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A Circuit Analysis Of Current Limiter Powe Supply As Charging System Protection In Batteries

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ABSTRACT
Power Supply Current Limiter CircuitThe current limiter to be analyzed works to create an overcurrent protection system and is able to work quickly, when overcurrent occurs due to overload or short circuit. The current limiter circuit uses two transistors configured as a differential pair, combined with a fixed current source to limit the current available to the pass transistor of the voltage regulator. From the research results, it was obtained that the measurement results of the current limiter had been successfully made, namely for a 5 VDC load with a limit of 0.30 A and a 12 VDC load with a limit of 0.7 A. In normal condition testing with a resistor value of more than 16 Ω for a 0.30 A current limiter and a resistor value of more than 20 Ω for a current limiter with a limit of 0.7 A, the output current of the current limiter has a value based on the resistor load value (Ω), namely the greater the resistor value, the smaller the current will be for a 0.30 A current limiter and for a 0.7 A current limiter. In overcurrent condition testing with a resistor load value smaller than the resistor load under normal conditions, namely less than 18 Ω for a 5 VDC current limiter with a limit of 0.30 A and less than 20 Ω for a 12 VDC current limiter with a limit of 0.7 A, the output current of the current limiter for a 5 VDC load. The output current of the current limiter is in accordance with the current limit in the circuit according to the ability of the synchronous buck converter and the battery and the devices connected to it to withstand the current. In short circuit condition testing, the current limit value is in accordance with the designed limit, namely 0.22A and 0.45A.

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INTRODUCTION

Most modern power supply devices have an overcurrent protection system to protect the circuit from overcurrent caused by excessive load. However, the overcurrent protection system in modern power supply circuits still uses many components such as fuses and relays because of the fluctuating power supply voltage. In the Hybrid Charger Controller system, the power supply used has a constant output voltage, namely from a 12 V to 24 Volt battery. From this problem, an overcurrent protection system will be analyzed in the form of a circuit that works as a current limiter using several electronic components such as

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current sense resistors and Bipolar Junction Transistors (BJT) because in the Hybrid Charger Controller system the output voltage of the power supply does not change in value.

In the Power Supply Current Limiter CircuitThe current limiter that will be analyzed works to create an overcurrent protection system and is able to work quickly, when an overcurrent occurs due to overload or short circuit.In the Power Supply Current Limiter Circuit(electronic fuse) is used in microsatellite systems that use high flexibility and good results, thus indicating that the circuit*Current Limiter Power Supply*can limit the current of each device to 0.900 and 1.9502 Amps.Power Supply Current Limiter Circuitor The current limiter for the switching power supply is a means of sensing current through switching transistors using a current sense resistor.

The current limiter circuit uses two transistors configured as a differential pair, combined with a fixed current source to limit the current available to the pass transistor of a voltage regulator. Current limiters are very useful as safety features in medical testing equipment or the like. The circuit consists of a field effect transistor connected in series with a center field effect transistor that is biased into conduction. Another center field effect transistor is used to control the voltage drop across the center field effect transistor for conduction.

METHODS

This circuit consists of two current limiters with limits of 0.30 A each for a 5 V load and 0.7 A for a 12 V load, the following is a block diagram of the entire current limiter hardware in the Hybrid Charger Controller system which can be seen in the image below:

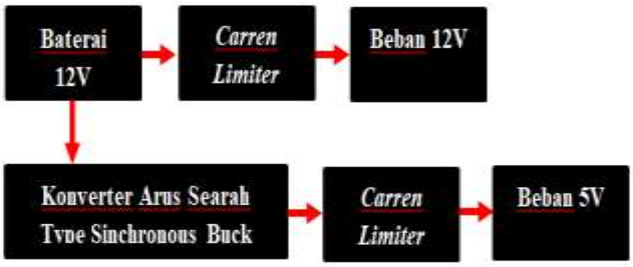

Figure 1. Device Block Diagram

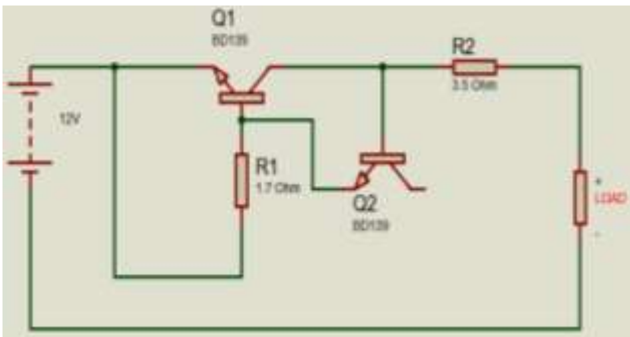

Figure 2. Current limiter circuit

In the current limiter circuit image above, there is a current limiter circuit in this circuit consisting of Bipolar Junction Transistor components. In this current limiter, an NPN type BJT is used as a switching component. The NPN type BJT BD139 functions as a switch to limit the current.

In this current limiter, an NPN type BJT is used as a switching component. The NPN type BJT BD139 operates with a maximum collector emitter saturation voltage (VCEsat) of 0.5V and has a base emitter voltage (VBE) of 0.7V and a maximum collector current (IC) of 1.5A. The current limiter limits the 12 V load current by 0.7A, the voltage source of which comes from a 12V battery. In addition to the DC input voltage from the battery, the current limiter with a limit of 0.30A receives input voltage from a Synchronous Buck type direct current converter of 5V. The maximum DC current of the NPN type BJT BD139 of 1.5A is considered safe enough to withstand current according to the designed current limiter current limit of 0.7A for a 12V load and 0.30A for a 5V load. DC Current Gain (hFE) or current gain symbolized by β is a constant for a transistor, where the value of β is the ratio between the value of Ic and the value of Ib usually worth around 100-200. The value of β can be seen in the transistor datasheet. In the current limiter circuit, the value of β is used to find the margin or limit of the current Ib flowing to the base of the BJT BD139 to regulate the amount of collector current Ic flowing to the load. So that the calculation is obtained as follows:

*Current limiter*for 12V load limit 0.7 A

$$\beta = \frac{I_C}{I_b}$$

$$30 = \frac{700mA}{I_b} \quad \text{...} (1)$$

$$I_b = \frac{700mA}{30}$$

$$I_b = 23{,}33mA$$

To activate transistor Q2, a current is required that is two to three times greater than the current Ib of transistor Q1, so the Ib margin used is 50 mA.

*Current limiter*for 5 VDC load limit 0.30 A

$$\beta = \frac{I_C}{I_b}$$

$$95 = \frac{300mA}{I_b}$$

$$I_b = \frac{500mA}{95}$$

$$I_b = 5{,}26mA$$

To activate transistor Q2, a current is required that is two to three times greater than the current Ib of transistor Q1, so the Ib margin used is 7 mA.

Where
B= DC Current Gain(hFE)
Ib=Base Current (mA)
Ic = Collector Current (mA)

In this current limiting circuit, the total power dissipation of the transistor is also considered, namely the power in the form of heat that is wasted. This power dissipation will damage the transistor if it is too excessive, therefore the transistor is given a heat sink in the form of (heatsink). For a 12 V load current limiter with a limit of 0.7 A, having an Ib value of 50 mA and VCEsat of 0.5 V, then the maximum value of the transistor power dissipation can be calculated as follows:

$$P_{Tot} = P_B + P_C + P_{Load}$$
$$P_{Tot} = I_b V_{BE} + I_C V_{CEsat} + (V_{In} - V_{BE}) I_C$$
$$P_{Tot} = 0{,}05.0{,}7 + 0{,}7.0{,}5 + (12 - 0{,}7)0{,}7 \quad \text{...(2)}$$
$$P_{Tot} = 0{,}035 + 0{,}35 + 7{,}91$$
$$P_{Tot} = 8{,}295\, Watt$$

