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ИНОСТРАННЫЙ ЯЗЫК

ЭЛЕКТРОПРИВОДЫ И СИСТЕМЫ УПРАВЛЕНИЯ ЭЛЕКТРОПРИВОДОВ

Методические указания к самостоятельной работе для студентов магистратуры направления 13.04.02

FOREIGN LANGUAGE

ELECTRIC DRIVES AND CONTROL SYSTEMS

САНКТ-ПЕТЕРБУРГ
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ИНОСТРАННЫЙ ЯЗЫК. Электроприводы и системы управления электроприводов: Методические указания к самостоятельной работе / Санкт-Петербургский горный университет. Сост.: *Е.В. Виноградова*, *Н.Э. Горохова*. СПб, 2019. 32 с.

Предлагаемый материал направлен на совершенствование навыков и умений просмотрового и изучающего чтения профессионально-ориентированных текстов с последующим использованием полученной информации в речи, а также на развитие навыков самостоятельной работы с аутентичными текстами. Данные методические указания могут быть использованы как дополнительный материал на занятиях со студентами 2-го курса.

Предназначены для студентов магистратуры направления 13.04.02 «Электроэнергетика и электротехника» (программа «Электроприводы и системы управления электроприводов») и согласованы с программой по иностранному языку для студентов неязыковых вузов.

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ПРЕДИСЛОВИЕ

Данные методические указания предназначены для учебно-методического сопровождения курса английского языка для студентов магистратуры неязыковых вузов, обучающихся по направлению подготовки 13.04.02 «Электроэнергетика и электроника» направленность программы «Электроприводы и системы управления электроприводов».

Изучение материала преследует цель развития навыков и умений просмотрового и изучающего чтения текстов по направлению подготовки, а также их перевода на русский язык с последующим использованием полученной информации для речевой практики; овладение студентами иноязычной коммуникативно-речевой компетенцией, позволяющей будущему специалисту осуществлять профессиональную коммуникацию; формирование активного словарного запаса, который включает наиболее употребительные английский термины и слова общетехнического характера.

Методические указания состоят из тематических разделов, каждый из которых посвящен одному из аспектов, связанных с электроприводами и системами управления. Задания для чтения и перевода составлены на материале аутентичных текстов и сопровождаются упражнениями, направленными на активизацию когнитивной деятельности обучающихся, освоение нового лексического материала, и способствуют развитию коммуникативных навыков в сфере профессионального общения на английском языке.

Приложение содержит тексты для дополнительного чтения и глоссарий.

UNIT 1.
ELECTRIC DRIVE: GENERAL DESCRIPTION

Reading Activities

1. In groups, write down five things that you know about an electric drive.

2. Read text 1 to check if any of your points were mentioned.

Text 1
ELECTRIC DRIVE

An electric drive is an **electromechanical system** [1] (mechatronic system) intended to set into motion technological equipment. It consists of an electric **motor** [2] (motors), a transfer mechanism, an electrical energy converter, and a control system. The control system consists of a microcontroller with data connection interfaces, data channels (data network), sensors and **actuators** [3]. In general, the main task of the electric drive is the motion control of mechanisms. An electric drive is an automatic control system with a number of **feedbacks** [4] where different automatic control principles, such as error driven feedback control, model based control, logical binary control, or fuzzy logic control methods, are used. Depending on a particular technical solution and selected control principle, **different sensors** [5] for measuring of currents, **voltages** [6], **velocity** [7], **acceleration** [8], torque etc. in an electric drive are used. Other information, like pressure signal for controlling pumps and compressors, **air humidity** [9] and/or temperature signal for **controlling of fans** [10] etc. is also necessary. For that reason, the controller of the drive must process different information.

(www.ene.ttu.ee/elektriajamid/oppeinfo/materjal/AAV0020/4Drives_Lehtla.pd)

NOTES

[1] **electromechanical system** – электромеханическая система
[2] **electric motor** – электродвигатель
[3] **actuator** – привод
[4] **feedback** – обратная связь
[5] **different sensors** – различные датчики
[6] **voltage** – напряжение

[7] **velocity** – скорость
[8] **acceleration** – ускорение
[9] **air humidity** – влажность воздуха
[10] **controlling of fans** – управление вентиляторами

3. Read text 1 again and answer the questions.

1. What is an electric drive intended to?
2. What does an electric drive consist of?
3. Can you describe the main task of the electric drive?
4. What are the key functions of using different sensors?
5. How important is pressure signal information?

4. In pairs, write down those definitions of 'an electrical drive' that you can think of. Read the definitions below and share your view point for or against.

