ITISE 2019

International Conference on Time Series and Forecasting

PROCEEDINGS OF PAPERS

Volumen 2

ITISE 2019
International Conference on Time Series and Forecasting

Proceedings of Papers
25-27 September 2019
Granada (Spain)

Editors and Chairs
Olga Valenzuela
Fernando Rojas
Héctor Pomares
Ignacio Rojas

I.S.B.N: 978-84-17970-78-9
Legal Deposit: Gr 1209-2019
Edit and Print: Godel Impresiones Digitales S.L.

Patent Analysis as a Tool for Revealing Promising Trends of Technological Development

V. Avdzeyko, V. Karnyshev, E. Pascal

Tomsk State University of Control Systems and Radioelectronics (TUSUR), Lenin Ave., 40, Tomsk, 634050, Russia
http://www.tusur.ru, pio@main.tusur.ru

Abstract. The paper proposed to use the method of patent analysis for revealing promising trends of technological development. In the authors' view such approach may be useful for short-term forecasting of new products. This method is considered to be perspective and accurate due to the fact that patent information goes ahead of industrial implementation of technological solutions. The given approach is demonstrated by using the International Patent Classification (IPC) and analysis of relevant US patents based on the example of the IPC main group H02M3/00 "Conversion of DC power input into DC power output". The results are based on time series of US patents issued in from 1976 to 2017 and covers the development trends of DC to DC power converters corresponding to IPC subgroups H02M3/02 – H02M3/42.

Keywords: Patent analysis, IPC, time series, short-term forecasting,US patents, power converters, trends

1 INTRODUCTION

To succeed in a project to be implemented, it is necessary to choose the most promising trend of development in the relevant area. Forecasting and planning significantly facilitate this choice and give an opportunity to concentrate financial, material, personnel, and other resources for solving the most urgent and promising engineering problems, to shorten the time needed for R&D, design engineering, and production of new equipment, to increase the equipment operating life, and to maximize the profits from the product sales.

A way for revealing the most promising trends of engineering (technological) development is the elaboration and practical use of forecasting methods.

2 TECHNOLOGICAL FORECASTING BASED ON PATENT ANALYSIS

In recent years, much attention has been paid to examination and improvement of advanced forecasting methods. The methods are intended to reveal prospects for specific

adfa, p. 1, 2011.

trends of research and development by gathering, processing, and analyzing the data contained in patents, papers, reports, and other published works that advance the state of the art of modern equipment and technology.

Intuitive forecasting methods are increasingly inferior to methods based on the analysis of statistical information representing the background of an area under study. We share the opinion of many authors engaged in R&D forecasting [1, 2] that bibliometric methods are gaining acceptance. These methods are based on the property of scientific and technical information (articles, patents, theses, conference proceedings, etc.) to reflect and be ahead of scientific and technological gains in industry

The bibliometric methods used for technological forecasting include patent, publication, and citation-index analyses and also methods for evaluating the significance of inventions and innovations. They have gained acceptance as they provide the opportunity to directly relate the dynamics of scientific and technological information to the progress in science and technology and to display the state of the art in various fields of science and technology and the trends in their development.

In predictive assessment of technology development, patent information, which contains a large amount of specific technical data (objectives, keywords, assignees, authors, etc.) is used most frequently [2]. An additional advantage of patent information is, in our opinion, the use of the International Patent Classification (IPC).

Patent statistics serves as a reliable and stable indicator of trends in the development of various technological areas. Campbell et al. [3] showed that patent data can be considered a forecasting tool for decision-making at the national, industry-specific, and corporate levels. Mogge [4] pointed out that statistical analysis of international patent data is a valuable tool for corporate technology forecasting and planning. Patent analysis is currently one of the best ways to detect engineering and technological changes, as it allows the occurrence of new products to be predicted at least 6-18 months before their market appearance.

3 USE OF THE INTERNATIONAL PATENT CLASSIFICATION

The above forecasting approaches and methods are associated with considerable data processing costs and loss of information during processing [5]. These shortcomings can be significantly reduced and even eliminated by using the IPC [6]. A method of technological forecasting was proposed [7] which uses the IPC for patent analysis. Using the IPC and ranking relevant patents according to the filing or registration date allows one to reveal trends in the development of technologies under investigation [8].

3.1 Patent analysis using the database of the US Patent and Trademark Office

The US Patent and Trademark Office (USPTO) has one of the largest seeded databases. In contrast to the databases of the European Patent Organization and other national agencies, it provides direct access to full-text patent descriptions.

