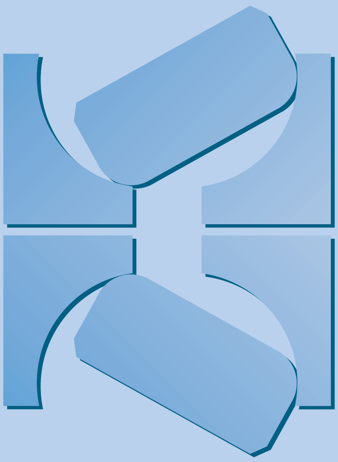
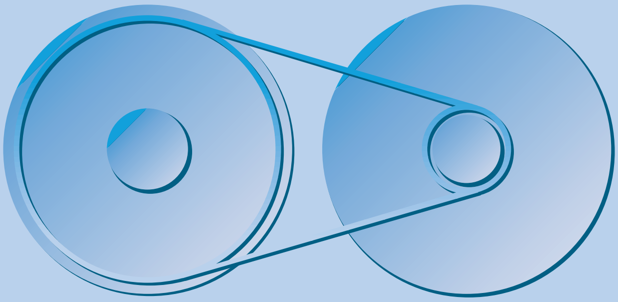
TECHNICAL NOTE

EXTROID CVT For Application to Rear-Wheel-Drive Cars Powered by Large Engines

Nissan's CVT Technologies





NISSAN

Preface

A continuously variable transmission (CVT) is a superior automotive transmission that provides outstanding efficiency and smooth, powerful driving performance. Nissan has been vigorously developing CVTs for many years. In 1992, Nissan implemented the N-CVT on the March, and subsequently developed the HYPER CVT in 1997 as the world's first unit designed for application to front-wheel-drive cars fitted with 2.0-liter class engines. Now, Nissan's latest accomplishment is the EXTROID CVT for application to rear-wheel-drive cars powered by 3.0-liter class engines.

Nissan intends to continue wide-ranging efforts to develop CVTs and other innovative technologies in line with the development concept of "combining environmental friendliness with superb driving pleasure."

Concept of CVTs

Automatic transmissions (A/Ts) have been evolving toward a greater number of gear speeds in pursuit of more efficient transfer of the engine's power, improved shift smoothness and more powerful driving performance. The CVT concept takes this idea of additional gear speeds to the realm of an unlimited number of gear ratios with the aim of achieving the ultimate in efficiency and driving performance.

Benefits of CVTs

The outstanding benefits of CVTs are summed up in the three points noted below.

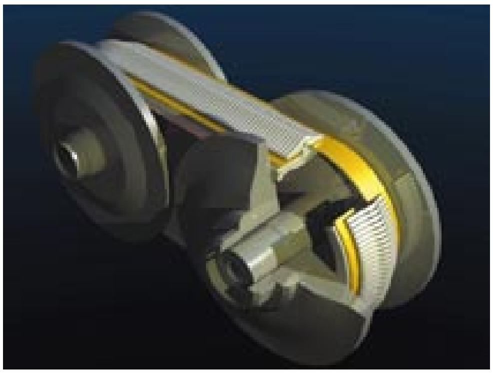
By continuously varying the gear ratio, CVTs:

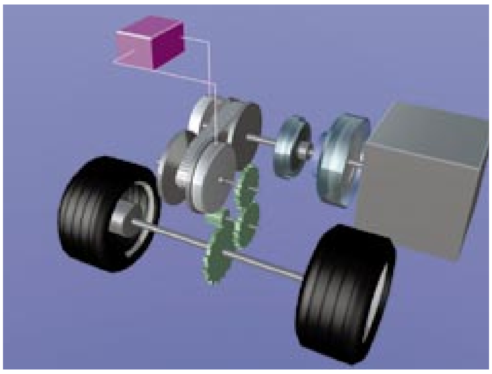
- Improve fuel economy dramatically by enabling the engine to operate under conditions of optimum efficiency.
- Achieve exceptionally smooth power delivery free of any shift shock.
- Provide powerful driving performance by continually eliciting high engine power, owing to the fact that minimal power loss occurs during ratio changes.

