RENEWABLE ENERGY TECHNOLOGIES

INVESTIGATION OF ELECTRICAL SYSTEMS

DigiEnergy 4.0
DIGITALIZATION IN ENERGY 4.0 TECHNOLOGIES
2021-1-TR01-KA210-VET000034519




This individual learning material was written as part of the Erasmus plus ENERGY 4.0 TECHNOLOGIES NO: 2021-1-TR01-KA210-VET000034519 TRACKING DIGITALIZATION Project. It is intended to guide vocational education trainers. It is free for users, cannot be sold. It cannot be duplicated. It will be published as an e-book on the Project Website (http://www.digienergy40.com).

It is funded by the Erasmus+ Program of the European Union. However, the European Commission and the Turkish National Agency cannot be held responsible for any use of the information contained herein.


CONTENTS

EXPLANATIONS

AREA	Renewable Energy Technologies
BRANCH / PROFESSION	Solar Energy Systems
MODULE NAME	Investigation of Electrical Systems
DESCRIPTION OF THE MODULE	This module will deal with the renewable energy system and what these systems will be in a complex structure and their interaction with other systems.
DURATION	40/32
PRECONDITION	This module has no prerequisites.
COMPETENCE	Panel arrangements of solar energy systems provide autonomous power to the system (following the sun) and panel connections.
PURPOSE OF THE MODULE	General Purpose When the environment of the solar energy systems workshop is provided, you will be able to perform solar panel system installation and detailed panel connection solar tracking system practically. Purposes Recognize the elements of the installation system and will be able to install. Increasing energy efficiency by using the system as solar tracking by using engines.
EDUCATIONAL ENVIRONMENTS AND EQUIPMENT	**Setting:** Renewable energy technologies field, renewable energy systems workshop **Hardware:** Basic electrical knowledge, Basic electronic knowledge, Basic mechanics knowledge, stepper motor, servo motor, electrical panel and gear system.
QUANTIFICATION AND CONSIDERATION	You will evaluate yourself with the measurement tools given after each learning activity in the module. At the end of the module, the teacher uses the measurement tool (multiple choice test, true-false test, fill in the blanks, matching, etc.) He or she will evaluate you by measuring your skills.

INTRODUCTION

Dear Student,

The importance of Solar Energy Systems is increasing day by day. With the increasing importance of these systems, the importance of electrical systems comes to the fore. In this context, the installation, reliability and performance of the system and its continuity are important, and it is obvious that there will be a tendency towards systemization, control and automated solar power in the industry and many enterprises and institutions of the world countries, and it is necessary to learn the electrical system.

With this module, you will learn the material feasibility study autonomous systems to be used in the Investigation of Electrical Systems, which is one of the subjects related to your profession in the field of Renewable Energy Technologies. When you buy this module; You will learn the general state of the systems and the electrical solutions. It is always aimed to perform the analysis in complete safety, as quickly as possible with the least error. This can only be achieved with the control of the discipline and control systems in the study area. When you successfully complete this module, you will increase your professional competence and become an employee with the qualifications required by the sector.

In this module you will learn Investigation of Solar Electrical Systems.

LEARNING ACTIVITY –1

PURPOSE

What is a system, its components and definitions of these components will be discussed.

RESEARCH

- Share your observations with your teacher and friends.

1. THE SYSTEM

1.1. Description of the System

Systems are the basic building blocks of a whole to be formed, and the structures that emerge when they work together towards their general purpose. According to Ackoff, a system is a group of elements that interact with each other to achieve a specific purpose

1.2. System Approach

The system approach is accepted as a framework where we can examine the events, situations and problems as a whole, and it expresses the approach from the point of view of system view and system thinking. System; It can be defined as a coherent whole with a boundary separating internal and external factors, interacting with the environment to determine system-related inputs and outputs. Features of the System The system is a whole. Systems are interrelated, systems express more than the sum of their subsystems. Every system has an environment. Subsystems are parts of the system that affect each other and have a complex structure between them. Subsystems can be added and removed from systems. The structure of the system constantly changes cyclically in accordance with its environment and its own characteristics. The system creates outputs with the inputs it receives. Since the systems are interrelated, it is impossible to define the boundaries of the systems precisely.

1.3. System Types

Open and Closed Systems:

An open system becomes an open system when matter receives energy or information inputs and outputs from this information, and open systems depend on the environment.
A closed system is a system that is open only for information input and is independent of the environment in all other activities.

1.4. Purpose of the System

The aim of the system is to reach the determined target in the shortest time, at the least cost, with the least loss. If the system is considered as a whole, it is seen that there should be a joint work to achieve the goals. Elements are both part of the system and subsystems of the system.

1.5. System Benefits

The system is a small system created for a whole and we can consider it as the basis of automatic structure formation in our globalizing world as a benefit. Systems are generally called the beginning of autonomous structures.
Systems play an important role in mass production and facilitating human life in the fields of industry and machinery. The development of these systems will make life easier and increase production. In this module, we will examine the combination of systems with renewables.

1.6. System Analysis

Another issue of the system structures is their analysis. Even if the systems are open or closed systems, they are analyzed as a result and their outputs and inputs are evaluated. We are examining the systems for more technology development in the way of analysis and if we take the renewable energy sector as a basis, it should be operated more in the installation of solar power plants. important for the analysis.

1.7. System Structure

The structures of the systems depend on what the input and output of that system are. .The powers and dimensions of the systems can be linked to their purposes. As the systems encompass a wide scope, they are also in question even in the smallest area depending on the development of technology.
The structure and examination of the systems can also be handled with the analysis section.

Photovoltaic systems and another module of renewable energy, Fundamental installation, we have explained as a basis, now we will consider it as a system and autonomous remote control.

2. Photovoltaic Systems and Components

A photovoltaic system that produces solar electricity; Solar panels are composed of accumulators, inverters, battery charge controller, system control unit (SCU) and various circuit elements depending on the application.

Photovoltaic (PV) system has two basic components: solar panel and DC/AC converter. While the charge controller and battery are added to this in island systems, only MPPT (Maximum Power PointTracer) unit is added in grid-connected systems.

Parts such as cables, switches, relays-contactors, fuses, which take part in the transmission of PV system energy and in combining its units, are also important elements of the system.

The most important issue that we will pay attention to when choosing the system elements mentioned above in PV system design is the compatibility of the elements with each other. If this is not provided, the system will run inefficiently.

2.1.MODULS

Photovoltaic cells are sensitive to certain wavelengths of sunlight. It is the smallest unit of photovoltaic systems.

Working like a semiconductor diode, the solar cell converts the energy carried by sunlight directly into electrical energy through a photoelectric reaction.

The highest voltage occurring in the cells produced in standard sizes of 100x100,125x125 or 156x156mm and in 0.2-0.4 mm thickness is 0.6V. These cells

Modules are created by connecting 36-54-60 or 72 in series.Modules are produced to feed a 12V or 24V DC system.

2.2. THE PANELS

Solar panels are modules that convert certain wavelengths of sunlight into DC electricity.

They are manufactured in standard dimensions of 100x100, 125x125 or 156x156mm cell sizes. Cell thickness is 0.2-04 mm. They contain 36-54-60 or 72 series cells, depending on the voltage and power values they are produced.

They are produced in crystalline panels to feed the system voltage 12V or 24V DC.

Voltage 17Vmax-22Voc on 12V panel,

In 24V systems, it is 33Vmax – 44Voc on average. The solar system voltage to be installed can be adjusted in various ways and according to the solar panel with serial/parallel connections (12-24-48-200 or 400V etc.).

2.3. THE SERIES

When it is desired to make a directory according to the requirement;

Ppanel=Vpanel x Ipanel=(Vindex/Ns)x (Index/Np) = Pindex/NsxNp

If we pull Pindex the expression becomes Pindex = Ns x Np x Ppanel

By using this expression, panel indexes can be designed in the desired value and configuration.

2.4. THE CONVERTERS

The second important element of the photovoltaic system is converters, electronic devices that convert DC power to AC power.

Converters with MPPT feature are smart devices that can also communicate remotely.

2.5. TYPES OF INVERTER

Converters are of three types according to the Alternating Current wave-AC shape they produce.

square wave

Sine-assisted (modified)

full sine wave

There are two types according to the usage area:

Grid-connectable converters

Converters used for off grid systems.

2.6. THE ACCUMULATORS

They are elements that support the use of solar energy.

They store electrical energy chemically. There are dry, watery and gel varieties.

2.7. THE SOLAR CHARGING REGULATORS

They are intelligent electronic circuits that perform and manage the charge-discharge process and automatically select the operating mode according to the status of the system energy and loads.

They direct the most efficient energy flow by constantly controlling solar panels, batteries and loads thanks to their microprocessors.

2.8. THE CONNECTORS

Panels should be set securely to floors or bodies and electrical connections with other elements should be made in accordance with the specified standards.

As seen in the figures, solar system connectors are specially designed and produced.

2.9. NETWORK DEPENDENT AND INDEPENDENT SYSTEMS

In renewable energy installation, it is formed in two ways when creating the system. These are the systems we call ten grid and of grid, that is, they are of two types, dependent and independent from the grid.

2.9.1. On Grid System (Grid Connected System)

Grid-connected photovoltaic systems work on the principle that the electricity produced is consumed at the production site instead of being stored in batteries. During project planning, the amount of energy that is desired or needed to be produced is determined. sun from atmosphere DC electrical energy is produced by the contact of the rays on the solar modules. The generated energy is connected to the central city grid system with inverters with high cycle power, which can be connected to the central grid. Thus, the energy produced from the panels directly into the grid system gets sent. If the area and radiation conditions are suitable, it is possible to produce electrical energy at the desired power with the electricity generation system connected to the grid.