Taking into account the peculiarities of the access to patent information provided by the USPTO, a software approach was proposed [9, 10] that allows one to build up lists of US patents according to a given set of patent numbers, IPC subgroups, and keywords, to create local seeded databases of US patents, to obtain information on quantitative distribution of patents over the IPC subgroups, to form patent data series, process them, and plot the results for the period since 1976 to the present.

In this paper, we consider a way to reveal promising trends of technology development by using the IPC and analysis of relevant US patents based on the example of the IPC main group H02M3/00: Conversion of DC power input into DC power output.

3.2 Analysis of DC/DC converters

DC/DC converters are designed to match the DC voltage of a power supply line (power source) to the input voltage of a load.

According to the IPC, DC/DC converters can be made to operate without conversion (subgroups H02M3/02 – H02M3/20) and with (H02M3/22 – H02M3/44) intermediate conversion into AC.

Converters without intermediate DC/AC conversion (direct DC/DC converters) are used, for example, when specifications do not require galvanic isolation between the primary power supply (battery) and the load, or when one or more auxiliary power supplies or converter units of a control circuit need to be directly connected to the supply line. Recently, electric circuits of this type have found wide application in microelectronic devices.

Converters with intermediate DC/AC conversion (DC/AC/DC converters) are used to provide galvanic isolation between the power supply line and the load. In this case, the sequential DC/AC plus AC/DC conversion is performed with an increased frequency to provide high weight and size parameters of the converters.

To perform patent analysis for DC/DC converters, a database of US patents belonging to the IPC main group H02M3/00 was created for the period from 1976 to 2017. Figure 1 presents diagrams showing the number of registered US patents for direct DC/DC converters and for DC/AC/DC converters. The total number of patents for the period from 1976 to 2017 for the main group was 14,309. The number of patents for direct DC/DC converters and for DC/AC/DC converters was 6,863 and 7,840, respectively.

Until 2002, the number of patents for both types of converters increased, and from 2002 to 2006, there was a sharp decrease in their number. Since 2006 to 2017, there was an increase in the number of granted patents: from 42 to 1409 for direct DC/DC converters and from 181 to 837 for DC/AC/DC converters.

The sharp decrease in the period from 2002 to 2006 can be explained by a number of reasons:

- an almost 20% decrease in the total number of issued US patents in these years;
- a sharp increase in the industrial production of converters with various input and output parameters (which proves the relation of patent activity to the output and range of industrial products);

- registration of the claimed patents in irrelevant groups and subgroups of the IPC, modification of the IPC itself, as well as by many other factors the study of which is beyond the scope of this work.

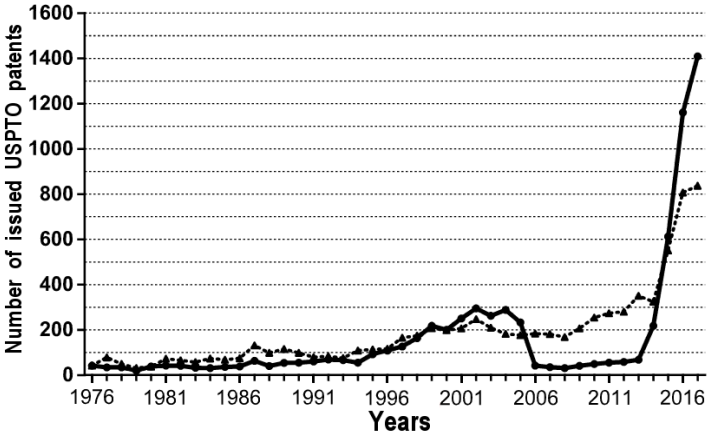

Fig. 1. Number of USPTO patents issued for direct DC/DC (solid line) and DC/AC/DC converters (dashed line).

As we dealt with short-term and medium-term forecasting, the analysis of the trends of converter development was carried out for the period from 2007 to 2017.

3.3 Analysis of converters without intermediate DC/AC conversion

In accordance with the IPC, direct DC/DC and DC/AC/DC converters can be made as static converters (SCs), dynamic converters (DCs), or as a combination of static and dynamic converters, or as a combination of rotary converters and other dynamic and/or static converters.

In view of the fact that only static converters are currently used in practice, an analysis of devices made on their basis has been carried out for the last 10 years since the beginning of the increase in the number of registered patents (Fig. 2).

