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A Low Cost Boost Converter Design for Mini Telecommunication Tower's UPS

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Abstract: This paper presents a low cost DC-DC converter design for uninterruptible power supply for Mini Telecommunication Tower (MTT) utilizing solar power as its main energy source. The proposed design is based on boost topology switched mode power supply with a simple voltage control mode controller but maintain good efficiency in its operation. This converter is set to operate at high switching frequency in order to produce a decent and high power-to-volume ratio design. Passive low pass filter is implemented to produce a very low ripple output voltage in the design. Experimental results show that the proposed converter interacts very well with the constructed choke design. Output voltage is regulated at 48V and switching frequency is set at 30 kHz to minimize the switching stress and conduction losses. Practical implementation of the converter shows that the converter operates effectively using commercial 18V solar panel and only produces 20mVp-p ripple output voltage which is considered good for a regulated DC output.

Keywords: Boost Converter, UPS, MOSFETs, Low Ripple, Regulated DC

I. INTRODUCTION

Nowadays, the telecommunication development around the world shows a very huge success. We witness a rapid development in the technology used and the increasing number of subscribers together with the service providers. Thus, reliable uninterruptable power supply for telecommunication station is very critical in order to maintain an interruptible and continuous transmission. Commonly, the main power supply for the station is delivered from the national grid and backed up by the fossil fuel generator [1]. However, catastrophic phenomena like flood, earthquake and tsunami will isolate the station from the national grid and totally shut down the transceiver operation. In rural areas where access to national grid is very limited added with uneven earth topology, alternative sources must be obtained to provide a stable power source. For now, fossil fuel generator provides the backup power supply for almost all telecommunication systems. With the higher cost of fossil fuel and unstable market price, there is major need to integrate alternative sources as stable backup power supply while at the same time reducing the operation cost. In this design, renewable energy which is solar power has been chosen as the alternative source to provide a stable yet inexpensive uninterruptable power supply for 48V mini telecommunication tower targeted for 2G signal transmission. The photovoltaic panels will be used to charge the battery bank storage rated at 12VDC. The battery bank will then become the main input power to power the UPS for the telecommunication tower. Finally, the DC-DC converter will convert the 12V to 48V for the transceiver system to operate in interruptible and continuous operation.

II. DESIGN AND CONSTRUCTION OF CONVERTER CIRCUIT

In this design, boost topology is chosen as the best topology to be used because it is highly practical for the application with output power less than 150W [2,3]. Furthermore, the construction can be made simple because no isolation is needed to isolate the input and output. The typical efficiency is also good which is more than 80% and it is also the cheapest to manufacture compared to other PWM topologies [4,5]. Table 1 shows the black box parameters for determining the minimum inductance value for the choke design.

Table 1 Converter parameters

Input voltage, V_{in}	12 Volt
Output voltage, V_{out}	48 Volt
Output Current, I_{out}	1 Ampere
Switching frequency, f_{sw}	30 kHz
Efficiency, η	80%

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The first parameter that need to be determined is the maximum duty cycle, D_{max} based on the converter parameters value in Table 1. This value will set the effectiveness of the converter in order to generate the desired output voltage, V_{out} during operation.

Maximum duty cycle, $D_{max} = 1 - \frac{Vin * \eta}{Vout} = 0.8$

For a simple and reliable controller design based on the maximum duty cycle calculated, SG3524 is selected as the driver circuit to control the power switch. This controller IC is able to produce switching frequency up to 300kHz and a 0.9 combined duty cycle which is adequate to work in the proposed design. Assuming maximum ripple conduction current of 20%,

Ripple current, $\Delta I_L = 0.2 * I_{out} \frac{Vout}{vin} = 0.8A_{p-p}$

Minimum inductance value, $L_{min} = \frac{Vin\,(Vout - Vin)}{\Delta I_L * f_{sw} * Vout} = 375uH$

An inductor (1433445) with rating of 330uH and capable of handling maximum current of 4.5A is ordered from a vendor to be integrated in the boost converter.

The minimum output filter capacitance, C_{out} is calculated to smoothing the final DC output waveform.
Assuming the maximum ripple of the output voltage of 5%,

Minimum output filter capacitance, $C_{out} = \frac{I_{out} * D_{max}}{f_{sw} * V_{ripp}} = 533uF$

Fig 1 shows the complete schematic design of the boost converter using the calculated parameter values.

