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ADJUSTABLE ELECTRONIC CHARGING SYSTEM FOR LEAD ACID BATTERIES SUITABLE FOR AGRICULTURAL EQUIPMENTS IN REMOTE AREAS

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ABSTRACT

This paper illustrates a full design of charge controller regulate the charge of 155 Ahr,12V lead acid battery. This battery has wide applications especially with agricultural equipments such as tractors, scrapers, loaders.........etc. In agricultural remote areas in Egypt, battery play important role in agricultural environment. This due to that, the batteries are a source of electrical energy in all modern agricultural equipments. Consequently, the regulation of its charge becomes very important due to increase the equipment performance reliability. The paper presents all design steps of the whole circuits of proposed battery charger controller. The battery is charged from solar cell array. This type of charge system is very suitable for the previous agricultural remote areas. The designed charge controller may be used with different charge system rather than solar cells array. The paper presents also the test of all controller elements in the operating field.

INTRODUCTION

The Ahr counting charge controller can improve battery charging by recharging the battery as quickly as possible without excessive overcharge during high resource or low load periods. Appropriate overcharge is necessary to compensate for battery efficiency losses, prevent electrolyte stratification, prevent hard sulfating, and minimize premature capacity loss[Wood.J.R.1994]. In the application of power electronics in designing and implementing a digitally controlled stand-alone PV power supply, DC chopper is used as an interface between solar array and a battery for MPPT (Maximum Power Point Tracker) and battery charging [Hansen.A.D 2000].

For proper design of battery charge controller, voltage regulation set points must be determined firstly. The effect of the selection of these points on charging battery are , battery capacity life time and system reliability is shown in [Hund.T.D 1997]. The charge controller set points has an impact to performance of the battery array combination and on the battery failure to maintain load for the designed days of autonomy and premature battery failure. Information in this area is illustrated in [Stevens.J.J.1993].

A DC chopper is used as a voltage regulator for voltage at load supplied by SCA at any insolation level. The voltage at maximum power point of SCA is selected as a suitable operating load voltage. This is due to the fact that, it has fixed values at different insolation levels [Eskander S. S. 2001].

Battery manufacturers often refer to three modes of battery charging, normal or bulk charge, finishing or float charge and equalizing charge [3]. Bulk or normal charging is the initial portion of a charging cycle, preformed at any charge rate which does not cause the cell voltage to exceed the gassing voltage. Bulk charging generally occurs up to between 80 and 90% state of charge. Once a battery is nearly fully charged, voltage and/or current regulation are generally required to limit the amount of the energy supplied to the battery to prevent overcharge[Tom Hund, 2004]

1. Charge Characteristics of The Lead Acid Battery

There are two basic ways to charge a battery. The first of them is from a voltage source and the other is from a current source. It is necessary to include voltage source charging for three reasons. First, line-powered voltage source charging is the way most batteries are charged and the method is recommended by battery manufactures. Second, voltage source chargers are important tools for maintain batteries. Third, most solar panel charge control schemes rely on voltage sensing to detect the battery's state of charge and share some common characteristics with voltage source chargers[Gaumont.O,2000].

Figure (1) shows typical current and voltage curves for lead acid battery during charging from constant voltage source medium power voltage source.

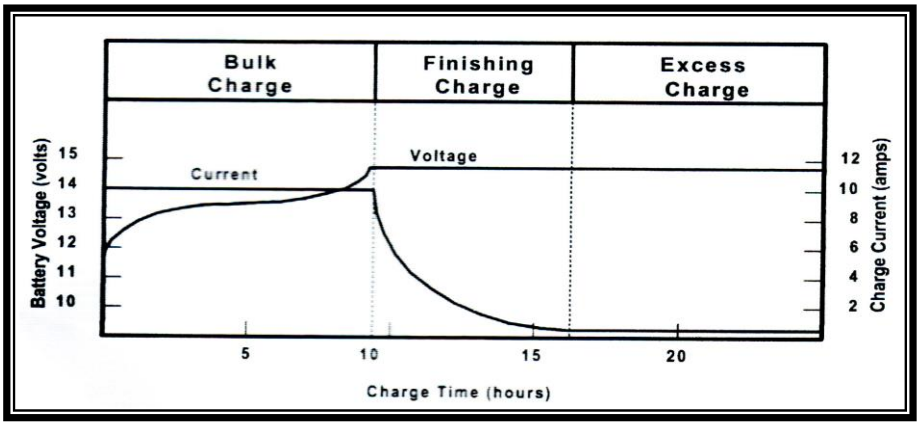


Figure (1): Current and Voltage Curves for the lead acid battery charging

There are three regions of the charge curves. The first region is Bulk charge. In this region the voltage source is in current limit because the battery can accept more current than the charger is able to produce. At the end of the bulk charge period, the charger's output voltage reaches the set point to which the charger must be get away from the battery. The battery is the 80% to 90% charged can no longer store all the current the charger can produce. This is the finishing charge region. During this period, the current from the charger decreases rapidly as the plates have less and less lead sulfate to convert to active material. The charger output voltage remains constant. At the end of the finishing charge period the battery is fully charged. The output of the charger is above the battery gassing voltage so the battery continuous to draw current after the finishing charge period even through it can no longer store it as charge. The battery is in over charge and electrolyte water is decomposing. This is the Excess Charge Period.

2 Charger Set Points

For determing the battery set point, experimentally, the lead acid battery (12V) is charged using solar cell array. The battery voltage level at which a charger performs control or switching functions are called the charger set points. Four basic control set points are defined for most charge that have battery overcharge Figure.2 shows the basic charger set points on a simplified diagram plotting battery voltage versus time for a charge and discharge cycle [Dunlop.j.p, 1997].

