Soft Switching Snubber Circuit for PWM inverter

Dr. Warsame H. Ali

Abstract

- The main goal of this proposal is to design and implement a digital signal processor (DSP)-based system to digitally control pulsed modulated (PWM) DC to AC converter of a flywheel energy storage system, which is an integral part of a high speed permanent magnet synchronous motor/generator (PMSM)

The methodology used is first simulated by using the ANSOFT software packages such as ANSOFT Maxwell 2D-3D and RM-xpert which will be implemented for finite element analysis of the PMSM/Voltage Source Inverter. Also, ANSOFT-Simplorer will be employed for the PMSM/Voltage Source Inverter simulations and for A/D controlled schemes. Simulations results from the PMSM, inverter and controls schemes will then be analyzed, optimized and then implemented through dSPACE DSP system.

CECSTR

Center of Excellence for Communication Systems Technology Research

- This project will investigate the performance of a flywheel energy storage system by developing strategies to solve the inherent uncertainty of motors. The project can also be applied to Crew Exploration Vehicle, Crew Launch Vehicle, International Space Station Battery Replacement, and Energy Storage on the Moon. In the short term, this project will contribute to macro-scale manufacturing and vehicle control. In the long-term, it will impact micro-scale manufacturing.

CECSTR

Project Description

- The relevance and potential contribution to the major objective of this research is development of a cost effective, light mass and power efficient motor drive systems oriented for future space exploration power systems and architectures. Although this proposed research and development effort initially will be dedicated toward a highly reliable design and implementation of flywheel energy storage system, it is not just limited to flywheel applications. It can also be applied to controlled momentum gyros, motor actuators, pumps and solar array (S/A) alpha joint control motors and auxiliary systems, such as automatic voltage regulators, and uninterruptible power supply system.

- Design and construct a high efficiency half-bridge converter with 3-for-2 redundancy scheme, and with components that are qualified for low-earth-orbit LEO) applications, Crew Application Vehicle Power System, lunar surface power systems and other space explorations power systems.

A N:

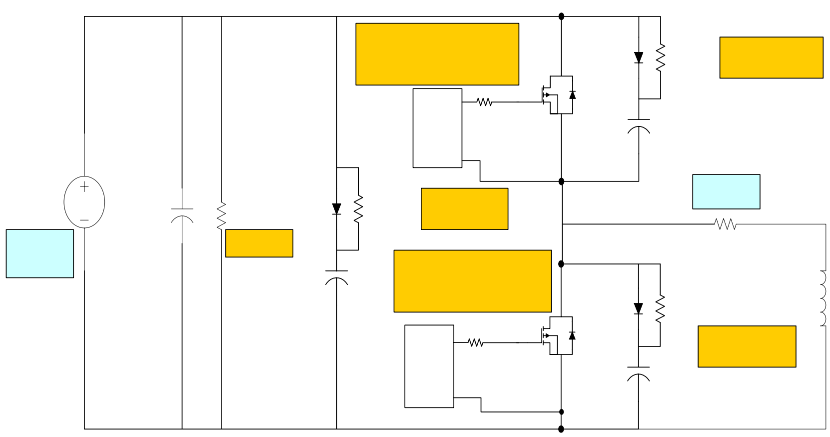
- This task is to work on a snubber circuit for power MOSFET switches and reverse channel conduction to achieve soft-switching without significant switching power losses and be utilized for high speed permanent magnet synchronous motor/generator for a flywheel energy storage system. It develops the performance of the soft switching circuits and ultimately results higher switching frequency, in higher efficiency, smaller size, lower weight, and lower EMI. The fundamental concept of a snubber is to absorb energy from the reactive elements in the circuit. The advantage includes circuit damping, controlling the rate of change of voltage or current or clamping voltage overshoot. The consequence of using the snubber is to limit the amount of stress which the switch must endure and this increases the reliability of the switch. Turn–on, Turn-off, and Over-voltage snubbers when properly designed will reduce stress on components and to minimize or lower average power dissipation

A N:

- The performance test of the single phase inverter of both simulation and implementation is shown in Table-1 and Table-2 respectively. Fig. 1 shows the half-bridge inverter circuit and the simulation waveform result of the single phase inverter is shown in fig. 2. Fig. 3 also shows the implementation waveforms of the single-phase inverter. The turn-on and Turn off waveforms illustrate the dv/dt is reduced and voltage overshoot clamped at below 400V. For simplicity purpose, we used 30V input for implementation and simulation. In the implementation six cascaded MOSFETS connected in parallel are used in order to reduce the resistance, while the simulation, a MOSFET is used with lower resistance, which can cause different results in losses. The dead time is 1.05 microsecond, duty cycle is 50%, and upper and lower switches has six IRF360 MOSFETS in Parallel

