



FALLBROOK[®]
T E C H N O L O G I E S

NuVinci[®] Planetary Analogy

Discussion of Planetary Analogy

- **An ordinary planetary gear has three components:**
 - A ring gear
 - A sun gear
 - A carrier with planet gears
- **Each one of these three components can be the input, the output, or held stationary. For each connection case, the planetary produces a different ratio between input and output.**

This arrangement is very advantageous for transmission designers because it allows multiple gear ratios to be achieved using a single set of gears in a very compact space. This, along with other advantages like high torque capacity, is the reason planetary gears are so widely used in everything from electric drills to automotive transmissions to earthmoving equipment.

- **The planets in *NuVinci* technology, unlike those in the conventional single planetary, are in contact with two rings simultaneously, hence the “compound” term in compound variable planetary, and of course *NuVinci* technology’s ability to smoothly and continuously change ratios is the “variable” part.**

Discussion of Planetary Analogy (continued)

- In the same manner that different ratios can be obtained by changing which parts of a conventional planetary are the input, output, and held stationary, different ranges of variability can be obtained from *NuVinci* technology simply by changing which components are the input, output, and held stationary.

The key difference is that, because there are four components, one must be allowed to turn freely, and this is also the case for compound conventional planetary gears. For example, in a standard *NuVinci* CVP, the carrier is held stationary, the sun is left to turn freely, ring 1 is the input and ring 2 is the output, as shown in the IVP video in the video player.

- Looking more closely at *NuVinci*, the same basic components plus an extra ring emerge:
 - Ring 1
 - A carrier with planets
 - A central sun
 - Ring 2
- If, however, a *NuVinci's* ring 1 is held stationary, the sun is again free, but the carrier is used as the input, and ring 2 is the output, an infinitely variable planetary (one where there is a “powered zero” state where the input turns but the output does not, and where there is a smooth, seamless transition from reverse to forward is obtained, as shown in the video.

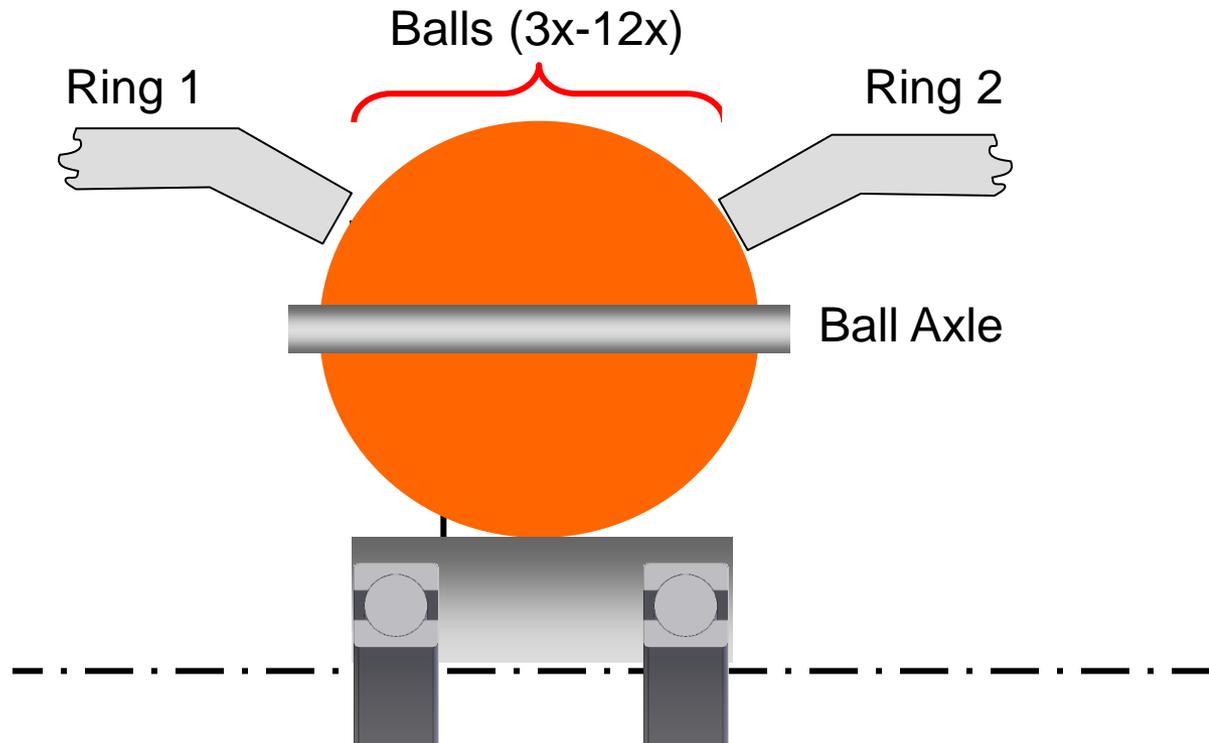
Infinately Variable, Infinately Applicable

