Harmonic mitigation in a single phase inverter

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Abstract. This study aims to mitigate harmonics in a Single Phase Inverter in the design of inverter products with harmonics filters which can later be used as a basis for consideration of the quality of electricity on the harmonics side for the use of AC load power with power plants sourced from DC generators using an inverter. An experimental electrical circuit was configured by giving nonlinear loads effect to determine the number of harmonics that appear. Then design filters on the circuit to mitigate the harmonics that occur in accordance with IEEE 1531-2003 standard. The greater the non-linear loads, the greater the voltage and current harmonics were produced. To mitigate the harmonic value due to non-linear loading with a tolerance of 5% to conform with IEEE 1531-2003 standards, a non-linear load of 60 W need to be fitted with a filter of an inductor 6.705594 Henry and a capacitor 1.50121990 Micro Farad in the inverter, a non-linear load of 104 W need to be fitted with a filter of an inductor 4.680568 Henry and a capacitor 2.15045863 Micro Farad in the inverter, a non-linear load of 146 W need to be fitted with a filter of an inductor 4.012541 Henry and a capacitor 2.50837720 Micro Farad in the inverter, a non-linear load of 187 W need to be fitted with a filter of an inductor 1.601979 Henry and a capacitor 6.28333291 Micro Farad in the inverter.

1. Introduction

In power generation applications using solar panels or DC generators in renewable energy alone or through a combination of various types of plants such as solar panels, wind, and fuel cells require an inverter device to convert direct current (DC) into an electric current alternating (AC) so that it can be used to supply electrical loads with alternating electric current (AC) with a voltage of 220V AC 50 Hz [1-4]. However, based on research done earlier that the inverter produces harmonics and the number of harmonics will change when influenced by non-linear loads [5].

The high percentage of harmonics in an electric power system can cause some serious harmonics problems in the system and its environment. Such as the resonance in the system that makes the
system power factor worse [6], heat on the conductor [7], electronic equipment operation errors, inaccurate measurement readings, protection relay operation errors, and cause interference with telephone circuits [8], increase losses - power losses at conductors [9]. In a distribution system, harmonic distortion can cause power losses [10].

To overcome the problem of harmonics in the electric power system is done by installing harmonic filters [11]. However, there is no research that discusses of harmonic filter installation in mitigating harmonic in the inverter. This work proposes a method for harmonic filter installation in a single-phase inverter such that the harmonic can be mitigated.

2. Method
An experimental electrical circuit was configured by giving non-linear loads effect to determine the number of harmonics that appear. Then design filters on the circuit to mitigate the harmonics that occur in accordance with IEEE 1531-2003 standard.

To achieve the goals and objectives of this study the stages of the research process are as follows: 1). Literature Study. It is an activity that includes searching the literature, localizing, and analysing documents related to the problem that we are going to examine. Documents can be in the form of theories, and can also be in the form of research results that have been carried out regarding the problems to be examined. namely: harmonics, inverters, and harmonics fitter. 2). Data Collection. Data collection - the necessary data consisting of primary data (primary data is a source of research data obtained directly from the results of the measurements themselves at the study site. Measurement data that has been collected will be entered into a table to facilitate data reading. The data to be entered into the table is a data load from the recording of the mattering instrument) and secondary data (secondary data is a source of research data obtained indirectly in the form of component data and equipment specifications used).

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![Figure 1. Schematic circuit.](image-url)