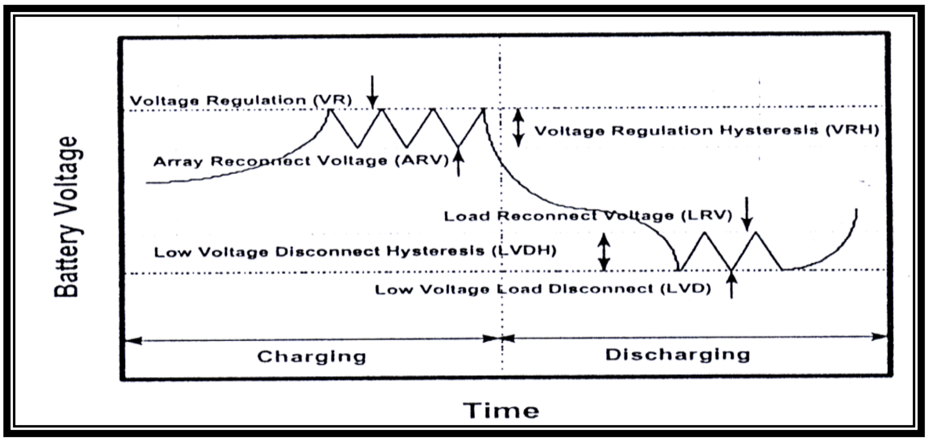


Figure (2): Charge Controller Set Points.

The voltage regulation (VR) is14 volt for 12 volt lead acid battery and the solar cell array reconnect voltage (ARV) is12.5 volt refer to the voltage set points at which the array is connected. The low voltage load disconnects (LVD) and load reconnect voltage (LRV) refers to the voltage set points at which the load is disconnected from the battery to prevent over discharge.

3 Definitions of Lead Acid Battery Voltage Set Point .

3.1 Voltage Regulation (VR) Set Points

The voltage regulation set point is defined as the maximum voltage that the charge controller allows the battery to reach, limiting the overcharge of the battery. The controller senses that the battery reaches the voltage regulation set point, the controller either discontinue battery charging or being to regulate (limit) the amount of current delivered to the battery. Selecting of the voltage regulation set point may depend on many factors, including the specific battery chemistry and design, sizes of the load and array with respect to the battery, operating temperatures, and electrolyte loss considerations. For a battery under test, voltage regulation set point is called upper trigger point (UTP) which is equal to the voltage corresponds to 100% state of charge equal to 14 volt.

3.2 Solar cell array Reconnect Voltage (ARV) Set Points

When the battery voltage decreases to a predefined voltage the array is again reconnected to the battery to resume charging. This voltage at which the array reconnected is defined as voltage ARV set point.

This voltage for a battery under test is defined as LTP lower trigger voltage which equal to 89.3% of upper trigger voltage for a battery (14volt) under test and equal to 12.5 volt. The array will be reconnect and the array current will flow into the battery in an On-Off manner, disconnecting at the regulation voltage set point UTP and reconnecting at the array reconnect voltage set point LTP.

3.3 Voltage Regulation Hysterises (VRH)

The voltage difference between the voltage regulation set point and the array reconnect voltage is called the voltage regulation hysterises VRH.

The VRH is a major factor which determines the effectiveness of battery recharging for interrupting (ON-OFF) type controller.

If the hysterises is too great, the array current remains disconnected for long periods, effectively lowering the array energy utilization and making it very difficult to fully recharge the battery.If the regulation hysterises is too small, the array will cycle on-off rapidly.

4 CONTROLLER TYPES

4.1 Series Controllers

This type of controller works in series between the array and battery. This type of controller is commonly used in small PV systems; it is also the practical choice for larger systems due to the current limitations of shunt controllers. Figure.3 shows an electrical design of a series type controller. In a series controller design, a relay or solid-state switch either opens the circuit between the array and the battery to discontinuing charging, or limits the current in a series-linear manner to hold the battery voltage at high value, in the simpler series interrupting design, the controller reconnects the array to the battery once the battery falls to the array reconnect voltage set point [Dunlop.J.P, 1997].

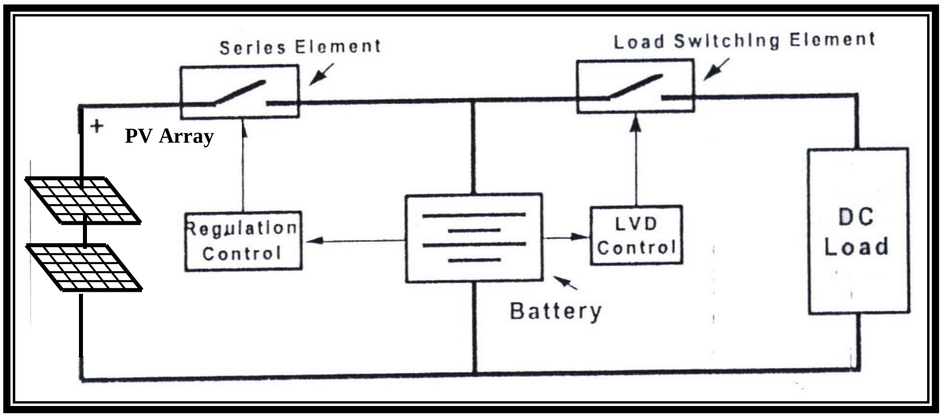


Figure (3): Basic Series Regulator.

4.2 Shunt Type Controller

The ability to short-circuit modules or an array is the basis of operation for shunt controllers.

The shunt controller regulates the charging of battery from the PV array by short-circuiting the array internal to the controller. All shunt controllers must have a blocking diode in series between the battery and the shunt element to prevent the battery from short circuiting when the array is regulating. Because there is some voltage drop between the array and controller and due to wiring and resistance of the shunt element, the array is never short-circuited, resulting in some power dissipation within the controller. For this reason, most shunt controllers require a heat sink to dissipate power, and are limited to use in PV system with array currents less than 20 amp. The regulation element is shunt controller is a power transistor switch of BD911. Figure.4 shows the circuit of a typical shunt type controller [Dunlop.J.P, 1997]. This paper illustrates proposed method constructing the shunt charger suitable with different charging sources.

