Introduction

Hybrid vehicle technology has grown rapidly over the last decade because of its fuel efficiency and low emissions. Today’s hybrid systems are more sophisticated than conventional engines and leverage the best operating characteristics of the combustion engine and electric motor based on driving conditions. This helps to achieve superior fuel efficiency and reduce CO₂ emissions.

An Overview of Critical Hybrid Connections

Conventional engine vehicles operate between 12 to 14 V to activate the combustion engine. The use of hybrid technology adds a high-voltage system and expands the operating voltage to as high as 650 V to power the electric motor in the hybrid vehicle. The high-voltage (HV) system includes the HV battery, inverter assembly, and the motor generators. These elements are connected using an HV power cable, which is color-coded in orange to easily distinguish it from regular cables. An insulation resistance test is performed to check the integrity of the HV power cable between the HV battery and the inverter system, and between the inverter and motor generator.

Hybrid System Components

The hybrid system consists of the following main components:
- Gasoline engine – Powers the wheels during normal and accelerated driving
- Motor generators (MG) – Generates electrical power and recharges the HV battery
- Inverter system – Converts the high DC voltage (HV battery) to AC (MG) and vice versa
- HV batteries – Supplies electric power to the motor generator during start-off, low speed, acceleration, and uphill driving
Testing the Insulation Resistance of the HV Power Cable in a Hybrid Vehicle’s HV System

Before measuring insulation resistance, it is important to ensure that the HV system is shut down. This is done by conducting a voltage test. Since exposure to any leakage in the HV system’s high-voltage insulation may be harmful, technicians use personal protective gear during the testing process, such as insulating gloves, safety glasses, and safety footwear.

An insulation resistance test is conducted according to the test voltage recommended by the vehicle’s manufacturer. The test result is then compared with the recommended acceptance insulation resistance value. Further investigation is carried out if the insulation resistance value for the power cable is found below the defined limit. A low resistance value will be displayed if there is leakage or a puncture in the HV power cable. Sometimes contamination or moisture in the HV battery assembly or the inverter assembly can result in a low insulation resistance reading.

Keysight U1450A/U1460A Series Insulation Resistance Testers

The U1450A/U1460A Series insulation resistance tester can detect if voltage is present at the input terminal of the insulation mode before the insulation test is initiated. If external voltage is detected and is greater than the default limit, 30 V (or 50 or 75 V, depending on the voltage selection in the setup mode), the insulation test will be prohibited. This additional precautionary feature safeguards the service technician by detecting the undesired voltage present in the test connection before turning on the insulation resistance test. The insulation resistance tester auto-discharges the device under test when the test is completed. This further simplifies insulation testing and enables the service technicians to achieve higher productivity.

Summary

The hybrid vehicle uses a high-voltage system, which requires service technicians to constantly adhere to all the safety precautions and be cautious of voltage present in the HV system. The Keysight U1450A/U1460A Series insulation resistance tester now includes a built-in digital multimeter. This two-in-one functionality allows technicians to use a single device to perform the basic electrical measurement, followed by the insulation resistance test. This saves time and minimizes the pieces of equipment needed by the technician.