

Design of Single phase inverter using PID controller For nonlinear load application

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Abstract

The paper presents a single phase transformer based inverter for nonlinear load application using PID controller. A capacitive full bridge circuit is used to provide instant current under nonlinear load conditions and thereby reducing the harmonics. A new proportional plus integral controller for inverter control is proposed to eliminate the dc current component, and steady state error under heavy load applications.

The proposed controllers consist of PID controller act as voltage controller and DC offset canceller. The experimental result derived by using the MATLAB software.

Introduction

Single phase inverter is widely used in various applications such as UPS, Renewable energy conversion, power source etc. The single phase inverter can be divided into half bridge, full bridge, and three level structures. The main function of the inverter is to provide an AC output voltage with less voltage distortion under both linear and nonlinear load applications. The inverter can be divided into transformer based and transformer less types. Although transformer less inverter without line frequency transformer is placed in front of load for isolation purpose, and to provide the compact size, lowest cost, less voltage distortion from the line frequency transformer and to provide fast response, but there is no galvanic isolation between power source and load. The transformer based inverter has the important characteristics is to provide the galvanic isolation between power source and the load, with the line frequency transformer between inverter and the load. For safety application such as

medical installation, data center UPS system require isolation between the output neutral and power source, the transformer based inverter are heavy in demand.

The transformer based inverter has the capable to block the DC voltage, and filter out the high frequency noise generated by the inverter and to increasing the output voltage range. Nonlinear load, such as rectifier is very popular during this year. Blocking the DC voltage is also very important for the load contained magnetic component such as inductor, and transformer.

DC voltage component exist in the output of AC inverter which may cause saturation and increase the power loss of line frequency transformer. The voltage feedback signal is taking from the transformer at the inverter output and uses low pass filter to separate the DC voltage, and thereby reducing the control method. In case of direct control of current is provided to block the DC current component in order to avoid core saturation of the line frequency transformer connected at the output of single phase PV inverter.

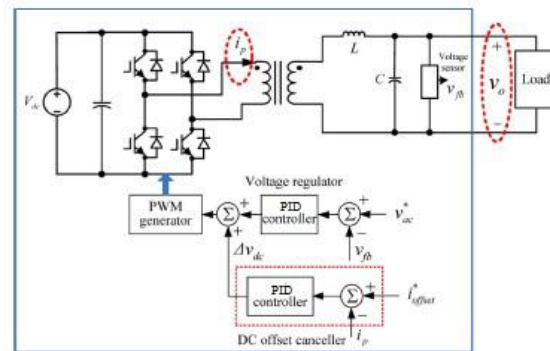


Fig.1. Block diagram of the conventional inverter with PID control .

The single phase transformer based inverter for nonlinear load applications, a nonlinear load

compensating module with fast current response, which is constructed by a capacitive powered full bridge circuit, is added to load side to provide instant current for nonlinear load. The peak current of the inverter is limited to the rating of the line frequency transformer, and thereby reducing the capacity of the line frequency transformer can be significantly reduced and thereby reducing the cost, size and weight.

DC offset canceller is presented to mitigate the DC current of the line frequency transformer. As the DC component is reduced to zero, the normal voltage command is added to control the voltage applied to load. A proportional plus integral plus derivative controller is applied to provide the output voltage under no load and light load condition and further improving the accuracy of output voltage under heavy load and the transient condition.