For a 5V load current limiter with a limit of 0.30 A, having an Ib value of 7 mA and VCEsat of 0.12V, the maximum value of transistor power dissipation can be calculated as follows:

$$P_{Tot} = P_B + P_C + P_{Load}$$
$$P_{Tot} = I_b V_{BE} + I_C V_{CEsat} + (V_{In} - V_{BE}) I_C$$
$$P_{Tot} = 0{,}007.0{,}7 + 0{,}30.0{,}5 + (5 - 0{,}7)0{,}30 \quad \text{...(3)}$$
$$P_{Tot} = 0{,}0049 + 0{,}15 + 1{,}29$$
$$P_{Tot} = 1{,}444\, Watt$$

Where
$Ptot$ = Total power dissipation (Watts)
PB = Base emitter power dissipation (Watt)
PC =Base emitter power dissipation (Watt)
$PLoad$ = Load power dissipation (Watts)

From the calculation above, the use of BJT NPN BD139 as an active component in the current limiter is correct because the power dissipation value used must be less than the power dissipation value listed so that the transistor is not damaged due to excessive heat. Under normal conditions where transistor Q1 is on and transistor Q2 is off, the input current is the current when the transistor is off and the output current is when the transistor is on at Q1. To activate the transistor, a VBE voltage of 0.7 V is required because it is made of silicon and the input voltage in the circuit is 12 V and the Ib value is 50 mA. By using Kirchoff's voltage law, the following calculations are obtained:

$$V_{In} - I_b R_{Bias} - V_{BE} = 0$$
$$R_{Bias} = \frac{V_{In} - V_{BE}}{I_b}$$
$$R_{Bias} = \frac{12 - 0{,}7V}{0{,}7A} \quad \text{.........(4)}$$
$$R_{Bias} = 161\Omega$$

To make the Ic current greater than 0.7A and considering the availability of resistors on the market, the resistor used is worth 161 Ω. While for the 5V load current limiter with a limit of 0.30 A, the same formula can be used, and the Ib value is 7 mA, then the Rbias calculation is obtained as follows:

$$V_{In} - I_b R_{Bias} - V_{BE} = 0$$
$$R_{Bias} = \frac{V_{In} - V_{BE}}{I_b}$$
$$R_{Bias} = \frac{5 - 0{,}7V}{0{,}007A} \quad \text{.........(5)}$$
$$R_{Bias} = 614\Omega$$

To make the Ic current greater than 0.30A and considering the availability of resistors on the market, the resistor used is worth 614 Ω. In the current limiter circuit there is a resistor that functions as a current sense (Rsense), namely monitoring the Ic current when there is an overcurrent passing through transistor Q1 and making transistor Q2 on because the voltage drop on Rsense is the same as the VBE voltage of transistor Q2, which is 0.7 V.

During overcurrent conditions, transistor Q1 is not fully cut off or full off when the large Ic current exceeds 0.7 A so that the Ic current still flows to Rsense, then the voltage at the point between the base of Q2 and Rsense is more than 0.7 V. This makes transistor Q2 on and transistor Q1 off so that some Ic current will flow from the collector of transistor Q2 through Rbias and be diverted to ground and keep the base voltage of transistor Q2 less than 0.7 V. After the voltage at the point between the base of transistor Q2 and Rsense is less than 0.7 V, the current limiter will return to normal operation where transistor Q1 is on and transistor Q2 is off. The Rsense value can be calculated as follows:

$$R_{Sanse} = \frac{V_{BE\,Q2}}{I_C}$$
$$R_{Sanse} = \frac{0{,}7V}{0{,}7A} \quad \text{.........(6)}$$
$$R_{Sanse} = 1\Omega$$

$Rsense$ = Current sense resistor (Ω)
$VBE\ Q2$ = Base emitter voltage (V)
Ic = Collector current (A)

