Journal of Advances and Scholarly Researches in Allied Education
Vol. 13, Issue No. 2, July-2017, ISSN 2230-7540

Operation of Transformer Less On-Line UPS using Sinusodial Pluse with Modulation (SPWM) Technique and Its Simulation

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Abstract – In 21st century static uninterruptable power supply systems are very commonly used. They have a very wide variety of applications in low, medium and high power like as modern computer, CNC and VMC machinery and textile machinery. UPS is becoming more popular because its efficiency is higher; comparatively lower total harmonic distortion and reliable operation. This paper presents the operation and its results of simulation using software tool of Transformer less On-line UPS.

Keywords: Transformer, Uninterruptible Power Supplies, Power Electronic Converters, Rectifiers, Integrated Converters, Battery Charger, Inverters

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I. INTRODUCTION

An Inverter section of a high-performance single-phase transformer-less online uninterruptible power supply is implemented. The UPS is composed of a four-leg-type converter, which operates as a rectifier, a battery charger and discharger, and an inverter. The battery charger and discharger eliminate the need for the transformer and the increase of the number of batteries and supplies the power demanded by the load to the DC-link capacitor in the event of the input-power failure or abrupt decrease of the input voltage. The inverter provides a regulated sinusoidal output voltage to the load. By utilizing the battery charger/discharger, the overall efficiency of the system is improved, and the size, weight, and cost of the system are significantly reduced.

UPS systems are generally used to supply clean and continues power to censorious loads, such as medical equipment, computers, defense systems, etc. as usage of this critical load is increasing, if they are interrupted because of power failure, they may cause certain accidents. This problem can be solved by using UPS systems. UPS system generally has following features: low change over time from online mode to backup mode, low THD, regulated output voltage, high efficiency.

II. OPERATION OF TRNASFORMER LESS ON-LINE UPS

The operation of the proposed UPS can be divided into three modes: the online mode, the backup mode, and the bypass mode. When the DC-link voltage is detected as a normal voltage, the online mode is started. The battery charger/discharger operates as a buck converter while charging the battery. The upper switch S3 of the battery charging/discharging leg are independently controlled by the PWM strategy. The lower switch S4 is consistently turned off in this mode, and the body diode of the switch S4 is conducted for the inductor current ib to be freewheeling.

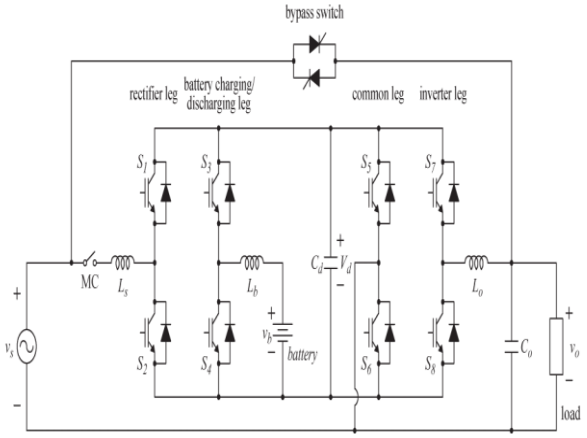

Figure 1. Transformer less On-Line UPS

The operation of the rectifier and inverter in the online mode is divided into four modes. Modes 1 and 2 show the flow of current and switching states during the positive half cycle of the input voltage, respectively. Modes 3 and 4 occur during the negative half cycle. Since the common leg is

