ISOLATED UNIDIRECTIONAL FULL-BRIDGE DC-DC CONVERTER WITH SNUBBER CIRCUIT

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***Abstract*— An isolated bidirectional full-bridge dc–dc converter with high conversion ratio, high output power, and soft start-up capability is proposed in this paper. The use of a capacitor and diode can clamp the voltage spike caused by the current difference between the current-fed inductor and leakage inductance of the isolation transformer. It can reduce the current flowing through the active switches at the current-fed side. Operational principle of the proposed converter is first described, the design equation is derived. A 1.5-kW prototype with low-side voltage of 48 V and high-side voltage of 360 V has been implemented, from which results have been verified using MATLAB/Simulink Software.**

***Index Terms*—Flyback converter, isolated full-bridge Unidirectional converter, soft start-up.**

I. INTRODUCTION

Power quality is the set of limits of electrical properties that allows electrical systems to function in their intended manner without significant loss of performance or life. The term is used to describe electric power that drives an electrical load and the load's ability to function properly with that electric power. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power. The quality of electrical power may be described as a set of values of parameters, such as: 1. Continuity of service 2.Variation in voltage magnitude 3.Transient voltages and currents 4. Harmonic content in the waveforms for AC power Whether it's a factory, a bank, a hospital, the market or simply your home, the one problem common to all of these location is "electrical pollution" sudden short duration, high amplitude disturbances in the normal voltage levels across power lines are called voltage transients [1].

Transient voltage is a term often used to describe these extremely short lived bursts of high voltage electricity found in almost all electrical system. Although lightning causes some of the transients, most are caused by the switching on and off of internal and external loads and occur regularly on any power system. On residential 120VAC lines, these voltage transients can peak momentarily at many thousands of voltage when caused by lightning and at several thousand volts when caused by switching. With the age of electronics upon us, "transient voltage is a problem". No matter how much care is taken by the power companies to supply with clean electrical power, the fact remains that simple variables such as load switching and florescent lighting can and will cause transient voltage problems. These high voltage power surges are almost always present when power is restored to a dead line and immediately following the voltage drop.

Transient voltage is transmitted to all parts of the building via electrical wiring. Transients (spikes or surges) can be generated any time when there is a change in current flow demand or a load shift. The random cycling of motors, energizing or de-energizing of transformers and motor circuits and power source faults create havoc with the electrical system, even such routine things as turning on and off light switch can cause a vast amount of voltage transients. An Active Gate Signaling scheme to reduce voltage/current spikes across insulated gate power switches in hard switching power electronic circuits. Voltage and/or current spikes may cause EMI noise. In addition, they increase voltage/current stress on the switch. Traditionally, a higher gate resistance is chosen to reduce voltage/current spikes. Since the switching loss will increase remarkably, an active gate voltage control scheme is developed to improve efficiency of hard switching circuits while the undesirable voltage and/or current spikes are minimized. The main objective of the project is to suppress the voltage transients. In a DC-DC converter the voltage transients are produced by the current difference between the current fed inductor and the leakage inductance of the transformer [2]. This voltage transients produced in the circuit may affect the switches or the load. To reduce this RCD snubber circuit is used.

Isolated full bridge dc-dc converter is used for medium and high power application. It is an alternative source of electrical energy. The snubber can alleviate the voltage spike caused by the current difference between the current-fed inductor and leakage inductance of the isolation transformer, and can reduce the current flowing through the active switches at the current fed side [3]. An active gate voltage control scheme is developed to improve efficiency of hard switching circuits while the undesirable voltage and/or current spikes are minimized. The output voltage regulation in the DC-DC converters is achieved by continuously adjusting the amount of energy absorbed from the source and that injected in the load which in turn can be achieved by the time intervals of energy absorption and energy injection in the circuit.

II. POWER QUALITY ISSUES

Common power quality disturbances include surges, spikes and sags in power source voltage and harmonics or

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noise on the power line. Each of these occurrences is discussed briefly below. Surge is a rapid short-term increase in voltage. Surges often are caused when high power demand devices such as air conditioners turn off and the extra voltage is dissipated through the power line. Since sensitive electronic devices require a constant voltage, surges stress delicate components and cause premature failure. Spike is an extremely high and nearly instantaneous increase in voltage with a very short duration measured in microseconds. Spikes are often caused by lightning or by events such as power coming back on after an outage. A spike can damage or destroy sensitive electronic equipment. Turn the equipment off during a power outage. Wait a few minutes after power is restored before turning it on, and then turn on one device at a time. Transients are very short duration (sub-cycle) events of varying amplitude. Often referred to as "surges", transients are probably most frequently visualized as the tens of thousands of volts from a lighting strike that destroys any electrical device in its path. Transients can be caused by equipment operation or failure or by weather phenomena like lightning. Even relatively low voltage transients can cause damage to electrical components if the occur with any frequency. A properly sized industrial-grade surge suppressor is usually ample protection from the damaging effects of high voltage transients.