Belt-drive CVTs

The N-CVT adopted on the Nissan March in 1992 was a belt-drive unit that utilized a combination of pulleys and a steel belt in place of conventional gearsets to transmit power. The HYPER CVT that was commercialized in 1997 for use with 2.0-liter class engines further expanded the range of CVT application.

Both the N-CVT and the HYPER CVT have been highly acclaimed by customers as automotive transmissions that achieve amazingly smooth driving performance together with low fuel consumption.





EXTROID CVT

Only CVTs are capable of delivering such smooth, powerful driving performance combined with remarkably low fuel consumption. Nissan has wanted to exploit this superior transmission performance in rear-wheel-drive cars powered by large engines, in addition to applying CVTs to front-wheel-drive vehicles fitted with small engines. To accomplish that goal, Nissan has now developed the EXTROID CVT that can be used even on rear-wheel-drive cars fitted with powerful engines displacing more than 3.0 liters. Using a combination of discs and power rollers to transmit drive torque and execute ratio changes, this all-new type of CVT is the world's first CVT to be successfully implemented on rear-wheel-drive production vehicles equipped with high-torque engines.

3 Benefits

Three Outstanding Benefits of the EXTROID CVT

●Quick response and smooth ratio changes

The EXTROID CVT changes the gear ratio by moving the power rollers, which react instantaneously to the force applied by the input discs. This enables the EXTROID CVT to provide quicker ratio change responsiveness than ever before, thereby achieving linear ratio changes in response to the driver's accelerator inputs. Moreover, similar to belt-drive CVTs, the gear ratio is varied continuously to allow the driver to enjoy seamlessly smooth shifting free of any shift shock.

●High torque capacity

The EXTROID CVT is capable of handling high torque of 39.5 kg-m, giving it ample capacity for application even to vehicles fitted with a 3.0-liter turbocharged engine. This remarkable capability stems largely from the adoption of a dual-cavity design consisting of two sets of input/output discs and power rollers and the development of new materials.

●Improved fuel economy

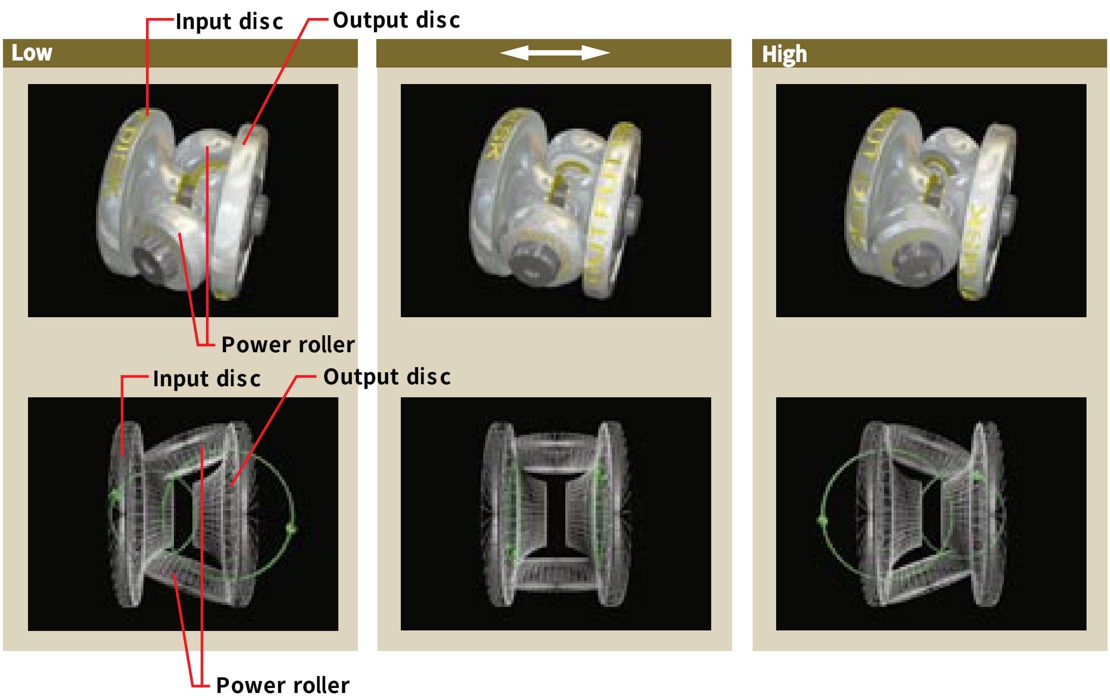
By varying the gear ratio continuously, the EXTROID CVT suffers no power loss during shifting, allowing the engine to operate under conditions of optimum efficiency. Additionally, the range of lockup operation has also been expanded. Thanks to these remarkable features, the EXTROID CVT improves fuel economy by approximately 10%* over a conventional automatic transmission.

