

# A simple three-phase three-wire

*by* Hanny Tumbelaka

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**Submission date:** 11-Dec-2020 04:20PM (UTC+0700)

**Submission ID:** 1471945978

**File name:** Binder7.pdf (5.43M)

**Word count:** 8215

**Character count:** 47533

ISBN : 978-1-4799-64314



2014

The 1st International Conference  
on Information Technology,  
Computer, and Electrical Engineering

**ICITACEE**

Semarang, 8-9 November 2014

# PROCEEDINGS

*Green Technology and its Applications  
for a Better Future*



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Kyushu Institute of Technology

## GREETINGS FROM THE GENERAL CHAIR

Welcome to 2014 1<sup>st</sup> International Conference on Information Technology, Computer, And Electrical Engineering (ICITACEE) held in Semarang, the capital city of Central Java! This conference provides a forum for researchers, academicians, professionals, and students from various engineering backgrounds and also from cross-disciplinary research in the development and the design of Information Technology & Computer, Power System, Circuit & Control, and Communication Systems, as well as the Interdisciplinary topics to interact and to disseminate the latest issues and research.

The ICITACEE 2014 is held in the ICT building of Diponegoro University on November, 8. Three distinguished scholars will start the session as keynote speakers: Prof. Hiroshi Ochi as a wireless expert from Kyushu Institute of Technology Japan, Dr. Trio Adiono as an IC design expert from Bandung Institute of Technology, and Mr. Adi Rahman Adiwoso as an aeronautics expert from PT Pasific Satellite Nusantara. We are very grateful for them to share their knowledge, experience, and their motivation for always doing the best. We recently received more than 140 papers, however only of 87 high quality papers were accepted and being presented in this event. All the accepted and presented papers will be then published in the IEEE Xplore ( ISBN 978-1-4799-6432-1 ). We will select the best papers of each categories mentioned above.

Organizing such an ambitious conference has always been incredibly challenging and would have been impossible to happen without our outstanding committee supports. I would like to thanks all staffs of Department of Electrical Engineering and Department of Computer System as well as IEEE Student Branch of Diponegoro University. They have been working very hard and been always providing me with unprecedented support, advice, and kind assistance on all aspects of the conference. Special thanks goes to the IEEE Indonesia Section, Cisco, Des Net, and PSN for all support to ICITACEE 2014. I also would like to thank all of the steering committee, technical program committee, reviewers, authors, session organizers and chairs, and other volunteers and participants. I expect that everyone is able to enjoy some of what Semarang City has to offer! Hopefully The ICITACEE 2014 conference would become the event of our best deeds.



Wahyul Amien Syafei

General Chair,

2014 1<sup>st</sup> International Conference of Information Technology,  
Computer and Electrical Engineering (ICITACEE)

**FOREWORD FROM HEAD OF DEPARTMENT OF ELECTRICAL ENGINEERING,  
UNIVERSITAS DIPONEGORO, SEMARANG-INDONESIA**

It is pleasant to welcome all the participants in the International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE 2014) at Semarang. This is the second conference held together by Electrical Engineering Department and Computer System Department of Engineering Faculty Universitas Diponegoro. I would like to welcome several keynote speakers from Kyushu Institute of Technology Japan and Institut Teknologi Bandung.

As the Chief of Electrical Engineering Department Universitas Diponegoro, I would like to appreciate the vast work in this conference as collaborative effort among Electrical Engineering Department, Computer System Department Universitas Diponegoro, IEEE Student Branch of Universitas Diponegoro and IEEE Indonesia Section. I also wish that this conference to be a needed forum for engineers and scientists to communicate and sharing their findings and precious researches.

I would like to express hearty gratitude to Organizing Committee members, staffs, and students of Electrical Engineering and Computer System Department of Universitas Diponegoro for their efforts and supports. I do expect that this conference will give important contribution to development of Electrical Engineering and Computer Science locally and internationally.



