Design of DC Accumulator Charging using Backup Accumulator Based on Inverter and Converter Device

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***Abstract*— The charging of DC accumulator that experiences a lack of electric charge energy, usually utilizes an AC input power from the PLN network. When the AC input power from the PLN network is unavailable, a DC power source is used from the backup DC accumulator as a substitute. The research objective is to design an internal DC accumulator charging using a backup DC accumulator equipment based on inverter and converter equipment. The charging system will use input power from the backup DC accumulator to replace the AC input power from the PLN network. The electric voltage of the internal DC accumulator that is filled (charged) is the initial condition of $V_{DC(Acu.Int.)}$ = 8.76 Volts until it reaches the normal condition of 12.05 Volts with a capacity of charging current of 5 Ah (Ampere.hours) absorbs electrical energy of $W_{(Acu.Int.)}$ = 16.45 Wh (Watt.hours). The results show that the equipment supply a DC charger of 13.0 volts and P_{DC} of 21.32 watts to the internal DC accumulator. The comparison of $W_{(Acu.Int.)}$ to P_{DC} produces time charging, $t_{(charging)}$ of 46.29 minutes.**

Keywords— backup DC accumulator, DC inverter, DC converter, charging energy and internal DC accumulator.

I. INTRODUCTION

Electric motors are selected as the driving force for the automotive vehicles offering comfortable and easier operation than internal combustion-powered vehicles. The electrical energy sources as the driving force for the automotive engines uses a DC power from the battery/accumulator. The internal DC accumulator supplies power to the electric motor machine and to the other electrical load such as lamps. The battery will experience a decrease in stored energy while driving the electric motor, so it is necessary to recharge the accumulator energy. Generally, recharging the internal DC accumulator utilizes AC electrical energy from the PLN AC power generation network. If the availability of PLN electrical energy network is not available, then it needs other electrical source equipment for recharging the internal DC accumulator to replace the availability of PLN networks. The backup DC accumulator is used as a substitute for AC electrical energy sources from PLN [1],[2].

The DC inverter equipment is expected as a solution to the problem of the unavailability of 220-volt AC electrical energy sources of PLN network. The input of DC inverter power comes from a backup DC accumulator to produce an output voltage of 220 volts AC. Furthermore, the output voltage of 220 volts AC is connected to the input of the AC converter to be converted into a DC voltage for charging the internal DC accumulator.

The purpose of this study is to charge internal DC accumulators by utilizing the input power source from a backup DC accumulator, when the input power source from the PLN AC power network is not available.

II. METHODS

The DC battery/accumulator has a shortage of electrical energy, it can be charged by DC electric sources. In the battery charging, the positive pole is connected to the positive electric current source and the negative pole is connected to the negative electric current source. The voltage of DC accumulator which has a shortage of electric charge capacity is smaller than normal conditions. For example, the electric voltage level is less than 12 volts DC or about 10.0 to 11.0 volts DC. Charging process is supplied by a DC voltage source that is greater than 12 volts DC, which is about [12 volts DC + (10% x 12 volts DC)] = 13.2 volts DC. Thus, the source voltage can supply electric current to the DC accumulator electrical load. The parameter specifications for the current capacity of the DC accumulator are in ampere hours (Ah). The duration of electric current charging to reach the full electrical capacity in Ah (amperes.hours) is formulated in equation (1).[3]

$$t = \frac{C}{I} \quad (1)$$

Where:
t = Duration of charging (hours)
C = The old capacity of the charger, (Ah)
I = Current supply, amperes (A).

The duration is proportional to the supply of electric voltage and the capacity of charging electric current as shown in equation (2). [3], [7]

$$W = V.I.t \quad (2)$$

Where:
W =Charging capacity, Watt.hour (W.h)
V = Supply voltage, volts.
I = Charging current, Amperes.
t = Duration, hours (h).

The electric power is proportional to the electric voltage and the electric current as formulated in equation (3). [3]

$$P = V.I \quad (3)$$

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Where:
P = Electric power capacity, watt
V = DC voltage source, volts
I = current supply, amperes.

