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Wind Energy Based Single Stage Three Level Isolated AC/DC PFC Converter

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Abstract: ***A power supply is an electronic device that supplies electric energy to an electrical load. The primary function of a power supply is to convert one form of electrical energy to another and, as a result, power supplies are sometimes referred to as electric power converters. A switched-mode power supply is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, it transfers power from a source, like mains power, to a load, such as a personal computer, while converting voltage and current characteristics. Some DC power supplies use AC mains electricity as an energy source. Such power supplies will sometimes employ a transformer to convert the input voltage to a higher or lower AC voltage. A rectifier is used to convert the transformer output voltage to a varying DC voltage, which in turn is passed through an electronic filter to convert it to an unregulated DC voltage. In this paper we implement a prototype of Cost Effective Single stage Three level Isolated AC/DC PFC Converter. The converter topology is very simple, and this method of control used to achieve both power factor correction and AC-DC conversion. Converter operation is explained and power factor is improved in this paper. Finally the efficiency of the new converter is compared with that of previously proposed converter.***

Keywords: ***AC–DC power conversion, Single-stage power factor correction (SSPFC), Three-level converters, PSM (Phase Shift Modulation).***

Introduction:

Power supplies are categorized in various ways, including by functional features. For example, a regulated power supply is one that maintains constant output voltage or current despite variations in load current or input voltage. Conversely, the output of an unregulated power supply can change significantly when its input voltage or load current changes. Adjustable power supplies allow the output voltage or current to be programmed by mechanical controls (e.g., knobs on the power supply front panel), or by means of a control input, or both. An adjustable regulated power supply is one that is both adjustable and regulated. An isolated power supply has a power output that is electrically independent of its power input; this is in contrast to other power supplies that share a common connection between power input and output.

Power supplies can be broadly divided into linear and switching types. Linear power converters process the input power directly, with all active power conversion components operating in their linear operating regions. In switching power converters, the input power is converted to AC or to DC pulses before processing, by components that operate predominantly in non-linear modes (e.g., transistors that spend most of their time in cutoff or saturation). Power is "lost" (converted to heat) when components operate in their linear regions and, consequently, switching converters are usually more efficient than linear converters because their components spend less time in linear operating regions.

Some DC power supplies use AC mains electricity as an energy source. Such power supplies will sometimes employ a transformer to convert the input voltage to a higher or lower AC voltage. A rectifier is used to convert the transformer output voltage to a varying DC voltage, which in turn is passed through an electronic filter to convert it to an unregulated DC voltage. The filter removes most, but not all of the AC voltage variations; the remaining voltage variations are known as ripple. The electric load's tolerance of ripple dictates the minimum amount of filtering that must be provided by a power supply. In some applications, high ripple is tolerated and therefore no filtering is required. For example, in some battery charging applications it is possible to implement a mains-powered DC power supply with nothing more than a transformer and a single rectifier diode, with a resistor in series with the output to limit charging current.

Normally high power ac–dc converters are required to have some power factor correction (PFC) capability. PFC methods are generally divided into the following three categories:

1) Passive PFC converters: These converters are using passive elements such as inductors and capacitors. These filters are used to get the sinusoidal input current. Although these converters are inexpensive, heavy and bulky in size and these used for limited number of applications.

2) Two-stage converters: They consist of an ac–dc boost pre-regulator converter and an isolated dc–dc full-bridge converter. These Two-stage converters are require two separate switch-mode converters and this can be increase the cost of the converter. Mainly these converters are having poor efficiency when operating under light-load conditions.

3) Single-stage converters: These converters can perform PFC/ac–dc conversion and dc–dc conversion with just a single full-bridge converter. Previously proposed single-stage ac–dc full-bridge converters have the following drawbacks.

a) Some are current-fed converters are having boost inductor connected to the input of the full-bridge. Any way these converters can achieve a near-unity input power factor, these converters are lack an energy-storage capacitor across the converter input side of dc bus, which can result in the appearance of high voltage over shoots we can observer across the dc bus.

b) Most are voltage-fed, single-stage, pulse width modulation (PWM) converters with a large energystorage capacitor connected across their primary-side dc bus.These converter are operating with fixed switching frequency, and the bus capacitor prevents voltage overshoots and ringing from appearing across the dc bus. However, have the following drawbacks:

i) The primary-side dc-bus voltage of the converter may become excessive under highinput-line and low-output-load conditions.

ii) The input power factor of a single-stagevoltage-fed converter is not as high as that of current- fed converters.

iii) The converter is operating with an output inductor current that is discontinuous for all operation conditions. But some problems are also available in single-stage converters. This is excessive dc-bus voltages due to the lack of a dedicated controller to regulate these voltages, large output ripple, distorted input currents, and reduced efficiency.