Ir. Agung Warsito. D.H.E.T

Head, Department of Electrical Engineering – Faculty of Engineering  
Universitas Diponegoro, Semarang – Indonesia  
and

Vice Chairman of FORTEI (Indonesia Electrical Engineering Forum)



## **FOREWORD FROM DEAN OF FACULTY OF ENGINEERING UNIVERSITAS DIPONEGORO, SEMARANG – INDONESIA**

The International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE 2014) is now held in Semarang, Indonesia and being organized under the collaborative committee effort among Electrical Engineering and Computer System Department Diponegoro University and IEEE (Institute of Electrical and Electronics Engineers ) Indonesia Section. This event also becomes a part of 56<sup>th</sup> Faculty of Engineering Dies Natalis and 57<sup>th</sup> Diponegoro University Dies Natalis agenda

The goals of the conference are to obtain and extend the knowledge of the recent issues, opinions, bright ideas about the development of a comprehensive green technology constructively from distinguish scholars, researchers, and academics. Furthermore, this forum is expected to bring new innovations in technology for a better future, especially in the field of information technology, computers, and electrical engineering and also create cooperation between institutions of science at the college level, industries and government.

It is a great pleasure to welcome all the participants of this conference and also several keynote speakers from Kyushu Institute of Technology Japan, Bandung Institute of Technology and Pasific Satelite Nusantara.

I do hope that this conference to be a valuable forum for engineers and scientist to share their precious researches and this event will give significant contributions to the development of Electrical Engineering and Computer Science. It is hope that this conference will rise the awareness of scientific community members in bringing better life.

I hope that the conference will be stimulating and memorable for you. So, enjoy your time in Semarang.



Ir. Bambang Pudjianto, M.T.  
Dean, Faculty of Engineering  
Universitas Diponegoro, Semarang – Indonesia

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2014 1st International Conference on Information Technology, Computer and  
Electrical Engineering (ICITACEE)

CONFERENCE PROGRAM

SATURDAY, 8 NOVEMBER 2014

7:30 - 8:00	Registration			
8:00- 8:45	Opening ceremony			
	Photo session			
8:45 - 9:00	Coffee break			
9:00 - 9:50	Invited speaker 1: Prof. Hiroshi Ochi ( <i>Kyushu Institute of Technology, JAPAN</i> ) <i>Multi-MIMO Wireless System - from Theory to Chip Design</i>			
	Invited speaker 2: Prof. Dr. Trio Adiono (Institut Teknologi Bandung) <i>Challenges and Opportunities in Designing Internet of Things</i>			
10:40 - 11:30	Invited speaker 3: Dr. Adi Rahman Adiwoso (PT. Pasifik Satelit Nusantara) <i>Role of Satellite Telecommunication in Indonesia</i>			
11:30 - 12:30	LUNCH BREAK			
12:30 - 15:00	Parallel session 1			
	ROOM A	ROOM B	ROOM C	ROOM D
15:00 - 15:15	coffee break			
15:15 - 17:30	Parallel session 2			
	ROOM A	ROOM B	ROOM C	ROOM D
18:30 - 20:00	GALA DINNER			

SUNDAY, 9 NOVEMBER 2014

8:00 - ...	<i>cultural program (city tours)</i> <i>(*with additional arrangements)</i>
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## PARALLEL SESSION