1. **An electrical drive** can be defined as an electromechanical device for converting electrical energy into mechanical energy to impart motion to different machines and mechanisms for various kinds of process control.
2. **An electrical drive** is an industrial system, which performs the conversion of electrical energy into mechanical energy or vice versa for running and controlling various processes.
3. **An electrical drive** is defined as a form of machine equipment designed to convert electrical energy into mechanical energy and provide electrical control of the processes.
4. The system employed for motion control is called **an electrical drive.**

5. Read text 2 paying attention to the words in bold.

Text 2

BASIC COMPONENTS OF AN ELECTRIC DRIVE SYSTEM

A modern electric drive system has five main functional blocks: a mechanical load, a motor, a converter, a **power source**, and a **controller**. The power source provides the energy the drive system needs. The converter interfaces the motor with the power source and provides the motor with adjustable voltage, current, and/or frequency. The controller supervises the operation of the entire system to enhance overall system performance and stability.

The basic criterion in selecting an electric motor for a given drive application is that it meets the power level and **performance** required by the load during steady-state and dynamic operations. Certain characteristics of the mechanical loads may require a special type of motor. For example, in the applications for which a high **starting torque** is needed, a **dc series motor** might be a better choice than an induction motor. In constant-speed applications, synchronous motors might be more suitable than induction or dc motors.

Environmental factors may also determine the motor type. For example, in food processing, chemical industries, and aviation, where the environment must be clean and free from arcs, dc motors cannot be used unless they are encapsulated. This is because of the electric discharge that is generated between the **motor brushes** and its commutator segments. In those cases, the **squirrel cage induction motor** or other brushless machines are probably the better options.

The cost of the electric motor is another important factor. In general, dc motors and newer types of **brushless motors** are the most expensive machines, whereas squirrel cage induction motors are among the cheapest.

The function of a converter, as its name implies, is to convert the electric waveform of the power source to a waveform that the motor can use. For example, if the power source is an ac type and the motor is a dc machine, the converter transforms the ac waveform to dc. In addition, the converter adjusts the voltage (or current) to desired values. The controller can also be designed to perform a wide range of functions to improve system stability, efficiency, and performance. In addition, it can be used to protect the converter, the motor, or both against excessive current or voltage.

by M.A. El-Sharkawi

6. Match the words from text 2 with the translation.

power source	регулятор
controller	эксплуатационные качества
performance	источник питания
starting torque	щетки двигателя
motor brushes	пусковой крутящий момент
squirrel cage induction motor	бесщеточный двигатель
dc series motor	короткозамкнутый асинхронный электродвигатель
brushless motors	сериесный двигатель постоянного тока

7. Read text 2 again and answer the questions.

1. What are five main functional blocks and their functions?
2. What are the criteria of choosing a motor for the electric drive?
3. In what cases is it reasonable to use brushless motor?
4. What is the price range for the electric motors?
5. What is the function of a converter?

8. Read text 3 and insert the missing words from the box into the gaps.

Text 3
ELECTRICALLY ACTUATED SYSTEMS

electricity	stepper	faults	rotation	expensive
loop	fixed	screw	valve	

Electrically actuated systems are very widely used in control systems because they are easy to interface with the control systems which are also electric and because (1) …………. is easily available unlike fluid power which requires pumps and compressors.

The advantages of electric systems are the following. a) Electricity is easily routed to the actuators; cables are simpler than pipe work. b) Electricity is easily controlled by electronic units. c) Electricity is clean. d) Electrical (2) …………. are often easier to diagnose.

The disadvantages of electric actuators are as follows. a) Electrical equipment is more of a fire hazard than other systems unless made intrinsically safe, in which case it becomes more (3) ……….. . b) Electric actuators have a poor torque-speed characteristic at low speed. c) Electric actuators are all basically rotary motion and complicated mechanisms are needed to convert (4) …………. into other forms of motion.

There are three types of motors used in control applications: A.C. motors, D.C. motors, and (5) ………. motors.

A.C. motors are mainly used for producing large power outputs at a (6) …………… speed. Typically these are 1420 or 2900 rev/min. Such motors are controlled by switching them on and off.

Increasingly, speed control is being used with A.C. motors on applications such as pumps where it is found to be more economical to control the flow rate by changing speed rather than by opening or closing a pipe line (7) ………… . Speed control is achieved electronically by varying the frequency or by chopping the power supply. These motors are usually geared down in order to produce a greater torque and increase the control range. They may also have the rotation converted into linear movement by a lead (8)…………. mechanism.

Direct current motors are more widely used in control applications and they are usually referred to as servo motors. The development of more powerful magnets is improving the power to weight ratio but they are still not as good as hydraulic motors in this respect. Servo motors usually have a transducer connected to them in order to measure the speed or angle of rotation.

Basically a stepper motor rotates a precise angle according to the number of pulses of electricity sent to it. Because there is confidence that the shaft rotates to the position requested, no transducer is needed to measure and check the position and so they are common on open (9)………… systems.

