■MG1, MG2, AND MGR

1. General

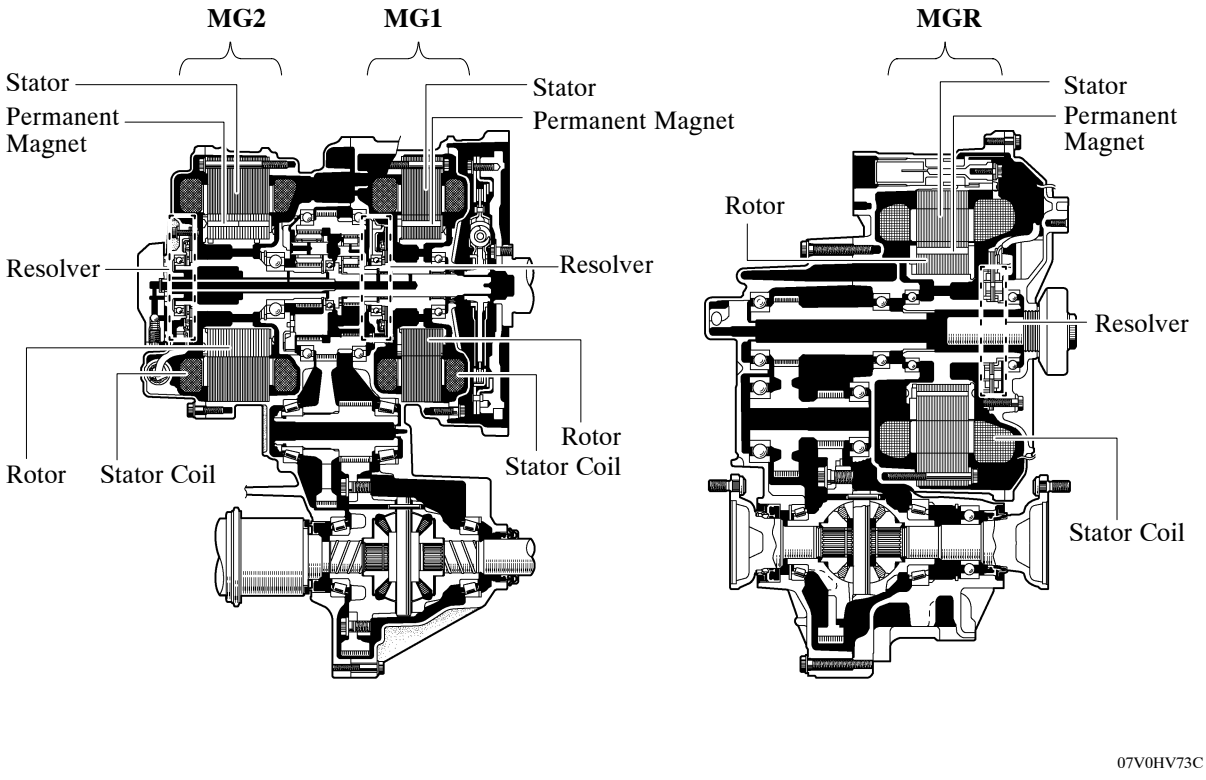
- MG1, MG2, and MGR are compact, lightweight, and highly efficient alternating current permanent magnet motors.
- When a three-phase alternating current is passed through the three-phase windings of the stator coil, a rotating magnetic field is created in the electric motor. By controlling this rotating magnetic field according to the rotor's rotational position and speed, the permanent magnets that are provided in the rotor become attracted by the rotating magnetic field, thus generating torque.
- The generated torque is for all practical purposes proportional to the amount of current, and the rotational speed is controlled by the frequency of the alternating current.
- Furthermore, a high level of torque, all the way to high speeds, can be generated efficiently by properly controlling the relationship of the rotating magnetic field to the angle of the rotor magnets.
- When the motor is used to generate electricity, the rotation of the rotor creates a rotating magnetic field, which creates current in the phases of the stator coils.