For the safety of users and devices and the availability of resistors on the market, the current limiter circuit for a 12 V load with a limit of 0.7 A uses a resistor of 1 Ω. Because the current flowing in Rsense is quite large, the power on the resistor must be considered. For a current of 0.7 A and an Rsense value of 1.7 Ω, the power calculation on the resistor is as follows:

$$P = I_C^2 R_{Sense}$$
$$P = 0{,}7^2 .1{,}7$$
$$P = 0{,}833\,Watt$$

Where:
P= Resistor power (Watt)
$Rsense$ = Current sense resistor (Ω)
Ic = Collector current (A)

To avoid excessive heat and damage to the resistor, a resistor with a power of 5 Watts is used. While for the current limiter circuit of a 5 V load with a limit of 0.30 A, the large Rsense value with the same formula can be calculated as follows:

$$R_{Sanse} = \frac{V_{BE\,Q2}}{I_C}$$
$$R_{Sanse} = \frac{0{,}7V}{0{,}30A}$$
$$R_{Sanse} = 2{,}33\Omega$$

For the safety of users and devices and the availability of resistors on the market, the current limiter circuit for a 5 V load with a limit of 0.30 A uses a resistor of 2.33 Ω. Because the current flowing through Rsense is quite large, the power on the resistor must be considered. For a current of 0.30 A and an Rsense value of 3.5Ω, the power calculation on the resistor is as follows:

$$P = I_C^2 R_{Sense}$$
$$P = 0{,}30^2 .3{,}5$$
$$P = 0{,}315\,Watt$$

To avoid excessive heat and damage to the resistor, a resistor with a power of 5 Watts is used. To find the minimum load value Rload under normal conditions, it can be calculated using the Kirchoff voltage law equation based on the output current flow of transistor Q1.

***Current limiter*for 12 V DC load limit 0.7 A**

$$V_{In} - V_{CE(Sat)} - I_C\ R_{Sanse} - I_C\ R_{Load} = 0$$
$$12 - 0{,}5 - 0{,}7.1{,}7 - 0{,}7R_{Load} = 0$$
$$0{,}7R_{Load} = 12 - 0{,}5 - 0{,}7.1{,}7$$
$$0{,}7R_{Loas} = 18{,}2$$
$$R_{Load} = \frac{18{,}36}{0{,}7A}$$
$$R_{Loas} = 26{,}22\Omega$$

Meanwhile, for the current limiter with a limit of 0.30 A, the VCEsat value is 120mV, so the calculation results are as follows:

***Current limiter*for 5 VDC load limit 0.30 A**

$$V_{In} - V_{CE(Sat)} - I_C\ R_{Sanse} - I_C\ R_{Load} = 0$$

$$5 - 0.12 - 0{,}30.3{,}5 - 0{,}30 R_{Load} = 0$$

$$0{,}30 R_{Load} = 5 - 0{,}12 - 0{,}30.3.5$$

$$0{,}30 R_{Loas} = 16{,}03$$

$$R_{Load} = \frac{16{,}03}{0{,}30 A}$$

$$R_{Loas} = 53{,}43\Omega$$

RESULTS AND ANALYSIS

Current Output Testing under Normal Conditions

In this test, data was taken using a load in the form of a pure resistor that has a value greater than 18 Ω for a current limiter with a limit of 0.30 A and a resistor with a value greater than 20 Ω for a current limiter with a limit of 0.7 A. The output current of the current limiter was measured using a DM-133D multimeter with a current probe connected in series with the pure resistor load.

Table 1. Current limiter data limit 0.30 A normal condition

Load R (Ω)	Voltage (V)	Current (A)	
		MEASUREMENT	COUNT
18.1	5.03	0.13	0.27
26	5.07	0.10	0.18
38	5.07	0.07	0.12
46	5.07	0.06	0.12
52.5	5.0	0.05	0.11
81	5.05	0.04	0.07
99	5.05	0.03	0.06
179	5.0	0.03	0.04
219	5.0	0.03	0.03
319	5.0	0.01	0.03

Based on the data in table 1, it can be seen that the current limiter with a limit of 0.30 A with an input voltage of 5.07 VDC can work well under normal conditions. There is an error in the measured current value and the calculated current of 0.01 A. The following is a graph of the relationship between the current and the magnitude of the pure resistor load.