(http://www.freestudy.co.uk/control/t2.pdf)

9. Name the noun suffixes you can remember. Then form the nouns from the verbs in the table, where possible.

VERB	NOUN -ion	NOUN –er/or	NOUN -ment
Actuate			
Control			
compress			
transduce			
Move			
Step			
Rotate			
Develop			
Connect			

10. Find English equivalents in Text 3.

Системы с электроприводом; для гидравлики требуются насосы и компрессоры; отказ электросистемы проще диагностировать; опасность возникновения пожара; искробезопасный; механические характеристики зависимости крутящего момента от скорости вращения; преобразовать вращательное движение в другие формы движения; шаговый электродвигатель; электродвигатель постоянного тока; электродвигатель переменного тока; регулировать скорость тока жидкости; сервомотор; вращение вала.

<u>Discussion Points</u>

1. Discuss the main characteristics of the electric drive in technological equipment.

2. Point out all the information necessary for the controller of the drive.

3. Elicit the role of each part of the electric drive.

4. Point out the advantages and disadvantages of the electrically actuated systems.

UNIT 2.
KEY CHARACTERISTICS OF ELECTRIC DRIVERS

Reading Activities

1. What do you expect to be covered in the extract? Can you name the main features of the electric drive?

Text 1
OPERATIONAL ADVATAGES

An electric drive provides electrical retarding and reduces service brake wear. It also has many **operational advantages** [1]. It includes the control of wheel slip and slide thus reducing the **tire wears** [2]. The system delivers a smoother ride for the operator. The electric drive system enhancements include improved retarding grids, slip control algorithms, the latest in diagnostic and troubleshooting software and silencers.

These are the advantages of electric drives:

1. Cost is too low as compared to another system of the drive.
2. The system is more simple and clean.
3. The control is very easy and smooth.
4. **Flexible** [3] in the layout.
5. Facility for **remote control** [4].
6. **Transmission of power** [5] from one place to other can be done with the help of cables instead of long shafts, etc.
7. Its maintenance cost is quite low.
8. It can be started at any time without delay.

NOTES

[1] **operational advantages** – эксплуатационные преимущества
[2] **tire wears** – износ шин
[3] **flexible** – гибкий
[4] **remote control** – дистанционное управление
[5] **transmission of power** – передача энергии

2. Read text 1 for the second time and answer the questions.

1. What does an electric drive reduce?
2. What can you say about the cost of the drive as compared to another system?

3. How much does maintenance of the electric drive cost?
4. What do the electric drive system enhancements include?

<u>Discussion Points</u>

1. Discuss where electric drives are actually used. Then, read the applications of the electrical drives. What haven't you mentioned?

Electric drives are used in boats, traction systems, lifts, cranes, electric car, etc. They have flexible control characteristics. The steady state and dynamic characteristics of electric drives can be shaped to satisfy the load requirements. They are available in wide range of torque, speed, and power. They can be started instantly and can immediately be fully loaded. They can operate in all the four quadrants of the speed-torque plane. They are adaptable to almost any operating conditions such as explosive and radioactive environments.

3. Read text 2 about electric drives. Fill in the gaps with appropriate words from the box.

Text 2

FAQ ABOUT ELECTRICAL DRIVES

leaks	advantages	conditions	complex
impacts	fluids	guns	control

Q**: What are the reasons for choosing electric actuators over hydraulic actuators?**

A: Hydraulic actuators have some (1) …………….. in certain cases. They have a high power density, low component cost, moderate to high stiffness, high speed, and are a commonly used technology with several commercial outlets. However, in certain situations, hydraulic actuators can be less beneficial to a system. They have a moderate accuracy and repeatability without the additional help of extra tuning equipment. They also have intricate and (2) ……….. installation and maintenance due to hydraulic pumps and tubing. Additionally, they have a high installation cost, low energy efficiency, large environmental (3)……………, and limited scalability and modularity. These are the cases where electric actuators offer a better solution.

Q: **What are the primary benefits of using an electric actuator system over hydraulics?**

A: Electric actuators offer high speed and force, are flexible and easily programmable for a variety of load (4) ………….., have high accuracy and repeatability, are efficient, simple to install, require little maintenance, and are environmentally friendly. By not using a hydraulic system, the user can eliminate oil (5) ……….., reduce pollution, and improve worker safety. Other environmental benefits of electric actuation include: higher energy efficiency/lower energy consumption; quieter operation/lower noise levels; and near zero power consumption when not operating (hydraulic system pumps operating during idle periods consume substantial energy). Additionally, there is no disposal of hydraulic (6) ………….. (upon normal maintenance or repair, hydraulic fluids need to be disposed of properly). Electric actuators are also a non-toxic solution especially in the food industry.

Q: What current industries are using electric actuators to their benefit?

