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Design Of DC Motor Coupling System As Backup Electric Energy Based On Microcontroller

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ABSTRACT
This research aims to design and analyze a DC motor coupling system as a backup electrical energy source controlled by a microcontroller. This system is designed to provide an efficient, reliable and economical backup energy solution, which can be used in various applications such as industrial, household and critical infrastructure. The design process includes integrating a DC motor with a microcontroller to regulate speed, monitor performance, and manage power automatically. Simulations and experimental testing were carried out to analyze the system performance in terms of energy conversion efficiency, operational reliability and response to various load conditions. The research results show that the DC motor coupling system controlled by a microcontroller is able to increase energy efficiency and reliability as a backup power source. The system can also be optimized to ensure maximum efficiency and stable performance. Sustainability evaluation and operational cost analysis show that this system has the potential for significant energy savings and low maintenance costs. Overall, this research contributes to the development of more efficient and adaptive backup energy source technology. This microcontroller-based DC motor coupling system offers a practical and innovative solution to meet backup energy needs in various sectors.

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INTRODUCTION

In the modern era which is characterized by high dependence on electrical energy, the need for reliable and continuous electrical resources is increasing. This dependency is not only felt in the industrial and commercial sectors, but also in the household sector and critical infrastructure such as hospitals, emergency services and communications facilities. When an electrical disturbance occurs, the impact can be very detrimental, ranging from economic losses to potential safety risks.

One solution to overcome electrical disturbances is to use a backup electrical energy system. This system functions to provide electricity supply when the main source fails. There are different types of backup energy systems, including fossil fuel generators, batteries, and renewable energy sources. However, each of these solutions has its own

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limitations, such as high operational costs, dependence on fossil fuels, and complexity in installation and maintenance.

Dc (direct current) motor technology offers an attractive alternative as a backup energy source. Dc motors have advantages in terms of energy efficiency and the ability to be controlled with high precision. With microcontroller integration, dc motor coupling systems can be optimized for automatic operation, real-time performance monitoring, and efficient power management. Microcontrollers enable more intelligent and adaptive control, so the system can adapt to different load conditions and ensure a stable power supply.

In this context, this research focuses on the design and analysis of a dc motor coupling system controlled by a microcontroller as a backup electrical energy solution. This system is expected to provide a reliable and efficient electricity supply, as well as have low operational and maintenance costs. Thus, this research not only offers a practical solution to backup energy needs but also contributes to the development of more environmentally friendly and sustainable technologies.

By considering the need for reliable and efficient sources of electrical energy and the potential of dc motor technology controlled by microcontrollers, this research aims to develop innovative solutions that can be applied in various sectors, providing significant economic and operational benefits.

Pln's main power supply has a big influence on the supply of electrical energy for public services, both large power and small power. However, the main power supply from pln is not always continuous in distribution. At some point there will definitely be a total blackout which can be caused by disturbances in the generating system, or disturbances in the transmission system and distribution system. Meanwhile, the supply of electrical energy is very necessary in trade centers, hotels, banking, hospitals and industry in carrying out their production. So if pln goes out, the supply of electrical energy stops, and as a result all production activities stop. Based on the above, so that there is no total blackout in the lighting of rooms or important areas that must receive a continuous supply of electrical energy, a generator set (genset) is needed as a back-up for the main supply (pln).

As a backup electricity supply, many people use generators, plts and other sources of electrical energy. However, from an economic perspective, factory-made ats modules are expensive. Therefore, as an alternative, in writing this thesis we try to design by utilizing two dc motors with a cople system so that they can produce 12v electrical energy and convert it using an inverter to reach a voltage of 220v ac to supply the electrical load. The generator system that will be designed uses a 12v dc battery to power the dc motor, the output from the inverter. The author will try to design an automatic charger to charge the battery so that the battery can last a long time to supply the dc motor as a backup power supply.

Literature Review

Previous Research

Previous research is the researcher's attempt to find comparisons and then to find new inspiration for further research. In addition, previous studies help research position the research and show the originality of the research. In this section, the researcher includes

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various results of previous research related to the research to be carried out, then makes a summary, whether research that has been published or not yet published. The following is previous research that is still related to the theme the author is studying. As shown in the table below:

Table 1. Previous Research.