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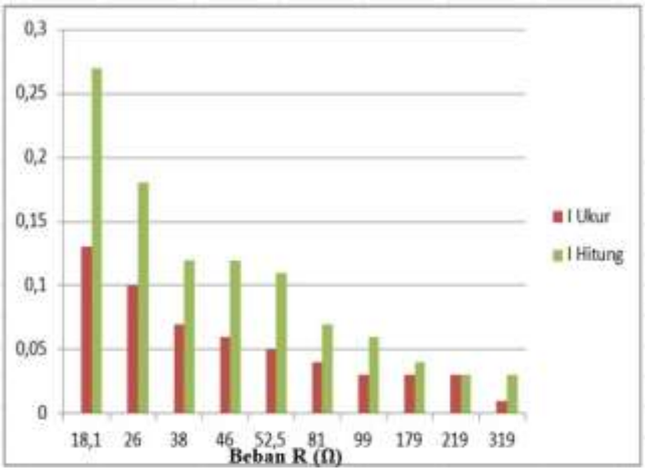

Figure 3. Graph of the relationship between current and load at the current limiter limit of 0.30 A

In the image above, it can be seen that the current limiter with a limit of 0.30 A works well where the load current value is based on the size of the installed resistor load. This is in accordance with Ohm's law, namely with the same voltage value and the greater the value of the resistor load, the current flowing in the resistor load will be smaller. The following is the test data for the Current limiter with a limit of 0.7 A under normal load conditions

Table 2. Data Current limiter limit 0.7 A normal condition

Load R (Ω)	Voltage (V)	Current (A)	
		MEASUREMENT	COUNT
20.5	12.20	0.40	0.40
26	12.20	0.34	0.34
38	12.20	0.25	0.31
46	12.20	0.20	0.25
52.5	12.20	0.18	0.23
81	12.20	0.11	0.14
99	12.20	0.09	0.11
179	12.20	0.05	0.06
219	12.20	0.04	0.05
301	12.20	0.03	0.03

Based on the data in the table below, it can be seen that the current limiter with a limit of 0.7 A with an input voltage of 12.20 VDC can work well under normal conditions. There is an error in the measured current value and the calculated current of 0.03 A. The following is a graph of the relationship between current and the magnitude of the pure resistor load. In the graph below, it can be seen that the current limiter with a limit of 0.7A works well where the load current value is based on the magnitude of the installed resistor load. This is in accordance with Ohm's law, namely with the same voltage value and the greater the resistor load value, the smaller the current flowing in the resistor load.

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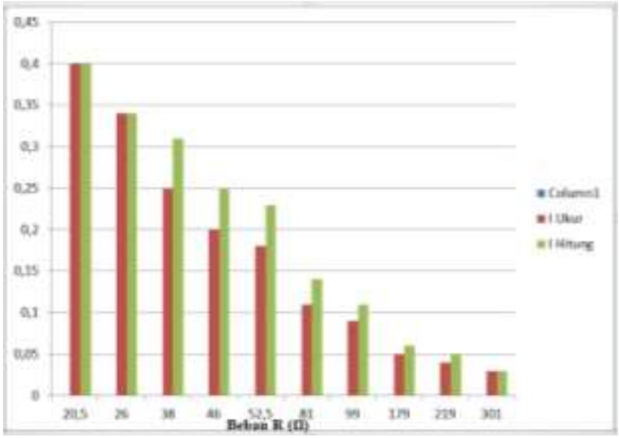

Figure 4. Graph of the relationship between current and load at the current limiter limit of 0.7 A

Output Current Testing Overcurrent Condition

In this test, data was taken using a load in the form of a pure resistor with a value of less than 18 Ω for a 5 VDC load current limiter with a limit of 0.30 A and a pure resistor with a value of less than 20 Ω for a 12 VDC load current limiter with a limit of 0.7 A. The output current value of the current limiter was measured using a DM-133D multimeter with a current probe connected in series with the pure resistor load. The following is the data taken on the Current limiter in overcurrent conditions.