A: Several industries are utilizing electric actuators for their systems. For example, they are used in the automotive manufacturing world and robotic end tooling like weld (7)………, bearing presses, and powering position arms. Food processing equipment uses electric actuators for volumetric filling, cubing, and conveying and indexing product. The oil and gas industries are using electric actuators to replace hydraulic and pneumatic actuators due to their environmental benefits and more flexible and precise (8) ………… . Both hydraulics and pneumatics have the potential for leakage, creating possible hazardous conditions (i.e., contamination or ignitable gas where methane is commonly used as the pneumatic fluid in the oil field). Electric actuators are increasingly being used to address all these concerns.

https://exlar.com/content/uploads/2016/06/Exlar-FAQ-MD-HP-063016-V3.pdf

UNIT 3.
TYPES OF MOTORS

Reading Activities

1. Read text 1 and try to retell the main points stipulated in the text.

Text 1
SYNCHRONOUS MOTOR

Synchronous motors[1] are synchronous machines used to convert electrical power to mechanical power.

Since synchronous motors are usually connected to power systems containing generators much larger than the motors, the frequency and terminal voltage of a synchronous motor are fixed. The equivalent circuit of a synchronous motor is the same as the **equivalent circuit**[2] of a synchronous generator, except that the assumed direction of the **armature current**[3] is reversed. Synchronous motors supply power to loads that are basically constant-speed devices. They are usually connected to power systems very much larger than the individual motors, so the power systems appear as **infinite buses**[4] to the motors. This means that the terminal voltage and the system frequency will be constant regardless of the amount of power drawn by the motor. The speed of rotation of the motor is locked to the rate of rotation of the **magnetic fields**[5] and the rate of rotation of the applied mechanical fields is locked to the applied electrical frequency, so the speed of the synchronous motor will be constant regardless of the load.

A synchronous motor has no net **starting torque**[6] and so cannot start by itself. There are three main ways to start a synchronous motor:

1. Reduce the stator frequency to a safe starting level.
2. Use an external **prime mover**[7].
3. Put **damper windings**[8] on the motor to accelerate it to nearsynchronous speed before a direct current is applied to the field windings.

If damper windings are present on a motor, they will also increase the stability of the motor during **load transients**[9].

By Stephen J. Chapman

NOTES

[1]**synchronous motors** – синхронный двигатель
[2]**equivalent circuit** – эквивалентная схема (замещения)
[3]**armature current** – ток якоря

[4]**infinite buses** – шина бесконечной мощности
[5]**magnetic fields** – магнитное поле
[6]**starting torque** – пусковой крутящий момент
[7]**prime mover** – пусковой двигатель
[8]**damper windings –** демпферная обмотка
[9]**load transients** – переходные колебания нагрузки

2. Read the text again and answer the following questions.

1. What is the main difference between a synchronous motor and a synchronous generator?
2. Why are the terminal voltage and the system frequency of a synchronous motor constant?
3. What are the main ways to start a synchronous motor?
4. What is the additional function of the damper windings?

3. Think of the possible applications of the synchronous motor. Then read the abstract below to find out if you were right.

APPLICATIONS OF SYNCHRONOUS MOTOR

Because of high efficiency and high speed of the synchronous motors, these motors are used for those applications where constant speed is required. Speed above the 500rpm, synchronous motors are used for drives, such as centrifugal pumps, compressors, rubber and paper mills, line shafts, blowers etc. Speed below the 500rpm synchronous motors are used for drives such as ball and tube mills, electroplating, generators, vacuum pumps, metal rolling mills, screw-type pumps etc.

http://www.apseee.com/applications-of-synchronous-motor/

4. Read text 2 to identify the message of the author. After reading the text, try to put the facts in succession and summarize.

Text 2
SOFT START OF INDUCTION MOTORS

Today most commonly used electric motor is an **induction motor** [1]. As compared to other electrical machines, induction motor is reliable, durable in hard conditions and needs little current **maintenance** [2]. Because of this, induction motors are economically efficient. For a long time, induction motors were known as electric machines difficult to control and were used only in electric drives with constant speed. Induction motors are mainly used to set into motion general purpose machines, like fans, compressors, pumps and other machines, like **disc saws** [3], wood planes. These machines operate in a continuous duty regime, but to optimize processes and save energy, speed or torque control is often necessary. Because 10 years ago, flexible speed control of induction motors was very difficult, lower efficiency of a machine or lower quality of production was the case. Problems of starting, braking and protection of induction machines may be solved by help of power electronics and microprocessor techniques using **soft starters** [4]**.** The progress of **power semiconductor techniques** [5], microelectronics calculation techniques and other technologies make it possible to develop an operating regime optimizing soft starters to control the induction motors.

Earlier, induction motors caused a number of problems. For example, high power induction motor start was a problem**.** With direct online start of the induction motor, the stator current increases up to seven times over the rated value, causing high current peaks in the electrical power lines. Starting current of an induction motor does not depend on the **motor load** [6] and is a constant value for each motor.

(www.ene.ttu.ee/elektriajamid/oppeinfo/materjal/AAV0020/4Drives_Lehtla.pd)

NOTES

[1] **induction motor** – асинхронный двигатель

[2] **maintenance** – техническое обслуживание

[3] **disc saws** – дисковые пилы

[4] **soft starters** – плавные пускатели

[5] **power semiconductor techniques** – технологии силовых полупроводников

[6] **motor load** – нагрузка двигателя

5. Read text 2 for the second time to answer the questions.

1. What is most commonly used electric motor today?
2. What characteristics does an induction motor have if you compare it to other electrical machines?
3. Where are induction motors are mainly used?
4. What kind of problems induction motors caused some years ago?