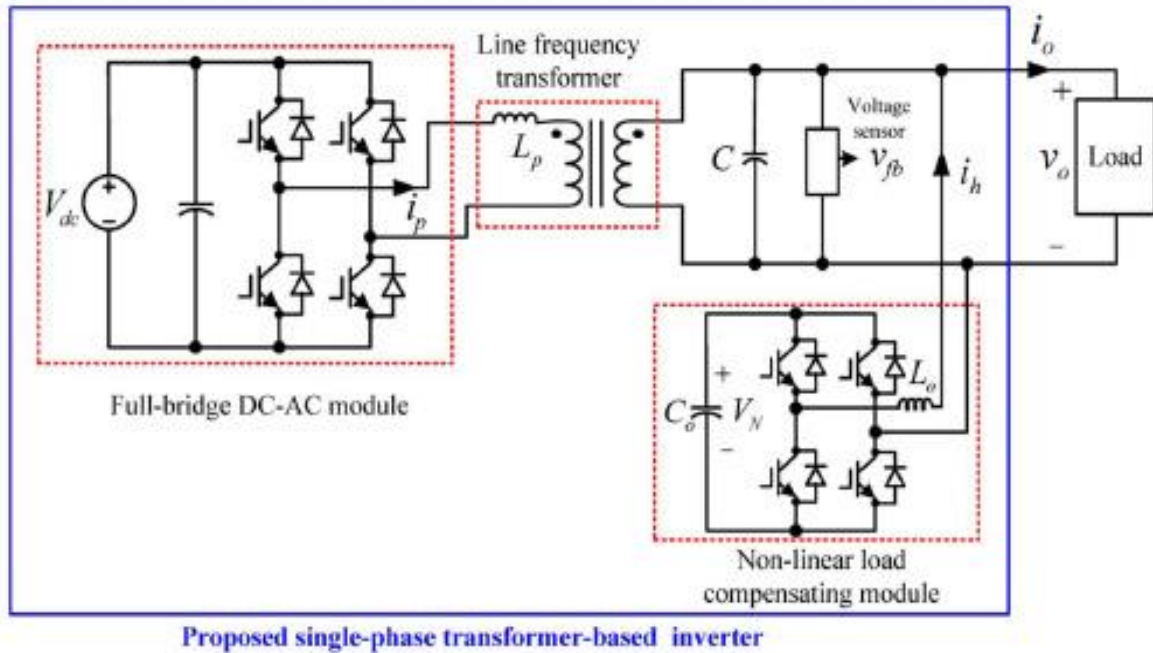


Fig.2. Proposed circuit of single-phase transformer-based inverter

Proposed Single Phase Inverter

A. Proposed Topology

The proposed single inverter consists of full bridge DC-AC module, line frequency transformer, and a nonlinear load compensating module. An LC filter is placed in the output of DC-AC module to obtain the sinusoidal voltage. The line frequency transformer is connected to the other end of LC filter. This structure leads to good voltage measure at LC filter output. In order to reduce the loading effect on LC filter a leakage inductance L_p of the transformer and a capacitor C installed at load side of the transformer are used to replace the traditional LC filter in the proposed inverter. The nonlinear load compensating module connected in load side is structured by a full bridge circuit, an inductor L_o

and capacitor C_o which act as energy buffer instead of a dc power source.

B. Proposed integrated controller

DC offset canceller and RMS compensator output voltage of the DC-AC module and reduce the steady state error between voltage command and its feedback respectively. In order to improving the load side voltage, a nonlinear load compensator is added to generate instant current such that both the voltage harmonics and reduce the capacity of transformer can be reduced for nonlinear load applications.

C. Voltage controller

The voltage controller is used to maintain the stability and regulating the voltage errors caused by load disturbance and imperfect tracking control. Only proportional gain is used to keep the controlled voltage more stable.

D. RMS voltage compensator

The RMS voltage compensator is used to reduce the RMS voltage difference between command signal and output voltage which is getting from the PI type of voltage controller.

E. DC offset canceller

The DC voltage occurs, the voltage generated by the voltage controller, and RMS compensator will be reducing the DC voltage without DC offset canceller mechanism. The canceller is arranged to let the DC current be reduced to zero by a PI type closed loop controller.

F. Nonlinear load compensator

The current limiter and current controller are provided to improve the accuracy of output voltage under nonlinear load conditions. The current limiter restrict the output current of the inverter to the peak value of rated current of the transformer and the remaining current required for nonlinear load is offered by the nonlinear load compensating module.

Result and Discussion

The single phase transformer based inverter for nonlinear load application using PI controller is verified with single phase rectifier load using MATLAB Software. The simulated result shows that the single phase inverter has been eliminate the DC current component and steady state error under nonlinear load condition.