Table 3 Data Current limiter limit 0.30 A overcurrent condition

Load R (Ω)	Voltage (V)	Current (A)	
		MEASUREMENT	I measure without current limit
1	5.03	0.21	5.04
2.6	5.07	0.25	1.86
3.6	5.07	0.25	1.35
3.8	5.07	0.25	1.28
4.6	5.0	0.25	1.06
5.5	5.05	0.25	0.89
8.1	5.05	0.20	0.61
11	5.0	0.19	0.50
11	5.0	0.18	0.41
14	5.0	0.17	0.33

Based on the table below, it can be seen that the current limiting circuit for a 5 VDC load during overcurrent conditions is able to limit the measured current limit. This is because the resistor used has a tolerance value. The current limiting current value is in accordance with the current limit capability of the synchronous buck type direct current converter, this proves that the component calculations are in accordance with the current limiting design made.

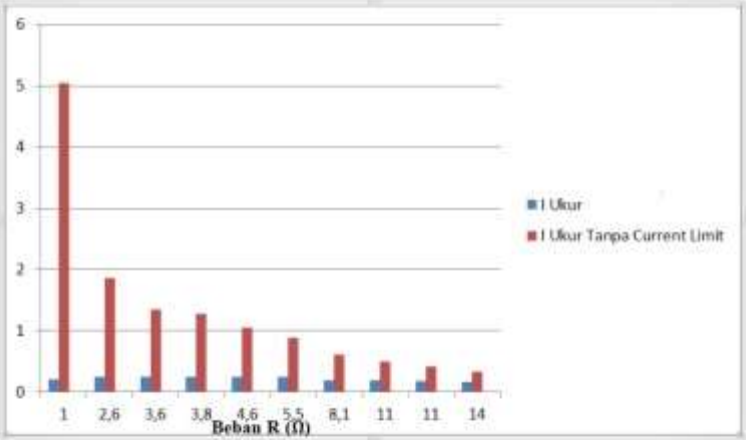

Figure 5 Current limiter graph with 0.30A limit

In the graphic image above, it can be seen that the calculated current is a representation of the actual load current. It can be seen that when the overcurrent condition is in the form of a variation in the resistor load value of less than 18 Ω, the current limiter for the 5 VDC load is able to limit the current. This shows that the current limiter works well and is in accordance with the designed limit of 0.30 A so that it is able to protect the synchronous buck type direct current converter when an overcurrent occurs. The following is the test data from the Current limiter with a limit of 0.7 A under overcurrent load conditions

Table 4 Data Current limiter limit 0.7 A overcurrent condition

Load R (Ω)	Voltage (V)	Current (A)	
		MEASUREMENT	I measure without current limit
1	12.20	0.46	12.41
2.6	12.20	0.45	4.59
3.6	12.20	0.45	3.35
3.8	12.20	0.45	3.17
4.6	12.20	0.45	2.63
5.5	12.20	0.45	2.21
8.1	12.20	0.44	1.50
11	12.20	0.43	1.23
11	12.20	0.41	1.03
14	12.20	0.42	0.82

Based on the table above, it can be seen that the current limiting circuit for a 12 VDC load during overcurrent conditions is able to limit the current. This is because the resistor used has a tolerance value. The current limiting current value is in accordance with the current limit designed with the battery capacity and the device connected to the battery, which is 0.7 A, this proves that the component calculation is in accordance with the current limiting design made.