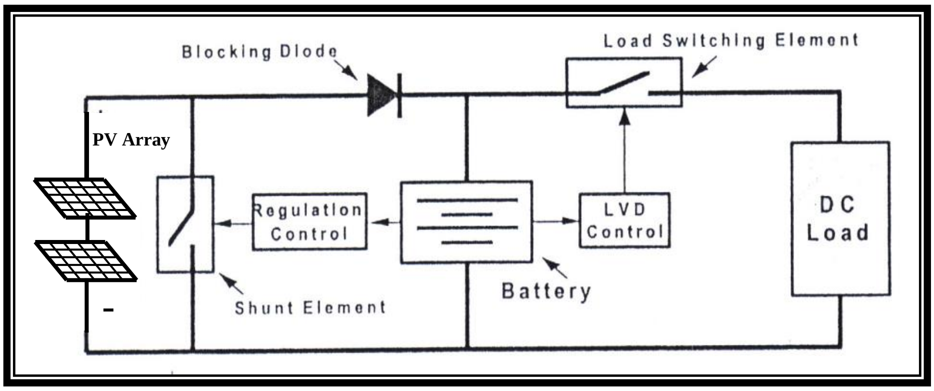


Figure (4): Basic Shunt Regulator.

There are a couple of variations of the shunt controller design. The first is a simple interrupting, or (on-off type) controller design. The second type limits are array current in a gradual manner by increasing the resistance of the shunt element as the battery reaches full state of charge.

4.3 Selection of Charge Controllers

The selection and sizing of charge controllers and system controls in PV systems involves several factors, depending on the control options required. While the primary function is to prevent battery overcharge, many other functions may also be used including low voltage load disconnect-load regulation and control.

The following list some of the basic considerations for selecting charge controller for PV systems.

- System voltage.
- PV array and load currents.
- Battery type and size.

- Regulation and load disconnect set points.
- Environmental operating conditions.
- Mechanical design.
- Over current, disconnects and surge protection devices.
- Costs, warranty and availability.

This paper introduces the design and operation of a regulating circuit required for controlling the charging of energy storage element of photovoltaic power system. The design procedure of the control element is illustrated.

An actual test of the charger connected with the lead acid battery carried out experimentally. The electrical behavior of all elements involves the controller are measured experimentally. The setting points of the controller can be simply changed to any preset values.

Objectives:

The objective of this paper is the design of charging system (charge controller) suitable for any battery especially lead acid battery. The main objective for the design of the controller is to protect the battery from over charging condition. The paper contains brief steps for the controller design as well as the schematic diagram of the controller.

MATERIALS AND METHODS

1 Materials;

1.1 Equipments

For preparing this research various equipments wear used. Groups of solar cell modules of single crystalline silicon solar cell. Each module has 20 $V_{o.c;}$ 3A short circuit current. The charge and discharge element used in the experimental work is a lead acid battery. The battery used is that connected with agricultural tractor with specification of 12V, 155 Ahr. Its set point are experimental reached as in previous items .The electronic elements are used for designing the charger are a group of resistors, capacitors, transistors and integrated circuits of Ic 741 The elements specifications are illustrated later which are depend upon the design process .

1.2 Instrumentations

The experimental research is based upon measuring devices. The storage oscilloscope is used for recording the various wave forms at different points of the charger. Program ring computer (PC) is used with the oscilloscope for recording the output waves of charge regulator. Measuring instruments such as voltmeters and ammeters are also used. DC supplies were used with the designed circuit for supplying the ICS and transistors with the required power.

1.3 Electrical Load

The electrical load used for discharging the tested battery is the electrical equipments of the agricultural tractors which are, lighting system, injecting pump, indicating lamps, protecting hydraulic system and starting system.

Figure(5): represents diagram of the charging system includes PV supply as a charger connected with the tractor battery ,all switches and the electrical load which represents as the agricultural tractor .

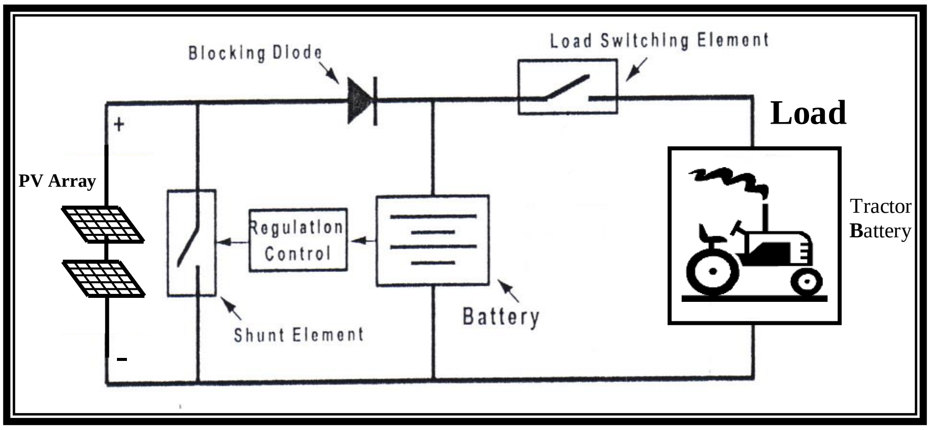


Figure (5): schematic diagram of the charging system.

2. Methods

2.1 Proposed Charger Circuits

The proposed charger is constructed as shunt controller which has three main circuits; the first circuit is a comparator which has two setting points known as upper trigger point (UTP) and lower triggers point (LTP). The two points are not equal in magnitude and both have a positive quantity. The UTP and LTP are selected experimentally by measuring the electrical behavior of the lead acid battery under test during charging process. The UTP is the upper limit of battery voltage during charging conditions. On the other hand, the LTP is selected such that, it is not equal to the battery breakdown voltage. Consequently, it is selected slightly smaller than the UTP. The controller is designed with adjustable LTP in a wide range. Hence, the proposed designed controller can be applied with different types of batteries. The proper UTP of the testing battery is selected experimentally by measuring the battery electrical characteristic (Ib_c, t_c) and (Vb_c, t_c).

Where;

Ib_c = battery charging current.

Vb_c = battery charging voltage and

t_c = charging time.

