2011 Chevrolet Volt

Advanced Vehicle Testing – Baseline Testing Results



VEHICLE SPECIFICATIONS[1]

Vehicle Features
Base Vehicle: 2011 Chevrolet Volt
VIN: 1G1RD6E48BUI00815
Class: Compact
Seatbelt Positions: 4
Type[2]: Multi-Mode PHEV (EV, Series, and Power-split)

Motor
Type: 12-pole permanent magnet AC synchronous
Max. Power/Torque: 111 kW/370 Nm
Max. Motor Speed: 9500 rpm
Cooling: Active – Liquid cooled

Generator
Type: 16-pole permanent magnet AC synchronous
Max. Power/Torque: 55 kW/200 Nm
Max. Generator Speed: 6000 rpm
Cooling: Active – Liquid cooled

Battery
Manufacturer: LG Chem
Type: Lithium-ion
Cathode/Anode Material: $LiMn_2O_4$/Hard Carbon
Number of Cells: 288
Cell Config.: 3 parallel, 96 series
Nominal Cell Voltage: 3.7 V
Nominal System Voltage: 355.2 V
Rated Pack Capacity: 45 Ah
Rated Pack Energy: 16 kWh
Weight of Pack: 435 lb
Pack Location: Underneath vehicle center
Cooling: Active – Liquid cooled

Engine
Model: DOHC I-4
Output: 63 kW @ 4800rpm
Configuration: Inline 4-Cylinder
Displacement: 1.4 L
Fuel Tank Capacity: 9.3 gal
Fuel Type: Premium gasoline

Weights
Design Curb Weight: 3,781 lb
Delivered Curb Weight: 3,782 lb
Distribution F/R (%): 61/39
GVWR: 4,548 lb
GAWR F/R: 2,515/2,033 lb
Max. Payload: 750 lb
Performance Goal: ≥400 lb

Dimensions
Wheelbase: 105.7 in
Track F/R: 61.2 / 62.1 in
Length/Width: 177.1 in/70.4 in
Height: 56.6 in
Ground Clearance: 6.0 in
Performance Goal: ≥6.0 in

Tires
Manufacturer: Goodyear
Model: Assurance
Size: P215/55R17
Pressure F/R: 35/35 psi
Spare Installed: N/A - Tire sealant and inflator

CHARGE-DEPLETING PERFORMANCE STATISTICS[3,4]

Charge-Depleting Acceleration 0-60 mph[5]

Measured Time: 9.8 s

Performance Goal: ≤13.5 s

Peak power from battery: 111.8 kW

Charge-Depleting Maximum Speed

At ¼ Mile: 80.7 mph

At 1 Mile[6]: 101.4 mph

Performance Goal: ≥90 mph at one mile mark

Charge-Depleting Braking from 60 mph[7]

Measured Time: 3.1 s

Distance: 131 ft

Peak power into battery: 26.7 kW

Change in battery SOC: No change

Charge-Depleting Deceleration from 60 mph[8]

Distance: 3,920 ft

Peak power into battery: 10.2 kW

Change in battery SOC: 0.3%

Charge-Depleting Gradeability (Calculated)[9]

Maximum Speed @ 3% Grade: 98.0 mph

Performance Goal: ≥55 mph

Maximum Speed @ 6% Grade: 87.2 mph

Performance Goal: ≥45 mph

Maximum Grade: 43.1%

Performance Goal: ≥25% Grade

Charge-Depleting Dynamometer Results w/o Accessories

Fuel Economy[10]: N/A

Electricity Consumption Rate[10]: 236.3 DC Wh/mi

UDDS Driving Range[10]: 44.5 mi

HWFET Driving Range[10]: 41.9 mi

Charge-Depleting Dynamometer Results w/ Accessories[12]

Fuel Economy[10]: N/A

Electricity Consumption Rate[10]: 270.8 DC Wh/mi

UDDS Driving Range[11]: 38.8 mi

HWFET Driving Range[11]: 36.6 mi

NOTES (also from previous page):

