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Real Time Harmonic Analysis on Rural Industries

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Abstract

Background/Objectives: Objective of study is discussing about the harmonic effect on electrical apparatus as well as its mitigation methods. Then power quality analysis is performed to four textile and one coffee rural industries. **Methods/Statistical Analysis:** The power quality analysis is performed by using Clamp on Power meter. It is measured voltage, load current, power component variations and total harmonic distortion on industries. The measurement was carried out at supply fed end. **Findings:** Review shows, the growth of electronic components on power system causes harmonic distortion. Although, rapid capacity addition of renewable energy resources on the conventional grid injecting harmonic distortion on electrical networking. These power quality issues are reduced life span of electrical utilities. Hence, these power quality issues are rectified by suitable compensating devices. The total harmonic distortion on textile industries is much higher that of the coffee industry. Since textile industry is used variable speed drives, whereas content speed motors are used in the coffee industry. Also voltage swell is occurs on all industry but it within limit. The harmonic suppressing technique is needed in present day trend. In addition, Load management system in a textile industry is poor. So reforms the load management systems in industries is also recommended. **Applications/Improvements:** Textile industry and Coffee industry.

Keywords: Coffee Industry, Current Harmonics, Clamp on Power Meter, Harmonic Analysis, Textile Industry, Voltage Fluctuation

1. Introduction

Power quality is the measure, analysis and improvement the load bus voltage to maintain that voltage being a sinusoidal at rated voltage and frequency. The primary causes of power quality problem are external factors such as switch operation, insulation failure and power electronics components of the electric network. The power quality issues lead to premature failure of equipments and malfunctioning of electrical utilities. So that monitoring of power quality on electrical network is very essential. This improves the system reliability[1].

In recent years, the industrial load management system is converted into fully automated which are made by electronic components. They introduce harmonic distortion on the power system. Although, the electronic components are highly sensitive to harmonic disturbances. Harmonic disturbances are caused to improper operation and enormous heat generation of electrical apparatus. This reduces the life span of electrical apparatus and production efficiency[2].

Due to industrialization and growth of population the required demand of electric energy is increased. Renewable energy resources are playing vital role in the power production industry. This includes wind, solar, bio-mass, tidal and hydropower, etc. Past few years, Renewable Energy power Systems (RES) are installed isolated system. Presently energy demand is rapidly increasing. Due to such that reason, RES are interconnected with non renewable energy system using a grid. This is arises power

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quality issues in power system[3,4]. The power quality issues are namely voltage instability such as voltage sag, swell and current harmonics.

The voltage instability of the power system depends on the real and reactive power. The electrical energy dissipated by the load is called real power, whereas power is absorbed and return in load is called reactive power. Basically, industrial loads are inductive these are absorbs reactive power thus causes low lagging power factor. Hence it requires larger conductor for transmitting same power on compared to conductor operated at high power factor[5, 6]. So that continuously monitoring signature of voltage waveform is essential.

The power quality disturbances are rectified by using suitable compensator or suppressors. The voltage sags and swell is perfectly rectified by using distribution static compensator, Static Synchronous Compensator (STATCOM), Dynamic Voltage Restorer (DVR). These devices work on voltage source converter principle. Resent years, three types of harmonic mitigation technique are commonly used. Such as passive, Active and Hybrid Mitigation technique is used. In passive harmonic technique is require low cost and simple structure Whereas active harmonic mitigation technique is cost wise is high also structure is complicate than active. Active harmonic mitigation technique suppress the harmonic current and also perform a power factor correction, isolation, damping and load balancing. Hybrid technique includes both active and passive harmonic techniques for suppressing the harmonic distortion of the power system[7,8].

