

# Starters & Alternators: Technical Manual

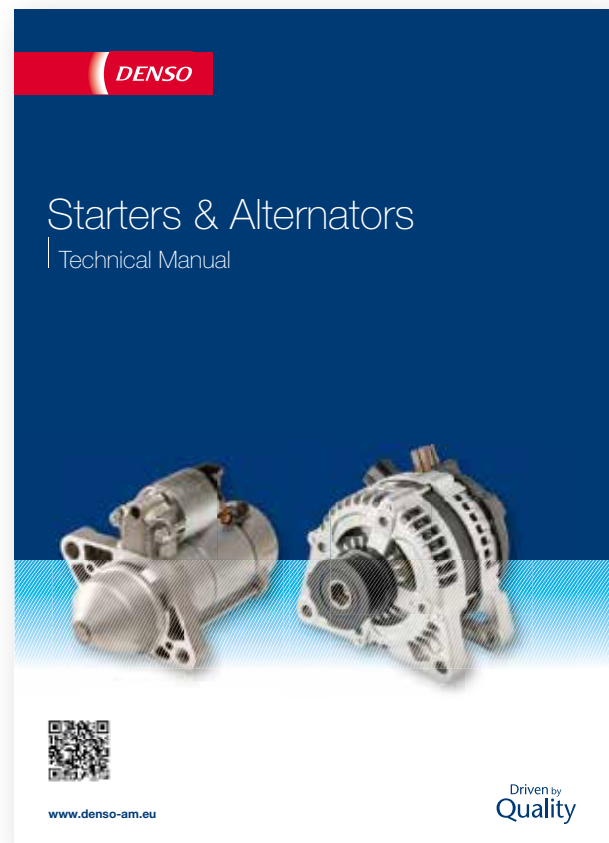
Learn about DENSO Starters & Alternators

DENSO released a Starters & Alternators Technical Manual to provide distributors, wholesalers and end users with everything you need to know about our unique, OE specification rotating units.

From system data to case studies, and visually showing each type, this handy manual will provide all the technical information required. This handy manual can be ordered via your DENSO Sales Representative quoting part number DESA16UK03MM.

To celebrate the release of the Technical Manual, below is a snapshot of the content available in the Manual.

Request your copy of the Technical Manual via your DENSO Sales Representative. English versions are available with more languages to be released in the near future.