5. In your view, what makes it possible to develop an operating regime optimizing soft starters to control the induction motors?

Discussion Points

1. Discuss how technologies have influenced the use of induction motors.
2. Name the typical terms referring to the synchronous motor; to induction motor.

UNIT 4.
FREQUENCY CONTROL

Reading Activities

1. What do you know about the problems with velocity control of an induction?
2. Explain the notion 'a frequency converter'.
3. Read text 1 and do the tasks below.

Text 1
FREQUENCY-CONTROLLED ELECTRIC DRIVERS

Many problems arise with **velocity control** [1] of an induction and a synchronous motor. It is well known that the best way of speed control of a squirrel cage induction motor and a synchronous motor is **variation of frequency of the supply voltage** [2]. For a long time, there was no simple and cheap way for frequency control. For that reason, the variation of the pole number of a motor is used. The speed control of an induction motor makes it possible to use the **induction motor with the phase winding** [3] (with slip-rings and brushes) because the slip of the rotor and the speed of this motor are inversely proportional to the **resistance of the rotor circuit** [4]. However, in this case, there are high losses in the rotor rheostat.

Today, the **frequency control** [5] of induction machines is the main method of speed regulation and frequency converters are the main components of electric drives. Traditionally, the frequency converter was intended for smooth control of voltage and frequency of a motor. But modern frequency converters have a number of functions. In principle, a frequency converter with an induction motor is a complex electric drive. A frequency converter consists of a feeding converter, sensors and a control system. The control system is able to control the actuator or complicated automatic circuits of the technological process. By help of **network interface** [6], a frequency converter is usable on automatic systems with a number of levels. A frequency converter has a user interface for the drive operation mode control.

(www.ene.ttu.ee/elektriajamid/oppeinfo/materjal/AAV0020/4Drives_Lehtla.pd)

NOTES

[1] **velocity control** – управление скоростью

[2] **variation of frequency of the supply voltage** – изменение частоты напряжения питания

[3] **induction motor with the phase winding** – асинхронный двигатель с фазовой обмоткой

[4] **resistance of the rotor circuit** – сопротивление контура ротора

[5] **frequency control** – частотное управление

[6] **network interface** – сетевой интерфейс

4. Match the words from column A to the words from column B to form word combinations.

A	B
supply	converter
speed	control
high	components
frequency	automatic circuits
complicated	voltage
main	losses

5. With a partner, try to find the English equivalents.

Наилучшим способом контроля скорости асинхронного двигателя; для управления режимом работы привода; обратно пропорциональны сопротивлению контура ротора; для плавного управления напряжением и частотой двигателя; можно использовать в автоматических системах; имеются большие потери; современные частотные преобразователи имеют ряд функций.

6. Read text 1 again and answer the questions.

1. What is the best way of speed control of a squirrel cage induction motor and a synchronous motor?

2. What functions do modern frequency converters have?
3. What is the main method of speed regulation?

7. Read text 2, pay attention to the words in bold.

Text 2
VARIABLE FREQUENCY DRIVES (VFDS)

The demand for efficient motor controls due to rising energy prices and a trend toward energy efficiency has resulted in a growing demand for **variable frequency drives (VFDs)**[1]. The market for VFDs is expected to increase at a rate of 5.94% (CAGR) in the next three years, so it's not surprising manufacturers are investing in state-of-the-art VFD technology. The latest advances in VFD software and hardware tackle common problems original equipment manufacturers (OEMs) and manufacturers have been wrestling with for years: enabling teams to do more – faster and easier – with fewer resources.

1. Wireless diagnostics

Wireless diagnostics[2] represent the future of VFDs whether it's Wi-Fi, Bluetooth, or something else entirely. In a typical plant where access to a drive in a closed enclosure may be limited, engineers can connect directly to the system from a distance using the wireless signal built into the drive. Online software enables engineers to view and diagnose problems without touching the drive or its **enclosure**[3].

2. Flexible integration

VFDs with flexible integration allow engineers to solve for the application challenge once and then interface to an upper-level **programmable logic controller**[4] (PLC) of choice. When an OEM is selling a given machine to customers domestically and abroad, regional trends in PLC preference are not an obstacle for machine integration.

The OEM can take a drive with multiple communication options, solve the machine application once, and pick the option that matches the upper-level controller choice for each customer.

3. Modular memory

Gone are the days when technicians would have to go into the keypad to program a replacement VFD. Soon, having to use a PC or even just a **USB stick**[5] to transfer the configuration to a replacement drive will be a thing of the past. Today, drives with removable, modular, **nonvola-**

tile memory[6] make maintenance quick and easy. They eliminate the need to connect additional hardware. If a piece goes bad, device replacement is as simple as taking the memory module out of the old drive and putting it into a new one.