TIME	NO	ROOM A (HALL, 5th FLOOR)		ROOM B (5th FLOOR)		ROOM C (4th FLOOR)		ROOM D (4th FLOOR)	
		CODE	TITLE	CODE	TITLE	CODE	TITLE	CODE	TITLE
12.30 - 15.00	1	PS01	Design and Implementation of Solar Power as Battery Charger Using Incremental Conductance Current Control Method based on dsPIC30F4012	IP01	Visual Object Tracking using Particle Clustering	CC01	Enhancement of DRAMs Performance using Resonant Tunneling Diode Buffer	ITC01	The Development of 3D Educational Game to Maximize Children's Memory
	2	PS02	An Adaptive Neuro Fuzzy Inference System for Fault Detection in Transformers by Analyzing Dissolved Gases	IP02	Selective Encryption of video MPEG use RSA Algorithm	CC02	Real-time SoC Architecture and Implementation of Variable Speech PDF based Noise Cancellation System	ITC02	The Influence of Knowledge Management to Success Collaborative Design
	3	PS03	Optimal Power Flow based upon Genetic Algorithm deploying Optimum Mutation and Elitism	IP03	Analytical Hierarchy Process for Land Suitability Analysis	CC03	Application of Supervised Learning in Grain Dryer Technology Recirculation Type Cooperated with Wireless Sensor Network	ITC03	Knowledge and Protocol on Collaborative Design Selection
	4	PS04	Design Analysis and Optimization of Ground Grid Mesh of Extra-High Voltage Substation Using an Intelligent Software	IP04	Training Support for Pouring Task in Casting Process using Stereoscopic Video See-through Display - Presentation of Molten Metal Flow Simulation Based on Captured Task Motion -	CC04	Design of Real-Time Gas Monitoring System Based on Wireless Sensor Networks for Merapi Volcano	ITC04	Mobile-Based Learning Design with Android Development Tools
	5	PS05	Design and Simulation of Neural Network Predictive Controller Pitch-Angle Permanent Magnetic Synchronous Generator Wind Turbine Variable Pitch System	IP05	Feature Extraction and Classification of Heart Sound based on Autoregressive Power Spectral Density	CC05	ANFIS Application for Calculating Inverse Kinematics of Programmable Universal Machine for Assembly (PUMA) Robot	ITC05	A mobile diabetes educational system for Fasting Type 2 Diabetes in Saudi Arabia
	6	PS06	Inverse Clarke Transformation based Control Method of a Three-Phase Inverter for PV-Grid Systems	IP06	Smart-Meter based on current transient signal signature and constructive backpropagation method	CC06	MRC NN Controller for Arm Robot Manipulator	ITC06	Aggressive Web Application HoneyPot for Exposing Attacker's Identity
	7	PS07	Control of a Single Phase Boost Inverter with the Combination of Proportional Integrator and Hysteresis Controller	IP07	AUTOMATIC DOOR STOP SAFETY SYSTEM BASED ON IMAGE PROCESSING WITH WEBCAM AND SCANNER	CC07	Development of Microcontroller-based Stereoscopic Camera Rig Positioning System	ITC07	Adjustment Levels for Intelligent Tutoring System using Modified Items Response Theory
	8	PS08	A Simple Three-phase Three-wire Voltage Disturbance Compensator	IP08	Print Identification for User Verification based on Line Detection and Local Standard Deviation	CC08	Design of a Digital PI Controller for Room Temperature on Wireless Sensor and Actuator Network (WSAN) System	ITC08	Smile Recognition System based on Lip Corners Identification
	9	PS09	Analysis of Protection Failure Effect and Relay Coordination on Reliability Index	IP09	Cerebellar Model Articulation Controller (CMAC) for Sequential Images Coding	CC09	Display and Interface of wireless EMG measurements	ITC09	An Integrated Framework for Measuring Information System Success Considering the Impact of Culture in Indonesia
	10	PS10	Extreme Learning Machine Approach to Estimate Hourly Solar Radiation On Horizontal Surface (PV) in Surabaya and East Java	IP10	A Comparative Study on Signature Recognition	CC10	Accuracy Enhancement of Pickett Tunneling Barrier Memristor Model	ITC10	Pre-Processing Optimization on Sound Detector Application Auditron (Android Based Supporting Media for the Deaf)
COFFEE BREAK									
15.15 - 17.30	11	PS11	Maximum Power Point Tracking Control for Stand-Alone Photovoltaic System using Fuzzy Sliding Mode Control/Maximum Power Point Tracking Control for Stand-Alone Photovoltaic System using Fuzzy Sliding Mode Control	IP11	Study of Environmental Condition Using Wavelet Decomposition Based on Infrared Image	CC11	Data Fusion and Switching Function For UAV Quadrotor Navigation System	ITC11	EVALUATION OF DISTRIBUTION NETWORK RELIABILITY INDEX USING LOOP RESTORATION SCHEME
	12	PS12	The Influence of Meteorological Parameters under Tropical Condition on Electricity Demand Characteristic: Indonesia Case Study	IP12	Very High Throughput WLAN System for Ultra HD 4K Video Streaming	CC12	Data logger Management Software Design for Maintenance and Utility in Remote	ITC12	Efficient Message Security Based Hyper Elliptic Curve Cryptosystem (HECC) for Mobile Instant Messenger
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20		TE07	Design and Analysis of Dualband J-Pole Antenna with Variation in T-Shape for Transceiver Radio Communication at VHF and UHF Band	CC20	Temperature Response Analysis Based on Pulse Width Irradiation of 2.45 GHz Microwave Hyperthermia	ITC20	Providing Information Sources Domain for Information Seeking Agent From Organizing Knowledge
21		TE08	Low Cost Implementation for Synchronization in Distributed Multi Antenna Using USRP/GNU-Radio	ITC24	Visualization of Condition Irrigation Building and Canal Using Web GIS Application	ITC21	Decision Support System For Stock Trading Using Decision Tree Technical Analysis Indicators and Its Sensitivity Profitability Analysis
22		TE09	Development of the First Indonesian S-Band Radar	ITC25	Comparison of three back-propagation architectures for interactive animal names utterance learning	ITC22	Design Web Service Academic Information System Based Multiplatform
23				ITC26	WORK IN PROGRESS - OPEN EDUCATION METRIC (OEM) : DEVELOPING WEB-BASED METRIC TO MEASURE OPEN EDUCATION SERVICES QUALITY	ITC23	Effects of VANE-T's Attributes on Network Performance