# Content available in the Technical Manual

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- > How Starters work

### Types

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### Wall Chart

### Stop & Start Technology

### Replacement Guide

### Troubleshooting

- > Diagnostic Chart
- > Inspection
- > Q&A

## PART 2 – DENSO Alternators

### Characteristics

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- > How Alternators work

### Types

- > Conventional Type
- > Type III
- > SC Type

### Wall Chart

### Replacement Guide

### Troubleshooting

- > Diagnostic Chart
- > Inspection
- > Q&A

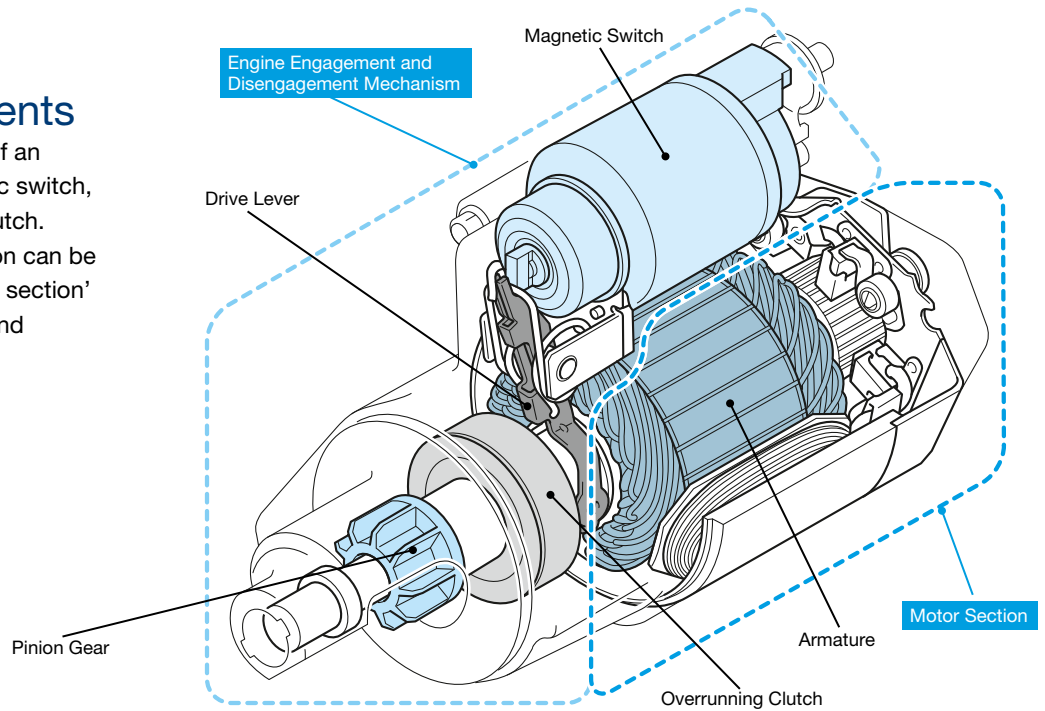


# DENSO Starters | Characteristics

## > How Starters work

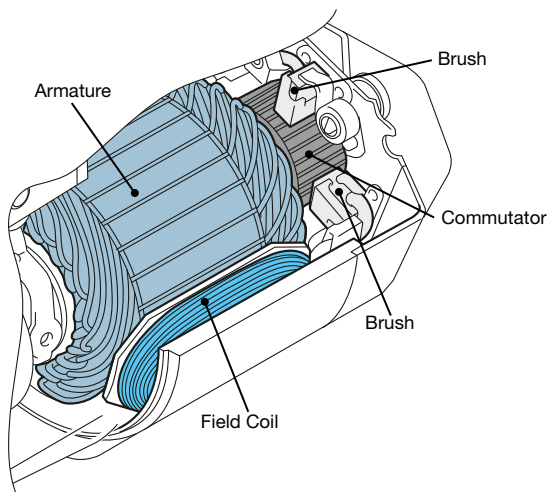
### Primary Components

The starter primarily consists of an armature, pinion gear, magnetic switch, drive lever, and overrunning clutch. Additionally, starter construction can be broadly divided into the 'motor section' and the 'engine engagement and disengagement mechanism'.



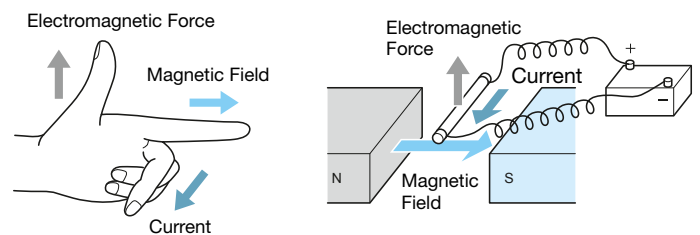
### Motor Section

The motor section primarily consists of an armature, field coil, and brushes.



### Principles of the motor section

Motor principles are explained using Fleming's Left-Hand Rule\*. The size of the electromagnetic force is proportional to the strength of the magnetic field, size of the current, and length of the conductor.

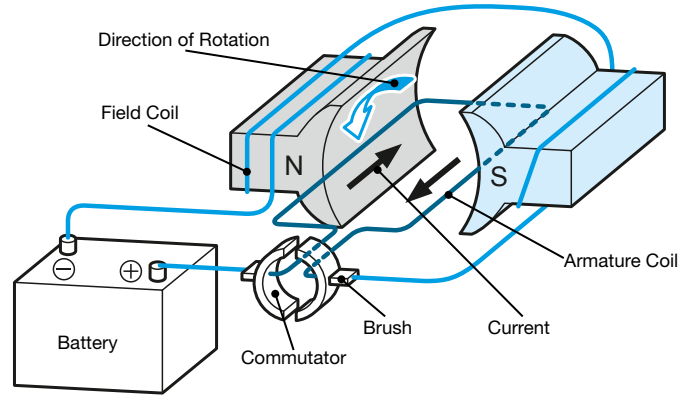


\*According to Fleming's Left-Hand Rule, three fingers on the left hand can be used to represent the following phenomenon; pointer finger: direction of the magnetic field (North to South), middle finger: direction of current (positive to negative), thumb: direction of electromagnetic force.



**Operations of the motor section**

For the starter to operate as a motor, the electromagnetic force must be continuous and work in a fixed direction. Therefore, the motor is equipped with a commutator and brushes so that current always flows in a fixed direction to the North pole side or South pole side of the armature. As a result, the coil generates a force that works in a fixed direction so that the motor can rotate continuously. An actual starter combines multiple armature coils with the commutator.