Electricity generation with solar energy is not only an easy-to-install power generation tool, but also a primary choice for reasons such as being long-lasting, free of operating costs, practical and mobile.

BASIC COMPONENTS OF THE SYSTEM;

- Photovoltaic Panel
- Inverter
- Bidirectional counter (Network counter).

Grid-connected systems can be installed in high-power-plant size or in smaller-powered installations for domestic needs. For example, in these systems, while the electricity requirement of a house can be met, the excess energy produced is given to the electricity grid, and in cases where sufficient energy is not produced, energy is taken from the grid. In such a system, there is no need to store energy, it is sufficient to convert the DC electricity produced to AC electricity and be compatible with the grid.

ADVANTAGES OF NETWORK CONNECTED SYSTEMS:

• Since storage units such as batteries will not be used in the system, there will be no additional cost for storage.

• Since there will be consumption close to the system and there is no storage, the loss will be minimal due to less energy conversion.

• Since the energy produced is connected to the grid, when the produced energy is not enough, the grid will be activated and the energy will feed the load completely.

• While designing the system, it has the flexibility to design according to the desired amount or area, since there is no obligation to cover the entire load.

• If the area is sufficient, the installed capacity of the system can be increased.

2.9.2.OFF GRID BATTERY SYSTEM(OFF GRID)

Off grid systems can be named as island systems, off grid systems or battery systems. The basic equipment used in the system are solar panel, battery, charge controller, inverter and tracker. In places where there is no mains line or a functional electrical network, the healthiest solution is to install an off grid system that is calculated correctly according to the need. The installation of battery-powered systems in places where there is a power line increases the cost of the system and increases the system turnaround times.

For this reason, the places where these systems are installed are mostly places where there is no mains electricity or more than 800m away from the transmission line. Especially in plateau-mountain houses, farms, signaling systems, remote information systems (highway signage), base stations, etc. This type of setup is common.

Removing the transmission line to such places creates a serious cost of transformer, pole and cable. The most important advantages of the systems are;

• It is an economical solution in case of no network,

• Affordable and feasible compared to the installation cost of the grid connection,

• There is no fuel cost,

• Qualified but few personnel are sufficient for installation,

• Its installation time is short,

•Systems can be increased according to energy needs

•Systems can be installed in stages, so there are flexible installation costs:

The points to be considered while designing the system can be listed as follows:

• The first thing to do is to replace the equipment available at the place where the system will be used, with economical products. This will reduce the amount of energy consumed. In some applications, system costs are thus reduced by half.

• Then, what should be known is how much daily consumption is. In order for this to be calculated, it is necessary to list which household appliances are operated for approximately how many hours a day in the installation site. Thanks to this list, the

daily/weekly energy need of the house will be determined and the system calculation will be carried out in line with this information.

• Preliminary work at the place where the system will be installed is important in terms of installation design and determination of connection equipment. In addition, the presence of objects-structures that can cast shadows on the panels at the installation site should be carefully examined. In addition to this information, if the panels are to be lined up one after the other, the distance between the panels should be chosen appropriately and the panels should not be shaded on each other.

• Whether the place where the system is designed is a summer house or a place of residence throughout the year also seriously affects the system design and costs. If it is a place to be used all year round, the panel design is made according to the worst seasonal conditions.

• If the place used is a seasonal or summer house, the first thing to know is between which months the house is used. In the sizing, system calculations are made based on the radiation values in the summer months.

• In this case, the calculated system cost corresponds to almost half of the system cost made according to bad conditions. The design should be calculated according to the usage period and season so that the system cost should be optimized.

• It is important to choose the appropriate power inverter while designing the system. According to the devices to be used, the inverter should be calculated with the voltage and power appropriate for the amount of energy taken instantly. The most important point to be considered in the inverter to be selected is that the devices used (motorized appliances such as refrigerators) are strong enough to handle the inrush current. The inrush current can be up to 3-4 times the nominal current. The inverter supply should be strong enough to handle this current according to the characteristics of the device.

• If the area where the system will be installed will be a roof, the roof direction and slope should be calculated in detail. The construction to be installed must be mounted in such a way that it does not damage the roof insulation. If the system is to be installed in the garden, it can be mounted with fixed feet or by installing systems that follow the sun. Depending on whether the tracker is uniaxial or biaxial, the amount of energy produced can be increased by 15-35%.

• Preservation of battery groups is very important for the life of the batteries. For this reason, while designing the batteries, besides the autonomy period, the place where the batteries will be placed should be seriously considered. The airy place where the batteries are placed is very effective in preventing the heating of the batteries.

• During the transfer of energy as DC, the amount of energy lost can reach quite significant amounts as the distance increases. For this reason, the distance between the devices (solar panel-battery-inverter) to be used should be minimum. In addition, cables of appropriate cross-section should be used.

After the system calculation is completed, the autonomy period will be determined according to the annual/seasonal use of the house and the energy need of the house.

2.9.3.Hybrid systems

Electricity generator powered by wind or oil and biogas for photovoltaic systems

When added, they are called a hybrid system.

IMPLEMENTATION ACTIVITY

Process Steps Suggestions	Process Steps Suggestions
➢ Create system wiring diagrams.	➢ Create system wiring diagrams.
➢ It is useful to have separate schemes.	➢ Build the circuit by drawing.
➢ Draw and explain the ten grid system.	➢ Set up the circuit by drawing.
➢ Consider what equipment we can use to design an Electrical System.	➢ Design will be made according to electrical equipment.
➢ Share the project you are considering with your friends.	➢ Evaluate management and monitoring activities with your friends.

CONTROL LIST

Evaluate yourself by putting an (X) in the box for the skills you have gained from the behaviors listed below within the scope of this activity: Yes, and for the skills you have not acquired, in the No box.

Değerlendirme Ölçütleri	Yes	No
➢ Did you get general information about the system and what electricity does?		
➢ Have you learned the definition and scope of the system?		
➢ Do you understand what the system and its sub-domains are for?		
➢ Have you learned about the functions of electrical systems?		
➢ Have you learned the system on grid and off grid networks?		

EVALUATION

Read the questions below and write the appropriate words in the blanks. These are the questions of the unit of learning activity 1.

Read the following questions carefully and mark the correct option.

The input, process, and output sequence of which the parts form a whole is called …….

The system is examined in two ways as …….. and ……..

The grid-dependent system is called ……..

If the hydraulic power plant is included in the renewable energy system, it is called …….. ..

EVALUATION

Compare your answers with the answer key. Return to the activity and repeat the topics related to the questions that you gave wrong answers or hesitated to answer. If all your answers are correct, proceed to the next learning activity.

LEARNING ACTIVITY –2

PURPOSE

When the necessary environment and equipment are provided, you will be able to determine the location of the solar panel converter system.

RESEARCH

Investigate electrical panels.

Gather information about the translator.

LOCATION OF 2 INTERTERS

2.1. Determination of Mounting Location

The converter converts the DC energy produced by the solar panels to the AC energy used in homes (220V-50 Hz). In general, inverters are divided into two as modified sine inverters and full sine inverters in terms of output waveforms (Figure 1.1). The subtle difference between the two waveforms is difficult to discern, but their performance should be looked at in terms of the devices they run.

2.1.1. Modified sine inverters: Modified sine wave is an imitation of full sine wave. With square wavelets, a sine wave is obtained. The advantage is that it is cheap; TV, computer, small appliances, lamps etc. it is running smoothly. Some televisions and computers, especially professional and industrial devices, can understand this very subtle difference. This will not harm the device, but it can be annoying. For example, on some televisions, a thin line may appear on the screen.

2.1.2.Full sine inverters: Full sine wave is the output we get from the network just like in the house. It is very clean, neat and the best. Therefore, it can be used in all applications without any problems, and your devices will heat up less. The full sine feature is required to meet and not disrupt inductive loads such as washing machines, dishwashers and refrigerators. If you are going to run a motor, air conditioner, refrigerator as a load, or for industrial devices and applications, a full sine inverter is definitely recommended.

The power of the inverter (inverter) should be selected according to the instantaneous total power of the devices that are thought to work at the same time. For example, if a 2 kW washing machine, a 300 W television and a 200 W lamp are to be operated simultaneously, a 2500W (2000W+300W+200W) inverter will be required.

Inverters used in solar energy solar PV systems can be divided into three groups. These;

Central inverters to which the whole system is connected, String to which Panel strings are connected

Converters (inverters) are the products at the heart of the system that converts solar energy sources that produce direct current into alternating current (mains current). They are divided into two as on-grid (on-grid) and off-grid (off-grid).

2.1.3.On Grid And Off Grid Network

On-grid: By converting direct current from solar panels to alternating current

These are inverters that can sell to or feed into the grid.

Off-grid: These are inverters that charge the batteries with the direct current coming from the solar panels and convert the direct current from the batteries to alternating current.

System data can be obtained by establishing a connection between the RS 232 port on some inverter types and the computer. Especially in inverters used in grid-connected PV systems, the power and the generated electrical energy value can be seen on the screen on the device.