- In fact, there are 10 possible combinations with *NuVinci* technology alone, and well over 300 possible combinations when a single conventional planetary is mated to either the input or the output of a CVP/IVP. This versatility is virtually unmatched by other CVTs and IVT technologies, and is the basis for our “infinately variable, infinately applicable” tagline.

The following slides depict graphically the planetary analogy.

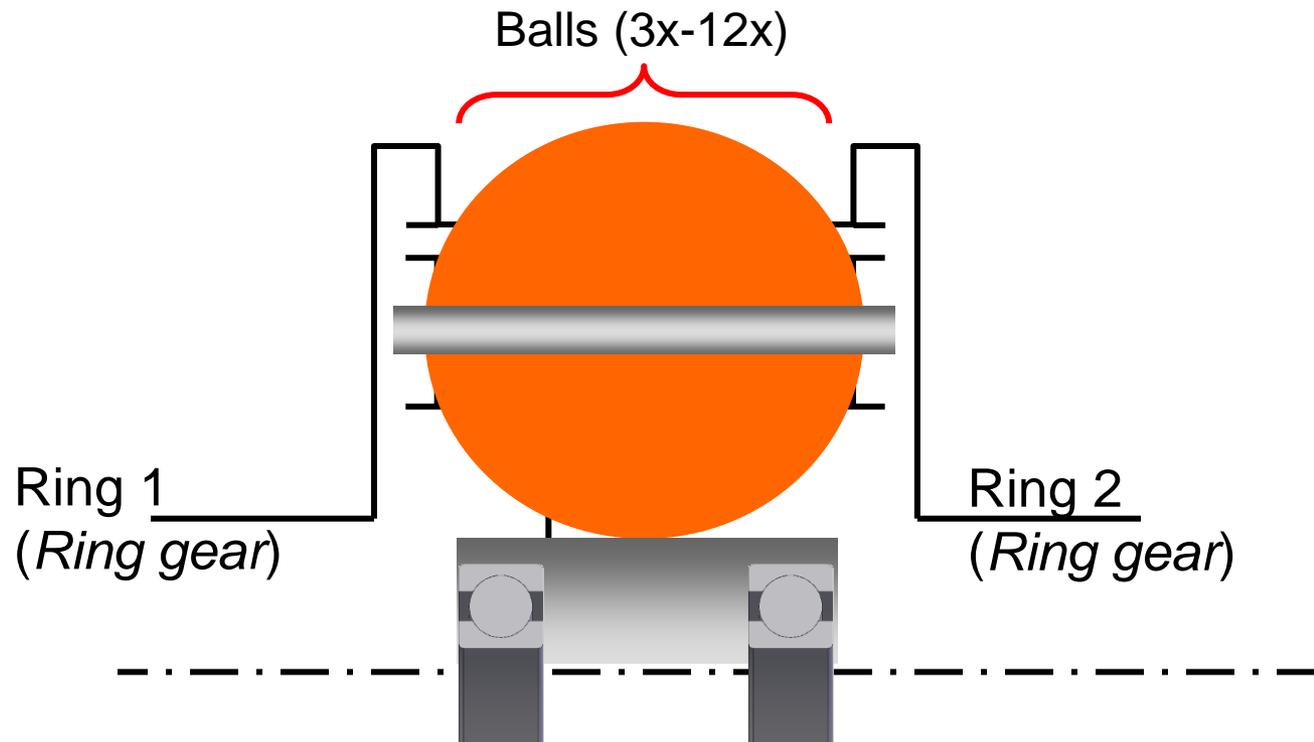
NuVinci® Planetary Analogy

NuVinci CVP Basic Elements



NuVinci Planetary Analogy

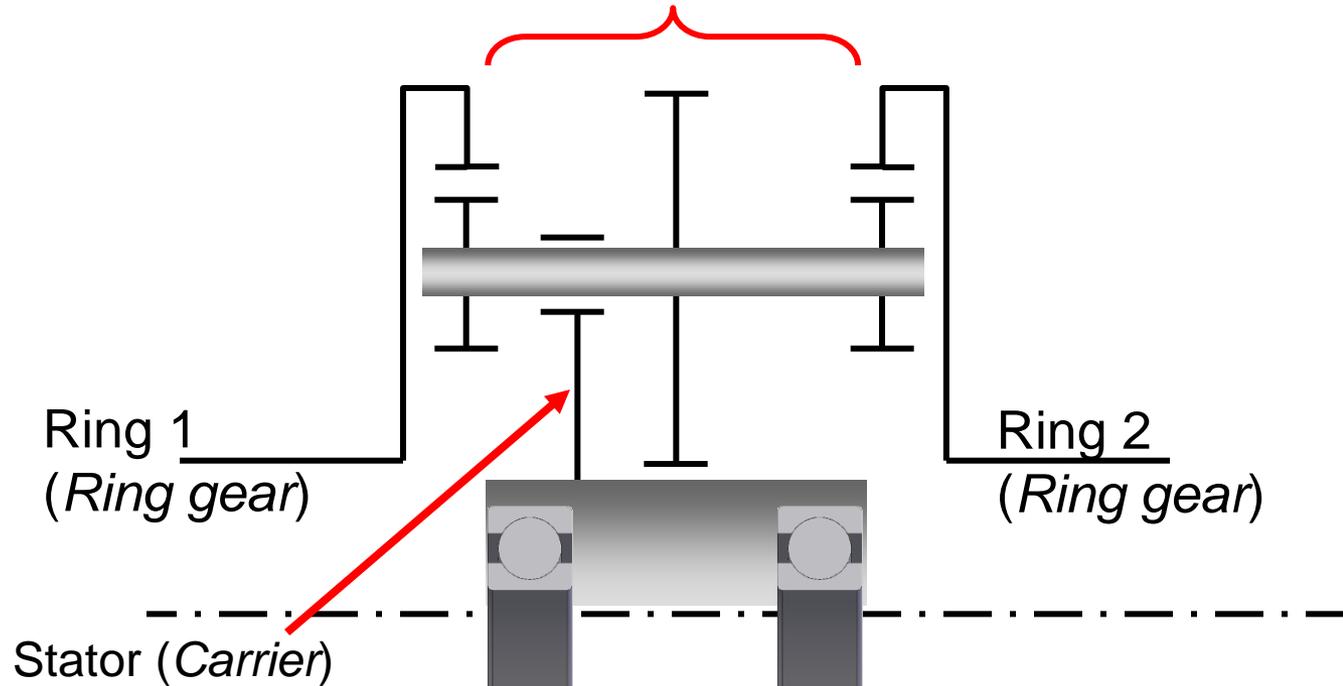
Draw a Kinematic “Stick Figure” of *NuVinci*



