ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

Х А Б А Р Л А Р Ы

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НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Казахский национальный исследовательский технический университет им. К. И. Сатпаева

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Kazakh national research technical university named after K. I. Satpayev

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

1 (433)

JANUARY – FEBRUARY 2019

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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«ҚР ҰҒА Хабарлары. Геология мен техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан республикасының Мәдениет пен ақпарат министрлігінің Ақпарат және мұрағат комитетінде 30.04.2010 ж. берілген **№10892-Ж** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., 220, тел.: 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

Редакцияның мекенжайы: Қазақстан, 050010, Алматы қ., Қабанбай батыра көш., 69а.
Қ. И. Сәтбаев атындағы геология ғылымдар институты, 334 бөлме. Тел.: 291-59-38.

Типографияның мекенжайы: «Аруна» ЖК, Алматы қ., Муратбаева көш., 75.

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан (г. Алматы)
Свидетельство о постановке на учет периодического печатного издания в Комитете информации и архивов Министерства культуры и информации Республики Казахстан **№10892-Ж,** выданное 30.04.2010 г.

Периодичность: 6 раз в год
Тираж: 300 экземпляров

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, ком. 219, 220, тел.: 272-13-19, 272-13-18, http://nauka-nanrk.kz /geology-technical.kz

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Институт геологических наук им. К. И. Сатпаева, комната 334. Тел.: 291-59-38.

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty)
The certificate of registration of a periodic printed publication in the Committee of information and archives of the Ministry of culture and information of the Republic of Kazakhstan N 10892-Ж, issued 30.04.2010

Periodicity: 6 times a year
Circulation: 300 copies

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19, 272-13-18,
http://nauka-nanrk.kz/geology-technical.kz

Editorial address: Institute of Geological Sciences named after K.I. Satpayev
69a, Kabanbai batyr str., of. 334, Almaty, 050010, Kazakhstan, tel.: 291-59-38.

Address of printing house: ST "Aruna", 75, Muratbayev str, Almaty

N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 1, Number 433 (2019), 107 – 111 **https://doi.org/10.32014/2019.2518-170X.13**

UDC 621.314.5

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MICROPROCESSOR CONTROL SYSTEM FOR SOLAR POWER STATION

Abstract. In this article, there has been developed a microprocessor control system that provides synchronous operation of a solar power station with an electric grid. It is shown that, in practice, the voltage in the mains does not correspond to a pure sinusoid and has distortions to which the output voltage of the inverter must be adapted.

Keywords: microprocessors, control system, solar power station, inverter, power network, synchronization, voltage.

Currently, the electricity voltage does not correspond to a pure sinusoid and has distortions that occur when using semiconductor converters (controlled rectifiers, power converters, converters and other devices). Therefore, inverters of solar power plants must be adapted to the power grid.

The scientific novelty of this work is the development of a microprocessor-based inverter control system for a solar power plant that transforms electricity into an energy grid. It should be noted that the microprocessor control system of the inverter reacts instantly to changes in the mains voltage, excluding emergency modes. At the same time, solar cells are saved and the maximum transformation of the electric power of the solar power station into the power grid. Thus, the development and practical application of the microprocessor control system is an actual problem.

In most inverters existing to date, the output voltage is formed by a circuit that produces rectangular pulses in the form of a meander at the output. This is sufficient for working in an autonomous mode, but not suitable for working together with the power grid. To correct this shortcoming, there are two principal ways to improve the inverter output voltage curve by the circuit:

- the pulse width modulation of the output voltage curve;
- the amplitude-pulse modulation of the output voltage curve.

Figure 1 shows a stepped voltage form close to a sinusoid with amplitude-pulse modulation [1].

In this work, there was developed and presented [2, 3] a scheme of a multilevel inverter with amplitude-pulse control, where each of n sources of direct voltage (solar cells) are connected in series and through **n** switching keys are connected to a bridge inverter with a common load. In this work it is used amplitude-pulse control in such a way that a multilevel voltage is provided at the output of the inverter, which is close in shape to the sinusoid (figure 1).

Figure 2 shows a block diagram of the organization and connection of a multilevel inverter that allows tracking and synchronizing the output voltage of the inverter with the voltage of the city network in order to maximize the energy of solar cells in the grid.

To connect a power inverter to an industrial network it is very important to achieve synchronous operation of the inverter with the power network. For this, it is necessary to fulfill all the requirements for parallel operation of electric power sources (generators, inverters) and the power grid, which are expressed by the following conditions:

$$f_1 = f_c;\ U_1 = U_c;\ \propto = \pi\ , \tag{1}$$

where f_1 and f_c – respectively, are the frequencies of the source of electrical energy and the power system; U_1 and U_c – respectively, are the voltages of a source of electrical energy and a power system; $\propto$ – is an angle between the vectors of voltages U_1 and U_C and the order of rotation of the phases of the sources of electrical energy must be the same.

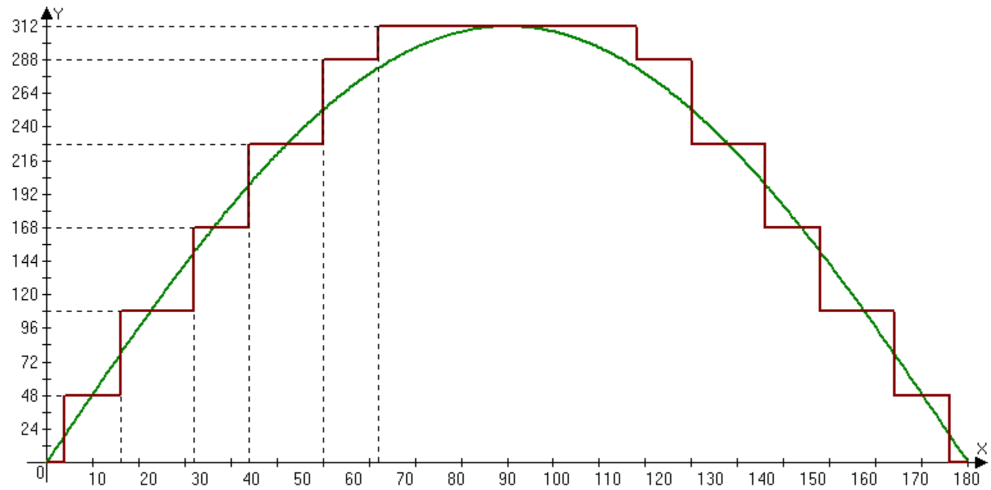

Figure 1 – Stepped voltage form close to sinusoid

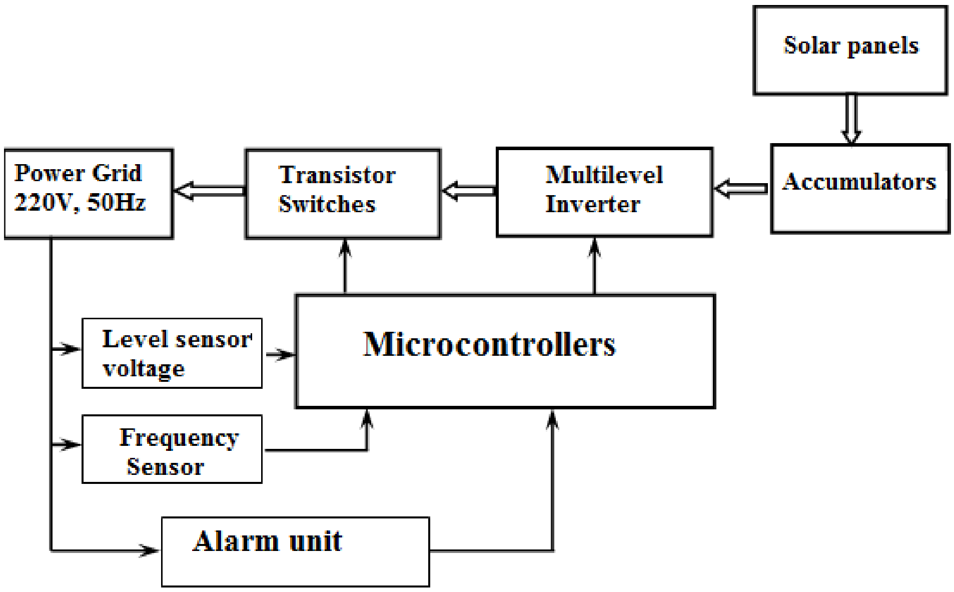

Figure 2 – The block diagram of the inverter's synchronization with the power grid

To fulfill the condition of synchronization of the inverter voltage with the mains voltage, a pulse former was developed. Sync pulses have a periodicity equal to the period of the AC network and are designed to control the frequency and phase of the AC voltage at the output of the inverter.

To synchronize the mains voltage with the voltage of the inverter, there has been developed a device that generates the front of the synchronization pulse at the time of alternating current polarity in the industrial network. A scheme for converting and matching the network voltage level with the level of the multistage inverter voltage has also been developed.

Figure 3 shows the developed circuit of the microcontroller control system of the inverter. For the inverter control system, it was decided to use the Atmel microcontroller of the Mega family. This microcontroller has three 8-bit data I / O ports, which meets the management requirements. The control system was developed in the software environment Code Vision.

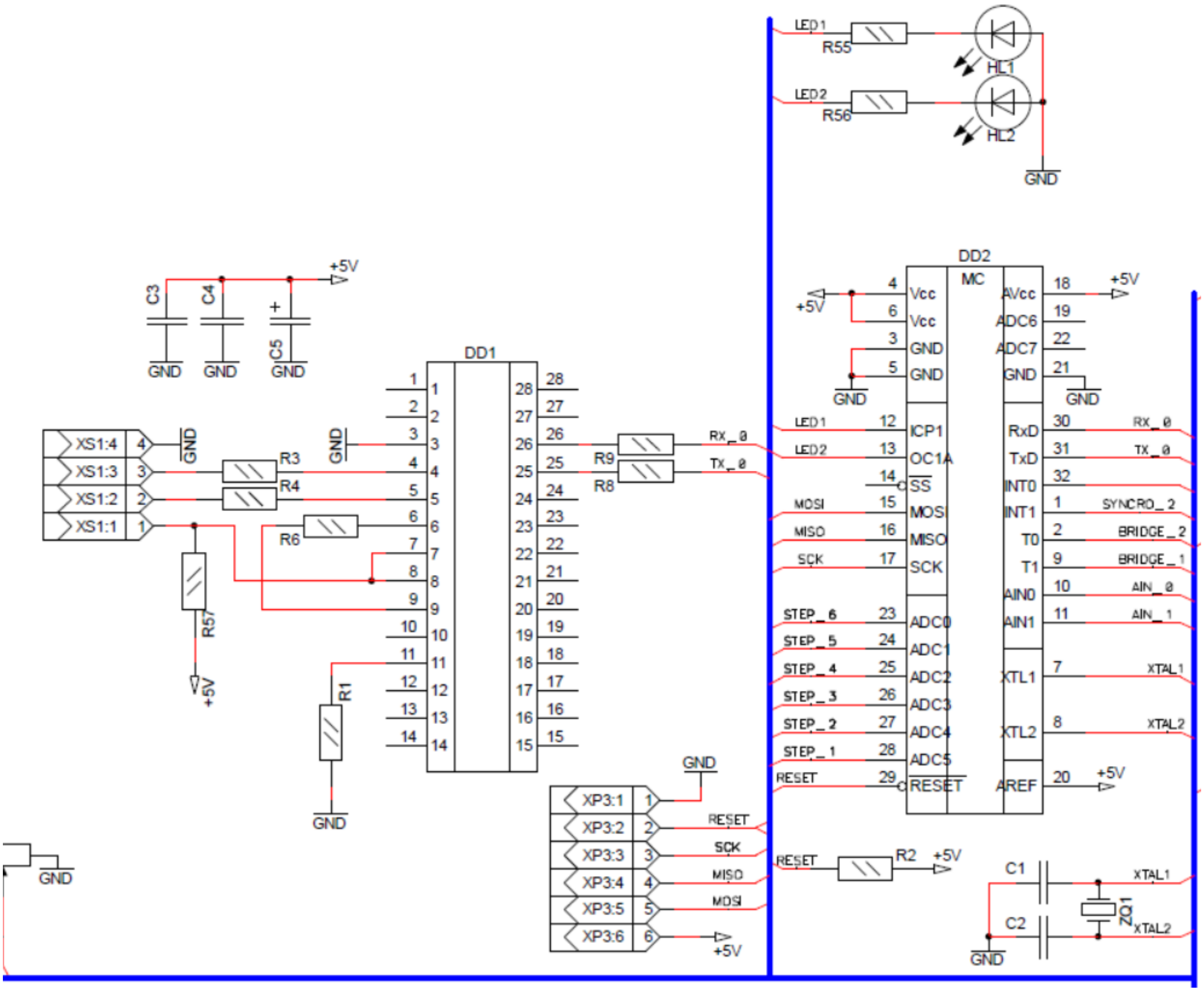

Figure 3 – The scheme of the microcontroller control system

For accuracy of compliance with the commutation angles, the minimum performance is 12 MIPS that the microcontroller AVR of the ATMEGA series can be made by connecting to a 12 MHz crystal oscillator. Programming was performed in the AVR Studio 4 environment, in the programming language C.

Figure 4 shows the scheme of the synchronization block of the inverter with the power grid. The microcontroller synchronizes with the external network and calculates the sine period. For this, the microcontroller reads pulses from the synchronization block. In this case, it uses two blocks with optocouplers to calculate the timing of the synchronization. The input SYNCRO_2 receives pulses from the optocoupler U10, which is connected to the external network through the lowering resistance R63 (figure 4). At the input SYNCRO_2, a pulse is produced for each half-period of the input voltage.

In the scheme of the synchronization block of the inverter with the power grid, there is determined the time point of the positive and negative half-cycle of the mains voltage. In order to calculate the exact time of the sinusoid transition from the positive half cycle to the negative half and back, there are used pulses arriving at the input SYNCRO_1.

In addition, the block calculates the time of the positive and negative half-cycle of the sinusoid. After calculating the time of the input voltage period, the step-on time is calculated. To do this, the analogue comparator inputs compare the voltage of the stage and the voltage of the external network and when the external voltage becomes greater than the step voltage, the value of the timer counter is recorded. Taking into account the value of the counter in the timer, the next voltage stage of the inverter is switched on in subsequent counts.

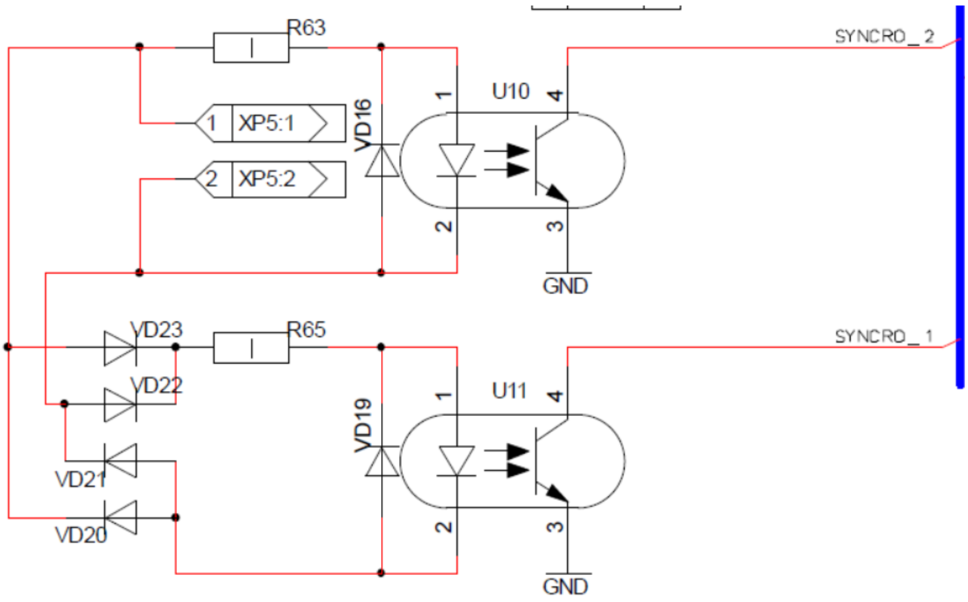

Figure 4 – The scheme of the synchronization block

After completion of reading and comparing, the inverter goes into the basic mode of operation strictly according to the countdown timer. In this case, the external voltage is monitored by the comparator. If the interrupt of the comparator occurred before the timer has tripped, then the step countdown time decreases, otherwise the run time of the step increases. In order that no false alarms occur, the minimum operating time of the stage is set.

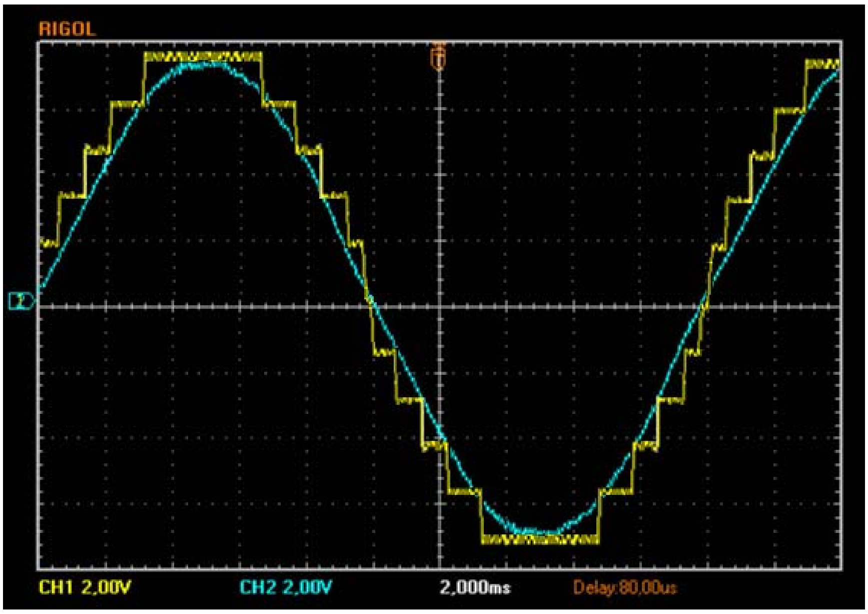

Figure 5 – The oscillogram of the output voltage of the inverter and the power grid during synchronization

In this work there have been made a microcontroller control system circuit and a synchronization block circuit. There have been carried out experimental studies of the operation of the inverter with the power network. Figure 5 shows an oscillogram of the output voltage of the inverter and the power grid during synchronization. As can be seen from the voltage oscillogram, the microcontroller control system ensures full synchronization of the output multistage voltage of the inverter with the power grid. In this case, six voltage levels are used. Thus, it was possible to realize the theoretical positions (figure 1) in practice (1) of synchronization of the output multistage voltage of the inverter with the power grid.

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КҮН ЭЛЕКТРСТАНЦИЯСЫН БАСҚАРУҒА АРНАЛҒАН МИКРОПРОЦЕССОРЛЫ ЖҮЙЕ

Аннотация. Ғылыми мақалада микропроцессорлы басқару жүйесі өңделген. Ол жүйе күн электр станциясын электжелісімен бірге синхронды жұмыс істеуін қамтамассыз етеді. Тәжірибеде көрсетілгендей, электржелісі таза синусоиданы бермейді жәнеде көптеген бұрмаланулары бар, яғни инвертордың шығыс кернеуін синусоидаға келтіру қажет.

Түйін сөздер: микропроцессорлар, басқару жүйесі, күн электр станциясы, инвертор, энергожелі, синхрондау, кернеу.

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МИКРОПРОЦЕССОРНАЯ СИСТЕМА УПРАВЛЕНИЯ ДЛЯ СОЛНЕЧНОЙ ЭЛЕКТРОСТАНЦИИ

Аннотация. В статье разработана микропроцессорная система управления, которая обеспечить синхронную работу солнечной электростанции с электросетью. Показано, что на практике в электросети напряжение не соответствует чистой синусоиде и имеет искажения, к которым необходимо адаптировать выходное напряжение инвертора.

Ключевые слова: микропроцессоры, система управления, солнечная электростанция, инвертор, энергосеть, синхронизация, напряжение.

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REFERENCES

[1] Issembergenov N., Taissariyeva K.N., The research of the “Solar panels – commutator – inverter – load” system with the pulse-amplitude control // PROCEEDINGS OF SPIE Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments. 2014. Vol. 9290. P. 92903H-1-7 (Scopus, Web of Science).

[2] Issembergenov N., Taissariyeva K.N. The multilevel on IGBT transistors for transformation of slar energy to the electric power // Bulletin of National academy of sciences of the Republic of Kazakhstan. 2015. Vol. 2, N 354. P. 183-186.

[3] Issembergenov N, Kasymov A.O., Moldakhmetov S.S. Multilevel inverter based on level switch and H-bridge. ARPN Journal of Engineering and Applied Sciences. VOL. 10, NO. 16, SEP TEMBER 2015. (Scopus).

[4] Taissariyeva K., Issembergenov N. Experimental studies of a prototype model of the multilevel 6KW-power inverter at supply by 12 accumulators // PROCEEDINGS OF SPIE Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments. 2016. Vol. 10031.

[5] Kucheruk Volodymyr, Katsyv Samuil, Glushko Mykhailo, Wójcik Waldemar, Tomasz Zyska, Taissariyeva K. Deterministic chaos in RL-diode circuits and its application in metrology // PROCEEDINGS OF SPIE Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments. 2016. Vol. 10031.

[6] Frede Blaabjerg. Control of Power Electronic Converters and Systems. First edition. 2018. Vol. 1. ISBN 9780128052457,

[7] Mohan Undeland Robbins. Power Electronics: Converters, Applications, and Design, third edition. ISBN-13: 978-1118880944, IEEE Press Series on Power Engineering, 2014.

[8] Jean Pollefliet. Power Electronics, first edition, ISBN 9780128146439. Academic Press, 2017.

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ISSN 2518-170X (Online), ISSN 2224-5278 (Print)

http://www.geolog-technical.kz/index.php/en/

Верстка *Д. Н. Калкабековой*

Подписано в печать 06.02.2019.
Формат 70x881/8. Бумага офсетная. Печать – ризограф.
16,7 п.л. Тираж 300. Заказ 1.

Национальная академия наук РК
050010, Алматы, ул. Шевченко 28, т. 272-13-19, 272-13-18