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LIST OF ABBREVATIONS

CB-PWM	Carrier-Based Pulse width Modulation
CHB-MLI	Cascaded H-Bridge Multilevel Inverter
CRCC	Conventional Ripple Correlation Control
DSP	Digital Signal Processing
EGAT	Electricity Generating Authority of Thailand
EMC	Electromagnetic Compatibility
GCPVS	Grid-Connected Photovoltaic System
GUI	Graphical User Interface
HB	H-Bridge
HPF	High Pass Filter
IEA PVPS	International Energy Agency Photovoltaic Power Systems Program
IGBT	Insulated-Gate Bipolar Transistor
LPF	Low Pass Filter
MPP	Maximum Power Point
MPPT	Maximum Power point Tracking
MRCC	Modified Ripple Correlation Control
PF	Power Factor
PI	Proportional-Integral Controller
PV	Photovoltaic
PWM	Pulse Width Modulation
RCC	Ripple Correlation Control
RMS	Root Mean Squre
SPWM	Sinusoidal Pulse Width Modulation
THD	Total Harmonic Distortion
VSC	Voltage Source Converter
VSI	Voltage Source Inverter
InCond	Incremental Conductance
P&O	Perturbation and Observation

LIST OF SYMBOLS

dP	derivative powers
dP_1, dP_2	derivative powers of in different time
dp_{PV}	derivative PV power
di_{PV}	derivative PV current
dv_{PV}	derivative PV voltage
∂p_{PV}	partial derivative PV power
∂v_{PV}	partial derivative PV power
η_{mppt}	efficiency of maximum power point tracking
η	efficiency of inverter
i_{PV}	instantaneous photovoltaic current
i_{PV1}, i_{PV2}	instantaneous photovoltaic current of upper and lower H-Bridge cells
i_{C}	instantaneous decoupling capacitor current
i_{C1}, i_{C2}	instantaneous decoupling capacitor current of upper and lower H-Bridge cells
i_{INV}	instantaneous input current of H-Bridge inverter
i_{INV1}, i_{INV2}	instantaneous input current of H-Bridge inverter of upper and lower H-Bridge cells
i_{g}	instantaneous grid current
i_{g}^{*}	grid current reference
i_{gP}^{*}	peak grid current reference
$\tilde{i}_{\mathrm{PV}}$	PV current ripple
$\overline{i}_{\mathrm{PV}}$	dc component of PV current
$i_{\mathrm{gd}}, i_{\mathrm{gq}}$	direct and quadrate grid currents

i_{gd}^{*}, i_{gq}^{*}	direct and quadrate grid current references
$i_{g\alpha}, i_{g\beta}$	grid current in stationary frame alpha and beta
I_{SC}	short circuit PV current at the standard test condition (STC) of a PV module
I_{mpp}	the maximum power point PV current at the STC of a PV module
I_{Rated}	the maximum power point PV current at the STC of a PV array
m_a	modulation index
P_{PVt}	average total photovoltaic power
$\bar{p}_{PV}$	dc component of PV power
$\tilde{p}_{PV}$	PV power ripple
p_{INV1}, p_{INV2}	instantaneous input power of inverter of upper and lower H-Bridge
P_{INV1}, P_{INV2}	average input power of inverter of upper and lower H-Bridge
p_{PV1}, p_{PV2}	instantaneous input power of inverter of upper and lower H-Bridge
	average photovoltaic power
P_{PV1}, P_{PV2}	average input power of inverter of upper and lower H-Bridge
p_{C1}, p_{C2}	instantaneous decoupling capacitor power
P_{C1}, P_{C2}	average decoupling capacitor of upper and lower H-Bridge
G_i	irradiation (W/m^2)
$S_1, S_3,$	The upper power electronic switches on left and right leg of an H-Bridge
$S_2, S_4,$	The lower power electronic switches on left and right leg of an H-Bridge
$S_{11}, S_{12},$	Power electronic switches on left leg of an upper H-Bridge in the CHB-MLI
S_{13}, S_{14}	Power electronic switches on right leg of an upper H-Bridge in the CHB-MLI

