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Battery Voltage Control System to Avoid Deep Charging in Control Battery Unit (CBU)

Deni Permana Kurniadi[1] , Arief Budi Santiko[2]
[1,2]*(Research Center for Electronics and Telecommunication - Indonesian Institute of Sciencies (LIPI), LIPI – Campus, Sangkuriang Street, Building 20-4th floors, Cisitu, Bandung – Indonesia 40135)*

ABSTRACT: *Has done research on the voltage of the battery management system to avoid the phenomenon of deep charging. The phenomenon of deep charging is a situation where the over current in the process of charging the battery because the battery voltage is below the allowed minimum voltage levels, this course can shorten the life of the battery or even permanently damage the battery. To prevent this, it is a regulatory system that serves to regulate the use of electric current to the battery, so when battery voltage is approach the level minimum, so electric current flowing from the battery to the load is automatically disconnected. The working principle of the system is to use a comparative setting, where these systems will compare the desired voltage as the voltage of the signal, with the other insert voltage as a reference. When all requirements are met comparators, then the outcome of the comparison system will measured increase in the voltage that will make a switch transistor saturation. To increase the switching currents, then used a relay that placed the series between the collector and voltage sources. Regulatory system is designed using components easily available in the market, and has the same functionality as the functions contained in the Battery Control Unit (CBU)*
Keywords: *deep charging, over current, comparator, voltage reference*

I. INTRODUCTION

Battery capacity 100 Ah (ampere hour), it means when the load used for 100 Ampere, battery current will empty in an hour. Battery discharge level or minimum threshold level Voltage that recommended is up to 1.75 Volt per cell. The battery wil be damaged if the voltage per cell is less than 1.75 Volt (or 10.5 Volt recommended for battery type 12Volt) [1]. Battery life times counted in the number of cycle, one cycle is one time of use (discharge condition) and charging (charge condition). *Depth of discharge* (DoD) is the number usage of Battery ampere, affect the cycle number of battery. The condition at a temperature of 25 degrees celcius [1]:

- *Full discharge* is for 100% depth of discharge with the use of approximately 100-200 cycle
- *Partial* is for 50% depth of discharge with the use of approximately 400-500 cycle
- *Shallow discharge* is for 100% depth of discharge 100% of approximately 1000 cycle atau lebih.

Extended battery lifetime, the battery requires discharge periodic, discharge performed only abour 10 percent of total capacity. The use of full discharge of a battery is not recommended because it will reduce of battery lifetime.

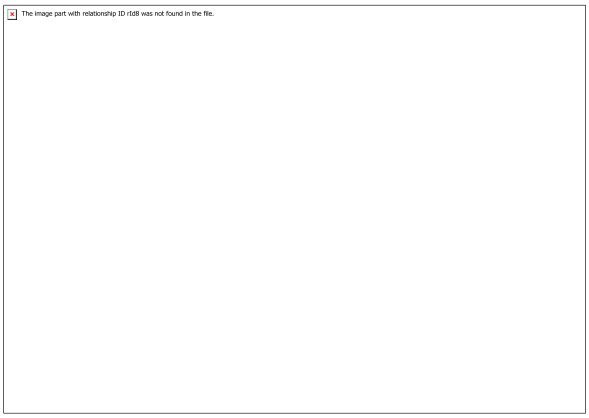

Figure 1. Deep Charging Curve [2]

II. DISCUSSION AND THEORY

Battery voltage regulator system using a operational amplifier (op-amp) are used as comparison. Comparison system is use a single voltage on one input will be compared with a reference voltage at the another input. The condition Non-Inverting input voltage is greater than Inverting Input voltage, comparator generate high voltage output and applies to the opposite situation [3].

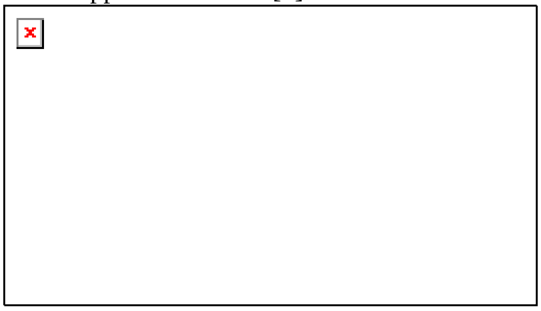

Figure 2. A schematic drawing System

Operating Amplifier used as comparator it becomes important to know the value transfer point will occur. Transfer point (threshold point or reference point) it means define as the value of the input voltage magnitude when the output voltage become to the condition switching state[3].