2. Specifications

Motor Generator	MG1	MG2	MGR
Type	Permanent Magnet Motor	Permanent Magnet Motor	Permanent Magnet Motor
Function	Generate, Engine Starter	Generate, Drive Front Wheels	Generate, Drive Rear Wheels
Maximum System Voltage	DC 650V	DC 650V	DC 650V
Maximum Output	-	123 kW (165 HP)	50 kW (67 HP)
Maximum Torque	-	333 N·m (246 ft·lbf)	130 N·m (96 ft·lbf)
Cooling System	Water-cooled	Water-cooled	Air-cooled

3. Construction

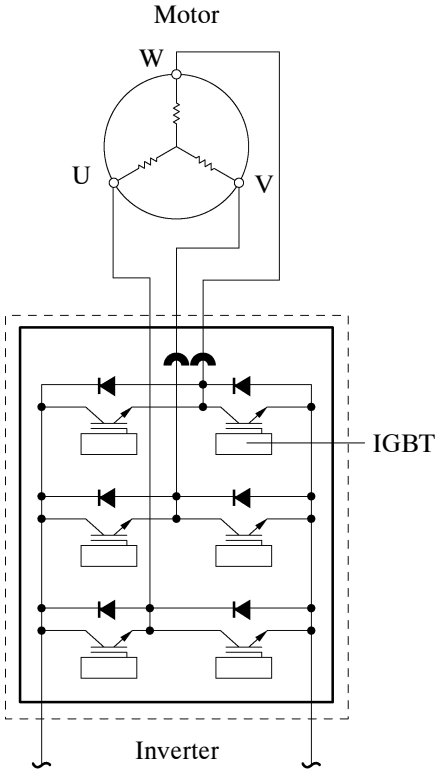
MG1, MG2, and MGR consist of a stator, stator coil, rotor, permanent magnets, and a resolver.