The measurements lead to obtain the relationship between the battery state of charge and its voltage. Hence, the voltage corresponding to 100% state of charge represents the UTP. The LTP is chosen as explained before. The second part of the controller main circuit is the interface stages. These stages connect between the comparator circuit which has a very low current of few millamperes and the power switch of a very large current than a comparator. These circuits represent an electrical buffer between the comparator and the controller power transistor. The number of interface stages depends upon the maximum values of charging current of the battery and the load current. The third circuit is the controller switch which is a bipolar transistor with high rating of current equal to the measured of the load current and maximum limit of battery charging current;

2.2 Power Switch Operating Strategy

The power switch must be in the off state during the charging process of the battery. On the other hand, it turns ON as the battery voltage reaches to the presetting value of UTP making a short circuit on solar cells arrays. As the battery voltages reaches to presetting value of LTP, the solar cells arrays are reconnected to the battery and the power transistor returns to OFF state again. So the charging process is continuity once again.

2.3 Design of Proposed charger

The design of the proposed controller initiates by designing comparator circuit.

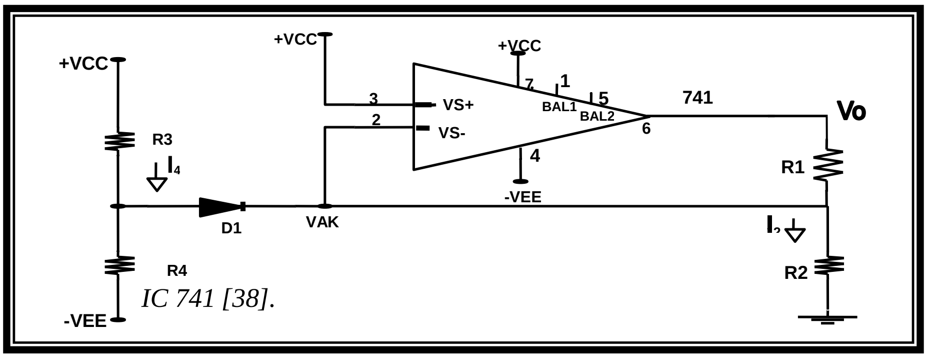


Figure (6): Instruction of the comparator circuit.

Figure 6 represents the construction of the comparator circuit designed using IC 741. The data required for designing the comparator elements are; UTP, LTP and the biasing voltage required for the IC 741. After that the following steps for the design are;

Let

$I_{biasing} = I_{biasmx} = 500$ nA

Where

$I_{biasing}$ = the current consumed by IC 741.

I_{biasmx} = the max. Value of IC biasing current.

For IC 741 used for the design where I_{biasmx} is the biasing current of the selected IC 741 and it obtains for its datasheet.

Select

$I_2 \geq I_{biasmx}$

$I_2 = 100\ I_{biasmx}$ ………………………………………………………………... (1)

Hence,

$R_2 = (UTP) / (I_2)$ …………………………………………………………………… .(2)

The value of R_1 is

$R_1 = (V_o - UTP) / (I_2)$ ……………………………………………………… (3)

Where;

R_1 = resistance connected to IC output.

UTP = upper trigger point

V_o = voltage output of IC 741 which is equal approximately (V_{cc}–1),

Where;

V_{cc} = voltage of biasing supply.

The values of R_3 and R_4 depend upon LTP which obtain as following;

$I_4 R_4 + V_{EE} = V_{DF} + LTP$ ………………………………………………………… (4)

Where;

I_4 = current passing through R_4 and R_5.

R_4 and R_5 = resistance connected to IC 741 input.

V_{EE} = negative value of the biasing supply voltage.

V_{DF} = forward voltage of the diode (D_1).

$R_4 = (V_{DF} + LTP – V_{EE}) / (I_4)$ ………………………………………………… (5)

Where

LTP = lower trigger point.

The value of R_4 is selected such that; it has a very large value than I_2

$I_4 = 100\ I_2$ …………………………………………………………………………… (6)

The design value of R_3 is calculated as,

$R_3 = (V_{CC} – V_{EE} – I_4 R_4) / (I_4)$ ………………………………………… … (7)

For selected values of UTP = 14 v and LTP = 12.5 v, V_{cc} = 15 v, V_{EE} = -15 v, the calculated values of comparator elements are written in the following table.

R_1 = 10 kΩ	R_3 = 1 kΩ
R_2 = 270 kΩ	R_4 = 5.6 kΩ

2.4 Design of Coupling Circuits

The buffer circuits are used for coupling the comparator circuit and the power transistor switches for safe operation of the whole circuits. The number of buffer circuits is determined by summation of load current and the maximum charging current of the battery.

The first stage of the circuit is considered as that connected with the load and battery. Hence, this stage is designed firstly as follows;

The circuit is considered as a normally off transistor circuit contains transistor Q_1, collector resistance R_{C1} and base resistance R_{b1}.

The collector resistance R_{C1} is determined as:

$R_{C1} = (V_{CC} – V_{CE1\ sat}) / (I_{C1})$ ……………….…………………………….. (8)

Where;

$R_{C!}$ = resistance connected to the collector of the transistor Q_1.

V_{CE1} = saturation voltage of collector emitter of Q_1,

I_{C1} = collector current of Q_1 which is obtained as:

$I_{C1} = I_{bc} + I_L$ ………………………………………………………………………. (9)

The base resistance of Q_1 is obtained as;

$R_{B1} = (V_{CC} – V_{BE1} – I_{B1}\, R_{C1}) / (I_{B1})$ ……………………………………….. .. (10)

Where;

V_{BE1} = voltage drop upon base emitter junction of Q_1,

I_{B1} = base current flow of Q_1 which is obtained as:

$I_{B1} = (I_{C1}) / (h_{FE\ min})$ ……………………………………………………. (11)

Where;

$h_{FE\ min}$ = minimum current amplification factor of transistor.

First coupling circuit is considered as a load to the second circuit. The last circuit of the coupling stages (second) is considered also as a normally off transistor circuit which contains transistor Q_2, R_{C2}, R_{B2}.