NuVinci Planetary Analogy

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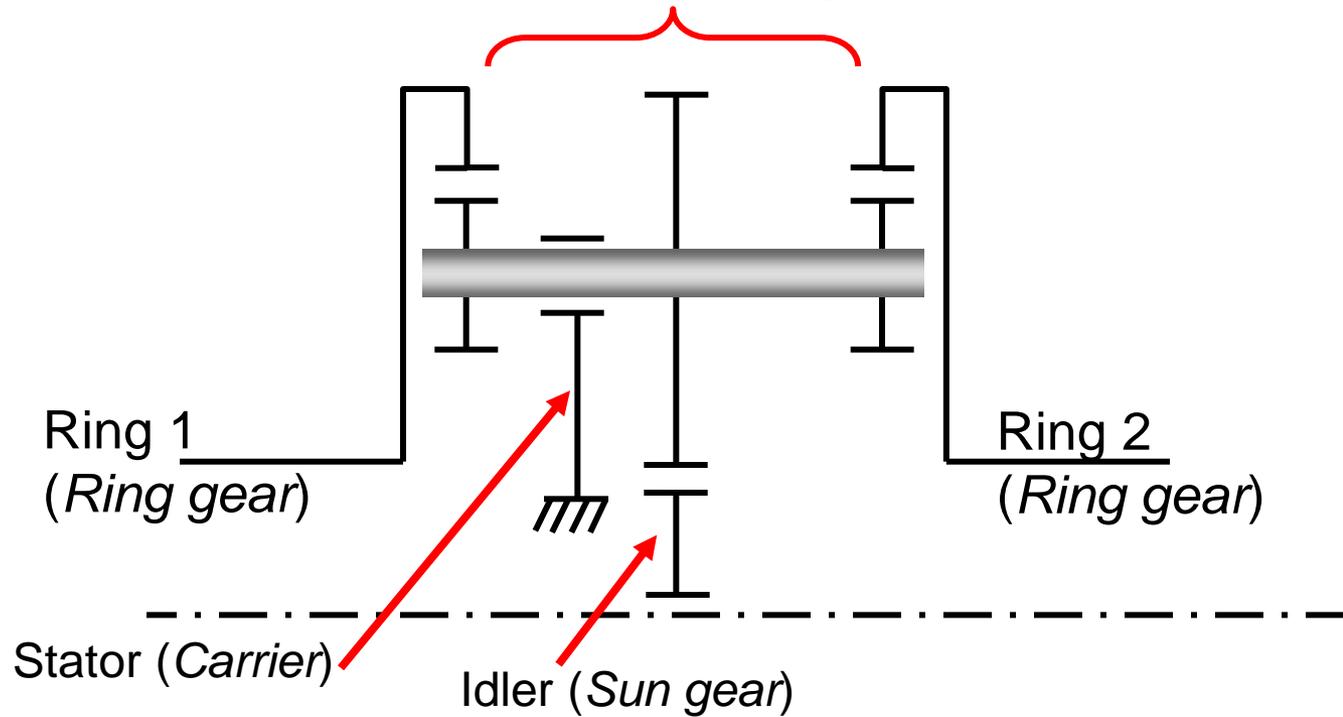
Balls = Planet Gear w/ 3 Major Diameters