*Reference value based on an in-house comparison

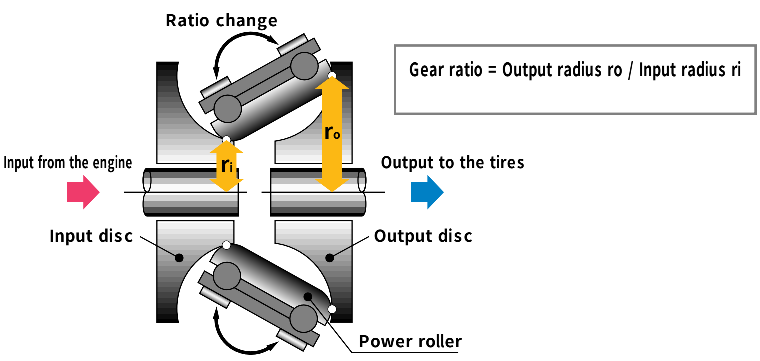
Ratio Change Mechanism of the EXTROID CVT

The engine's power is transmitted to an input disc the rotational motion of which is transferred to the power rollers and then from the rollers to an output disc. By changing the tilt of the power rollers continuously, the EXTROID CVT executes smooth, continuous gear ratio changes. The size of the circle traced by the contact point between the input disc and the power rollers and that of the circle traced by the contact point between the power rollers and the output disc vary according to the tilt of the power rollers. The ratio of the sizes of the circles corresponds to the ratio of the rotational speeds of the input and output discs, which is equal to the gear ratio.

When the circle on the output disc side is larger, the output disc rotates faster than the input disc. This corresponds to the low gear range of a conventional transmission (Low in the diagram below). Conversely, when the circle on the output disc side is smaller, the output disc rotates faster than the input disc. This corresponds to the top gear range of a conventional gearbox (High in the diagram below).



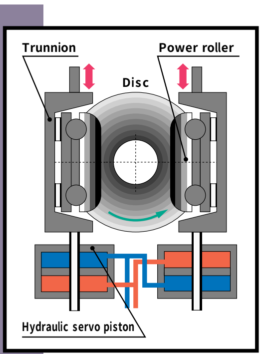
■Ratio change mechanism of the EXTROID CVT



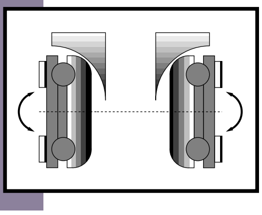
Mechanism for Changing the Tilt of the Power Rollers

Although ratio changes are accomplished by tilting the power rollers, it is not done by applying force to them directly. Rather, the rollers are tilted by using force produced by the discs that acts to tilt the rollers when they move vertically from their central axis. Using this force generated by the discs, which are rotating at high speed, allows the rollers to be tilted instantly with minimal movement and force, making it possible to obtain remarkably quick ratio change response. This results in linear acceleration and deceleration in response to the driver's accelerator inputs.

