Correlation between total harmonic distortion of load and error percentage of kWh meter on inverter

Imam Arif Rahardjo¹, Suyitno Muslim², and Massus Subekti ³

¹,²,³ Electrical Engineering Education Program, State University of Jakarta Rawamangun, Indonesia

E-mail: imam_ar@unj.ac.id

Abstract This study aims to describe the correlation between total harmonic distortion (current) of load and error percentage of kWh meter to overcome the electric circuit that supplied from inverter through digital kWh meter. The method used in this research was an experimental method with a design set that consists of an inverter connected to incandescent lamp as linear load through power quality analyzer and digital kWh meter. Next, researcher observed and recorded the total harmonic distortion (current) and energy on the power quality analyzer that connected to the loads circuit for 1 hour. Then compared the energy measurement results with a digital kWh meter, calculated, and analyzed it as an error to be concluded the correlation between total harmonic distortion (current) of load and error percentage of digital kWh meter on the inverter. The load that presented by incandescent lamp affect to measurement of kWh meter. The energy that be consumed of load of 100 watt during 60 minutes is 102.99 Wh. Based on the measurement data, the average error percentage of kWh meter is 2.52% for linear load that caused by 2.85% of total harmonic distortion (current). The higher the total harmonic distortion (current), the higher the error percentage of kWh meter on the inverter that occurs is. And the equation of the correlation between total harmonic distortion (current) of load and percentage of error in kWh meter in inverter gives the R² of 0.9236 that means the independent factors are not significant.

1. Introduction
In solar panel power plants or DC generators in renewable energy requires an inverter device to convert direct current (DC) into alternating electric current (AC) 220V AC 50 Hz [1],[2],[3],[4]. The process inverter to convert alternating current in a sine wave from direct current in square wave use pulse width modulation techniques with high-frequency sine wave harmonics into the waveform. Therefore, inverter device produces haronics in output sine wave [5] and must be eliminated before supplying a pure sine wave voltage to the load in the power system.

The high harmonics in the power system can cause many problems in electricity, such as power factor correction, heating conductor, and loss in the power distribution systems, etc [6],[7],[8],[9],[10]. So that the kWh meter connected to the inverter also cannot be separated from the bad influence of harmonics [11]. Thus, this paper explains the correlation between total harmonic distortion (current) of...
load and error percentage of kWh meter on the inverter to overcome the electric circuit that supplied from inverter through digital kWh meter.

2. Method
The method used in this research was an experimental method with a preparation, then design set that consists of an inverter connected to incandescent lamp through power quality analyser and digital kWh meter. Next, researcher observed and recorded the total harmonic distortion (current) and energy on the power quality analyzer that connected to the loads circuit for 1 hour. Then compared the energy measurement results with a digital kWh meter, calculated, and analyzed it as an error to be concluded the correlation between total harmonic distortion (current) of load and error percentage of kWh meter on the inverter.

Figure 1. Research Flow Diagram.
3. RESULT AND DISCUSSION

3.1. Result

The measured value of energy (Wh) when given load is shown in Table 1.

| Time (minute) | Linear 100 watts |
|--------------|------------------|
| 0            | 0                |
| 10           | 17.9             |
| 20           | 34.92            |
| 30           | 51.97            |
| 40           | 68.98            |
| 50           | 86.02            |
| 60           | 102.99           |

Table 1 shows the energy that be consumed of linear load 100 W during 10 minutes is 17.9 Wh, during 20 minutes is 34.92 Wh, during 30 minutes is 51.97 Wh, during 40 minutes is 68.98 Wh, during 50 minutes is 86.02 Wh, and during 60 minutes is 102.99 Wh. The measured value of total harmonic distortion (current) (%) and analysis of error percentage (%) values is shown in Table 2.

| Load Type | THD-I (%) | Error (%) |
|-----------|-----------|-----------|
| Linear    | 2.36      | 0.98%     |
|           | 2.64      | 2.00%     |
|           | 2.67      | 2.58%     |
|           | 3.25      | 2.99%     |

Table 2 shows the total harmonic distortion (current) of 2.36% causes error percentage of 0.98%. The total harmonic distortion (current) of 2.64% causes error percentage of 2.00%. The total harmonic distortion (current) of 2.67% causes error percentage of 2.58%. The total harmonic distortion (current) of 3.25% causes error percentage of 2.99%. Abbreviations in the title or heads unless they are unavoidable.

3.2. Discussions

Based on the measurement results, it is obtained that the higher total harmonic distortion (current) cause the higher error percentage of kwh meter on the inverter [12]. By using the data analysis above, the correlation between total harmonic distortion (current) of load and error percentage of kwh meter on the inverter can be seen through in figure 2.
Figure 2 show the higher the total harmonic distortion (current), the higher the error percentage of kWh meter on the inverter that occurs is. The equation of error percentage of kWh meter that caused by total harmonic distortion (current) of linear load is shown

\[ y = 0.075x^2 - 0.105x + 2.43 \]  

The correlation between total harmonic distortion (current) of load and percentage of error in kWh meter in inverter gives the \( R^2 \) value of 0.9236 that means the independent factors are minimal for the above function or not significant.

The energy value reading in digital kWh meter is processed by voltage sensor and current sensor inside microcontroller. The harmonic waveforms are added from load to the fundamental creating a distorted sine wave. This phenomenon influence the differentiation of energy value reading as error of kWh meter in inverter. The higher the total harmonic distortion (current) of load, the higher the error percentage of kWh meter on the inverter that occurs is.

4. Conclusion

The linear load that presented by incandescent lamp affect to measurement of kWh meter. The energy that be consumed of linear load of 100 watt linear load during 60 minutes is 102.99 Wh. The differentiation measured energy consumption of loads is caused by error of kWh meter that making the kWh meter is inaccurate.

Based on the measurement data, total harmonic distortion (current) of 2.36% causes error percentage of 0.98%. The total harmonic distortion (current) of 2.64% causes error percentage of 2.00%. The total harmonic distortion (current) of 2.67% causes error percentage of 2.58%. The total harmonic distortion (current) of 3.25% causes error percentage of 2.99%. The average error percentage of kWh meter is 2.52% for linear load that caused by 2.85% of total harmonic distortion (current). The higher the total harmonic distortion (current), the higher the error percentage of kWh meter on the inverter that occurs is.

And the equation of the correlation between total harmonic distortion (current) of load and percentage of
error in kWh meter in inverter gives the R2 of 0.9236 that means the independent factors are not significant.

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