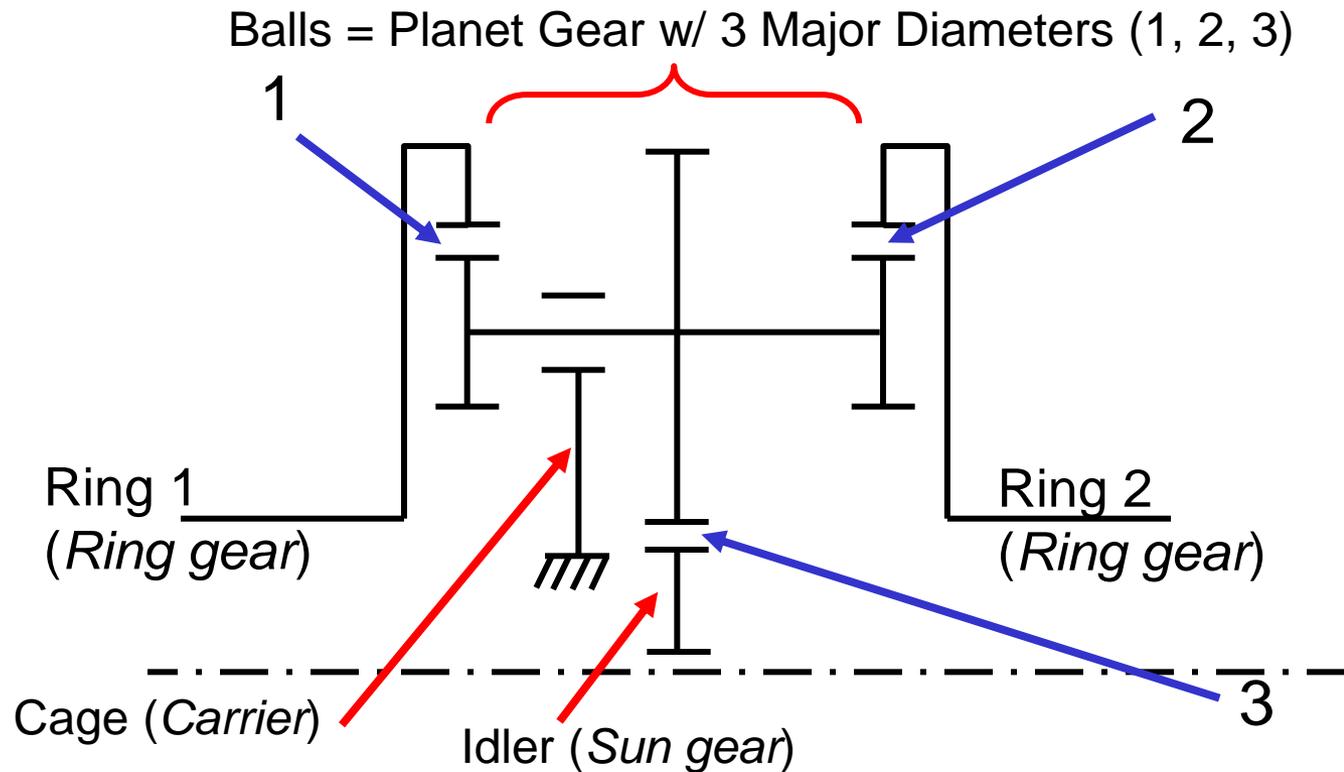
NuVinci Planetary Analogy

Draw a Kinematic “Stick Figure” of *NuVinci*

Balls = Planet Gear w/ 3 Major Diameters

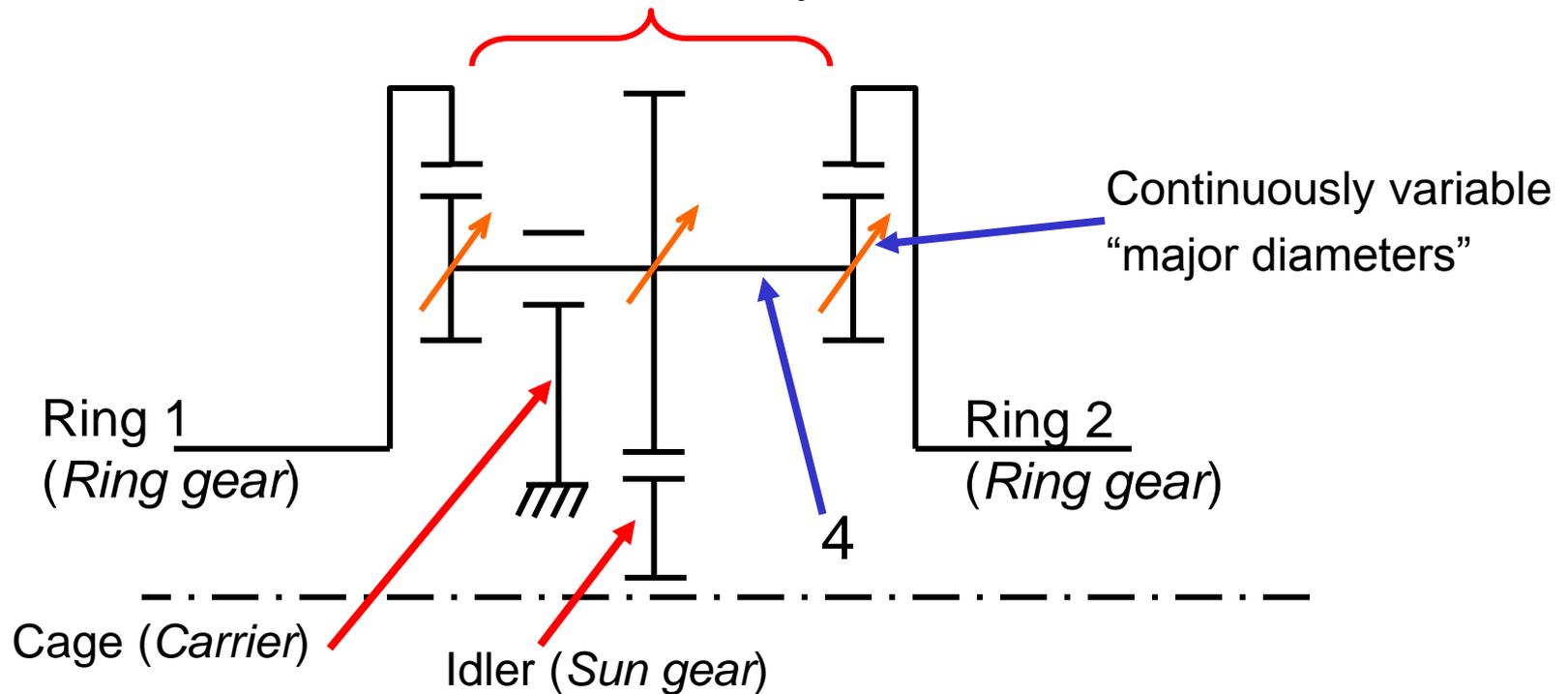