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# A Simple Three-phase Three-wire Voltage Disturbance Compensator

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**Abstract** – The two-leg four-switch VC-VSI with a direct load voltage controller has been developed as a three-phase multi-functional voltage disturbance compensator for a three-phase three-wire system. By controlling only two legs (two phases) of the inverter, the third leg automatically generates the correct third voltage. The VC-VSI is connected in series between the PCC and loads by three single-phase matching transformers. The transformer primary windings are connected in delta. The VC-VSI operates to directly control the load voltage rather than its output voltage using a simple PI controller. The VC-VSI is able to produce automatically a three-phase compensation voltage so that the load voltage is sinusoidal, symmetrical and constant at a nominal value. Computer simulation verifies that the VC-VSI is able to perform well as a voltage disturbance compensator, although there is still an insignificant deviation (around 1%). The THD of the load voltage reduces to 1.4%.

**Keywords** – Voltage sag/swell, Harmonic Voltage, Unbalanced Voltage, Three-phase Two-leg Inverter

## I. INTRODUCTION

A high quality of an electric source is important for an electric equipment to operate properly. A good three-phase AC voltage supply should be constant, sinusoidal and symmetrical. However, a real AC voltage supply experiences disturbances such as voltage sag and swell, harmonic distortion and unsymmetrical. The quality of the AC voltage supply decreases. Consequently, the electric equipment could be broken down.

