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DESIGN AND SIMULATION OF 3KW ELECTRICAL VEHICLE BATTERY CHARGER

Rohini Mali[1], Dr.Asha Shendge[2]
GHRIT, Electrical Department, Savitribai Phule University, Wagholi, Pune.

Abstract -
EV (Electrical Vehicle) on-board, single phase, ac charger used to charge the Li battery used in electrical vehicle. The conductive charger up-to 3kw power rating is designed and simulated. The charger consists of topology like rectification and dc-dc convertor. In first part ac is converted into dc by rectifier. Then DC is converted into required DC output by boost converter, to step up the voltage, to charge the Li-ion battery by the constant voltage method. For charger the closed loop is given by using PI controller to improve the output of charger.

Keywords— EV, Charger, Battery, Rectifier, Dc-dc convertor, Boost Convertor, PI Controller.

I. INTRODUCTION

The on-board ac charger of rating 3kw power is designed and simulated on MATLAB. [1] The charger topology has two parts. First is, the single phase 230V is step down to 60V. Then this AC voltage is converted into DC by rectification using universal full wave bridge rectifier. The voltage doubled circuit is added for doubling the voltage for PI controller.

The second part consists of DC-DC conversion. The boost convertor step -down or step up the voltage according to requirement. PI controller used to improve the steady state stability of voltage. The SoC of Li battery is considered to calculate the charging time required to charge the battery [2].

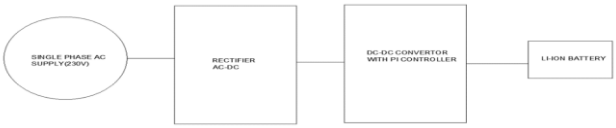

Fig.1: Block diagram of single-phase on-board battery charger

b) **Rectifier:** In the full-controlled bridge rectifier, the average DC load voltage is controlled using two diode per half-cycle. Diode D1 and D2 work together as a pair during the positive half-cycle, while D3 and D4 are also fired together as a pair during the negative half-cycle.[4][5]

1) Single phase full wave diode rectifier dc output voltage: $Vdc = 2Vm/\pi$

2) Single phase full wave diode rectifier dc output current:$I\,dc = 2Im/\pi$

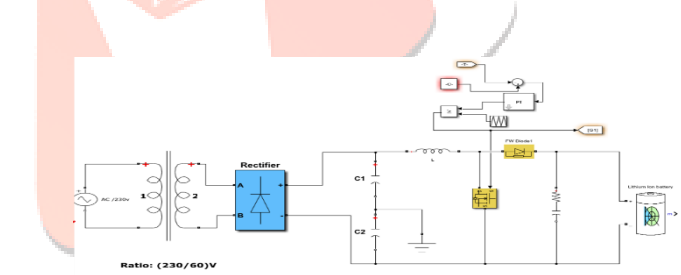

Fig 2: Circuit diagram of single-phase on-board battery charger.

I. AC TO DC RECTIFICATION

a) The step -down transformer is converted single phase 230v to 60v. [2][3]

Rating of transformer is 3VA+20% for overloading= 5KVA

c) Simulated Result for rectification:

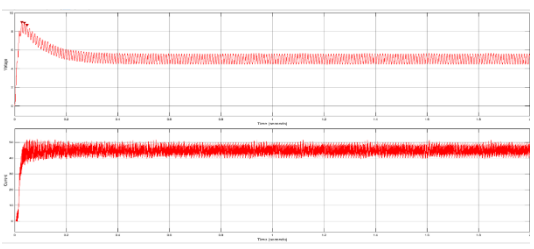

Fig.3: Circuit diagram for rectifier output

II. DC- DC CONVERTER

The dc converters can be used as switching mode regulators to convert a dc voltage, usually unregulated to a regulated dc output voltage. The regulation is normally achieved by PWM at a fixed frequency and the switching driver is normally MOSFET. The power regulator can be inductor based, switch-mode power converter.[6] **[7]**

DC-DC converter may be Boost, Buck or Buck-Boost Converter. Buck-boost regulator: A boost converter provides an output voltage that greater than the input voltage hence the name "boost". The boost converter in inverting techniques operates in ON and OFF state. The PWM generator used for 0-1 output with switching frequency 2500 rpm.[8][9]
PI controller for improve steady state, is gives feedback as control loop.[10]

