Electric Drive Vehicle Career and Technical Education Training (Secondary)

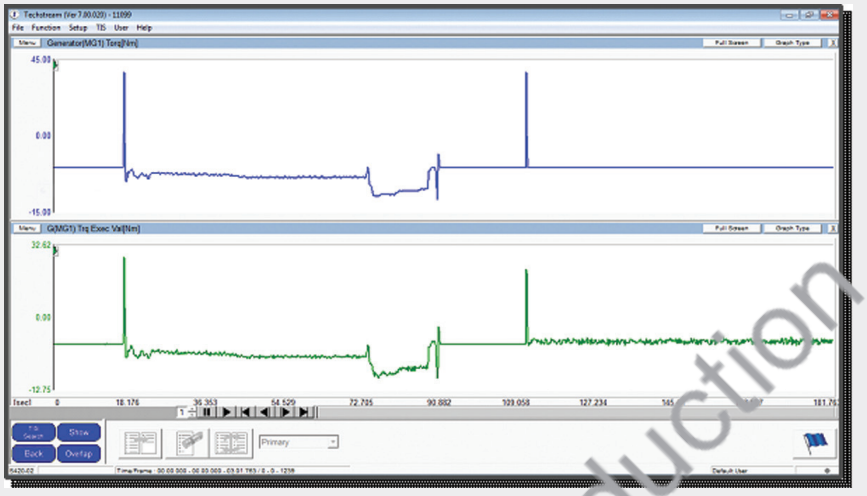
Hybrid Electric Vehicles | Plug-in Hybrid Electric Vehicles | Battery Electric Vehicles | Fuel Cell Electric Vehicles

Instructor's Manual

National Alternative Fuels Training Consortium

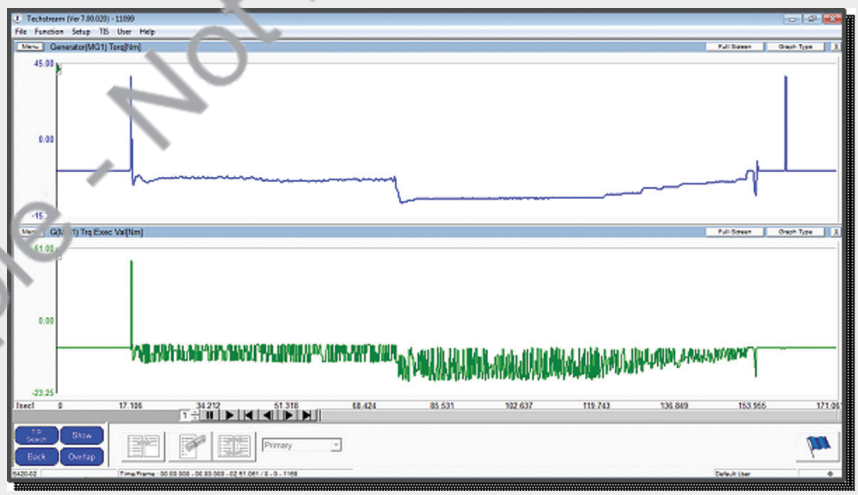
A Program of

West Virginia University



Some hybrid and electric vehicles monitor commanded motor-generator torque as well as actual motor-generator torque, and include that data in their datastreams.

Depending on the refresh rate of the datastream, the technician may be able to compare commanded torque to actual torque, and determine whether or not a motor-generator can produce the torque that is commanded by the hybrid control system, by way of the inverter. If not, an electrical or mechanical motor-generator issue may be indicated.



The first capture compares commanded torque to actual torque for a known good vehicle. The second capture compares commanded torque to actual torque for a vehicle that had set a DTC for an inverter or motor-generator performance issue. The scan data shows that the motor-generator was unable to accurately respond to the torque command. Upon inspection, a loose motor-generator cable terminal was found. The terminal was torqued to specifications, solving the issue. 2011 Toyota Prius scan data shown. Images courtesy NAFTC.

Some inverter data, if available, will be relevant to motor operation, such as:

- Output voltage
- Phase currents
- Inverter processor temperature
- Inverter coolant temperature

If the vehicle is a parallel hybrid, in which the motor-generator rotates exclusively in the same direction as the vehicle's engine, a positive torque value will usually indicate motor action, while a negative torque value will usually indicate generator action. Generally, motor-generator speed will not be described in positive or negative terms: a motor-generator, as used in most parallel hybrids, can only turn in one direction.

If, however, the vehicle is a series-parallel hybrid or an electric vehicle, in which at least one motor-generator can rotate in two directions, the technician may be called upon to distinguish between the two directions of rotation, as well as between motor and generator action. This can be done by comparing a motor-generator's RPM with its torque output, as follows.

RPM: Positive RPM (e.g. 2412 RPM, or +2412 RPM) is the direction of rotation that propels the vehicle forward. In a series-parallel hybrid, it is usually also the engine's direction of rotation. Negative RPM (e.g. -2412 RPM) is the direction of rotation that propels the vehicle in reverse.

Torque: Depending on the direction in which the motor-generator is rotating, torque can describe motor action, or generator action. If, for example, the direction in which torque is applied is the same direction as the direction of rotation, then the motor-generator is acting as a motor. For example, a motor-generator rotating at -1400 RPM and producing -52Nm of torque is functioning as a motor. A motor-generator rotating at +1400 RPM and displaying +52Nm of torque is also functioning as a motor.

Note:

In each example, the motor-generator's rotation is described using the same sign (+ or –) as the force applied at the motor-generator.

If, however, the + or – signs of the motor-generator's speed and torque PIDs don't match, the motor-generator is functioning as a generator, as force is being applied in the opposite direction to the direction of rotation. A motor-generator that is rotating at +782 RPM with a torque of –24Nm is therefore operating as a generator.

Not all vehicle manufacturers use the above conventions to indicate motor action and/or generation action. Information on a particular vehicle's scan data parameters can be found in OEM service information.

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10.6.1 Motor-generator faults

Motor-generators are typically monitored and tested by a hybrid or electric vehicle's on-board self-diagnostic system. If the system detects an issue that exceeds a predetermined threshold, a DTC is set, and a freeze frame is stored. The freeze frame contains information on the behavior of the system at roughly the time the fault was detected.

Most vehicle manufacturers use a mix of generic and manufacturer-specific codes for hybrid and electric vehicle powertrains. Some manufacturers may also include proprietary information (detail) codes that define the problem beyond the parent code's description. Some DTCs indicate a fault that may be present in the motor, the inverter, or elsewhere altogether. In such cases, the technician must pinpoint and confirm the root case of the fault.

A vehicle's powertrain control system may respond to a motor-generator issue by taking one or more actions, such as:

- Turning on the vehicle's MIL and/or a master warning light
- Displaying a warning message to the driver on an information screen
- Reducing power output from the vehicle's electric drive system
- (Hybrid only) Increasing engine speed and output
- Inhibiting all power output from the vehicle's electric drive system
- Shutting down the powertrain (READY is OFF)

10.7.1 Testing stator windings

As a supplement to a hybrid or electric vehicle's self-diagnostic tests, some vehicle manufacturers will direct the technician to perform measurements on a motor-generator's stator windings. Such measurements may include:

- Phase-to-phase stator winding resistance
- Insulation resistance between stator coils and component ground
- Insulation resistance between motor cables and cable shielding

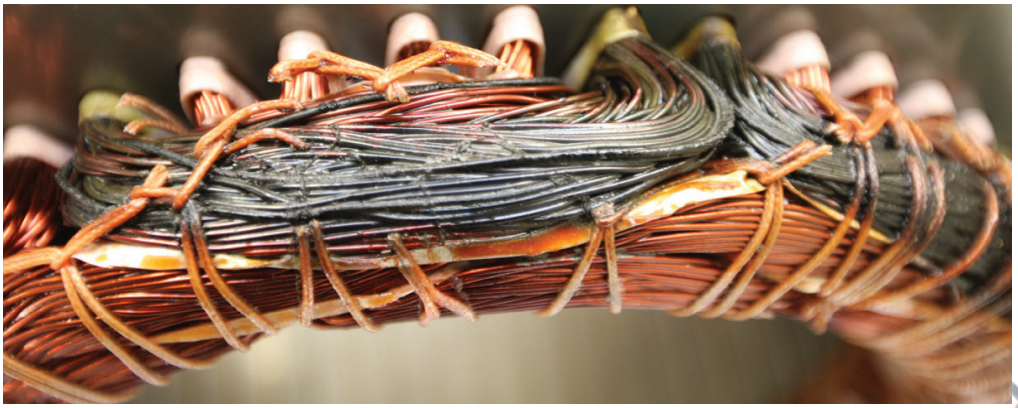

Figure 10.7.1: Although a stator winding fault technician must be able to diagnose a failed motor-generator component without disassembling the transaxle. Image courtesy Richard Young.

10.7.2 Measuring phase-to-phase stator winding resistance

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Figure 10.7.2: Phase-to-phase stator winding resistance is measured with a milliohmmeter, which can measure resistances of less than one ohm. Image courtesy Amprobe.

A motor-generator's stator winding insulation may deteriorate, creating a short circuit within a phase or between two phases. This will typically cause a hybrid or electric vehicle's control system to set a diagnostic trouble code (DTC) for a fault (for example, excessive motor current). As it is usually cost-prohibitive to remove and disassemble a hybrid or electric vehicle's transaxle to diagnose a fault, the technician may be called upon to diagnose it without disassembling the transaxle or transmission that encloses it.

Although such a fault can sometimes be confirmed by comparing the motor's phase resistances, motor-generator stator windings are normally wound in a wye configuration, with no accessible neutral terminal. This prevents the technician from measuring the resistance of a single phase. To measure winding resistance, the technician must access the motor-generator's three cable terminals and make resistance measurements between each of the motor's three **phase pairs**.