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11th **ERDT Conference** on Semiconductor and Electronics, Information and Communications Technology and Energy

16-17 November 2015
Metro Manila, Philippines



**Proceedings of the 8th AUN/SEED-Net RCEEE 2015 and 11th ERDT Conference
on Semiconductor and Electronics, Information and Communications Technology, and Energy**

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ISBN: 978-616-406-075-3

Published by: ASEAN University Network / Southeast Asia Engineering Education Development Network
(AUN/SEED-Net) JICA Project
Faculty of Engineering, Bldg. 2
Chulalongkorn University, Bangkok
Thailand 10330

Printed in the Philippines by: ERZALAN PRINTING PRESS
45 Cotabato Street, Luzviminda Village, Batasan Hills, Quezon City, Philippines

8th AUN/SEED-Net Regional Conference on Electrical and Electronics Engineering 2015

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Development Network (AUN/SEED-Net) in partnership with Engineering Research and
Development for Technology (ERDT) and University of the Philippines Diliman.

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Engineering 2015 and 11th ERDT Conference on Semiconductor and Electronics, Information
and Communications Technology, and Energy.

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STUDY OF THE HARMONICS FROM NON-LINEAR LOADS IN RESIDENTIAL AND ITS AFFECTION TO ANALOG KILOWATT-HOUR METER

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ABSTRACT

This paper studies the quantity of harmonics cause from the nonlinear load and its affection to the analog Kilowatt-Hour Meter. This research aims to compare the accuracy of analog Kilowatt-Hour Meter to the Fluke 345. As the experimental results show that, the analog Kilowatt-Hour Meter measures the energy greater than Fluke 345 and the accuracy of the measurement is depended on the percent of Total Harmonic Distortion (THD) of the voltage and current waveform.

At present there are many electrical appliances are the nonlinear load equipped in the residential such as: Television, Personal Computer (PC), Fluorescent lamp with ballast electronic, Microwave Oven, Amplifier, Air Conditioner, Power charger, and so on. On another hand, the equipment used to measure electrical energy (analog kilowatt hour meter) are used the induction motor, the true measurement amount of consumed energy will appear when the voltage and current waveform are pure sine waveform [1], but nowadays most of all equipment in residential are nonlinear loads that produce the voltage and current waveform include with harmonic that cause of the distort sinusoidal waveform, high total harmonic distortion and affect to the accuracy of analog meter [2].

Therefore, this paper proposed the study of the quantities of harmonics cause from the nonlinear load, which is used in the residential. The experimental methods are observed the accuracy of the analog Kilowatt-Hour Meter (15A-60A and 20A-80A) and Fluke 345. The circuit diagram of the measurements is shown in Figure 1.

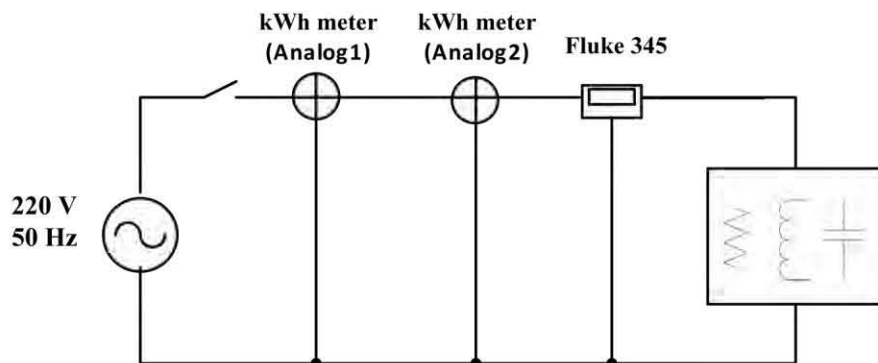


Figure 1. The circuit diagram of installing analog Kilowatt-Hour Meter and Fluke 345

The experiments are measured by the Kilowatt-Hour meter continuously 8 hours and there are 6 difference types of the linear and non-linear load are observed as following: 11 Units of Incandescent bulb 1100 W, 3 units of 300 W Electric fan, 12 unit of Fluorescent with magnetic ballast 36W, 12 unit Fluorescent with electronic ballast 36W, 1 unit of Air conditioner 1 phase (12000 BTU/hour), and Combine Load: Fluorescent lamp 36W 12 unit + Air conditioner 1 phase (12000 BTU/hour) + Refrigerator 1 unit (408 liter). The experimental results are shown in the Table 1.

Table 1: results of %THD and Power factor

Case	THD_v (%)	THD_i (%)	PF	Power (W)
1. Incandescent bulb	0.4	0.2	0.998	1100
2. Electric fan 3 unit	1.1	1.0	0.854	318 - 340
3. Fluorescent with magnetic ballast	1.1	4.6	0.54	350 - 410
4. Fluorescent with electronic ballast	1.8	78.8	0.69	240 - 275
5. Air conditioner 1 phase	1.7	21.4	0.97	800 - 12000
6. Fluorescent e-ballast+ Air + refrigerator	1.9	16	0.98	1300 - 1450

Table 2: results of kWh meter and Percent of Error

Case	Consume Energy (kWh)			Percent of Error (%)	
	Analog1	Analog2	Digital	Analog1	Analog2
1. Incandescent bulb	8.2	8.2	8.2	0	0
2. Electric fan 3 unit	2.7	2.7	2.69	0.3	0.3
3. Fluorescent with magnetic ballast	2.8	2.8	2.82	0.7	0.7
4. Fluorescent with electronic ballast	2.1	2.1	2.0	5	5
5. Air conditioner 1 phase	5.0	4.9	4.75	5	3.15
6. Fluorescent e-ballast+Air + refrigerator	11.1	11.0	10.8	2.77	1.85

The results of experimental shows that analog Kilowatt-Hour Meter measured the energy greater than Fluke 345 in case of using the non-linear load and the accuracy of measurement is depended on the percent of Total Harmonic Distortion of the signal. In this research can conclude that Total Harmonic Distortion of current will affect to an error of measurement, at the minimum of $THD_i = 16\%$ could make the error to the analog Kilowatt-Hour Meter if compare to the Fluke 345. The further study should be focused on higher power, use the constant and inconstant loads, long time observation and also find the solutions to reduce the harmonics.

Keywords: Fluke 345 PQ clamp meter, Harmonic, Kilowatt-hour meter, Non-linear load, Total Harmonic Distortion.

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