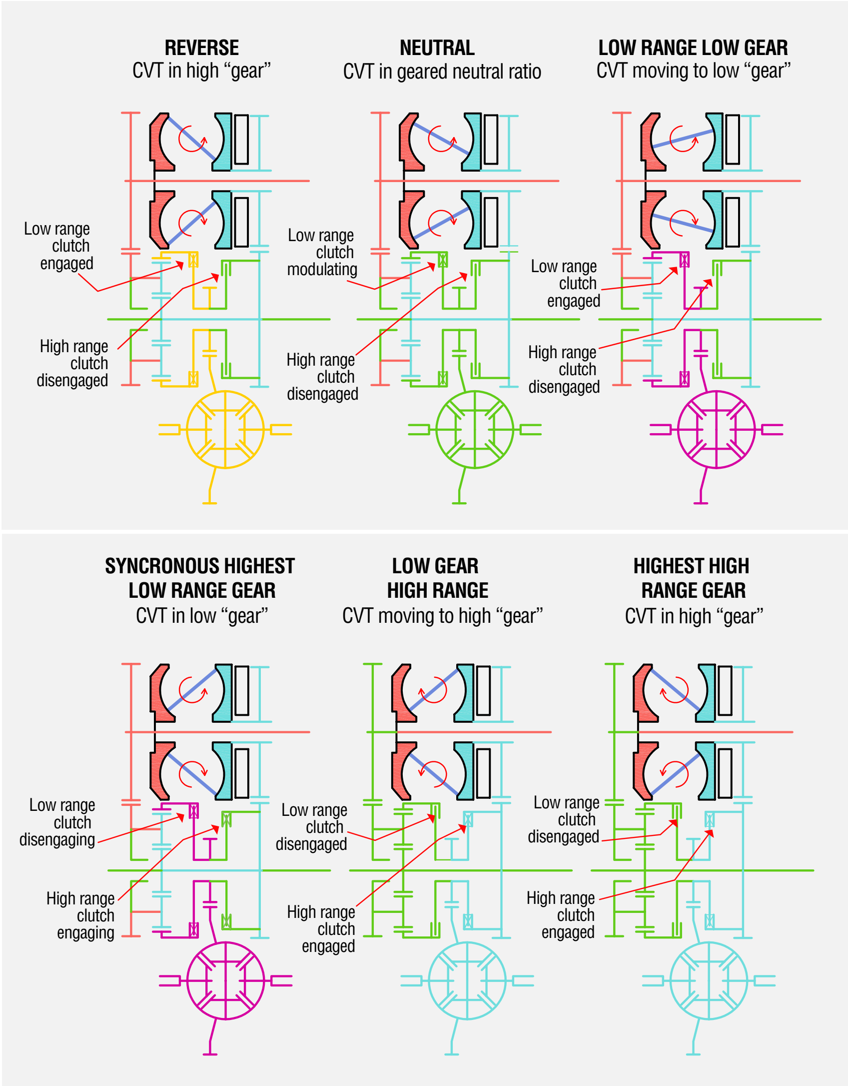
The DFTV IVT Architecture

Ultimate Transmissions use the dual clutch arrangement in a similar manner to Torotrak and NSK as shown in the diagram.

The variator sweeps the toroidal cavity twice, first with the low range clutch engaged and high range disengaged, and then with this reversed when the synchronous ratio is reached. The first sweep moves from High gear (CVT ratio) to Low gear then after the switchover, which disconnects the planetary gear set the CVT moves from low to high.

In this arrangement the synchronous ratio occurs at 106.51km/hr. with the IC engine at 3,600 RPM. At 1,200RPM it happens at 36.52km./hr.