The remaining stages (third, fourth, fifth) are also considered as a normally off transistor circuits connected in cascade form. The general equations required for obtaining the design values of collector resistance, base resistance, collector current and base current of any stage is obtained as;

$R_{Cn} = (V_{CC} – V_{CE\ n\ sat}) / (I_{Cn})$ ……………………………………………… (12)

$R_{Bn} = (V_{CC} – V_{BEn} – I_{Bn}\, R_{(n+1)}) / (I_{Bn})$ ……………………………………… (13)

for n = 1 to 6

Ic_n must be selected such that:

$Ic_{(n+1)} >>> I_{Bn\ min}$

In the design this current is selected such that:

$Ic_{(n+1)} = 2\,(I_{B\ n\ min})$ ……………………………………………………… (14)

The base current of n stage is;

$I_{B\ n} = (Ic_n) / (h_{FE\ min\ n})$ ……………………………………………… (15)

for n = 1 to 6

The base current of the last stage must be selected such that it is very smaller than the 100 biased current of IC 741 this due to the fact that the coupling stage are considered as a load of IC 741.

The design of different stages change according to the collector current of each transistor. The ratings decrease as increasing of the stage number. For 12 v, 155 Ah, UTP = 14 v and LTP = 12.5 v lead acid battery .

The parameter of all stages of the coupling circuits are listed in the table 2 . The table represents the amplification factor, collector resistance, base resistance, collector current and the base current of each stage . Table 3 illustrates the ON/OFF conditions of all transistors in the coupling circuits .

Table (2): Parameter of Buffer Stages.

N	$h_{FE\ min\ n}$	Rc_n	$R_{B\ n}$	Ic_n	$I_{B\ n}$
1	5	1.7 Ω	5 Ω	10 A	2 A
2	15	2.5 Ω	27 Ω	8 A	1.6 A
3	25	20 Ω	220 Ω	4 A	0.267 A
4	25	118 Ω	2.7 kΩ	0.8 A	32 mA
5	25	1.5 kΩ	98 kΩ	96 mA	40 µA
6	100	74 kΩ	5.3 µΩ	8 mA	80 µA

Table(3): Condition and Type of Buffer Stages and Comparator Circuit O/P.

Buffer Stages	Comparator Condition		Type
	Positive	Negative	
Q_1	OFF	ON	BD911
Q_2	ON	OFF	BD911
Q_3	OFF	ON	BD135
Q_4	ON	OFF	BD135
Q_5	OFF	ON	2N3904
Q_6	ON	OFF	2N3904

2.5 Design of Snubber Circuit

Snubber circuit contains resistor R_S, capacitor C_S, and diode D. This circuit is used for protection purpose of the power switches. Figure 4.7 illustrates the circuit diagram of snubber circuit used.

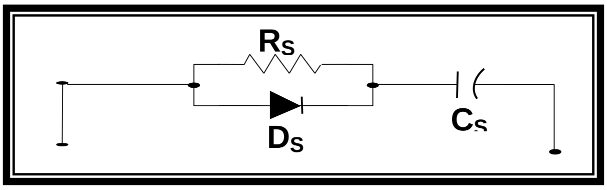


Figure (7): The Circuit Diagram of Snubber Circuit used

Using of this circuit limits the (dv / dt) across the collector emitter of the power switch. Resistance R_S is used to limit the discharging current of C_S through the power switch during on condition.

The design values of C_S and R_S are,

$C_S = (I_o\ T_f) / (2\ V_b)$ ………………………………………………………… (16)

Where;

C_S = Snubber capacitor.
I_o = collector current prior off condition of the transistor,
T_f = off time of the transistor.
V_b = battery voltage.

$R_S = (V_b) / (I_o)$ ………………………………………………………….. (17)

The design values of C_{S1} and R_{S1} under the previous condition are 200 µf and 4.3 kΩ for the first transistor stage Q_1. The design values of this circuit for Q_2 are C_{S2} = 100 µf and R_{S2} = 5.6 kΩ.

Before the design of charge controller begins the battery under control must be tested to define the UTP (upper trigger point).

The method for this test is as follows:

1- The battery initially must be discharged completely.
2- The battery is charged step by step and its current and voltage are monitored the charging process from suitable D.C. supply such as solar cell array.

3- The energy input to the battery is recorded during definite intervals at the instant of charging period.
4- The energy input to the battery during the different periods charging is accumulated.
5- As a cumulated energy reaches to the installed capacity of the battery, the battery voltage is represented by the battery UTP.

These steps must be accrued before begging of the charge controller design. In this paper the battery test is not illustrated but in another paper the test is carried out.

RESULTS AND DISCISSION

1-Testing of Proposed Charger :

The electronic element used for designing the charge controller represents in fig. 8 are;

- D1 is a blocking diode of type P/N junction.
- IC 741 used for detecting the battery voltage level during over charge condition.
- Resistors R_1:R_4 are designed for the detecting circuit for sharing the output and the input voltage of IC 741.
- group of interface transistor which are;
  - Q_1 of type BD911 is the load transistor.
  - Q_2 of the type BD911
  - Q_3 and Q_4 of the type BD135.
  - Q_5 and Q_6 of the type 2N 3904.
- Transistors Q_1 and Q_2 are a power transistor where Q_3 and Q_4 ,Q_5 and Q_6 are signal transistor.
- Resistors R_{C1} to R_{C6} are the collector resistor connect with the collectors of Q_1 to Q_6.
- Resistors R_{B1} to R_{B6} are resistor connect with the base of transistors Q_1 to Q_6.
- The circuit contains the elements D_{S1}, D_{S2}, and R_{S1}, R_{S2} and C_{S1},C_{S2} are snubber circuit designed for protecting the power transistor Q_1 and Q_2 against the rate of change of the voltage during OFF condition.
- D2 is a blocking diode prevents the reverse current from the battery during the ON condition of the transistor Q_1.

The proposed designed charge controller circuit is shown in Figure.8.

This Figure contains the previous three main circuits connected together. The conditions of all transistors at the collector terminal are as follows;

Q_6	Q_5	Q_4	Q_3	Q_2	Q_1
ON	OFF	ON	OFF	ON	OFF

Figures (.9 a, b, c, d, e and f) represent the state conditions of transistors Q_6, Q_5, Q_4, Q_3, Q_2, Q_1 which are obtained experimentally.