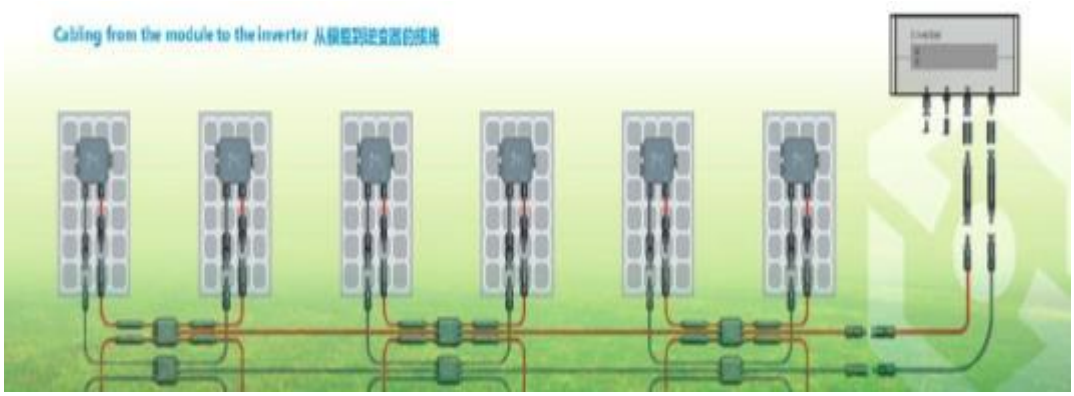
The inverter, which is one of the basic elements of the solar panel system, should be inside the solar panel system power panel (Picture 1.1). In the power panel of the solar panel system, there is a charge regulator together with the converter. In some cases, there may be battery groups inside the solar panel system panel, and sometimes there may be external battery boxes outside the panel.
Solar panel system power panel, in buildings in buildings; in open areas, it should be in a place that can be controlled in accordance with the project.
The following cautions should be observed when installing the inverter inside the solar panel system power panel:
The inverter is only securely mounted with bolts in a vertical position and on a solid base.
It is checked whether the distance between the two inverters and the cooling are sufficient.
The place where the inverter will be installed should be protected from direct sunlight, high temperature and high humidity.
The inverter should never be installed in the immediate vicinity of easily flammable materials.

Converter Cable Connections
An inverter is a device that converts the DC voltage in the battery to the alternating voltage we use at home. In other words, it converts 12, 24 or 48V DC battery voltage to 1 phase 230V – 3 phase 400V AC 50 Hz voltage. Solar type converter cables, which are specially produced for the converter in photovoltaic applications, are specially produced with high quality raw materials.

Cables used for inverters contain tinned copper conductor wire conforming to VDE 0295 / IEC60228 class 5.

The inner part of the cable consists of a special opolymer combined with rays in the electronic environment and a second polyolefine copolymer layer surrounding it. The nominal cable cross-section of the solar cables must be approved by TUV.

It should have a dense cable diameter and should not take up too much space. It should definitely be long-lasting and durable (durable). Solar cables and connectors should be used while connecting the converters.



Before starting the inverter wiring or maintenance work, turn off the mains voltage and observe a waiting period of at least 10 minutes. This time is used so that the capacitors can discharge to a safe voltage value after the mains voltage is turned off. Measure the voltage between the P/+ and N/− terminals with a meter.

There is a risk of electric shock if connection work is not carried out without voltage.

Keep the signal cables 10 cm away from the power cables to avoid noise problems when connecting the inverter cable. After the cable connections are finished, there should be no cut wire parts inside the inverter. For example, cut wire parts can cause alarm or malfunction. Do not allow sawdust or foreign matter to enter the inverter while drilling the mounting holes.

Take care to set the current/voltage input selector switch correctly. An incomplete adjustment may cause malfunctions. Tighten the fastening screws to the specified torques. If a screw is tightened more loosely than specified, it may cause a short circuit or malfunction. Tightening a screw harder than specified may cause short circuit, malfunction, cracking or breakage. Use insulated ferrules/lugs for energy input and motor connections long distance cable

In case of using (especially shielded motor cable), the inverter may be affected by the charging current caused by the capacitance in the cables.

2.2 INVERTER SELECTION IN SYSTEMS

2.2.1 INVERTER SELECTION

Inverter selection is made according to the capacity of the installed system, but in some cases, the capacity is exceeded and the inverter is selected in different sizes.

As we explained in the previous issues, while making the battery system connections (series-parallel) according to the current and voltage values requested from us, we also determine the capacity in line with the values requested from us, otherwise we see that the system does not work properly or malfunctions occur in the system, so inverters are on grid or of grid. Apart from the systems, it is selected according to the power of the system or within other desired parameters.

2.2.2. REGULATION

It is necessary for a full and fluctuating regulator output voltage, rather than being independent of the system while being regulated, otherwise the system will cause errors and malfunctions.

IMPLEMENTATION ACTIVITY

Install the inverter in the solar panel system power panel and make the cable connections.

Operational Steps	Suggestions
➢ Select the appropriate inverter to be mounted on the panel.	➢ Wear work clothes, work gloves and work shoes before you take the safety precautions and start work. ➢ Prepare the working environment and provide the necessary tools and materials for the working environment. ➢ Pay attention to the work safety required for the application to be made.
➢ To mount the inverter, mark the board and drill the appropriate holes. ➢ Provide screws, bolts and nuts to be used for assembly. ➢ Only install the inverter in the permitted mounting position.	➢ Only mount the inverter on fire resistant materials such as metal or concrete. Mounting on combustible material may cause fire. ➢ Make sure that the mounting location can withstand the weight of the inverter.
➢ Mount the inverter to the panel.	➢ To prevent damage from static electricity, before touching the inverter, do not touch any metal nearby.

CONTROL LIST

Evaluate yourself by putting an (X) in the box for the skills you have gained from the behaviors listed below within the scope of this activity: Yes, and for the skills you have not acquired, in the No box.

Evaluation Criteria	Yes	No
1. Did you wear a work apron and take the necessary safety precautions?		
2. Have you selected the appropriate inverter to be mounted on the switchboard?		
3. Did you get the correct size of the inverter mounting location?		

At the end of the evaluation, review your answers as “No”. If you do not think you are proficient, repeat the learning activity. If all your answers are “Yes”, proceed to “Assessment and Evaluation”.

EVALUATION

Read the questions below carefully and fill in the blanks.

When making panel wiring ……. should be used.

The part of the system that converts the energy it receives from the panel is called ……..

Inverters that charge the batteries with the direct current coming from the solar panels and convert the direct current from the batteries into alternating current are called …… inverters.

To the system element that regulates the energy ……. is called.

The interter that gives a clean output is called …….

EVALUATION

Compare your answers with the answer key. Return to the activity and repeat the topics related to the questions that you gave wrong answers or hesitated to answer. If all your answers are correct, proceed to the next learning activity.

LEARNING ACTIVITY –3

PURPOSE

Gerekli ortam ve donanım sağlandığında çevirici kumanda panosu elemanlarının bağlantısını yapıp kumanda panosu montajını yapabileceksiniz.

RESEARCH

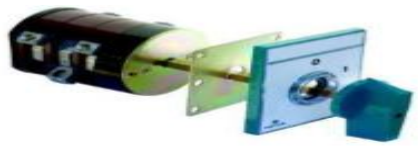
- Gather information about the control panel components.
- Research the control panel supply cables and present them to other group members as information.

3. DIALER CONTROL PANEL

3.1. Control Panel Elements and Layout

Control panel elements; It consists of package switches, control buttons, signal lamps, contactors, fuses, charge regulator and inverter. In addition to these, connectors, cable ducts, carrier rails and terminal blocks are the elements used in the panel.

3.2.Package switches: Packet switches are multi-position switches consisting of many contact sockets arranged and packaged one after the other on a pivot that can rotate around an axis. denir.



3.3.Control buttons: To start or stop the execution of a circuit

elements used for the purpose. start, stop and

It is divided into three as jog (double-track) buttons.

3.4. Signal lamps: The element that indicates whether a control element or its circuit is working or not is called a signal lamp.

3.5.Contactors: Large powerful electromagnetic switches, which are used to open and close electrical circuits and can be remotely controlled by the drive system, are called contactors.

3.6.Fuses: It is a circuit element used to protect the receivers working in the circuit with electrical supply lines against overloads, high currents caused by short circuits and possible accidents that may occur to the people who use them.

3.7.Charge regulator: The direct current taken from the solar panels will prevent the batteries from being overcharged thanks to the charge regulator, thus preventing the batteries from being damaged and consequently reducing the performance and lifetime of the batteries. The charge regulator controls the charge level in the batteries and prevents any damage to the batteries by regulating the charge in case of overshoot.

3.8.Inverter: Converts 12 volt DC voltage obtained from solar panels to 220 volt AC voltage

The following rules must be observed in the placement of the control panel elements:

Before placing the panel elements, it should be determined how many sections the panel will consist of according to its characteristics. Entry and exit points of energy to the panel should be determined. For easier reading, measuring instruments should be placed near the top of the panel and on the front cover. Signal lamps should be above the ammeters. A residual current relay should be placed at the output of the main switch. Fuse and switches should be placed according to the direction of energy. If the energy supply is from above and the output is from below, fuses should be placed on the top. Signal lamps should be located above the switches. Signal lamps and switches must be on the front cover. Fuses must be located inside. Contactors should be placed in the middle part.

Control Panel Assembly

Before the panel is mounted in its place, the equipment belonging to the panel must be installed in its place. The equipment of the panels are first mounted on the platforms of the panel, and when the other operations of the panel are finished, these platforms are put inside the panel. In order to mount wall-mounted panels to the wall, the mounting process is carried out with the help of the wall mounting holes on the back of the panel. For the assembly process, the wall must first be drilled with the help of a drill. Attach the board securely to the wall.