3. Results
Research data obtained through measurements using a power quality analyser. Measurement data can be tabulated in Table 1 as follows:

| Nameplate Power (W) | Actual Power (W) | I (A)  | Frequency (Hz) | Pf    | U-THD (%) | I-THD (%) |
|---------------------|------------------|--------|----------------|-------|-----------|-----------|
| 45                  | 60,0             | 0,294  | 50,164         | -0,8857 | 1,3       | 25,5      |
| 90                  | 104,0            | 0,5    | 50,167         | -0,9092 | 1,7       | 29,2      |
| 135                 | 146,0            | 0,692  | 50,169         | -0,915  | 2,4       | 29,0      |
| 180                 | 187,0            | 0,87   | 50,168         | -0,9447 | 2,8       | 27,4      |
| 225                 | 230,0            | 1,066  | 50,164         | -0,948  | 3,2       | 28,4      |
| 270                 | 268,0            | 1,248  | 50,172         | -0,9499 | 3,5       | 29,4      |
| 315                 | 311,0            | 1,439  | 50,172         | -0,951  | 3,8       | 29,7      |
| 360                 | 351,0            | 1,624  | 50,166         | -0,9505 | 4,0       | 30,1      |
| 405                 | 390,0            | 1,813  | 50,166         | -0,9509 | 4,1       | 30,2      |
| 450                 | 429,0            | 2      | 50,166         | -0,9391 | 4,3       | 30,6      |
Based on the measurement data, the harmonic filter can be analysed. A LC passive filter used is to reduce harmonics which are generally dominant, the 3rd harmonic.

**Table 2. Recapitulation of inverter filters as harmonic mitigation.**

| Load (Watt) | Orde | Components | Value       |
|------------|------|------------|-------------|
| 135        | 3    | L          | 6.7055931353 H |
|            |      |            | 1.5012191353 μF |
| 135        | 3    | L          | 4.680567661 H  |
|            |      |            | 2.1501358625 μF |
| 135        | 3    | L          | 3.5239651354 H  |
|            |      |            | 2.8514633478 μF |
| 180        | 3    | L          | 4.012540785 H  |
|            |      |            | 2.508377204 μF |
| 225        | 3    | L          | 3.1355178375 H |
|            |      |            | 2.913473614 μF |
| 270        | 3    | L          | 3.0711061463 H |
|            |      |            | 3.27678662 μF  |
| 315        | 3    | L          | 2.7032135 H |
|            |      |            | 3.72269662 μF  |
| 3146       | 3    | L          | 2.372288424 H |
|            |      |            | 243062641 μF   |
| 405        | 3    | L          | 2.151710751 H |
|            |      |            | 4.678030437 μF |
| 1350       | 3    | L          | 1.1461979161 H |
|            |      |            | 6.28333291 μF  |

By using the data analysis above, the correlation graph can be made as follows in:

![Correlation graph between capacitor value to load power.](image-url)

**Figure 2.** Correlation graph between capacitor value to load power.
4. Conclusion
The greater the non-linear loads, the greater the voltage and current harmonics were produced. To mitigate the harmonic value due to non-linear loading with a tolerance of 5% to conform with IEEE 1531-2003 standards, a non-linear load of 60 W need to be fitted with a filter of an inductor 6.705594 Henry and a capacitor 1.50121990 Micro Farad in the inverter, a non-linear load of 104 W need to be fitted with a filter of an inductor 4.680568 Henry and a capacitor 2.15045863 Micro Farad in the inverter, a non-linear load of 146 W need to be fitted with a filter of an inductor 3.523966 Henry and a capacitor 2.85603348 Micro Farad in the inverter, a non-linear load of 187 W need to be fitted with a filter of an inductor 4.012541 Henry and a capacitor 2.50837720 Micro Farad in the inverter, a non-linear load of 230 W need to be fitted with a filter of an inductor 3.455178 Henry and a capacitor 2.91347361 Micro Farad in the inverter, a non-linear load of 268 W need to be fitted with a filter of an inductor 3.071107 Henry and a capacitor 3.27678662 Micro Farad in the inverter, a non-linear load of 311 W need to be fitted with a filter of an inductor 2.703245 Henry and a capacitor 3.72269662 Micro Farad in the inverter, a non-linear load of 351 W need to be fitted with a filter of an inductor 2.372288 Henry and a capacitor 24306264 Micro Farad in the inverter, a non-linear load of 390 W need to be fitted with a filter of an inductor 1.601979 Henry and a capacitor 6.28333291 Micro Farad in the inverter.

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