The battery begins discharge through the load connected. The discharging process proceeds also forward till the battery voltage reaches to the LTP. At this point the conditions of comparator and transistors return back to the first conditions show in Figures (.9 a, b, c, d, e and f). Hence, the SCA returns supply the whole system again.

The charging and discharging repeat continuously in an automatic sort at preset values of the UTP and LTP.

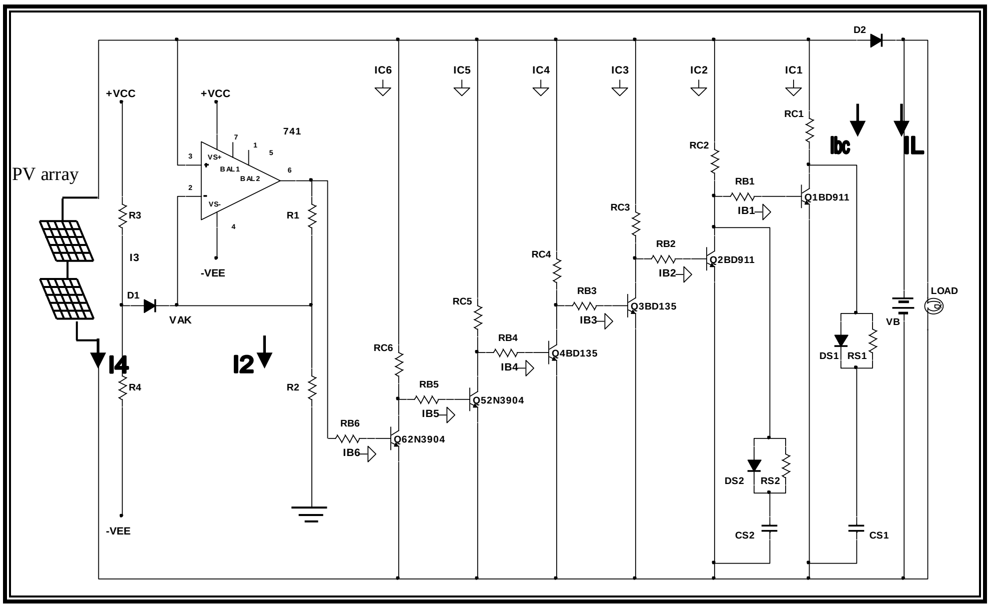


Figure (8): Topology of Charge Controller.

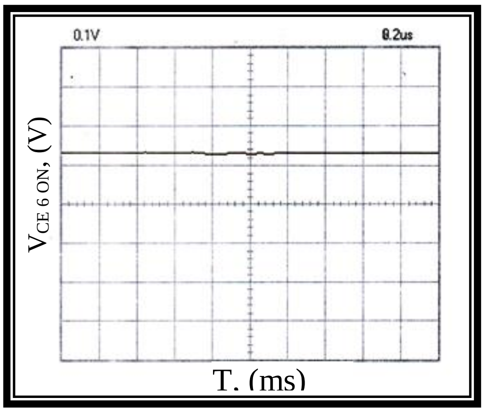
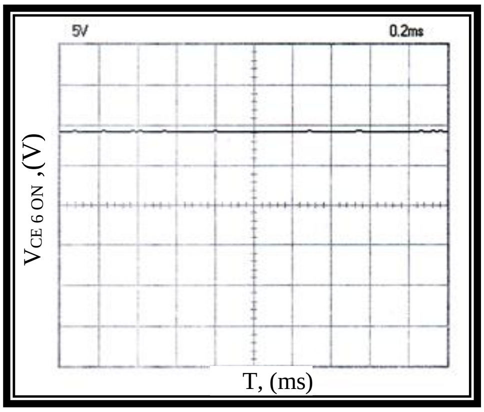
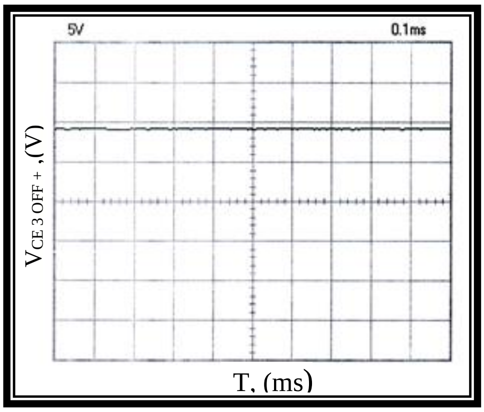


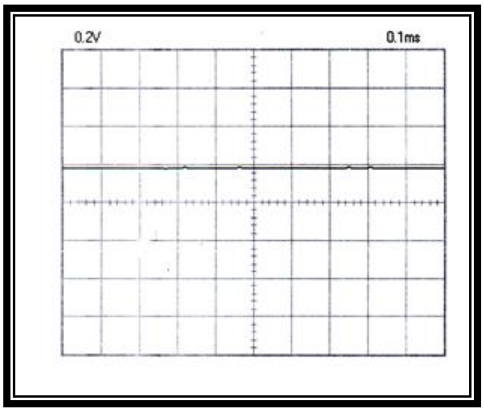
Figure (9a): Emitter-Collector Voltage of Interface Transistor Q6 at ON Condition.



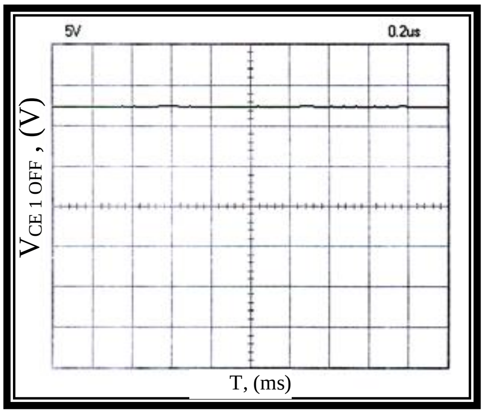
Figure(9b):Emitter-Collector Voltage of Interface Transistor Q5 at OFF Condition.