Pulse Width Modulation Techniques

The control of output voltage is done using pulse width modulation. The commonly used techniques are

- Single pulse width modulation.
- Multiple pulse width modulation.
- Sinusoidal pulse width modulation.
- Modified sinusoidal pulse width modulation.
- Phase displacement control.

Proposed method

The proposed method describes a three-level single-stage PFC ac/dc converter is proposed for low-power applications.The proposed converter exhibits high PF with less number of switches/diodes, operated at constant duty ratio. With the proposed converter and

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switching scheme, input current shaping and output voltage regulation can be achieved simultaneously without introducing additional switches or switching actions. In order to operate at high frequency and reduce the size of the circuit, high frequency two-stage active PFC converters have been proposed.

Block diagram

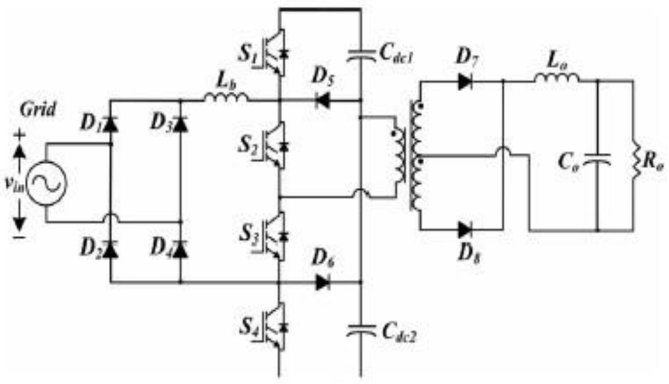

Fig. Proposed three-level single-stage fully integrated PFC ac–dc converter.

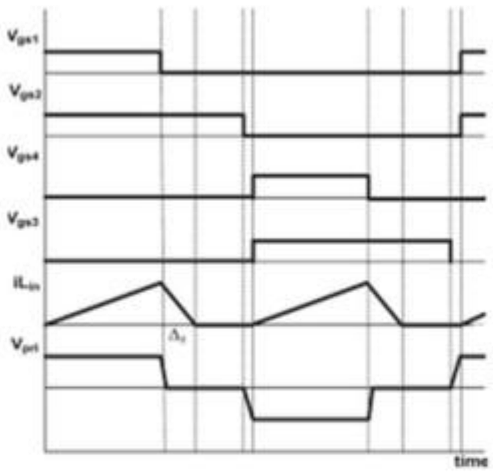

Fig: Typical waveforms describing the modes of operation.

Advantages

- Which increases the efficiency of the converter in comparison to hard-switched ac/dc single-stage converter.
- Furthermore, higher PF can be achieved at high line voltage due to the flexible dc-link voltage structure.

Operation Modes

Mode 1 *[$t0 < t < t1$]:* In this mode, both S1 and S2 are on. The upper capacitor, Cdc1, discharges to the load by applying $-V$dc/2 to the primary side of the transformer. The primary side current increases linearly under constant voltage. D8 conducts at the secondary side of the transformer. The voltage across the output inductor is VLo = Vdc/2N − Vo . In this mode, the boost inductor, Lb , does not interfere to the operation of the circuit.

Mode 2 *[$t1 < t < t2$]:* At $t = t1$, S1 is turned OFF and S2 is kept on. The current in the leakage inductance conducts D5 and the primary side current freewheels; hence, zero voltage is applied across the primary side of the transformer. The output inductor voltage is equal to $-V$o . The output inductor current decreases linearly.

Mode 3 *[$t2 < t < t3$]:* At $t = t2$, S3 is turned on, while S2 still remains on. The primary current continuous to freewheel and zero voltage is applied across the primary side; hence, the output inductor current continuous to decrease under output voltage. Meantime, Vin is applied across Lb , and input current increases linearly storing energy in the inductor.

Mode 4 *[$t3 < t < t5$]:* In the beginning of this mode, S2 is turned OFF, S4 is turned ON, while S3 is kept on. Within this time interval, the following two operations are completed. The energy stored in the input inductor is transferred to the dc-link capacitors. The inductor current decreases linearly under Vin − Vdc. Meantime, Vdc/2 is applied across the primary side of the transformer. The current in the leakage inductance is transferred to Cdc2. This causes the output current to commute from D8 to D7 . At the end of this time interval, the energy in the input inductor is completely transferred to the dc-link capacitors and the commutation of the output diodes is completed. Depending on the dc bus voltage, and input current, one of these operations ends earlier than the other one. In this case, the energy stored in Lb is transferred to

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the dc-link at $t = t5$. Then, the current commutation from $D8$ to $D7$ is completed at $t = t6$.

Mode 5 *[t5 < t < t6]:* Cdc2 discharges over to the load and Vdc/2 is applied across the primary side of the transformer. The voltage across the output inductor is $V_{Lo} = V_{dc}/2N - V_o$. The input current remains at zero in DCM mode.

