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A Novel Single Switch Resonant Power Converter for Renewable Energy Generation Applications

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ABSTRACT:

The increased emphasis on energy demand, nowadays renewable energy resources are used vastly. Solar energy is one of the major renewable energy source with more benefits. Solar systems include pv modules, power electronic devices etc,. the power electronic devices play crucial role in solar power energy conversion. Novel single switch resonant power converter in solar power application reduces the cost of active power switches, control circuits with pwm technique for resonant converter high energy conversion efficiency is obtained. The techniques used for power quality improvement are pwm, pi, pid and fuzzy. In this paper we discuss the circuit operating principles derivation of power converter for different operating modes.

I. INTRODUCTION

Nowadays, most power that is used to meet our daily needs is obtained from fossil fuels. Owing to increases in consumption, fossil fuel sources may be exhausted in the near future. The global reduction of greenhouse gas emissions that are produced by the burning of fossil fuels seeks a reduction in the use energy from such sources. Therefore, renewable energy has become attractive in recent years, following the implementation of a policy for sustainable development and mitigation of environmental pollution.

II. SYSTEM DESCRIPTION

It comprises a choke inductor *Lm*, a metal–oxide–semiconductor field–effect transistor (MOSFET) that operates as a power switch *S*, a shunt capacitor *C*, a resonant *Ls*, an energy blocking diode *D*, and a filter capacitor *Co*. The capacitor *Co* and the load resistance *R* together form a first-order low-pass output filter, which reduces the ripple voltage below a specified level.

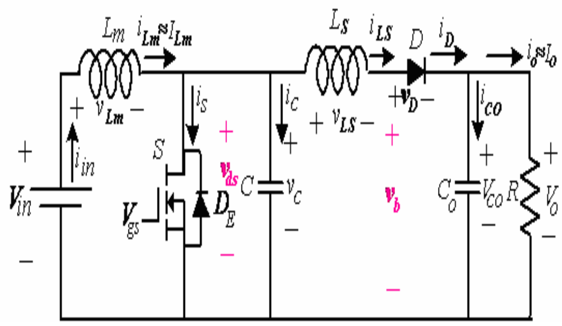


Fig. 1 Basic circuit diagram of proposed novel single-switch resonant power converter

The MOSFET is favored device because its body diode can be used as an anti-parallel diode *DE* for bi-directional power switch.

Notably, the shunt capacitance *C* includes the power switch parasitic capacitance and any other stray capacitances (such as the winding capacitance of the choke, *Lm*). Careful design of the circuit parameters guarantees that the power switch *S* is switched by ZVS and the energy blocking diode *D* is switched by ZCS, optimizing the operation of the converter.

ASSUMPTIONS

1) The switching elements of the converter are ideal, such that the drop in forward voltage across the resistance of the power switch in the on-state is negligible;
2) The equivalent series resistance of the capacitance and stray capacitances is negligible;
3) The characteristics of the passive components are linear, time-invariant and independent of frequency, and
4) The filter capacitance *Co* at the output terminal is typically very large; the output voltage across capacitor *Co* can therefore be treated as an ideal DC voltage in each switching cycle.

5) The choke inductance *Lm* at the input terminal of the novel single-switch resonant power converter is large.

Therefore, the input current through the inductor *Lm* can be treated as an idealized DC current in each switching cycle.

III. POWER CONVERTERS

Power converters are used for electrical power processing. They change the typical characteristics of electrical energy such as voltage level and frequency.
Here raw input power is processed according to the control command, which yields the desired form of output power.
Control is invariably required in power converters. Generally the objective is to have a well regulated output voltage, in the presence of line and load variations. The line can be a constant DC source such as a battery or fuel cell or a periodic AC voltage current source such as the utility or output of a generator. The load can be a network composed of one or more of passive circuit elements or another electrical source, or an electromechanical energy conversion device. Input and output filters are combinations of energy storage elements like inductor (L) and capacitor (C), provide filtering to eliminate switching noise or Electromagnetic Interference (EMI). Although feedback is generally from load, it can also be from the switch network as well as input and output filters depending on the control algorithm.