The Continuously Variable Planetary (CVP) Emerges



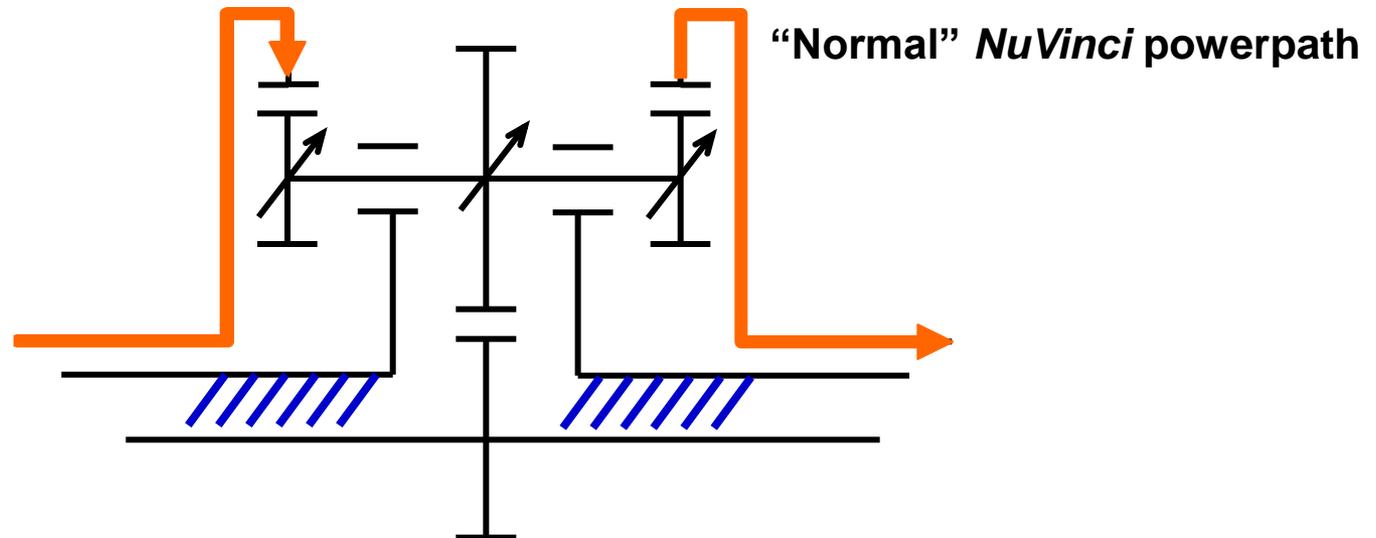
Tilting the Ball Axle (4) Enables Continuously Variable Planet “Gear” Major Diameters