The panel assembly process is completed with the help of dowels and screws of appropriate length to fix it. While mounting the control panel, attention should be paid to the following instructions: The control panel must be mounted on a flat surface and vertically. Since the panel will heat up when it is in operation, all four sides must be open and not blocked in any way. The cabinet must not be mounted inside another control cabinet or in a narrow enclosure. The hanger part of the panel should be firmly fixed to the wall with the screws and dowels that come with it, and then it should be hung on the panel hanger. To connect the supply cables of the control panel, the channels used in the panel must be selected according to the cable quantity. The small size of the channel causes the cables to be compressed too much and as a result, the heating. If the channel is too large, it takes up more space in the panel and increases the cost. It is more preferable to have the power cables in the open rather than in the duct. Since the power cables always carry high current, their being exposed provides cooling convenience. Power cables with a diameter greater than 6 mm2 are fed directly from the busbar and run open inside the panel. If both power and control cables are to pass through the same channel, it is recommended

that the power cable be at the bottom and the control cable at the top, because the control cables create more and more complex images than the power cables. Control cables are more likely to fail. Sometimes there is a need to make changes in the control structure. For all these reasons, keeping the control cable on top provides ease of intervention.

Control cables are laid in the duct and laced after the assembly work is completed. In this way, the cables gain a neater appearance. It also provides flexibility. For the lacing process, after the cables are tied with clips, they are attached to the clip clasps mounted to the bottom of the channel with rivets or bolts. If the number of wires is low, self-shrinking sleeving sleeves are used for the lacing process. After the cables are laid in the duct, the ducts are closed with the duct cover. The control cables are soft and difficult to shape. Since they go through the channel, their shaping is not very important. Therefore, it is collected with clips or macarons and fixed on the rail. While connecting the control cables to the devices, some redundancy is left in the cable by considering the possibility of shortening the cable in case of a later change in the device and in case of failure. This excess is removed by shaping the cable.

The following points should be considered in the assembly of cables that are cut to size and fitted with lugs/ferrules to the device and terminal: Elements such as lugs, ferrules, jacks must be attached or soldered to the end of the cable. Cables must be connected to the terminal specified in the project. The cables must be given a certain form and the cables standing next to each other must have the same shape. The bare part of the cable inside the terminal must not be exposed. The insulated part of the cable or lug / ferrule must not go into the terminal. In terminals that are tightened with a single screw, such as contactor, the cable should be inserted to the left of the screw according to the tightening direction. The terminal screw should not be

tightened loosely, the cable should not come off when pulled by hand. If it is mandatory to enter only one cable and double input to each terminal, terminal duplication should be done by using a hub bridge. Terminal screws must be tightened with a suitable screwdriver. When installing power cables to main busbars, they should be tightened with a torque wrench. The internal connection of the panel with the material placement is made by using control cables in accordance with the panel connection diagram. While making the conductor connections, the conductive ends should be carefully peeled off, the conductive part should not protrude beyond the connection and the connection points should be tightened well. Cable entries and exits should be numbered with the same number, and different cables should be numbered with different numbers in order to follow the circuit easily later. After the connection procedures are completed, the panel should be tested and make sure that the device is working. If the control elements are working properly, the cables should be clipped for a neat appearance and placed in the cable channel and the channel cover should be closed tightly. Installation of power cables of electrical panels is done with the help of busbars and cable lugs in large (large current) panels, and by connecting suitable lugs to the power cable in other panels.

THE SOLAR SYSTEMS ARRANGE COLLECTION PANEL

In a photovoltaic system, the modules are arranged in strings and fields, depending on the type of inverter used, the total power of the modules and their specifications. The serial modules are connected in the module itself, while the parallel connection of the strings is done inside the string aggregation boxes, which

also contain interconnection systems, surge protective devices, disconnectors and surge arresters.

String summation boxes form subsystems that can be standardized according to the number of strings, voltage, and rated current

For public utility scale installations, the combiners are equipped with monitoring devices to measure current, voltage and temperature to ensure array availability and maximize production.

ABB offers different product lines, each dedicated to specific installation conditions with typical configurations.

The main benefits

Plug and play

Global availability for the widest range of residential, commercial and public scale installations at 1000V and 1500VDC, enabling field delivery anywhere in the world.

Main Features

Mechanical properties: IP66, IK10, GWT 750°C, UV and chemical resistant

Electrical characteristics: double insulation (Class II), Ui/Ue: 1000V DC/1500V DC

Wide range (in terms of number of shows and monitoring systems)

Array combiner boxes without tracking

The installation of a photovoltaic system often occurs in complex logistical situations that are environmentally and time-critical. Having tested and certified preassembled components prevents the installer from doing unnecessary field assembly, wiring and certification activities for array boxes. String boxes contain components suitable for various voltage levels and number of connected strings, as well as functions such as string protection, surge protection and disconnection.

Stream boxes with tracking

Sequence monitoring is an important function in operating medium and large installations because it improves the efficiency and maintenance of the system. ABB offers a range of pre-connected string boxes for all installation conditions: they are equipped with both the necessary devices for string protection, surge protection and disconnection, as well as useful devices for string monitoring to measure string current, voltage and temperature within the enclosures.

Multi-output array boxes

The development and increasing adoption of multi-string inverters, mostly in residential applications, has made it necessary to take the necessary measures to reduce costs and space in string boxes, combining them with protective devices and disconnectors of multiple wires in a single combiner box. It is intended to be connected to a specific inverter input.

Multi-wire inverters are solved in conditions of an easy and low-cost system, characterized by modules installed in different bending and exposure positions, minimizing the problems associated with systematic shadowing of system parts.

Move the solar panel system power control panel to the appropriate place and assemble it.

Operational Steps	Suggestions
Move the panel to the assembly place in accordance with the rules. Place the control panel on a flat surface.	➢ Prepare the working environment. ➢ Organize your board by wearing your work apron. ➢ Take safety precautions.
➢ Perform the installation of the cover locks of the panel. ➢ Since the panel will heat up when it is in operation, all four sides must be open, ➢ There should not be anything around it.	➢ Use hand and power tools (pliers, screwdrivers, side cutters, pocketknife or small size knife, control pen) for their own purposes. ➢ Be meticulous and control everything you do.
➢ Check the assembly processes of the panel's covers, glasses, gaskets, hinges and door locks.	➢ Check every assembly process you perform and check whether it complies with the standards.
➢ Clean the material.	➢ Do the cleaning work with solutions.

CONTROL LIST

Evaluate yourself by putting an (X) in the box for the skills you have gained from the behaviors listed below within the scope of this activity: Yes, and for the skills you have not acquired, in the No box.

Evaluation Criteria	Yes	No
1. Did you move the panel to the assembly place in accordance with the rules?		
2. Have you placed the control panel on a flat surface?		
3. Have you done the installation of the cover locks of the panel?		
4. Have you checked the last assembly done?		

EVALUATION

At the end of the evaluation, review your answers as “No”. If you do not think you are proficient, repeat the learning activity. If all your answers are “Yes”, proceed to “Assessment and Evaluation”.

QUANTIFICATION AND CONSIDERATION

Read the questions below carefully and mark (D) for the correct sentences and (Y) for the incorrect ones.

1. ( ) Multi-position switches, which consist of many contact sockets arranged in succession and packed on a pivot that can rotate around an axis, are called package switches.

2. ( ) The element that indicates with light whether a control element or its circuit is working is called a control button.

3. ( ) The element that converts 12 volt DC voltage obtained from solar panels to 220 volt AC voltage is called a charge regulator.

4. ( ) For easier reading, measuring instruments should be placed near the top of the panel and on the front cover.

Compare your answers with the answer key. Return to the activity and repeat the topics related to the questions that you gave wrong answers or hesitated to answer. If all your answers are correct, proceed to the next learning activity.

LEARNING ACTIVITY –4

PURPOSE

Learning the structure of electrical machines and motors and mounting them to PV systems.

RESEARCH

- Gather information about engines .
- Record the information you have acquired and share it with your teacher and friends.

4. ELECTRICAL MACHINES

4.1 GENERATOR (ALTERNATOR)

They are the systems that convert the motion energy into electrical energy. It is the event that the alternator wheels rotate with another power and electrical energy is produced in the winding poles as a result of the magnetic field formed inside the system.

4.2 ELECTRIC MOTORS

As it is known, electrical machines are an ongoing and developing dimension of the developing technology with electricity. Machines have been offered to services in all sectors and have made life easier. The part that we will examine in this module is the motors part of electrical machines.

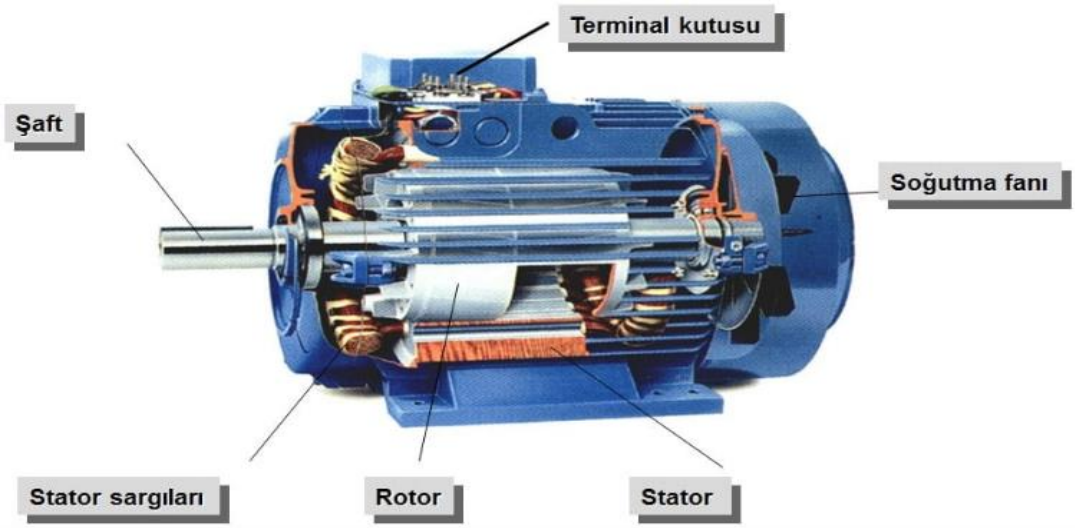
Electric motors, on the other hand, have established themselves as an indispensable part of technology in every part of life, converting electrical energy into circular motion energy. Let's examine the various motors and systems that will be included in renewable energy in this module.