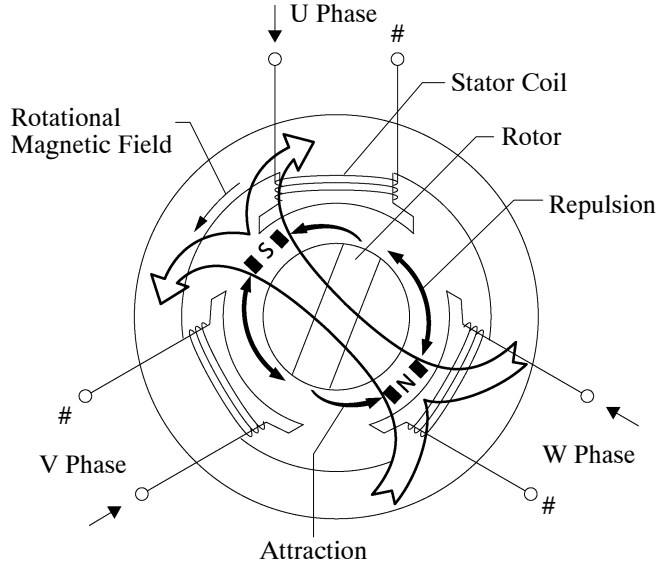


Hybrid Transaxle **Rear Drive Unit**

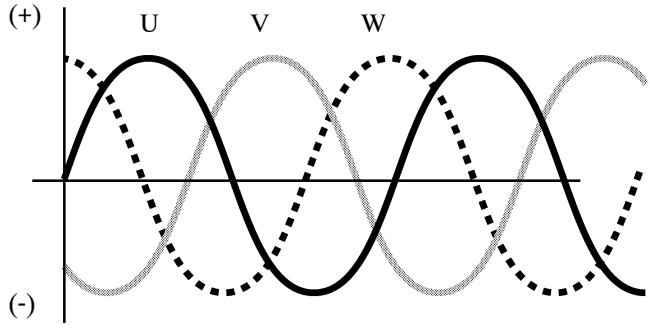
4. Function of MG1, MG2 and MGR

- MG1 (Motor Generator 1) charges the HV battery and supplies electrical power to drive MG2 and MGR. In addition, by regulating the amount of electrical power generated (thus varying the generator's rpm), MG1 effectively controls the continuously variable transmission function of the transaxle. MG1 also serves as the starter to start the engine.
- MG2 (Motor Generator 2) drives the front wheels using electric power from MG1 or the HV battery. In addition, it acts as generator when decelerating to charge the HV battery.
- MGR (Motor Generator Rear) is provided in the rear drive unit. MGR, which is powered by electricity from MG1 or the HV battery, drives the rear wheels in accordance with the driving conditions, thus realizing excellent driving stability. During deceleration, MGR and MG2 function as generators, charging the HV battery as needed.
- When a three-phase alternating current is passed through the three-phase windings of the stator coil, a rotating magnetic field is created in the electric motor. By controlling this rotating magnetic field according to the rotor's rotational position and speed, the permanent magnets that are provided in the rotor become attracted by the rotating magnetic field, thus generating torque.
- The generated torque is for all practical purposes proportional to the amount of current, and the rotational speed is controlled by the frequency of the alternating current.
- Furthermore, a high level of torque, all the way to high speeds, can be generated efficiently by properly controlling the relationship of the rotating magnetic field to the angle of the rotor magnets.





#: Connected internally in the motor



Three-phase Alternating Current Output Waveforms

07V0HV12C

5. Resolver

- A resolver is an extremely reliable and compact sensor that precisely detects the magnetic pole position. Knowing the precise position of the magnetic poles of the motor rotor is indispensable for ensuring efficient control of MG1, MG2 and MGR. MG1, MG2 and MGR each have their own resolver.
- The stator of the resolver contains three types of coils: excitation coil A, detection coil S, and detection coil C.
- The rotor of the resolver is oval, the distance of the gap between the stator and the rotor varies with the rotation of the rotor.
- The flow of alternating current into excitation coil A results in the creation of a constant frequency magnetic field. Using this constant frequency magnetic field, coil S and coil C will output values that correspond to the position of the rotor. Therefore, the MG ECU detects the absolute position based on the difference between the coil S and coil C output values. Furthermore, the MG ECU calculates the rotational speed based on the amount of change in the position within a given length of time.
- The +S and -S pairs of the S detection coil are staggered by 90 degrees. The +C and -C pairs are also staggered in the same way. The C and S pairs of coils are located 45 degrees from each other.
- The detection coils have an electrical orientation as shown below.