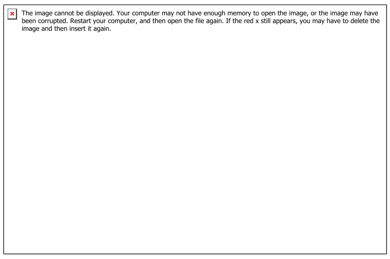

Figure 3. Operating Amplifier system for comparison with Symmetrical Supply[3] 18-163

Transfer point same with Vref because when this input voltage have a value, on the other side the output voltage become the condition switching state. Condition Vin greater than Vre_f, then output value is high level. Conversely, if Vin less than Vref, output value is low level.

Dimana :
V_{acu} = Voltage Reference
R_1 dan R_2 = Resistor as Voltage Divide
V_{CC} = Voltage Source

Avoid ripple from power supply and roar on Voltage Inverting Input mounted bypass capasitor to ground. In order to work properly, the value of main frequency this simple circuit must less than value of ripple frequency. The calculation for determine frequency on main circuit :

Simplify the design, created a NOT simple circuit made from a single low power class A Transistor inserted between Op-Amp Output and input of the gate switch circuit. Thus, when the condition of OpAmp on low level, the Output of NOT simple circuit will be high level, as did the oposite. Measure the level Basis Voltage on NOT simple circuit, use the equation :

....(3)

Because the value Voltage basis-emitter (V_{BE}) is about 0.7 Volt for Silicon Transistor types and 0.3 Volt for Germanium Transistor types so the values of Emitter Current (I_E) which also considered nearly equal to Quiet Collector Current (I_{CQ}), can be calculated by the following equation :

....(4)

By knowing, the quiet collector current which is idenctical Emitter Current, so the value of DC Voltage emitter-collector can be calculated by the following equation :

.... (5)

For DC cut-off voltage is Vcc, so the value of DC saturated current can be calculated [3] :

....(6)

On the quiet condition or the condition when Basis Voltage equal to zero, transistor can be operates at a Q point on the DC load line. Meanwhile, when the condition of the Basis Voltage equal to half the Vcc Voltage,then the Q point operates or oscillate along AC load line. This is due to DC load resistance different with AC load resistance[3].

Basicly DC saturated point and cutoff point different with AC saturated point and cutoff point, the methode used to get the AC load line is summing all close looping AC voltage's on Basis and Collector, so to determining value AC saturated current and AC cut-off Voltage calculated by the following equation :

.. ..(7)

where :
$I_{C\text{-}(SAT)\text{-}AC}$ = AC saturated current
I_{CQ} = DC collector current
V_{CEQ} = DC voltage collector-emitter
r_C = AC resistance on collector
$V_{CE-(CUT)}$ = AC cut-off voltage

.... (8)

The switch system, used VMOS type (metal-oxide semiconductor vertical) where V_{in} on low level or high level so VMOS operate as switch that can cutoff and conduct current. While the Condition of V_{in} low level, then VMOS is cutoff and V_{out} (voltage out) same with supply voltage and aplicable to the contrary [2]. Detemine the value of Current that flows on Load resistance (R_D), used following equation :

(9)

....(10)

where:

$I_{D\ sat}$ = Drain Current Satturated
V_{DD} = Voltage Source
$V_{DS\ on}$ = Voltage Drain Source
R_D = Drain Resistor

III. DESIGN SYSTEM

The first planning in this experiment ist to determine the lowest point of the battery is still safe to do discharge. Generally, the recomended discharge level until 1.75 Volt per cell. The battery wil be damaged if the voltage per cell is less than 1.75 Volt (or 10.5 Volt recomended for battery type 12Volt) [1]. It also recommended charging current is about 10% from batery capacity, its is to keep the battery from damage due to the charging current is too large (deep charge) and maintain the lifetime battery becomes longer. Recomended for minimum voltage is 1.75 voltX6 cell = 10.5 volt

By known value of the source voltage is 12 Volt (nominal voltage of the battery), refference voltage is 10.5Volt which is the recomended for minimum threshold voltage and setting the divide resistor at 10 KΩ so the value of the resistance on Series Circuit (R_1) can be determined by the following equation :

By known both of Divide Resistance on Inveting Input, for condition V_{in} is greater than 10.5 Volt, so Output value will be high level, otherwise condition while V_{in} is smaller than 10.5 Volt so Output value will be low level, with positive polarity at the both condition. Determine value of Voltage Basis on NOT circuit , choose

