

# The Lightest Automated Transmission Possible



Overview

The Lightest Toroidal Variator

The Nissan Ivt Concept Mass

The Torotrak Cvt/Ivt Concept Mass

The Ultimate Transmissions CVT Concept Mass

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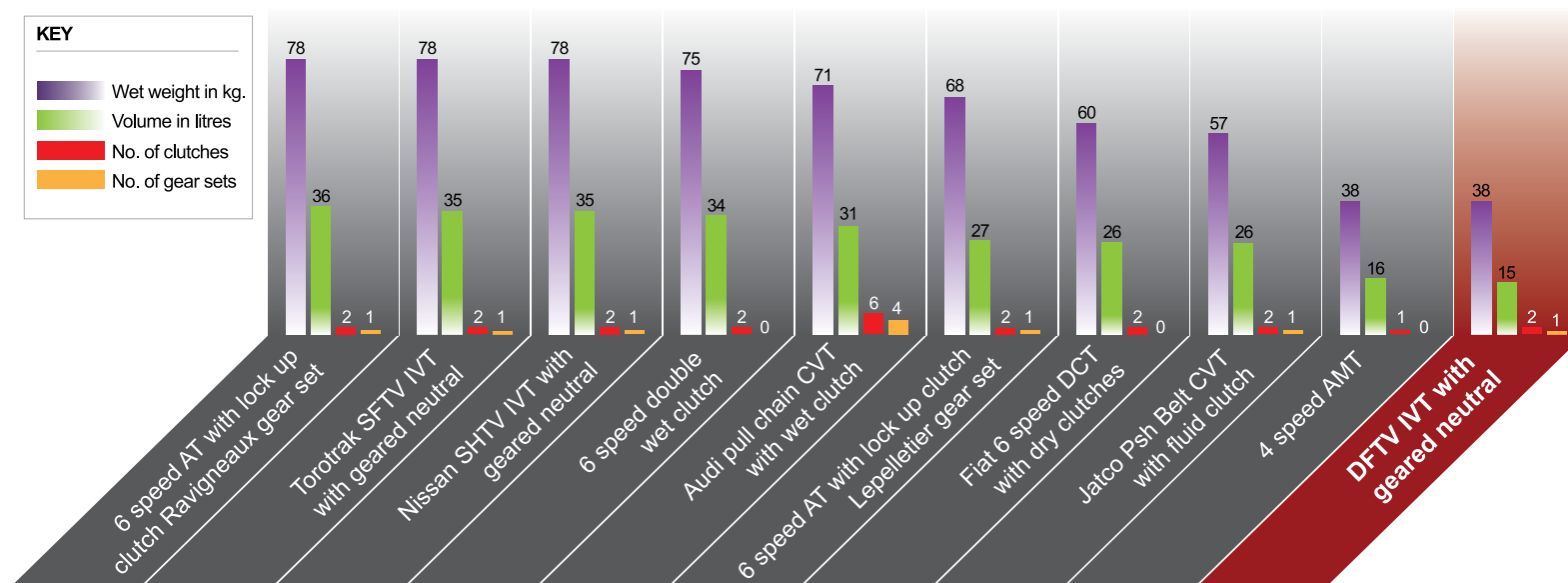
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The combination of the extremely compact Double Roller Full Toroidal Variator (DFTV) and a typical High Low regime IVT produces a transmission that is lighter than any Automatic transmission using a torque converter as a starting device.



## Comparison of Size, Weight and Complexity of Various Transmission Types

*This chart was developed by Ultimate transmissions using information available about the size and mass of other forms of transmission. All transmissions are rated at 250Nm. input torque*

The weight saving stems directly from the reduced mechanical volume and the removal of over 5 litres of oil to operate the fluid clutch.

Transmissions that use wet or dry clutches in place of the fluid clutch can be lighter but continue to be heavier than a similar DFTV based IVT.

The SFTV and SHTV based IVT transmissions are always heavier because of the relative mass involved in the CVT itself. The chart defines the comparative mass of the three based on a maximum input torque of 430 Nm.

## The Nissan IVT Concept Mass

NSK/Nissan has published figures on its experimental IVT in the paper below stating that it remains comparable in mass to a rear wheel drive 6 speed automatic at 98 kg dry weight capable of absorbing 450 Nm of torque. This transmission does not include a differential or the hydraulic gear pump.