4.3. Engines Working with Alternating Current

Alternating current is the current that consists of phases and whose direction is constantly changing and is not constant. Motors working with alternating current are used in industrial applications where high power is required.

For example; In the trains produced to carry us, this power is provided by synchronous motors working with alternating current. Now, we will talk about **asynchronous** and **synchronous** motors working with alternating current.

4.3.1. Asynchronous Motor



Above we see a cross section of an induction motor. Asynchronous motors; It consists of two main parts called rotor and stator. The stator is formed by pressing high permeability steel laminates onto a steel or cast chassis.

It is the part surrounding the rotor as well as containing the coil windings. Rotor, on the other hand, is the name given to the rotating part surrounded by the stator but not in contact with the stator. There are two types of rotors, squirrel cage and ring rotor.

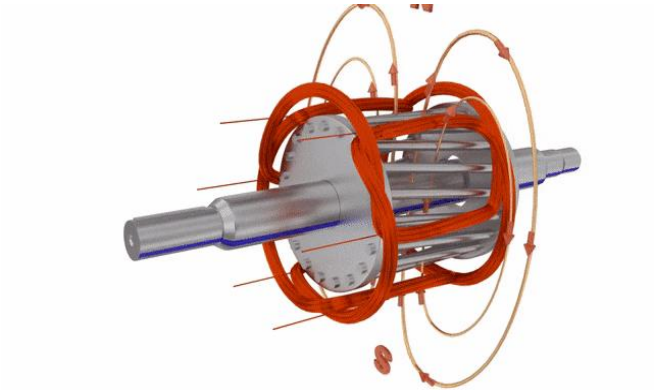
The heat released by the energy losses in asynchronous motors increases the temperature and a cooling fan is used to distribute it. The movement of the rotor is transferred out through the shaft and the connections necessary for the operation of the motor are made in the terminal box.

How Do Asynchronous Motors Work?

In the stator part of the induction motor, there are coils that receive input from three phases. An interesting situation occurs when current flows through these coils. Every conductor through which current flows creates a magnetic field around it. If the magnitude of the current flowing changes with time, the magnitude of the magnetic field formed around the conductor also changes with time.

Well, what happens if we apply three phase alternating voltage to three separate coil windings positioned 120° between them? The amounts of current going to the coils change constantly and regularly. As the amount of current going to a coil decreases, the amount of current going to the coil next to it increases, as it becomes continuous and regular, so a rotating magnetic field is formed. The speed of this rotating magnetic field is called the "synchronous speed".

Synchronous speed depends on the frequency of the electricity coming to the coils and the number of poles of the motor. The rotating magnetic field created by the coils in the stator will cause the conductor in the rotor to generate a current on it as per Faraday's Law, because; According to Faraday's Law, conductors in a variable magnetic field produce eddy current. The current passing through the conductor in the rotor causes a magnetic field to be formed around that conductor. According to Lorentz's Law, two magnetic fields exert a force on each other and the rotor starts to rotate.



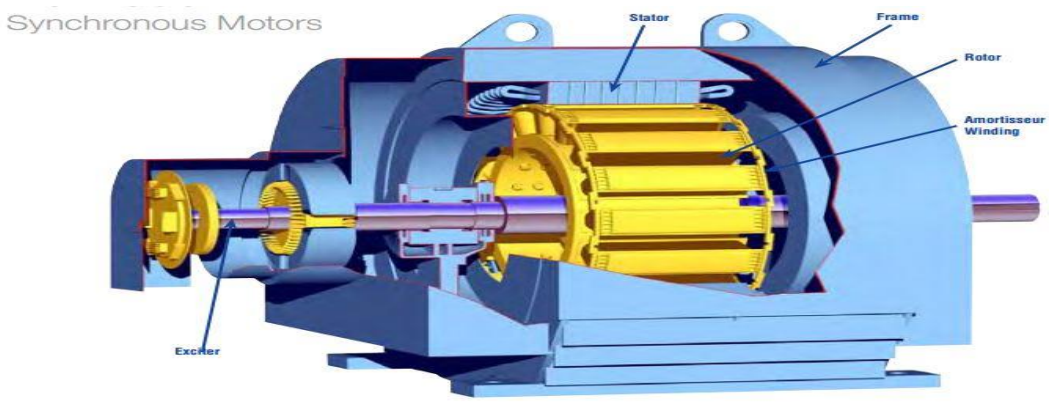
The rotation speed of the magnetic field determines the speed of the rotor. After the rotor starts to rotate with the rotating magnetic field under the influence of the rotating magnetic field, it accelerates and its speed finally becomes equal to that of the rotating magnetic field.

However, in this case there is no magnetic field "rotating" with respect to the rotor, since they both rotate at the same speed, so their velocity relative to each other is zero. In this case, the net force acting on the rotor becomes zero and the rotor starts to slow down.

When the speed of the rotor decreases, it accelerates because it will be exposed to a rotating magnetic field again. What we mean here is that the speed of the rotor can never be equal to the speed of the rotating magnetic field. Therefore, the rotor and the rotating magnetic field move asynchronously. It is this phenomenon that gives this engine type its name. The rotor always rotates slightly slower than the speed of the rotating magnetic field.

2. Synchronous Motors

Synchronous motors are used where speed control is more important and high precision is required. For example; If the place where the motor will be applied is a car or a train, the synchronous motor is selected.



The sections of synchronous motors are the same as induction motors; The stator, which creates a rotating magnetic field through the voltage taken from the three phases, the rotor that performs the rotational movement by interacting with the stator, the cooling fan that undertakes the task of distributing the generated heat, the terminal box where the connections are made and the shaft where the movement is transmitted are the same. caused by its occurrence.

How Do Synchronous Motors Work?

Above we see the rotor of a synchronous motor. The windings on the rotor are connected to the direct current source to be fed from an external source, and when the rotating magnetic field created through three phases in the external direct current stator windings comes together with the electromagnets on the rotor, a different situation occurs compared to the induction motor.

The poles of the electromagnet, which is formed by applying direct current to the windings in the rotor of the synchronous motor, match the rotating magnetic field. With the principle of attraction of opposite poles, the magnetic field and the rotor cling to each other, rotate synchronously at the same speed, thanks to the pulling force they apply to each other. As a result of this situation, the slip in the asynchronous motor (the magnetic field frequency and the rotor frequency are different, the rotor frequency is less, the slip) does not happen in the synchronous motors.

Electric Motors Working with Direct Current

Direct current consists of high potential positive and low potential negative poles. Such motors are preferred in systems where direct current is used. Vibration motor in phones, laptop cooling fans are examples of DC motors. They are preferred especially in places where working with alternating current can be dangerous (for example, in toys) because they can be operated by means of a small battery/battery. DC motors are basically divided into four as Brushed DC motors, Brushless DC motors, Servo motors and Stepper motors.

1. Brushed DC Motors

In general, electric motors convert the electrical energy they receive into motion energy thanks to some electromagnetic effects. Manufacturers group them in terms of some usage requirements. Brushed DC motors, which are one of these groups, work with the same principle as other motor types. Therefore, although the parts it contains may contain some structural differences, they are mostly the same in name. The rotor, stator, shaft, junction terminal box and cooling fan (not needed for small motors) are also found in DC motors. However, the main point that separates DC motors from AC motors is this: Let's remember that in AC motors, we provide a rotating magnetic field by feeding the coils in the stator with three-phase alternating current.

Since the DC current is constant and does not change, it is not possible to create a rotating magnetic field for the stator of DC motors. In order to eliminate the lack of this and make the system work, some changes are made by adding a brush and a commutator.

Of course, the brush we are talking about is a spring-loaded and conductive component. The commutator is the part that comes into contact with the brushes and is fixed to the rotor.

How Do Brushed DC Motors Work?

The stator of brushed DC motors has a magnet positioned between its poles to receive the rotor. When direct current is supplied to the rotor located between this magnet, current flows through the conductor in the rotor. A torque acts on the conductor, which is exposed to the magnetic field created by the magnet and through which current flows, and starts to rotate because if the current-

carrying conductor is placed in a magnetic field, a force will act on that conductor. Here, the indispensable thing to ensure the continuity of the movement is the brush.

Let's try to understand this situation by looking at the picture above. When the metal plate with its positive and negative poles is energized, a clockwise current flows through the plate and a force acts on the plate according to the right hand rule. According to the picture, this force is clockwise.

When the metal plate rotates 180°, if there were no brushes, this time the current would be counterclockwise and the force would act counterclockwise. As a result, the rotor would go back to where it was. Meaningless movements that occurred in this way would render the system unusable. Thanks to the brushes used, even if the metal sheet rotates, the current is always given to flow clockwise from the sheet, and thus the motor rotates continuously.