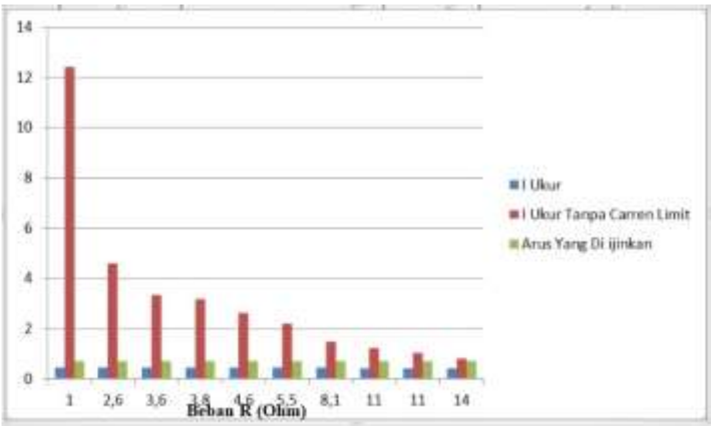

Figure 6 Current limiter graph 0.7 A

Short Circuit Output Current Testing

In this test, the Hybrid Charger Controller system is in working condition where all DC converter devices in the Hybrid Charger Controller system are connected to the battery power supply, while on the 5 VDC and 12 VDC load sides, jumpers are installed which are connected to the positive and negative sides so that the current limiting circuit becomes short circuited. The following is a picture of a 0.30 A current limiter when a short circuit test is carried out. With an input voltage of 5.03 VDC when the current limiting circuit is in a short circuit condition, the output current of the current limiter is measured at 0.22 A. The amount of current measured on the current limiter is in accordance with the amount of current limit that has been designed for a 5 VDC load, which is 0.30 A. This shows that the current limiter can work when a short circuit occurs so that it can prevent damage to the synchronous buck type direct current converter due to short circuit current. The following is a picture of the 0.7 A current limiter data when in a short circuit condition. Testing was also carried out with an input voltage of 12.20 VDC when the current limiter circuit was in a short circuit condition, the output current of the current limiter was measured at 0.45 A. The current measured on the current limiter corresponds to the current limit that has been designed for a 12 VDC load, which is 0.7 A. This shows that the current limiter can work when a short circuit occurs so that it can prevent damage to the battery and other devices connected to the battery due to short circuit currents.

CONCLUSION

The current limiter circuit has been successfully created for a 5 VDC load with a limit of 0.30 A and a 12 VDC load with a limit of 0.7 A. In normal condition testing with a resistor value of more than 16 Ω for a 0.30 A current limiter and a resistor value of more than 20 Ω for a current limiter with a limit of 0.7 A, the output current of the current limiter has a value based on the resistor load value (Ω), namely the greater the resistor value, the smaller the current will be for a 0.30 A current limiter and for a 0.7 A current limiter. In overcurrent condition testing with a resistor load value smaller than the resistor load under normal conditions, namely less than 18 Ω for a 5 VDC current limiter with a limit of 0.30 A and less than 20 Ω for a 12 VDC current limiter with a limit of 0.7 A, the output current of the current limiter for a 5 VDC load. The output current of the current limiter is in accordance with the current limit in the circuit according to the ability of the synchronous buck converter and the battery and devices connected to it to withstand current. In the short circuit condition test, the current limiter value is in accordance with the designed limits, namely 0.22 A and 0.45 A. So that the current limiter is able to protect the synchronous buck hardware and the battery as well as other devices connected to the battery when a short circuit occurs.

REFERENCES

Ari Bawono Putranto, Fakhruddin Mangkusasmito, Much Azam, Zaenul Muhlisin, Megarini Hersaputri, 2021 Computer Systems Journal “Design and Construction of Adjustable Power Supply with Overload Current Protection Based on IC LM723” Vol. 13, No. 1 | June 2021 ISSN 2355-3286

Aryza, S., Efendi, S., & Sihombing, P. (2024). A ROBUST OPTIMIZATION TO DYNAMIC SUPPLIER DECISIONS AND SUPPLY ALLOCATION PROBLEMS IN THE MULTI-RETAIL INDUSTRY. *Eastern-European Journal of Enterprise Technologies*, (3).