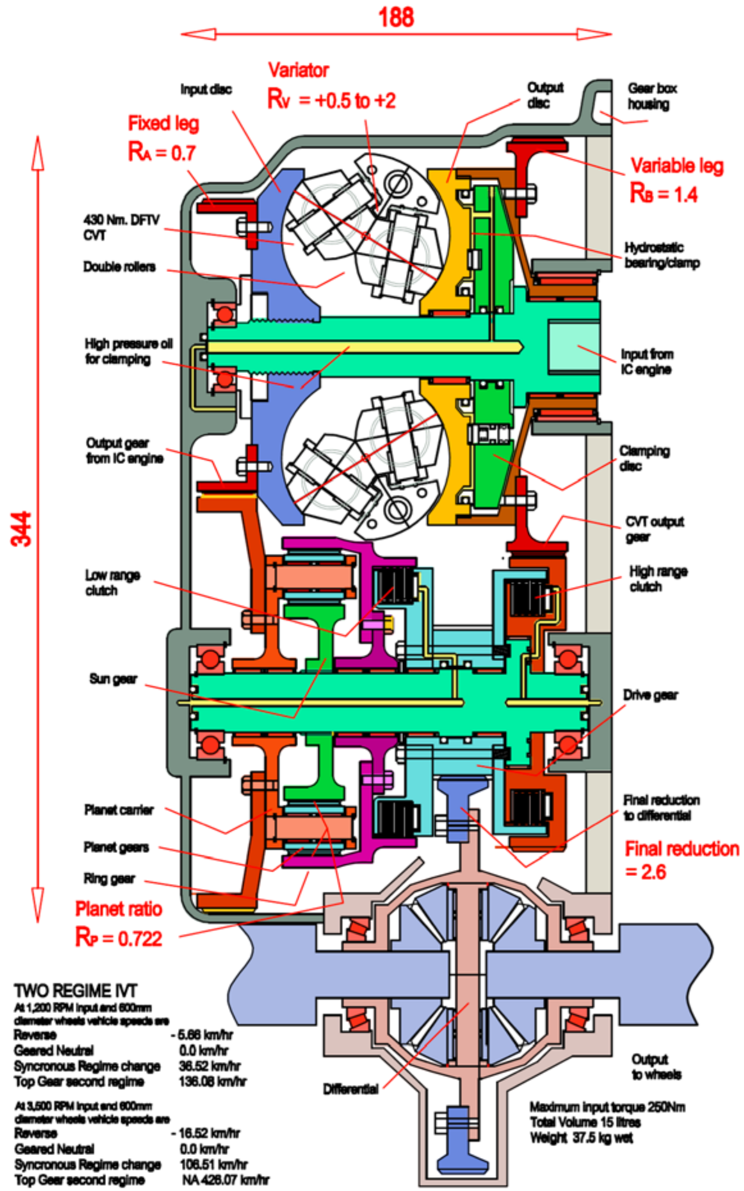
It can be seen that because of the single cavity only possible with the DFTV and the coincidental rotation of both input and output discs the architecture of this arrangement is very simple and suited to front wheel drive arrangements. The fixed gears required between the planetary gear set and the input and output from the CVT are arranged very simply as the coincidental rotations from the input to the CVT and the output from it are passed to the shafts of the Planetary set. This very simple architecture is much more compact than the coaxial arrangement needed by the SFTV and the SHTV for rear wheel applications.



TWO STAGE IVT TRANSMISSON WITH GEARED NEUTRAL

ULTIMATE TRANSMISSIONS

Double Roller Full Toroidal Variator based IVT (DFTV-IVT)



The Torotrak and NSKControl Strategy for Geared Neutral

Achieving a safe and stable geared neutral is a very complicated process when you do not have direct control of the CVT ratio.

This is the case for both the Torotrak and NSK style of design. It is also the case for the belt drives.

Torotrak uses the Reaction Torque Force (TRF), balanced against a control force, created by a hydraulic pressure supplied to a piston, to create a “target” ratio. The target ratio is not a stable ratio as it requires continuous closed loop feedback in order to achieve geared neutral. When a vehicle fitted with a Torotrak based IVT is facing up hill or down hill there is a positive or negative TRF and this control has some reference, but only if it can register the actual state of the vehicle. When the vehicle is on level ground it is possible for the TRF to become zero and the control system looses its reference resulting in at best vibrations or at worst unpredictable behavior.