Name Of Research	Tittle	Vol and ISSN	Result
Timotius William Kristianto,dkk 2022	Design Get up Bicycle Static As Simple Power Generation	*E-JOINT(Electronica And Electrical Journal Of Innovation Technology),* Vol.03, No.2, ISSN:2745 -9292	This research aims to make a stationary bicycle as a simple electricity generator for simple electronic devices. This tool works by pedaling a bicycle to rotate a DC generator which is then distributed to the Solar Charge Controler (SCC). The results of the electric voltage are stored in the accumulator with a watt meter as an indicator of the generator output voltage and current. This research found the minimum RPM to turn on the watt meter at RPM 50 on a bicycle pedal which produces a voltage of 6.09V. Maximum RPM is 85 RPM with a voltage of 13.61V, where the accumulator will be filled when the voltage is above From 12V
Denny R. Pattiapon,dkk 2019	Use of Salient Pole Type Three Phase Synchronous Motor as a Synchronous Generator	Jurnal Simetrik Vol.9, No.2, Desember 2019 ISSN: 2302-9579/e-ISSN: 2581-2866	Where the synchronous motor is operated as a synchronous generator using a separate field amplifier, with a load of 0 – 210 Watts, it turns out that what happens is that the greater the load given to the generator, the generator rotation and the output voltage produced from the generator decreases, so

Name Of Research	Tittle	Vol and ISSN	Result
			the generator rotation must be stabilized. back at 1500 Rpm and the output voltage on each phase must be stabilized at 220 VAC
Iham Akbar Syahputra,dkk 2020	Simple Generator Prototype Using Neodymium Magnets and Internet of Things (IoT) Based Output Monitoring	Prosidingseminar Nasional Inovasi Teknologi Penerbangan (Snitp) Tahun 2020issn : 2548-8112	A simple generator using neodymium magnets as an alternative backup power supply that is environmentally friendly and can be an innovation in the future to create a power supply that saves electricity costs. The test results of the tool show that the performance of the tool runs as desired and also for the voltage coming from a variable power supply of 3 Volts-7 Volts and can be used in a simple magnetic generator, which can produce a voltage output of 5 V at a magnet rotation speed of 2838 (RPM) with a current of 0.52 A

From the results of previous research that has been carried out in the table above, the author can conclude that the engine that will be designed in this thesis uses two 12V DC motors to be coupled using a clutch, for the DC motor prime mover the author uses a 12V/7 battery, 2 Ah. The output of the DC motor as a coupled generator will be connected to the inverter to convert DC electricity into 220 V AC.

Electrical energy

Energy is a major need during human civilization, energy needs have increased as an indicator of human prosperity, but in its application there are problems in providing energy as petroleum reserves in the world are depleting. So that several natural energies are formed as alternative energy that is safe and has unlimited supply, often known as renewable energy. Illustrated in the following figure to understand why energy supply and demand on a global macro scale depends so much on the balance between energy input and output in the devices we use at home and at our workplaces. (Adi Candra, et al 2020)

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The National energy strategy reflects the National commitment to greater efficiency in every element of energy production and use. Greater energy efficiency can reduce energy costs to consumers, improve environmental quality, maintain and improve our standard of living, increase our energy freedom and security, and promote a strong economy. With this energy there is an electric charge as a working force. The experiment carried out the force, its relative position and speed depending on the electric charge. The force that arises, there are two differences, if there is a charge, is called electric force, if it is caused by the speed of the charge, it is called magnetic force.

Electric current is a flow of electric charge or electrical charge that flows per unit time. Charge is the smallest unit of an atom or subpart of an atom. Charges will move if there is external energy influencing them. As long as the charge continues to move, an electric current will appear, but when the charge is stationary the current will disappear. The direction of electric current is from high potential to low potential and is in the opposite direction to the flow of electrons.