switched by the polarity of the input voltage, the switch S6 is consistently turned on during the positive cycle of the input voltage. On the contrary, the switch S5 is turned on during the negative cycle of the input voltage. In Mode 1, the switches S2 and S6 are turned on. The input voltage is applied to the inductor Ls. Thus, the inductor current increases in a positive direction, and the magnetic energy is stored in Ls. In accordance with the switching states of the unipolar PWM strategy in the inverter leg, Modes 1a and 1b are determined. Since the switch S7 is turned on in the Mode 1a, the DC-link voltage Vd is applied to the load, and the output current Io flows through the load. On the other hand, the switch S8 is turned on in the Mode 1b. Hence, a zero voltage is applied to the load, and the output current is freewheeling through S6 and S8. In Mode 2, the switch S2 is turned off, and the switch S1 is turned on. The stored energy in Ls is transferred to the DC-link capacitor Cd. Since the positive voltage Vd is applied to the load, the DC-link capacitor is discharged, and the output current Io flows through the load. In Mode 2b, zero voltage is applied to the load and the output current is freewheeling, as in Mode 1b. Similarly, Modes 3 and 4 show the operation modes during the negative half cycle of the input voltage.

In case of the instantaneous decrease of the DC-link voltage due to the input power failure or abrupt decrease of the input voltage, the backup mode is started. The battery charger/discharger operates as a boost converter and supplies the power demanded by load to the DC-link capacitor Cd. The lower switch S4 of the battery charging/discharging leg is independently controlled by the PWM strategy. The upper switch S3 is consistently turned off in this mode, and the body diode of the switch S3 is conducted to supply power to the DC-link capacitor. The inverter leg is switched with the unipolar PWM strategy, as in the online mode. The operation is straightforward. In the event of an internal malfunction or an overload, the bypass mode is started. The bypass switch is turned on, and the power demanded by the load is directly supplied from the utility line.

III. SIMULATION AND RESULTS

A simulation model of the combined system is shown in Fig.2; where one leg works as a rectifier and one works as battery charging and discharging circuit; one will operate as common leg for both rectifier as well as inverter and one leg will act as inverter.

A. Inverter Control of Combined System

In inverter control, the actual output voltage is compared with reference voltage and error is generated; this error is given to the PI controller block so that it is reduced to zero. The output of PI controller is multiplied with sine wave and compared with triangular wave, thus generating SPWM.

