The battery is the main source of electrical energy on Toyota vehicles. The battery powers these major electrical systems:

- Starting
- Ignition
- Charging
- Lighting
- Accessories
Battery Functions

**Engine off** - The battery provides energy to operate lighting and accessories.

**Engine starting** - The battery provides energy to operate the starter motor and ignition system during starting.

**Engine running** - The charging system provides most of the energy required with the engine running; the battery acts as a voltage stabilizer to protect voltage sensitive circuits, particularly digital circuits.
Battery Type

**Lead-Acid** - Virtually all automotive batteries are lead-acid batteries. Two different metals, both lead compounds, are immersed in an acid electrolyte. The chemical reaction produced provides electrical energy.

**Low Maintenance/No Maintenance** - Some manufacturers use this terminology. “Low maintenance” means that electrolyte can be added. “No maintenance” means that the battery is sealed.

**Vented** - Most batteries have removable vented caps that are used to check electrolyte level and add distilled water as necessary to restore the level. The caps also allow hydrogen gas, a byproduct of battery charging, to escape during charging.

**Sealed** - Some lead-acid batteries are sealed, that is, there are no removable caps to check electrolyte or replenish it. Some of these batteries have a small “eye” to indicate charge level. Still others are sealed, but include connections to external vent tubes.

**NOTE**

For all types of batteries, always follow the manufacturers’ recommendations for charging and testing.
Battery Case

The battery case holds and protects all of the internal components and contains the electrolyte.

Battery Case
The battery case and cover...

- Form a sealed container.
- Protect the internal parts.
- Keep the internal parts in proper alignment.
- Prevent electrolyte leakage.
Plates  Two types of plates are used in a battery: positive and negative.

Positive  - Positive plates are made of antimony covered with an active layer of lead dioxide (PbO2).

Negative  - Negative plates are made of lead covered with an active layer of sponge lead (Pb).

Only the surface layers on both plates take part in the chemical reaction.

Plate surface area  - As the surface area of the plates increases, so does the current capacity of the battery. Surface area is determined by the size of each plate, as well as the total number of plates in a battery. Generally speaking, the larger the battery, the higher is its current capacity.

Surface area has no effect on battery voltage.

---

Positive and Negative Plates

Positive plates are covered with lead dioxide (PbO2); negative plates are made of lead (Pb).
**Separators**  The plates are separated by thin porous insulators. These allow electrolyte to pass freely between the plates, but prevent the plates from touching each other and shorting out.

![Diagram of separators](Fig. 3-06 TL623306c)
**Cells** A typical lead acid battery is organized into cells.

Each cell ...  
• Consists of multiple positive and negative plates immersed in their own electrolyte reservoir.  
• Produces about 2.1 volts, regardless of battery size.

Automotive batteries are rated at 12 volts. To make up this voltage, six cells, each producing 2.1 volts, are connected in series.

\[6 \times 2.1 \text{ volts} = 12.6 \text{ volts}\]

As a result, actual battery voltage is typically closer to 12.6 volts.

Cells are connected in series with heavy internal straps.

A positive and a negative terminal post provide connection points for the vehicle's battery cables.

---

**Battery Cells**  
A typical automotive battery contains six cells connected in series. Each cell produces 2.1 volts.

---

Fig. 3-07  
TL6239307
Venting System  On some batteries, vent caps allow a controlled release of hydrogen gas. This gas forms naturally during battery recharging, whether by the vehicle's alternator or by an external charger.

**Battery Vent Caps**

Vent caps allow the controlled release of hydrogen gas as the battery charges.

![Battery Vent Caps Diagram]

Fig. 3-08
TL623f308c
Electrolyte  The electrolyte is a mixture of sulfuric acid (H₂SO₄) and water (H₂O). The electrolyte reacts chemically with the active material on the plates to produce a voltage (electrical pressure).

Battery Electrolyte

Acid in the electrolyte reacts chemically with the positive plate’s lead oxide (PbO₂) and the negative plate’s sponge lead (Pb) to produce a voltage.