There are many ways to deal with the voltage problems. One of the solutions is to install a superior electric equipment that is reliable and tolerant to disturbance. The equipment would be expensive because it is not easy to produce it. Another possible solution is to mitigate the voltage disturbances by installing a voltage compensator at the point of common coupling (PCC). The equipment compensates for disturbances so that electric loads will receive a high quality AC voltage. The examples of a voltage compensator are a series active power-filter (SAPF) and a dynamic voltage restorer (DVR), which are made of power electronic devices

SAPF is generally used to reduce voltage harmonics from an electric source. The filter consists of power electronic

devices (commonly six transistors as switches) to form a voltage source inverter (VSI). The VSI is connected in series between the distorted source and loads using a matching transformer. Then the VSI injects an equal-but-opposite voltage harmonics according to its reference harmonic voltage [1,2]. As a result, the terminal voltage of loads will receive a sinusoidal voltage waveform. Losses due to voltage harmonics will be minimized. SAPF could also compensate for voltage harmonics generated by a non-linear load. In this case, the filter is inserted between the load and PCC so that other loads connected at PCC will receive a clean voltage.

DVR is mostly used to mitigate voltage sag and swell. In voltage sag or swell, the voltage of the power system fluctuates exceeding a tolerable working voltage of equipment in a period of 0.5 cycles to a few seconds. Voltage sag/swell usually happens when a load with high power is on/off or a fault occurs/disappears on the power system. Similar to SAPF, DVR is an inverter (VSI), which is connected in series between the PCC and loads using a matching transformer [3,4,5]. DVR compensates for a voltage drop/rise ( $\Delta V$ ) according to voltage deviations detected at the PCC so that the load voltage will be maintained at a nominal voltage.

To improve the mitigation strategy, it is a challenge to eliminate voltage harmonic and voltage sag/swell as well as voltage unbalance with one multi-functional compensator rather than applying one compensator for one specific voltage disturbance. The simultaneous compensation is possible because voltage disturbances need a series type of a compensator. However, the problem is to create an inclusive control strategy especially to generate a single reference voltage for handling several types of voltage disturbances. Therefore, a different approach is chosen, which is directly controlling the load voltage.

Moreover, since three-phase loads such as fixed- or variable-speed induction motors are the most common equipment in industries, the application of the compensator will focus on a three-phase three-wire system (a delta system). Therefore, it is a challenge to use a four-switch VSI as the main power circuit. Reducing the number of switches may reduce the cost and simplify the controller.





voltage difference ( $D_{VC} = k \Delta V_C$ ) is added to the error signals [6]. This method is useful to improve the performance of the phase C output voltage.

The compensation process will be successful when the load voltage is the same as the reference voltage. The VC-VSI injects the compensation voltage as needed through matching transformers.

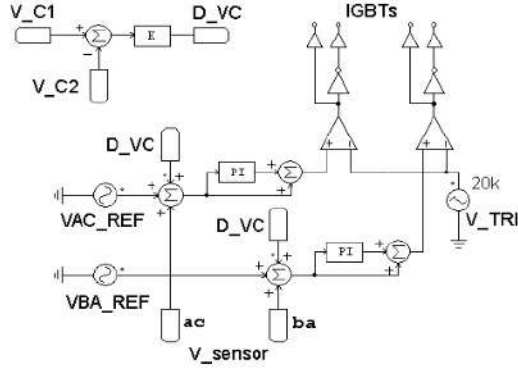


Fig. 3. A Simple and Direct Load Voltage Controller

#### IV. SIMULATION AND DISCUSSION

##### A. Simulation Parameter

To verify the concept of the three-phase three-wire voltage disturbance compensator, the proposed circuits (Fig. 1 to Fig. 3) have been built and simulated using PSIM® simulator. Then, the performance of the circuits will be evaluated.

The compensator is working on a three-phase three-wire system. The source voltage (phase-phase) has a fundamental component of  $380V_{rms}$  ( $f_1 = 50\text{Hz}$ ) and a fifth harmonic. The load is a three-phase RL load and connected in delta. Without compensation and additional voltage disturbances, the three-phase load voltage, which is the same as the voltage at the PCC, and the three-phase load current can be seen in figure 4. Total Harmonic Distortion (THD) of  $V_{PCC} = 6.2\%$ .