4. **Predictive maintenance**[7]

The Internet of Things (IoT), a global trend in every industry, has had an impact on VFDs by speeding and simplifying the flow of information from machine to technician and back again. As such, manufacturers are making changes to everything from their machines to their information technology (IT) departments to facilitate the collection, analysis, and application of drive data. Basic IT departments are familiar with Ethernet switches, hubs, and routers, resulting in a more seamless integration for **data transfer**[8]. Complex communication strategies are requiring modern VFDs to report lifetime counters, production rates, downtimes, power output, and more for better real-time decision making.

(by Joel Kahn)

NOTES

[1]**variable frequency drives (VFDs)** – частотно-регулируемый электропривод

[2]**wireless diagnostics** – беспроводная диагностика

[3]**enclosure** – корпус

[4] **programmable logic controller** – программируемый логический контроллер

[5]**USB stick** – флеш-карта

[6]**nonvolatile memory** – энергонезависимое запоминающее устройство

[7]**predictive maintenance** – диагностическое обслуживание

[8]**data transfer** – передача данных

8. Read text 2 again and find synonyms to the following words.

Effective, increasing, producer, up-to-date, headway, to fight, factory, foreign, hindrance, variant, replaceable, influence, standstill.

9.Explain in English what the following abbreviations mean. Using a dictionary, find Russian equivalents.

VFD	PC
CAGR	USB
OEM	IoT
PLC	IT

10. Match the words from column A to the words from column B to form word combinations.

A	B
Flexible	efficiency
Energy	memory
Wireless	integration
non-volatile	signal
business	integration
Seamless	intelligence

Discussion Points

1. Talk to a partner. Discuss all possible problems that can arise with velocity control of an induction and a synchronous motor.
2. Describe the advantages of variable frequency drives.

APPENDIX 1.

ADDITIONAL TEXTS FOR TECHNICAL READING

In this section, you will find some additional texts and articles on the topics of the corresponding units included in the manual. They can be used either as an additional classroom material for the unit, home reading, or as an extra reading activity for the advanced learners in the group.

TEXT 1.

WHAT IS ELECTRIC DRIVE?

Whenever the term electric motor or electrical generator is used, we tend to think that the speed of rotation of these machines is totally controlled only by the applied voltage and frequency of the source current. But the speed of rotation of an electrical machine can be controlled precisely also by implementing the concept of drive. The main advantage of this concept is, the motion control is easily optimized with the help of drive. In very simple words, the systems, which control the motion of the electrical machines, are known as electrical drives. A typical drive system is assembled with a electric motor (may be several) and a sophisticated control system that controls the rotation of the motor shaft. Now days, this control can be done easily with the help of software. So, the controlling becomes more and more accurate and this concept of drive also provides the ease of use.

This drive system is widely used in large number of industrial and domestic applications like factories, transportation systems, textile mills, fans, pumps, motors, robots etc. Drives are employed as prime movers for diesel or petrol engines, gas or steam turbines, hydraulic motors and electric motors.

(From https://www.electrical4u.com/electrical-drives/)

TEXT 2.

MODERN POWER ELECTRONICS AND DRIVES

Nowadays, modern power electronics and drives are used in electrical as well as mechanical industry. The power converter or power modulator circuits are used with electrical motor drives, providing either DC or AC outputs, and working from either a DC (battery) supply or from the conventional AC supply. Here we will highlight the most important aspects, which are common to all types of drive converters. Although there are many different types of converters, all except very low-power ones are based on some form of electronic switching. The need to adopt a switching strategy is emphasized in the Wrist example, where the consequences are explored in some depth. We will see that switching is essential in order to achieve high-efficiency power conversion, but that the resulting waveforms are inevitably less than ideal from the point of view of the motor. The thyristor DC drive remains an important speed-controlled industrial drive, especially where higher maintenance cost associated with the DC motor brushes (c.f. induction motor) is tolerable. The controlled (thyristor) rectifier provides a low-impedance adjustable DC voltage for the motor armature, thereby providing speed control.

TEXT 3.

THEORY: HOW DOES AN ELECTRIC MOTOR WORK

(*By Chris Woodford*)

The link between electricity, magnetism, and movement was originally discovered in 1820 by French physicist André-Marie Ampère (1775-1867) and it’s the basic science behind an electric motor. But if we want to turn this amazing scientific discovery into a more practical bit of technology to power our electric mowers and toothbrushes, we've got to take it a little bit further. The inventors who did that were Englishmen Michael Faraday (1791-1867) and William Sturgeon (1783-1850) and American Joseph Henry (1797-1878). Here's how they arrived at their brilliant invention.