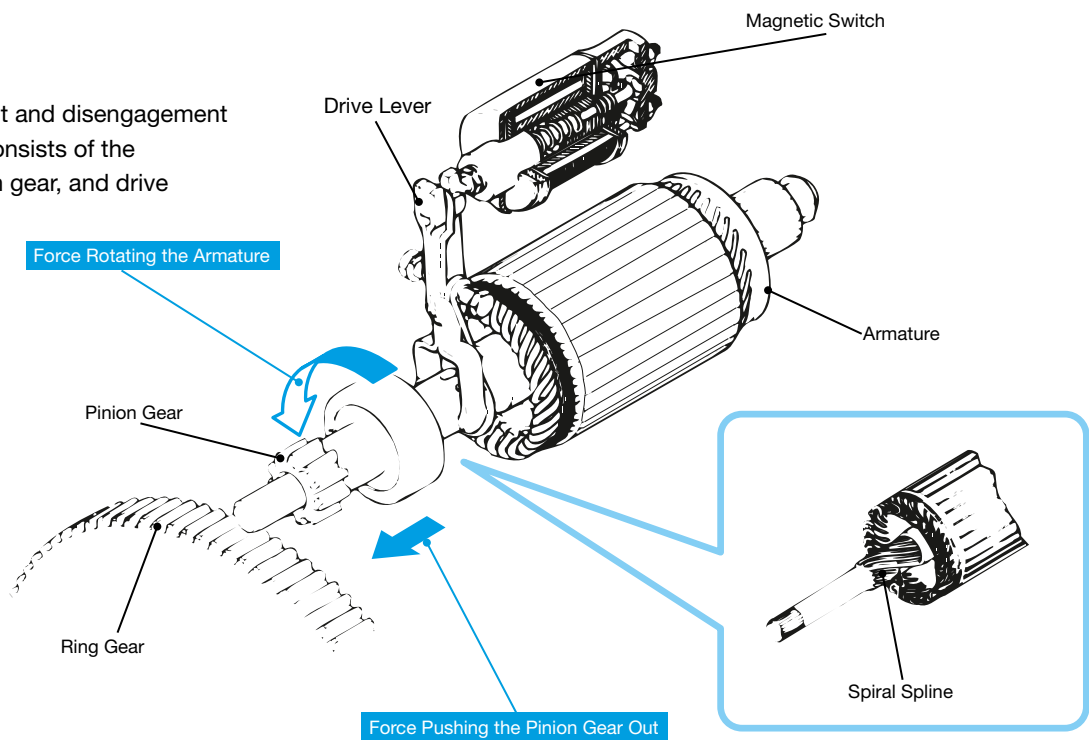


**Engine engagement and disengagement mechanism**

The starter rotates the engine by engaging the starter pinion gear with the engine ring gear. If the pinion gear and ring gear remain engaged after the engine is started, the pinion gear will be rotated by the engine at high speeds, causing starter breakage. Therefore, the pinion gear must smoothly engage the ring gear only when the starter is operating, and must disengage immediately after the engine has started.

**Primary Components**

The engine engagement and disengagement mechanism primarily consists of the magnetic switch, pinion gear, and drive lever.





## Engagement

When the starter is operated, the armature begins to rotate, and the drive lever pushes the pinion gear out to engage the ring gear.

However, there are instances when the pinion gear and ring gear collide. In such cases, the force pushing the pinion gear out, and the force rotating the armature work to assuredly engage the two gears. The effect of the two previously mentioned forces combined with the spiral spline make the

pinion gear slip onto the ring gear, enabling assured gear engagement.

### **Role of the spiral spline**

The spiral spline is engraved into the armature shaft (engraved into the drive shaft for reduction type, and planetary type starters) to push the pinion gear out. Even when the pinion gear only slightly engages the ring gear, the spiral spline allows the pinion gear to be pushed out to ensure complete engagement using the force rotating the armature.

## Disengagement

Once the engine has started and the starter has been stopped, the pinion gear is drawn back and disengages from the ring gear. Simultaneously, the armature stops rotating.