1. Vehicle specifications were either supplied by the manufacturer or derived from a literature review.
2. The powertrain of this vehicle has multiple configurations, which allows the vehicle to operate in various modes to maximize fuel economy and/or performance under different conditions and driver demands.
3. Vehicle track testing occurs when the vehicle has achieved its "break-in mileage" of between 4,000 to 6,000 miles, and at the delivered curb weight plus 332 ± 10 lb (including driver and test equipment), distributed in a manner similar to the original curb loading of the vehicle. Coastdown testing began on June 23, 2011 with an odometer reading of 5,860 miles and ambient temperatures between 96 °F to 100 °F. Dynamometer testing began on September 12, 2011 with the vehicle odometer reading 6,144 miles. A comprehensive explanation of the dynamometer facility and methodology can be found at http://www.transportation.anl.gov/D3/, titled "Chassis Dynamometer Testing Reference Document". The ABC coefficients derived from track coastdown testing and matched on the dynamometer were A: 31.7925 lb, B: 0.1544 lb/mph, and C: 0.0164 lb/mph^2. The remainder of the track testing took place between February 6-13, 2013, with a beginning vehicle odometer reading of 7,845 miles and ambient temperature ranging from 55 °F to 70 °F for this testing.
4. Performance numbers based on "Normal" vehicle mode and SAE J1711 methodology, including Cold Start UDDS, Hot Start UDDS, and HWFET cycles. Performance numbers are averages from multiple tests.
5. The acceleration is measured from the point at which the vehicle begins to move. The acceleration and maximum speed testing results were averaged from 6 runs in which the vehicle state of charge (SOC) was at 77.8%, 71.4%, 64.7%, 58.7%, 51.5%, and 44.8%, respectively, at the beginning of the accel event.
6. The maximum speed was reached before the one-mile mark.
7. Controlled braking on dry surface. Brake data for CD mode only. The brake testing results averaged from two runs in which the vehicle SOC was at 29.0% and 32.5%, respectively, at the beginning of the brake event.
8. Coasting in drive on dry surface. The deceleration testing results were averaged from 6 runs in which the vehicle SOC was at 33.9%, 30.4%, 26.2%, 46.3% and 42.1%, respectively, at the beginning of the deceleration event. Test run data were cut off when the vehicle reached 5 mph, which is approximately the creep speed in drive.
9. Gradeability calculations use acceleration test data to derive the gradeability values.
10. No fuel is used in charge-depleting mode. Fuel Economy and Electricity Consumption Rate are calculated using SAE J1711 methodology.
11. Range without accessories is measured by conducting multiple, consecutive drive cycles until charge-depleting mode is exited and charge-sustaining mode is entered. No ranges for the cycles with accessories were measured; the values for range with accessories are estimates based on range without accessories data.
12. Accessories represented by air conditioning on maximum with full blower.

This vehicle meets all PHEV America Minimum Requirements listed at the end of this document.
Values in red indicate that the Performance Goal was not met.

CONSTANT-SPEED RANGE AND CHARGE TESTING IN CHARGE-DEPLETING MODE[1]

	45-mph Test[2,3]	60-mph Test[2,4]	70-mph Test[2,5]
Average DC power out of battery (kW):	10.1	17.5	22.8
(A) DC energy out of battery (kWh):	9.4	9.0	8.9
Battery capacity discharge (Ah):	26.0	25.1	24.9
(B) Total distance traveled (mi)[6]:	42.9	31.0	27.4
(C) Post-test charge AC energy from EVSE @ 240 V to onboard charger (kWh):	11.1	11.3	11.2
(D) Post-test charge DC energy into battery from onboard charger (kWh):	9.7	9.6	9.7
Post-test charge duration (HH:MM):	03:35	03:45	03:45
AC electricity consumption rate (Wh/mi)[7]:	259	341	409
DC electricity consumption rate (Wh/mi)[8]:	226	290	325
(A/D) Battery Roundtrip Efficiency[9]:	97%	94%	92%
(D/C) On-Board Charger Efficiency[10]:	87%	85%	87%
(A/C) Overall Trip Efficiency[11]:	85%	80%	79%

NOTES:

1. Vehicle track testing at delivered curb weight plus 332 ± 10 lb (including driver and test equipment), distributed in a manner similar to the original curb loading of the vehicle.
2. Values obtained from drive cycle data without accessories.
3. During the 45-mph range test, the maximum battery temperature was 25 °C and the average ambient temperature was 17 °C. During the post-test charge, the maximum battery temperature was 29 °C and the average ambient temperature was 20 °C.
4. During the 60-mph range test, the maximum battery temperature was 25 °C and the average ambient temperature was 15 °C. During the post-test charge, the maximum battery temperature was 28 °C and the average ambient temperature was 22 °C.
5. During the 70-mph range test, the maximum battery temperature was 28 °C and the average ambient temperature was 24 °C. During the post-test charge, the maximum battery temperature was 28 °C and the average ambient temperature was 22 °C.
6. Total distance traveled for the 45-mph, 60-mph, and 70-mph tests includes drives of approximately 0.8, 1.7 and 1.2 miles, respectively, from test prep area to point at which vehicle test speed is achieved and maintained. Range is considered reached when vehicle operational mode transitions from charge-depleting to charge-sustaining.
7. The AC electricity consumption rate is calculated by dividing the AC energy from the EVSE **(C)** by the total distance travelled **(B)**.
8. The DC electricity consumption rate is calculated by dividing the DC energy from the on-board charger into the battery **(D)** by the total distance travelled **(B)**.
9. The Battery Roundtrip Efficiency is calculated by dividing the DC energy out of the battery **(A)** by the DC energy from the on-board charger into the battery **(D)**.
10. The On-Board Charger Efficiency is calculated by dividing the DC energy from the on-board charger into the battery **(D)** by the AC energy from the EVSE **(C)**.
11. The Overall Vehicle Efficiency is calculated by dividing the DC energy out of the battery **(A)** by the AC energy from the EVSE **(C)**.

This vehicle meets all PHEV America Minimum Requirements listed at the end of this document.
Values in red indicate that the Performance Goal was not met.

CHARGE-SUSTAINING PERFORMANCE STATISTICS[1,2]

Charge-Sustaining Acceleration 0-60 mph[3]

Measured Time: 9.5 s

Performance Goal: ≤13.5 s

Peak power from battery: 90.9 kW

Charge-Sustaining Maximum Speed

At ¼ Mile: 84.4 mph

At 1 Mile[4]: 101.5 mph s

Performance Goal: ≥90 mph at one-mile mark

Charge-Sustaining Gradeability (Calculated)[5]

Maximum Speed @ 3% Grade: 100.8 mph

Performance Goal: ≥55 mph

Maximum Speed @ 6% Grade: 99.0 mph

Performance Goal: ≥45 mph

Maximum Grade: 42.0%

Performance Goal: ≥25% Grade

Charge-Sustaining Dynamometer Results w/o Accessories

Fuel Economy[6]: 47.3 mpg

Electricity Consumption Rate[7]: N/A

Driving Range[8]: 440 mi

Charge-Sustaining Dynamometer Results w/Accessories[9]

Fuel Economy[6]: 40.7 mpg

Electricity Consumption Rate[7]: N/A

Driving Range[8]: 379 mi

NOTES:

1. Vehicle track testing occurs when the vehicle has achieved its "break-in mileage" of between 4,000 to 6,000 miles, and at the delivered curb weight plus 332 ± 10 lb (including driver and test equipment), distributed in a manner similar to the original curb loading of the vehicle. Coastdown testing began on June 23, 2011 with an odometer reading of 5,860 miles and ambient temperatures between 96 °F to 100 °F. Dynamometer testing began on September 12, 2011 with the vehicle odometer reading 6,144 miles. A comprehensive explanation of the dynamometer facility and methodology can be found at http://www.transportation.anl.gov/D3/, titled "Chassis Dynamometer Testing Reference Document". The ABC coefficients derived from track coastdown testing and matched on the dynamometer were A: 31.7925 lb, B: 0.1544 lb/mph, and C: 0.0164 lb/mph2. The remainder of the track testing took place between February 6-13, 2013, with a beginning vehicle odometer reading of 7,845 miles and ambient temperature ranging from 55 °F to 70 °F for this testing.
2. Performance numbers based on "Normal" vehicle mode and SAE J1711 methodology, including Cold Start UDDS, Hot Start UDDS, and HWFET cycles. Performance numbers are averages from multiple tests.
3. The acceleration is measured from the point at which the vehicle begins to move. The acceleration and maximum speed testing results were averaged from 6 runs in which the vehicle state of charge (SOC) was at 21.7%, 22.5%, 22.5%, 22.2%, 22.3%, and 22.2%, respectively, at the beginning of the acceleration event.
4. The maximum speed was reached before the one-mile mark.
5. Gradeability calculations use acceleration test data to derive the gradeability values.
6. Fuel Economy is calculated use SAE J1711 methodology.
7. Electricity Consumption Rate is not listed for Charge-Sustaining Mode. When the dynamometer testing is conducted, the Net Energy Change (NEC) Tolerance, which is the ratio of the change in energy of the energy storage system to the total fuel energy, must be less than 1% such that the test is repeatable. The Electricity Consumption Rate is thus neglected.
8. Driving range value based on fuel economy and fuel tank size; the electricity consumption rate is neglected.
9. Accessories represented by air conditioning on maximum with full blower.