Fig. 3-09
TL623f309c
The function of a lead acid cell is based on a simple chemical reaction. When two dissimilar metals are immersed in an acid solution, a chemical reaction produces a voltage. Using this reaction, a lead-acid battery can be discharged and charged many times.

There are four stages in the discharging-charging cycle:

**Fully Charged**
- Positive plate covered with lead oxide (PbO₂).
- Negative plate covered with sponge lead (Pb).
- Electrolyte contains water (H₂O) and sulfuric acid (H₂SO₄).

**Discharging**
- Current flows in the cell from the negative to the positive plates.
- Electrolyte separates into hydrogen (H₂) and sulfate (SO₄).
- The free sulfate combines with the lead (both lead oxide and sponge lead) and becomes lead sulfate (PbSO₄).
- The free hydrogen and oxygen combine to form more water, diluting the electrolyte.

**Fully Discharged**
- Both plates are fully sulfated.
- Electrolyte is diluted to mostly water.

**Charging**
- Reverses the chemical reaction that took place during discharging.
- Sulfate (SO₄) leaves the positive and negative plates and combines with hydrogen (H₂) to become sulfuric acid (H₂SO₄).
- Hydrogen bubbles form at the negative plates; oxygen appears at the positive plates.
- Free oxygen (O₂) combines with lead (Pb) at the positive plate to become lead oxide (PbO₂).
Lead Acid Chemical Reaction

The charging-discharging cycle has four distinct stages, all based on a reversible chemical reaction with lead and sulfuric acid.

![Diagram of lead acid battery in fully charged, discharging, discharged, and charging states](Fig. 3-10 TL623F310c)
Capacity Ratings

An automotive battery must be able to crank the engine for starting and still have enough reserve capacity to operate the vehicle systems once the engine starts.

Battery capacity is:

- The amount of electrical energy the battery can deliver when fully charged.
- Determined by the size and total number of plates and the volume and strength of the electrolyte.

Refer to the manufacturer’s specification for information specific to a particular Toyota vehicle.

Cold-Cranking Amperes

While it is operating the starter, the battery experiences a large discharge current.

The measure of a battery’s ability to provide this current is expressed as Cold-Cranking Amperes, or CCA Rating.

The CCA Rating specifies (in amperes) the discharge current a fully charged battery can deliver ...

- at 0°F (-18°C),
- for 30 seconds,
- while maintaining at least 1.2 volts per cell (or 7.2 volts total for a six-cell, 12-volt battery).

Batteries in Toyota vehicles typically have a CCA rating between 350 to 560 amperes, depending on vehicle model. Refer to TIS to obtain information for specific Toyota vehicles.

Reserve Capacity (RC)

The battery must provide reserve energy for the ignition system and for lights and accessories if the charging system fails.

The Reserve Capacity rating measures (in minutes) the amount of time a fully charged battery can ...

- discharge at 25 amperes, while maintaining a voltage of at least 1.75 volts per cell (total of 10.5 volts for a 6-cell, 12-volt battery).

Batteries in Toyota vehicles typically have an RC rating between 55 and 115 minutes, depending on vehicle model. Refer to TIS to obtain information for specific Toyota vehicles.
The Battery

**Ampere-Hours (AH)** The Ampere-Hours, or AH rating, is another important measure of a battery’s design performance.

The AH rating expresses the discharge current a fully charged battery can deliver for 20 hours ...

- at 80°F (27°C),
- while maintaining a voltage of at least 1.75 volts per cell (total of 10.5 volts for a 6-cell, 12-volt battery).

**EXAMPLE** A battery that can deliver 4 amps for 20 hours is rated at 80 amp-hours.

Batteries in Toyota vehicles typically have an AH rating between 40 and 80 amp-hours, depending on vehicle model. Refer to TIS to obtain information for specific Toyota vehicles.
Visual Inspection

Battery service should always begin with a thorough visual inspection. Such an inspection may reveal simple, easily corrected problems or problems that require battery replacement without further testing.