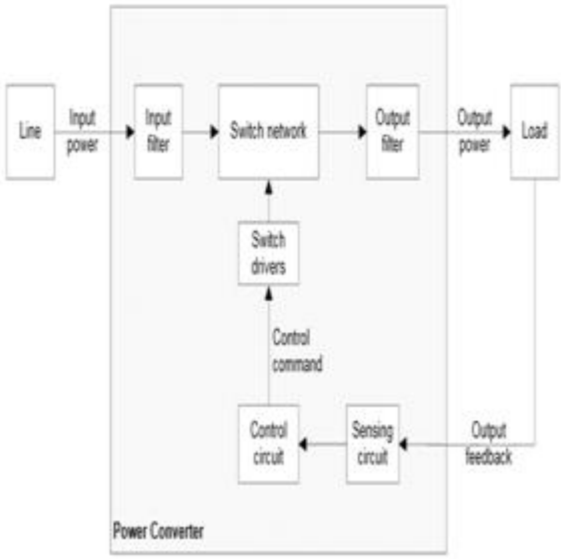


Fig. 2. Block Diagram of a Typical Power Converter

For most of the converters, many different topologies have been produced by manipulating the structures of the input filter, the output filter and the switch network. Depending on the desired function of the power converter, other circuit elements that perform auxiliary functions (such as isolation and protection) can be added. Nevertheless this does not affect the main function of a power converter which is shaping the electrical energy to a certain form.

Power converters can be classified into four categories on the basis of the type of input line and desired load characteristics:

1. DC/DC converters
2. DC/AC converters (inverters)
3. AC/DC converters(rectifiers)
4. AC/AC converters (cyclo converters or AC controllers)

RESONANT CONVERTERS:

Resonant power converters contain resonant L-C networks whose voltage and current waveforms vary sinusoidally during one or more subintervals of each switching period. These sinusoidal variations are large in magnitude, and the small ripple approximation does not apply.

Some types of resonant converters:

- Dc-to-high-frequency-ac inverters
- Resonant dc-dc converters
- Resonant inverters or rectifiers producing line-frequency ac

Resonant converters use a resonant circuit for switching the transistors when they are at the zero current or zero voltage point, this reduces the stress on the switching transistors and the radio interference. We distinguish between ZVS-and ZCS-resonant converters (ZVS: Zero Voltage Switching, ZCS: Zero Current Switching).

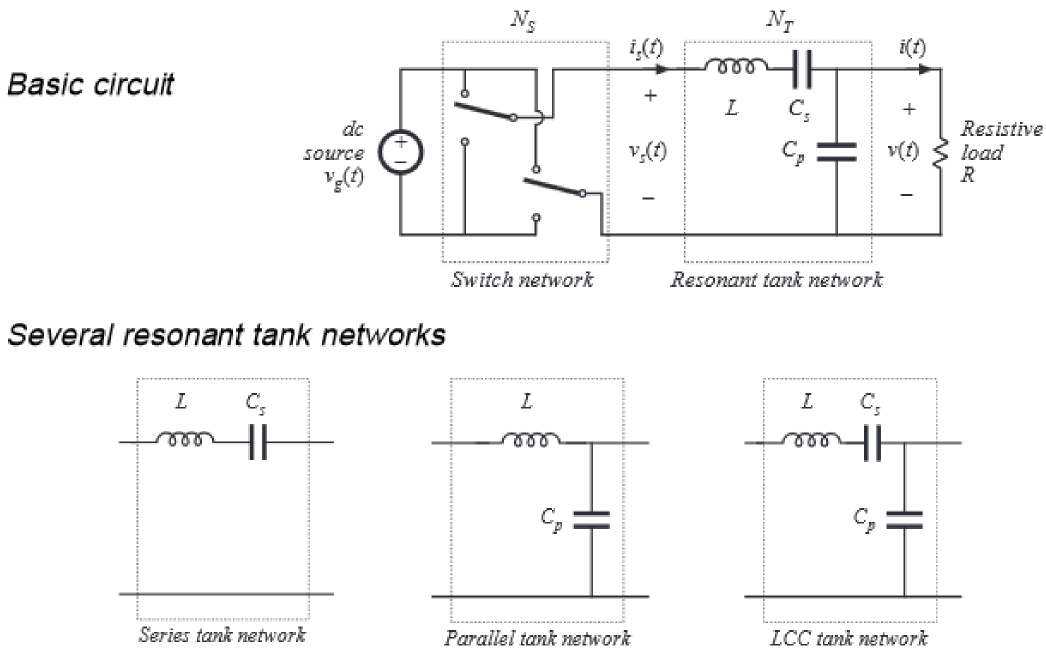


Fig. 3 basic circuit of resonant converter

To control the output voltage, resonant converters are driven with a constant pulse duration at a variable frequency. The pulse duration is required to be equal to half of the resonant period time for switching at the zero-crossing points of current or voltage.