This vehicle meets all PHEV America Minimum Requirements at the end of this document.
Values in red indicate that the Performance Goal was not met.

CUMULATIVE FUEL ECONOMY DYNAMOMETER PERFORMANCE STATISTICS

UDDS[1]			HWFET[1]		
Miles	**Cumulative Fuel Economy (mpg)**	**Cumulative Electricity Consumption Rate (DC Wh/mi)**	**Miles**	**Cumulative Fuel Economy (mpg)**	**Cumulative Electricity Consumption Rate (DC Wh/mi)**
10	N/A[2]	244.2	**10**	N/A[2]	247.8
20	N/A[2]	236.6	**20**	N/A[2]	241.0
40	N/A[2]	230.1	**40**	N/A[2]	236.3
60	171.1	174.4	**60**	168.0	170.6
67.1	98.8[3]	156.7[3]	**80**	105.4	129.7
			82.0	102.5[4]	126.6[4]

NOTES:

1. Values for fuel economy and electricity consumption rate obtained from drive cycle data without accessories and using SAE J1711 methodology. The vehicle is driven on consecutive drive cycles, with fuel economy and electricity consumption rates calculated for each cycle. Where a distance travelled is during a drive cycle, the values have been interpolated.
2. No fuel is used in charge-depleting mode.
3. The UDDS cycle is 7.45 miles long and testing ended at 67.1 miles. The vehicle achieved a total of 42.0 miles in charge-depleting mode over 5.9 UDDS cycles. The Performance Goal is to complete two UDDS cycles or 14.90 miles in charge-depleting mode.
4. The HWFET cycle is 10.25 miles long and the testing ended at 82.0 miles. The vehicle achieved a total of 44.5 miles in charge-depleting mode over 4.1 HWFET cycles. The Performance Goal is to complete two HWFET cycles or 20.5 miles in charge-depleting mode.

This vehicle meets all PHEV America Minimum Requirements listed at the end of this document.
Values in red indicate that the Performance Goal was not met.

This vehicle meets the requirements of PHEV America Vehicle Technical Specification, Revision 1 as follows:

(1) Vehicles shall comply with Federal Motor Vehicle Safety Standards (FMVSS) applicable on the date of manufacture and such compliance shall be certified by the manufacturer in accordance with 49 CFR 567. Suppliers shall provide a completed copy of Appendix A and Appendix B with their proposal, providing vehicle specifications and the method of compliance with each required section of 49 CFR 571. If certification includes exemption, the exemption number issued by the National Highway Transportation Safety Administration (NHTSA), the date of its publication in the Federal Register and the page number(s) of the Federal Register acknowledging issuance of the exemption shall be provided along with Appendix B. Exemptions for any reason other than non-applicability shall not be allowed.

(2) Suppliers shall supply Material Safety Data Sheets (MSDS) for all unique hazardous materials the vehicle is equipped with, including Energy Storage System (ESS) batteries or capacitors, and auxiliary batteries.

(3) Suppliers shall provide recycling plans for batteries and other vehicle hazardous materials including how the plan has been implemented.

(4) All vehicles shall comply with the Federal Communications Commission (FCC) requirements for unintentional emitted electromagnetic radiation, as identified in 47 CFR 15, Subpart B, "Unintentional Radiators."

(5) Vehicles shall have a minimum payload of at least 400 pounds.

(6) For conversions, Original Equipment Manufacturer (OEM) gross vehicle weight ratings (GVWR) shall not be increased. For conversion vehicles, Suppliers shall specify the OEMs GVWR.

