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A NOVEL BATTERY CHARGER WITH CONSTANT CURRENT AND VOLTAGE CONTROL USING DIGITAL CONTROL TECHNIQUE

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ABSTRACT

A constant current charging control method for a battery charger is proposed in this project. The basic idea is to keep constant current charging by limiting the duty cycle of charger. Based upon the proposed constant current charging technique, a digital-controlled charger is designed in software. Moreover, when the battery voltage is increased to the preset voltage level using constant current charge, the charger changes the control mode to constant voltage charge. A digital-controlled charger is designed and implemented for battery charging applications. The charger control is based upon the proposed control method in software. Closed loop PID control is also provided to achieve the desired output voltage . Digital controlled battery charger consist of three stage. The first stage is a power factor correction rectifier used to transform the 50Hz electrical quantities into DC quantities with a good input power factor. The second stage is a fly back dc-dc converter which adjusts the levels to the value required by the battery and moreover provides a galvanic isolation.Third stage is digital control technique is used to maintain the constant current charging and voltage charging. The main objective of this project to maintaining the voltage and current as constant.The Simulation is done with the help of MATLAB Software using Simulink Experimental results demonstrate that the effectiveness of the design and implementation.

.**Keywords:** Charger, constant current charge, constant voltage charge

I. INTRODUCTION

Nowadays, rechargeable battery has been widely used in various kind of electronic device, such as portable devices, uninterrupted power supply (UPS) system, electrical vehicle, etc. Therefore, battery charger plays a very important role in recharging batteries efficiently and prolonging the battery life. Traditional chargers are controlled by analog controller, such as UC384x, L6561 . . . etc. control ICs; these controllers can regulate charge voltage and also perform current control. However, in analog controller, compensation parameters are composed of resistor and capacitors, where the components are highly dependent on temperature variation and with aging issues.

For digital control, the compensation parameters are implemented digitally, therefore, temperature and aging issues can be mitigated. Moreover, it has some advantages including implementing complex control methods robustness to noise, programmable compensator, short-time to market, and on-the-fly parameter tuning . Therefore, in this paper, a digital controlled charger is implemented to charge the batteries

A constant current charging control method for charger is proposed in this project. The basic idea is to keep constant current charging by limiting the duty cycle of charger. Based upon the proposed constant current charging technique, a digital-controlled charger is designed and control method in software. The proposed digital-controlled charger has been applied to an on-line UPS prototype Fig.1. Fully digital controlled battery charger.

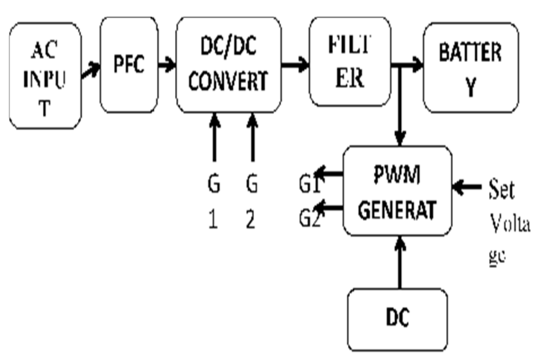

Fig.1 Fully digital controlled battery charger

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shows the digital-controlled charger (a fly back converter)with the proposed constant current charging technique .The charger consists of an input capacitor Cin, a high frequency transformer TR, a controlled power switch Q, a secondary rectifier diode D, a output capacitor Cout, voltage divide resistorsR1, R2, and batteries. The digital controller includes voltage controller, the proposed duty cycle limit controller, and digital PWM generator

.

II. THE PROPOSED BATTERY CHARGER

The proposed on-board charger is shown in Fig. 1.The proposed charger consists of a front end power factor correction converter and a second stage flyback converter dc-dc converter.

Circuit diagram for Digital Control Battery Charger:

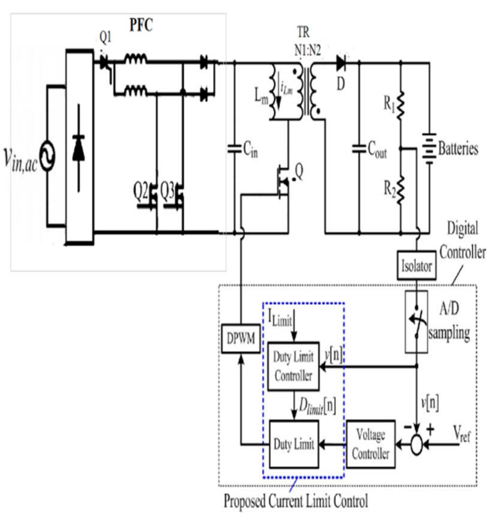

Fig.2. Circuit diagram for digital control battery charger

A. Front-End First Stage AC-DC PFC Rectifier

The interleaved PFC consists of two CCM boost converters in parallel, which operate 180° out of phase [15] –[16] .The input current is the sum of the inductor currents in LB1 and LB2. Since the inductor ripple currents are out of phase, they tend to cancel each other and reduce the input ripple current.

B. Second Stage fly back DC-DC Converter

The Fly-back converter is the most commonly used SMPS circuit for low output power applications where the output voltage needs to be isolated from the input main supply. The output power of fly-back type SMPS circuits may vary from few watts to less than 100 watts. The overall circuit topology of this converter is considerably simpler than other SMPS circuits. Input to the circuit is generally unregulated dc voltage obtained by rectifying the utility ac voltage followed by a simple capacitor filter. The circuit can offer single or multiple isolated output voltages and can operate over wide range of input voltage variation. In respect of energy-efficiency, fly-back power supplies are inferior to many other SMPS circuits but its simple topology and low cost makes it popular in low output power range.

C. Basic Topology of Fly-Back Converter

The basic topology of a fly-back circuit is shown in below. Input to the circuit may be unregulated dc voltage derived from the utility ac supply after rectification and some filtering. A fast switching device (‘S’), like a MOSFET, is used with fast dynamic control over switch duty ratio (ratio of ON time to switching time-period) to maintain the desired output voltage. The transformer, in Figure, is used for voltage isolation as well as for better matching between input and output voltage v and current requirements.

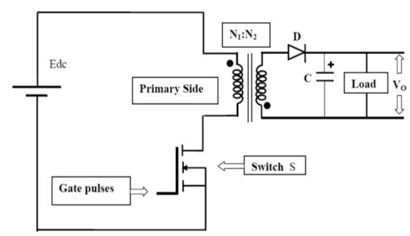

Fig. 3 Circuit diagram of Fly back Converter

The output section of the fly-back transformer, which consists of voltage rectification and filtering, is considerably simpler than in most other switched mode power supply circuits. The secondary winding voltage is rectified and filtered using just a diode and a capacitor. Voltage across this filter capacitor is the SMPS output voltage.

D . Principle of Operation

When switch ‘S’ is on, the primary winding of the transformer gets connected to the input supply with its dotted end connected to the positive side. At this time the diode ‘D’ connected in series with the secondary winding gets reverse biased due to the induced voltage in the secondary (dotted end potential being higher). Thus with the turning on of switch ‘S’, primary winding is able to carry current

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but current in the secondary winding is blocked due to the reverse biased diode. The flux established in the transformer core and linking the windings is entirely due to the primary winding current.

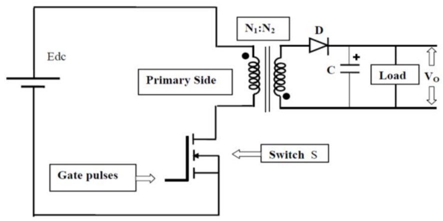

Fig.4. Fly back Converter

Mode-1 of circuit operation:

Figure shows the current carrying part of the circuit. In the equivalent circuit shown, the conducting switch or diode is taken as a shorted switch and the device that is not conducting is taken as an open switch. This representation of switch is in line with our assumption where the switches and diodes are assumed to have ideal nature, having zero voltage drop during conduction and zero leakage current during off state.