R_1 = 100 Ω; R_2 = 100 Ω ; R_E = 680 Ω ;
R_C = 470 Ω ; R_L = 10 Ω ; V_{CC} = 12 Volt

Because the value of Emitter Current (I_E) same with Collector Current (I_{CQ}), then the value Voltage collector-emitter (V_{CEQ}) can be calculated:

Determine the value of AC saturated current and AC cut-off Voltage, firstly it must be calculated the value of AC Thevenin Resistance that drive the basis voltage and AC load resistance which is views by collector on OpAmp:

By calculate series resistance on gate base the result is 47 Ω, so the value of current on gate base can be calcualted and the current on gate base known is 65.3 mA, this current value sufficient to drive switch circuit on saturated level. The condition while switch circuit on saturated level, the value of current on load circuit can be calcualted by knowing Voltage Drain-Source obtained from datasheet is 1.8Volt. Because the load of switch circuit shaped from relay coil, the value Load resistance can be obtained with doing measuring the value of Inductance that exist in coil. Measurement of relay coli inductance obtained the value is 2.195mH. By knowing, the value of the relay coil inductance, so value of inductive reactance can be calculated by frequency that used at the time of measurement.

By entering all result calculation on fig.3 (OpAmp as comparision) and added a switch circuit combained with a single relay on Load resistance, it can be made a regulator system to cutoff short circuit between battery and load system while Voltage Comparator Input close to Voltage minimum level (10.5 volt).

IV. CHARACTERIZATION AND IMPLEMENTATION

Measurement has been done for all system by using Instrumentation LCR Meter type "Escort ELC – 131D" to measure value of Inductance, Capacitance dan Reactance. Multimeter type "Fluke 8060A" to measure the value of the Voltage and Current in the circuit and Tektronix Oscilloscope type "TDS 3032" to measure the value of Input Voltage on switch circuit.

Table 1. Measurement on Coil

NO	BASIC QUANTITY	MEASUREABLE	UNIT
1.	L	2,195 X 10^{-3}	H
2.	C	5,201 X 10^{-9}	F
3.	R	163,9	Ω
4.	Q	5,97	

By Measurement on relay coil which function as Load Resistance (R_D) measureable the value of Induktance, Capacitance, Resistance and magnitude of Q factor at frequency 1 KHz , as shown in table 1.

Table 2. Measurement Output Voltage Comparator

NO	NON-INVERTING VOLTAGE	OP-AMP OUTPUT
1.	13.50 Volt	1.64 Volt
2.	13.40 Volt	1.66 Volt
3.	13.30 Volt	1.65 Volt
4.	13.20 Volt	1.66 Volt
5.	13.10 Volt	1.66 Volt
6.	13.00 Volt	1.67 Volt
7.	12.90 Volt	1.65 Volt

8.	12.80 Volt	1.64 Volt
9.	12.70 Volt	1.64 Volt
10.	12.60 Volt	1.65 Volt
11.	12.50 Volt	1.64 Volt
12.	12.40 Volt	1.64 Volt
13.	12.30 Volt	1.65 Volt
14.	12.20 Volt	1.64 Volt
15.	12.10 Volt	1.64 Volt
16.	12.00 Volt	1.64 Volt
17.	11.90 Volt	1.65 Volt
18.	11.80 Volt	1.64 Volt
19.	11.70 Volt	1.64 Volt
20.	11.60 Volt	1.64 Volt
21.	11.50 Volt	1.65 Volt
22.	11.40 Volt	1.64 Volt
23.	11.30 Volt	1.64 Volt
24.	11.20 Volt	1.64 Volt
25.	11.10 Volt	1.65 Volt
26.	11.00 Volt	1.64 Volt
27.	10.90 Volt	1.64 Volt
28.	10.80 Volt	1.64 Volt
29.	10.70 Volt	10.14 Volt
30.	10.60 Volt	10.10 Volt
31.	10.50 Volt	10.15 Volt
32.	10.40 Volt	10.11 Volt
33.	10.30 Volt	10.14 Volt
34.	10.20 Volt	10.17 Volt
35.	10.10 Volt	10.15 Volt
36.	10.00 Volt	10.15 Volt

