# Power-Split Hybrid: Planetary Speeds and Torques

Speeds and torque split of a power-split hybrid's planetary gear (engine on carrier, generator on sun, wheels on ring) for an engine point and road speed.

**Method:** Planetary gear kinematics (Willis equation) and torque split

## Input parameters

Unit system: SI

| Parameter | Value | Unit |
|---|---|---|
| Sun gear teeth | 30.000 | |
| Ring gear teeth | 78.000 | |
| Engine (carrier) speed | 2,000.0 | rpm |
| Engine torque | 110.00 | N·m |
| Vehicle speed | 60.000 | km/h |
| Ratio from ring gear to wheels | 4.1100 | |
| Tyre rolling radius | 310.00 | mm |

## Calculated results

| Parameter | Value | Unit |
|---|---|---|
| Ring gear speed | 2,110.1 | rpm |
| Sun gear (generator) speed | 1,713.8 | rpm |
| Torque to the ring (wheels) | 79.444 | N·m |
| Torque on the sun (generator) | 30.556 | N·m |
| Generator power (positive = generating) | 5.4837 | kW |
| Mechanical power to the ring | 17.555 | kW |

### Notes for this case

• In a power-split hybrid the engine drives the planet carrier, the generator sits on the sun and the wheels (with the traction motor) on the ring. The speeds obey the planetary relation Z_s n_s + Z_r n_r = (Z_s + Z_r) n_c, so for a given road speed the generator speed sets the engine speed, giving a continuously variable ratio. The engine torque divides in fixed proportions: Z_r/(Z_s + Z_r) to the ring and Z_s/(Z_s + Z_r) reacted by the generator. Generator power returns to the motor electrically; a negative value means the generator is motoring (at high road speed).

## Formula and method

$$Z_s n_s + Z_r n_r = (Z_s + Z_r) n_c, \quad T_r = T_e \frac{Z_r}{Z_s + Z_r}, \quad T_s = T_e \frac{Z_s}{Z_s + Z_r}$$

### Variables

| | | |
|---|---|---|
| $Z_s$ | Sun gear teeth | - |
| $Z_r$ | Ring gear teeth | - |
| $n_e$ | Engine (carrier) speed | rad/s |
| $T_e$ | Engine torque | N·m |
| $v$ | Vehicle speed | m/s |
| $i_f$ | Ratio from ring gear to wheels | - |
| $r$ | Tyre rolling radius | m |
| $n_r$ | Ring gear speed | rad/s |
| $n_s$ | Sun gear (generator) speed | rad/s |

| | | |
|---|---|---|
| $T_r$ | Torque to the ring (wheels) | N·m |
| $T_s$ | Torque on the sun (generator) | N·m |
| $P_s$ | Generator power (positive = generating) | W |
| $P_r$ | Mechanical power to the ring | W |

### Method and standards

Power split.

### Assumptions and limits

- Ideal gears; steady speeds; no losses.

### References

Planetary gear kinematics (Willis equation) and torque split

## Report details

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|---|---|
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| Release checks | 3 reference cases of this calculator, computed independently, are checked on every release |

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

### This calculator online

https://calc.firecad.com/automotive/transmission/hybrid-power-split-speeds

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.