Title of thesis:

Multilayered Coreless Printed Circuit Board (PCB) Step-down Transformers for High Frequency Switch Mode Power Supplies (SMPS)

Abstract of thesis:

Power Supply Unit (PSU) plays a vital role in almost all the electronic equipments. The continuous efforts in the improvement of switching devices such as MOSFETS, diodes lead to the increased switching speeds of power supplies. By increasing switching frequency of converter, the size of passive elements such as inductors, transformers and capacitors gets reduced. Hence, the high frequency transformer became the backbone in isolated AC/DC and DC/DC converters. The main features of transformers are to provide isolation for safety purpose, multiple outputs in telecom applications, to build step down/step up converters and so on. The core based transformers when operated at higher frequencies has limitations such as core losses which are proportional to operating frequency. Even though the core materials are available in few MHz frequency regions, because of the copper losses in windings of transformers these commercially available transformers were limited up to few hundreds of kHz to 1MHz. The skin and proximity effects because of induced eddy currents become major drawbacks while operating these transformers at higher frequencies. Therefore, it is necessary to mitigate these core losses, skin and proximity effects while operating the transformers at very high frequencies. This can be achieved by eliminating the magnetic cores of transformers and by proper winding structure.

A new multilayered coreless printed circuit board (PCB) step down transformer for power transfer applications has been designed by maintaining the advantages of existing core based transformers such as high energy efficiency, high voltage gain, high coupling coefficient and sufficient input impedance with the help of resonant technique. Also different winding structures have been studied and analysed for higher step down ratios in order to reduce copper losses in the windings and to achieve higher coupling coefficient. The advantage of increasing the layer for the given power transfer application in terms of coupling coefficient, resistance and energy efficiency was reported. The maximum energy efficiency of the designed three layered transformers was found to be in the range of 90%-97% for power transfer applications operated in few MHz frequency regions. The designed multilayered coreless PCB transformers for given power applications of 8, 15 and 30W shows that the volume reduction of approximately 40-90% is possible compared to its existing core based counter parts. The estimation of EMI emissions from the designed transformers proves that the amount of radiated EMI from three layered transformer is less than that of two layered transformer because of the decreased radius for the same amount of inductance.

Multilayered coreless PCB gate drive transformers were designed for signal transfer applications and successfully driven the double ended topologies such as half bridge, two switch flyback converter and resonant converters with low gate drive power consumption of about half a watt. The performance characteristics of these transformers were also evaluated with the high frequency magnetic material made up of NiZn and operated in 2-4MHz frequency region.

These multilayered coreless PCB power and signals transformers together with the latest semi conductor switching devices such as SiC and GaN MOSFETs and SiC schottky diode is an excellent choice in the next generation compact SMPS.

Subject: **Electronics**

Name of institution: **Mid Sweden University, Sundsvall**

Date, time and place for the seminar: **20th May 2011, 13.00, O102, Sundsvall**

A photo of Radhika Ambatipudi