III. DC-DC CONVERTER

The first problem is that there’s a practical limit on how much you can reduce the ripple voltage. Unregulated supplies are used whenever small size and/or low cost are the primary design goals. Therefore, the filter cap ends up being on the small side, so all practical unregulated supplies put out a significant amount of ripple [7]-[9]. The other main problem is that an unregulated power supply simply puts out an analog of the AC input voltage as DC: any variation on the AC side is directly translated into DC variation. 120V AC to 20V DC power supply depicted above, and that there’s a brownout that drops the wall voltage to 108VAC. Because the transformer puts out 1/6 the input voltage no matter what that is, the power supply will put out 18V as long as the brownout lasts. The same sort of thing happens if your wall power has hash or voltage spikes on it: the ugliness appears on the power supply’s output, albeit in a reduced form.

IV. SYSTEM DESIGNAND SIMULATION

1. The conduction losses in the rectifier are the same for conventional PWM and ZVS PWM.

$$P_{rect} = 4(I_{out} / 2V_f) \tag{1}$$

V_f is the forward drop for the rectifier diodes, assuming that a full bridge rectifier is used.

2. The conduction losses on the primary bridge diodes are.

$$P_D = V_{diode} I_{av} \tag{2}$$

V_{diode} is the forward voltage drop on the diodes and Iav is the average current.

3. The conduction losses due to channel resistance of the switches can be calculated as

$$P_Q = R_{on} I_{rms} \tag{3}$$

The formula used to find the parameters of the components used in circuit are as follows

$$\begin{aligned} L &= V_0 / F\Delta I \\ I_0 &= V_0 / R \\ P_0 &= 2V_0 / R \\ E_1 &= 4.44 N_1 \phi f \\ E_2 &= 4.44 N_2 \phi f \end{aligned} \tag{4}$$

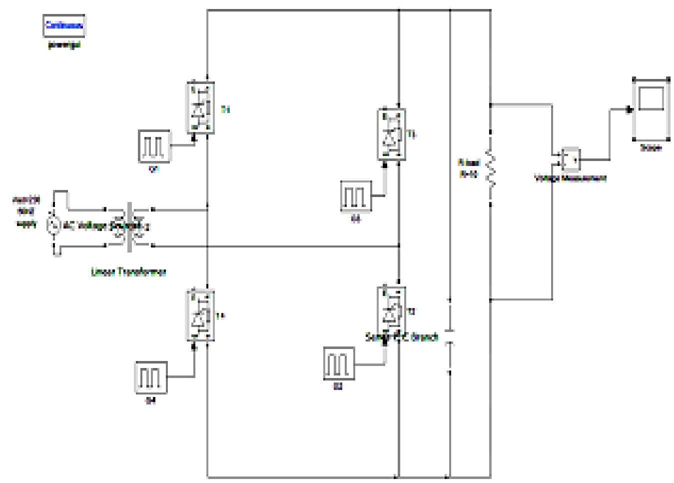

Fig 1 Rectifier Circuit

The Fig 1 shows the rectifier circuit. The full wave bridge rectifier is designed to convert an AC sine wave to full wave pulsating DC. The bridge is normally connected to the secondary of the transformer. Current will flow from the point with the higher potential to the point of lower potential. The input given to our Circuit is 12V DC. Here the rectifier circuit is used to convert the 230V AC to 12V DC. The operation of the rectifier circuit is 230V AC supply is stepped down into 12VAC.the output from the transformer is given to the full bridge rectifier. This then filtered and 12V unregulated DC is obtained [11]-[12].

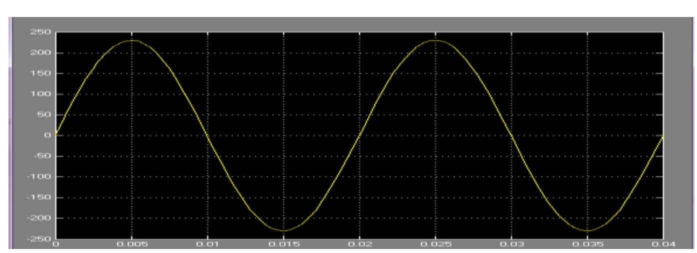

Fig 2. Input Waveform of Rectifier circuit

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The Fig 2 shows the input waveform. The single phase AC supply is 230V 50 Hz is given to the rectifier circuit.

