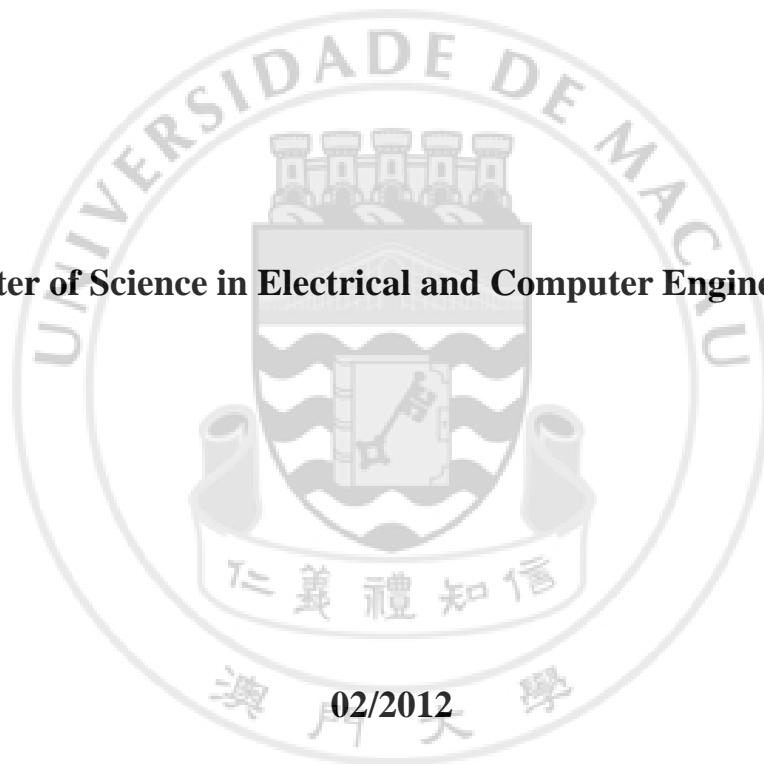


Power Quality Study in Macau and Virtual Power Analyzer

by

Sio-Un Tai

Master of Science in Electrical and Computer Engineering



**Faculty of Science and Technology
University of Macau**



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A thesis submitted in partial fulfillment of the
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Approved by _____

Supervisor

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Abstract

**POWER QUALITY STUDY IN MACAU AND VIRTUAL
POWER ANALYZER**

by Sio-Un Tai

Thesis Supervisor: Dr. Man-Chung Wong, Dr. Chi-Kong Wong, Dr. Ning-Yi Dai

Electrical and Computer Engineering

This thesis proposes a power quality site measurement at thirteen buildings of Macau including special facility building, residential buildings, commercial building, public administrative buildings, hotel, school and indoor sport center due to the lack of power quality information for Macau in the past and only three power quality standard limits are used in Macau. This study will let us know more about the power quality status in Macau. The measured data is compared with the existing Macau, Mainland China, Hong Kong and IEEE standards to see whether the power quality indices exceed the standard limits or not. The measurement indices include voltage RMS variation, voltage sag/swell, voltage imbalance, voltage flicker, voltage harmonic, neutral current, current harmonic, power factor and frequency variation. In addition, neutral voltage, background voltage harmonic, neutral current harmonic, current THD₁% vs. TDD₁% and more current harmonic caused by VRV A/C are also reported.

On the other hand, three-phase four-wire systems are widely used in modern buildings, but its power factor definition is still debated continuously. It affects system design,

performance evaluation, control, energy accounts, and compensation design etc. Therefore, a study of power factor definition in three-phase four-wire systems is recommended. In this study, a detailed comparison among complete-cycle power factor methods including IEEE Std. 100, IEEE Std. 1459-2000, Europe Std. DIN40110-2, Willems' positive sequence power factor, Willems' maximum positive sequence power factor and Willems' fundamental frequency power factor and instantaneous power factor methods including Akagi's power theory, Peng's power theory and $p-q-r$ power theory is studied under different voltage and current conditions (totally seven conditions) from the viewpoints of definition and compensation. This study will let us know which methods are the most suitable ones for both definition and compensation. Also, it will let us know the differences between complete-cycle power factor and instantaneous power factor. Besides, during the study, a lot of special conditions for power factor are pointed out. These conditions let us know why and when the methods are invalid. Finally, a power factor using the definition in IEEE Std. 1459-2000 with a related difference between IEEE Std. 1459-2000 and Europe Std. DIN40110-2 is proposed to use as power factor definition in three-phase four-wire systems. In addition, a virtual power analyzer is developed to measure the power factor with its related difference.



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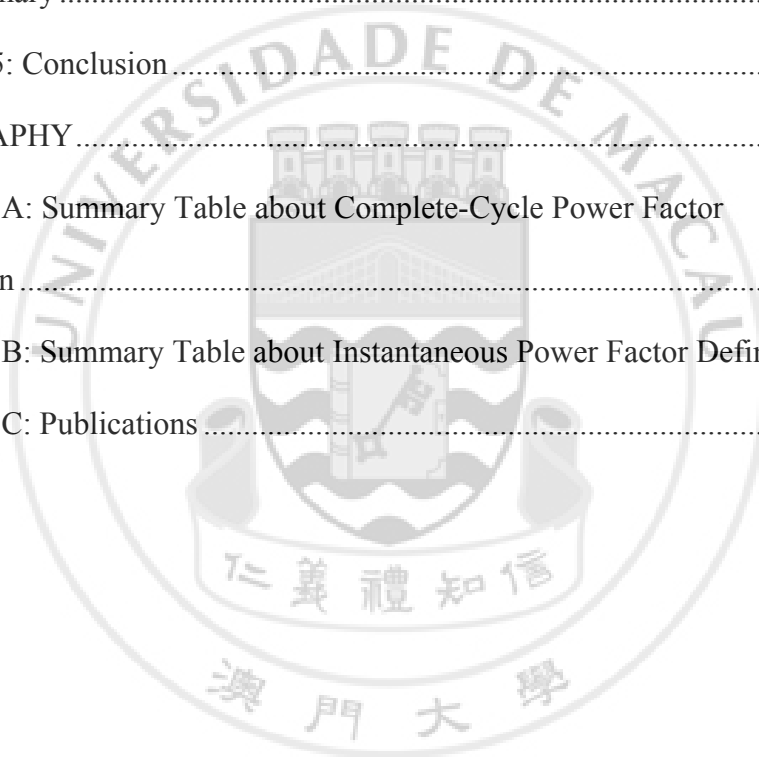
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LIST OF ABBREVIATIONS

A	Ampere
kA	Kiloampere
V	Voltage
kV	Kilovoltage
HV	High voltage
DC, dc	Direct current
CEM	Companhia de Electricidade de Macau
IEEE	Institute of Electrical and Electronics Engineers (USA)
PCC	Point of common coupling
UPS	Uninterruptible power supply
RMS, rms	Root mean square
S	Second
p.u.	Per-unit
VI	Virtual instrument
I_{sc}	Maximum short-circuit current
I_L	Maximum demand load current
SAIDI	System average interruption duration index
SAIFI	System average interruption frequency index
THDV%	Total voltage harmonic distortion
THDI%	Total current harmonic distortion
THDV_{rms}	Total voltage harmonic distortion
THDI_{rms}	Total current harmonic distortion
TDDI%	Total current demand distortion
T-I	Industrial type
T-P	Public sector & street lighting type
T-D	Domestic type
T-C	Wholesale & retail, hotels & recreation, commercial type
B-S	Special facility building
B-PA	Public administrative building A
B-PB	Public administrative building B

B-PC	Public administrative building C
B-RA	Residential building A
B-RB	Residential building B
B-RC	Residential building C
B-RD	Residential building D
B-RE	Residential building E
B-C	Commercial building
B-H	Hotel
B-M	Middle school
B-SP	Indoor sport center



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