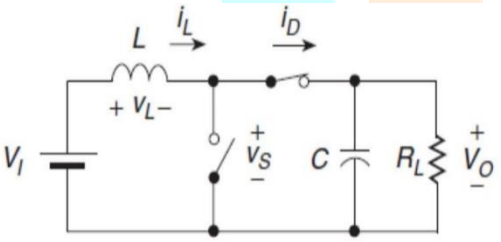

Fig. 4: Equivalent circuit when the switch is ON and the diode is OFF

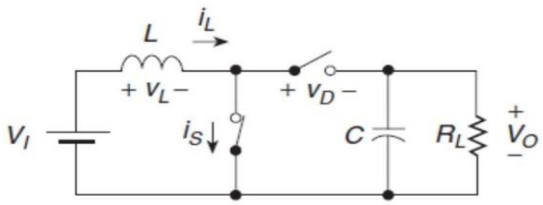

Fig.5: Equivalent circuit when the switch is OFF and the diode is ON

For steady state operation of the Boost converter, the inductor current is continuous and this is possible by selecting an appropriate value of L.

Duty cycle, for which switch should be on or off:

$$D = \frac{Ton}{T}$$

D can be varied from 0 to 1.

When, D = 0; V_o = 0. When D = 0.5, V_o = VS, When, D = 1, $V_o = \infty$.
Hence, in the interval $0 \le D \le 0.5$, output voltage varies in the range $0 \le V_O \le V_S$ and we get step down or Buck operation.
Whereas, in the interval $0.5 \le D \le 1$, output voltage varies in the range $V_S \le V_O \le \infty$ and we get step up or Boost operation. The output voltage is V0 and input voltage Vin, then,

$$V0 = \frac{Vi}{1 - D}$$

The value of inductor for operation,

$$Lmin = \frac{2}{27}\frac{Rlmax}{fs} = 925\mu H$$

The Li-Ion battery of 120V and 25ah used for proposed charger.

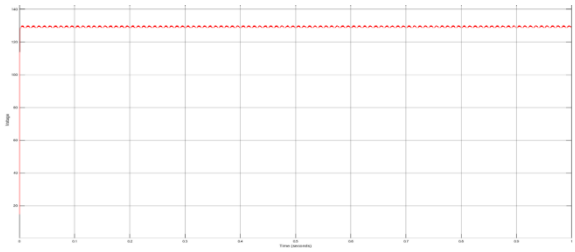

Fig.6: Simulation for Boost Converter for Output Voltage

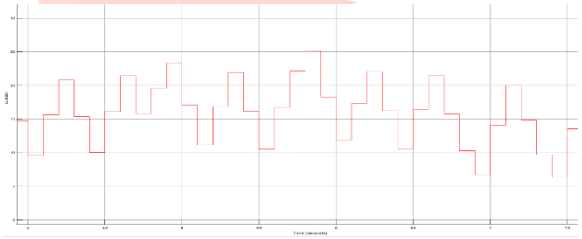

Fig.7: Simulation for Buck-Boost Converter for Output Current

TABLE 1: Charger Parameter Values

Parameter of Charger	Values
Input voltage	230V
Input Current	21A
Transformer Rating	5KVA
Rectifier Output Voltage, Current	65V,35A
The ripple frequency	100HZ
Capacitor Rating	1000 μF
Boost Convertor Output Voltage	130V

Boost Convertor Output Current	25A
Inductor of Convertor	925μ*H*
Li Battery	120V ,25ah
Full Charging Time Required for Battery	5-6Hours

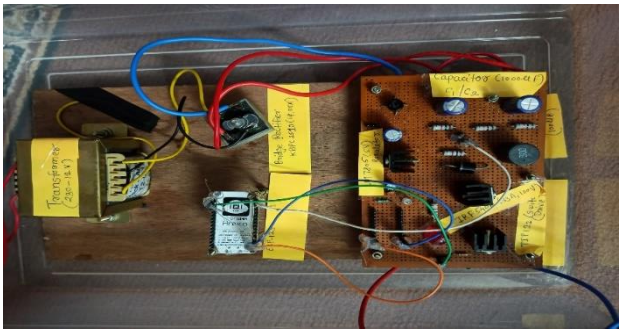

Fig.8: Hardware model for EV battery charger.

III. CONCLUSION

In this paper the single- phase ac charger of rating up-to 3kw is designed. The input voltage 230 V to 60Vstepped down. At the Boost convertor the output voltage is 120-130V and current value is 25A.The Lithium- ion battery is used as load. The SoC of battery is calculated from 0-100%. The charging time required to charge 100% of battery is 5-6hours.The proposed prototype is done for 100W for conveniency.

IV. FUTURE SCOPE

The Level 2 charger is used as charging station for commercial purpose. The 3kw charger have output current rating up-to 80A.The charger is un-isolated & smart charger can be designed for proper connection of charger to detect whether charger is plug in or not, current detection, etc.

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