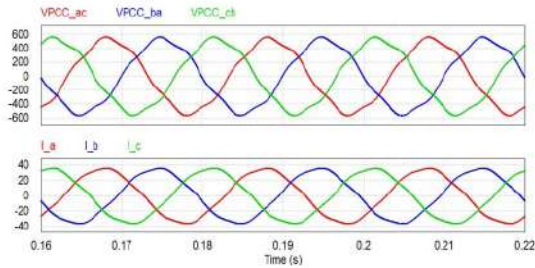


Fig. 4. The three-phase PCC voltage (= load voltage) (top) and load current (bottom) without compensation

At the DC side of the VC-VSI, there is a DC source of 575V. The split capacitor  $C1 = C2 = 10\text{mF}$ . The AC side has a high-pass filter  $L = 0.14\text{mH}$  and  $C = 100\mu\text{F}$ . Constants of the PI controller,  $K_p = 10$ ,  $T_i = 0.45$ . The frequency of a triangular carrier signal = 20kHz. Winding ratio of the matching transformer = 1. Winding connection: delta/open-wye

##### B. Simulation Results

When there is no additional voltage disturbance, the voltage compensator is working as a harmonic filter to eliminate the harmonic voltage at the load from the source. As a result, figure 5 shows the clean load voltage and current. The three-phase load voltage is sinusoidal, symmetrical and constant around  $377V_{rms}$  identical to the reference voltage. THD of  $V_{Load}$  decreases significantly to 1.3%. The load voltage is also in-phase with the PCC voltage. Figure 6 shows the compensation voltage at the secondary side of the matching transformers generated by the VC-VSI, which is the same as the harmonic voltage produced by the source.

Thus, by controlling only two legs of the inverter, the third leg automatically produces the proper third voltage (phase C). Moreover, by directly controlling the load voltage, automatically the VC-VSI is able to generate a three-phase anti-harmonic voltage and to eliminate the distortion at the load through the matching transformers.

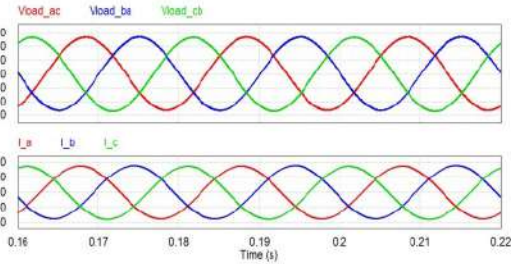


Fig. 5. The load voltage (top) and the load current (bottom) after harmonic compensation

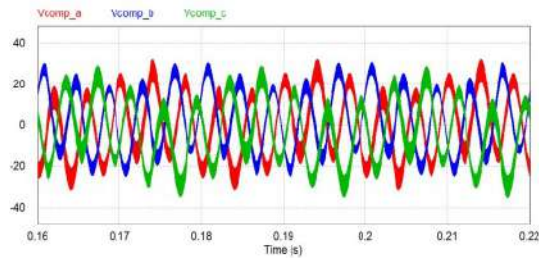


Fig. 6. Compensation for harmonic voltage

Another case, when there is a sudden voltage drop at the PCC, the voltage compensator should be able to operate as both a harmonic filter and a voltage restorer. The voltage drop could be balanced or unbalanced. The unbalanced voltage drop could be single phase or two phases.

The three-phase balanced voltage drop can be seen in figure 7. In this case, the three-phase PCC voltage decreases to  $278V_{rms}$ . Similar to the previous case, by controlling the load voltage to be sinusoidal, symmetrical and constant at a normal value, the VC-VSI is able to produce the compensation voltage (Fig. 8) so that the load voltage would stay at a normal value and balance. The rms value of the load voltage are as follows:  $V_{AC} = 370V$ ,  $V_{BA} = 379V$ ,  $V_{CB} = 368V$ .