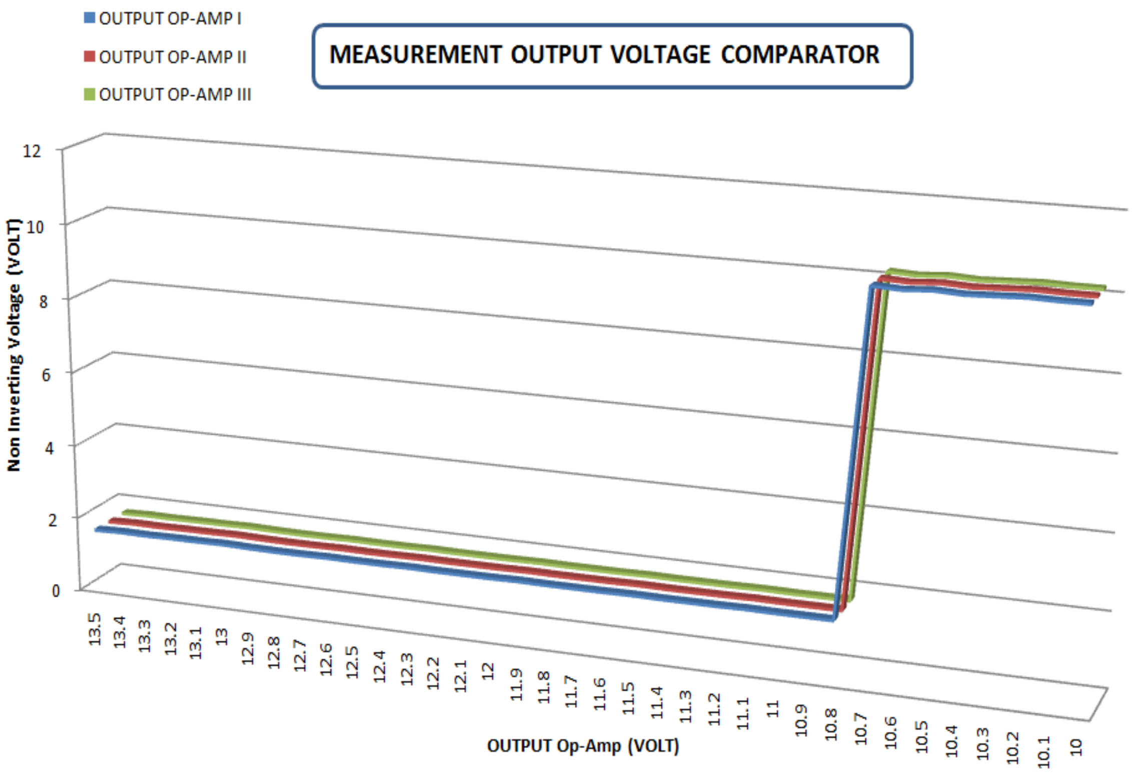

Figure 4. Measurment Output Voltage Comparator

Result of measurement has shown in fig.4 performed 3 times trial experiment with almost same result, while the value of Battery voltage at minimum level (10.5 Volt) as in the design system, then Voltage

Output of comparator is 10 Volt enough to drives switch-Transistor Saturated which ultimately can drives relay components to break/cutoff short circuit between the Battery to the Load.

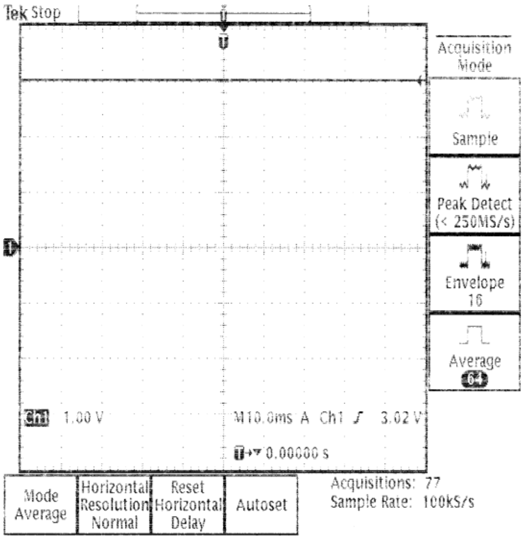

Figure 5. Voltage Input on VMOS from Comparator Output.

V. CONCLUSION

From all the measurement result and performance overall system, it can be concluded that the system can work well and functionate as regulator Battery voltage. From the measurement shown, the output of the comparator will be in high level when the Input comparator having the specified minimum level.

Acknowledgement

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