Two charged objects, A and B, are connected by a conductor. If potential A is higher than potential B, then current will flow from A to B. This current flows in a very short time. Once potential A is equal to potential B, current stops flowing. So that electric current continues to flow from A to B, the positive charge that has arrived at B must be transferred back to A. In this way, A's potential is always higher than B. So it can be concluded that in order for electric current to flow in a conducting wire, then between The two ends of the wire must have a potential difference.

The strength of the electric current flowing through a conductor is the amount of electric charge that flows every second through a conductor. The symbol for current strength is I. So, electric current strength is formulated

$$I = \frac{\Delta Q}{\Delta t} \quad \text{.....} \quad (1)$$

Where ΔQ is the amount of charge that passes through the conductor at a location during a period of time Δt. The unit of electric current strength is the Ampere (A). (Joko Siswanto, et al 2018).

Electrical power is a capacity or ability to do energy or work. The amount of power is work in units of time. Meanwhile, electric power is part of the magnitude of the potential difference, current strength, resistance and time. Electrical power is defined as the rate of energy required. This electrical power is related to electrical energy every second. The unit of electric power in international units is the watt. One watt is the amount of power when one joule of energy is released in an interval of 1 second. The following is the electric power equation:

$$P = \frac{W}{T} \quad \text{.....} \quad (2)$$

The capacity of electrical power is given in Watts or Joules/second (J/s). The unit of electrical energy is often called Kilo Watt (KW), when stated 1 kW = 1,000 Watts, while for larger capacities it is given the unit Mega Watt (MW), when stated 1 MW = 1,000,000 Watts. If expressed in Joules then 1 Watt per second (Ws) = 1 Joule, if the electrical power

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is expressed in hours (h) then 1 Wh = 3,600 Joules. Thus the use of electrical power in a certain time is expressed in Joule units. Because W = V.I.t, the electric power equation can be formulated. (Hantje Ponto, 2018)

$$P = \frac{V.I.t}{t} \quad \text{.....} \quad (3)$$

Where:

P = electric power, in Watts

V = electric voltage, in units of Volts

I = Flowing current, in Amperes

The equation above is simplified to P=V.I. This equation was explained in the previous chapter.

Where:

P = electrical power, in Watt units

V = electric voltage, in units of Volts

I = Flowing current, in Amperes.

In an alternating current source, if the applied load is purely resistive, then the voltage and current waves are in phase as shown in the figure below

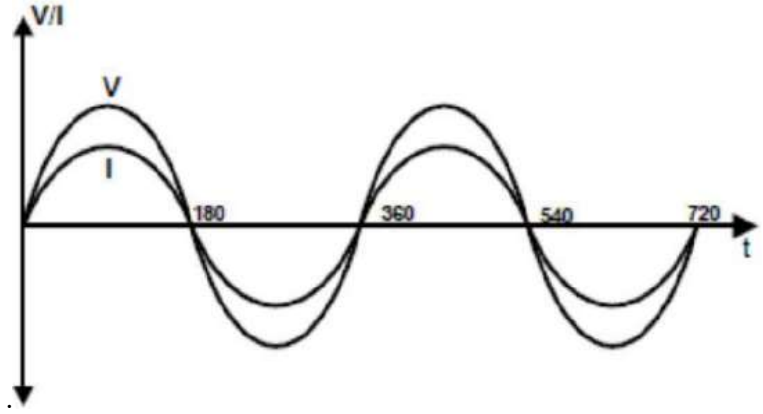

Figure 1. Resistive Load

Loads that are inductive or capacitive can shift the zero crossing point between voltage and current. If the load is an inductive load, the zero crossing of the current wave appears some time after the zero crossing of the voltage wave appears. This is usually said to be a lagging current, as shown in the figure below:

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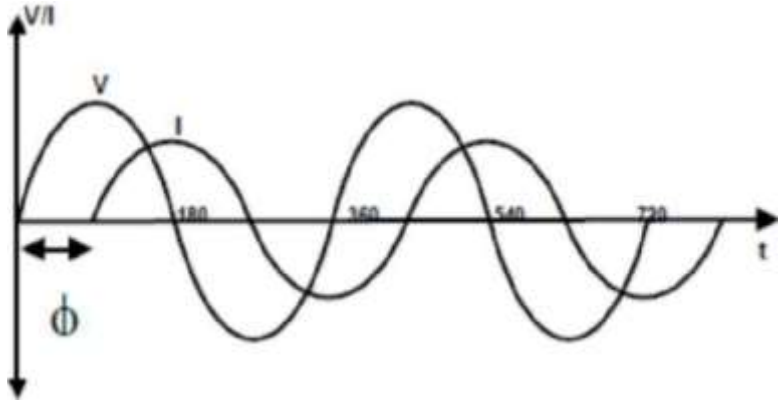