Table.1 Main specifications \*

Vehicle	Lexus LS430
Engine type	3UZ-FE (430 N-m/206 kW)
Torque capacity	450 N-m
Maximum input rev.	6 600 rpm
Transmission size	Compatible size and interface as 6AT (A761E)
T/M Reduction ratio (T/M Speed ratio)	-6.25 to $\infty$ to 0.52 (-0.16 to 0 to 1.92)
Launch device	None (geared-neutral system)
T/M weight (Dry)	98 kg
Oil pump type	External gear pump
Traction Fluid	IDEMITSU TDF 2210

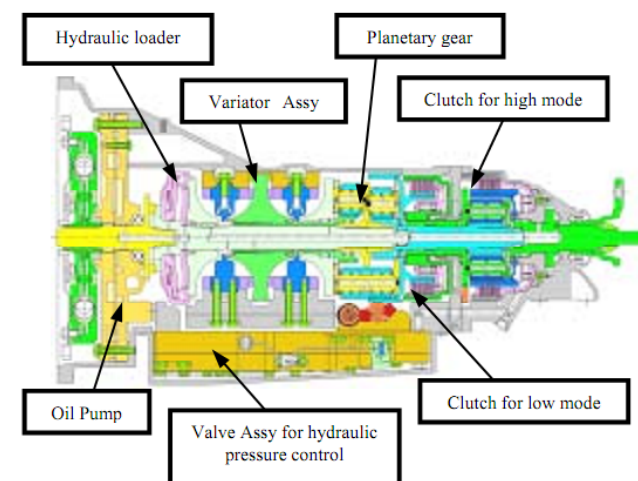


Fig.2 Basic structure of next-generation CVT

\* Extract from SAE Paper Number 2004 – 34  
– 2878 “Development of the Next Generation  
Half Toroidal CVT with Geared Neutral and  
Power-Split Systems for 450 N-m Engines”  
Takumi Shinojima, Toshiro Toyoda,  
Shinji Miyata, Takashi Imanishi, Eiji Inoue, &  
Hisashi Machida – NSK Ltd.

## The Torotrak CVT/IVT Concept Mass

Torotrak have also published information on an experimental IVT installed in a rear wheel drive Ford Expedition. Torotrak claim that the transmission fitted inside the 6AT envelope as did Nissan.

The saving in mass associated with the adoption of a DFTV for the CVT function for a 450 Nm. transmission are 25kg. or almost 30% of the overall wet weight of the transmission.

This guarantees that the mass of a DFTV based IVT transmission is equal or less than that of a 4 speed AMT and less than a 4 speed AT.

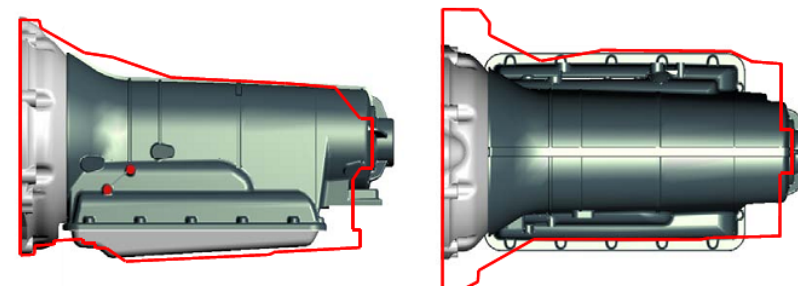
It should be noted however that the Torotrak paper contains many contradictions including an indication that the roller diameter may be 120mm. (the transmission tested) 100mm. (an anticipated target) and 90mm. as the one being used for this diagram.

Studies by Ultimate Transmissions indicate that for a torque capability of 450Nm. and a design life of 400,000 kms. that a minimum roller diameter of 104mm. is required. It is likely that the Torotrak comparison with a 6 speed automatic is slightly skewed and that the Nissan information is more reliable.

Although an IVT using a push-belt CVT has been proposed by Jatco no indication of its size and mass has been stated.