Power roller construction

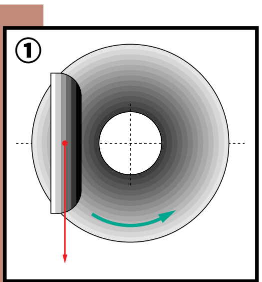


A power roller is supported above and below by a support called a trunnion. The entire assembly is connected to a hydraulic servo piston that moves the assembly up and down.

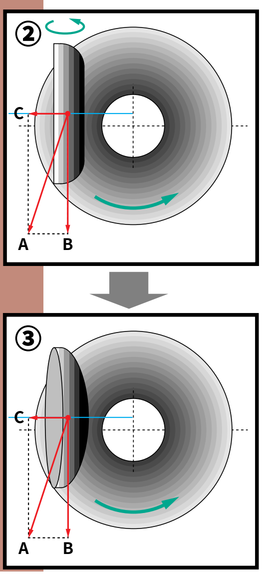


The power rollers are constructed so that they move in the direction of rotation centered around the trunnions.

Roller tilting mechanism

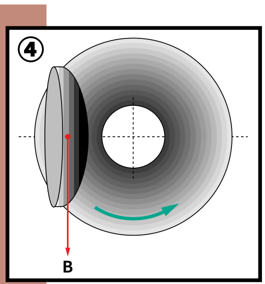


When the axis of a power roller passes the center of the disc, force for tilting the roller is not generated. Consequently, since the tilt of the roller remains the same, no ratio change is executed.

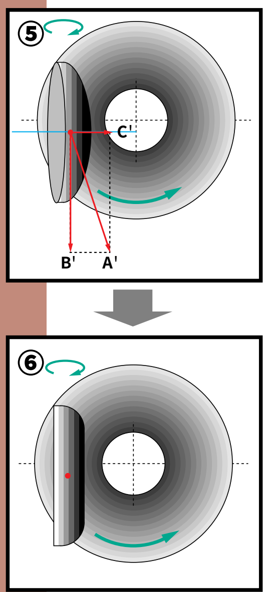


When the axis of a power roller moves upward, the force (A) transmitted from the input disc produces force (B) that rotates the roller and force (C) that acts to push the roller toward the outside. This latter force (C) tilts the power roller around the center of the trunnion axis.

Roller tilting mechanism

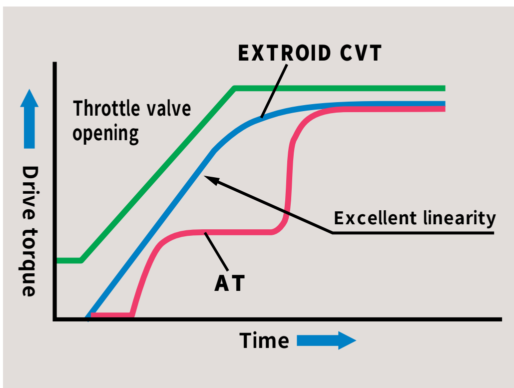


When the tilted power roller returns to the center of its axis, the force acting to push it toward the outside disappears, so the roller maintains its tilted orientation.



Then when the axis of a power roller moves downward, the force (A') transmitted from the input disc generates force (B') that rotates the roller and force (C') that acts to pull the roller toward the inside. This latter force (C') tilts the power roller in the opposite direction.

Since the discs are rotating at high speed, the rollers can be tilted the necessary amount by moving them up or down only slightly (around 0.1mm - 1.0mm). This enables the EXTROID CVT to respond instantly to a ratio change command and results in exceptionally quick ratio changes.