Figure 2. Inductive Load

On the other hand, for capacitive load currents, the zero crossing of the current wave will appear some time before the zero crossing of the voltage wave. This is usually said to be a leading current as shown in the figure below:

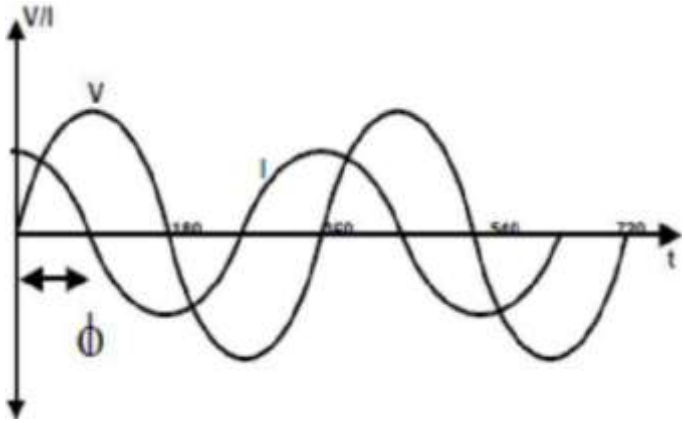

Figure 3. Capacitive Load

Generator Set (Genset)

A generator set is a combination device between a power generator (generator) and a driving engine combined in one set of units to produce electric power. The driving engine in a generator is generally an internal combustion engine in the form of a motor/diesel engine with diesel fuel and an engine with gasoline fuel. Meanwhile, a generator is a device that converts mechanical energy into electrical energy. The working principle of a generator uses Faraday's experimental principle, namely rotating a magnet in a coil or vice versa. penetrates perpendicular to the coil, causing a potential difference between the ends of the coil (which causes electricity).

The working principle of a generator is that a combustion engine (diesel engine or gasoline engine) will convert fuel energy into mechanical energy, then this mechanical energy is changed or converted by the generator to produce electrical power. Generators have two types, namely AC generators or what are usually called alternators and DC generators. An AC generator (alternator) is a generator that produces alternating electric current (AC), while a DC generator is a generator that produces direct electric current (DC). Actually, AC generators have the same working system as DC generators, namely

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producing electricity from electromagnetic induction, Apart from that, both AC generators and DC generators basically produce alternating electric current. However, AC generators and DC generators have differences in their construction design. DC generators use a split ring or what is usually called a commutator which acts as a rectifier, so that the current produced by a DC generator is direct current (DC).

Meanwhile, the AC generator (alternator) uses two slip rings to produce alternating current. Generator sets are usually used to produce alternative electrical power, such as when the electrical power supply from the power generation industry goes out, or in situations where there is no electricity network supply in the area, or are also commonly used when additional electrical power is needed.

Motor DC

A direct current motor (DC motor) is a machine that converts direct current electrical energy into mechanical energy. In terms of operating principle, a direct current motor is very identical to a direct current generator. In fact, a machine that works as a direct current generator will be able to work as a direct current motor. Therefore, a direct current machine can be used both as a direct current motor and a direct current generator.

Physically, direct current motors generally consist of a stationary part and a rotating part. The stationary part (stator) is where the field coil is placed which functions to produce magnetic flux, while the rotating part (rotor) is occupied by a series of anchors such as the armature coil, commutator and brushes. Direct current motors work based on the principle of interaction between two magnetic fluxes. Where the field coil will produce magnetic flux in the direction from the north pole to the south pole and the anchor coil will produce circular magnetic flux. The interaction between these two magnetic fluxes creates a force which will give rise to a twisting moment or torque.