Simulation Diagram And Waveform

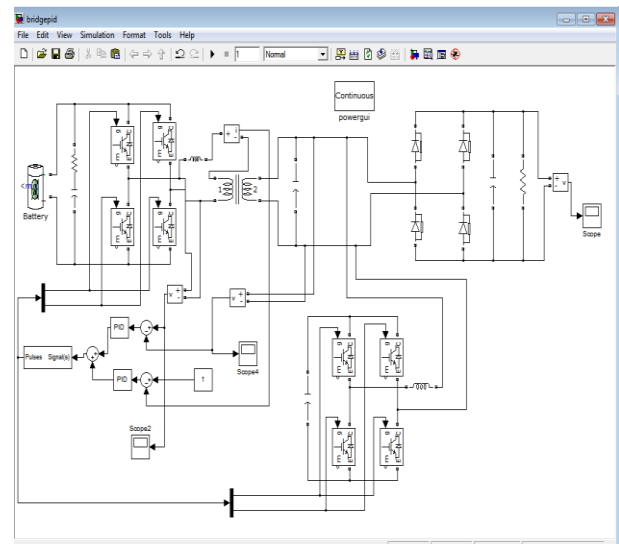


Fig.3. MATLAB Simulink model of proposed single phase inverter with Rectifier load.

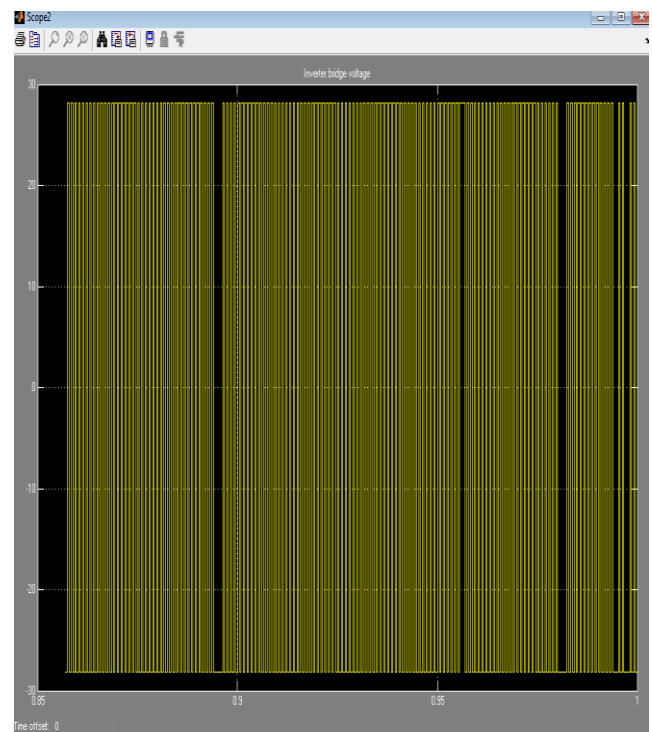


Fig.4. DC-AC Inverter Bridge output voltage.

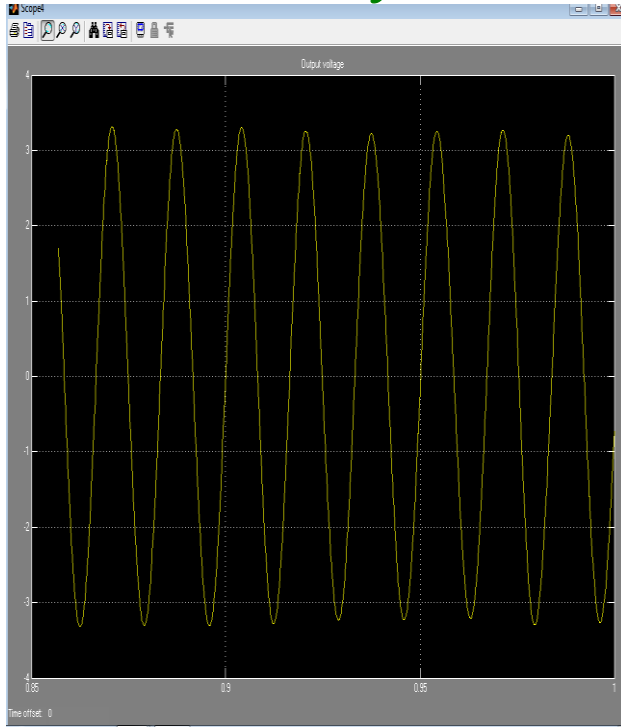


Fig.5. AC output voltage for rectifier load.