## 8 The Pre-Production Transmission\*

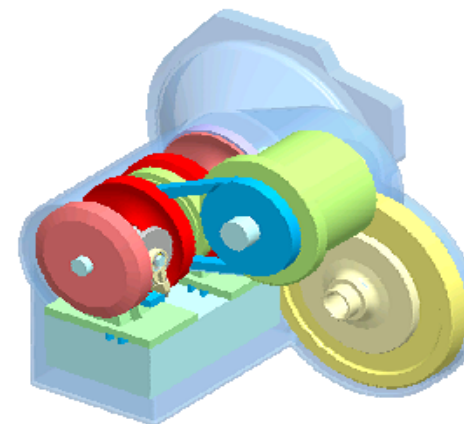
The research and development work that has generated the steps forward in technology overviewed above have also generated bespoke design tools for the optimisation of the IVT in any powertrain system, to any desired selection of vehicle attributes [9]. The uses of the latest advancements in the technology and the design tools have been used to specify the latest generation IVT. This transmission is targeted for a 210kW, 450Nm luxury sedan application. A 90mm roller diameter compact lever variator has been incorporated into a coaxial transmission design. Figure 14 clearly illustrate that the IVT is equivalent in dimensions to the current production 6AT transmissions, one of which it will replace in a demonstrator platform in early 2005.



Figures 14 – Co-axial IVT inside current 6AT envelope

\* Extract from SAE paper 2005 – 01 – 1461  
"Powertrain Control of Torotrak Infinitely  
Variable Transmission" by Matthew Field, &  
Matthew Burke Torotrak (development) Ltd.

In a paper written in 2006 Torotrak proposed a simplified CVT based transmission shown above. For a delivery of only 150 Nm of torque the weight of 50 kg. is considerably heavier (more than twice) than what Ultimate Transmissions can deliver for a simple DVFT based CVT. The poor performance is attributed to the use of a ratio controlled 4 roller (two per cavity) that simplifies the complicated torque controlled system proposed by Torotrak for most of its “theoretical” transmissions.



**Figure 8 – Toroidal Continuously Variable Transmission (TCVT).**

The main dimensions for a typical TCVT in a small car application are:

	TCVT 1	TCVT 2
Roller Diameter	60 mm	70 mm
Length (RFoB)	325 mm	345 mm
Weight	43 Kg	50 Kg
Ratio Spread	6.25	6.25
Power capacity (Gasoline)	50 kW	75 kW
Torque capacity(Gasoline)	100 Nm	150 Nm
Engine capacity(Gasoline)	~ 1.0 L	~ 1.6 L

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\* Extract from Paper by Torotrak (Development) Ltd. "Full Toroidal Traction Drives for Front Wheel Drive Applications" by Chris Brockbank & Dave Burt 2006

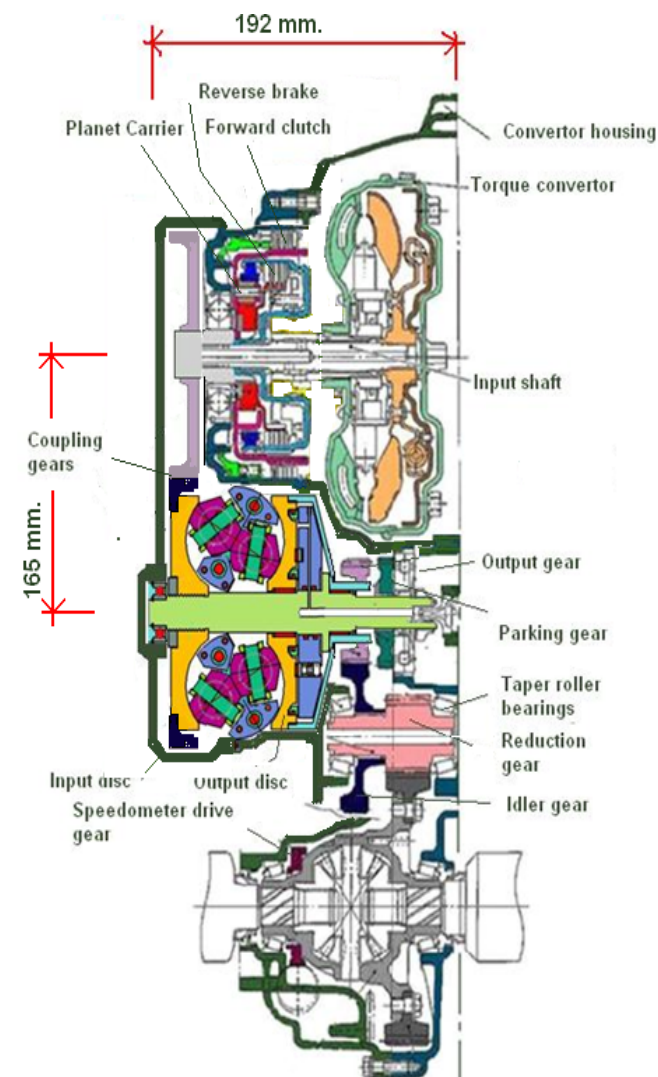


# The Ultimate Transmissions CVT Concept Mass

A DFTV – CVT transmission with a capacity of 250 Nm will have the following characteristics.