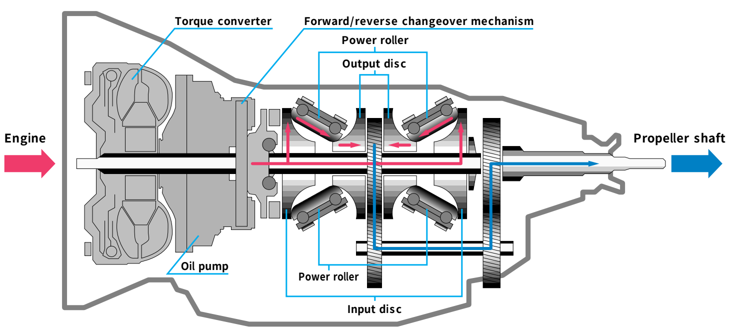


Dual Cavity

The EXTROID CVT features a dual-cavity design consisting of two sets of input/output discs and power rollers arranged consecutively. By doubling the number of contact points between the discs and rollers, the force applied at each contact point is reduced, making it possible to handle higher levels of torque.

The two sets of discs and rollers are oriented in opposite directions with the output discs positioned in the center. The power transmitted to the central output discs is transferred to a countershaft from which it is output to the propeller shaft for transmission to the tires.

■Power flow in the EXTROID CVT



●High-strength materials for handling high torque

The force applied to the input/output discs and power rollers is normally around three tons and can reach a maximum of nearly ten tons. Since conventional materials could not possibly withstand such force, it is necessary to use materials with much greater durability and hardness.

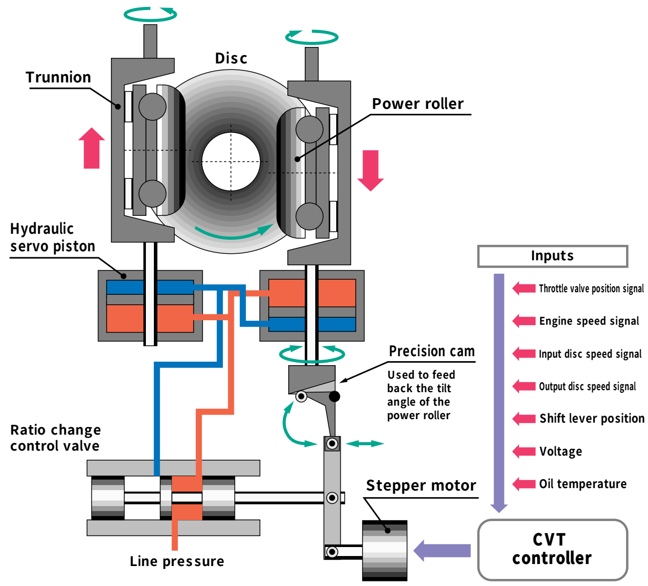
For the EXTROID CVT, a special hardening technique was developed for penetrating carbon deeply into a highly purified steel. Nissan thus succeeded in obtaining highly durable discs and rollers which are made of an exceptionally tough and pure bearing steel that is without equal anywhere in the world.

Control of Four Power Rollers

The EXTROID CVT adopts a dual-cavity construction to allow application to rear-wheel-drive cars fitted with large engines. While this design enables the CVT to handle greater torque, it can also give rise to problems if the motion of the four power rollers is not synchronized. For instance, power losses occurring at the rollers could result in unacceptable heat generation.

To avoid such problems, Nissan developed a control system for accurately synchronizing the gear ratios of the four power rollers. Each of the power rollers is supported by a dedicated hydraulic servo piston to which hydraulic pressure is supplied from a single hydraulic pressure source. In addition, the tilt angle of each roller is detected and that information is fed back to ensure precise synchronization.

■Ratio change control system



Power Transmission Mechanism

The EXTROID CVT transmits power by means of the shear force* of the traction oil between the discs and power rollers rather than by direct contact between these rotating elements.

*Shear force is the force produced by parallel displacement of cross sections of the oil in opposite directions due to deformation under pressure.