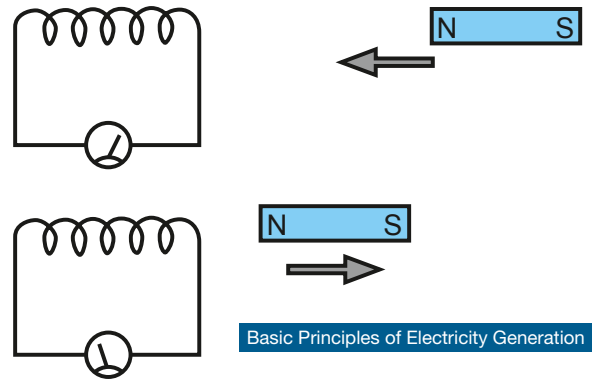


# DENSO Alternators | Characteristics

## > How Alternators work

### Basic Principles of Electricity Generation

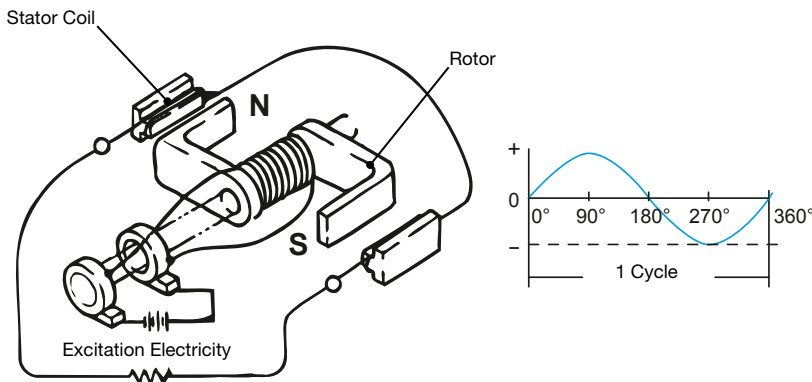
When a magnet is moved in the vicinity of a coil, a voltage is generated. The stronger the magnet, the larger the voltage generated and the faster the magnet is moved, the larger the voltage. Also, the greater the number of windings in the coil, the larger the voltage.



Basic Principles of Electricity Generation

### Generating an Alternating Current

#### Basic Principles of the Alternator

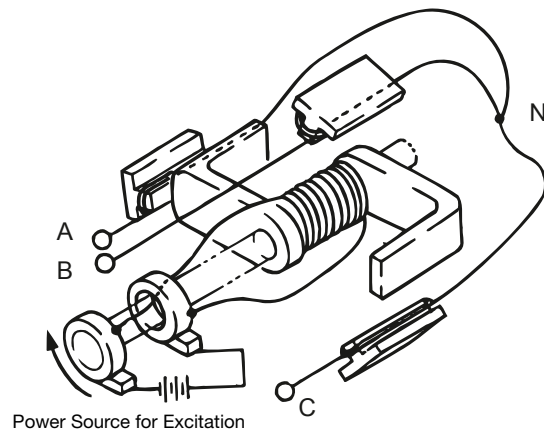


In an actual alternator, a rotor fulfills the role of the magnet in the above figure, while a stator coil fulfills the role of the coil. The rotor does not move in and out from the stator; instead, it rotates within the stator itself. As the rotor rotates the N pole or the S pole of the rotor alternately approach the stator coil, and a current is generated in the stator coil.

#### Alternator With 3-Phase Coil

The alternator generates 3-phase alternating current, which offers significant advantages when compared with a single phase alternating current.

Taking the example of a simple bipolar alternator, in a single phase, current is received from a generator with one coil. In a 2-phase current, the generator has two coils placed at an interval of 90°, while in a 3-phase current there are 3 coils placed at an interval of 120°.



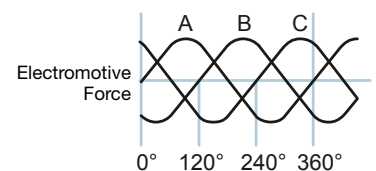
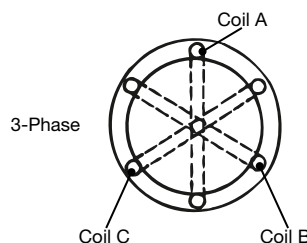
A stator and rotor such as those below are installed in actual alternators.



Stator



Rotor



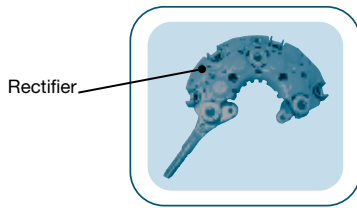


## Rectification

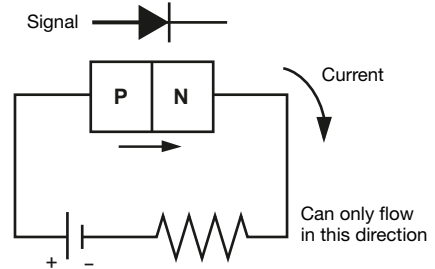
One objective of the alternator is to charge the battery, so the alternating current cannot be used unchanged. A diode (solid state rectifier) is used to perform rectification by converting the alternating current into direct current.

