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A clutch with dual accumulators as a reserve power source

Abstract. *-The use of accumulators as an energy source so far has been limited to only as a source of energy in an emergency and is limited by usage time. The tool of an energy source that is used in an emergency and is limited in usage time is called an Uninterruptible Power Supply (UPS). The way this tool works has not been effective enough and is still unreliable, therefore, there should be new innovations, so that it can be used not only for emergency usage and the usage time is not limited. The result of the study is in the form of The Clutch with Dual Accumulators as a Reserve Power Source that will become as one of the main energy source providers that can provide a way out in the event of interference of State-Owned Electricity Company (PLN), and can operate in a relatively long time. The Clutch with Dual Accumulators as a Reserve Power Source is initiated by determining the characteristics of each component such as accumulators, inverters, rectifiers, current booster circuits, and voltage sensors. The next stage is to determine the maximum loading so that the system works long enough. Then it is thoroughly analyzed by taking a long time, so that the results of the design will really be suitable to be used as a Clutch with Dual Accumulators as a reliable Reserve Power Source.*

Streszczenie. *Stosowanie akumulatorów jako źródła energii ograniczało się do tej pory jedynie do źródła energii w sytuacjach awaryjnych i jest ograniczone czasem użytkowania. Narzędzie źródła energii, które jest używane w sytuacjach awaryjnych i jest ograniczone w czasie użytkowania, nazywa się zasilaczem bezprzerwowym (UPS). Sposób działania tego narzędzia nie był wystarczająco skuteczny i nadal jest zawodny, dlatego powinny pojawić się nowe innowacje, aby można je było wykorzystać nie tylko do użycia w sytuacjach awaryjnych, a czas użytkowania nie był ograniczony. Wynikiem badania jest Sprzęgło z Podwójnymi Akumulatorami jako Rezerwowe Źródło Zasilania, które stanie się jednym z głównych dostawców źródeł energii, mogącym stanowić wyjście w przypadku ingerencji Państwowego Zakładu Energetycznego (zł) i może działać przez stosunkowo długi czas. Sprzęgło z podwójnymi akumulatorami jako rezerwowe źródło zasilania jest inicjowane przez określenie charakterystyki każdego elementu, takiego jak akumulatory, falowniki, prostowniki, obwody wzmacniaczy prądu i czujniki napięcia. Kolejnym etapem jest określenie maksymalnego obciążenia, aby system działał wystarczająco długo. Następnie jest on dokładnie analizowany przez długi czas, tak aby wyniki projektu rzeczywiście nadawały się do wykorzystania jako sprzęgło z podwójnymi akumulatorami jako niezawodne źródło zasilania rezerwowego.* (***Sprzęgło z podwójnymi akumulatorami jako rezerwowym źródłem zasilania***)

Keywords: Accumulator, Inverter, Rectifier, Current Booster Circuit, Voltage Sensor
Słowa kluczowe: sprzęgło, akumulator energii

Introduction

Human dependence on electrical energy has become a major feature of today's modern era. The electrical energy produced today is mostly obtained from the primary energy such as petroleum, natural gas, and coal which are non-renewable. The utilization of fossil energy has given negative impacts such as air pollution and global pollution. According to the Energy Information Administration (EIA), the electrical power generated by factories using natural gas increased annually by 28% in 2014, 35% in 2018 and 36% in 2019. Furthermore, world consumption and production of liquid fuels increased from 94 million barrels per day in mid-2014 to 100 million barrels in mid-2018 leading to increased energy costs. To cope with the global growth in consumption of fossil fuels, which are quite expensive and have an impact on world pollution, other forms of energy that are environmentally friendly emerged at the end of this decade [1].

Nicolas Tesla once said "Electric power is everywhere in infinite quantities and can drive the world's engines without coal, oil or any other fuel". This statement encourages a new trend of using natural energy from the environment to produce electricity that is cheap, environmentally friendly and sustainable. Now, the interest in renewable energy which can be obtained from abundant natural sources such as thermal energy, solar, motion/vibration and others and converting it into electrical energy to supply electronic equipment and machinery is growing rapidly. To overcome this energy demand problem is to innovate as an effort to find alternative energy sources. One of the potential energy sources with new innovations is the optimal use of accumulators. The use of accumulators should be considered because the use of accumulators as an energy source has not been optimal, especially for meeting energy needs at locations and for certain uses, such as utilization in isolated locations and others. The energy produced by the accumulator comes from the electric charge on the accumulator. The accumulator is an active component that converts from electric charge into electrical energy. In recent years, accumulators have been re-examined as a source in terms of energy use, both large and small depending on size, power and materials used [2].