DFTV – CVT Specifications	
Developer	Ultimate Transmissions
Factory Designation	DFTV - IVT 250
Gearbox type	Continuously Variable with torque converter.
Maximum transferrable torque	250Nm. +
Range of ratios	Low gear Top 0.7 Reverse 4.21
Spread	5.8
Ratio of auxiliary reduction gear step	NA
Final drive ratio	4.6
ATF specifications	5.0 litres of Santotrak traction fluid
Gross weight without flywheel	42 kg
Overall length	390 mm.
Overall depth	192 mm.
Volume	18litres

*The diagram (right) depicts a typical 250Nm. DFTV based IVT. This Transmission is around half the size of the 150Nm. CVT transmission proposed by Torotrak, weighing 30 kg. wet.*



# The Ultimate Transmissions CVT Concept Mass

Torotrak prepared the following chart (a) in order to demonstrate where their technology is claimed to fit within the other competing technologies.

Torotrak state that the Toroidal CVT is likely to be 60% the mass of a belt CVT but acknowledge that their technology will always produce the heaviest form of transmission when compared to MT, AMT, AT, or DCT.

Studies by Ultimate transmissions reveal that both types of Toroidal CVT's are considerably heavier than the Push belt varieties supplied by Jatco.

**A DFTV based IVT will always remain among the lightest transmission within this group.**

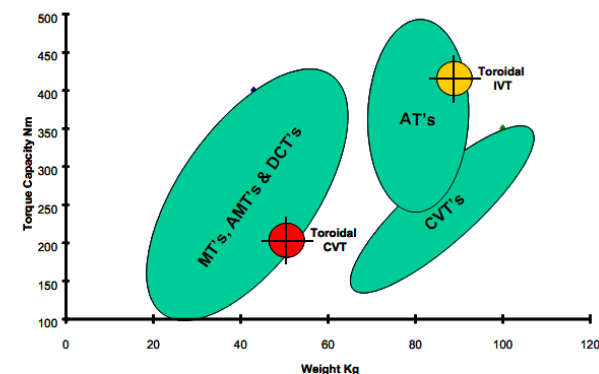
This diagram (b) plots the position of a small DFTV CVT and a larger DFTV IVT showing the relative positions within this Mass and Torque relationship diagram created by Torotrak.

Ultimate Transmissions do not agree with Torotrak on where they have placed belt type CVT's as they are much lighter than this diagram purports

UT is also uncertain about where Torotrak places themselves at 50 kg and 200Nm. When they have stated in the same academic paper that a 150 Nm. Torotrak transmission will be 50 kg.

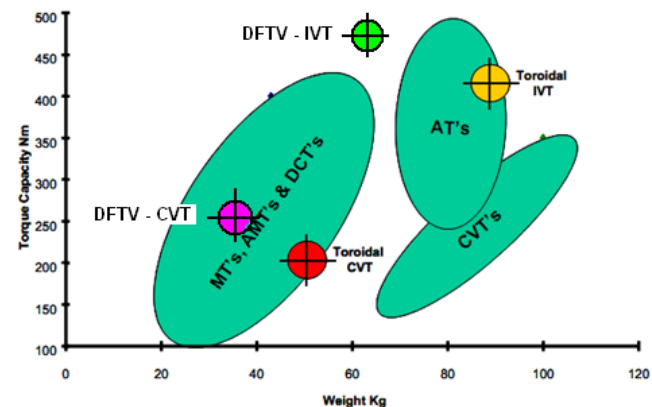
Exactly why the AT's are represented in such a way is also difficult to understand.

The full toroidal traction drive technology is compared with existing transmissions in figure 13. Clearly the IVT and TCVT offer attractive solutions for front wheel drive cars.



a

Figure 13 – IVT and CVT comparison to existing products.\*



b

ULTIMATE TRANSMISSION'S, DFTV BASED IVT, PLOTTED ON TOROTRAK'S COMPARISON CHART

\* Extract from Paper by Torotrak (Development) Ltd. "Full Toroidal Traction Drives for Front Wheel Drive Applications" by Chris Brockbank & Dave Burr 2006