Balls = Planet Gear w/ 3 Major Diameters



NuVinci Planetary Analogy

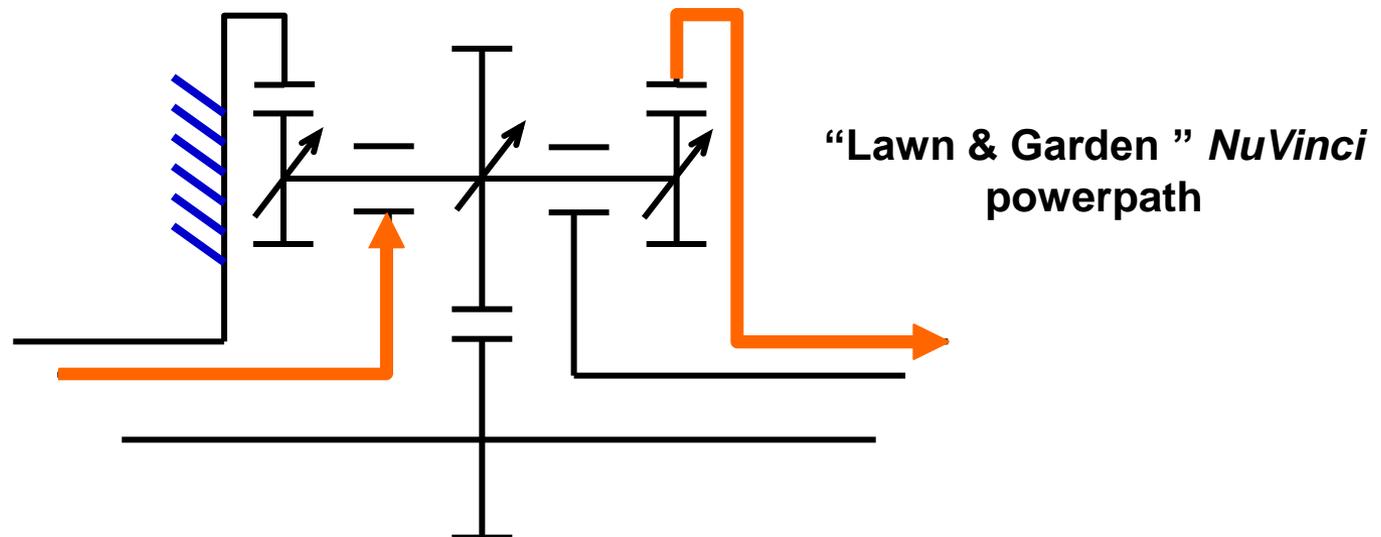
- **NuVinci's unique planetary kinematics are ideally suited for hybrid vehicles, where more than one prime mover is used**



- **NuVinci's unique planetary kinematics also enable it to be the only variator that can be both a CVT and an IVT without the use of additional mechanical power paths**