Previously, the use of this accumulator was as an energy source that was used in an emergency and was limited to a limited time of use, which was called an Uninterruptible Power Supply (UPS). The way this tool works has not been effective enough and unreliable, so there should be new innovations that can make it usable not only for emergencies and can be used for a long period of time. This study results the clutch with dual accumulators as a power source reserve as one of the main energy sources that can provide a way out in the event of a disturbance or blackout from the PLN energy source.

Research Method

Literature Study

This study presents the state of the art of the use of the accumulator. This paper differs from other writings in terms of the use of accumulators. Previously, the use of accumulators was as an energy source in an emergency with limited time of usage which was called Uninterruptible Power Supply (UPS) [3]. The results of this study are in the form of a clutch with dual accumulators as a reserve power source as one of the main energy sources that can provide a way out of dependence on fossil energy. Each of the equipment in the Clutch with Dual Accumulators as a Permanent Power Source is as follows:

Accumulator or Storage Battery [4] is a cell or a secondary element and is a source of direct current that can convert chemical energy into electrical energy. Accumulators are classified as electrochemical elements that can affect the reactants, so they are called secondary elements. The positive pole of the accumulator uses an oxide plate and the negative pole uses a lead plate, while

the electrolyte solution is a sulfuric acid solution. When the accumulator is used, a chemical reaction occurs which results in deposits at the anode (reduction) and cathode (oxidation). As a result, at a certain time between the anode and cathode there is no potential difference, meaning the accumulator becomes empty. In order for the accumulator to be used again, it must be filled (charger) by flowing an electric current in the opposite direction to the electric current issued by the accumulator. When the accumulator is charged (charger) there will be a collection of electric charge. The accumulation of the amount of electric charge is expressed in ampere hours, which is called the accumulator power. In fact, the use of the accumulator cannot release all the energy stored in the accumulator. Therefore, the accumulator has yield or efficiency. In this study the accumulator used is an accumulator with a voltage source of 12 Volt dc. The ability of the accumulator to produce an electric current is called the capacity. The electric current capacity in the accumulator is expressed in Ampere hour (Ah). Voltage sensor is an electrical equipment that functions to connect (ON) or disconnect (OFF) the voltage from an electrical power source. Figure 1 is a basic circuit of a single-phase full-bridge inverter with a resistive load and its waveform [5]. As in the half-bridge inverter circuit above, in this circuit two capacitors are needed to produce N points so that the voltage on each Vi/2 capacitor can be kept constant. There are two sides of the switch, namely: switches S1+ and S1- and S2+ and S2-. Each side of this switch, switches S1+ and S1- and or S2+ and S2-, must not operate simultaneously, because a short circuit will occur. The ON and OFF conditions of both sides of the switch are determined by modulation techniques, in this case using the PWM principle, as described in the single-phase half-bridge inverter above.

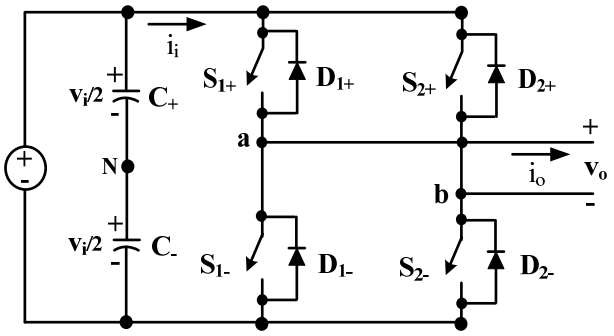

Fig 1. Full Bridge Single Phase Inverter Circuit.

Rectifier is a rectifier circuit in which alternating current is converted into direct current. In this study, the rectifier used is a full wave rectifier [6], the symbol for the rectifier is as shown in Figure 2.

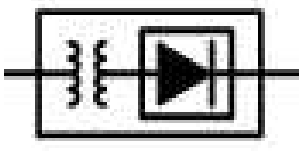

Fig 2. Rectifier Symbol.

The Current Booster circuit is a circuit that functions to increase a small input current into a large output current, in which the output current (I_{out}) can be adjusted as needed. This circuit uses a TIP 3055 current-boosting transistor. In which this transistor has a maximum current capacity of 15 Amperes with a voltage of 18 Volts [7], the TIP 3055 transistor specification is obtained. This Current Booster circuit is to increase the current to 15 Amperes with a working voltage of 30 Volts dc. The workings of the Current Booster circuit is as shown in Figure 3 below [8].

