

COMPANY RANKING OF DOMESTIC AND FOREIGN PATENT FAMILIES
IN KEY COMPONENT TECHNOLOGIES OF ELECTRIC VEHICLES

1. Purpose

In recent years, the market for electric vehicles such as electric vehicles (EV), hybrid vehicles (HV) and fuel cell vehicles (FCV) has been expanding.

We, NGB Corporation, focuses on the key component technologies of electric vehicles and investigates domestic and foreign patent filings related to the key technologies.

2. Key Component Technologies

Electric vehicles are powered by an electric motor. This is a major difference from conventional vehicles powered by an engine.

In this study, we set a motor, an inverter, and a battery, as the key component technologies of electric vehicles, which support an electric drive propulsion system, as shown below.

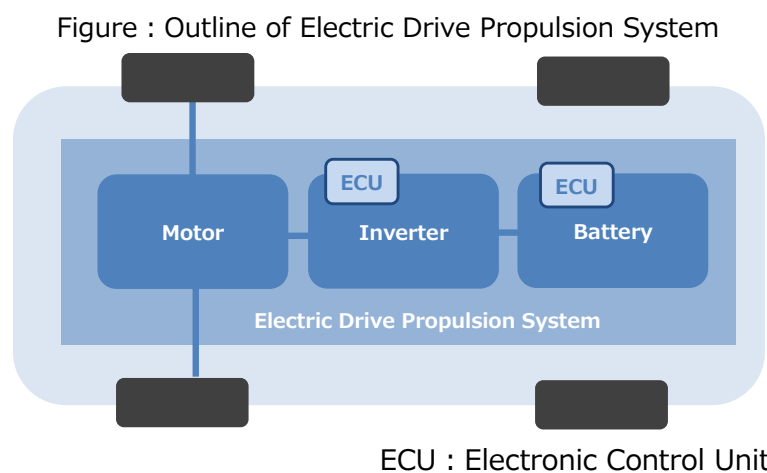


Table : Key Component technologies subject to this study

1	Motor		We focused on an electric vehicle motor, which generates the driving power of the vehicle when running and recovers energy as a generator when braking.
2	Inverter	Structure	We focused on a technology relating to a cooling structure of (1) a circuit configuration to control motor speed, etc., by converting the power from the battery, from direct current to alternating current, or (2) a semiconductor module.
		Control	We focused on a control technology of motor torque and rotation speed, and power conversion control such as PWM control.
3	Battery	Structure	We focuses on a technology of battery structure for storing electric power needed to drive electric vehicles. (excluding fuel cells)
		Control	We focused on a control technology for efficiently managing a battery, such as monitoring and controlling the voltage and temperature of multiple batteries.

3. Search Specification

We compiled and ranked the number of patent applications and patents for each of the key component technologies classified by the using the search queries according the above table.

The search specification is as follows:

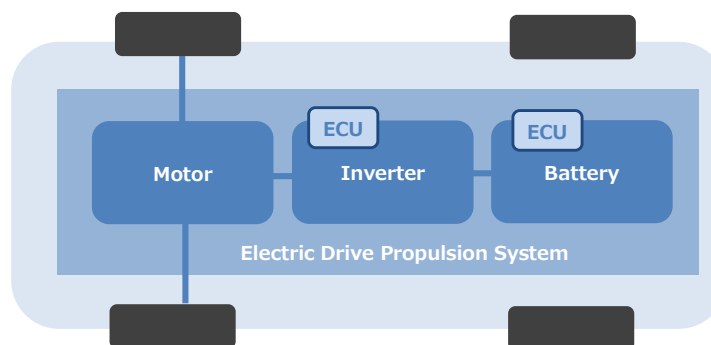
- We searched and compiled the number of patent applications and patents in term of patent family. (One number = one patent family).
- We treated the subject patent family if the patent family has at least one pending application or at least one patent within the valid period.
- We compiled the hit records of the subject patent family without reading the contents of the patent applications and patents (without noise reduction).

4. Search Results

The company ranking of each key component technology is set forth below.