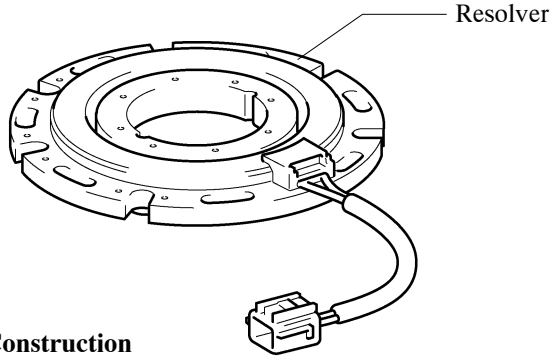
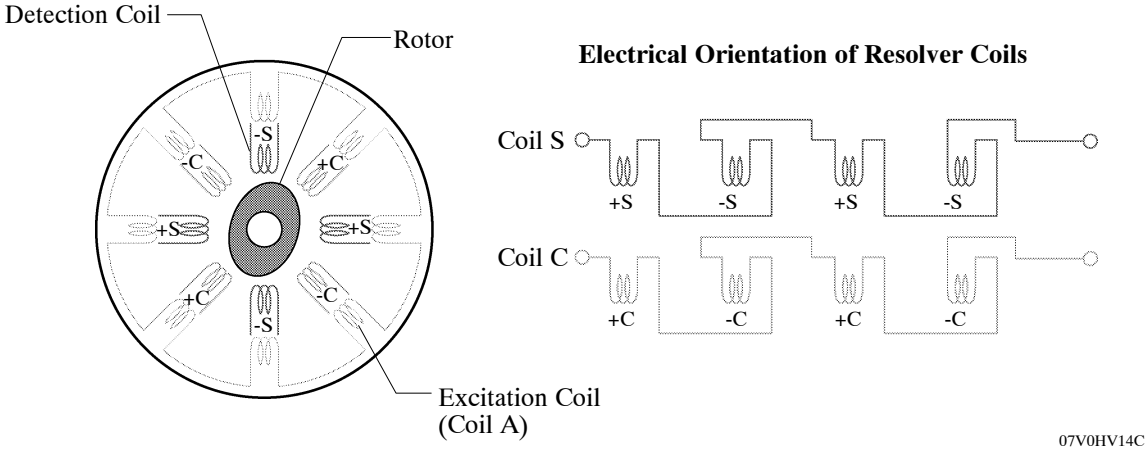