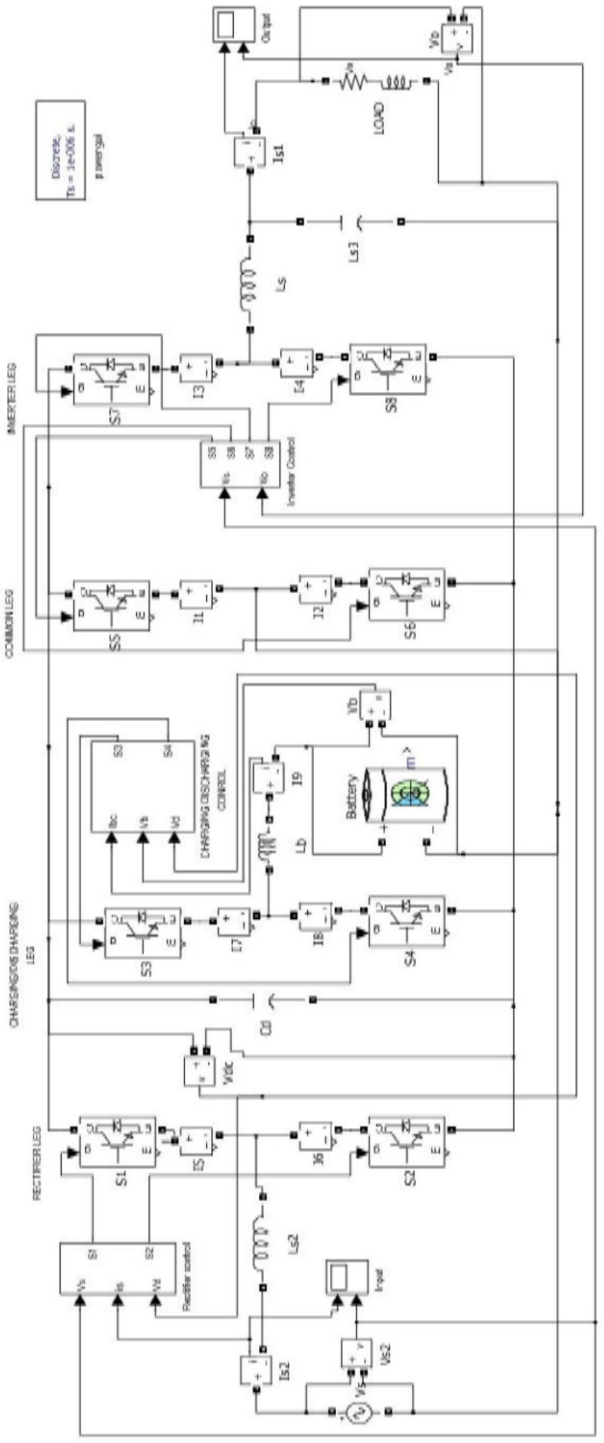

Figure 2. Combined System

Similarly, a square wave is generated by comparing sine wave with zero. Now, performing 'AND' operation of that SPWM with a square pulse of positive half cycle's, SPWM for positive half is obtained and similarlyfor the negative half cycle. Fig 3 shows inverter control of the combined system.

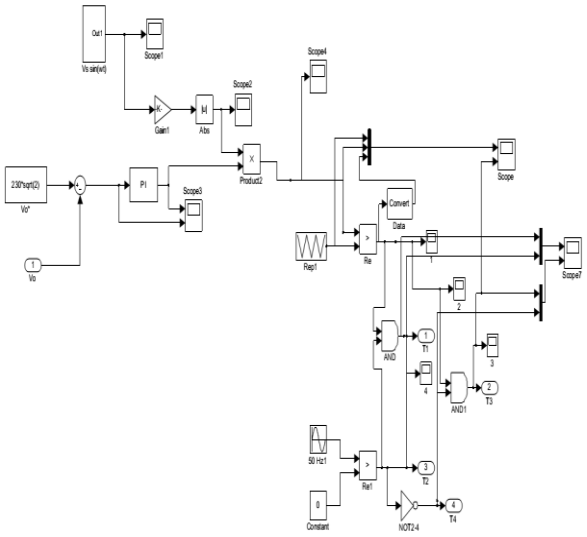

Figure 3. Inverter Control of Combined System

B. Battery Charging and Discharging Control of Combined System

In a combined system, the operation of battery charging and discharging will remain the same as a standalone system. Here, DC link voltage is continuously sensed and according to that, charging or discharging section of battery will operate. If the battery is discharged to some level, then by sensing the battery voltage, it will charge again through DC link voltage. Here, one added feature is that, in order to prevent frequent charging of battery, if the battery gets discharged below some level, only then will it charge. And in the discharging of battery,in order to stop its frequent discharge, a few conditions are given; that if the DC link voltage falls below one level, then only it will discharge and if supply voltage itself goes below one level or it is cut off, then only battery will discharge. This provision in charging and discharging of battery is provided to prevent frequent use of battery and thus this helps improve the life of the battery. Fig.4 shows control of battery charging and discharging circuit.

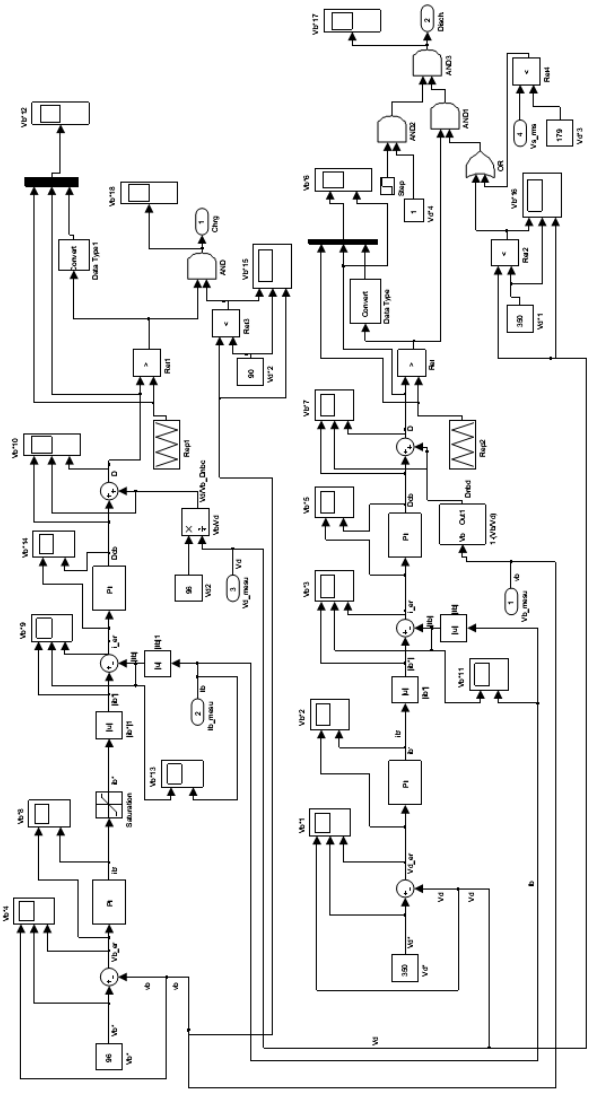

Figure 4. Battery Charging and Discharging Control of Combined System

C. Result of Combined System

The complete system is now operated by combining all the subcomponents. The main input supply voltage given to the combined system and the obtained output voltage waveform when resistive load is connected. Fig. 5 shows input voltage and Fig.6 shows output voltage.

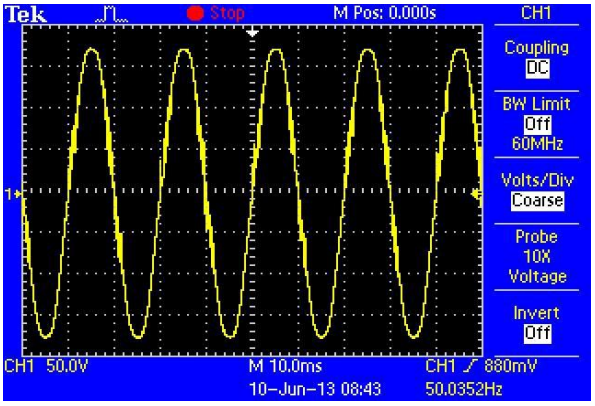

Figure 5. Input Voltage Waveform

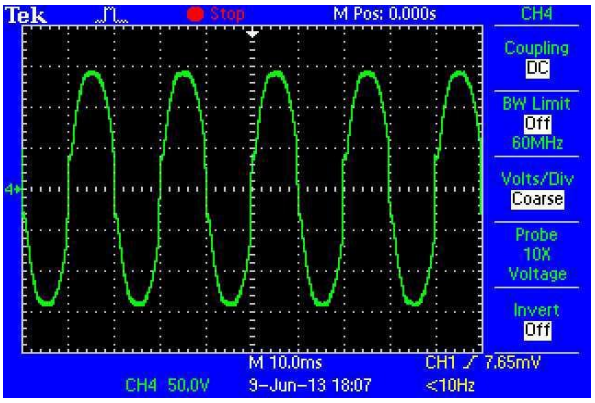

Figure 6. Output Voltage Waveform

IV. CONCLUSION

Simulation of the standalone inverter section and battery charging and discharging process is carried out and comprehensive results are obtained. By utilizing the battery charger/ discharger, the overall efficiency of the system is improved, and the size, weight, and cost of the system can be significantly reduced. The inverter is independently operated regardless of the line condition, and the UPS transfers uninterrupted power to the load.

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