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Transformer Charger Design based on 12V CT Equipped Overcharge Protection

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Abstract

The need for electrical energy continues to increase and more and more equipment requires electrical energy as its main supply. The fulfillment of electrical energy can be generated by the battery. In the battery, there is a process of discharging and charging. The duration of discharging and charging the battery is affected by the capacity of the battery. Therefore, a charging device is needed for the battery charging process. The 12 V charger uses a CT transformer as a voltage reducer, then rectifies it using a diode. In the charging process, overcharge protection is provided that utilizes TL431 as a comparator that will detect when the battery is full so that no overcharge can cause overheating and damage to the battery. The test results obtained that the longer the charging time the battery voltage increases with a maximum current of 13.5 V. The current will automatically cut off due to the overcharge protection system. Based on the test, it was found that the efficiency of the tool was 61.0835%.

Keywords

Charger, Battery, Transformer CT, TL431

INTRODUCTION

The battery is used as an energy supply if there is no energy supply from PLN. The battery will experience a state of discharging and charging. When the energy in the battery runs out, the charging process must be carried out by connecting the battery to an electrical energy source [1]. A charger is an important tool used for charging batteries. The incorrect battery charging process can reduce battery performance and life. For this reason, the process of charging and discharging must be considered so that the battery life can last a long time [2]. Based on the explanation above, a 12 Volt Charger project design with a CT Transformer was made for battery charging. With this tool, it is hoped that it will make it easier for people to charge the battery. In addition, it can be studied and analyzed the current and voltage at the time of charging.

RELATED THEORY

A charger is a device used in charging energy in batteries and stored in the form of chemical energy. The process of charging and discharging the battery can cause overcharging or over-discharging, this can lead to reduced battery life [2]. In the process of charging the charger, there is a rectification of the AC voltage into a DC voltage. This conversion process has an efficiency value. Charger efficiency is calculated by dividing the output power by the input power [3]. The voltage that does not match the capacity of the battery will result in battery damage. On the solar charger, there is a controller that will regulate battery charging [4]. The charger consists of a rectifier and a transformer. Where the rectifier functions as a voltage rectifier. Based on the output wave rectifier is divided into two, half-wave rectifier (Half Wave Rectifier) and full-wave rectifier (Full Wave Rectifier). The configuration of the circuit will affect the shape of the resulting signal. Half wave rectifier uses only one diode. For full-wave, the rectifier can use a center tap and diode bridge [5].

The rectifier is equipped with a capacitor that functions as a filter for the output waveform of the rectifier. The capacitor will store the charge so that the resulting waveform will be smoother. Transformers are used to step down the voltage. The charger uses a CT transformer which has a 0 coil construction in the middle of the secondary side of the transformer. Due to this construction, the secondary stress is calculated concerning the CT

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point. In addition to lowering the voltage, CT is used as a rectifier using the center-tapped method [6]. In the Zener Adjustable circuit, it is a component that acts as protection and a voltage comparator. Protection plays a role in regulating the voltage so that the voltage is stable and does not damage the tool. Used as a battery voltage detector which will then be a determinant of the refraction of the transistor. Zener Adjustable has a function as a comparator and an active transistor with a precise voltage reference. The way the TL431 works is to determine the VZ and then it will be compared with the voltage on the battery, when it reaches VZ, the TL431 will be active.

PROCEDURE

The research method was carried out by the experimental method, which took the data in the form of voltage, charger current, and indicators on the tool. The charger uses a 220 VAC PLN source which is then lowered by the CT Transformer. For the voltage to become VDC, a rectifier circuit is given using a HER506 diode equipped with a capacitor as an output filter. The diodes used are installed on both taps of the transformer, because, if using center-tapped, the rectifier uses CT on the transformer, which is connected to the ground [6]. The cut-off circuit works to cut off the current to prevent overcharge. TL431 plays an important role as protection when charging which functions as a voltage level. Then it is equipped with a potentiometer, BD139, 1N4004 diode, and a 12 V relay. Here is the circuit schematic made:

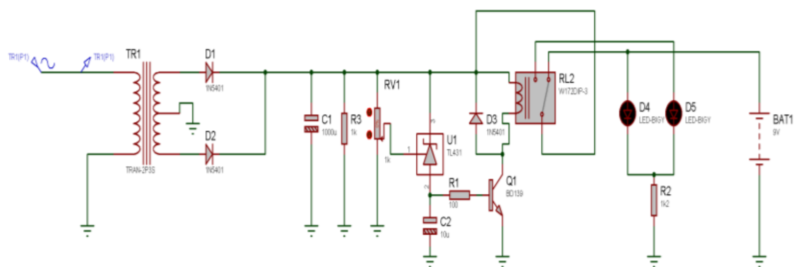

Fig. 1. CT Transformer Charger Circuit with Overcharge Protection

The specifications of the components used are obtained through the design and calculations that have been carried out. The following tools and materials are used in a charger with a CT transformer, namely: CT Transformer, HER506 diode, Diode 1N4004, Resistor 1k, Resistor 15K, Capacitor 10000uF, Capacitor 10uF, TL431, Potentiometer 1k, Transistor BD139, Relay 12 V.