(7) For conversions, OEM gross vehicle axle weight ratings (GAWR) shall not be increased. Suppliers shall provide axle weights for the vehicle as delivered, and at full rated payload.

(8) Tires shall be subject to the following requirements:
- Tires provided with the vehicle shall be the standard tire offered by the plug in hybrid electric vehicle (PHEV) Supplier for the vehicle being proposed.
- Tires shall correspond to the requirements of the placard installed in accordance with 49 CFR 571.109, 110, 119 and 120, as applicable.
- Suppliers shall specify manufacturer, model and size of the standard tire.
- Tires sizes and inflation pressures shall be in accordance with the requirements of the placard.
- At no time shall the tire's inflation pressure exceed the maximum pressure imprinted upon that tire's sidewall.
- The tire shall be operable across the entire operation/load range of that vehicle.
- Replacement tires shall be commercially available to the end user in sufficient quantities to support the purchaser's needs.
- Tires provided as original equipment by the PHEV manufacturer shall not have warranty restrictions in excess of those of the tire's manufacturer, unless the Supplier is the sole warrantor for the tires.
- If the vehicle may be equipped with more than one standard tire, this information shall be provided for each type/manufacturer of each standard tire.

(9) Seating capacity shall be a minimum of 1 driver and 1 passenger. Suppliers shall specify seating capacity (available seat belt positions) for their vehicle. For conversion vehicles, if the vehicle's seating capacity is changed from that specified by the OEM on their FMVSS placard, the seat(s) being added or abandoned shall be modified as required by 49 CFR 571.207, et al, and a new FMVSS placard installed as required by 49 CFR 567, 568 or 571, as applicable.

(10) For conversion vehicles, the OEM passenger space shall not be intruded upon by the ESS or other conversion materials.

(11) The vehicle may utilize a single-speed, multi-speed automatic, manual transmission, or a Continuously Variable Transmission (CVT), and shall have a parking mechanism.

(12) The controller/inverter shall limit the minimum ESS battery discharge voltage to prevent degradation of battery life, and should limit the maximum regeneration voltage to prevent external gassing of the batteries.

(13) Vehicles shall comply with the requirements of 49 CFR 571.105.S5.2.1, or alternatively, 49 CFR 571.105.S5.2.2 for parking mechanisms.

(14) If different, customer available and battery available Department of Energy (DOE) ratings shall both be provided.

(15) Batteries shall comply with the requirements of SAE J1718. Vehicles shall not auto-start the engine to charge the batteries while the vehicle is parked and the key switch is in the OFF position. For vehicles capable of off-vehicle charging (OVC), ESS batteries shall meet the requirements of NEC 625-29 (c) or (d) for charging in enclosed spaces without a vent fan. The vehicle shall be labeled as not requiring ventilation for charging (or have the appropriate classification label from an Underwriters Laboratory (UL)-recognized Testing Laboratory).

(16) For vehicles with ESS system voltages of 48 volts (V) and higher, batteries or capacitors and their enclosures shall be designed and constructed in a manner that complies with 49 CFR571.305. For vehicles with ESS system voltages below 48 volts direct current (VDC), batteries or capacitors, and their enclosures, shall be designed and constructed in accordance with the requirements of SAE J1766. Further, irrespective of ESS system voltage, batteries or capacitors, and electrolyte will not intrude into the passenger compartment during or following FMVSS frontal barrier, rear barrier and side impact collisions, and rollover requirements of 49 CFR 571.301. Suppliers shall provide verification of conformance to this requirement.

(17) Concentrations of explosive gases in the battery box shall not be allowed to exceed 25% of the LEL (Lower Explosive Limit). Suppliers shall describe how battery boxes will be vented, to allow any battery gases to escape safely to atmosphere during and following normal or abnormal charging and operation of the vehicle. Battery gases shall not be allowed to enter the occupant compartment.
Batteries shall comply with the requirements of SAE J1718, and at a minimum shall meet the requirements of NEC 625-29 (c) or (d) for charging in enclosed spaces without a vent fan.

(18) If a Supplier provides a vehicle with parallel battery packs, the Supplier shall provide detailed information on the equipment and charging algorithms required to prevent the parallel strings from becoming unbalanced.

