Pradipta Patra

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Present status:
Employed as Analog Engineer HIP group of Intel Corporation, Bangalore, India.

Objective:
Contributing significantly to the field of engineering and technology being a part of an esteemed organization where I can share and enrich my knowledge.

Research Experience:

I. **PhD Research:** Single-inductor multiple-output (SIMO) dc-dc converter topologies serve as an important replacement to today's multiple supply PMU's. The operation of SIMO converters is based on inductor current ripple and to operate them at high loads (CCM), they need to be operated in single-energizing scheme for the inductor. With the available advantages of these SIMO converters the associated problem that comes in, is the cross-regulation amongst the coupled-outputs and controlling these converters becomes a serious issue. Available literature does not present an accurate modeling for these converters. Conventional state-space modeling (which ignores the ripple in the inductor current and averages the current over one switching cycle ignoring all the states), used for traditional buck and boost converters does not hold good for these SIMO converters. No available literature gives a control scheme that successfully minimizes the cross-regulation amongst the outputs. The present research, under the guidance of Prof. Amit Patra, comes up with a ripple space modeling technique for SIMO converters to accurately map the operation in all possible conditions. The model can also predict the operating range of the outputs and the possible operating range of load at the outputs. This aids in developing a control scheme which can minimize the cross-regulation amongst the outputs during transient operation. Consequently a cross-derivative-feedback control scheme has been designed which can efficiently minimize the cross regulation. SIMO converters, as available in all existing literature, are capable of generating buck and boost outputs simultaneously. With the developed ripple space modeling technique it has been shown that buck, boost and inverted outputs can be generated simultaneously using SIMO topology. Simultaneous generation of all these type of outputs is a major contribution in today's world of portable applications. All the concepts have been modeled, simulated and finally implemented with discrete components as a proof of the concept. The concepts have already been patented and some publications are on its way. The work has been done under the ambit of AVLSI Consortium, in the Advanced VLSI Design Laboratory, IIT Kharagpur in collaboration with Freescale Semiconductor Inc, India and US under the mentorship of John Pigott, Freescale Semiconductor Inc, AZ.

II. **MS Research:** As a part of my Masters of Science (by Research) I have designed and implemented a "Single Inductor Triple-Output (SITO) DC-DC Buck converter" under the supervision of Prof Amit Patra and Prof D. Kastha. The converter has interleaved switched capacitor outputs with only the passive elements being off-chip. The cross coupling effects amongst the coupled outputs has been minimized using a priority based novel control technique. The dead band circuitry amongst the output switches have been optimally designed so that the power MOSFET's do not breakdown at the instance when all the output switches are momentarily turned OFF. The voltage mode control scheme has been subsequently changed to current mode control for the inner loop to achieve faster dynamic response. However, even with significant low duty cycles the system becomes unstable quite unlike single stage current controlled dc-dc converters. The compensating ramp required to stabilize the system has been evaluated and confirmed in simulation. The chip with voltage mode control scheme was taped out in 1.5u process from National Semiconductor and fabricated there itself through the planet run of National Semiconductor and tested in IIT Kharagpur.

Professional Experience

I. **Internship --** Worked as a *"Training Engineer"* in Robert Bosch, both in Bangalore, India and Reutlingen, Germany
Period: April '08- Dec '08
Technical Assignments undertaken: Current controlled buck converter for automotive applications. Developed a novel current sense technique with Thoralf Rosahl, analog lead, Automotive Electronics, Bosch, GmBH for similar applications

II. **Work Experience -** Worked as a *"Development Engineer"* in the R&D division of Webfil LTD, Kolkata for two years & four months.
Period: Since November 2001- March 2004
Technical Assignments undertaken: Associated with the design & development of **"N+1 Power Supply System"**. An SMPS based power supply with an output varying up to 5000W. 1+N Power Supply signifies that N number of power supplies can be added (in parallel) as per the requirements with 1 as spare. The system can drive 50V D.C. at 100Amp. Each Power Supply module can generate 50v DC/12.5A from 230V AC input. The system can simultaneously charge battery back up to the equipment it is supplying to and also drive the equipment. Separate charging of batteries can also be generated. The battery charge management, the equipment status and the current sharing of each of the modules are software controlled through N80C196KD micro controller. Future enhancements to this project will be 50V/100A, 24V/12.5A, and 24V/25A

Highlights of Educational Career

I. **Master of Science (by research)** - From the Dept. of Electrical Engineering, IIT Kharagpur, 2007 CGPA-- 8.77.

II. **Bachelor in Technology** - From the Dept. of Electronics & Communication Engineering, Kalyani Government Engineering College, Kalyani, West Bengal, India. 2001. Marks obtained 75.27%.