The performance of the load voltage can be improved by balancing the split-capacitor voltage on the third leg of the VSI. By adjusting the value of  $k = -0.2$ , the rms value of the load voltage becomes as follows:  $V_{AC} = 375V$ ,  $V_{BA} = 379V$ ,  $V_{CB} = 376V$ . There is still a voltage drop ( $\Delta V_{max} 1.3\%$ ) and a voltage unbalance (1.05%). But, the deviation is small and considered insignificant. The harmonic voltage is also eliminated (THD  $V_{Load} = 1.4\%$ ). The value of  $k = -0.2$  will be applied to all cases of voltage disturbances.

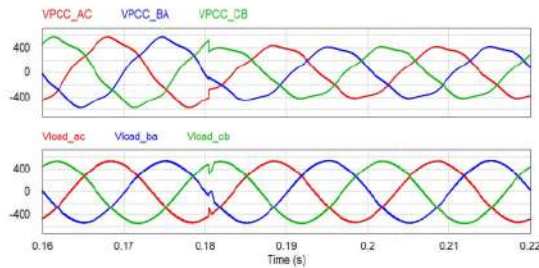


Fig. 7. The PCC voltage (top) and the load voltage (bottom) after compensation for a balanced fault

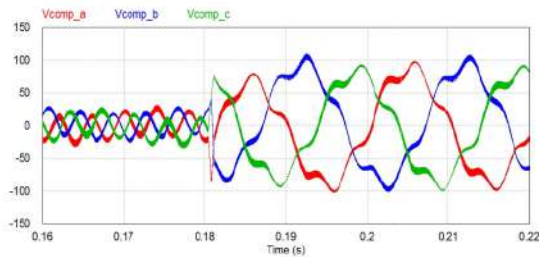


Fig. 8. Compensation for harmonic and voltage drop due to a balanced fault

From figure 7, it can be seen at  $t = 0.18ms$ , when a fault occurs, there is a notch on the load voltage waveforms. It seems that the response of a PI controller with triangular modulation is not quick enough for the sudden voltage drop so that the compensation is not successful. However, the process

takes only 0.6ms, which is considered insignificant. For the fast response, a sliding mode type of controllers such as a hysteresis or a ramp-time controller [5,7] might be an option. The sliding mode controller may also be able to enhance the steady state performance of a direct load voltage control system.

To prove the ability of the voltage disturbance compensator to handle the unbalanced voltage drop is described in figure 9 and 10. In this case, the two-phase unbalanced voltage drop due to a phase-to-phase fault is selected for a three-phase three-wire system.

Figure 9 shows that, after compensation, the load voltage becomes sinusoidal, symmetrical and constant.  $V_{AC} = 375V$ ,  $V_{BA} = 378V$ ,  $V_{CB} = 376V$ . The performance of the controller is the same as the previous case. There is still a voltage drop ( $\Delta V_{max} 1.3\%$ ) and a voltage unbalance (0.8%). But, the deviation is small and considered insignificant. The harmonic voltage is also eliminated (THD  $V_{Load} = 1.4\%$ ). The VC-VSI generates the compensation voltage (Fig. 10) to maintain the load voltage at a normal value and to eliminate the harmonics. Compared to figure 8, it is proved that the VC-VSI is automatically able to generate a different compensation voltage for a different disturbance voltage as long as its operation satisfies (1) to (5).

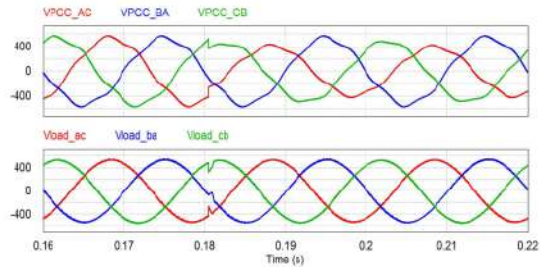


Fig. 9. The PCC voltage (top) and the load voltage (bottom) after compensation for an unbalanced (phase-to-phase) fault

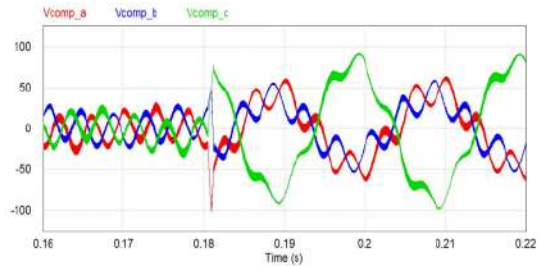


Fig. 10. Compensation for harmonic and voltage drop due to an unbalanced (phase-to-phase) fault.