An actual alternator has 3-phase alternating current, so 6 diodes are used for 3-phase full wave rectification. In (a), a large voltage is generated between phases I and II, and the current flows to the load through diode 1 and flows back from diode 5. In the next process as shown in (b), the voltage becomes higher between phases I and III, and current leaves through diode 1 and comes back through diode 6. Following on in sequence to (c), (d), (e) and (f), the current size and direction flowing to each phase and wire is varied, however the current is always delivered to the load in a constant direction.

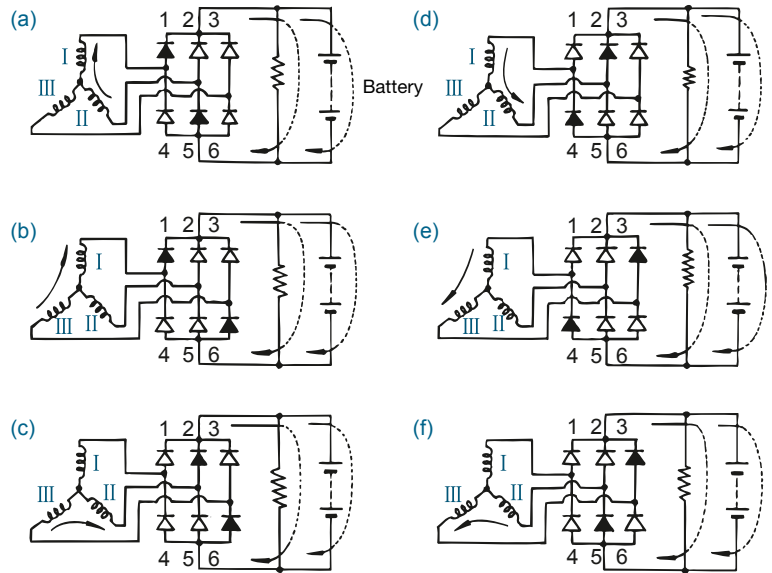
This rectification action is performed by a rectifier.



Rectification Action of the Diode



Schematic Diagram of 3-Phase Full Wave Rectification





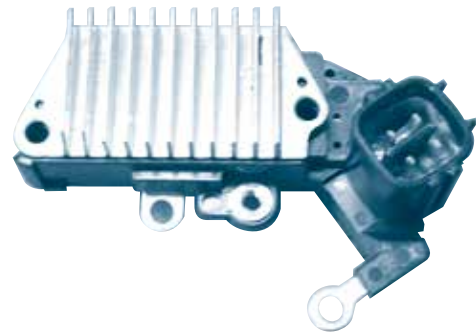
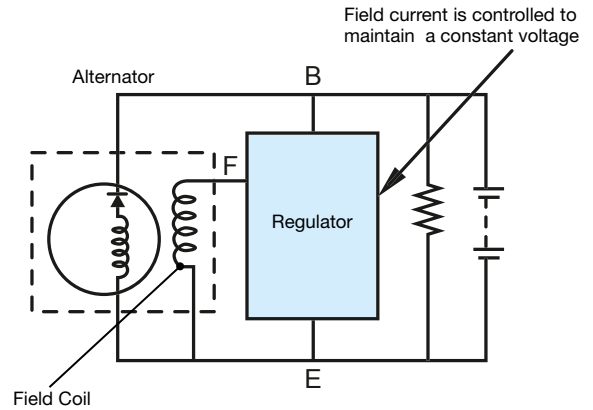
## Generated Voltage Control

The voltage generated in the alternator increases as the rotating speed of the rotor increases. If the generated voltage is then directly supplied to an electrical load such as a battery or light, increases in alternator speed can result in electrical equipment failure (excessive charging, blown lights, etc.).

Therefore, a constant output must be maintained. The alternator controls this by varying the current flowing to the field coil. When the rotational speed is high or the load is light and the output voltage seems ready to exceed the specified value, the current flowing to the field coil is reduced. This ensures that the output voltage is always within the specified value range.

The component that performs this control is called the regulator.

The IC regulator is currently the most common type.



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