Include these steps in a visual inspection:

1. Check for cracks in the battery case. Check particularly around battery terminals. These are sometimes overstressed when removing and installing battery cables. Replace the battery if there is any evidence of cracking.

2. Check for cracked or broken cables or connections. Replace cables or connectors as necessary.

3. Check for corrosion on terminals and dirt or acid on the case top. Clean the terminals and case top with a mixture of water and baking soda. Wire brush heavy corrosion on the terminals.

4. Check for a loose battery hold-down and loose cable connections. Tighten as needed.

5. On batteries with removable vent caps, remove the caps and check the electrolyte level. Add distilled water to each cell to restore the level if necessary. Avoid overfilling and never add additional acid. Tap water adds contaminants, and will reduce battery efficiency.
6. Check the indicator eye. A red eye indicates the battery is severely discharged or the electrolyte is low. The electrolyte level is sufficient and the battery is at least 25% charged if at least some blue is showing.

7. Check for cloudy or discolored electrolyte. This can be caused by overcharging or excessive vibration. Correct the problem and replace the battery.
Safety should be your first consideration whenever you inspect, test, or replace a lead acid battery. The electrolyte contains sulfuric acid. This acid can burn your skin, injure your eyes, and damage the vehicle, your tools, or your clothing.

If you splash electrolyte onto your skin or into your eyes, immediately rinse it away with large amounts of clean water. Contact a doctor immediately.

If you spill electrolyte onto any part of the vehicle, neutralize the acid with a solution of baking soda and water, then rinse liberally to remove any residue.

When a battery is charging, the electrolyte may release gasses (hydrogen and oxygen). Hydrogen gas is explosive, and oxygen supports combustion. A flame or spark near a charging battery can cause an explosion.

Precautions
Take the following precautions when working with automotive batteries:

- Wear gloves and safety glasses.
- Never use spark-producing tools near the battery.
- Never lay any tools on the battery.
- If it is necessary to remove the battery cables, always remove the ground first.
- When connecting battery cables, always connect the ground cable last.
- Do not use the battery ground terminal when checking for ignition spark.
- Take care not to spill electrolyte into your eyes, onto your skin, and onto any part of the vehicle.
- If you mix electrolyte, pour the acid into the water (not the water into the acid).
- Always follow the recommended procedures for battery testing, charging, and for connecting jumper cables between two batteries.
Battery Drain Tests

There are two tests for battery drain:

1. Parasitic load
2. Surface discharge

A parasitic load is created by a device that draws current even when the ignition switch is turned to “Off.” Even a small current can discharge the battery, if the vehicle is not used for an extended time.

Check for a parasitic load as follows:

1. Connect an ammeter in series between the battery negative terminal and the ground cable connector.
2. Select the appropriate scale and read the current draw.
3. Toyota vehicles typically draw between 20 and 75 milliamps (this is current used to maintain electronic memories).
4. Any reading higher than 100 milliamps is unacceptable. Locate and correct the cause of the excess parasitic drain.
5. Make sure that you wait a few minutes before checking for parasitic load. After the vehicle is shut down or a door is opened, parasitic load may be 50-75 milliamps, depending on model, for a few minutes.
Surface discharge is a small current that runs between the two battery terminals, across the surface of the battery. This can occur only when that surface is dirty.

Check for surface discharge as follows:

1. Connect a voltmeter, black test lead (negative) to the battery’s negative terminal; red test lead (positive) to the top of the battery case.
2. Select an appropriate scale and read the voltage.
3. If the meter reading is higher than 0.5 volts, clean the case top with a solution of baking soda and water.

**Two Tests for Battery Drain**

Parasitic load current and battery surface discharge can cause batteries to discharge over time.
Micropro 815 Battery Analyzer

You can use a battery analyzer to obtain an indication of battery condition that is more accurate than just its state of charge. The Midtronics Micropro 815 Battery Analyzer uses conductance testing to evaluate the condition of the plates inside the battery.