RESULT

The tool testing procedure is carried out by measuring the current and voltage both the input and output of the charger. Before testing the charger, the CT Transformer is tested and tested for overcharge protection. Testing is done by taking data periodically. The following tests were carried out for 1 hour, and data were collected every 10 minutes. From these tests, the efficiency of the transformer can be calculated, the following table is the efficiency of the CT Transformer,

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Fig. 2. Charger Physical Form

TABLE I
Transformer efficient

Vp (V)	Vs (V)	Ip (I)	Is (I)	Ef
230	27	0.29	2.15	87.03%
229	26	0.29	2.15	84.17%
227	25	0.28	2.03	77.09%
220	26	0.29	2.03	82.73%
220	26	0.30	1.93	76.03%
220	26	0.28	1.78	75.12%

From the data obtained, the CT Transformer has an efficiency above 75%, so the CT Transformer functions as a voltage reducer quite well. The PLN voltage after being lowered is measured at 27VAC then the voltage is submitted by the HER506 diode. After being rectified, the output voltage of the rectifier is 14.6 VDC. The voltage decreases due to a drop caused by component losses. Then the voltage is filtered by the capacitor using the charge stored in the capacitor so that the resulting wave is smoother. Auto cut-off on the variable resistor circuit is used to adjust the clamp voltage on the TL431, which can be used as a determinant of transistor bias. TL431 protection works by comparing the voltage on the battery with the specified VZ. When data collection, the battery voltage is 12.2 V and has not reached VZ, the TL431 is not active, and the transistor will not flow current to the relay coil. The refraction condition occurs when the battery voltage is at TL431 calculated with the AVOmeter 13.5 V. In this condition, the base current of the transistor is more than the collector current of 0.18 A so that the VCE approaches the value 0, then the VCC current flows to the relay coil, so the relay automatically disconnects flow to the battery. The output wave generated by the charger is unidirectional.

Charger performance testing is a circuit test by taking current and voltage data when charging a 7Ah 12V battery. Testing aims to determine whether the circuit works according to the plan. The following data were obtained when testing the charger performance:

TABLE III
Charger Performance Testing on 7 Ah 12 V Baterai Battery

Jam	Vin (VAC)	Vout (VDC)	Vbatt (VDC)	Iin (I)	Iout (I)
10.20	25	12.53	12.2	2.43	3.06

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10.30	25	12.5	12.2	2.43	3.06
10.40	26	12.70	12.3	2.33	2.88
10.50	25	12.91	12.68	2.18	2.71
11.00	26	13.05	12.83	2.01	2.61
11.20	26	13.05	12.80	2.05	2.61
11.20	27	13.19	12.94	2.04	2.63
11.30	26	13.21	13.00	2.03	2.64
11.40	26	13.30	13.05	1.90	2.39
11.50	25	13.40	13.18	1.89	2.37
11.00	26	13.53	13.32	2.30	2.30
12.10	30	12.80	12.79	0.06	0

The input voltage condition has a stable voltage value. While the battery voltage, the more charged the voltage will increase. Current is inversely proportional to voltage, the higher the voltage, the lower the current.

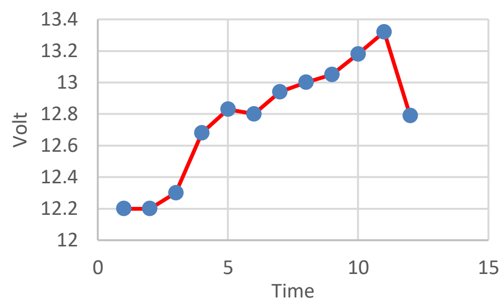

Fig. 3. Graph of Battery Voltage on Charging 7Ah 12V Baterai Battery

In the graph of charging the 7Ah 12V battery, it can be seen that the longer the charging time the battery voltage increases, this is because the energy in the battery increases, the battery voltage also increases. The highest output voltage is 13.53 V, then after auto-off, the voltage drops to 12.8V.

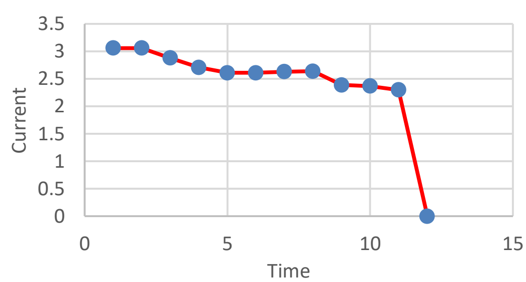

Fig. 4. Current Graph When Charging 7 Ah 12V Baterai Battery

The current condition during the 7Ah 12V battery charging process is getting lower and lower, with a maximum current of 3.06, charging is complete at 12.20 with an average current of 2.43 A, requiring a charging time of 1 hour 50 minutes. From the two graphs, it can be seen that the relationship between the charging current and battery voltage is inversely proportional. Testing the tool on 12 Ah 12 Volt battery charging is done by measuring the voltage, current at the input, and output of the tool.

