

PERPUSTAKAAN UMP



Z-SOURCE INVERTER IN PV SYSTEM USING SIMPLE
BOOST PULSE WIDTH MODULATION

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LIST OF ABBREVIATIONS

B	boost factor
D_0	shoot-through duty ratio
f_a	fundamental frequency
f_c	carrier frequency
f_s	switching frequency
f_{sam}	sampling frequency
G	voltage gain
M_i	modulation index
THD	total harmonic distortion
THD_i	current total harmonic distortion
$V_{AC(peak)}$	peak AC output voltage
V_{input}	input DC voltage
$V_{DClink\,(peak)}$	peak voltage stress
V_{ref}	reference voltage
V_{tri}	triangular voltage

LIST OF ACRONYMS

AC	alternating current
ADC	analogue-to-digital converters
CSI	current source inverter
DC	direct current
DSP	digital signal processing
EMI	electro-magnetic interference
IGBT	insulated gate bipolar transistor
MIPS	millions of commands per second
PWM	pulse width modulation
RMS	root mean square
RTW	real time workshop
ST	shoot-through
UPS	uninterruptible power supply
VSI	voltage source inverter
ZS	Z-source
ZSI	Z-source inverter

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ABSTRAK

Galangan-sumber rangkaian atau dikenali sebagai rangkaian Z-sumber adalah satu X gandingan rangkaian dua liang yang terdiri daripada dua pengaruh dan dua kapasitor. Rangkaian Z-sumber disambungkan pada masukan penyongsang H-jambatan membentuk penyongsang Z-sumber (ZSI). Sifat-sifat ZSI yang mengatasi penyongsang konvensional yang boleh diakses, iaitu julat voltan keluaran dalam penyongsang konvensional adalah terhad sama ada besar atau lebih kecil daripada voltan masukan. Ini mendorong ahli akademik dan industri untuk mengkaji kerana sejak penemuannya, banyak penyelidikan dan pembangunan telah dijalankan, seperti meningkatkan topologi yang sedia ada, mencadangkan skim pemanduan baru, membangunkan kawalan gelung dan melaksanakan pada aplikasi baru. Sebaliknya, dalam operasi penyongsang tiga fasa, kaedah enam langkah modulasi lebar denyut (PWM) menghasilkan riak kekerapan tork yang rendah. Masa bagi riak kekerapan penyongsang tork harmonik dalam mesin pada n fasa terjadi disebabkan oleh harmonik masa bekalan kuasa pada $2n \pm 1$. Peningkatan dalam bilangan fasa perintah $2n \pm 1$ mesin dapat menyelesaikan tork frekuensi rendah riak. Oleh itu, tesis ini adalah untuk meningkatkan lagi pengetahuan mengenai skim pemanduan sistem ZSI berbilang kerana perlaksanaannya yang agak terhad. Sistem dengan nombor fasa yang lebih tinggi akan menyebabkan tekanan voltan yang lebih rendah, kebolehpercayaan yang lebih tinggi, meningkatkan kuasa dalam kerangka yang sama dan mengurangkan herotan harmonik. Justeru, cabaran penyelidikan ini adalah untuk mengisi jurang dengan menggunakan rangsangan mudah modulasi nadi-lebar (SBPWM) untuk skim pemanduan sistem ZSI lima fasa. SBPWM adalah skim pemanduan yang dipercayai kerana ia boleh dilaksanakan pada sebarang topologi ZSI, boleh digunakan dalam pengawal digital, mempunyai keteguhan tinggi dan menggunakan persamaan matematik yang mudah. Kajian ini dijalankan dengan membentuk semula SBPWM untuk memenuhi sistem ZSI lima fasa di bawah lima isyarat rujukan dengan isyarat pembawa di pensuisan frekuensi 1.5 kHz. Melalui operasi ini, mod benar-das boleh disusun secara setara. Ini akan menyebabkan sistem boleh mengalak dan meronta. Kajian ini mendapati bahawa pada 0.253 msesaat selang masa penalti sistem memberikan ralat kurang daripada 7%. Kedua, proses simulasi menggunakan MATLAB@Simulink @ dengan perlaksanaan di bawah 2 kWatt dengan kepelbagaian indeks modulasi (M_i) dari 0.562 sehingga 1.1 dengan voltan masukan DC 40 V. Pada M_i 0.62, sistem ZSI lima fasa menghasilkan 4.6 % jumlah herotan harmonik (THD) arus keluaran untuk Fasa A pada sambungan beban rintangan jenis bintang. Akhir sekali, kajian disahkan lagi dengan menjalankan ujikaji menggunakan pelantar prototaip dengan pengukuran THD arus keluaran untuk Fasa A di mana THD arus keluaran berkenaan mematuhi piawaian IEEE 519-1992 dan EN 61000-3-2 yang dibenarkan iaitu pada 5% dan 27%.