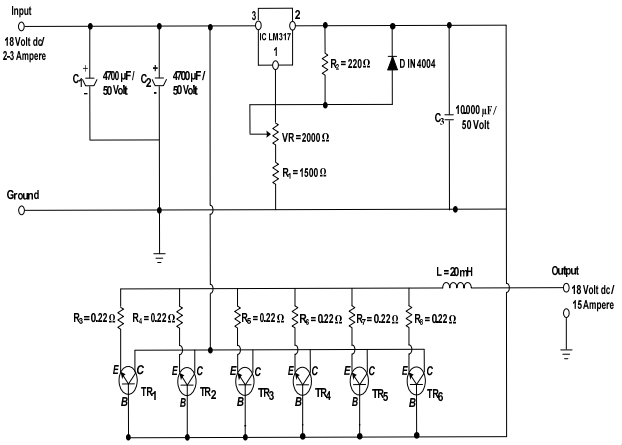

Fig 3. Current Booster Circuit.

Input starts from pin 3 on IC LM 317 as a voltage and current regulator. Input voltage and current will be filtered by capacitors C_1 and C_2 with a capacity of 4700 µF/50 Volt dc, and from pin 2 on IC LM 317 installed R_2 which functions to avoid reverse current to pin 1 of IC LM 317 and IN 4004 diode as switching (breaker and connector), and VR (Variable Resistor) which functions to set the large / small voltage. The regulated voltage and current from IC LM 317 will be filtered again at the output of this circuit using an electrolytic capacitor C_3 with a capacity of 10,000 µF/50 Volt dc. The current and the voltage which are already stable, namely 2-3 Amperes current and 18 Volt dc voltage, then the current will be increased by the transistors TR_1, TR_2, TR_3, TR_4, TR_5, and TR_6 to 15 Ampere with a voltage of 30 Volt dc. The current is increased by the collector (I_C) and the transistor specifications is obtained of TIP 3055 [7] [9] [10] a total of 10 Amperes, the base current (I_B) is a total of 8 Amperes. The TIP 3055 transistor specification [7] can determine the number of transistors needed, that is, by first determining the power required.

Application of the Clutch with Dual Accumulators As Reserve Power Supply

The block diagram application and the working principle of the Clutch with Dual Accumulators as a Reserve Power Source are presented in Figure 4.

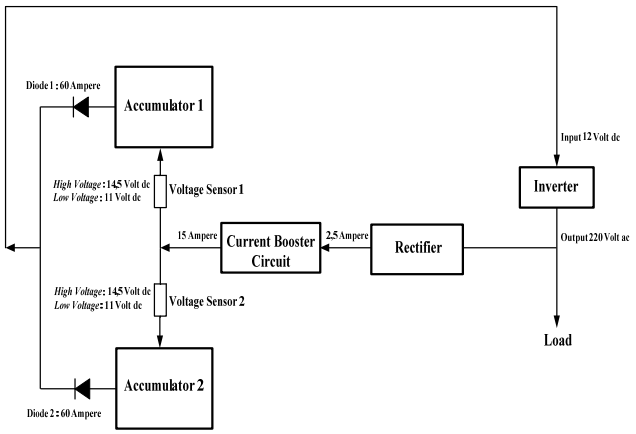

Fig 4. Block Diagram of the Clutch with Dual Accumulators as a Reserve Power Source

The working principle of the Clutch with Dual Accumulators as a Permanent Power Source in Figure 4 above is that Accumulator 1 produces voltage and current. The voltage from Accumulator 1 will be changed from 12 Volt dc to 220 Volt ac through the Inverter. The output voltage and current of the Inverter will be supplied to the Load, and another branch is made to the Rectifier. The Rectifier is a circuit to change the current from ac to dc, the output voltage of the Rectifier is 18 Volt dc, the output current is 2.5 Amperes dc. The output of the Rectifier is as the input to the Current Booster Circuit. The current entering the Current Booster Circuit, which is 2.5 Amperes dc, will be increased to an output of 5 Ampere dc. The output of the Current Booster Circuit to charge the Accumulator 1 or the Accumulator 2. The voltage on the Accumulator 1 will be controlled by the Voltage Sensor 1. When the voltage on the Accumulator 1 decreases to ± 11 Volts dc, the Voltage Sensor 1 will be "OFF", and the Voltage Sensor 2 will be "ON" to charge the Accumulator 1. Furthermore, the power supply to the Load can be from the Accumulator 2. The voltage on the Accumulator 2 will be controlled by the Voltage Sensor 2. When the voltage on the Accumulator 2 decreases to ± 11 Volt dc, the Voltage Sensor 2 will be " OFF", and the Voltage Sensor 1 will be "ON" to charge the Accumulator 2. And that is the working principle of the Clutch with Dual Accumulators As a Permanent Power Source. The maximum voltage of each accumulator is 14.5 Volt dc.

Results and Analysis

Design Tools

The materials used in making this tool are as follows: four resistors R = 10 kΩ, two resistors R = 220 kΩ, two R = 1 kΩ, one R = 2 kΩ, one variable resistor VR = 1 kΩ, one 5 Volt zener diode, one IN4001 diode, one 40 Ampere diode bridge, one transistor TR C1815, one regulator IC 7809, one IC LM 555 N, one capacitor C = 470 µF/50 V, one capacitor C = 100 nF/100 V, one red and green LED, one 5 pin 12 Volt relay, one PCB, one single tap transformer with 220 Volt input and 12 Volt output voltage at 5 Amperes, and two accumulators 100 Ah/12 Volt DC.