PWM power converters can now operate at a much higher switching frequency, reducing the size of passive components, reducing the overall cost of the system. However, the converter switching loss also increases proportionally increases in proportion to the frequency. The increase in *dv*/*dt* and *di*/*dt* caused by the increased speed increase stress on the device and system electromagnetic interference (EMI) noise. These effects set an upper limit on the frequencies at which conventional hard-switching PWM converters can operate. In the last few decades, various researches have been performed to improve the switch transition to overcome this inherent problem of hard-switching PWM converters. By solving these high voltage and current stress problems, energy conversions using resonant converters has been important in ensuring both high performance and supporting energy conservation applications in renewable energy generation systems.

IV. SIMULATION RESULTS

The simulation model for an active switch is proposed to operate in the zvs and zcs switching pattern and by using pulse with modulation (PWM) for the pv grid system will be as shown in below figure.

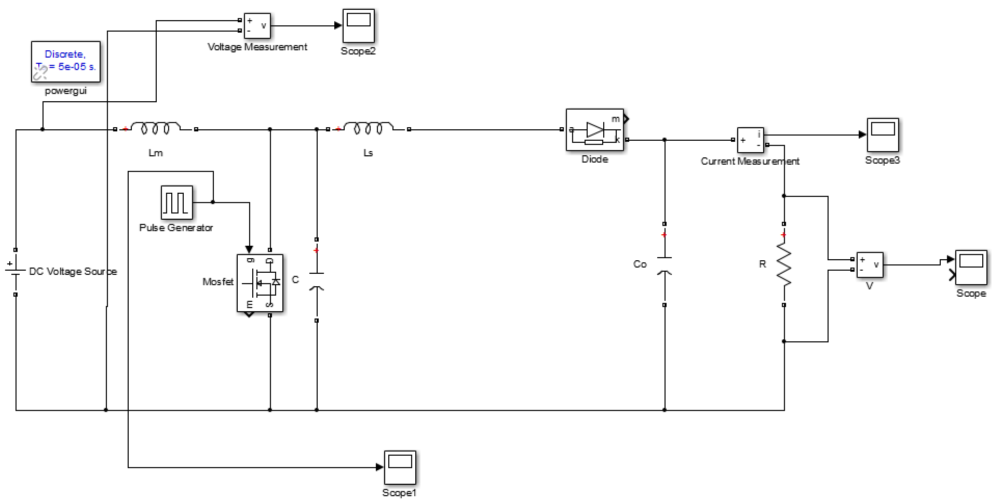
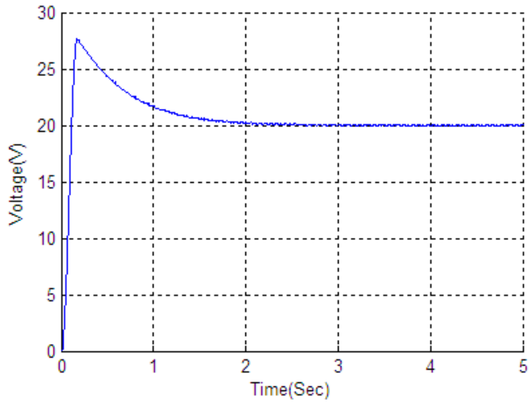
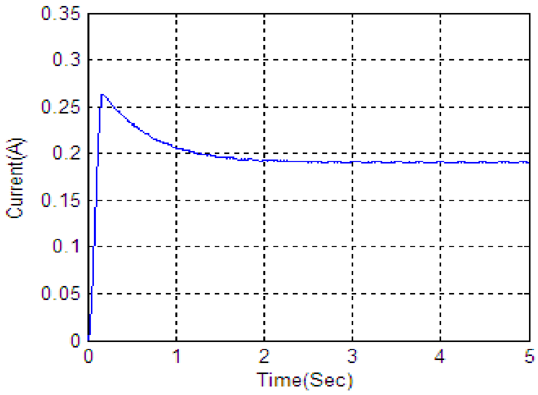


Fig. 4. Simulink model of a novel single-switch resonant power converter using PWM technique



(a) PV Voltage



(b) PV current

The extension for the proposed methodology will be used with fuzzy technique to regulate the output parameters of PV grid system to improve the power quality improvement and the active power switch can be operated with zero-voltage switching and also we can achieve maximum energy conversion efficiency, which is especially suited to the energy conversion applications in renewable energy generation systems.

To mitigate current harmonic in the resonant converter using active filter and common mode noise filter will be eliminated. This method is used for common mode current noise reduction and Total Harmonic Distortion (THD) is minimized in source side of the resonant power converter. Active switch is controlled using Fuzzy Logic Controller and the common mode (Electromagnetic interference) EMI noises are reduced. The methodology is implemented in the MATLAB/Simulink model.

