FPGA based digital controller for switch-mode converter – P-2013-025

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1. Abstract:

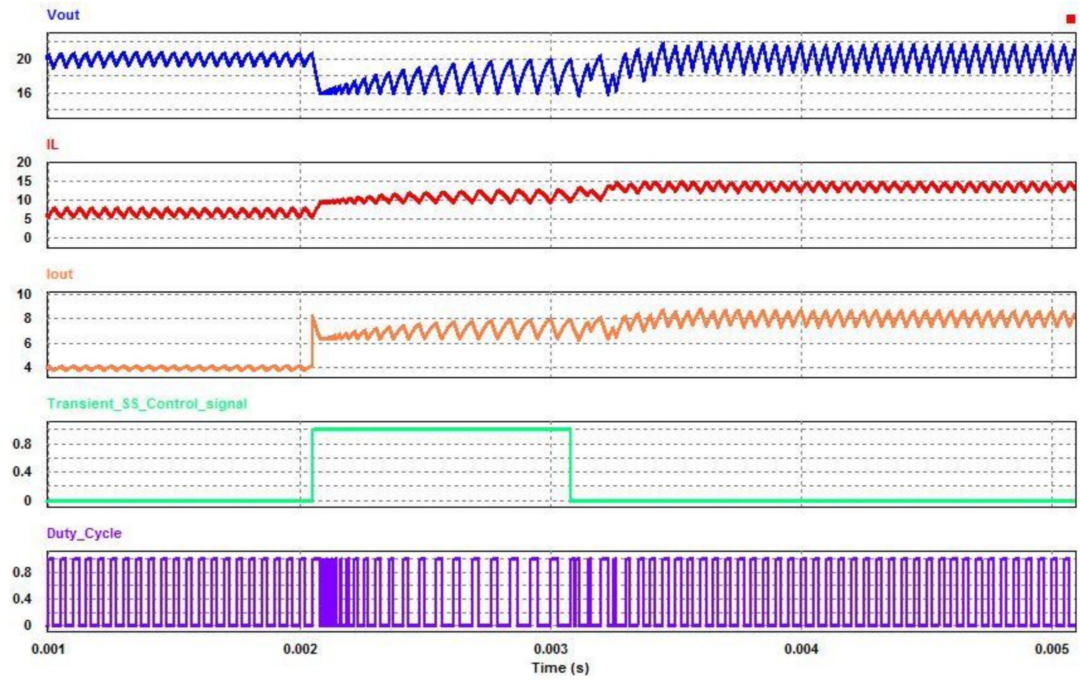
The main goal of the project is to implement, test, and compare a new control scheme for DC-DC converters such as: boost or buck-boost.

The control scheme is designed to optimally handle a load change. A load change in the converter will cause a transient response which includes a rise/fall in the output voltage and inductor current. The transient response may have many implications on the load. The implications may include shut down, overheating and more. The proposed control scheme will offer a solution to these problems.

There are two conventional methods for dealing with transients. The “Peak current mode” method is a linear method. This method is limited by band width. Transient response to load change includes fast changes to the voltage and current and therefore this method is more suitable for steady state rather than transient. The “Time optimal” method is a non-linear control method designed to minimize the overall transient time. In converters that have a direct connection between the conductor and the input and output voltages, minimal response time results in minimal deviation. These converters are called “Direct energy transfer”. But, in “Indirect energy transfer” converter’s minimal response time will not result in minimal deviation.