The results of the design of the Clutch with Dual Accumulators as a Reserve Power Source are as shown in Figure 5.

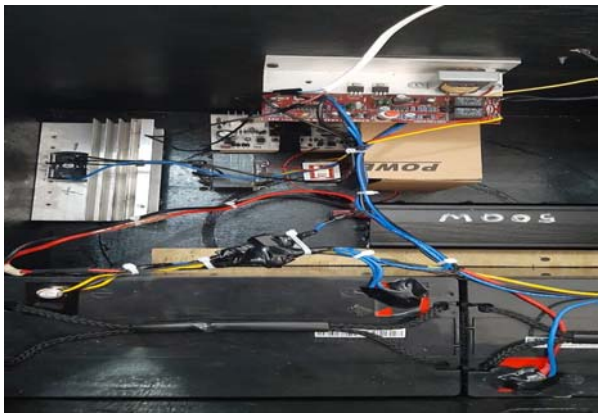

Fig. 5. The Results of the Clutch with Dual Accumulators Design As a Reserve Power Source

Measurement Results

The clutch with dual accumulators as a reserve power source is loaded with hannochs led lamps with watt range from 5 watt to 300 watt. The measurement results of the clutch with dual accumulators design as a reserve power source are presented in tables 1 and 2.

Table 1. Measurement Results of the Clutch with Dual Accumulators Design Using Current Booster As a Reserve Power Source

Load (Watt)	Initial Voltage in the Accumulator (Volt DC) :		Currents Exiting Accumulator (Ampere DC), in the Accumulator :		Currents Entering Accumulator (Ampere DC), in the Accumulator:		Length of Time of Load Usage (Hours)	Charger in the Position in the Accumulator:		Voltage After Being in the Accumulator (Volt DC) :	
	1	2	1	2	1	2		1	2	1	2
75	12,42	-	7,93	-	-	-	32,11	√	-	10,96	-
100	-	12,45	-	8,14	5	-	26,75	-	√	-	11,04
125	12,47	-	8,57	-	-	5	24,68	√	-	11,07	-
150	-	12,45	-	9,27	5	-	20,37	-	√	-	10,78
200	12,39	-	11,13	-	-	5	13,28	√	-	11,15	-
225	-	12,28	-	13,45	5	-	8,83	-	√	-	10,85
250	12,25	-	14,24	-	-	5	7,82	√	-	10,74	-
275	-	12,21	-	17,25	5	-	5,25	-	√	-	11,03
300	12,17	-	21,42	-	-	5	3,09	√	-	10,28	-

Table 2. Measurement Results of the Clutch with Dual Accumulators Design Without Using Current Booster As a Reserve Power Source

Load (Watt)	Initial Voltage in the Accumulator (Volt DC) :		Currents Exiting the Accumulator (Ampere DC), in the Accumulator:		Length of Time of Load Usage (Hours)	Charger in the Position in the Accumulator:		Voltage After Being in the Accumulator (Volt DC) :	
	1	2	1	2		1	2	1	2
75	12,45	-	7,28	-	14,36	√	-	11,02	-
100	-	12,36	-	8,27	12,32	-	√	-	11,21
125	12,47	-	9,54	-	10,53	√	-	11,13	-
150	-	12,40	-	11,24	9,31	-	√	-	10,58
200	12,37	-	11,93	-	8,07	√	-	11,04	-
225	-	12,38	-	13,38	7,85	-	√	-	10,95
250	12,35	-	15,38	-	6,97	√	-	10,94	-
275	-	12,17	-	19,18	3,42	-	√	-	10,07
300	12,06	-	23,54	-	2,03	√	-	10,04	-

Analysis

Comparative results of the measurement of the Clutch with Dual Accumulators Design using the Current Booster Circuit as a Reserve Power Source and without using the Current Booster Circuit as presented in Table 1 and Table 2 reveal that when using the Current Booster Circuit the load usage is long enough for the next accumulator charging transfer, while without using the Current Booster Circuit the length of time of the load usage is shorter for the next accumulator charging shift. The longer time period for the transfer of charging the accumulator is due to the influence of the charging Current Booster Circuit. The incoming current in the Current Booster Circuit is ± 2 Ampere, while the output is constant at 5 Ampere.

Conclusion

As a reserve energy source in the event of a disturbance or blackout from the PLN energy source, the results of the Clutch with Dual Accumulators Design using the Current Booster Circuit are quite effective since it has a quite long operation time.

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