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Dual Mode Low Power Smart Charger For Rural Areas

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ABSTRACT

This paper deals with the design & analysis of the Smart battery charger specifically designed for rural areas. The design and performance analysis of a power factor corrected(PFC), single switch forward buck converter is carried out for low power battery charging applications. The battery charger are low cost, fast charging, high power factor, high efficiency, minimum ripple and high reliability. The converter with the help of an isolated single switch forward buck converter topology operating at discontinuous mode.

Keywords: Single switch, Isolated forward Converter, DCM operation, Power factor, Efficiency.

1. INTRODUCTION

The idea about this project came to my mind when I last month visited to my native village. There I face many difficulties due to limited electricity supply. Although we have electricity connection and also solar panel installed but there functioning is too challenging to handle.

The main constraints in villages are availability of electricity which is very variable and unreliable. To overcome this problem solar power system has been developed. But it becomes costly for heavy load since there is a need of excess backup capacity. Secondly, due to fluctuating weather condition makes the system vulnerable to power outage. Here our specially designed Smart Power Solution system appears as a salvation. This smart power system is such that it will either work on solar panel or from local power distribution which is available. In case of both are available solar power is given preference.

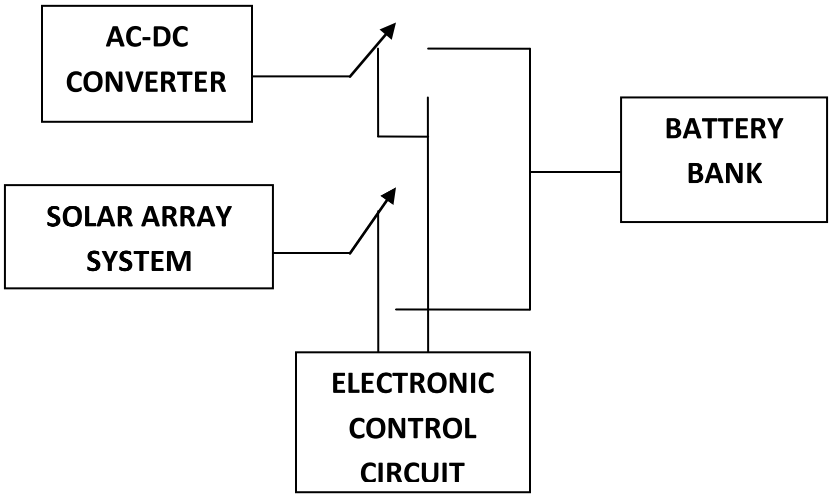

Fig.1:- Blocks of Smart Power System

1. TECHNICAL ASPECTS

The key issue in the design of power system is to keep the efficiency of charger very high and current distortion low even at very low charging or load current. Due to fluctuation of charging current with change in solar radiation and also due to change in impedance of the battery with the change in its state of charge there will be a difficulty arise in solar charging. Idea of a low power single switch high power factor AC-DC converter is proposed to overcome first complexity. Single switch forward buck converter topology with operation in discontinuous mode (DCM) is designed for converter and developed to achieve self power-factor correction in voltage follower mode. Secondly with implementation of tri-state charging, so that the battery bank should charged optimally by solar power by giving it priority with help of a programmed microcontroller.

The developed Power system is inherited with efficiency and reliability. It has high power factor with low currents and hence meets the regularity requirement of emission standards. By matching the charging current with change in impedance associated with charging stage, we charge the battery bank to its utmost capacity.

The circuit of Smart Charger developed here is equipped with single switch forward buck converter in DCM (Discontinuous Conduction Mode) to maximize efficiency and enhance power factor. In DCM voltage follower approach is applied for the PWM control of the converter, which needs output voltage sensing only. The output voltage regulation is provided by the feedback loop as shown in fig. below, where the o/p voltage detected V_{oref} and the error is amplified in a proportional integrator controller which is compared.

The converter consists of AC power source (V_{in}) input, EMI filter of Inductors (L_f) and Capacitor (C_f), Full Wave Rectifier (FWR), high frequency transformer having two primary windings N_1 & N_3, one secondary winding N_2, high frequency diodes D_1, D_2 and Dr, output filter of inductor Lo and capacitor Co. To reduce the ripple in the input current and power factor correction an additional input filter is added. The value of input filter should be small as a large value of input capacitor distorts the input current waveform. The reason behind is that reactive energy of capacitor C_f cannot be feedback to input supply in presence of one-directional diode bridge and hence input current becomes discontinuous. The role of third demagnetizing winding N_3 and diode Dr is very important because in a practical forward converter, the transformer magnetizing current must be selected for the proper converter otherwise the converter will failed due to energy stored in the transformer core.

The output voltage regulation is provided by the feedback loop where the output sensing voltage Vo is compared with a reference V_{oref} Value and the error is amplified in a proportional integral (PI) controller which is compared with a saw-tooth ramp Vs, thus providing the pulses to power switch. Hence the circuit is controlled by the change of on-time interval and constant switching frequency f_s.