In this study, the $V_{DC(Acu.Cad.)}$ from the backup DC accumulator power supply as the main input source is connected to the input of DC inverter device to generate AC power voltage. The voltage is adjusted to have similar characteristic with the PLN AC power supply voltage level, at the ranges from 200 volts to 230 volts. Then, it is connected to the input of AC converter device to be converted into a DC mains voltage, $V_{DC(supply)}$. The $V_{DC(supply)}$ is used to charge the internal DC accumulator that has a low energy level. The block diagram of the internal DC accumulator charging method using the main input from a backup DC accumulator based on the DC inverter and AC converter as shown in Figure 1.

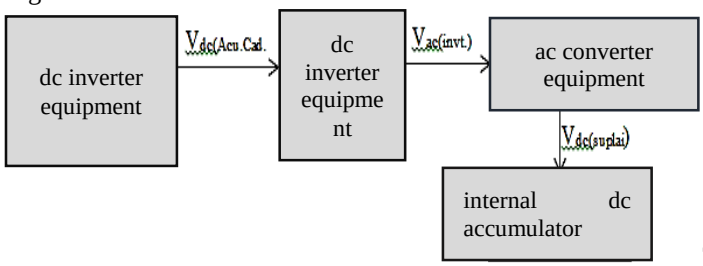

Fig. 1. Block diagram

The flow chart of this methodology is shown in Figure 2.

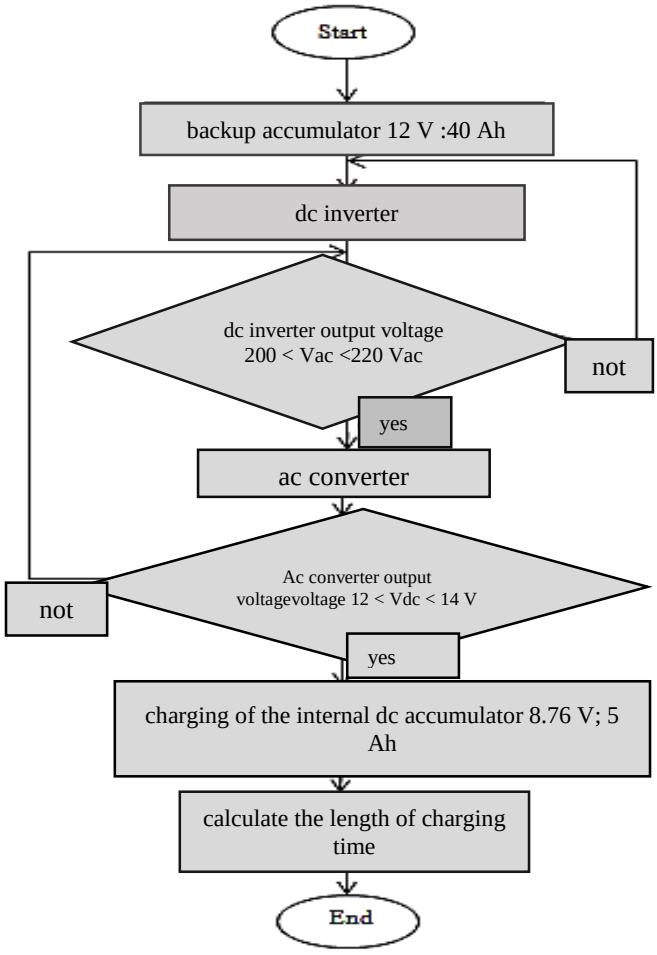

Fig. 2. Flow chart

2.1 Backup DC accumulator

The main input power in this comes from the backup DC accumulator, $V_{DC(Acu.backup)}$. The backup DC accumulator has voltage level of 12.53 volts DC with electric capacity of 25 Ah.

2.2 DC inverter and AC converter

The DC inverter produces an AC output voltage, $V_{AC(invt.)}$ at the range of 200 volts to 230 volts, as a substitute for the AC power source from PLN. The AC converter converts it into the DC voltage, $V_{DC(convt.)}$ at the range of 12.0-13.0 Volts DC. The measurement results of the backup DC accumulator based on the DC inverter and AC converter are shown in the table 1.

Table 1. Measurement results of $V_{DC(Acu.backup.)}$, $V_{AC(Invt.)}$ and $V_{DC(convt.)}$

Backup DC accumulator	DC Inverter	AC converter
$V_{DC(Acu.backup)}$	$V_{AC(invt.)}$	$V_{DC(convt.)}$
(volt DC)	(volt AC)	(volt DC)
12.53	218.5	13.0

III. Results and Discussions

The overall design of the internal DC accumulator charging equipment are shown in Figure 3.

