DECLARATION

I, MANU SINGH (2K13/PSY/08) hereby declare that the work, which is being presented in the project report entitled, **“CASCADED RENEWABLE ENERGY SOURCES IN TANDEM WITH STORAGE SUPPORT FOR CURBING INTERMITTENCY IN GRID TIED OPERATION”** submitted for partial fulfillment of the requirements for the award of the degree of Mater of Technology (Power System) is an authentic record of my own work carried out under the able guidance of Dr. VISHAL VERMA, Professor, EED, DTU. The matter embodied in the dissertation work has not been plagiarized from anywhere and the same has not been submitted for the award of any other degree or diplomain full or in part.

Submitted by:-

MANU SINGH
(2K13/PSY/08)
Power System
Electrical Department

DEPARTMENT OF ELECTRICAL ENGINEERING
DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)

CERTIFICATE

This is to certify that the thesis entitled, "**CASCADED RENEWABLE ENERGY SOURCES IN TANDEM WITH STORAGE SUPPORT FOR CURBING INTERMITTENCY IN GRID TIED OPERATION**", submitted by Ms. **MANU SINGH**, Roll No. 2K13/PSY/08, student of Master of Technology (Power System) in Electrical Engineering department from Delhi Technological University (Formerly Delhi College of Engineering), is a dissertation work carried out by her under my guidance during session 2013-2015 towards the partial fulfillment of the requirements for the award of degree of Master of Technology in Power System.

I wish her all the best in her endeavors.

(Dr. VISHAL VERMA)
Professor, EED, DTU
SUPERVISOR

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MANU SINGH

2K13/PSY/08

ABSTRACT

With depleting fossil fuel and threats for environmental hazards, the energy generation is witnessing a shift towards renewable energy sources(RES) globally. Such inclination towards the RES could only become possible due to advancement in power electronics and faster digital controller. Low capacity RES are connected to LV distribution system which offer low power capacity. Such low capacity system are vulnerable to problem of voltage regualtion caused by intermittency of power injection by RES in the weak system.

The onslaught from the load perturbance can be gradually reduced if the RES are integrated to high capacity microgrids at higher voltage in distribution syste, since the are meant for bulk power transfer and there exist very bleak possibility of current reversed. Therefore to the great extent problem of voltage regulation is subscribed. The source side intermittency is mitigated by storage support, which become costly if dealt as Battery energy storage system(BESS) connected in shunt with load and RES, being interfaced to higher voltage.

A cascade connection of RES with differential voltage support by the battery is proposed in the thesis for curbing the intermittency in the sources and enabling the connection of the proposed configuration to higher voltages. A bi-directional interface for battery is solicitated for incorporation, which is enabled though DAB, with high frequency isolation transformer providing the necessary boost in the voltage. The thesis has dealt with the design of high frequency isolation transformer and same is validated through simulation results when connected with DAB. The developed control algorithm for bi-directional control of DAB is also tested under MATLAB/Simulink environment for variable duty cycle control for requisite power. The results demonstrated the effectiveness of control and validate the analytic value through simulated results.

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ACRONYMS

PV	Photovoltaic
SST	Solid State Transformer
HF	High Frequency
δ	delta
PI	Proportional Integral
BESS	Battery Energy Storage System
DAB	Dual Active Bridge
IGBT	Insulated Gate Bipolar Transistor
HFT	High Frequency Transformer
IBDC	Isolated bi-directional Converter
BTB	Back-to-Back
PWM	Pulse Width Modulation
ZVS	Zero Voltage Switching
PPS	Pulse Phase Shift
DABCI	Dual Active Bridge Cascaded with Inverter
MV	Medium Voltage
LV	Low Voltage
DG	Distributed Generator
PS-PWM	Phase Shift-Pulse Width Modulation
Ap	Area Product
Ac	Core Cross Section
Aw	Window Area
N1	Primary turns

N2	Secondary turns
E_1	RMS Primary induced voltage
E_2	RMS Secondary induced voltage
I1	Primary rms currents.
I2	Secondary rms currents.
J	Current Density
Kw	Winding Factor
Kf	Form Factor
Bm	Maximum flux density
J	Current density
f	Frequency
V_{diode}	Rectifier Diode Voltage,
V_o	Output Voltage
d_{max}	Maximum duty cycle,
T_{max}	Maximum ambient temperature
η_t	Efficiency of transformer
P_{cu}	Copper loss
n	Turn ratio
k_h	a constant (material dependent)
x	Steinmetz factor
P_h	Hysteresis loss
P_c	Eddy current loss
c_l	Lamination thickness
ρ_c	Operating resistivity of the core
$\Delta\rho$	Thermal resistivity coefficient
ρ_{20^oC}	Material resistivity at 20^oC

R_h	Hysteresis loss equivalent resistance
R_{ec}	Eddy current loss equivalent resistance
R_1	Primary winding resistance
ρ_1	Resistivity of the primary winding wire
R_2	secondary winding Resistance
ρ_2	resistivity of the secondary winding wire
l	length of the wire
X_m	Magnetising reactance
X	Leakage Reactances.
μrc	Permeability of free space)
μ_o	Permeability of core
ζ_{12}	Winding Thickness Factor
BDC	Bi-directional DC Converter
HEV	hybrid electric vehicles
UPS	Uninterruptible Power Supplies
NBDC	Non Isolated Bidirectional DC converter
IBDC	Isolated Bidirectional DC converter
PSM	Phase Shift Modulation
RES	Renewable Energy Sources
WPS	Wind Power System
VSWT	Variable Speed Wind Turbines
PMSG	Permanent Magnet Synchronous Generators
PCC	Point of common coupling
VS	Voltage Source
WECS	Wind Energy Conversion System