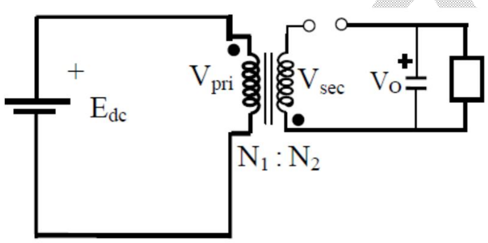

Fig 5.Mode 1 Equivalent Circuit

Mode-2 of circuit operation

When switch 'S' is turned off after conducting for some time. The primary winding current path is broken and according to laws of magnetic induction, the voltage polarities across the windings reverse. Reversal of voltage polarities makes the diode in the secondary circuit forward biased. The secondary winding current charges the output capacitor. The output capacitor is usually sufficiently large such that its voltage doesn't change appreciably in a single switching cycle but over a period of several cycles the capacitor voltage builds up to its steady state value. The secondary winding, while charging the output capacitor (and feeding the load), starts transferring energy from the magnetic field of the fly back transformer to the power supply output in electrical form. If the off period of the switch is kept large, the secondary current gets sufficient time to decay to zero and magnetic field energy is completely transferred to the output capacitor and load.

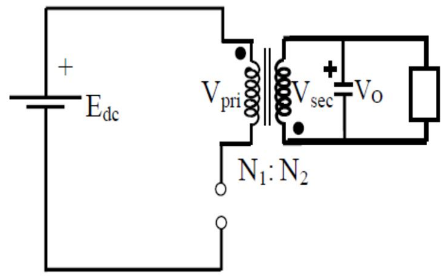

Fig.7. Mode 2 Equivalent Circuit

Mode-3 of circuit operation

Mode-3 ends with turn ON of switch 'S' and then the circuit again goes to Mode-1 and the sequence repeats. The two windings of the fly-back transformer don't conduct simultaneously they are still coupled magnetically (linking the same flux) and hence the induced voltages across the windings are proportional to their number of turns.

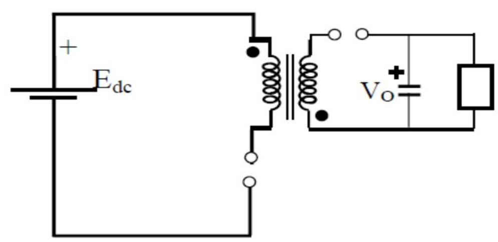

Fig 6.Mode 3 Equivalent Circuit

By solving the above two equations the voltages across C1 and C2 are obtained as

$$= \frac{\quad}{(1 - \quad)}$$

III DIGITAL CONTROLLER

To design the digital controller, a small signal model for charger is derived. Fig. 9 shows the small signal model without considering the battery model for charger operating in DCM[30]. Although the battery model is discussed in [31]–[33], the controller in the proposed charging technique only operates under constant voltage mode. In constant current mode, the controller is bypassed, and the duty is controlled by duty limit controller. Therefore, in this paper, the battery is modeled as a resistor with constant output voltage. As shown in Fig. 9, the model contains two dynamic elements; one is capacitor, and the other one is inductor. The current

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of inductor and voltage across capacitor are the state variable for modeling. Therefore, a second order model can be derived. However, the inductor pole is close to the switching frequency of charger. To design the digital controller, a small signal model for charger is derived. Although controller in the proposed charging technique only operates under constant voltage mode. In constant current mode, the controller is bypassed, and the duty is controlled by duty limit controller. Therefore, in this paper, the battery is modeled as a resistor with constant output voltage. The model contains two dynamic elements; one is capacitor, and the other one is inductor. The current of inductor and voltage\across capacitor are the state variable for modeling.

The PID and Pulse generation technique is used here; PID controller calculates an "error" value as the difference between a measured process variable and a desired set point.

The definition af proportional feed back control is still

$$u = K_P e \quad (1)$$

where

e = is the "error"

K_P = Proportional gain

The definition of the integral feed back is

$$u = K_I \int e \, d\tau \quad (2)$$

where KI is the integration gain factor.