The image below shows the construction of a direct current motor

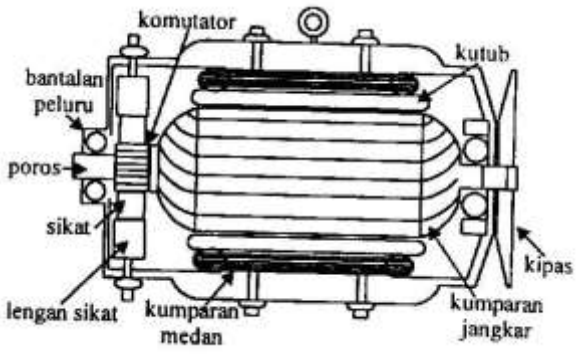

Figure 4. Direct Current Motor Construction

The description of the image above is

a. Motor body (frame)

The frame or yoke of a direct current machine, like other electrical machines, generally has two functions, namely:

1) Is a means of mechanical support for the machine as a whole
2) To carry the magnetic flux produced by the magnetic poles.

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For small machines, price considerations are more dominant than weight, usually the frame is made of cast iron, but for large machines it is generally made of cast steel or rolled steel. This frame is laminated on the inside to reduce core losses. Apart from that, this frame must also have high permeability, as well as being mechanically strong. Usually on motorbikes there is a name plate that says the general specifications or technical data of the machine, there is also an end box which is the place for the ends of the field amplifier winding and the anchor winding.

b. Pole

Field poles consist of a pole core and a pole shoe. The pole shoe adjacent to the air gap is made larger than the core body. The function of polar shoes is:

1) As a mechanical support for the field coil

2) Produces a better distribution of flux spread throughout the anchor by using a curved surface

c. Anchor Core

The armature core that is commonly used in direct current motors is cylindrical in shape which has grooves on its surface for winding the coils where the induced EMF is formed. The anchor core is made of ferromagnetic material, with the aim that the components (anchor winding) are located in an area where the magnetic induction is large, so that the induced emf can increase. Like the core of a magnetic pole, the anchor is made of thin layers of material to reduce the heat generated due to the presence of linear currents as shown in the figure below

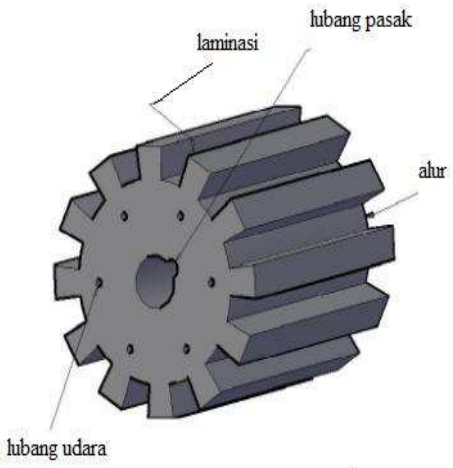

Figure 5. Layered anchor core

The material used for this anchor is a type of silicon steel mixture. In general, the groove is not only filled with one coil arranged in layers

d. Anchor Coil

The armature coil in a direct current motor is where the induced emf is generated. In DC motors the long compound gain of the field coil is in series with the armature coil,

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while in DC motors the short compound gain of the field coil is in series parallel to the armature coil.

e. Field Coil
A field coil is an arrangement of conductors wrapped around a polar core. The field circuit which functions to produce the main flux is formed from coils at each pole. In its application, the field circuit can be connected to an armature coil, either in series or parallel, and can also be connected directly to a voltage source according to the type of reinforcement on the motor.

f. Commutator
To obtain direct voltage, a rectifier is needed called a commutator and brushes. The commutator consists of a number of copper segments in the form of plates assembled into a cylinder mounted on a shaft. Where each commutator plate or segment is well isolated from each other

g. Brush-Brush
These brushes (figure 2.3) function as a bridge for the current flow to the armature coil. Where the surface of the brush is pressed against the surface of the commutator segment to transmit electric current. The amount of spring pressure can be adjusted according to your wishes

Figure 6. Brushes

Besides that, brushes play an important role in commutation. The existing carbon is sought to have high conductivity to reduce electrical losses. So that friction between the commutators and the brushes does not cause the commutator to wear out. So the brushes must be softer than the commutator

h. Air Gap
The air gap is a space or gap between the surface of the anchor and the surface of the pole shoe which prevents the anchor from rubbing against the pole shoe. The function of the air gap is as a place for the flux produced by the field poles to flow.

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METHOD

In this chapter the author creates several design methods including determining the time and place of research, tools and materials used in design, tool design systems, research methods, and research procedures. The author carried out several design system steps to find out how the tool works

In designing this tool the author conducted this research from October to November 2023, Jl P. Alibasa Gg melur no.4 Padang Sidimpuan, North Sumatra 22711. This hardware design is a set of interrelated elements that process one input with another input so that it is able to produce an output in the form of information that can be used in making a decision.

Block Diagrams are a form of process diagram for systems specialized in engineering activities. The diagram is arranged from a high level point of view or does not highlight too detailed parts of the system. The purpose of making it is to show the main parts when creating a new system or improving an existing system

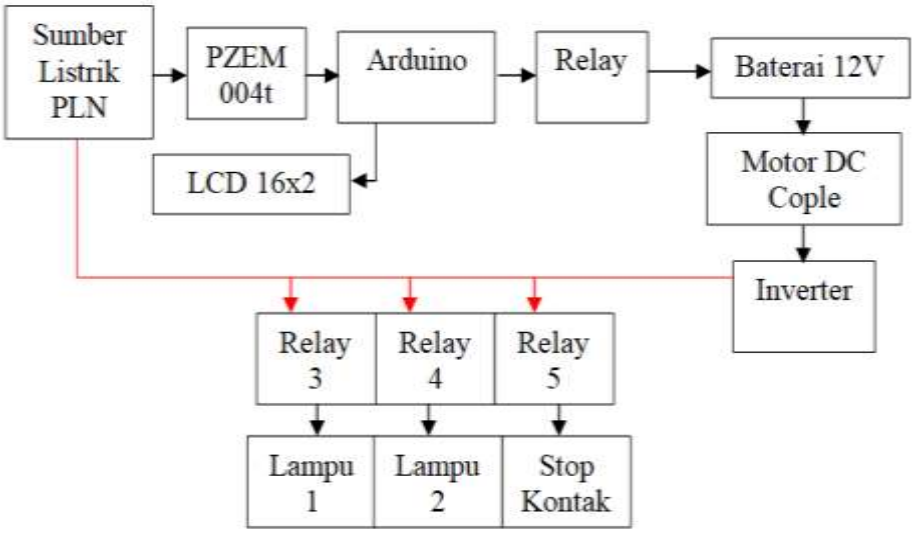

Figure 7. Block Circuit Diagram

In the block diagram above, the author can explain that if the PLN is off or has gone out, the Pzem004t sensor detects that there is no voltage from the PLN, the Arduino will order the coupling motor to be active so that the output voltage on the coupling motor is converted via the inverter to 220 VAC so that the electrical load can be turned on. return. If the PLN is back on, the sensor will detect voltage from the PLN and the Arduino orders the relay to deactivate the coupling motor, so that the coupling motor which functions as a replacement for the generator is in standby state.

The minimum system circuit is the minimum circuit in which the microcontroller chip can work (run). The Atmega AVR chip is equipped with an internal oscillator so, to save costs, there is no need to use an external crystal/resonator to source the CPU clock.

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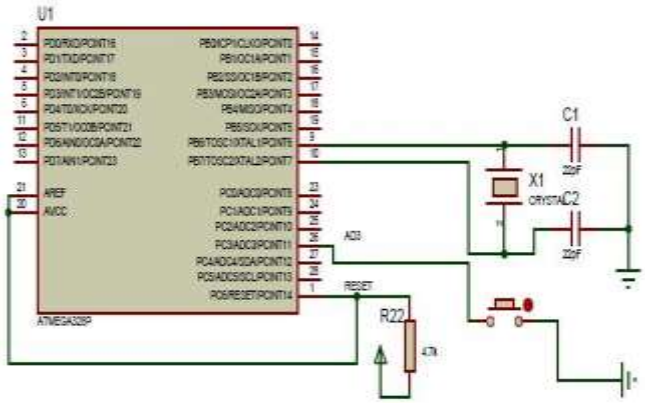