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TABLE IIIII
Charger Performance Testing on 12 Ah 12 V . Battery Charging

Jam	**Vin (V_{AC})**	**Vout (V_{DC})**	**Vbatt (V_{DC})**	**Iin (I)**	**Iout (I)**
20.30	26	13.16	12.9	2.12	2.22
20.40	25	13.52	12.98	2.21	2.83
20.50	26	13.16	12.93	2.12	2.72
21.00	25	13.22	12.99	1.95	2.55
21.10	25	13.29	13.05	1.82	2.33
21.20	26	13.37	13.14	1.73	2.29
21.30	26	13.48	13.22	1.81	2.23
21.40	26	13.55	13.33	1.82	2.19
21.50	26	13.69	13.44	1.74	2.00
22.00	26	13.65	13.35	1.74	2.00
22.10	26	13.69	13.44	1.81	2.06
22.20	26	13.75	13.49	1.88	1.81
22.30	26	13.80	13.50	1.80	1.59
22.40	26	13.82	13.52	1.94	1.50
22.50	29	13.07	13.00	0.10	0

On charging a battery with a capacity of 12Ah 12Volt, the relationship between the battery voltage and the output current is the same as in the previous test. The following graph is obtained from the 12Ah 12Volt battery test data.

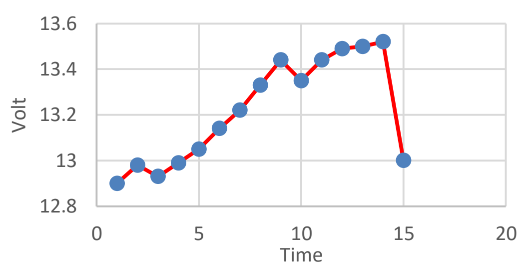

Fig. 5. 12 Ah 12V Battery Charging Voltage Chart

The value of the voltage increases over time, this is because the energy stored in the battery is increasing. Once the charger stops supplying voltage, the battery voltage drops as its input decreases.

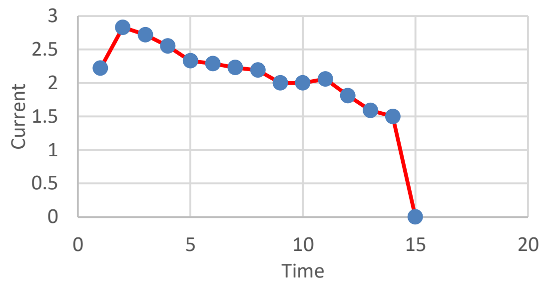

Fig. 6. Current Graph When Charging 12 Ah 12V Baterai Battery

The current condition during the 12Ah 12V battery charging process is getting higher and higher, with a maximum current of 2.83 A, charging starts at 20.30 to 22.50. With an average current of 2,021 A with a larger battery capacity than before, the charging process will take longer, which is 2 hours 20 minutes. The indicator also works the same as in the previous battery charge test. Voltage Drop Test with CT Transformer. The test is carried out by applying a voltage to the transformer primary, then analyzing the secondary output voltage and current. In testing the input 220 at the transformer primary has decreased and at the secondary output, the output is measured at 25V. Then the CT transformer as a voltage reducer works well. In the voltage drop test using a CT Transformer, the transformer used has an efficiency of 79.1983%. Protection Tool works when TL431 detects when the battery voltage has met the set voltage, ranging from 13.2-13.5 V. When the voltage is met, the TL431 will trigger BD139 so that the base current on the transistor is greater than the collector. With this condition, the current will flow to the relay and induce so that the relay automatically cuts off the charging current and flows to the full charge indicator. With this protection, the battery is protected from being overcharged.

CONCLUSION

The battery charging path, namely the PLN input voltage is lowered by a CT Transformer, then rectified to a DC voltage using two HER506 diodes which are then fed to the battery and controlled by a cut-off circuit. LM431 as a reference voltage that will control the relay. TL431 works as a comparator and stabilizer, in the circuit, determines the clamp voltage so that it can be a protection so that there is no overcharge in the battery charging process. The higher the capacity of the charged battery, the higher the battery voltage, because the energy in the battery increases. While the current is inversely proportional to the battery voltage. The overcharge protection works well, as indicated by the current measurement results when the battery is full, which is 0. From the test, the current and voltage can be calculated so that the efficiency of the tool can be calculated, and it is 61.0835% with sufficient tool work.

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