ABSTRACT

Impedance-source network or known as Z-source network is an X form coupling of the two-port network consists of two inductors and two capacitors. The Z-source network is connected to the input of the H-bridge inverter forming into a Z-source inverter (ZSI). The attributes of ZSI that overcome the conventional inverter, which their accessible of output voltage range in the conventional inverter is restricted to either greater or smaller than the input voltage. This quickly brought interest to the academicians and industry since its inception, a lot of research and development were carried out to improve the existing topology, proposing a new driving scheme, developing control loop and implementing new application. On the other hand, in three-phase inverter operation, the six-step modes of pulse width modulation (PWM) produce the low-frequency torque ripple. Since the lowest frequency torque ripple harmonic in an n -phase machine is caused by the time harmonics of the supply of the order $2n \pm 1$, an increase in the number of phases of the order $2n \pm 1$, then the machine is able to resolve the low-frequency torque ripple. Thus, this thesis is to further enhance the body of knowledge on the driving scheme of multiphase ZSI system since the implementation is rather limited. A system with a higher number of phases would result in lower voltage stress, higher reliability, increase power in the same frame and reduced harmonic distortions. Thus, the research challenge is to fill the gap by using simple boost pulse-width modulation (SBPWM) for the driving scheme of the five-phase ZSI system. SBPWM is a trusted driving scheme since it can be implemented at any ZSI topology, can be embedded in a digital controller, has high robustness and has low mathematics complexity. The research is carried out by remodelling SBPWM to suit the five-phase ZSI system specification under five reference signals that is compared with a carrier signal at switching frequency of 1.5 kHz. The equally contributed at the shoot-through mode in the operation make the system capable of both boosting and bucking operation. It is found that at the 0.253 msec shoot-through time interval gives less than 7% error. The remodelled SBPWM is then implemented on operations below 2 kW via MATLAB@Simulink simulation, where the modulation index (M_i) varied from 0.562 until 1.1 and input DC voltage fixed at 40 V. At M_i 0.62, the five-phase ZSI system offers 4.6% total harmonic distortion (THD) output current for resistive load at the star formation connection. Finally, the result verification is carried out with hardware experiment prototype, where the output current's THD is compiled to the IEEE 519-1992 and EN 61000-3-2 standards.

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LIST OF PUBLICATIONS

Conference Papers and Journals:

1. **M.S.BAKAR**, N.A.RAHIM, H.DANIYAL, K.H.GHAZALI “Experimental Study Of SBPWM For Z-Source Inverter Five Phase” in International Journal of Power Electronics & Drives (IJPEDS – Scopus Cited), Vol 6, No 1: March 2015.
2. **M.S.BAKAR**, N.A.RAHIM, K.H.GHAZALI, H.DANIYAL “Evaluation on Performances of Carrier-Based PWM for Z-Source Five Leg Inverter” in The 2nd Power and Energy Conversion Symposium (PECS2014), 2014.
3. **M.S.BAKAR**, N.A.RAHIM, K.H.GHAZALI, H.DANIYAL, “An Open Loop Evaluation Of Five-Phase Z-Source Inverter” in Journal of International Review Of Automatic Control, 2013(IREACO – Scopus Cited) , Vol. 6.No. 5. pp. 607-611.
4. **M.S.BAKAR**, N.A.RAHIM, K.H.GHAZALI, A.H.M.HANAFI, “Feasibility Study On Z-Source Inverter Topologies” in International Conference on Electrical, Control and Computer Engineering 2013 (InECCE), 2013, pp.14-18.
5. **M.S.BAKAR**, N.A.RAHIM, K.H.GHAZALI, A.H.M.HANAFI, “Z-source inverter pulse width modulation: A Survey” in International Conference on Electrical, Control and Computer Engineering 2011 (InECCE), 2011, pp. 313-3316.
6. **M.S.BAKAR**, N.A.RAHIM, K.H.GHAZALI, “Analysis of various PWM controls on single-phase Z-source inverter” in 2010 IEEE Student Conference on Research and Development (SCoReD), 2010, pp. 448-451.