Suppose we bend our wire into a squarish, U-shaped loop so there are effectively two parallel wires running through the magnetic field. One of them takes the electric current away from us through the wire and the other one brings the current back again. Because the current flows in opposite directions in the wires, Fleming’s Left-Hand Rule tells us the two wires will move in opposite directions. In other words, when we switch on the electricity, one of the wires will move upward and the other will move downward.

If the coil of wire could carry on moving like this, it would rotate continuously – and we'd be well on the way to making an electric motor. But that can't happen with our present setup: the wires will quickly tangle up. Not only that, but if the coil could rotate far enough, something else would happen. Once the coil reached the vertical position, it would flip over, so the electric current would be flowing through it the opposite way. Now the forces on each side of the coil would reverse. Instead of rotating continuously in the same direction, it would move back in the direction it had just come! Imagine an electric train with a motor like this: it would keep shuffling back and forward on the spot without ever actually going anywhere.

(Adapted from https://www.explainthatstuff.com/electricmotors.html)

TEXT 4.

UNIVERSAL MOTORS

(*By Chris Woodford*)

DC motors like this are great for battery-powered toys (things like model trains, radio-controlled cars, or electric shavers), but you don't find them in many household appliances. Small appliances (things like coffee grinders or electric food blenders) tend to use what are called **universal motors**, which can be powered by either AC or DC. Unlike a simple DC motor, a universal motor has an electromagnet, instead of a permanent magnet, and it takes its power from the DC or AC power you feed in:

1. When you feed in DC, the electromagnet works like a conventional permanent magnet and produces a magnetic field that's always pointing in the same direction. The commutator reverses the coil current every time the coil flips over, just like in a simple DC motor, so the coil always spins in the same direction.

2. When you feed in AC, however, the current flowing through the electromagnet and the current flowing through the coil *both* reverse, exactly in step, so the force on the coil is always in the same direction and the motor always spins either clockwise or counter-clockwise. What

about the commutator? The frequency of the current changes much faster than the motor rotates and, because the field and the current are always in step, it doesn't actually matter what position the commutator is in at any given moment.

(Adapted from https://www.explainthatstuff.com/electricmotors.html)

TEXT 5.

BIPOLAR CIRCUIT

(By H. Sax)

The advantage of the bipolar circuit is that there is only one winding, with a good bulk factor (low winding resistance). The main dis-advantages are the two changeover switches because in this case more semiconductors are needed.

The unipolar circuit needs only one changeover switch. Its enor-mous disadvantage is, however, that a double bifilar winding is required. This means that at a specific bulk factor the wire is thinner and the resis-tance is much higher. We will discuss later the problems involved.

Unipolar motors are still popular today because the drive circuit appears to be simpler when implemented with discrete devices. However with the integrated circuits available today bipolar motors can be driver with no more components than the unipolar motors.

The torque of the stepper motor is proportional to the magnetic field intensity of the stator windings. It may be increased only by adding more windings or by in- creasing the current.

A natural limit against any current increase is the danger of satu-rating the iron core. Though this is of minimal importance. Much more important is the maximum temperature rise of the motor, due to the power loss in the stator windings. This shows one advantage of the bipo-lar circuit, which, compared to unipolar systems, has only half of the copper resistance because of the double cross section of the wire.

(Adapted from http://users.ece.utexas.edu/~valvano/Datasheets/Stepper_ST.pdf)

TEXT 6.

BRAKING MODES

Are we able to stop the aircraft safely in the landing phase, at high speeds and on different runway surfaces and climate conditions? The braking could be either symmetric or non-symmetric to allow the aircraft to turn. In this example, we are only interested in the symmetrical braking during the landing or the rejected take-off phases. A functional decomposition of the ‘Brake the aircraft on land’ function shows that two types of component are needed: physical components to actually brake the system and control components to give appropriate commands to the physical parts. The physical components of the wheel-braking system are hydraulic components and power source that will act on the multi-disk brakes and consequently brake and/or stop the wheels. These parts are controlled by a controller called BSCU (Braking System Control Unit). A preliminary safety analysis shows that the considered function is critical to the functioning of the system since its failure could lead to catastrophic consequences like the aircraft leaving the runway or crashing the buildings or equipment on the airport. Thus the wheel braking system must be fault tolerant by using redundant components. For our example, the braking system is made of two redundant hydraulic lines, a normal line that is first activated and an alternate one that is activated when the normal chain is inoperative. Each of the two systems has an independent power source. A supplementary power source, called emergency power source, is also mandatory for the wheel-brake system in aircraft. In this case, an accumulator is also added and provides the braking system with hydraulic power when all the other power sources are inoperative.

(From https://www.researchgate.net/figure/State-machine-system-modes-of-the-wheel-braking-system_fig4_263357392)

APPENDIX 2.