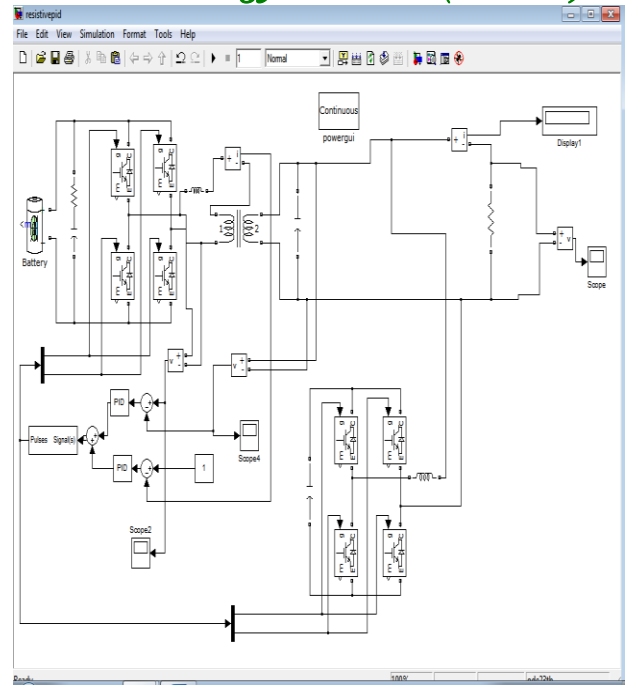


Fig.7. MATLAB Simulink model of single phase inverter with resistive load.

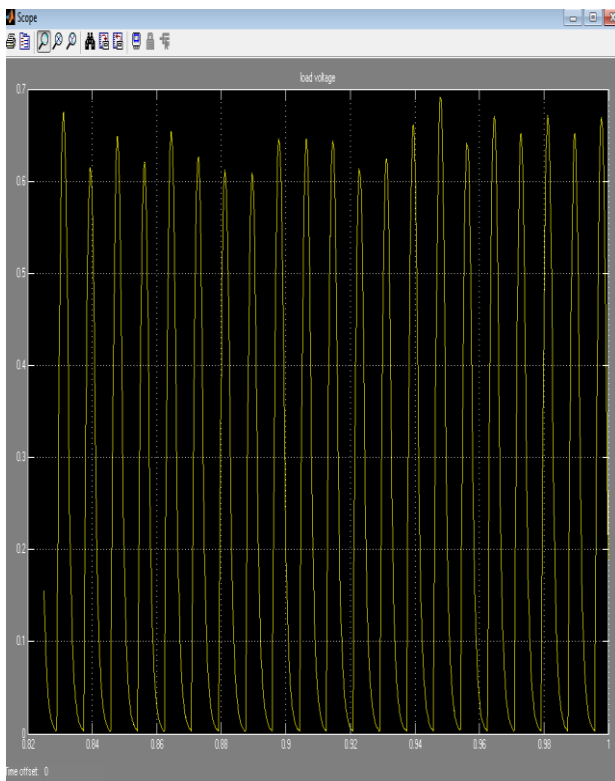


Fig.6. Load voltage for rectifier load.

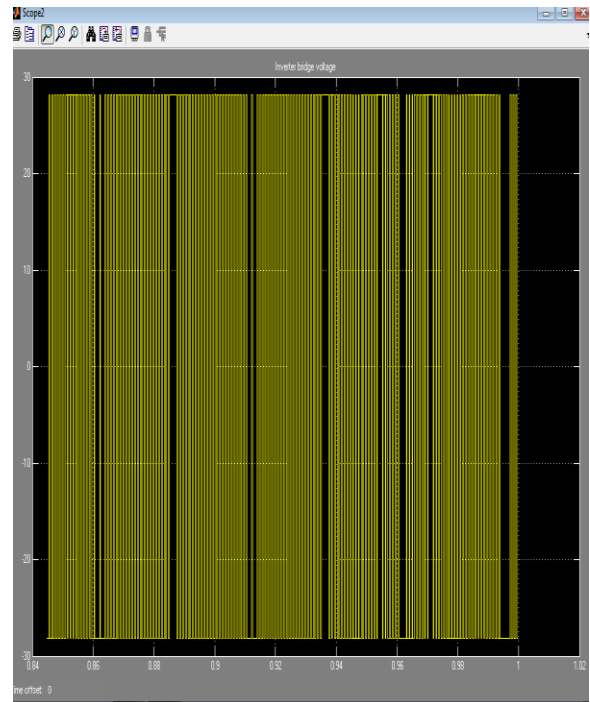


Fig.8. DC-AC Inverter bridge output voltage.