There are several advantages of using this battery analyzer:

- Battery can be tested even when it's not fully charged.
- No need to charge battery before testing; can be tested as soon as vehicle arrives for service.
- Information from analyzer lets you make a quick decision.
- Reduces costly mistakes.

---

**Micropro 815 Battery Analyzer**

A battery analyzer can help you make a quick and accurate determination of battery condition.

---

Fig. 3-14
TL623f314c
Preparing the Battery for Analyzer Tests

Prepare the battery for testing:

- Remove the battery’s surface charge.
- Disconnect the battery from the vehicle.
- Make sure the terminals are clean and free of corrosion.
- If the battery has removable vent caps, check the electrolyte level. Top up with distilled water if needed.

To remove a battery’s surface charge, turn on the headlights with the engine off. Leave the lights on for one minute.

You can test batteries either connected to or disconnected from the vehicle. In general, you get more reliable results with the battery disconnected. If you do leave the battery connected for testing, turn off all lights and accessories and set the ignition switch to the OFF position.

---

**Preparing the Battery**

To get the most accurate results, make sure the battery terminal posts are clean for testing.

![Preparing the Battery](image-url)
Setting Up the Battery Analyzer

Set up the battery analyzer as follows:

1. Connect the analyzer’s red lead to the positive battery terminal.
2. Connect the black lead to the negative battery terminal.
3. Check the analyzer’s display. It should illuminate and show four zeros to indicate a good connection. The analyzer’s display will not illuminate if there is a poor connection.

**Connections** - The teeth on both sides of each clamp must contact the battery terminal. Rock both clamps back and forth to ensure a good electrical connection.

4. Proceed to Testing the Battery (on the next page) if you have not charged the battery before test.
5. Press the Test Mode key once if you charged the battery before the test. The “After Charge” LED will light.
Press the Test Mode key twice if battery temperature is 32° F (0° C) or lower. The “Cold Battery” LED will light.
Testing the Battery

Use these steps to test an original equipment battery or OE replacement:

1. Select the correct STK# from the chart included with the tester (in the flap of the soft case).

2. Use the analyzer’s keypad to enter the 4-digit STK#.

3. Press the STK# key to start the test.

NOTE: A valid STK# is a requirement for warranty testing. Updated charts can be found on TIS.

---

### Testing the Battery

This table is enclosed with the Midtronics Battery Analyzer.

#### TOYOTA OE Battery

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<thead>
<tr>
<th>Model</th>
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<th>CCA</th>
<th>STK#</th>
<th>Supplier</th>
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<td>800AX</td>
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</table>

Fig. 3-17

TL623517
Use these steps to test a non-OE battery.

**For battery with CCA rating:**
1. Find the CCA (cold-cranking amps) rating on the battery label.
2. Enter the rating number via the keypad.
3. Press the CCA key to start the test.

**For battery with a CA (cranking amps) rating:**
1. Find the CA rating on the battery label.
2. Enter the rating number via the keypad.
3. Press the CA key to start the test.

**Use this procedure if you cannot determine any usable rating for a battery to be tested:**
1. Find an STK# on the chart that is recommended for the vehicle in which the battery is installed.
2. Use the analyzer’s keypad to enter the 4-digit STK#.
3. Press the STK# key to start the test.
Interpreting the Results

The results will be displayed in the Battery Condition area of the panel.

**Good return to service** - The battery is in good condition and ready to return to service.

**Charge and return to service** - The battery is good, but must be fully charged before returning to service.

**Charge and retest** - The test result is inconclusive. “Quick Charge” the battery and retest using the After Charge test mode.

**Replace** - The battery must be replaced. Press the STK#/CODE key to show the warranty code for the repair order.

---

### Interpreting the Results

The battery analyzer lights one of these LED's to tell you the battery condition.

---

![Battery Condition Diagram]
Fast Charging is used to charge the battery for a short period of time with a high rate of current. Fast charging may shorten battery life. If time allows, slow charging is preferred. Some low maintenance batteries cannot be fast charged.

1. Preparation for charging:
   - Clean dirt, dust, or corrosion off the battery; if necessary, clean the terminals.
   - Check the electrolyte level and add distilled water if needed.
   - If the battery is to be charged while on the vehicle, be sure to disconnect both (-) (+) terminals.

2. Determine the charging current and time for fast charging:
   - Some chargers have a test device for determining the charging current and required time.
   - If the charger does not have a test device, refer to the chart to determine current and time.

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<th>Reserve Capacity Rating</th>
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<th>5 Amperes</th>
<th>10 Amperes</th>
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<th>30 Amperes</th>
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<td>50 Ampere-Hours or less</td>
<td>10 Hours</td>
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<td>2½ Hours</td>
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<td>Above 75 to 115 Minutes</td>
<td>Above 50 to 75 Ampere-Hours</td>
<td>15 Hours</td>
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<td>3¼ Hours</td>
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<td>Above 115 to 160 Minutes</td>
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<td>20 Hours</td>
<td>10 Hours</td>
<td>5 Hours</td>
<td>3 Hours</td>
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<tr>
<td>Above 160 to 245 Minutes</td>
<td>Above 100 to 150 Ampere-Hours</td>
<td>30 Hours</td>
<td>15 Hours</td>
<td>7½ Hours</td>
<td>5 Hours</td>
<td>3½ Hours</td>
</tr>
</tbody>
</table>

3. Using the charger:
   - Make sure that the main switch and timer switch are OFF and the current adjust switch is at the minimum position.
   - Connect the positive lead of the charger to the battery’s positive terminal (+) and the negative lead of the charger to the battery’s negative terminal (-).
   - Connect the charger’s power cable to the electric outlet.
   - Set the voltage switch to the correct battery voltage.
   - Set the main switch at ON.
   - Set the timer to the desired time and adjust the charging current to the predetermined amperage.
4. After the timer is OFF, check the charged condition using a voltmeter.
   - Correct Voltage: 12.6 volts or higher.

If the voltage does not increase, or if gas is not emitted no matter how long the battery is charged, there may be a problem with the battery, such as an internal short.

5. When the voltage reaches the proper reading,
   - Set the current adjust switch to minimum.
   - Turn off the main switch of the charger.
   - Disconnect the charger cable from the battery terminals.
   - Wash the battery case to clean off the acid emitted.

**Slow Charging**

High charging rates are not good for completely charging a battery. To completely charge a battery, slow charging with a low current is required.

Slow charging procedures are the same as those for fast charging, except for the following:

1. The maximum charging current should be less than 1/10th of the battery capacity. For instance, a 40 AH battery should be slow charged at 4 amps or less.

2. Set the charger switch to the slow position (if provided).

3. Readjust the current control switch, if needed, while charging.

4. As the battery gets near full charge, hydrogen gas is emitted. When there is no further rise in battery voltage for more than one hour, the battery is completely charged.
   - Battery Voltage: 12.6 volts or higher.
Jump Starting

Jump starting requires proper battery connecting procedures to prevent sparks. Jump start a vehicle using the following procedure:

1. Connect the two positive cables using the positive jumper leads.
2. Connect one end of the negative jumper lead to the booster battery.
3. Connect the other lead of the negative jumper lead to a good ground on the vehicle with the dead battery. This location could be:
   - The vehicle frame.
   - The engine block.

Using this method ensures that any possible sparks occur away from the battery.

NOTE

Battery jumper leads should be high quality and have a large wire gauge (such as 4 gauge) to safely carry the current necessary to jump start a vehicle.

CAUTION

Never try to jump start a vehicle with a visibly damaged battery or if no battery is present. Vehicle damage and risk of battery explosion are possible.