In the PI controller we have a combination of P and I control, ie.:

$$u = K_P e + K_I \int e \, d\tau \quad (3)$$

$$u = K_P e + \frac{1}{\tau_I} \int e \, d\tau \quad (4)$$

$$u = K_P \left(e + \frac{1}{\tau_N} \int e \, d\tau \right) \quad (5)$$

where

τ_I = "Integration time" [s]

τ_N = "Reset time" [s]

The controller attempts to minimize the error by adjusting the process control inputs to achieve constant current and voltage charge.the output of the dc-dc converter is given to the controller .the cotroller provide perfect gate pulse tom the mosfet and maintaining the duty cycle below 33%.because controller provides the constant current and voltage charging to battery.

The Pulse Generator can emit scalar, vector, or matrix signals of any real data type. To cause the block to emit a scalar signal, use scalars to specify the waveform parameters.. Use the Pulse type parameter to specify whether the block's output is time-based or sample-based. If you select sample-based, the block computes its outputs at fixed intervals that you specify. If you select time-based, Simulink software computes the block's outputs only at times when the output actually changes. This choice can result in fewer computations for computing the block's output over the simulation time period.

IV. SIMULATION RESULTS

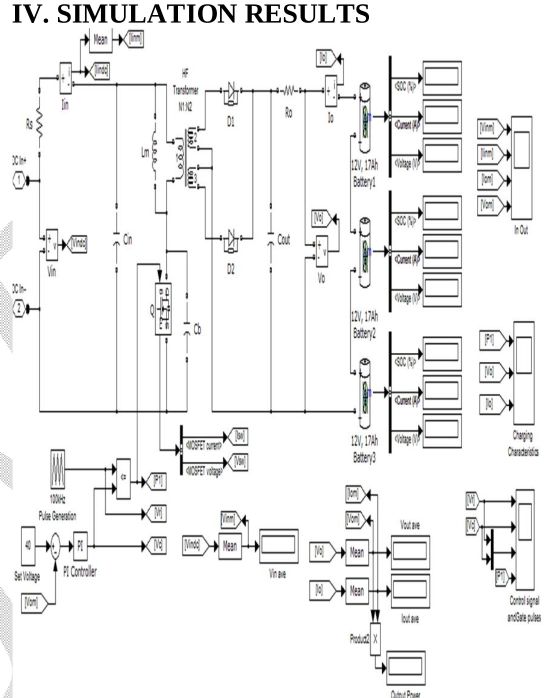

Fig.8. digital controlled battery charger

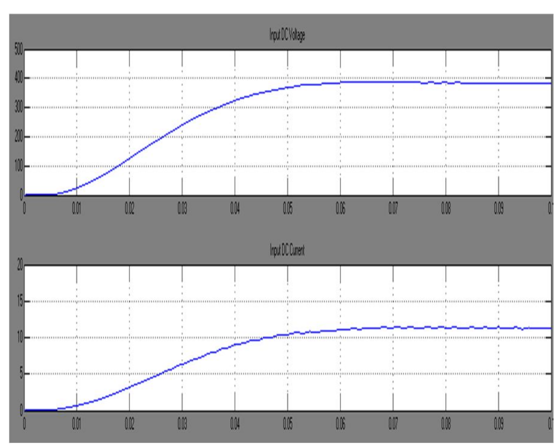

Fig.9. Input voltage and current waveforms

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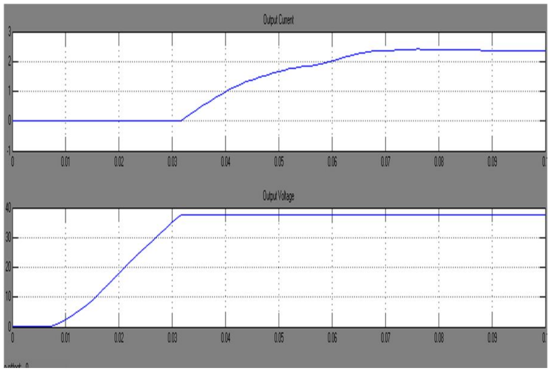