TECHNICAL VOCABULARY

A

A.C. power drive system – электропривод переменного тока
Accumulator battery – аккумуляторная батарея
Actuator – приводной механизм
Amplifier – усилитель
Armature current – ток якоря
Attenuation – колебательность
Automatic control system – система автоматического управления (регулирования)
Auxiliary electric drive – вспомогательный электропривод
Availability factor – коэффициент готовности

B

Base speed – номинальная частота вращения двигателя
Basic drive module – канал регулирования электропривода
Blower – вентилятор; воздухозаборник
Break-away torque – момент трогания
Brushless motors – бесщёточный двигатель

C

Capacitor motor – конденсаторный двигатель
Circuit diagram – электрическая схема
Combined control – комбинированное управление
Control device – управляющее устройство
Controlled electric drive – регулируемый электропривод
Control equipment – информационный канал электропривода
Control influence – управляющее воздействие
Control loop – замкнутая система регулирования
Current source inventor – инвертор тока
Centrifugal pumps – центробежный насос
Change direction – менять направление
Compressor – компрессор

Controller – регулятор; орган управления
Converter – преобразователь
Current – ток

D

D.C. power drive system – электропривод постоянного тока
Damper windings – демпферная обмотка
Design engineer – инженер-конструктор
Double-supply machine – электропривод с машиной двойного питания
Dynamic braking – динамическое торможение

E

Electric drive components – компоненты электропривода
Electric drive index – энергетические показатели электропривода
Electric energy convertor – преобразователь электрической энергии
Electric motor – электродвигатель
Electric shaft – электрический вал
Energy consumption – энергопотребление
Energy efficiency – энергетический выход
Equivalent circuit – эквивалентная схема (замещения)

F

Fire hazard – опасность возникновения пожара
Frequency control – частотное управление
Fuzzy logic – нечеткая логика

G

Gain factor – коэффициент усиления
Gear – устройство; механизм; оборудование; привод

H

Heat time constant – постоянная времени нагрева
Hollow shaft drive – электропривод с полым валом
Humidity sensors – датчики влажности

I

Idling – холостой ход
Impact loading – ударное приложение нагрузки
Induction motor – асинхронный двигатель
Infinite buses – шина бесконечной мощности
Interface – интерфейс
Intrinsically safe – искробезопасный; взрывобезопасный
Inverter – инвертер

L

Lighting – освещение
Line shaft – промежуточный вал
Linear motor – линейный двигатель
Load transients – переходные колебания нагрузки

M

Magnetic bearing – магнитный подшипник (опора)
Magnetic fields – магнитное поле
Magnetic sensors – магниточуствительные датчики
Maintenance – техническое обслуживание
Measuring flow sensors – датчики скорости потока (протока)
Micro actuator – микропривод
Micro motor – микродвигатель
Motor brushes – щетки двигателя

N

Networking module – сетевой модуль
Neural network – нейронные сети
Nonvolatile memory – энергонезависимое запоминающее устройство

O

Operational modes – зоны регулирования
Overload factor – перегрузочная способность

P

Paper mill – целлюлозно-бумажное предприятие

Parallel correction – параллельная коррекция
Performance –технические характеристики
Permanent magnet – постоянный магнит
Power density – удельная мощность
Power source – источник питания
Prime mover – пусковой двигатель
Proximity Sensor – бесконтактный датчик
Pump – насос

Q

Quality factor – показатель качества

R

Rectifier – выпрямитель
Reluctance motor – синхронный реактивный двигатель
Resolver – синус-косинусный преобразователь
Reversing electric drive – реверсивный электропривод
Rotation – вращательное движение

S

Safety connecting blocks – соединительные коробки безопасности
Self-turning electric drive – самонастраивающийся электропривод
Sensor – датчик
Sensorless control – бездатчиковое управление
Serial interface – последовательный интерфейс
Series motor – сериесный электродвигатель
Servo motor – сервомотор
Settling time – время регулирования
Short-time duty – кратковременный режим работы
Slip power – мощность скольжения / энергия скольжения
Solenoid – электромагнит
Speed range – диапазон регулирования скорости
Squirrel cage induction motor – асинхронный двигатель с коротко-замкнутым ротором
Starting torque – пусковой крутящий момент
Stepper motor – шаговый двигатель

Synchronous motor – синхронный двигатель

T

Technological unit – технологический агрегат
Three phase motor – трехфазный электродвигатель
Torque motor – двигатель вращающего момента
Transducer –преобразователь
Transform – преобразовывать
Transmission – механическая передача
Two-channel electric drive – двухканальный электропривод

U

Ultrasonic sensors – ультразвуковые датчики
Universal motor – универсальный электродвигатель

V

Variable frequency drive – частотно-регулируемый электропривод
Velocimeters – датчики скорости
Vision sensors – датчики изображения
Voltage – напряжение
Voltage source inventor – инвертор напряжения

W

Water-cooled motor – двигатель с водяным охлаждением
Wireless diagnostics – беспроводная диагностика
Working machine – рабочая машина

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ЭЛЕКТРОПРИВОДЫ И СИСТЕМЫ УПРАВЛЕНИЯ ЭЛЕКТРОПРИВОДОВ

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