The voltage compensator is also able to compensate for the voltage rise, although this phenomenon is less common than



the voltage sag. In this case, a balanced voltage rise is selected for a three-phase three-wire system.

Figure 11 shows that the three-phase PCC voltage increases from a normal voltage at  $t = 0.18\text{ms}$  to become  $443\text{V}_{\text{rms}}$ . Then, automatically the VC-VSI generates the compensation voltage (Fig. 12) to subtract the voltage rise. The load voltage is kept at a normal value. The controller performs well to handle the voltage rise. In this case, its transient response is better than the response for handling the voltage sag. The load voltage becomes sinusoidal, symmetrical and constant.  $V_{AC} = 377\text{V}_{\text{rms}}$ ,  $V_{BA} = 376\text{V}_{\text{rms}}$ ,  $V_{CB} = 378\text{V}_{\text{rms}}$ . The harmonic voltage is eliminated as well (THD  $V_{\text{Load}} = 1.4\%$ ).

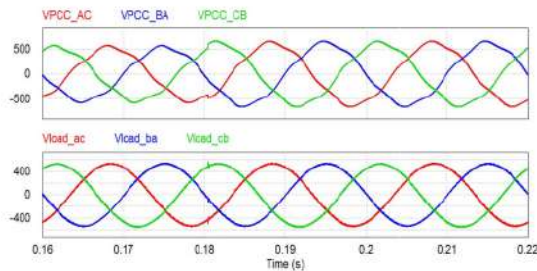


Fig. 11. The PCC voltage (top) and the load voltage (bottom) after compensation for a voltage rise

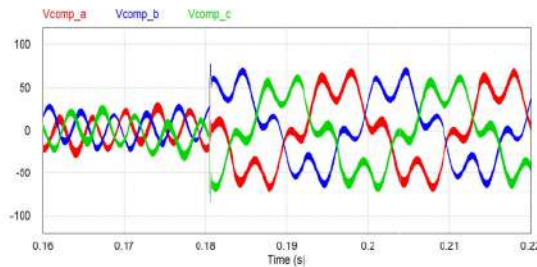


Fig. 12. Compensation for harmonic and voltage rise

## V. CONCLUSION

The two-leg four-switch VSI has been proven to be used as a three-phase multi-functional voltage disturbance compensator for a three-phase three-wire system. For voltage compensation, the VSI is operated as a voltage-controlled VSI (VC-VSI). A controller regulates the VC-VSI to generate a proper output voltage for eliminating the voltage disturbances. The VC-VSI is connected in series between the PCC and loads by three single-phase matching transformers. The transformer primary windings are connected in delta.

By controlling only two legs of the inverter, the third leg automatically generates the correct third voltage (phase C) so

that the VC-VSI produces a complete three-phase compensation voltage. Moreover, by directly controlling the load voltage rather than its output voltage, the VC-VSI is automatically able to generate the compensation voltage. As a result, the load voltage is sinusoidal, symmetrical and constant at a normal value.

Computer simulation verifies that the VC-VSI is able to compensate harmonic voltage and balanced/unbalanced voltage sag/swell. The performance of the VC-VSI supported by a simple PI controller is satisfied. Although there is still a voltage drop and a voltage unbalance, but the deviation is small (around 1%) and considered insignificant. The THD of the load voltage reduces to 1.4%.

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