Fig.10.Output voltage and current waveforms

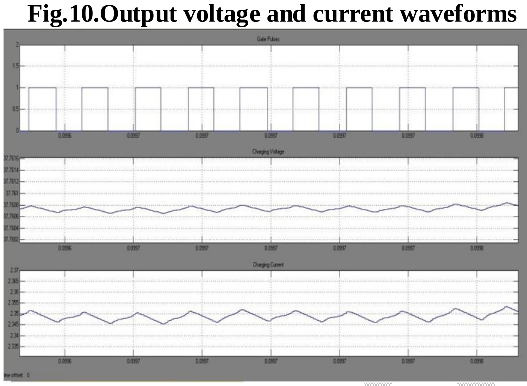

Fig.11.Control signal (pulse width modulation)

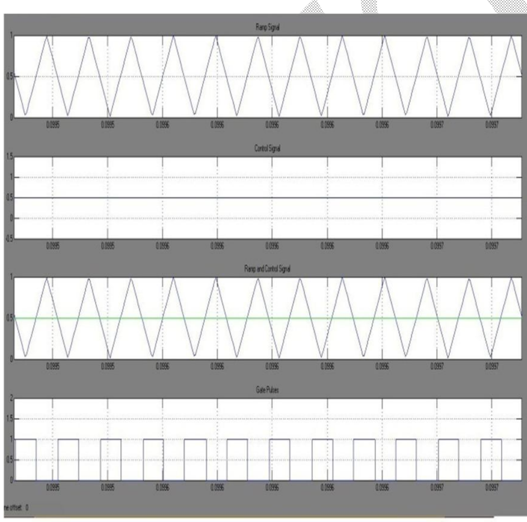

Fig.12.Gate signals for Battery charger

The simulink result shows the constant voltage and current charging without current feedback. The first stage is a power factor correction rectifier used to transform the 50Hz electrical quantities into DC quantities with a good input power factor. The second stage is a fly back dc-dc converter which adjusts the levels to the value required by the battery and moreover provides a galvanic isolation. the third stage is digital control technique is used to maintain the constant current charging and voltage charging. The main objective of this project The Simulation is done with the help of MATLAB Software using Simulink Experimental results demonstrate that the effectiveness of the design and implementation.finally we got the good power factor and effective battery charging with constant current and voltage charging.

V. CONCLUSIONS

Thus a battery charger is designed to get a constant current charging for UPS applications and the proposed topology is verified through simulation results. Through the simulation result, it can be applied to the renewable energy system and electrical vehicle using battery with high efficiency.

REFERENCES

- J. Rodríguez, J. Pontt, C. A. Silva, P. Correa, P. Lezana, P. Cortés, and U. Ammann, "Predictive current control of a voltage source inverter," *IEEE Trans. Ind. Electron.*, vol. 54, no. 1, pp. 495–503, Feb. 2007.
- Y. C. Chuang, Y. L. Ke, H. S. Chuang, and H. K. Chen, "Implementation and analysis of an improved series-loaded resonant DC-DC converter operating above resonance for battery chargers," *IEEE Trans. Ind. Appl.*,vol. 45, no. 3, pp. 1052–1059, May/Jun. 2009.
- M. B. Camara, H. Gualous, F. Gustin, A. Berthon, and B. Dakyo, "dc/dc converter design for supercapacitor and battery power management in hybrid vehicle applications-polynomial control strategy," *IEEE Trans. Ind.Electron.*, vol. 57, no. 2, pp. 587–597, Feb. 2010.
- Y. C. Chuang, "High-efficiency ZCS buck converter for rechargeablebatteries," *IEEE Trans. Ind. Electron.*, vol. 57, no. 7, pp. 2463–2472,Jul. 2010.
- P. A. Cassani and S. S. Williamson, "Design, testing, and validation of a simplified control scheme for a novel plug-in hybrid electric vehicle battery chager.