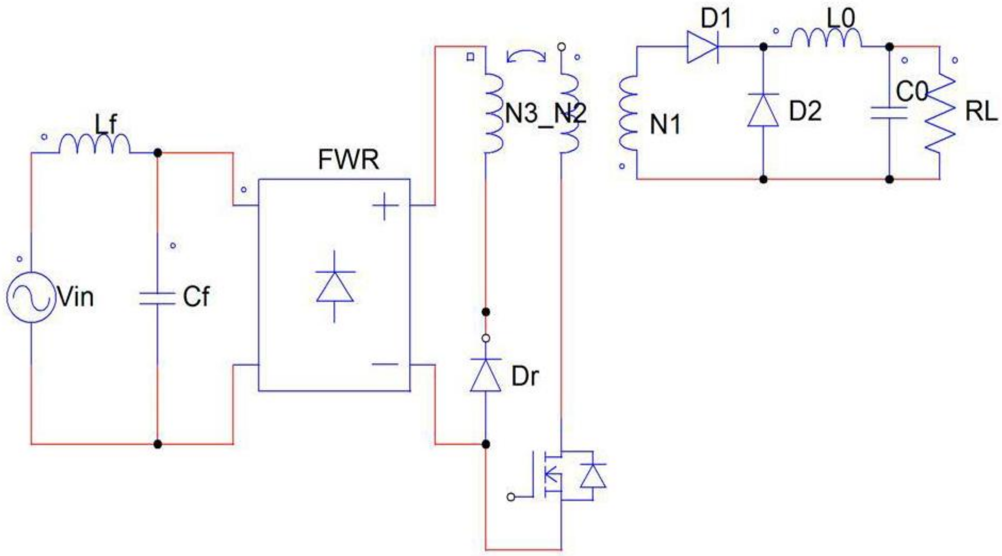

Fig. 2:- Practical Isolated Single Switch Forward Buck Converter

The data collected after different simulation and experiments on PSIM platform, are satisfactory and performance of our proposed converter has been improved. The observation shows the power factor at AC input mains is 0.986 and full load efficiency order of 82.6%.

Tri-state charging method is used for maximizing the extraction of available solar energy for fulfillment of second criterion. In first state, the battery is charged at maximum solar current till the battery voltages reaches first threshold voltage. In next state the charging current is in burst of pulses where the time between two bursts increases with increase in state of charge of battery thus the charging current is in burst of pulses where the time between two bursts increases with increases in state of charge of battery thus the charging current matches change in impedance of battery bank. The tristate charging process is shown in fig.3 below

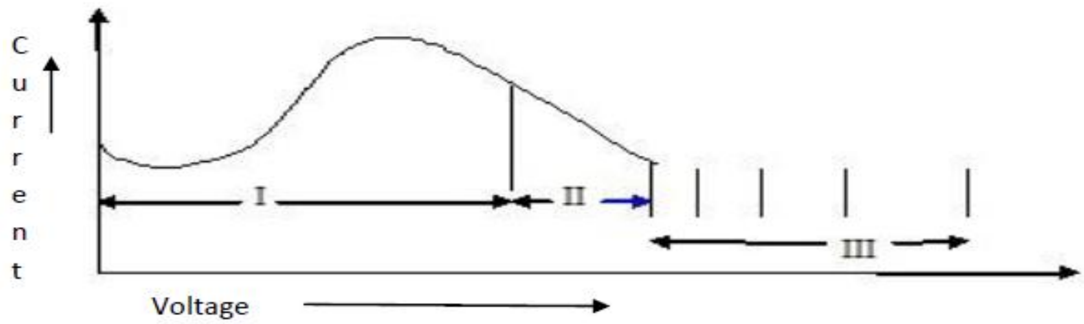

Figure 3:- Tristate Charging

Using a 16bit INTEL80196 µC the designing will be done according to the hour of need. Inbuilt A/D converters will measure the change in charging current, battery voltage to estimate change in state of charge (SOC) of battery bank. The digital input detects the availability of AC mains or solar power and gives precedence to solar charging if both are present. When solar power is not sufficient and battery bank capacity is below certain threshold then the charging current is made up by supplementary charging current from mains.

4. CONCLUSIONS

The simulated and experimental results shows the developed charger is highly efficient and meets the regulatory requirement of emission standards since it has high power factor with low current harmonics.

It also meets green product criteria as it gives precedence to renewable energy source and charge battery bank to its utmost capacity by matching the charging current to change in impedance according to charging state.

5. REFERENCES

[1] P.R.K. Chetty, "*Switch-Mode Power Supply Design*", BPB Publications ,1987.

[2] B.K. Bose, *"Recent advances in power electronics*", IEEE Trans. On Power Electronics, Vol.7,No.1, pp. 2~16,Jan.1992.

[3] Bhim Singh and Ganesh Dutt Chaturvedi, "*Analysis, Design and Development of a Single Switch Flyback Buck-Boost AC-DC Converter for Low Power Charging Applications*", Journal of Power Electronics, Vol. 7, No. 4, October2007.

[4] *IEEE Guide for harmonic control and reactive compensation of Static Power Converters* IEEE standards 519-1992.

[5] *Limits for harmonic current emissions,* International Electrotechnical Commission Standards 61000-3-2, 2004.

[6] R. Navaneethan, E. Annie Elisabeth Jebaseel I, "*A Single Phase Ac-Dc Converter With Improved Power Factor And Harmonic Reduction",* IJTEEER, Vol.2, Issue 3.