Declaration

I hereby declare that the work presented in this Thesis titled *Nonlinear Control for Mitigation of Second-order Harmonic Ripple Problem in Single-Phase Inverters* submitted to the Indian Institute of Technology Jodhpur in partial fulfillment of the requirements for the award of the degree of Doctor of Philosophy, is a bonafide record of the research work carried out under the supervision of Professor Deepak M. Fulwani. The contents of this thesis in full or in parts, have not been submitted to, and will not be submitted by me to, any other Institute or University in India or abroad for the award of any degree or diploma.

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Certificate

This is to certify that the thesis titled *Nonlinear Control for Mitigation of Second-order Harmonic Ripple Problem in Single-Phase Inverters*, submitted by *Aditya R. Gautam (PG201381001)* to the Indian Institute of Technology Jodhpur for the award of the degree of *Doctor of Philosophy*, is a bonafide record of the research work done by him under our supervision. To the best of my knowledge, the contents of this report, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

Dr. Deepak M. Fulwani
Ph.D.Thesis Supervisor

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List of Symbols

Symbol	Description
β	constant even number
C	Capacitance
C_{FC}	Capacitance of film capacitor
D_{st}	Shoot-through duty cycle
$D_{st_{ss0}}$	Steady-state shoot-through duty-cycle without SHC ripple
$D_{st_{ss}}$	Steady-state shoot-through duty-cycle with SHC ripple
E	Input DC voltage
G_c	Transfer function of current controller
G_v	Transfer function of voltage controller
i_{ac}	Instantaneous value of AC current
i_{FC}	Instantaneous current through film capacitor
I_{max}	Maximum value of i_{ac}
L	Inductance
λ	Eigen value
ω	Angular frequency of inverter
2ω	Angular frequency of second-order ripple
P_o	Average value of power at input of inverter
p_{ripple}	$2\omega-$Ripple component in average power
p_{ac}	Instantaneous value of AC power
φ	Phase-shift angle between AC voltages
$Q,\ \Gamma,\ \gamma,\ \psi,\ \mu,\ \nu,\ \eta$	Positive constant values
QF	Quality Factor
ρ	Uncertainty in system parameters
σ	Switching function
θ	Power factor angle
x_1	Instantaneous value of DC current through Inductor
x_2	Instantaneous value of DC voltage across DC-link capacitor
x_o	Instantaneous value of DC load current
x_{1r}	Reference value of x_1
x_{2r}	Reference value of x_2
x_{1i}	Initial value of x_1
x_{2i}	Initial value of x_2
x_{1f}	Final value of x_1
x_{2f}	Final value of x_2
v_{ac}	Instantaneous value of AC voltage
V_{max}	Maximum value of v_{ac}
V_{PV}	Output voltage of solar PV
V_o	Average DC voltage at DC-link
v_{FC} or v_c	Instantaneous voltage across film capacitor

Symbol	Description
u	Control input
u_{eqv}	Equivalent control input
u_n	Discontinuous control input
Z_{out}	Output impedance

List of Abbreviation

Abbreviation	Full form
APT	Active Power Decoupling Technique
AVVR	Allowed Voltage Variation Range
ALFRCD	Active Low Frequency Ripple Control Device
BJT	Bipolar Junction Transistor
BPF	Band Pass Filter
BPS − CVFS	BPF-incorporated Capacitor Voltage Feedback Scheme
CSI	Current Source Inverter
CPS − PAF	Current Pulsation Smoothing-Parallel Active Filter
CCM	Continuous Current Mode
CCT	Control-oriented Compensation Technique
CMC	Current Mode Control
CF − DHB	Current Fed Duel Half Bridge
DG	Distributed Generator
DCM	Discontinuous Current Mode
DLC	Dual Loop Control
DI	Differential Inverter
EES	Electrical Energy Storage
E − cap	Electrolytic capacitor
ESR	Equivalent series resistance
FB − RCR	Full Bridge Ripple Current Reduction
GaN	Gallium Nitrate
ISI	Impedance source inverter
ISMC	Integral Sliding Mode Control
IGBT	Insulated-Gate Bipolar Transistor
IGCT	Insulated Gate Commuted Thyristor
LFT	Low Frequency Transformer
LQR	Linear Quadratic Regulator
MPPT	Maximum Power Point Tracking/Tracker
MPP	Maximum Power Point
MOSFET	Metal-Oxide Semiconductor Field Transistor
MAF	Moving Average Filter
NF	Notch Filter
NF − CR	Notch Filter inserted Current Reference
NF − LCFFS	Notch Filter inserted Load Current Feed Forward Scheme
PR Controller	Proportional Resonant Controller
NSS	Nonlinear Natural Switching Surface
PE	Power Electronics
PFC	Power Factor Correction
PCC	Point of Common Coupling
PCS	Power Conditioning System
PLL	Phase Locked Loop

Abbreviation	Full form
PPT	Passive Power Decoupling Technique
$q-ZSI$	quasi Z-Source Inverter
$q-SBI$	quasi-Switched Boost Inverter
RE	Renewable Energy
SHC	Second-order Harmonic Current
SG	Synchronous Generator
SMC	Sliding Mode Control
$SVPWM$	Space Vector Pulse Width Modulation
THD	Total Harmonic Distortion
VMC	Voltage Mode Control
VSI	Voltage Source Inverter
WFC	Waveform Control
ZSI	Z-Source Inverter