NuVinci Planetary Analogy

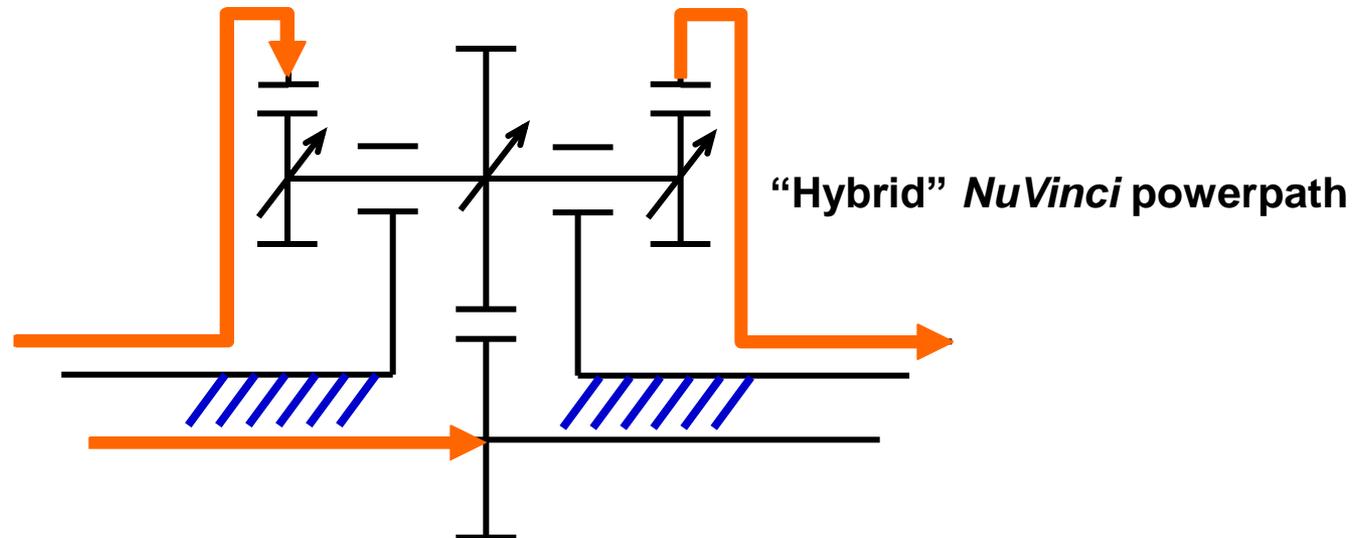
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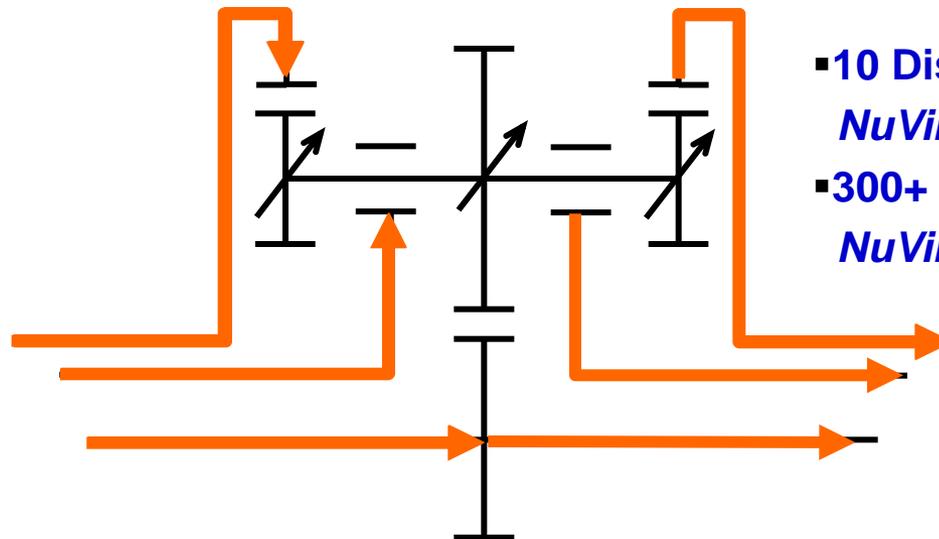
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NuVinci Planetary Analogy

- **NuVinci's** unique planetary kinematics are ideally suited for hybrid vehicles, where more than one prime mover is used



- 10 Discrete options with *NuVinci* alone
- 300+ Discrete options with *NuVinci* + geared planetary

- **NuVinci's** unique planetary kinematics also enable it to be the only variator that can be both a CVT and an IVT without the use of additional mechanical power paths

Summary of *NuVinci* Advantages

- **Standard precision shapes – low manufacturing costs**
- **Planetary configuration**
 - High torque density
 - Flexible packaging – *NuVinci* can package in applications where others can't
 - Flexible powerpaths – IVT and CVT from the same set of parts
 - Excellent durability
 - Usable as a single cavity – allows use of the CVP as one element in a planetary transmission
- **Stable, simple position-based control**
- **Does not need expensive, inefficient hydraulic controls for clamping**