(19) Flywheels and their enclosures shall be designed and constructed such that there is complete containment of the flywheel energy storage system during all modes of operation. Additionally, flywheels and their enclosures shall be designed and constructed such that there is complete containment of the flywheel energy storage system during or following frontal barrier, rear barrier and side impact collisions, and roll-over requirements of 49 CFR 571.301. Suppliers shall provide verification of conformance to this requirement.

(20) For vehicles using fuels other than gasoline, manufacturers shall indicate compliance with appropriate and applicable standards from SAE, NFPA, etc. [e.g., for vehicles using Compressed Natural Gas (CNG) as fuel, manufacturers should indicate compliance with NFPA 52, "CNG Vehicular Fuel Systems Code," as well as 49 CFR 571.303 and 304.].

(21) ESS shall be battery, capacitor, or electromechanical flywheel technology-based as defined in SAE J1711.

(22) Vehicles shall not contain exposed conductors, terminals, contact blocks or devices of any type that create the potential for personnel to be exposed to 60 V or greater (the distinction between low-voltage and high voltage, as specified in SAE J1127, J1128, et al.). Access to any high voltage components shall require the removal of at least one bolt, screw, or latch. Devices considered to be high voltage components shall be

clearly marked as HIGH VOLTAGE. These markings should be installed at any point the voltage can be accessed by the end user. Additionally, cable and wire marking shall consist of orange wire and/or orange sleeving as identified in SAE J1673.

(23) For propulsion power systems with voltages greater than or equal to 48 VDC, the system shall be isolated from the vehicle chassis such that leakage current does not exceed 0.5 MIU.
Charging circuits for ESS battery systems with voltages greater than or equal to 48 VDC shall be isolated from the vehicle chassis such that ground current from the grounded chassis does not exceed 5 mA at any time the vehicle is connected to an off-board power supply.

(24) The automatic disconnect for the ESS batteries shall be capable of interrupting maximum rated controller/inverter current. The Supplier shall describe the automatic disconnect provided for the main propulsion batteries.

(25) The vehicle shall be prevented from being driven with the key turned on and the drive selector in the drive or reverse position while the vehicle's charge cord is attached. Additionally, the following interlocks shall be present:
- The controller shall not initially energize to move the vehicle with the gear selector in any position other than "PARK" or "NEUTRAL."
- The start key shall be removable only when the "ignition switch" is in the "OFF" position, with the drive selector in "PARK."
- With a pre-existing accelerator input, the controller shall not energize or excite such that the vehicle can move under its own power from this condition.

(26) If the vehicle is capable of off-board recharging of the ESS, the charger shall be capable of recharging the ESS to a state of full charge from any possible state of discharge in less than 12 hours, at temperatures noted in Section 5.5, as applicable.
The charger shall be fully automatic, determining when "end of charge" conditions are met and transitioning into a mode that maintains the main propulsion battery at a full state of charge while not overcharging it, if continuously left on charge.

(27) If the vehicle is capable of off-board recharging of the ESS, the chargers shall use 120V or 208/240V single-phase 60-Hertz alternating current service, with an input voltage tolerance of 10% of rated voltage. Input current for chargers operating at 208V and 240V shall be compatible with 40-ampere circuit breakers.
Personnel protection systems shall be in accordance with the requirements of UL Standard 2202 and shall be determined based upon ESS system voltages. All personnel protection systems shall meet the requirements specified in the applicable sections of UL2231-1 and 2231-2.

(28) If the vehicle is capable of off-board recharging of the ESS using a 208/240 V charger, chargers shall have a true power factor of .95 or greater and a harmonic distortion rated at 20% (current at rated load).

(29) Regardless of the charger type used, the charger shall conform to the requirements of UL Proposed Standard 2202.

(30) The installation of options shall not relieve Suppliers of meeting other "shall" requirements.

(31) Vehicles shall be accompanied by non-proprietary manuals for parts, service, operation and maintenance, interconnection wiring diagrams and schematics.

(32) Vehicles shall be capable of completing the PHEV America Rough Road Test (ETA-HTP-005) including (1) driving through standing water without damage and without battery to chassis leakage current exceeding 0.5 MIU per UL Standard 2202, and (2) standing for extended periods in extreme temperatures without damage to or failure of the vehicle or its systems. Vehicle shall be capable of completing all HEV America tests without repairs exceeding a cumulative total of 72 hours.

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