● Traction oil (Dedicated CVT fluid for the EXTROID CVT)

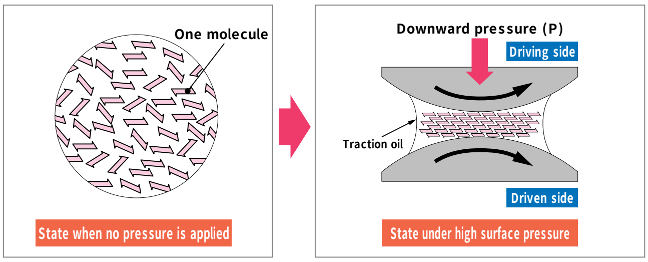
A special traction oil serves as the medium of contact between the discs and power rollers that rotate at high speed. The traction oil must provide lubrication and cooling performance just like an ordinary oil. Moreover, it must also serve the additional functions of transmitting power between the discs and the power rollers and preventing roller and disc wear.

To meet these requirements, Nissan has newly developed a special type of traction oil that never existed before. The molecules of this oil have wedge-shaped projections that interlock under the application of extremely high surface pressure to form a regularly aligned molecular structure

This interlocking of the oil molecules generates large shear force that accomplishes power transmission.

■Power transmission mechanism of the EXTROID CVT

The application of extremely high surface pressure causes the traction oil molecules to interlock in an aligned structure, enabling the transmission of large shear force.



Magnified schema of the traction oil | Schema of disc-roller contact

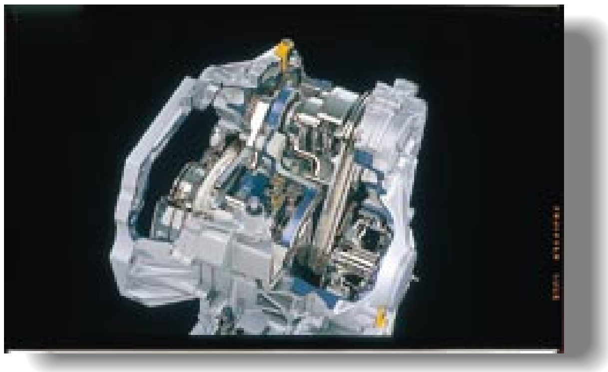
6-speed Manual Shift Mode (M Mode)

The EXTROID CVT is also available with a 6-speed manual shift mode that enables drivers to enjoy the pleasure of sporty driving. With the Dualmatic feature, shifting is possible either by the shift lever or by steering wheel-mounted shift buttons to provide the full enjoyment of sporty driving performance.

HYPER CVT

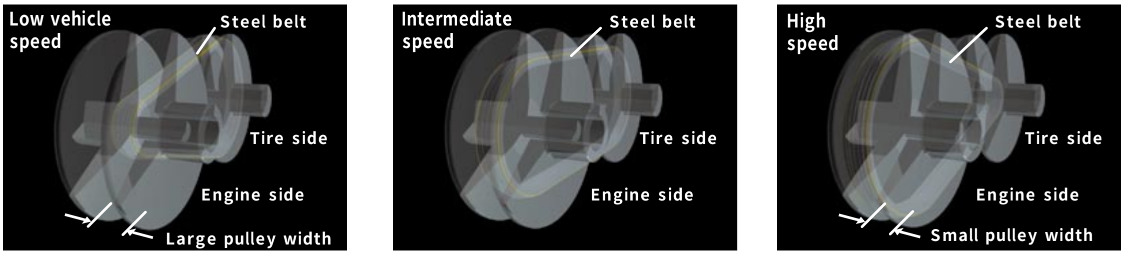
The HYPER CVT effectively brings out the engine's power to achieve low fuel consumption combined with powerful driving performance.

A belt-drive CVT uses pulleys and a steel belt in place of traditional gears to accomplish stepless gear ratio changes. Nissan's HYPER CVT is the world's first CVT that is applicable to 2-liter class engines.