Figure 8. Arduino Uno Minimum Circuit
Sumber: Penulis,2024

To create a minimum system circuit, several components are required, namely:

1. ATMega 328 microcontroller IC
2. 2 capacitors, namely 22 pF (C1 and C2) and 10 uF (C3)
3. 1 resistor whose value is 4k7 ohm
4. 1 reset pushbutton (PB1)

Program memory is Flash PEROM memory which is responsible for storing programs (software) that we create in the form of program codes (containing addresses along with program codes in the address memory space) which we compile in the form of hexa or binary numbers.

RESULT

Power Supply Testing

The voltage source used as the working voltage in the DC Motor Coupling System Circuit as Microcontroller-Based Backup Electrical Energy has a source originating from DC12 V.

Figure 9. Power Supply Voltage Output Measurement

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Power supply testing was carried out several times to get good results based on the data sheet of the power supply, but measurements carried out directly using a multitester can be seen in the table below:

Table 2. Power supply stability test measurements

	Expected based on data sheet	Measurement results
TEST	Vcc	Vcc
Ke-1	12 V	11,69 V
Ke-2	12 V	11,69 V
Ke-3	12 V	11,69 V
Ke-4	12 V	11,69 V
Ke-5	12 V	11,69 V
Nilai Rata-rata	12 V	11,69 V

Sumber: Penulis,2024

Testing the Voltage Regulator Output

The use of a regulator in a DC Motor Coupling System as Microcontroller-Based Backup Electrical Energy is used to provide a constant voltage to the device's minimum system circuit. Testing on the LM2596 regulator IC was carried out to determine the output voltage produced by the regulator IC. The reason for choosing to use the LM2596 regulator IC is because each component in the device on average works based on a voltage of 5V DC. To achieve more accurate test results, the voltage regulator output test was carried out up to 3 times. The following is the test Table

Figure 10. Measurement of Regulator Voltage Output

Table 3. IC Regulator Test Results

Test	Voltage Input (V)	Voltage Output (V)
Ke-1	11,69 V	5,05V
Ke-2	11,69 V	5,05V
Ke-3	11,69 V	5,05V
Averages	11,69 V	5,05V

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Relay Testing

Relay testing with a working system for moving the electricity source from PLN to the generator and from the generator to PLN has been designed and programmed with a working system where the contact will move from normally close (NC) to normally open (NO) according to the command received from the microcontroller, while The microcontroller orders the relay to work based on the voltage detection results sent via the pzem004t sensor.

Figure 11. Relay Testing

In Figure 11 above, the relay provides an indicator as a sign that the PLN or generator power source is on or off

Table 4. Relay Testing

Tegangan (V)		Relay	Relay	Kondisi PLN	Kondisi
PLN	Genset	PLN NO/NC	Genset NO/NC	(ON/OFF)	Genset (ON/OFF)
220V	0V	*NC*	*NO*	*On*	*Off*
0V	220V	*NO*	*NC*	*Off*	*On*

From the table above, if the voltage from the electrical energy source is 220V then the relay is in a normally closed (NC) state, meaning the relay is connected to supply the electrical load. If the voltage from the electrical energy source is 0V then the relay is in the Normally Open (NO) state, meaning the relay cuts off electricity to the load.

CONCLUSION

From the results of the discussion in the previous chapter, the writer will draw conclusions in writing this thesis as follows: The output voltage from the generator is designed to reach 11.17 Vol DC and the Converter uses an Inverter to increase the voltage to 220 VAC. The Coupling Motor will be active if the Pzem004T sensor detects voltage from PLN in the 0V condition and the Coupling Motor will be inactive if the Pzem004t Sensor detects the voltage from PLN in the 220V condition. The inverter used in designing this tool reaches 150 watts of power to supply the electrical load. The generator can only be activated if the

PLN is turned off, while the generator can be turned off automatically if the PLN returns to normal

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