S_{21}, S_{22}	Power electronic switches on left leg of an lower H-Bridge in the CHB-MLI
S_{23}, S_{24}	Power electronic switches on right leg of an lower H-Bridge in the CHB-MLI
v_{o}	instantaneous output voltage of CHB-MLI
$v_{\mathrm{o}\alpha}$	output voltage of CHB-MLI in stationary frame of alpha axis
v_{g}	instantaneous grid voltage
v_{PV}	photovoltaic voltage
v_{PV}^{*}	photovoltaic voltage reference
$\tilde{v}_{\mathrm{PV}}$	PV voltage ripple
$\overline{v}_{\mathrm{PV}}$	dc component of PV voltage
$\overline{\tilde{v}_{\mathrm{PV}} \cdot \tilde{v}_{\mathrm{PV}}}$	dc component of the product of double PV voltage ripple
$\overline{\tilde{p}_{\mathrm{PV}} \cdot \tilde{v}_{\mathrm{PV}}}$	dc component of the product between ripples of PV voltage and power ripple
$\omega_s t$	inverter electrical position
f_1	fundamental frequency
d, q	direct and quadrate indices for orthogonal components
d / dt	differential operation
ω	angular speed
ω_{g}	grid angular speed
L_{f}	inductance filter
MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking
$P_{\mathrm{g}}, Q_{\mathrm{g}}$	grid active and reactive powers
Temp	ambient temperature
V_{OC}	open circuit PV voltage at the standard test condition (STC)

V_{mpp}	maximum power point voltage at the standard test condition (STC) of a PV module
V_d, V_{dc}	dc-link voltage
V_{Rated}	maximum power point voltage at the standard test condition (STC) of a PV array

ข้อความแห่งการริเริ่ม

วิทยานิพนธ์นี้ได้นำเสนอ การสร้างแบบจำลอง การวิเคราะห์ และการพัฒนาวิธีการควบคุมอินเวอร์เตอร์หลายระดับคาสเกดเอชบริดจ์เฟสเดียวสำหรับระบบโฟโตโวลตาอิกที่ถูกเชื่อมต่อเข้ากับกริดโดยใช้หลักการติดตามจุดผลิตกำลังสูงสุดชนิดปรับปรุงวิธีการควบคุมความสัมพันธ์ของระลอกคลื่น วิธีการดังกล่าวสามารถตรวจติดตามจุดผลิตกำลังสูงสุดของระบบควบคุมอินเวอร์เตอร์แหล่งจ่ายแรงดันเฟสเดียวสำหรับระบบโฟโตโวลตาอิกที่ถูกเชื่อมต่อเข้ากับกริดที่มีความเที่ยงตรงและความแม่นยำสูง หลักการใหม่ที่วิทยานิพนธ์นี้นำเสนอมีรายละเอียดดังต่อไปนี้

1. วิธีการดึงสัญญาณระลอกคลื่นที่มีอยู่ในค่ากำลังและแรงดันชั่วขณะของโฟโตโวลตาอิก
2. ขจัดการใช้ตัวกรองฮาร์มอนิกจากแรงดันกระแสตรงทางด้านอินพุตของตัวควบคุมแรงดันดังกล่าวโดยใช้องค์ประกอบกระแสตรงที่หาได้จากอัลกอริทึมที่นำเสนอ
3. ไม่ต้องการตัวกรอง HPF และ LPF เพื่อสร้างสัญญาณระลอกคลื่นทั้งหมด อีกทั้งไม่ต้องการองค์ประกอบกระแสตรงที่ได้รับจากตัวกรองดังกล่าว
4. การพัฒนาชุดอินเวอร์เตอร์แหล่งจ่ายแรงดันแบบเอชบริดจ์สองระดับและห้าระดับคาสเกด ที่ใช้กับระบบเชื่อมต่อกริดแบบเฟสเดียวและสเตทเดียวด้วยวิธีการควบคุมความสัมพันธ์ของระลอกคลื่นแบบปรับปรุงที่นำเสนอ

STATEMENT OF ORIGINALITY

In this thesis, control of single-phase cascaded H-bridge multilevel inverter for grid-connected photovoltaic system based on the modified ripple correlation control MPPT has been modeled, analyzed, designed and implemented. This algorithm provides a high accuracy and precision MPPT solution for single-stage single-phase VSI grid-connected PV system application. The main contributions with a new modified RCC-MPPT algorithm for single-phase VSI grid-connected PV systems are:

1. The method to extract the ripple from the instantaneous PV power and PV voltage.
2. Eliminate the harmonic filter in the input dc voltage of dc voltage controller by means of the inherent dc component.
3. No need the HPF and LPF to generate all ripples and also dc component.
4. Development of single-stage single-phase H-bridge two level and five level VSI used in grid connected systems with the modified RCC-MPPT control.