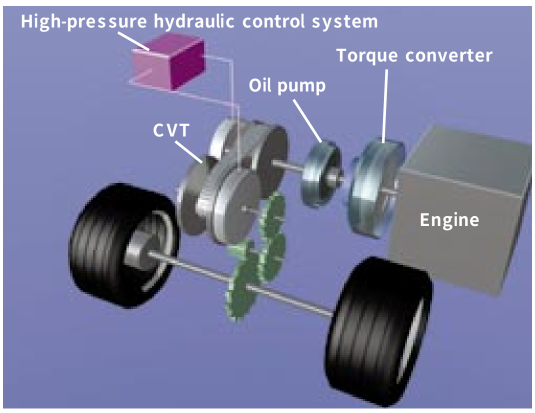
Belt-drive CVTs

A CVT transmits power by means of two pulleys and a steel belt in place of traditional gears. One pulley receives the torque generated by the engine and the other pulley transmits drive torque to the tires. The gear ratio is continuously varied by changing the respective width of the pulleys.



HYPER CVT - the world's first CVT applicable to 2-liter class engines

The previous belt-drive CVT unit was limited in application to 1.6-liter class engines at the most on account of problems related to belt strength and the system for managing high torque levels. Nissan has now overcome that barrier by applying its unique cutting-edge technologies to develop the HYPER CVT, the world's first CVT capable of handling the high torque generated by a 2-liter class engine.



Transmitting the high torque produced by a 2-liter class engine requires the application of greater pressure to the pulleys that squeeze the steel belt and a belt with sufficiently high durability to withstand the additional pulley pressure.
For the HYPER CVT, Nissan developed an oil pump capable of generating higher hydraulic pressure and a high-pressure hydraulic control system that provides improved accuracy. This system reliably applies high hydraulic pressure to squeeze the belt when large torque is transmitted and weakens the squeezing force to transmit less torque, thereby avoiding wasteful use of energy. As a result, this enables the HYPER CVT to achieve high reliability and improved fuel economy.
A high-strength steel belt that is wider than the conventional belt has been adopted for enhanced durability, enabling it to handle the increased pulley pressure.

HYPER CVT (for 1.0 to 1.3-liter class vehicles)

Nissan has developed a new HYPER CVT unit for use on compact cars to succeed the N-CVT that has been widely acclaimed for its nimble driving performance and low fuel consumption.
Like the CVT for 2.0-liter class cars, this new unit also adopts a torque converter for improved start-off acceleration and enhanced driving ease at very low vehicle speeds, such as when taking off on slopes or parking in a garage. It also features full electronic control of ratio changes for a further improvement in fuel economy of approximately 10% over the previous N-CVT.
Ease of operation when shifting has also been improved by adopting a multi-plate hydraulic clutch in the forward/reverse changeover mechanism. Moreover, a 6-speed manual shift mode is also provided to give drivers the added enjoyment associated with manual shifting.

CVT Milestones at Nissan

January 1992	Adopts the N-CVT on the March.
September 1997	Adopts the HYPER CVT on the Primera/Primera Camino Wagon and Sedan models and on the Bluebird to achieve the world's first implementation of a CVT on front-wheel-drive cars powered by 2.0-liter class engines.
February 1998	Adopts the N-CVT on the Cube.
August 1998	Adopts the HYPER CVT on the Avenir.
September 1998	Adopts the HYPER CVT paired with the NEO Di QG18DD direct-injection gasoline engine on the Primera/Primera Camino Wagon and Sedan models and on the Bluebird.
October 1998	Adopts the HYPER CVT paired with the NEO Di QG18DD direct-injection gasoline engine on the Sunny.
November 1998	Adopts the HYPER CVT on the Prairie Liberty.
November 1998	Adds a HYPER CVT-equipped model to the R'nessa lineup.
December 1998	Adopts the HYPER CVT on the Tino.
May 1999	Adopts the HYPER CVT on the Wingroad.
June 1999	Adopts the HYPER CVT paired with the Auto control 4WD on the Serena.
October 1999	Adopts on the Cedric/Gloria models the EXTROID CVT designed for application to rear-wheel-drive cars fitted with 3.0-liter class engines.

LINE UP

March

Prairie Liberty

Primera

R'nessa

Primera Wagon

Tino

Bluebird

Wingroad

Cube

Serena

Avenir

Cedric

Sunny

Gloria

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