For this period, 3,737 and 4,231 patents have been issued for direct DC/DC and DC/AC/DC converters, respectively. Thus, these converter types are equivalent in number of patents. However, while in 2014, DC/AC/DC converters went beyond direct DC/DC converters in number of patents, the number of patents issued in 2015-2017 for direct DC/DC converters (3546) is almost 30% more than for DC/AC/DC converters (2716).

Let us consider the element base of semiconductor devices used to design the converter types under comparison. In accordance with the IPC, direct DC/DC converter circuits can be based on thyristors (H02M3/125 – 3/142) or transistors (H02M3/145 – 3/158). Only 11 patents were issued for the thyristorized models in 2007-2017 and 2,869 for the transistorized models.

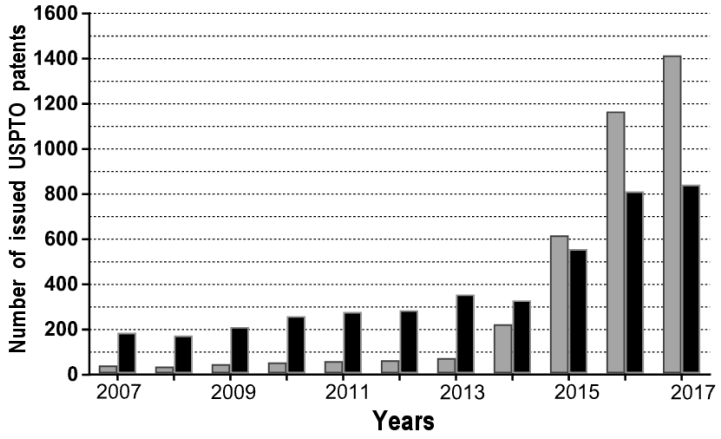

Fig. 2. Patent issuance dynamics for direct DC/DC (black bars) and DC/AC/DC (grey bars) converters.

It follows that thyristorized converters are not promising, which seems to be due to their large dimensions and the need for additional "quenching" devices. Let us consider transistorized converters of different circuit design.

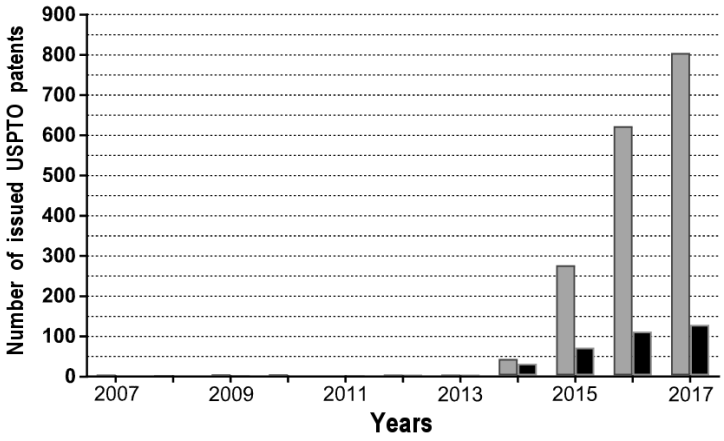

Fig. 3. Transistorized converter circuits with digital control and one semiconductor device (black bars) and with several semiconductor devices used as a terminal control unit for a single load (grey bars).

Figure 3 shows diagrams of the number of patents issued for converter circuits with automatically controlled voltage or digitally controlled current (H02M3/157) and for circuits made using several semiconductor devices as a terminal control unit for a single load (H02M3/158).

In 2017, the number of patents issued for circuits with several semiconductor devices switched by a given algorithm to control (stabilize) the output parameters of the converters was 6.4 times that issued for circuits with one semiconductor device.

3.4 Analysis of converters with intermediate DC/AC conversion

Similarly, we analyze converters with intermediate DC/AC conversion. Like with direct DC/DC circuit designs, the transistorized circuits are significantly superior to the thyristorized circuits. Over the past 10 years, 3,941 patents have been issued for transistorized converters (H02M3/325, H02M3/335 - H02M3/338) and only 30 for thyristorized ones (H02M3/305 - H02M3/315), indicating the promise of using transistors as semiconductor devices in the output units of converters. The search for promising converter circuits is illustrated by Fig. 4, which shows the number of patents issued for converters with push-pull circuits (H02M3/337) and with self-oscillating circuits (H02M3/338). In 2017, 102 patents were issued for push-pull converters and only 12 patents for self-oscillating converters.