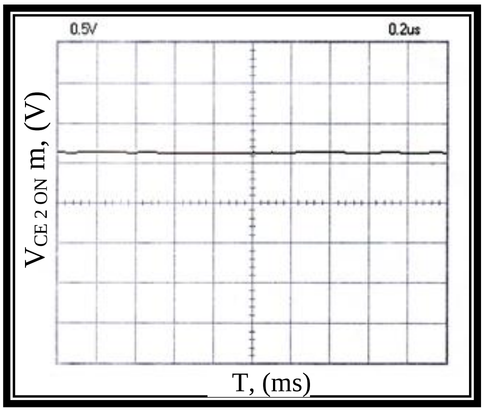
Figure(9c): Emitter-Collector Voltage of Interface Transistor Q4 at ON Condition



Figure(9d): Emitter-Collector Voltage of Interface Transistor Q3 at OFF Condition.

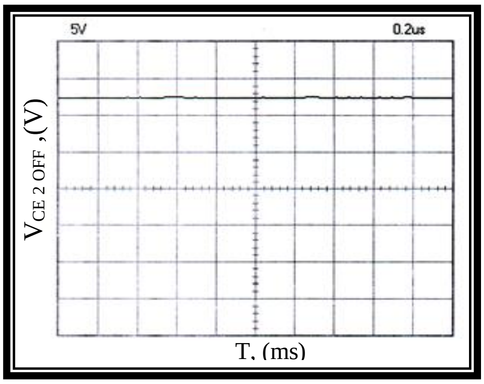


Figure(9e): Emitter-Collector Voltage of Interface Transistor Q2 at ON Condition

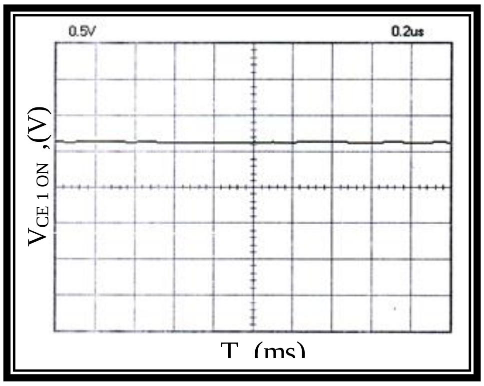


Figure(9f): Emitter-Collector Voltage of Interface Transistor Q1 at OFF Condition

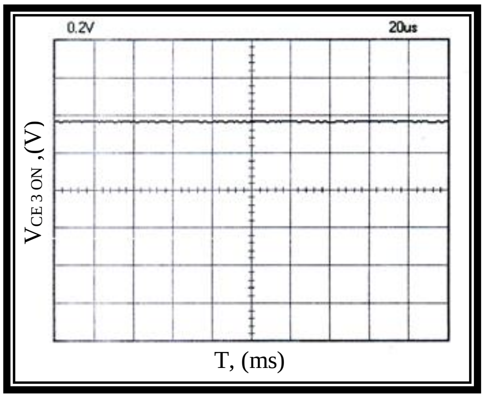
As Q_1 is in off state, the battery is charged from the SCA which is connected for powering the controller element, battery and the load. The charging process of the battery proceeds forward till its voltage reaches to the UTP. At this point conditions of the comparator and transistors are reversed as shown in Figures (10 a, b, c, d, e and f). Hence, Q_1 becomes ON and shorts the SCA.



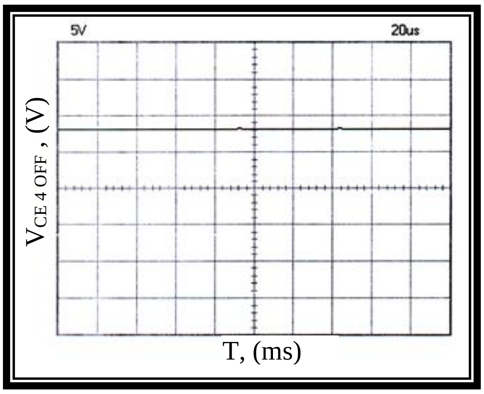
Figure(10a): Emitter-Collector Voltage of Load Transistor Q1 at ON Condition [recharge].



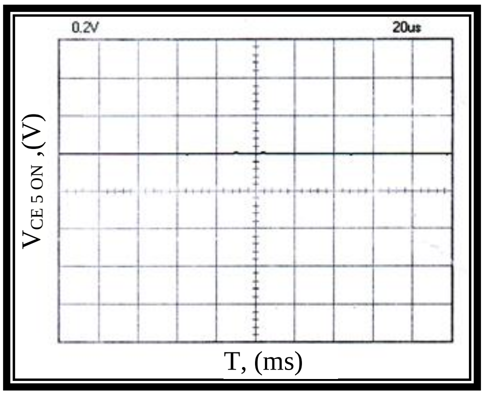
Figure(10b): Emitter-Collector Voltage of Load Transistor Q2 at OFF Condition [recharge].



Figure(10c): Emitter-Collector Voltage of Interface Transistor Q3 at ON Condition [recharge].



Figure(10d): Emitter-Collector Voltage of Interface Transistor Q4 at OFFCondition [recharge].



Figure(10e): Emitter-Collector Voltage of Interface Transistor Q5 at ON Condition [recharge].

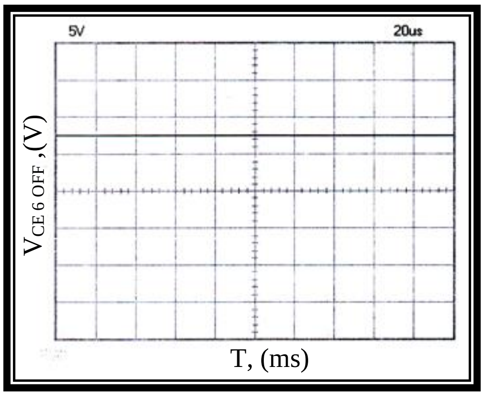


Figure (10f): Emitter-Collector Voltage of Interface Transistor Q6 at OFF Condition [recharge].

Consequently, the battery begins discharge through the load connected. The discharging process proceeds also forward till the battery voltage reaches to the LTP. At this point the conditions of comparator and transistors return back to the first conditions show in Figures (.9 a, b, c, d, e and f). Hence, the SCA returns supply the whole system again.