Fig. 3. The equipment designs

Source: original picture

The output voltage of AC converter produces a DC voltage output, $V_{DC(convt)}$ to be used as the supply voltage for the internal DC accumulator charger, $V_{DC(Supply)}$. The measurement of $V_{DC(Supply)}$ is 13.0 volts DC with the charging current, $I_{DC(Supply)}$ of 1.64 amperes (A). In this case, the DC power capacity of the internal DC accumulator charger, $P_{DC(supply)}$ is calculated using the equation of $P_{DC(supply)} = V_{DC(Supply)} \times I_{DC(Supply)} = 13.0 \times 1.64 = 21.32$ Watts. The electrical parameter for the internal DC accumulator charger are shown in Table 2.

Table 2. The $P_{DC(supply)}$ of internal DC accumulator

$V_{DC(Supply)}$	$I_{DC(Supply)}$	$P_{DC(Supply)}$
(Volt)	(Ampere)	(Watt)
13.0	1.64	21.32

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In the charging process, the initial condition of $V_{DC(Acu.Int.)}$ is 8.76 volts and it reaches the final condition of the normal electric voltage, which is presented in Figure 4. The charging results of the internal DC accumulator to normal condition, $V_{DC(normal)}$ is 12.05 volts DC with the electrical capacity of 5 Ah. The increasing of DC voltage, ΔV_{DC} = [$V_{DC(normal)}$ – $V_{DC(Acu.Int.)}$] = (12.05 volts – 8.76 volts) = 3.29 volts. The electrical charging energy to reaches normal condition is $W_{(normal)}$ = V_{DC} x $C_{(Ah.)}$ = 3.29 volts x 5.0 Ah = 16.45 Wh (Watt.hour). The charging results of the internal DC accumulator has is shown in the table 3.

Fig. 4. Internal DC mains voltage at initial condition and after charging process

Source: original picture

Table 3. The charging results of the internal DC accumulator

Voltage charging		Electrical energy		
$V_{DC(Acu.Int.)}$	$V_{DC(normal)}$	ΔV_{DC}	C(Ah.)	W(Ah)
(volt)	(volt)	(volt)	(Ah)	(Wh)
8,76	12,05	3,29	5	16,45

The duration of the charging time from the initial condition to the normal electric voltage condition is expressed as follow:

$$\mathbf{t}_{(charging)} = \frac{W_{(Ah.)}}{P_{(DC,supply)}}$$

By using the data of W(Ah) = 16.45 watt.hour (W.h) and the electric power, $P_{DC(supply)}$ = 21.32 watts (data in the table 2), the duration time to charge the dc accumulator. internal units in minutes, as follows:

$$\mathbf{t}_{(charging)} = \frac{W_{(Ah.)}}{P_{(DC,supply)}} = \frac{16,45}{21,32} = 0,772 \text{ (hour) x 60 minutes/1 hour} = 46,29 \text{ minutes}$$

$\mathbf{t}_{(charging)}$ = 46,29 minutes.

The data recapitulation of the $P_{DC(supply)}$, W(Ah) and $t_{(charge)}$ parameters for charging process of the internal DC accumulator is shown in table 4.

Table 4. Charging parameter of the internal DC accumulator

charger electric		charging energy	length of time
$Vdc_{(Suplai)}$	Pdc(Suplai)	W(Acu.Int.)	t(pengisian)
13 Volt	21,32 Watt	16,45 Wh	46,29 Menit

IV. CONCLUSIONS

When the input of 220 volt AC power from the PLN network is unavailable, it can use the power source from a backup DC accumulator as an alternative. The DC inverter device converts a backup DC accumulator to produce an AC voltage source as a substitute of AC power source from PLN network. To charge the internal DC accumulator, the AC voltage from the DC inverter output must be converted to DC electric voltage. The AC converter device converts the electrical voltage output from the DC inverter output to DC electrical voltage to supply the internal DC accumulator with low voltage at condition of 8.76 volt DC. The DC output voltage produced by the AC converter device can be used to supply electrical energy to the internal DC accumulator until it achieves the normal voltage. The results show that it need the duration of 46.29 minutes to charge the internal DC accumulator starting from a condition of 8.76 volts DC to the 12.05 volts DC.

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