Publications:
1. Pradipta Patra, Amit Patra and Neeraj Mishra, "A Single-Inductor Multiple-Output Switcher with Simultaneous Buck, Boost and Inverted Outputs," Power Electronics, IEEE Transactions on, vol. 27, no. 4, pp. 1936 – 1951, April 2012.
2. Pradipta Patra, Jyotirmoy Ghosh and Amit Patra, "Control Scheme for Reduced Cross Regulation in Single-Inductor Multiple-Output DC-DC converter topologies," Accepted in IEEE Transactions on Industrial Electronics.
3. Pradipta Patra and Amit Patra, "Inductor Current Ripple-Based Modeling and Analysis of Single-Inductor Multiple-Output Converters," Communicated to International Journal of Circuit Theory and Applications.
4. Susovon Samanta, Pradipta Patra, Siddhartha Mukhopadhyay and Amit Patra, "Optimal Slope Compensation for Step Load in Peak Current Controlled DC-DC Buck Converter," Power Electronics and Motion Control Conference, EPEPEMC, pp. 485–489, 2008.
5. Pradipta Patra, Amit Patra and D. Kastha, "On-chip implementation of a multi-output voltage regulator based on single inductor Buck Converter Topology". VLSI Design, 2007. *Held jointly with 6th International Conference on Embedded Systems., 20th International Conference on,* pp. 935 – 940, Bangalore, Jan 2007.
6. Pradipta Patra, Susovon Samanta, Souvik Chattopadhyay, Amit Patra and D. Kastha, "A novel Control Technique for Single-Inductor Multiple-Output DC-DC Buck Converters". *Industrial Technology, ICIT 2006, IEEE International Conference on*, pp. 807 – 811, Mumbai, 15-17 Dec, 2006.

Patents:
1. Amit Patra, Pradipta Patra and Jyotirmoy Ghosh, "A Control Scheme for Reduced Cross Regulation in Single-Inductor Multiple-Output DC-DC Converter Topologies," May 2011, Indian Patent Application No: 1301/KOL/2011.
2. Amit Patra, Pradipta Patra, Syed Asif Eqbal and Ashis Maity, "A Bi-Directional Multiple-Input Single-Inductor Multiple-Output Switcher with Buck/Boost/Inverted Outputs," 24th, Nov 2010, Indian Patent Application No:1328/KOL/2010.
3. Pradipta Patra, Syed Asif Eqbal and Amit Patra, "A Single-Input Single-Inductor Multiple-Output DC-DC Switcher Converter," 13th, July 2009, Indian Patent Application No: 964/KOL/2009.
4. Pradipta Patra and Thoralf Rosahl, "On-chip Current Sense for Automotive Applications," Nov 2008, German Patent Application No: R. 326871, Messeneines Laststroms eines Unterbrechers.

Awards and Achievements:
1. Pradipta Patra and Amit Patra, Winner of *Cadence Design Contest*, 2007

2. Guest Lecture on "Dynamics and Control of Switching Converter" in *Estimation and Control: Advanced Theory and Applications* organized by Dept. of EE, IIT Kharagpur and sponsored by MHRD/AICTE, 25-30, December, 2009
3. Track Chair for the track "Power and Control" in *IEEE TechSym 2011*

Extracurricular Activities:

1. Silver Medal at *Shaurya Sports meet*, 2009, IIT Kharagpur football team.
2. Hall President (2009-10) and Advisor (2010-11) of Vikram Sarabhai Residential Complex for the year 2009-2010.
3. Cultural Secretary (2009-10) and Advisor (2010-11) in **"Boikalik"** (the cultural platform for Bengalis in IIT Kharagpur).

Computer and CAD Skills:

1. **Hardware language and Design Tools:** Cadence Spectre, Virtuoso for layout, Diva-DRC and LVS, Assura, Verilog-A, Verilog and Spice-simulator. Saber circuit simulator. Matlab, Mathematica, OrCAD, 8085 based assembly language, Assembly Language Programming (phyton- PICE196 emulator) for 80KC196.
2. **Hardware Instruments:** Network Analyzer, Spectrum Analyzer, LCR Meter, Lab-view, FPGA

Hardware Design Skill

Board Design and development, Schematic & layout designs (ORCAD)

Personal Information

1. **Present Address:** Advanced VLSI Design Laboratory, Takshashila Building, IIT Kharagpur, Kharagpur-721302
2. **Permanent Address:** 6, Upendra Kishore Path, City Centre, Durgapur-16, WB
3. **Date of Birth:** 7th October, 1978
4. **Passport:** B2503493

References

1. Prof. Amit Patra
Department of Electrical Engineering, Indian Institute of Technology, Kharagpur.
Email: amit.patra@ieee.org

2. Prof. Debaprasad Kastha
Department of Electrical Engineering, Indian Institute of Technology, Kharagpur.
Email: kastha@ee.iitkgp.ernet.in

3. Thoralf Rosahl
Analog Lead, Automotive Electronics (AE/EIC1), Robert Bosch GmbH, Reutlingen, GERMANY. Email: thoralf.rosahl@de.bosch.com

4. John Pigott
Analog IC Designer, Freescale Semiconductor, Inc, M/S EL344, Analog Products Division, 2100 E. Elliot Rd, Tempe, AZ 85284-1801, US.
Email: John.Pigott@freescale.com