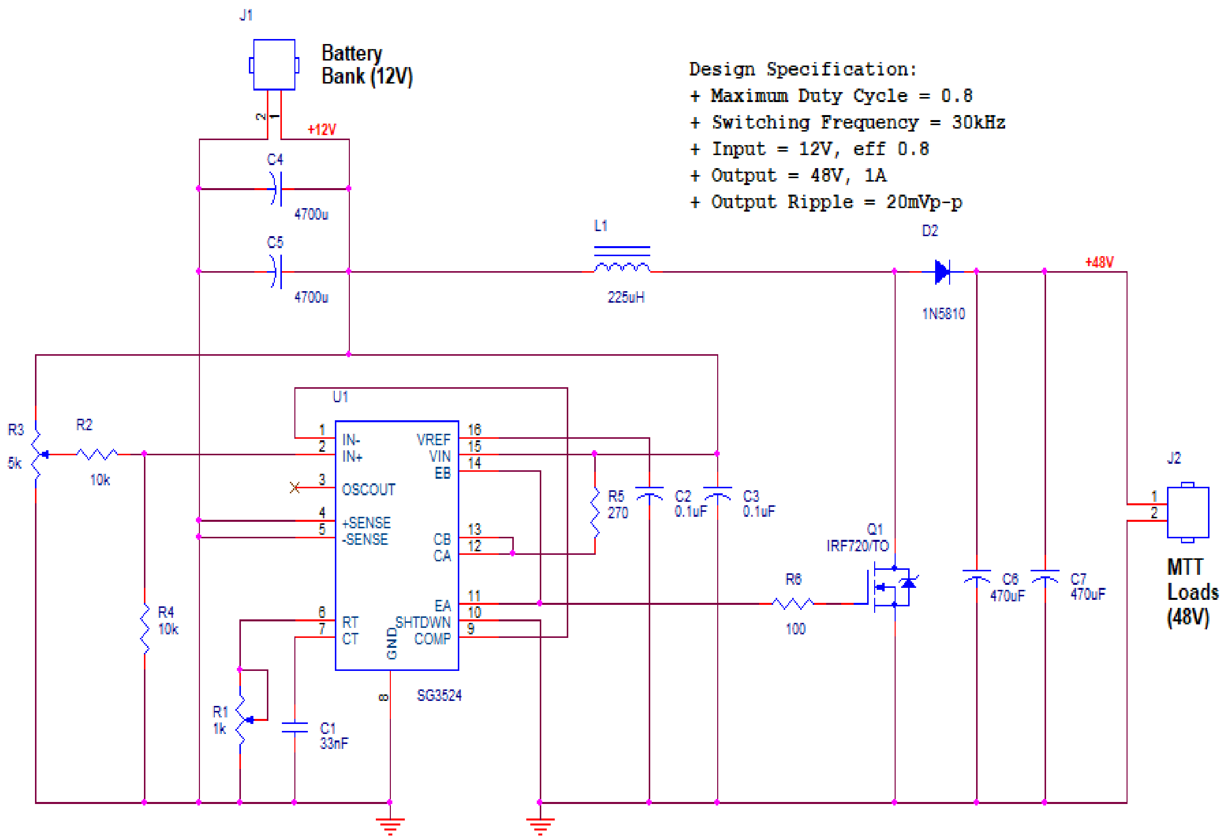

Fig 1 UPS Boost Converter Schematic Circuit

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III. EXPERIMENTAL RESULTS

The gate drive control signal of the controller circuit is generated from commercial IC SG3524 as shown in Fig 2. Using this IC, the switching frequency is set at 30 kHz with duty cycle fixed at 80%. A smooth pulse voltage is produced and then inputted to the gate of the power switch IRF720.

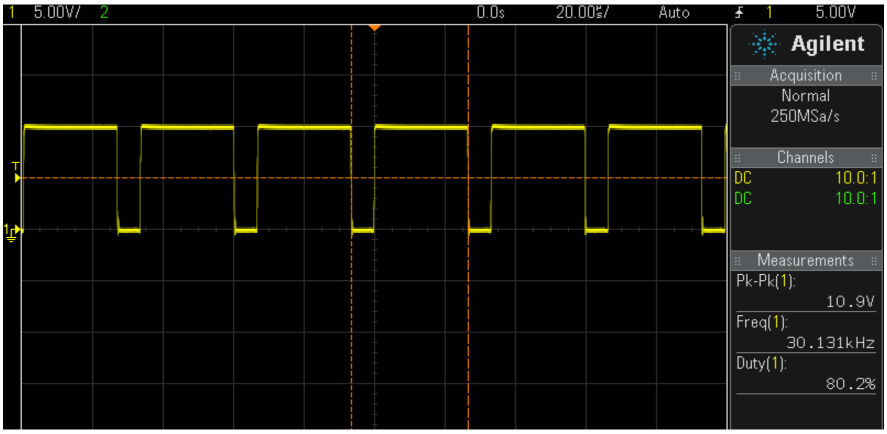

Fig 2 Gate drive control signals for power switch. (Scales: 5V/div; 20µs/div).

Fig 3 shows the waveform at the choke during operation. The waveform shows a clean and steady chopped output voltage without any undesirable spiking. The inductance produces a slightly higher output voltage before it will be rectified using 1N5810 rectifier diode.

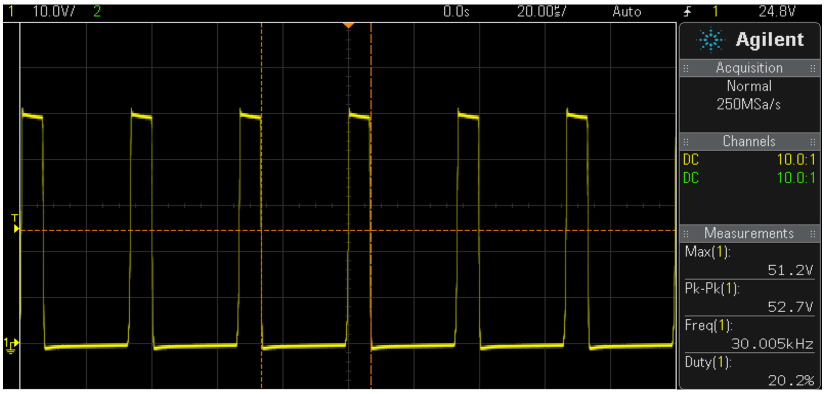

Fig 3 Chopped waveform at boost converter choke (Scales: 10V/div; 20µs/div).

Fig 4 shows the 48V regulated DC voltage after filtering using low pass filter without any surge or disturbances at all. Clearly the constructed design able to produce a smooth 48V with the desired 5% output ripple. The converter also operates steadily at 48V, 1A when it is tested using dummy load. Fig 5 shows the fabricated UPS converter for the mini telecommunication tower.

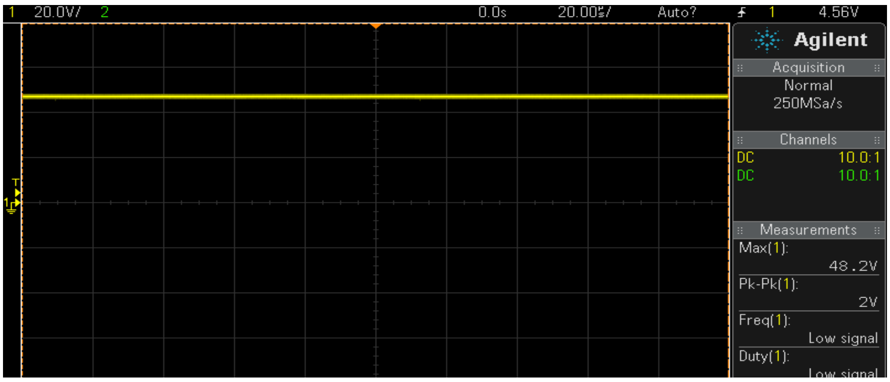

Fig 4 48V Regulated DC output waveform (Scales: 20V/div; 20µs/div).

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Fig 5 Final fabricated UPS boost converter

IV. CONCLUSION

A practical and inexpensive UPS for mini telecommunication tower can be constructed using conventional boost topology and a simple controller circuit. In this design, a reliable UPS converter has been successfully constructed to power a mini telecommunication tower using 48VDC feed supply system.

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