Brushless DC Motors

Brushes of brushed motors come out due to friction over time and can create sparks. Therefore, this type of motor never guarantees longevity and reliability. At the same time, the friction created by the brushes reduces the efficiency of the motor because the amount of energy that will be converted into heat increases. Brushless type DC motors, which do not have these negative effects, are preferred to make operations safer and less noisy.

3. Servo Motors

All the motors we have mentioned so far are motors that make continuous rotational motion. When energized, the rotor of the motor will constantly rotate around itself. Sometimes, however, we may want to control the action of the motor, stabilize its speed, or simply let the motor spin as much as we want it to. Let's imagine a situation like this: Let's say we have a solar panel on the roof of our house and we want to set up a system that we aim to get maximum efficiency by ensuring that this solar panel follows the sun.

In the arrangement we will establish;

When we want the motor we will use to rotate a certain amount at certain times and adjust the solar panel to always face the sun, if the motor in the system rotates constantly, we cannot run what we planned as we want. We need to use the engine in such a system that by adjusting the position of the engine, we can rotate it at certain angles and make it always look towards the sun. The system that provides this is servo motors.

The reason why we call it a system is that servo motors are mechanisms that contain more than just a motor. Servo units detect the motion of the motor with a feedback mechanism and enable us to control the action of the motor. Simply a servo motor; It consists of three parts: motor, feedback system and control circuit.

The motor used here can be AC or DC, brushed or brushless, and any size. For feedback, that is, to detect the movement of the motor, a potentiometer used by making use of the change in resistance on it, a Hall sensor that measures using the presence of a magnetic field, or any sensor that can help us detect the position of the motor can be used. To complete the servo system, there is a control electronics circuit that connects the sensor that receives data from the motor and makes sense of those values.

How Do Servo Motors Work?

The rotation of the DC motor connected to the system allows the trimpot to rotate through gears, and the amount of resistance falling on the trimpot changes as the motor moves. By reading these change values with the control circuit, we can have information about the position of the motor and even bring the motor to the position we want through the codes we write. Let's think like this; Let us have a potentiometer with a resistance of 10k ohms. Let's connect the potentiometer to a motor through gears when the resistance value is zero.

For the values we read through the control circuit, we may want the motor to take the following action: Start moving, rotate the motor until the resistance value of the potentiometer reaches 10k ohms, and stop the motor when it finally reaches. As you can see, we determined the position of the motor while it was moving through the potentiometer and made the specific movement we wanted.

As another example of servo motor, we can give cruise control in vehicles. The cruise control mechanism, which provides the necessary energy to the motor by interpreting the data received by the current speed sensor from the motor, is also an example of a servo motor, as can be seen.

The rotation amount of the servo motors can be adjusted with the PWM signals given over the PWM output pin, the motor can be rotated to the desired position.

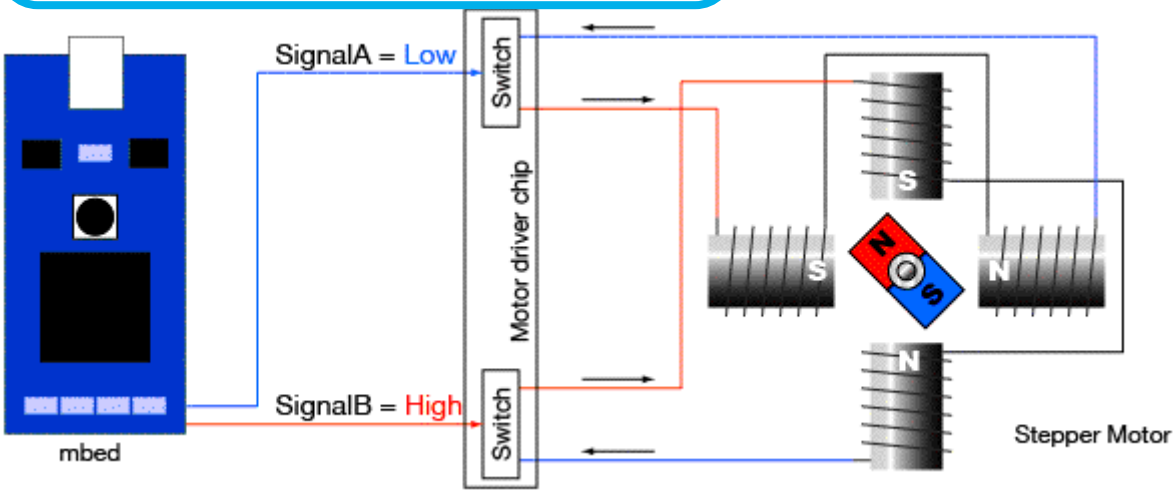
4. Stepper Motors

Stepper motors are motors that move step by step, as their name suggests. These features allow them to move very precisely. They are preferred in many areas such as printers, CNC machines, 3D printers, laser cutters, holding and placing machines where precision is important. There are stepper motors with a very advanced and complex structure used today, but in order to learn the working principle, let's try to understand the way of working by examining the operation of a four-stage stepper motor.

How Do Stepper Motors Work?

Stepper motors are formed by placing four coils on the stator. Each of the coils in the stator has an output that can be energized alone. There is a permanent magnet in the rotor. When any coil is energized, the magnet moves towards the energized coil. This is how the movement of the rotor is achieved, which is equal to one step. If two consecutive coils are energized at the same time, the rotor is positioned between the two coils. In this case, the rotor has taken half a step.

IMPLEMENTATION ACTIVITY ….



A four-stage stepper motor has 5 outputs. One of them is the common pole, and the others are outputs that control each coil separately. By energizing each output in a certain order, the motor is enabled to move in a meaningful way. Of course, it doesn't make sense to do this manually, so stepper motors are controlled by an external microcontroller. By energizing the outputs in a certain order according to the code written in it, the motor is provided to move in the desired way. To read similar articles, you can browse the "Power Quality" category on our site. This motor is used in tracker systems made as a project in systems that automatically track the sun with solar panels. Thanks to the reluctor, it is the most preferred engine in operations. We will examine autonomous systems with this engine in the next teaching activities.

CONTROL LIST

Evaluate yourself by putting an (X) mark in the "Yes" box for the skills you have gained from the behaviors listed below, and the skills you have not gained by placing a "No" box within the scope of this activity.

Evaluation Criteria	Yes	No
Have electrical machines been examined?		
Have you learned the types of electric motors?		
Servo motor learned?		
Has the stepper motor been examined?		

EVALUATION

At the end of the evaluation, review your answers as “No”. If you do not think you are proficient, repeat the learning activity. If all your answers are “Yes”, proceed to “Assessment and Evaluation”.

QUANTIFICATION AND CONSIDERATION 4

Read the questions below carefully and fill in the blanks.

The motor whose windings follow the rotating field behind with the given voltage is called ……..

Step by step moving motor is called …….

The magnetic field formed around a conductor causes that conductor to generate voltage is called ……..

The system that converts electrical energy into circular motion is called …….

LEARNING ACTIVITY –5

PURPOSE

You will know renewable energy systems and solar tracking system.

RESEARCH

- Gather information about light sensors (LDR).
- Record the information you have acquired and share it with your teacher and friends.

5. SOLAR ENERGY SYSTEMS SOLAR TRACKING SYSTEM AND APPLICATIONS

SOLAR ENERGY SYSTEM APPLICATIONS

GENERAL INFORMATION

We have shown the solar energy systems as the basic installation in the previous module, and in this module, which we wrote under the name of the continuation of the basic installation and the application of the developing technology to the renewable energy system, let's explain what are the system developers to make the systems more efficient.

SOLAR TRACKER APPLICATIONS IN GES PLANTS

With the widespread use of solar energy systems in recent years, great importance is attached to applications (solar tracking system) to increase efficiency in these systems.

There are many factors that affect efficiency in solar energy systems. It is difficult to get maximum efficiency from permanently installed panels due to the inability to continuously benefit from solar energy and the maximum efficiency of photovoltaic cells when the sun's rays are upright. One of the most effective ways to prevent yield loss caused by this reason; These are solar tracking (solar tracker) systems that increase efficiency up to 40%.

It is a known fact that it is important for fixed systems to face south in order to benefit from the sun all day long and increase energy efficiency. However, tracker ges systems (ges tracking system) take this efficiency one click further and extend the time to benefit from the sun throughout the day. Thanks to the solar tracking system, it is possible to benefit from the solar energy throughout the day, allowing the lost part to be reintegrated into the system and to increase the efficiency. Solar tracking systems differ according to the tracking axis and control methods. In general, we can classify solar tracking systems as follows:

According to the number of axes;

Single axis control

Dual axis control

According to the control method;

Passive controlled systems (closed loop)

Active controlled systems (open loop)

Solar Tracking Systems by Number of Axis Used

Single Axis Control Systems

In these control systems, the panel moves only in one axis. Thanks to the solar tracking system, it is possible to increase the efficiency by approximately 20-25%. In single-axis control systems, the panel is placed on the north-south line and its movement is made in the east-west axis.

Bi-Axis Solar Tracking Systems

In two-axis control systems, tracking is performed with two angle values that indicate the position of the Sun in the sky. In this control system, one of the axes moves in the azimuth axis and the other in the zenith axis. Panel efficiency 30%-

It can be healed by 40 percent.