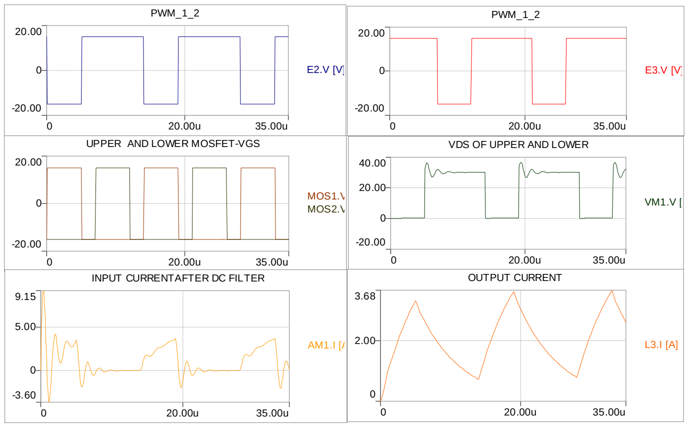
CECSTR

Half wave Snubber Circuit



CECSTR

Simulation



CECSTR

Table 1

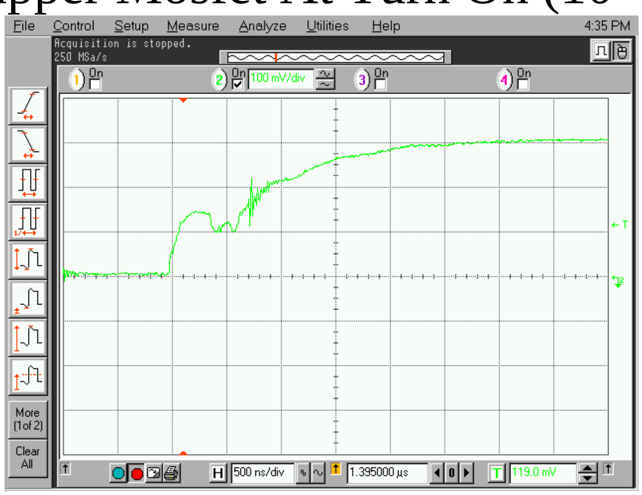
SINGLE PHASE INVERTER WITH SNUBBER OVERVOLTAGE SIMULATION RESULTS							
INPUT POWER(W)	OUTPUT POWER(W)	OVER_VOL. LOSS (W)	UPPER MOSFET LOSS(W)	UPPER SNUBBER LOSS(W)	LOWER MOSFET LOSS(W)	LOWER SNUBBER LOSS(W)	OVERALL GAIN
60.97	57.85	0.053	0.277	0.039	0.283	0.031	94.88272921

Implementation

IMPLEMENTATION OFSINGLE PHASE INVERTER WITH OVER-VOLTAGE SNUBBER @1ms with 5						
INPUT POWER(W)	OUTPUT POWER(W)	UPPER MOSFET LOSS(W)	UPPER SNUBBER LOSS(W)	LOWER MOSFET LOSS(W)	LOWER SNUBBER LOSS(W)	OVERALL GAIN
65.8	63	0.5292	0.001273	0.181	0.00304	95.74468085

A N:

Vgs-upper Mosfet At Turn On (10 V/div)



A N:

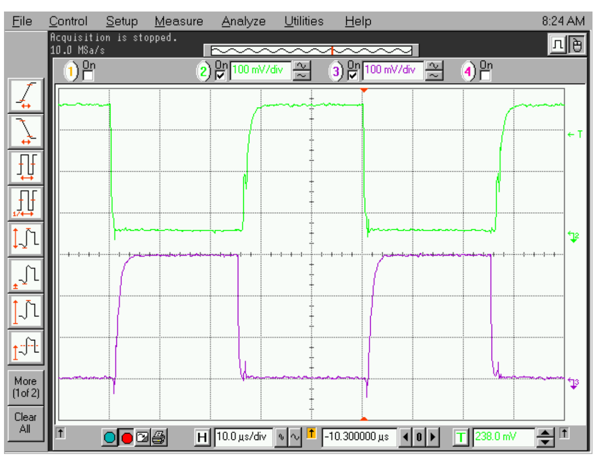
CECSTR

Vgs Upper Mosfet At Turn Off (10/div)

A N:

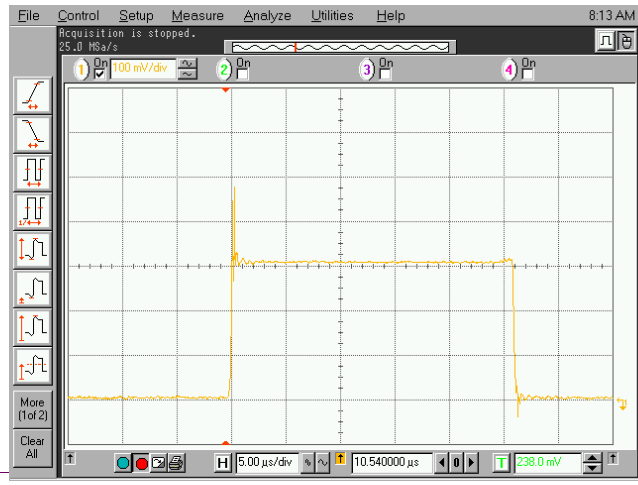
CECSTR

Vgs (UP) (10 V/div)and **Vgs (LOW) (10V/div)**



A N:

Drain to Source Upper Mosfet (10 V/div)



A N:

Design procedure

- Circuit to use power MOSFET switches and reverse channel conduction to reduce switching power losses.Turn-on, turn-off, and over-voltage snubbers to be designed for reduced stress on power electronic components and to minimize total power loss.
- Design to include gate drive circuits and auxiliary power supplies.
- Redundancy using the 3-for-2 scheme shall be designed into the half-bridge converter; three units in parallel and sized such that any two units can supply full power.
- Choose components that would make the half bridge converter flight qualified for a particular mission, such as a LEO spacecraft (low radiation, with environmental temperature as low as -10oC) applications, lunar surface power systems (medium radiation, with environmental temperature as low as -200 o C), and other space explorations (high radiation, extreme cold temperature).
- Design packaging for optimum thermal management performance (e.g. using heat pipes or advanced metal alloy composites to transport heat away from source to external radiations).

A N:

Conclusion

- The Design has been simulated using Simplorer and implemented in the lab.

CECSTR
Center of Excellence for Communication Systems Technology Research

Thank you….

A N: