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# Increasing the Efficiency of the Stop-Start System through the Application of Super Capacitors

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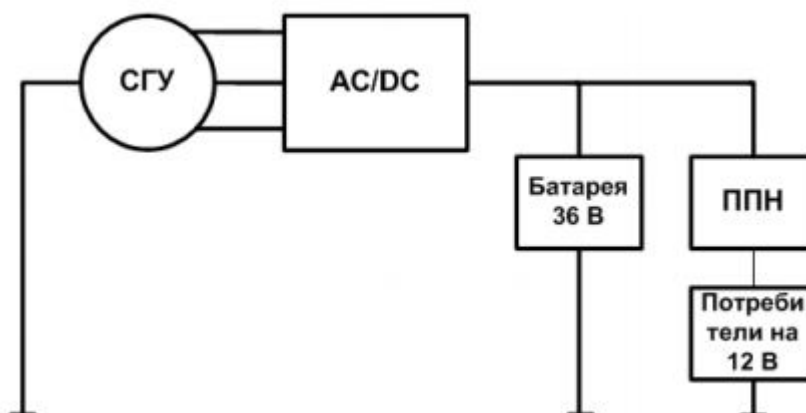
**ABSTRACT:** This paper discusses starter-generator as one of the most promising options for vehicle's fuel economy improvement, emission reduction, and increasing the power of power supply system. The types of starter-generators, their main functions and mild hybrid concept are reviewed. Also, main types of brushless electric machines for starter-generator application, their benefits and drawbacks are discussed and compared here.

**KEYWORDS:** starter-generator, mild hybrid, switched reluctance machine, induction machine, permanent magnet synchronous machine.

## I. INTRODUCTION

The development of technologies and the adoption of new international standards, caused by increased requirements for the safety and comfort of vehicles (TC), the number and power of electrical consumers in the car is increasing. In this regard, more powerful and highly efficient power plants are required that can provide a given level of electricity consumption. In addition, in recent decades, one of the main trends in the automotive industry is the reduction of harmful vehicle emissions into the atmosphere. Every year, the requirements for emission standards become more stringent, therefore, in the automotive industry, priority is given to technologies that can significantly reduce harmful emissions into the atmosphere. It becomes more difficult to provide the required performance by upgrading conventional vehicle systems. In this situation, the most priority and promising option may be combined electromechanical converters - starter-generator sets (GGU), which replace the traditional starter and generator with one non-contact electric machine (EM). This solution has such undoubted advantages as engine compartment savings, high reliability, increased power in generator mode (from 4 to 25 kW), and improved environmental friendliness of the vehicle. Unlike SGU, the traditional starter is not used after starting the internal combustion engine, and therefore, most of the time the vehicle is in operation, it acts as an additional load. In addition, the combination of an EM with an internal combustion engine makes it possible to reduce the working volume of the latter while maintaining the output characteristics of the power unit as a whole.

The currently used on-board vehicle network, designed for 12 (14) V, cannot provide increased power for the annually growing number of consumers on board. Therefore, the optimal voltage level of the on-board network increases with increasing load. With the same current strength of 71 A, the on-board network will have an optimal operating voltage level of 12(14) V, 24(28) V, 36(42) V, 48(56) V for 1–4 kW of power, respectively [1]. However, it is proposed to supply with increased voltage from the generator set exclusively powerful consumers of the vehicle (SGU in motor mode, electric air conditioner compressor, electric heating system and various electric motors). Thus, a 2-level architecture of the vehicle's on-board network is proposed (Fig. 1). The power supply of devices with standard voltage in this network will be carried out using a DC voltage converter (DCV).



**Figure 1. Structural diagram of the 2-level on-board network of the vehicle**

Types of starter-generator devices:

Starter-generator sets, according to the type of construction, are divided into SGU with a belt drive and integrated (Integrated starter-generator sets).

The DGS with a belt drive is located in the place of a traditional generator and is connected to the crankshaft of the internal combustion engine by means of a belt drive (Fig. 2a). The main devices of this type are a non-contact electric machine, a belt drive, a system that controls the tension of the drive belt, an inverter (AC / DC), a step-down DC voltage converter to power low-voltage circuits (DC / DC). Such a system is the cheapest and simplest option in terms of design, since it does not require significant changes in the design of the power unit. However, the resource and the maximum possible transmitted torque are limited by the imperfection of the belt drive system, so this type of electromechanical converter has fewer prospects for use compared to Integrated starter-generator sets.

An integrated starter-generator set (Integrated starter-generator sets) is the most rational type of execution, since the EM rotor in this case is located on the crankshaft between the internal combustion engine and the gearbox.

This type of construction has a number of significant advantages compared to the traditional and belt type: high reliability, as there are no wear parts; Integrated starter-generator sets allows for a faster and less noisy start ( $t_{\text{start}} = 200$  ms, compared with  $t_{\text{start}} = 800$  ms with a traditional starter) due to the absence of belt and gear drives [2]; high starting torque (200–400 Nm); starting speeds of rotation of the Integrated starter-generator sets reach the idle speed of the internal combustion engine (800-1000 min<sup>-1</sup>), which in turn leads to a decrease in harmful emissions into the atmosphere; the power of the EM used in Integrated starter-generator sets is limited only by the required characteristics, and not by design features; the ability to implement all the functions of a "soft" hybrid.

## II. THE CONCEPT AND FUNCTIONS OF THE "MILD" HYBRID

Based on the ratio of the electric power of the EV and the total power of the combined power plant, hybrid vehicles can be divided into 2 main types: "soft" (mild HEV) and "strong" (strong HEV). The main difference between the first type and the second is that it works exclusively in the auxiliary mode. In a "strong" hybrid, more powerful EVs and batteries are used, allowing the vehicle to move only on electric traction. In this article, only a "soft" hybrid will be considered, since this type has a lower cost compared to a "strong" one and allows you to improve a number of vehicle characteristics.

Figure 3 shows the block diagram of the Integrated starter-generator sets. The main blocks of this circuit are a battery, a DC-to-AC converter, a non-contact electric machine, and a converter control unit. These diagrams also show the direction of energy conversion in Integrated starter-generator sets in motor (a) and generator (b) modes. In addition, a buffer power source such as a supercapacitor may also be used. The use of a supercapacitor to start the internal combustion engine, especially when the "stop-start" system is operating, is more profitable, as it allows you to give short-term high current values. In addition, it has a large number of charge-discharge cycles (millions) [3]. This type of drive is "faster" than a storage battery, since there are no electrochemical reactions in it and only ohmic resistance is critical.

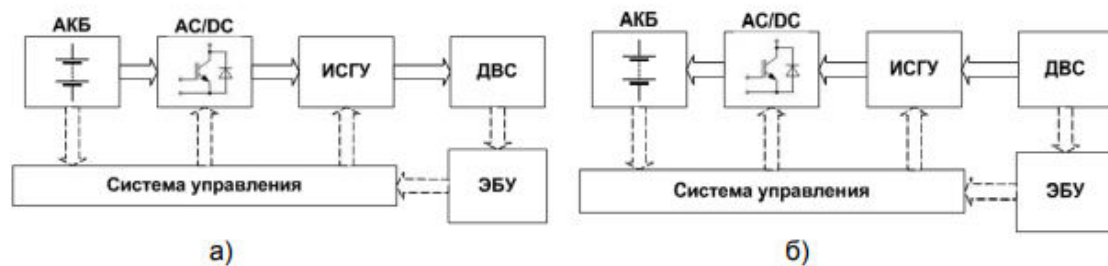


Figure 3. Distribution of energy and signals in Integrated starter-generator sets

Integrated starter-generator sets can operate in 4 main modes: starting, generating, braking (EM regenerative braking) and booster mode.

In the starting mode, the Integrated starter-generator sets develops sufficient starting torque and speed for a quick and silent start of the internal combustion engine. This mode allows you to implement the "stop-start" function, which in the urban traffic mode, when the vehicle stops, turns off the internal combustion engine and quickly restarts to continue driving, thereby reducing fuel consumption by reducing the time the internal combustion engine is in idle mode.

In the "booster" mode, the EM can work together with the internal combustion engine in acceleration modes, when the rotational speeds are low (1000–2000 min<sup>-1</sup>) and high torque is required, thereby increasing the dynamics of the vehicle movement.

As soon as the start-up of the internal combustion engine or the "booster" mode ends, the Integrated starter-generator sets switches to the generator mode, during which the battery is charged and the electrical consumers on board the vehicle are supplied.

In a conventional braking system, all of the frictional energy in the pads is converted into heat. Integrated starter-generator sets in the generator mode can also be used as an electromagnetic brake, which will allow converting part of the braking energy into electrical energy to charge the buffer energy source or battery, and if the battery is fully charged, then the electrical energy is dissipated in the brake rheostat. This system allows not only to receive electrical energy, but also, together with the traditional braking system, to stop the car, which in turn reduces the wear and tear and operating costs of the traditional braking system.

In addition to these functions, Integrated starter-generator sets can also perform active smoothing of ICE torque pulsations. Torque pulsations occurring in the internal combustion engine are observed due to the uneven release of energy in the cylinders during fuel combustion. "Active damping" is carried out as follows: when the set value of the torque ripple is exceeded, the crankshaft is braked by the generator, and the excess energy obtained as a result of this is stored in the supercapacitor and is used in the subsequent compression stroke to increase the speed of rotation of the crankshaft in case of insufficient energy supply.

Types of electrical machines used in the starter-generator set.

The use of Integrated starter-generator sets allowed manufacturers to expand the choice of EVs used in vehicles. At the moment, the most used and mentioned in the literature types of EM are asynchronous EM with a squirrel-cage rotor, synchronous EM with excitation from permanent magnets and valve-reluctance machine.

Synchronous machines with permanent magnets (SM with PM) are non-contact EMs with excitation from permanent magnets, which are either built into the rotor cavity or located on its outer part (Fig. 4a). SM with PM stand out among other types of machines in that they have the highest efficiency in a wide range of rotational speeds, a relatively low level of acoustic noise and a high degree of reliability, and the best weight and size indicators [4]. However, the main disadvantage of this type of EM is associated with its high cost, caused by the use of rare earth elements in its design for the manufacture of permanent magnets. The presence of permanent magnets in the design of the rotor complicates the control system of this type of EM, because the magnetic field created by the magnets constantly interacts with the stator winding. Also, SM with PM requires the presence of damper windings that prevent demagnetization of permanent magnets in starting modes [5]. Despite its high cost, this type of EM is most often used in hybrid vehicles such as Toyota Prius, Chevrolet Volt, BMW i3.

Asynchronous machines (AM) with a squirrel-cage rotor have stator and rotor windings (Fig. 4b). They have a number of advantages such as high reliability, low maintenance requirements and relatively low cost compared to SM with PM. However, in terms of energy efficiency, this type of EM is inferior to machines with permanent magnets, and the presence of a rotor winding complicates the cooling of the EM. Also, the disadvantages of such AM include the requirements for a relatively small gap between the stator and the rotor and additional capacitive elements necessary for



operation in the generator mode, the presence of which increases the overall performance of this type of electromechanical converter and its cost [5]. An experimental sample of Integrated starter-generator sets based on AM is presented in [2, 6].

The last type of EM is the switched reluctance machine (VIM) (Fig. 4c). This type of EM refers to synchronous reluctance machines that operate in the stepper drive mode with continuous rotation. However, VIM should be distinguished from a synchronous reluctance machine, which operates with a sinusoidally varying phase voltage of the armature winding, regardless of the position of the rotor. VIM has not been widely used, but the number of publications devoted to the use of this type of EM is growing every year [7]. Various calculation methods are proposed, and experimental samples are designed on their basis [8]. In [9], a comparison of the characteristics of an induction motor and VIM is presented.

### III. CONCLUSION

The analysis carried out in this article showed that a vehicle with a DGS and an increased voltage of the on-board network is a promising direction in the automotive industry, since this technology improves the fuel efficiency of the vehicle, its comfort and efficiency of the power plant as a whole, and reduces harmful emissions into the atmosphere. In addition, the ability to obtain a sufficiently high power in the generator mode and an increase in the voltage of the on-board network of the vehicle can make the SGU one of the integral parts of a modern car, since new systems are installed on board every year to ensure the comfort and safety of passengers and the driver. The development of modern electronics, automation systems, computer base and converter equipment, which allows accurate and efficient control of EM, also contribute to the introduction of DGS in the TS. Thus, a certain variety of existing types of EM at the moment allows the manufacturer, guided by technical and economic indicators, to choose the most suitable type of EM for a particular type of vehicle. At the same time, the concept of a “soft” hybrid with a parallel structure is of an auxiliary nature, unlike a “strong” hybrid, and does not require complex design solutions, therefore, from the point of view of mass production, vehicles with SGU are more profitable and cheaper.

### REFERENCES

1. Абдалова, С. Р. (2021). ТАЪЛИМ ОЛУВЧИЛАРНИНГ МУСТАҚИЛ ФИКРЛАШИНИ РИВОЖЛАНТИРИШДА ПЕДАГОГИК МАҚСАД ВА ВАЗИФАЛАРНИ АНИҚЛАШНИНГ МОҲИЯТИ. *ACADEMIC RESEARCH IN EDUCATIONAL SCIENCES*, 2(2), 617-623.
2. Abdalova S. R. THE IMPORTANCE OF DEFINING PEDAGOGICAL GOALS AND OBJECTIVES IN THE DEVELOPMENT OF INDEPENDENT THINKING OF STUDENTS // *Academic research in educational sciences*. - 2021. - Т. 2. - №. 2.
3. Мавлянов, А., Ачилов, Г. Б., Абдалова, С. Р. (2021). СОДЕРЖАНИЕ УЧЕБНОЙ ПРАКТИКИ И ТРЕБОВАНИЯ К НИМ. *Экономика и социум*, 5(2), 996-1003.
4. Абдалова, С. Р. (2021). Таълим сифатини оширишда ўқитиш технологияларининг ўрни ва роли. *Science and Education*, 2 (Special Issue 1), 218-228.
5. Мавлянов, А., Абдалова, С. Р. (2021). ОСОБЕННОСТИ ОРГАНИЗАЦИИ УЧЕБНОГО ПРОЦЕССА. 65-я МЕЖДУНАРОДНАЯ НАУЧНАЯ КОНФЕРЕНЦИЯ АСТРАХАНСКОГО ГОСУДАРСТВЕННОГО ТЕХНИЧЕСКОГО УНИВЕРСИТЕТА, 990-992.
6. Аллаhverдиева, Х. В., Абдалова, С. Р., Кахраманов, Н. Т. (2020). Свойства металлополимерных систем на основе полиэтилена низкой плотности и меди. *Молодежь в науке-2020*, 483-485.
7. Zuparova, S., Shegay, A., & Orazova, F. (2020). Approaches to Learning English as the Source of All. *European Journal of Research and Reflection in Educational Sciences*, 8(5).
8. Zuparova, S., Shegay, A. (2021). Methods of Teaching Foreign Languages. *Eastern European Scientific Journal*, 1(7), 141-143.
9. Djurayeva, Y., Ayatov, R., & Shegay, A. (2020). Current Problems and Resolutions of Teaching English Grammar. *Academic research in educational sciences*, 1(3).
10. Ўлжаев, Ў. Б., & Бердиев, Ш. Х. (2021). Углерод нанотрубкасида олтин кластери ва углеводородли молекулаларнинг ўзаро таъсирини моделлаштириш. *Academic Research in Educational Sciences*, 2(5), 1189-1195.
11. Tursunov, I. G., Berdiyev, S. X., & Usmonov, M. M. (2021). Fizikani o'qitishda pedagogik ta'lim klasteri metodidan foydalanishga doir tavsiyalar. *Academic research in educational sciences*, 2(5), 1129-1136.
12. Djurayeva, Y., Ayatov, R., & Shegay, A. (2020). Current Problems and Resolutions of Teaching English Grammar. *Academic research in educational sciences*, 1(3).



13. Ruzmetova, M., Orazova, F., & Kayumova, G. (2020). The Role of Teaching Vocabulary Competence in English. *Academic Research in Educational Sciences*, 1 (3), 509-513.
14. Ruzmetova, M., Otajonova, D., & Babadjanova, N. (2021). CONSIDERATIONS ON UNDERSTANDING THE MEANING OF A WORD. *ACADEMIC RESEARCH IN EDUCATIONAL SCIENCES*, 2(2), 1238-1242.
15. Krivosheyeva, G., Zuparova, S., & Shodiyeva, N. (2020). INTERACTIVE WAY TO FURTHER IMPROVE TEACHING LISTENING SKILLS. *Academic Research in Educational Sciences*, 1 (3), 520-525.
16. Bahromova, M. M. (2022). ZAMONAVIY KASBLARNI EGALLASHDA MATEMATIK MANTIQLIQNING O'RNI VA USHBU KASBLARGA YO'NALTIRISH QAMROVINI KENGAYTIRISH. *Ekonomika i sotsium*, 1(92), 1334-1339.
17. Bahromova, M. M. (2021). The importance and necessity of teaching computer science and programming for primary school students. *Asian Journal of Multidimensional Research*, 10(9), 162-166.
18. Bahromova, M. M. (2021). MULTIMEDIALI INTELLEKTUAL O'YINLAR ORQALI BOLALARDA DASTURLASH KO'NIKMASINI RIVOJLANTIRISH. *ACADEMIC RESEARCH IN EDUCATIONAL SCIENCES*, 2(6), 1189-1193.
19. Khasanov, B. A., Eshboev, U. T., Hasanova, R. B., Mukumov, Z. A., Alikulov, A. I., Djumanova, A. B. (2019). Calculation of the invested capital profitability in the financial condition analysis process. *International Journal of Advanced Science and Technology*, 28(14), 42-48.
20. ISMATULLAYEVA, N. N., DJUMANOVA, A. B. (2021). ROLE AND FUNCTIONS OF TAX ACCOUNTING. *ТЕОРИЯ И ПРАКТИКА СОВРЕМЕННОЙ НАУКИ*, 11(77), 9-11.
21. Джуманова, А. Б., Игамбердиева, К. Э. (2021). МЕХАНИЗМ ВЛИЯНИЯ АМОРТИЗАЦИОННОЙ ПОЛИТИКИ НА ПОКАЗАТЕЛИ ЭФФЕКТИВНОСТИ И ФИНАНСОВЫЕ РЕЗУЛЬТАТЫ РАБОТЫ ЖЕЛЕЗНОДОРОЖНОГО ТРАНСПОРТА. *Экономика и социум*, 9(88), 338-344.
22. Djumanova, A. B., Bobomurodov, N. (2021). FEATURES OF THE ORGANIZATION OF MANAGEMENT ACCOUNTING AND ITS IMPACT ON ENTERPRISES. *Теория и практика современной науки*, 9, 3-7.
23. Джуманова, А. Б., Алимова, Ш. М. (2020). СОВЕРШЕНСТВОВАНИЕ УПРАВЛЕНЧЕСКОГО УЧЁТА УП" O'ZTAMIROY'LMASHTA'MIR". *Экономика и социум*, 5(1), 566-570.
24. Джуманова, А. Б. (2019). ФОРМИРОВАНИЕ УЧЕТНОЙ УПРАВЛЕНЧЕСКОЙ ИНФОРМАЦИИ В СИСТЕМЕ КОНТРОЛЯ ДЕЯТЕЛЬНОСТИ ПРЕДПРИЯТИЙ АО «УЗБЕКИСТАН ТЕМИР ЙУЛЛАРИ». *Инновационное развитие экономики*, 5(3), 55-58.
25. Djumanova, A. B. (2019). THE ROLE OF INTRA-PRODUCTION ACCOUNTING IN THE MANAGEMENT SYSTEM OF ENTERPRISES OF JSC" UZBEKISTAN TEMIR YULLARI». *Journal of Tashkent Institute of Railway Engineers*, 15(4), 57-61.
26. Джуманова, А. Б., Буртабаева, Б. А. (2019). ВЛИЯНИЕ ИЗУЧЕНИЯ ИНОСТРАННЫХ ЯЗЫКОВ КАК В РАЗВИТИИ И РОСТА ЛИЧНОСТИ ТАК И ЭКОНОМИКИ ГОСУДАРСТВА. *Мировая наука*, 4, 274-277.
27. Джуманова, А. Б., Юлдашева, М. М. (2018). ТРАНСФОРМАЦИЯ БУХГАЛТЕРСКОЙ ОТЧЕТНОСТИ РЕСПУБЛИКИ УЗБЕКИСТАН В СООТВЕТСТВИИ С МЕЖДУНАРОДНЫМИ СТАНДАРТАМИ ФИНАНСОВОЙ ОТЧЕТНОСТИ. *Теория и практика современной науки*, 5, 214-218.
28. Джуманова, А. Б., Кушакова, М. Н. (2018). СТРАТЕГИЯ РАЗВИТИЯ АО" УЗБЕКИСТОН ТЕМИР ЙУЛЛАРИ" НА ПЕРИОД 2015-2019 ГОДЫ. *Экономика и социум*, 10, 245-248.
29. Джуманова, А. Б., Игамбердиева, К. Э. (2018). ПОСЛЕДСТВИЯ БЕЗРАБОТИЦЫ И ИХ ВЛИЯНИЕ НА РАЗВИТИЕ ЭКОНОМИКИ. *Экономика и социум*, 10, 243-245.
30. Джуманова, А. Б., Кушакова, М. Н. (2018). РОЛЬ АО" ЎЗБЕКИСТАН ТЕМИР ЙЎЛЛАРИ" В РАЗВИТИИ ТУРИЗМА В УЗБЕКИСТАНЕ. *Экономика и социум*, 10, 249-252.
31. Юсупова, Г. (2021). Состояние концепций моделирования обучения в системе образования. *ЎЗМУ ХАБАРЛАРИ ВЕСТНИК НУУз*, 6(6), 243-246.
32. Юсупова, Г. Ю., Выборнов, С. (2021). «ИНТЕРАКТИВНЫЕ МЕТОДЫ ПРОФИОРИЕНТАЦИОННОЙ РАБОТЫ НА УРОКЕ ИНФОРМАТИКИ». *INNOVATION IN THE MODERN EDUCATION SYSTEM*, 1(6), 342-349.
33. Юсупова, Г. Ю. (2021). Формирование и подготовка компетентности учителей информатики с использованием ресурсов информационно-образовательной среды. *Fizika matematika va informatika*, 1(4), 42-49.
34. Yusupova, G. (2021). Model of development of model competences of a future teacher of informatics. *Экономика и социум*, 9(88), 1022-1031.
35. Юсупова, Г. Ю. (2021). Формирование компетентности у учителей информатики с использованием ресурсов информационно-образовательной среды. *Педагогика журналы*, 2(2), 56-58.



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