SOLAR TRACKING SYSTEMS ACCORDING TO THE CONTROL METHOD USED

2.1 Passively Controlled Systems

The position information required for the system to follow the sun is provided by sensors and are closed-loop systems. Photosensitive sensors or specially developed sensors can be used as sensors in systems that work with the principle of directing solar panels to the direction where the light is intense. The sensor (ldr or photo diode, etc.) placed on the front of the solar panel detects the direction where the light is more intense according to the changing hours of the day and generates a signal accordingly. This signal is processed by the controller and the system moves in one or two axes. The advantage of passively controlled systems is that their algorithms are not complex. However, the sensors used in the system can be very affected by the ambient conditions and can make erroneous measurements. As a result, the position of the sun may be detected incorrectly and the system may become unstable. Since the data received from the sensor is constantly monitored by the controller and a control signal is produced accordingly, these systems operate in closed loop. After explaining the general working structure, we will examine the sensors for sun tracking.

2.2 Active Controlled Systems

It is an open-loop tracking system that does not use any sensor system to determine the sun's position, and the position information is obtained with the help of mathematical algorithms.

It can be mathematically modeled with some approaches according to daily behavior. Angle values according to the obtained mathematical model form the control variables of the system. It is more complex than passive control systems, but gives more reliable results.

Errors caused by the sensors due to the closed air in the outside environment, pollution, rain and similar disruptive factors are not present in these systems. Even if the weather is cloudy or cloudy, the panels can be positioned to receive a continuous vertical beam, since the position of the Sun is known mathematically.

Active controlled systems can also be designed as uniaxial or biaxial. While creating the control structure, it is sufficient to know the latitude, longitude and local time information of the region where the panels are located, as well as a few more variables.

There are two modes of operation valid for both control methods. These modes of work are continuous work and piecemeal work. In continuous operation, the position information of the sun is instantly followed by the controller and the instantaneous movement information is transmitted to the motors. In this way, the position of the sun is continuously monitored. In the form of partial operation, the controller still receives the location information instantaneously, but the process of tracking the sun is carried out at certain time intervals. The reason for this is to reduce the energy consumption of the tracking system.

How much energy the solar tracking system consumes is an important parameter. It is the last thing that an energy-producing system would want to spend extra on the energy it produces. Especially the mechanical and related electrical components

required for moving large-sized systems may require high energy. In such systems, the control systems are fed directly from the network or controlled in parts and the sun is followed.

Wind Protection

In addition, these systems also protect the panels against possible damage by fixing them in a position that will be least affected by the wind in adverse weather conditions (high winds).

OPTICAL TRANSDUCERS AND SENSORS

Elements that change the current passing over them depending on the light falling on them are called optical elements. Optical transducers convert the changes in the amount of light into electrical signals. These elements are generally small current elements. Optical transducers generally do not carry the current of the receiver, they only control the elements that operate the receiver.

Photo Resistor (LDR)

Working Principle

The element whose resistance decreases when light falls on it, and whose resistance increases when it is dark, is called photoresistor.

Photoresistors are called LDR (Light Dependent Resistance). Some materials, such as calcium sulfate and cadmium selenide, show a resistance change inversely proportional to the light falling on them. The resistance of the LDR is very high as long as it does not receive any light on it.

(10 Mohms). As the applied light intensity increases, this resistance value decreases (75-300 Ohm).

Usage areas

It can be used in all circuits that want to be controlled depending on the light. It is used in alarm circuits, counters, flash cameras, park, garden and street lighting.

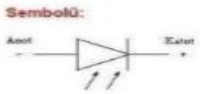
Robustness Test

The avometer is brought to the ohm level. The LDR shows a very small value in the light. This value is about 100 ohms. When the LDR is covered, the resistance value shown by the avometer will increase. Otherwise, the LDR is broken.

Photo Diode

Working Principle

Photodiodes are diodes that conduct in the opposite direction with the effect of light. They are connected in reverse to the circuit. A negative voltage is applied to the anode and a positive voltage to the cathode.



Usage areas

Photodiodes are used in transistor and thyristor triggers, light-controlled circuits, alarm circuits, electronic flashes, light measuring devices, oprocouplers and counter circuits.

Robustness Test

We set the avometer to the ohm range. After connecting the photo diode to the avometer terminals in reverse, we need to see that the resistance of the photodiode in the dark is high and the resistance is low in the light. Otherwise, the photodiode is defective.

LDR AND ENGINE ASSEMBLY

The sensors that should be included in the tracker system are LDR sensors. It is useful and ergonomic.

For the tracker system, it will guide the panel step by step by using the motors (stepper motor) on the panels as a result of the sensors used, the number of which is determined and used on all four sides of the panel that will follow, and this system is supported by both electronic card and ardunio software.

The motor will be used in two ways, the first determines the anchorage direction, while the second panel determines the direction up and down.

THE SYSTEM FOLLOWING THE DAY

Although solar energy is one of the renewable energy sources that can be easily reached in nature, there are many factors that have a negative effect on electricity production from the sun's rays reaching the earth. The efficiency of PV systems depends primarily on the solar radiation value, which is dependent on climate conditions, environmental temperature changes and wind speed, the compatibility of the designed electrical converter system with the load, and the correct positioning of the solar panels.

Since most of the systems used today are fixed, it is obvious that they cannot produce the maximum electrical energy that they can produce with the radiation reaching the surface of the PV panels.

The system that follows the sun is the system that follows the sun throughout the day with various methods and ensures that the sun rays are perpendicular to the PV

system in which they are integrated. In this way, the PV panels will start to produce maximum energy with the radiation falling on it.

Before the development of solar trackers, PV systems were installed at an acceptable angle considering the location of the system on the earth. This tilt angle may change depending on which of the radiation values that the sun will produce in the winter or the summer will produce while the system is being designed. Because the angle of the sun's rays with the earth changes depending on the seasons. For example, inclining a system planned to be installed in the southern hemisphere to the "south" and a system planned to be installed in the northern hemisphere inclined to the "north" will increase the amount of energy to be produced.

The fact that a PV panel produces the highest energy it can produce with the radiation reaching the panel surface depends on the fact that the sun's rays come at an angle of 90◦ to the panel surface. Therefore, since we cannot control the direction of the sun's rays in order to maximize the energy to be produced, PV panels can be mounted on mobile devices so that the system follows the sun and the angle of incidence of the sun rays falling on the panel is 90◦. Studies related to GTES for the last 20-30 years have shown that smart solar trackers maximize energy production within the capacity of the PV system. In addition, although the costs are decreasing day by day, electricity generation from PV systems is still significantly expensive at the moment. For this reason, in addition to the negative effects of atmospheric conditions in a PV system to be established, not being able to get full efficiency from the system will extend the recovery period of the investment made. Therefore, it is important in this respect to get the maximum energy that can be obtained from an

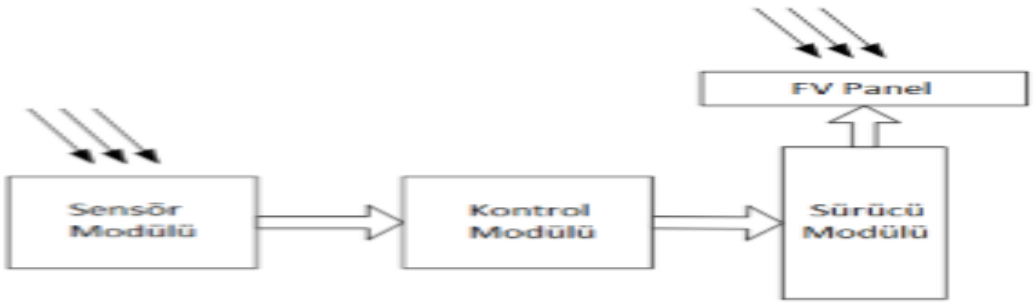
installed PV system. One of the most cost-effective and easy methods to be used for this is to use a system that follows the sun.

Studies have shown that a well-designed solar tracking system increases the PV system efficiency between 20% and 50% compared to a fixed PV system.

Solar Tracking Systems Structures and Types

System Structures

Solar tracking system structures are structures that consist of both mechanical and electrical parts. Mechanical equipment consists of suitable construction that will provide PV panel movement and equipment that will provide the connection between this structure and electrical elements. The electrical part simply consists of motor, motor driver, controller and various sensors (eg, heat sensitive sensor). A block diagram of an example sun tracker system in its most general form is shown below.

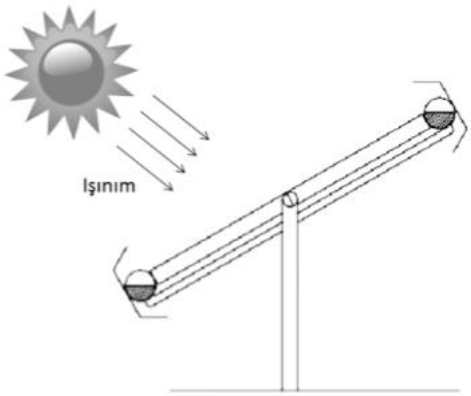


In some solar tracking system structures, systems for storing energy in the electrical part (for example, battery, accumulator) and electronic systems to charge these systems can also be used. In this way, it can be ensured that the sun tracking system follows the sun without cutting off its energy.

System Types

If a Solar Tracking System can track all positions of the sun, the PV system will provide the highest level of electricity production. This will be possible by the solar tracker following both the daily horizontal movement of the sun and the seasonal vertical movement of the sun. For this reason, we can divide solar followers into two main categories: passive (mechanical) followers and active (electrical) followers. Let's remember the above mentioned again.

Of these, passive followers work mainly on the principle of thermal expansion of matter, or shape memory alloy. Such systems usually have two actuating mechanisms that act in opposition to each other. When these systems are illuminated differently from each other, the unbalanced force difference sets the system in motion in a way that creates a balance between the forces. An example passive follower is shown below.