Fauziah Sholikhatun Nisa1, Oto Sunandar Dinata2, Imam Saukani3, Fahmi Riski Istiawan, 2022 ELTEK JOURNAL “Overcurrent effect analysis on 0-30 VDC linear power supply using LM 723 in basic electronics laboratory” Vol.20, No.2, October, pp.111~118p-ISSN: 1693 –4024|e-ISSN: 2355-0740DOI:10.33795/eltek.v20i2.349

Alfathan Seratama Yudan Christianto, Sigit Yuwono, 2020 e-Proceeding of Engineering “Led Power Supply System On Bycycle” Vol.7, No.1 April 2020 ISSN: 2355-9365.

Setyawan P. Sakti, 2016 Electrical Technology “Design and Construction of a Microcontroller-Based 220VAC Small Power Current Limiting System” Vol. 15, No.1, January – June 2016 p-ISSN: 1693 – 2951; e-ISSN: 2503-2372

S. Aryza (2022) PENINGKATAN STABILITAS SISTEM KELISTRIKAN MESIN TUNGGAL BERBASIS METODE RUNGE KUTTA ORDE 4 *Jurnal Elektro dan Telkomunikasi*, *8*(2), 1-6.

Kukuh Pambudi, Amani Darma Tarigan, Hamdani, 2024, Jurnal Scientia “*Analysis Efficiency Of 3 Phase AC Motor Use A Centrifugal Pump Drive On The Water Tower Of PDAM Tirtanadi*” North Sumatra” Volume 13 , Number 02, 2024, DOI 10.58471/scientia.v13i02ESSN 2723-7486 (Online)

Rahmaniar, R., Syahputra, M. R., Lesmana, D., & Junaidi, A. (2022). Sosialisasi Pemahaman Bahaya Tegangan Sentuh Dan Hubung Singkat Sistem Kelistrikan Bagi Masyarakat Desa Kota Pari. *RESWARA: Jurnal Pengabdian Kepada Masyarakat*, *3*(2), 357-362.

S Anisah, et al. (2018, June). Analisis Perbaikan Tegangan Ujung Pada Jaringan Tegangan Menengah 20 KV Express Trienggadeng Daerah Kerja PT PLN (Persero) Area Sigli Rayon Meureudu Dengan Simulasi E-Tap. In *SEMNASTEK UISU 2018*.

Rahmat Faisal Wahyudi1, Sigit Yuwono2, Estananto, 2018 e-Proceeding of Engineering “Charger Design For Lithium Polymer Smart Phone Battery With A Capacity Of 4a At 3.7v Battery Voltagecharger Design For Lithium Polymer Smart Phone Battery With A Capacity Of 4a At 3.7v” ol.5, No.3 December 2018 ISSN : 2355-9365

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Volume 13, Number 02, 2025, DOI 10.58471/infokum.v13i02
ESSN 2722-4635 (Online)
https://infor.seaninstitute.org/index.php/infokum

Eno May Leny, 2019Journal of Electrical Engineering "Current Limiter System and Current and Voltage Monitoring Using SMS for Protection in Household Load Use" Volume 08 Number 01 Year 2019

Rizal Riswanto, 2020 Electrical Engineering Journal "Current Limiter and Short Circuit System Using SMS for Household Load Protection" Volume 09, Number 02, Year 2020, Pages 277-284

Jessy Kris Dayanti, Trias Andromeda and Yuli Christyono, 2018 Transient “Current Limiter Design as Battery Charging System Protection” Vol. 7, No. 4, December 2018, Issn: 2302-9927, 942

Retno Aita Diantari, St., Mt, Shulli Alifiannisa Putri, 2016 Journal of Energy & Electricity “Protection System on Boeing 737 – Classic Aircraft” Vol. 8 No. 2, June - December 2016 Issn: 1979-0783