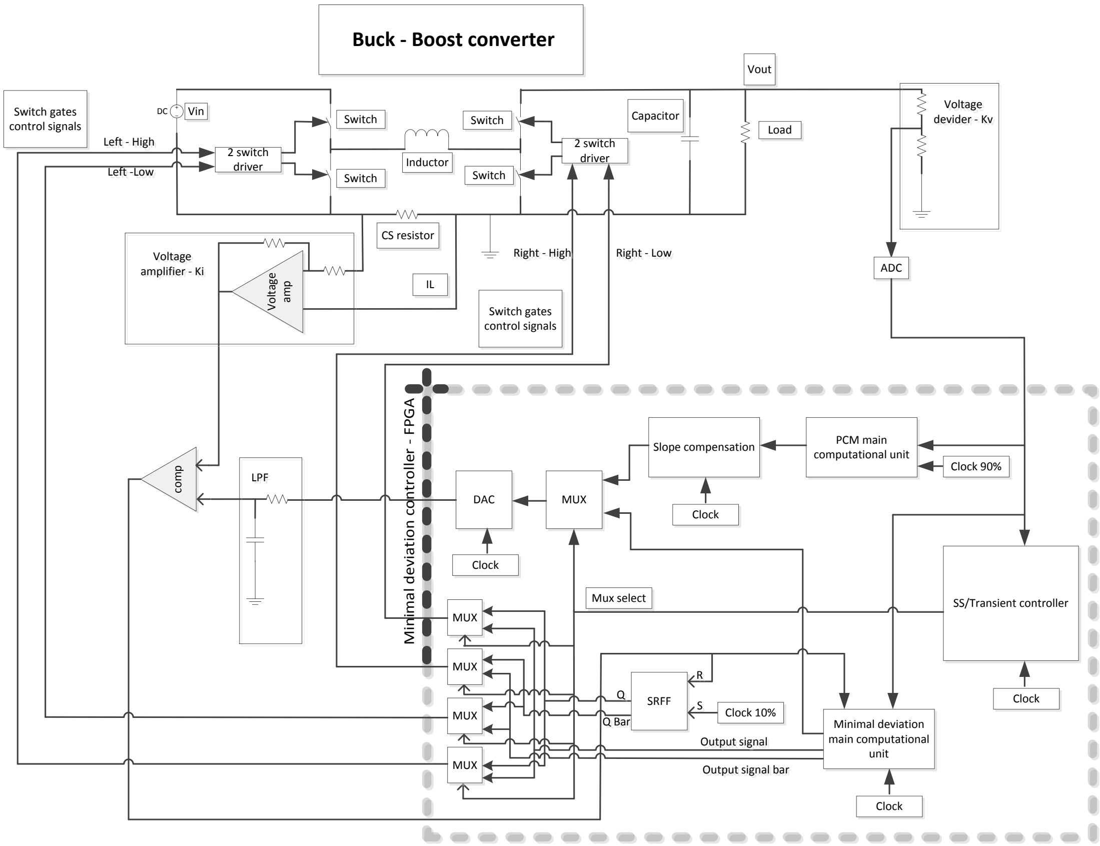
The proposed control scheme is called “minimal deviation”. The method combines linear and non-linear control methods. By combining the properties of the two methods we have received a scheme capable of returning to steady state quickly and with minimal deviation. Using these advantages we can lower costs and the area of the converter.

During this project an implementation of the "minimal deviation" control scheme was made. The converter chosen was of the type "Buck-Boost", and implemented on a printed circuit board. The control scheme was designed and implemented on a FPGA platform. The control scheme is to be empirically tested and the empirical results will be compared with the theoretical results of the simulations. Furthermore, the empirical test results will be compared with empirical test results of the current commonly used control schemes.

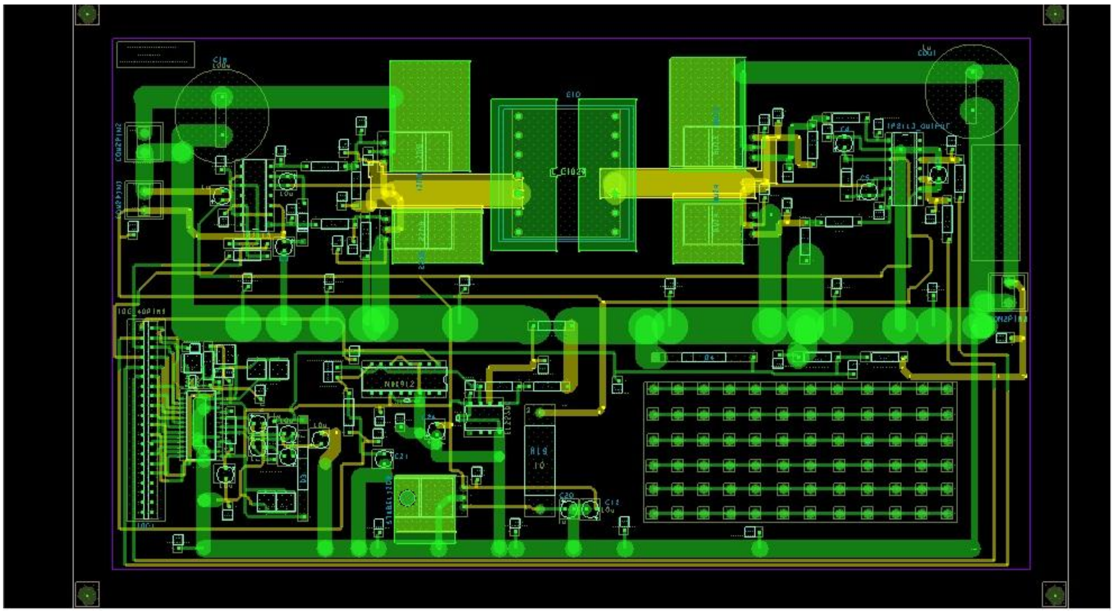


Simulation of minimal deviation control scheme on Boost converter using PSIM

2. Realization:



Block Diagram of the complete system



Final PCB layout

3. Advantages:

1. Minimal deviation of the current and voltage of the load. This advantage minimizes the risks of damage to the load during transients and allows safer use of DC-DC converter in electronic devices.
2. Lower overall "Transient" recovery time. Allows the load to return faster to the steady state, which is the preferred working condition.

4. Bibliography:

1. M.Peretz, “Hardware-Efficient Programmable-Deviation Controller For Indirect Energy Transfer Dc-Dc Converters”, 2012.
2. W.W. Burns and T.G.Wilson, "state trajectories used to observe and control dc-to-dc converters". IEEE Trans. Aerosp. Electron. Syst., vol. AES-12, no. 6, pp. 706-717, 1976