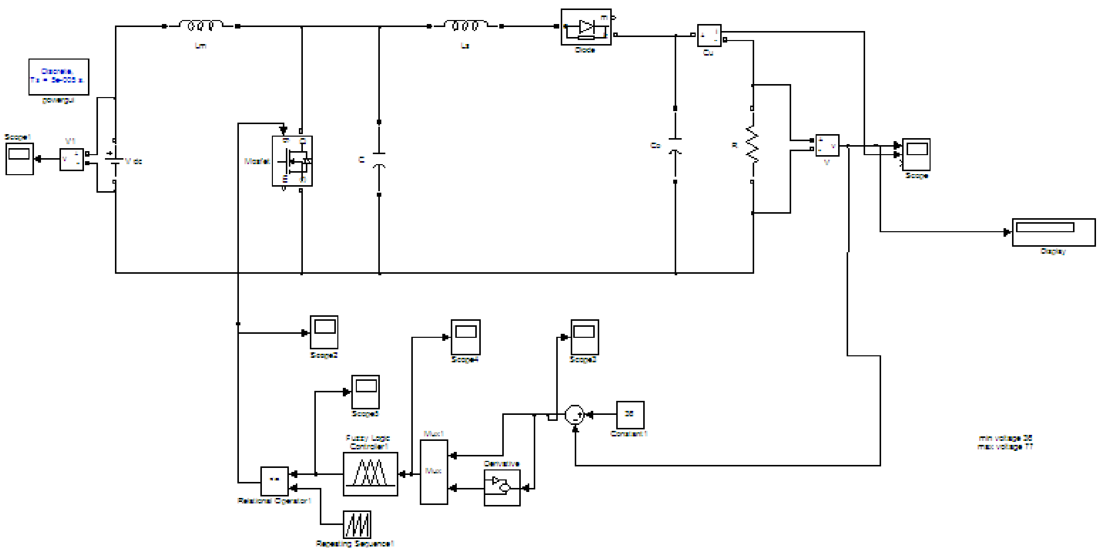
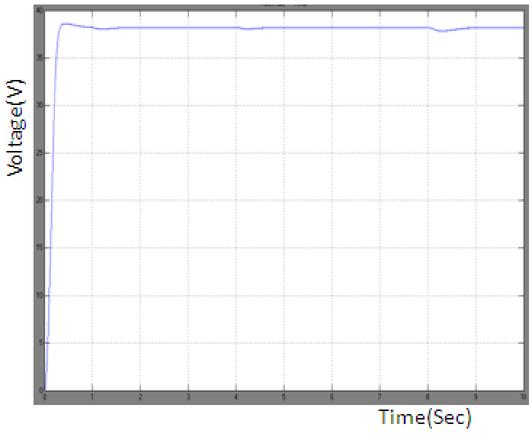
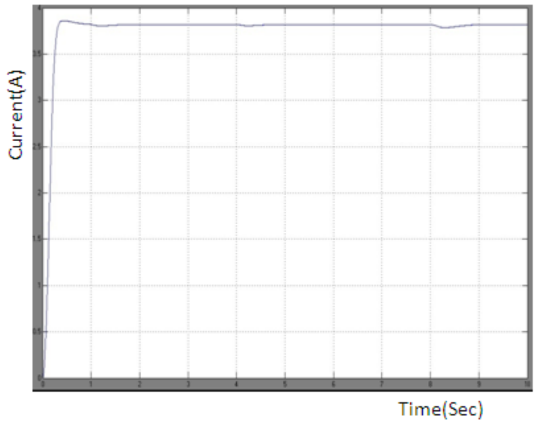


Fig 5. simulink model of a novel single switch resonant converter with fuzzy controller



(a) PV Voltage



(b) PV Current

V. CONCLUSION

The control structure of the proposed system comprises of active power switch, which operates as a resonant power converter with an energy-blocking diode was designed for use in a pv generation system. The novel single-switch resonant power converter is supplied by a solar energy generation system to yield the required output conditions. The experimental results reveal the effectiveness of the developed novel single-switch resonant power converter in solar energy generation. When the high-frequency novel single-switch resonant power converter is applied to a resistive load, a satisfactory energy conversion efficiency is 97. 3% than conventional class-D resonant converters. The methodology is implemented in the MATLAB/Simulink model. Thus, noises are reduced by using the filter circuits and the power quality in source side and voltage and current are improved.

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