Torotrak demonstrate forward and reverse hill holding in the Ford Expedition but not on the level with simulated torque convertor creep. Ultimate Transmissions believe that this may be associated with such uncontrollable behavior, and one of the reasons the Torotrak IVT never made it to mainstream automotive. See YouTube http://www.youtube.com/watch?v=IPXz2fQsi_o

NSK use a different approach and use a stepper motor to indirectly place the rollers in the correct ratio for geared neutral. They maintain that they achieved simulated “creep” with this strategy. Because the control of a NSK roller requires hydraulic pressure and a hydraulic link to keep it in a stable position the rollers will always be unstable because of the volumetric changes that can occur in a hydraulic link associated with leakage, changes in pressure and changes in temperature.

The Belt Drive Control Strategy For Geared Neutral

The development of IVT using Belt or Chain CVT’s has only been researched in an academic manner and no serious explanation of how geared neutral could be safely achieved has been offered.

The ratio control of a belt and pulley CVT is achieved by using lookup tables that provide the quantum of the two pressures in the input and output pulley clamps to achieve a ratio under certain conditions including input torque, and perhaps temperature.

The ratio is again a target and the margins for error are quite high. Any perturbations in the torques passing through the system will cause the ratio to change until a new set of look up numbers are in place. As already stated quite large torque perturbations can occur as the geared neutral state is approached.

No vehicle demonstrations of a pulley based IVT have been seen by Ultimate Transmissions. They believe that this issue is at the root cause of this.

The Ultimate Transmissions Control Strategy for Geared Neutral

The Ultimate Transmissions strategy for control is much simpler than that of Torotrak or NSK. It relies on the absolute certainty of a mechanical link driven ratio change controlled by a stepper motor.

The Direct Roller Steering or DRS technology developed and patented by UT can deliver this simple and straight forward outcome when applying either a SFTV or a DFTV to an IVT system.

The perfect ratio for geared neutral is a known number. However because CVT's have internal slip or creep occurring at all times when under load it is in practice not possible to use the perfect ratio to get there as simply as this. It is possible to get very close but there will always be some forward or backward motion.

UT uses the Low range wet clutch to eliminate or take advantage of this imperfectness.

When a request for geared neutral is made typically foot off accelerator and onto brake. The CVT is driven towards a ratio that will almost achieve geared neutral in whatever state the vehicle is in (forward or reverse). A simple safety margin is maintained between the forward and reverse states of this geared neutral state so that the vehicle can never accidentally slip from forward to reverse.

The pressure supplied to the low range clutch is reduced to an extent that will still maintain some creep but only very little. Additional pressure on the accelerator will modulate this pressure to create differing amounts of creep, in a similar way that a driver can use a torque convertor in an automatic. The clutch is moving very slowly and will not build up any appreciable heat. The clutch can also be used as a torque fuse to eliminate any shock load reaching the CVT or geared components.

When the driver wishes to move off, a sharp depression of the accelerator will result in a rapid increase in engine revs, a controlled lockup of the Low-regime clutch and a very rapid acceleration of the vehicle expected from the low range gear ratios that exist on either side of geared neutral.

It will also be possible to have a “dial-up” mode in which vehicle speed can be controlled by digital input. The dial-up mode can also be used to create a type of cruise control that employs both the engine revs and the gear ratio allowing for creep gears that offer the driver cruise control over a much wider speed range than is normally possible.

These creep gears are capable of providing very high torques, limited of course by the low regime clutch, but allowing a vehicle to execute maneuvers like curb mounting, controlled parking, with a precision not available to any other form of automated transmission. With some simple anti avoidance sensors it will be possible to automate driving in heavy traffic. Providing the output torques are planned for in the transmission it becomes a simple extension to off-road or semi off road vehicles with extra low and creeper gears available in both forward and reverse.