Mode 6 *[t6 < t < t7]:* At $t = t6$, S4 is turned OFF, and only S3 is on. This allows leakage current to freewheel through $D6$, and zero voltage is applied to the primary side. The output current decreases linearly under $-V_o$.

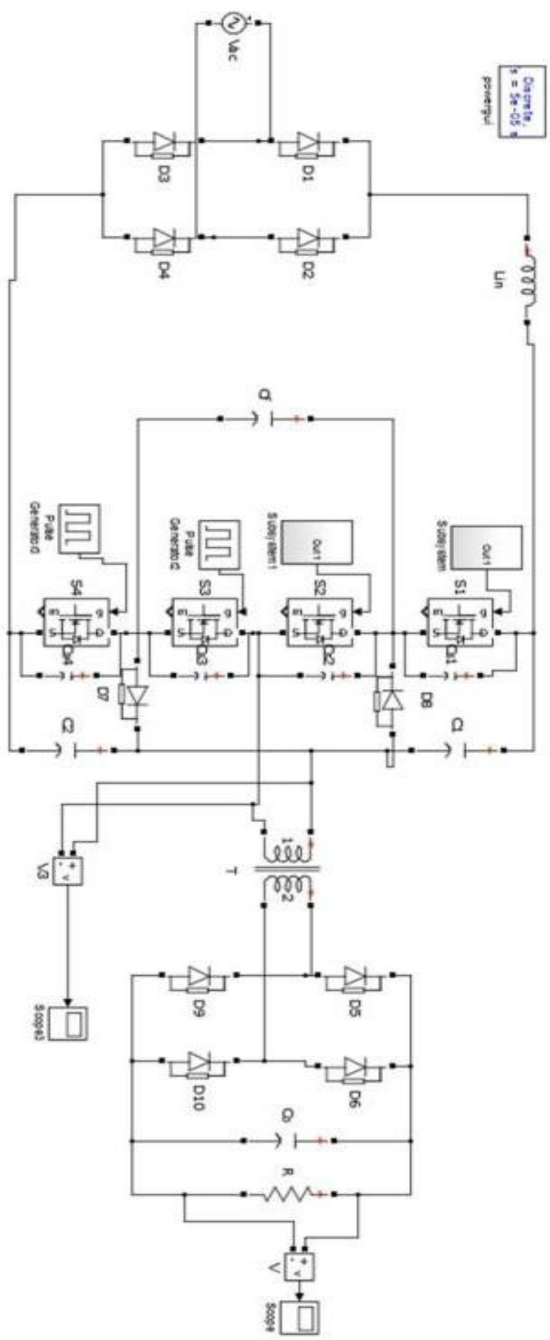
Mode 7 *[t7 < t < t8]:* At $t = t7$, S2 is turned ON. The energy from the input is stored in the inductor. This is similar to Mode 3, except that this time the primary side current is opposite to that in Mode 3 and freewheels through $D6$.

Mode 8 *[t8 < t < t10]:* At the beginning of this interval, S3 is turned OFF, S1 is turned ON, and S2 remains ON. This mode is similar to Mode 4, where the stored energy in the inductor is transferred to the dc bus capacitors, and $-V_{dc}/2$ is applied to the primary windings. In the meantime, the output inductor current commutates from $D7$ to $D8$.

The Proposed converter has the following features:

- The converter can operate with universal input voltage range (90– 265 Vrms) with wide output load variation
- The converters provide high power factor at input ac line current that complies with the IEC1000-3-2. It is because it can have higher dc bus voltage.
- The converter can operate with continuous output inductor current for load more than 50% without its components being exposed to excessive peak voltage stresses.
- The voltage stress for each switch is just half of the dc bus voltage due to multilevel structure.

Simulation Diagram For Three Level Ac-Dc Converter



Conclusion:

Here a new three level integrated ac-dc converter is implemented.The proposed converter uses auxiliary windings taken from its power transformer as magnetic switches to cancel the dc bus voltage so that the input section operates like a boost converter. The proposed

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converter has the advantages over the conventional two-stage converter and also this converter reduces the size when it compared to previous converter. The outstanding feature of this converter is that it combines the performance of two stage converters with single converter and reduce the cost of single-stage converters. A PFC inductor and a diode bridge are added to the conventional three-level isolated dc/dc converter, while the switching scheme is modified to be compatible with single-stage operation. The input current ripple frequency is twice of the switching frequency contributing to using smaller PFC inductor. Two independent controllers, in favor of shaping the input current and regulating the output voltage, are adopted which simplifies the design and control of the circuit. The tradeoff between the PF and overall efficiency in the case of adopting a variable dc-link voltage is analyzed through developed loss model. Simulation results that confirm the performance of the converter are also presented in the paper.

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