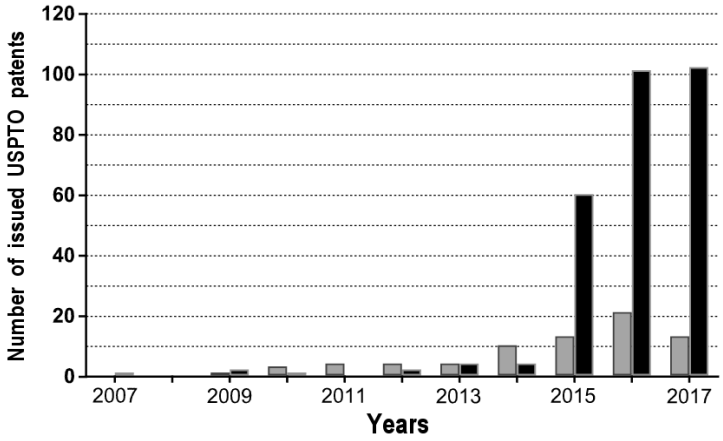

Fig. 4. The number of patents issued for push-pull (black bars) and self-oscillating converters (grey bars).

4 CONCLUSIONS

1. The analysis performed on the example of one group of the IPC not only has shown the capabilities of the patent analysis method for revealing promising trends of technological development, but also has substantiated the possibility to develop forecasts for further development based on the results obtained.
2. Classification of specific research areas in terms of the IPC makes it possible to use patent analysis for revealing both promising and dead-end trends in the development of equipment and technology.

3. The advantage of converter circuits without intermediate DC/AC conversion is based on advanced solutions in microelectronics.
4. Circuits with intermediate DC/AC conversion are advisable to use in converters with increased output power or with a significant difference between the voltage of the primary power source and the required output voltage of the converter.
5. Direct DC/DC converters with self-controlled voltage or current are more promising to design based on several switched semiconductor devices.
6. DC/AC/DC converters based on push-pull circuits have a significant advantage over self-oscillating converters.

ACKNOWLEDGMENT

The work was supported in part by the Russian Foundation for Basic Research (Project No. 18-07-01270 A).

REFERENCES

1. Ayse Kaya Firat, Wei Lee Woon, Stuart Madnick. "Technological Forecasting – A Review," Working Paper CISL# 2008-15, September 2008.
2. V. Coates, M. Faroque, R. Klavins, K. Lapid, H.A. Linstone, C. Pistorius, A.L. Porter. "On the future of technological forecasting," Technol. Forecast. Soc. Change 67 (1) (2001), pp. 1-17.
3. R.S. Campbell. "Patent trends as a technological forecasting tool," World Patent Information. Vol. 5 (1983), pp. 137-143.
4. M.E. Mogee. "Using patent data for technology analysis and planning," Research Technology Management. Vol. 34, pp. 43-49 (1991).
5. M. Fattori, G. Pedrazzi, R. Turra. "Text mining applied to patent mapping: a practical business case," World Patent Information. Vol. 25 (2003), pp. 335-342.
6. S. Jun. "IPC code analysis of patent documents using association rules and maps-patent analysis of database technology," Communications in Computer and Information Science. Vol. 258 (2011), pp. 21-30.
7. J. Kim, M. Hwang, Jeong Do-Heon, H. Jung. "Technology trends analysis and forecasting application based on decision tree and statistical feature analysis," Expert Systems with Applications. Vol. 39 (2012), pp. 12618-12625.
8. M. Bengisu, R. Nekhili. "Forecasting emerging technologies with the aid of science and technology databases," Technological Forecasting & Social Change. Vol. 73, (2006), pp. 835-844.
9. V.I. Avdzejko, V.I. Karnyshev, R.V. Meshcheryakov, Parnyuk L.V. "Forecasting of development trends and spotting breakthrough technologies in the field of converter equipment," Izvestiya Vysshikh Uchehnykh Zavedenii. Elektromekhanika (Russian Electromechanics). Vol. 60 (2017), No. 2, pp. 51-56 (in Russian)
10. [10] V.I. Avdzejko, V.I. Karnyshev, R.V. Meshcheryakov. "Forecasting of power electronics development directions based on international patent classification time series," Elektrotekhnicheskie I Informatsionnye Kompleksy I Sistemy. Vol. 12 (2016), No. 2, pp. 23-28 (in Russian)