The charging and discharging repeat continuously in an automatic sort at preset values of the UTP and LTP.

Conclusions

This paper introduces proposed design of an automatic charge controller suitable for batteries connected with any power system and specially PVPS. These batteries have wide applications especially with agricultural equipments such as tractors, scrapers, loaders.........etc. The charge controller consists of three main circuits. The first one is the comparator designed according to limit the battery voltage between UTP and LTP. The second is the buffer circuits which are used for coupling the comparator circuit and the power transistor switches for safe operation of the whole circuits and the third circuit is the controller switch. An experimental test of the proposed charge controller is carried out. The results of the experimental test are illustrated and show the condition of the comparator and all transistors of the controller at different conditions of battery under control. The proposed controller designed is a kind of shunt controller. It can be used with different types of batteries

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نظام شحن الكترونى قابل للتحكم للبطاريات الحامضية ملائم للجرارات الزراعية بالمناطق النائية

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فى هذا البحث تم تصميم شاحن اوتوماتيكى للبطارية الحامضية ١٥٥أمبير ، ١٢ فولت. هذا النوع من البطاريات يستخدم على نطاق واسع فى المعدات الزراعية وخاصة الجرار الزراعى. حيث يتم شحن البطارية سالفة الذكر من مجموعة من الخلايا الشمسية عبارة عن مصفوفتين من الخلايا الشمسية مواصفات كل منهم ٧٥واط , ٢٠ فولت حيث ان الطاقة الناتجة من المصفوفتين تكون كافية لشحن البطارية للشحن الكامل. وتم شحن البطارية من خلال شاحن اوتوماتيكى مصمم لهذا الغرض. والنظام السابق مناسب جدا بالنسبة للمعدات الزراعية ومعدات الاستصلاح التى تعمل فى المناطق النائية وخاصة المناطق الصحراوية.

ويهدف البحث الى تصميم شاحن اوتاماتيكى يلائم شحن البطاريات الحامضية وبالاخص البطاريات الموصلة بالمعدات الزراعية كالجرارات واللوادر والحفارات ومعدات الاستصلاح . حيث يركب الشاحن المصمم على المعدة ويقوم بتنظيم شحن البطارية اثناء تشغيل المعدة . كما يمكن للشاحن ايضا ان يقوم بالشحن الاوتوماتيكى للبطارية فى حالة تلف او حدوث عطل بجهاز الشحن الخاص بالمعدة.

وترجع أهمية الشاحن الاتوماتيكى الى ان استخدامه يحافظ على البطارية من التلف وبالتالى يزيد عمرها الافتراضى حيث ان عملية اكسدة الالواح الفعالة تؤدى الى تحول الالواح الى مادة عازلة على أثرها تتلف البطارية ولا تقبل اعادة الشحن مرة اخرى بعد فترة وجيزة، ايضا يحافظ الشاحن على تنظيم جهد البطارية حيث يحافظ على ماء البطارية من التبخر. من هنا يتضح أهمية الشاحن الاتوماتيكى المقترح تصميمه فى هذا البحث. و الشاحن المقترح يوصل مع نظام الشحن فى الجرار إثناء تشغيله للمحافظة على شحن البطارية وكذلك أيضا على البطارية نفسها. كما انه عندما يراد اعادة الشحن للبطارية خارج نظام الشحن فى الجرار فانه يتم شحنها من مجموعة من الخلايا الشمسية الموصلة أيضا بالشاحن الاوتوماتيكى.

والشاحن المقترح تصميمه يحتوى على دائرة الكترونية وظيفتها الإحساس بقيمه الجهد الأعظم للبطارية ويقوم مصمم الشاحن المقترح باختيار هذه القيمة وهى قيمة الجهد الذى عنده تكون البطارية مشحونة بأقصى شحن ١٥٥أمبير ويقوم المصمم بتحديدها معمليا، و تحتوى دائرة الشاحن أيضا على مجموعة من الدوائر الالكترونية التى توصل دائرة الإحساس بترانزستور القوى (المفتاح).

ويحتوى الشاحن أيضا على مفتاح قوى الكترونى عبارة عن ترانزستور قوى وظيفته وصل وفصل البطارية عن الشاحن حيث يتم توصلها بالشاحن عندما يهبط جهدها عن قيمة الجهد الأعظم بمقدار معين (٠,٥ فولت) سمى بقيمة الجهد الأدنى المسموح بة. ويتم اختياره وتحديده من قبل مصمم الدائرة حيث يتوقف على الحمل المراد حمايته (البطارية). ويقوم مصمم الشاحن أيضا باختيار قيمة هذا الجهد معمليا. واذا ما اتصلت البطارية بالشاحن فان جهدها يعاود الزيادة مرة اخرى الى ان يصل الى قيمة الجهد الأعظم عندها يقوم الترانزستوربفصل البطارية عن الشاحن وهكذا من هنا فان عملية شحن البطارية تكون محكومة بين نقطتين يحددهم المصمم وهما قيمه الجهد الأعظم (UTP) ، قيمة الجهد الأدنى (LTP) التى لا تتجاوزه البطارية باى حال طول عمرها الافتراضى وبالتالى فان العمر الافتراضى للبطارية يزداد حيث يصل الى حوالى خمس سنوات.

اما بدون الشاحن الاوتوماتيكى المصمم فان عمر البطارية يقل الى اقل من شهر. من هنا يتضح اهمية وجود الشاحن الاتوماتيكى فى نظام شحن محكوم سواء مع نظام الشحن فى الجرار او خارجة.

فى هذا البحث تم عرض الخطوات التفصيلة لعملية الشحن وقد تم أيضا دراسة أداء الشاحن فى المعمل حيث تم تسجيل الأداء الكهربى لكل ترانزستور موجود فى الدائرة بما فيهم ترانزستور القوى وتم أيضا دراسة الأداء الكهربى فى المعمل لدائرة الإحساس المصممة حيث تبين الأداء الدقيق للشاحن ولكل مكوناته من نقطتي الجهد الأعظم والأدنى المختارين من قبل المصمم.