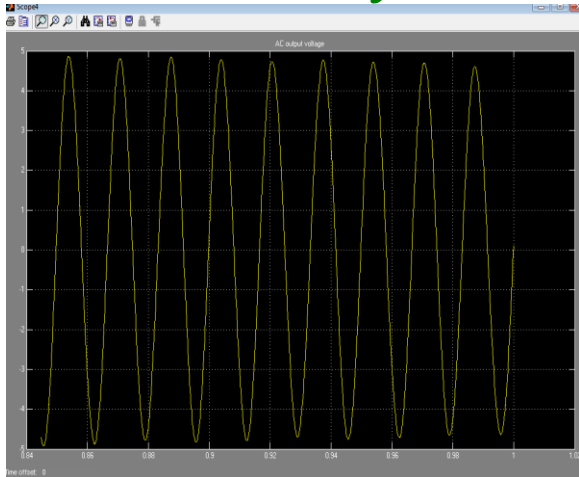


Fig.9. AC output voltage for resistive load.

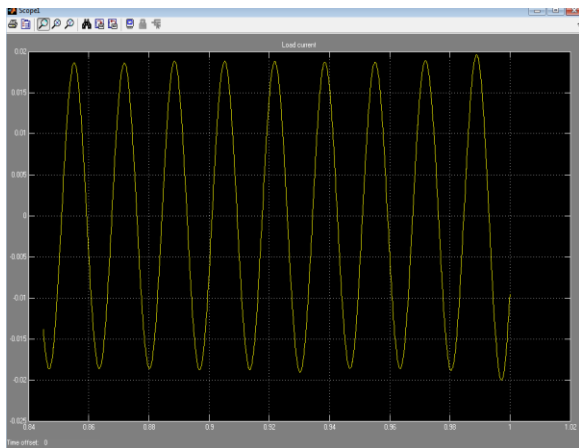


Fig.10. Load current for resistive load.

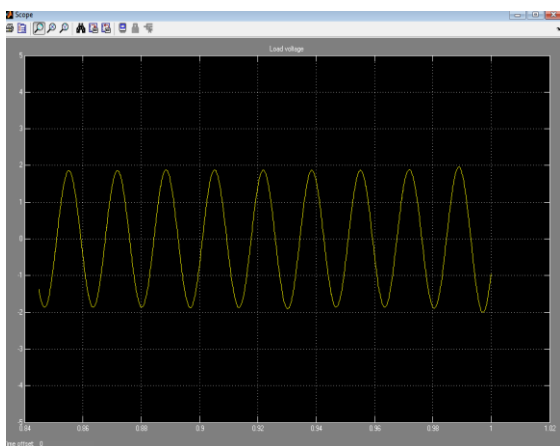


Fig.10. Load voltage for resistive load.

Performance Analysis

Resistance value in $k\Omega$	With compensation load currents (ma)	Without compensation load currents (ma)
1 $k\Omega$	3.1mA	5.4mA
2 $k\Omega$	2.3mA	5.0mA
3 $k\Omega$	1.5mA	2.1mA

Fig.11. Performance analysis of single phase inverter with resistive load.

Compensation Method	Load Currents (mA)
With Compensation	1.3mA
Without Compensation	8.6mA

Fig.12. Performance analysis of single phase inverter with rectifier load

Conclusion

The proposed a new single phase transformer based inverter for nonlinear load application using PID controller can significantly reduce the harmonic distortion under nonlinear load condition. The proposed integrated plus derivative controller eliminates the DC component and steady state error. To verified the result of single phase inverter for nonlinear load application by using MATLAB software.

References

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