Motor

Rank	Current Assignee	Num.
1	DENSO	1683
2	TOYOTA MOTOR	1261
3	ROBERT BOSCH	1084
4	MITSUBISHI ELECTRIC	930
5	HONDA MOTOR	834
6	HITACHI Group	630
7	VALEO EQUIPEMENTS ELECTRIQUES MOTEUR	588
8	AISIN Group	568
9	NIDEC	483
10	MITSUBA	413



Battery

Structure

Rank	Current Assignee	Num.
1	LG CHEM	3822
2	TOYOTA MOTOR	1977
3	SAMSUNG SDI	1447
4	ROBERT BOSCH	1386
5	PANASONIC Group	1104
6	CONTEMPORARY AMPEREX TECHNOLOGY	683
7	TOSHIBA	586
8	NISSAN MOTOR	578
9	BYD	539
10	HONDA MOTOR	512

Control

Rank	Current Assignee	Num.
1	TOYOTA MOTOR	2424
2	ROBERT BOSCH	1362
3	LG CHEM	1254
4	DENSO	1243
5	PANASONIC Group	977
6	SAMSUNG SDI	749
7	HYUNDAI MOTOR	689
8	HONDA MOTOR	658
9	FORD GLOBAL TECHNOLOGIES	578
10	TOYOTA INDUSTRIES	559

Inverter

Structure

Rank	Current Assignee	Num.
1	DENSO	1463
2	TOYOTA MOTOR	1172
3	MITSUBISHI ELECTRIC	877
4	HITACHI Group	793
5	ROBERT BOSCH	354
6	PANASONIC Group	340
7	TOSHIBA	321
8	NISSAN MOTOR	265
9	FUJI ELECTRIC	207
10	INFINEON TECHNOLOGIES	203

Control

Rank	Current Assignee	Num.
1	DENSO	1705
2	TOYOTA MOTOR	1575
3	MITSUBISHI ELECTRIC	1004
4	HITACHI Group	870
5	ROBERT BOSCH	448
6	TOSHIBA	389
7	PANASONIC Group	379
8	NISSAN MOTOR	351
9	HYUNDAI MOTOR	322
10	GM GLOBAL TECHNOLOGY OPERATIONS	295

Motor:

Denso and Toyota Motor are particularly high in the number. As foreign companies, BOSCH (DE) and VALEO (FR) are high in number.

Inverter:

Denso, Toyota Motor, Mitsubishi Electric, and Hitachi group are the most frequent patent filers in this order both in the structure and control. As foreign companies, BOSCH is the highest in number both in the structure and control, and GM (US) is in the second next to BOSCH in the structure.

Toyota Motor and Denso entered into a business transfer agreement to transfer the electronic component business from Toyota Motor to Denso¹². We confirmed some records of the ownership change from Toyota Motor to Denso in the data set of the subject patent families.

Battery:

In the structure, LG Chemical (KR) has the highest number, and Samsung SDI (KR), BOSCH (DE), CATL (CN), and BYD (CN) are at the top of the list. Foreign companies tend to put more effort to file patent applications in the battery structure than Japanese companies.

Nissan Motor in the raking 8th entered into a stock purchase agreement to transfer its battery business to ENVISION GROUP, a renewable energy company³. We confirmed some records of the ownership change from Nissan Motor to ENVISION GROUP in the data set of the subject patent families.

¹ Toyota Motor Web site in June 2018:

https://global.toyota.jp/newsroom/corporate/22763980.html?_ga=2.245778631.252435672.1585877054-552373323.1579666532

² Denso Web site in April 2019:<https://www.denso.com/global/en/news/newsroom/2019/20190405-g01/>

³ Nissan Motor news room Web site in Aug. 2018:<https://global.nissannews.com/en/releases/release-ed7b0014763a42e1693c5c954e0607c2-180803-01-e>

In the control, Toyota Motor has the highest number, followed by BOSCH, LG Chemical and Denso in this order. Similar to the structure, foreign companies tend to put more effort to file patent applications than Japanese companies in comparison to the other key component technologies.

Supplemental:

In generating the rankings, we considered the following points to control applicant names:

- (1) Names of companies that are in a parent-child relationship in terms of management
- (2) Names of companies that have been acquired or integrated
- (3) Names of the new company and the old company
- (4) Spelling variants and clear error in company names

5. Summary

Japanese mega-supplier Denso and Toyota Motor are filing particularly high numbers of patent applications in the key component technologies of the motor and inverter. On the other hand, a large percentage of battery patent applications were filed by South Korean, Chinese and European companies, suggesting that they are focusing on battery development.

In the key component technologies of electric vehicles, we expect to see fierce competition for market share, including business transfers and alliances, both in Japan and abroad, and the number of patents from each company is likely to move in tandem with that.

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