Active followers, on the other hand, can be microprocessor and electro-optical sensor-based, computer-controlled date and time-based, two-faced solar cell-based, and a combination of these three systems.

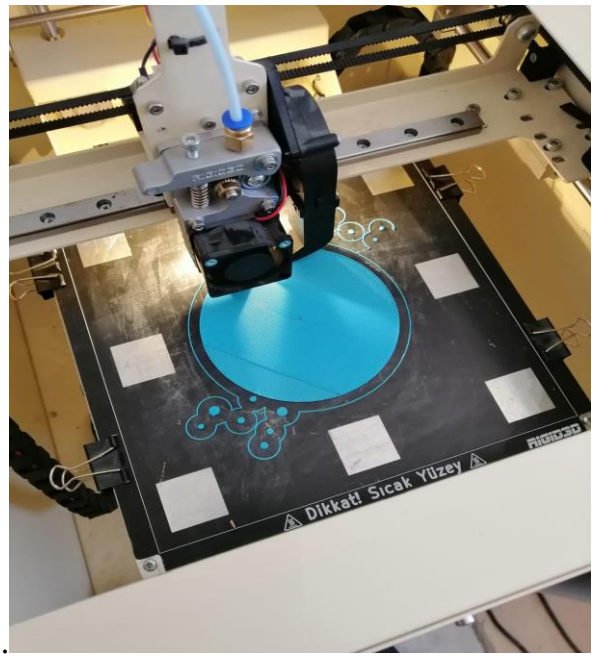
Electro-optical systems can consist of at least two photosensitive sensors or solar cells, usually arranged non-parallel to each other. Thus, system movement is ensured until all sensors detect the sun's heat equally. The DC motor to which the system is connected is controlled with the help of a microprocessor and moved towards the desired direction.

The two-sided solar cell detects the position of the sun and moves the system to the desired position. In these systems, solar cells (panels) are directly connected to the DC motor that provides the system movement. Therefore, electronic equipment such as battery and motor driver in the system are eliminated. Therefore, these systems offer a simple and reliable application for space and land applications.

In computer-controlled date and time-based systems, the computer tries to calculate the position of the sun using various time and date algorithms, and as a result, a control signal is generated to ensure the movement of the system towards the determined location. It is also explained in detail in the sensors section above.

TRACKER SYSTEM DESIGN AND IMPLEMENTATION

The design process of the system was made as a model of the panel holder construction and anchors in the outer movement, this system was made operational with a 3D printer. Only motors and panels were used in the interior design. Servo or stepper motors can be used in the system. If the system is large, the servo will be more appropriate. In small systems, stepper is preferably used.By using 4 ldr sensors, the 1st stepper motor in the east and west directions and the 2nd stepper motor in the north and south directions were activated, the motors were driven with the electronic driver card in the system and the process was completed.



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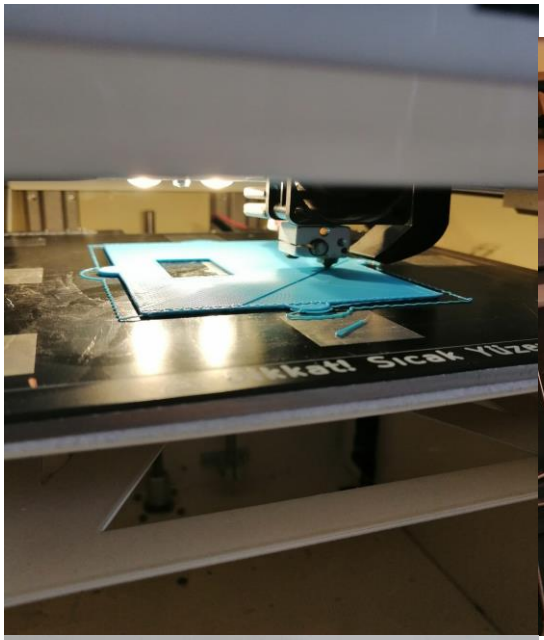

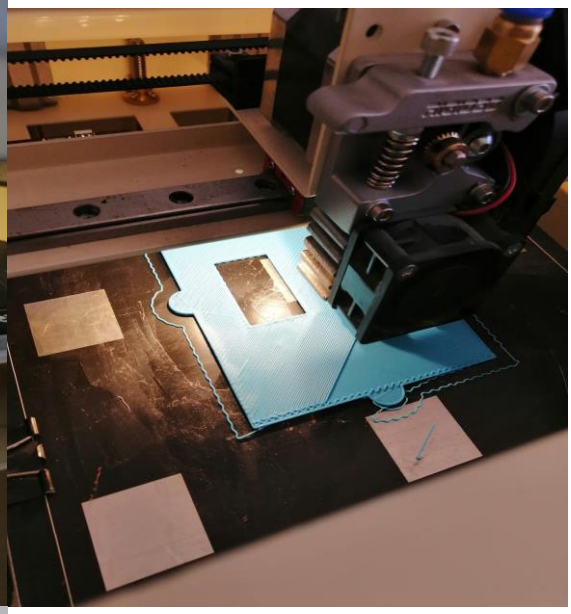

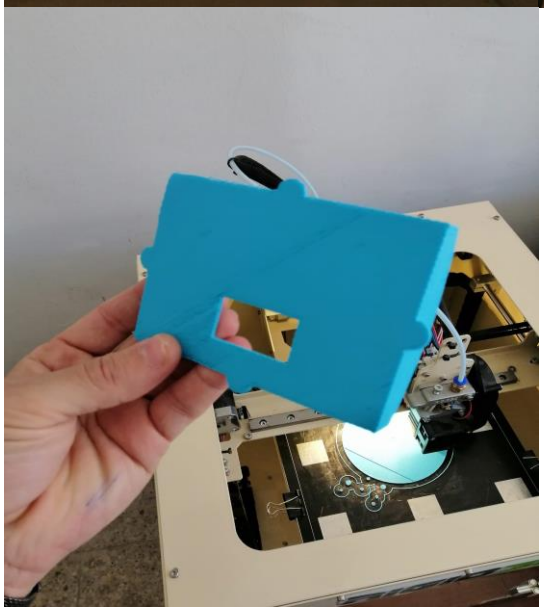

IMPLEMENTATION ACTIVITY

Operational Steps	Suggestions
Move the meter to the appropriate position to measure the voltage at the ends of the sensors..	➢ Give the light intensity sufficiently intense and examine the sensor status.
Apply voltage to the tracker system to test the motors.	➢ Take the measuring instrument to volt level.
Associate the LDR with the electronic board and apply light.	➢ Adjust the angles and try it that way.
Mount the motors to the tracker system.	➢ When the installation is complete, try and note if the system is working properly.

CONTROL LIST

Evaluate yourself by putting an (X) mark in the "Yes" box for the skills you have gained from the behaviors listed below, and the skills you have not gained by placing a "No" box within the scope of this activity.

Evaluation Criteria	Yes	No
Is the engine permanently mounted?		
Is the LDR fixed?		
Is the panel fixed to the construction?		
Does the tracker work and the data is received in a healthy way?		

EVALUATION

At the end of the evaluation, review your answers as “No”. If you do not think you are proficient, repeat the learning activity. If all your answers are “Yes”, proceed to “Assessment and Evaluation”.

Read the questions below carefully and mark (T) for the TRUE sentences and (F) for the FALSE ones.

( ) The system that follows the sun and generates electricity is called a tracker.

( ) The light sensitive sensor is called LDR (photo resistor).

( ) The tracker system is one-way only.

( ) Asynchronous motors are used in tracker systems.

MODULE EVALUATION

In the parentheses left blank at the beginning of the sentences below, write T if the information given in the sentences is true, and F if it is false.

( ) The array in which the parts form a whole is called a system.
( ) Systems are divided into open and closed systems.
( ) Machines that convert motion energy into electrical energy are called electric motors.
( ) There is a magnet in the stator of electric motors.
( ) Tracker systems are advantageous systems.
( ) electrical machines are long-lasting magnetic systems if they are maintained.

EVALUATION

Compare your answers with the answer key. Return to the activity and repeat the topics related to the questions that you gave wrong answers or hesitated to answer. If all your answers are correct, proceed to the next performance test.

CONTROL LIST

Evaluate yourself by placing a check mark (X) in the "Yes" box for the skills you have gained from the behaviors listed below within the scope of this module, and the "No" box for the skills you have not gained.

Evaluation Criteria	Yes	No
Is the system defined?		
Have systems and subsystems been identified?		
Have technological formations been taken into account in the Solar Energy System?		
Tracker system installation planned?		
Is the system autonomously controlled?		

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EVALUATION

At the end of the evaluation, review your answers as “No”. If you do not think you are proficient, repeat the learning activity. If all your answers are “Yes”, contact your teacher to move on to the next module.

ANSWER KEY TO LEARNING ACTIVITY-1

1	System
2	Open and closed system
3	ten grid
4	hybrid

ANSWER KEY TO LEARNING ACTIVITY-2

1	connector
2	converter
3	off grid
4	Regulator
5	full wave

ANSWER KEY TO LEARNING ACTIVITY-3

1	True
2	False
3	False
4	True

ANSWER KEY TO LEARNING ACTIVITY-4

1	asynchronous motor
2	stepper motor
3	Induction principle
4	Electric motor

ANSWER KEY TO LEARNING ACTIVITY-5

1	True
2	True
3	False
4	False

ANSWER KEY TO MODULE EVALUATION

1	True
2	True
3	False
4	False
5	True
6	True

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