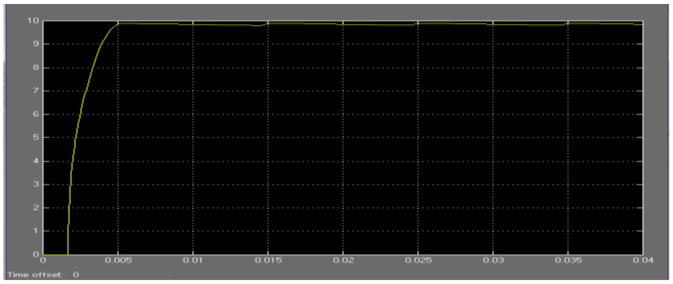

Fig 3 Output waveform of Rectifier Circuit

The Fig 3 shows the output waveform of the rectifier circuit. In the DC-DC converter we require 12V as the input so the 230V AC is rectified to 12V DC.

1. FULL BRIDGE DC-DC CONVERTER

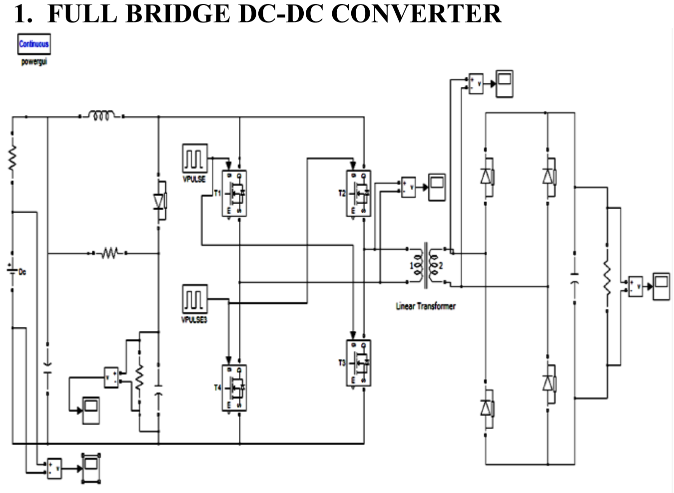

Fig 4 DC-DC Converter

The Fig 4 shows DC-DC converters. The DC-DC converters are electronic devices used whenever we want to change DC electrical power efficiently from one voltage level to another. They.re needed because unlike AC, DC can't simply be stepped up or down using a transformer. In many ways, a DC-DC converter is the DC equivalent of a transformer.

An important point to remember about all DC-DC converters is that like a transformer, they essentially just change the input energy into a different impedance level. So whatever the output voltage level, the output power all comes from the input; there is no energy manufactured inside the converter. The basic power flow in a converter is represented with this equation:

$$P_{in} = P_{out} + P_{losses} \quad (5)$$

Where Pin is the power fed into the converter, P_{out} is the output power and P_{losses} is the power wasted inside the converter. Of course if we had a .perfect. Converter, it would behave in the same way as a perfect transformer. There would be no losses, and Pout would be exactly the same as Pin.

$$V_{in} x I_{in} = V_{out} x I_{out} \quad (6)$$

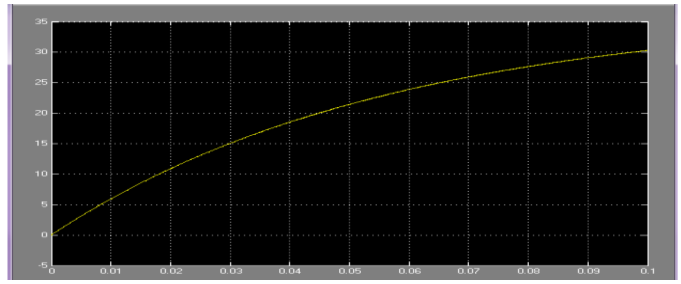

Fig 5 Output Waveform of DC-DC Converter

The Fig 5 shows the output waveform of DC-DC Converter. The unregulated DC voltage is converted in to regulated DC voltage and also stepped up to three times of the input voltage.

IV. CONCLUSION

In this paper, zero voltage switching, controller based DC-DC converter with snubber circuit is simulated and implemented. The snubber can alleviate the voltage spike caused by the current difference between the current-fed inductor and leakage inductance of the isolation transformer, and can reduce the current flowing through the active switches at the current fed side. Since the current does not circulate through the full-bridge switches, their current stresses can be reduced dramatically under heavy-load condition, thus improving system reliability significantly. The snubber can be also controlled to achieve a soft start-up feature. It has been successful in suppressing inrush current which is usually found in a start-up transition. Since the current level varies with load condition, it is hard to tune the switching timing diagram to match these two currents. Thus, a passive or an active clamp circuit is still needed

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