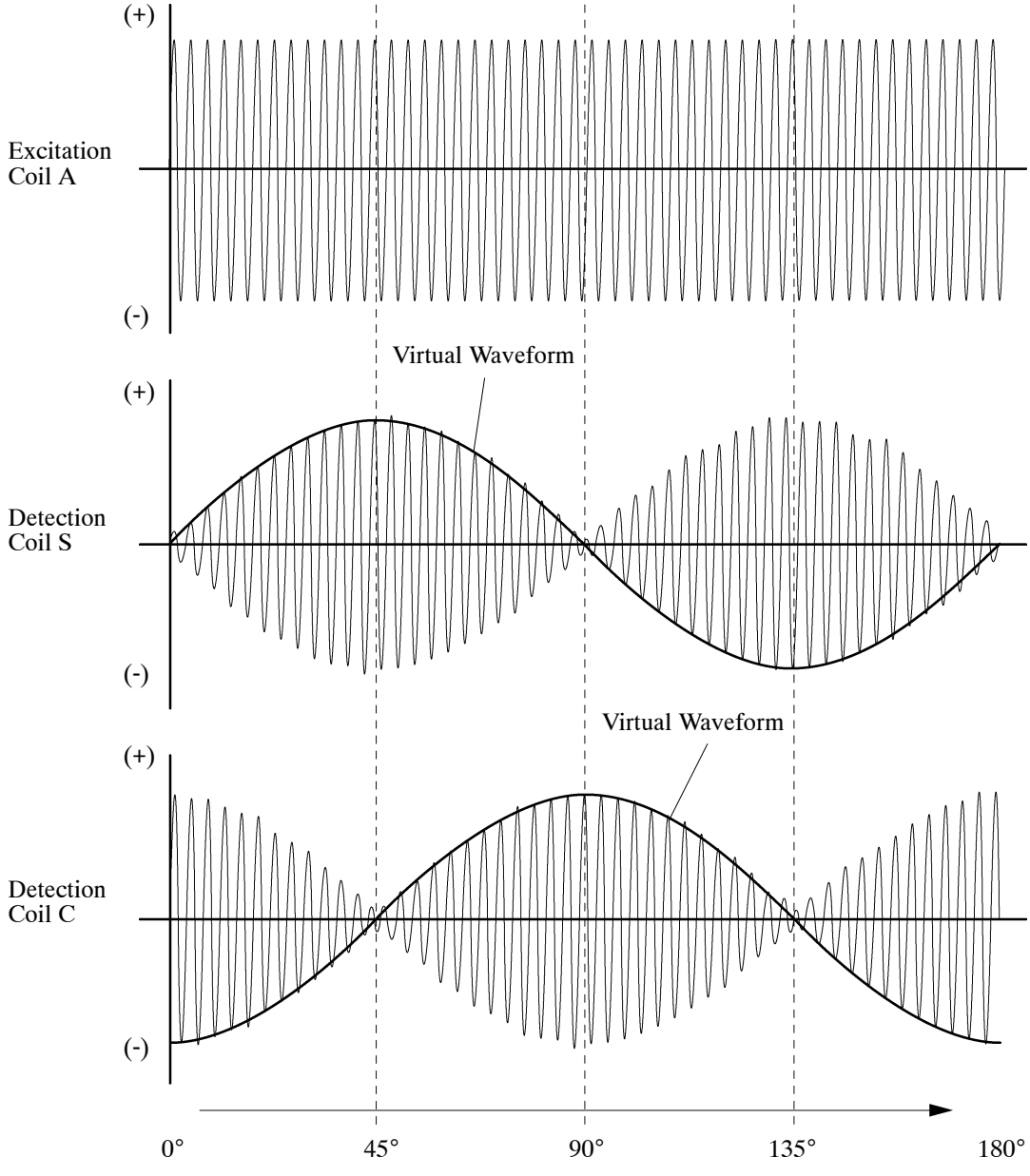
Image of Resolver Internal Construction



Electrical Orientation of Resolver Coils

07V0HV14C

- Because the excitation coil of the resolver is provided with alternating current at a constant frequency, a constant frequency magnetic field is output to coils S and C, regardless of rotor speed. The magnetic field of the excitation coil is carried to coils S and C by the rotor. The rotor is oval, and the gap between the stator of the resolver and the its rotor varies with the rotation of the rotor. Due to the variation of the gap, the peak values of the waveforms output by coils S and C vary in accordance with the position of the rotor.
- The MG ECU constantly monitors these peak values, and connects them to form a virtual waveform. The MG ECU calculates the absolute position of the rotor from the difference between the values of the coils S and C. It determines the rotor direction based on the difference between the phases of the virtual waveform of the coil S and the virtual waveform of the coil C. Furthermore, the MG ECU calculates the rotational speed based on the amount of change in the rotor position within a given length of time.
- The diagrams below illustrate the waveforms that are output at coils A, S, and C when the rotor makes a rotation of 180°.

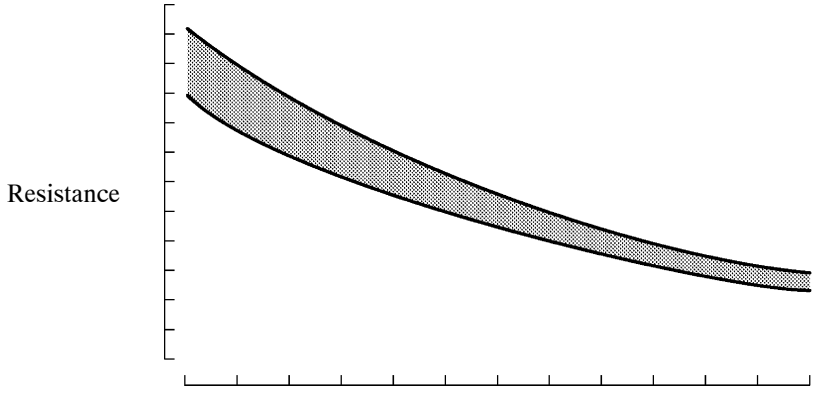


07V0HV15C

6. Temperature Sensor

- Temperature sensors are used to detect the temperature of the motor stators.
- When the temperature of a motor rises, motor output is limited.
- The temperature sensor thermistor resistance changes according to the change of motor temperature. The resistance of the thermistor is high when the temperature of the motor is low. Conversely, when the motor temperature is high, the thermistor resistance will be low.

Characteristics of Temperature Sensor



07V0HV16C