2. Effect of Harmonic Distortion on Transformer

Basically transformers are designed to operate at ratted frequency and power. Due to the harmonic distortion, the operating voltage and current is varies significantly. However, the voltage distortion is negligible on compared to current distortion. Since, the voltage variation on power system is less than 5%. While the current harmonic is increasing rapidly depends motor drivers, controller and aging factor. The current harmonics are increasing the stray, eddy current loss and skin effect on transformer. These losses are increasing the operating temperature of the transformer. Normally the operating temperature of the transformer is limited by liquid dielectrics. But the effect of harmonic content, the transformer operating temperature increases above the threshold limit. This leads to insulation breakdown and premature failure of a transformer[9-12].

3. Important Factors Related to Power Quality

3.1 Voltage Sag

It refers to short dip or a reduction in rms voltage. The drop is in the range between 10-90% of rms voltage. The duration of voltage sag is a half cycle for a minute. The cause of voltage dip is short-circuiting on industrial load, transmission line and disconnecting of power feeding sources[13].

3.2 Voltage Swell

When sudden disconnecting of heavy load on power system, the voltage swell is occured. It is defined as a transitory increase of a rms voltage which is between 1.1 p.u and 1.8 p.u for period stuck between 0.5 cycles to 1 minute[13].

3.3 Total Harmonic Distortion

It is defined as the summation of the effective value of the harmonic components in distorted waveform relative to the fundamental components[14].

4. Measurement Method

The measurements were carried out various industries at the power fed end such as Distribution Transformer secondary side. The Yokogawa-CW240 clamp on power meter is used. Following steps are used to carry out the measurements.

Step 1: Connect the supply source

Step 2: Switch on the Meter

Step 3: Press the reset button for erasing earlier measurement

Step 4: Select the memory location where is to be stored

Step 5: Select the Number of Phase

Step 6: Select the Wire configuration

Step 7: Select the handling voltage level

Step 8: Select the Ratted current

Step 9: Set time interval for measurement

Step 10: Press the start Button

5. Results

5.1 Textile Industry 1

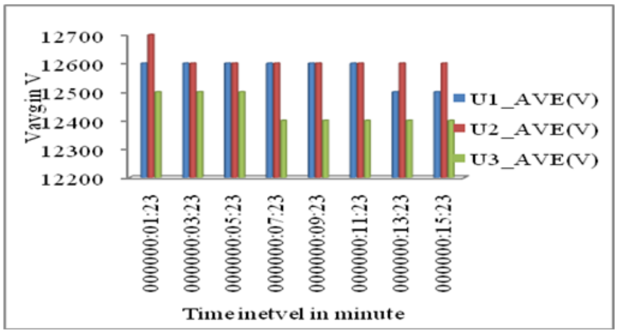

Figure 1. Relationship between system voltage vs. time..

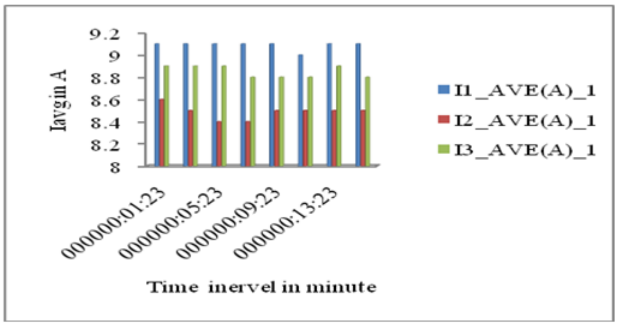

Figure 2. Relationship between load current and time.

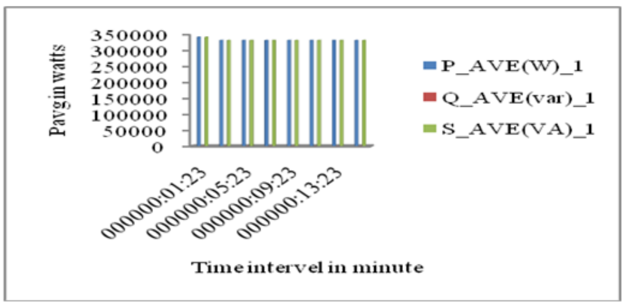

Figure 3. Relationship between average power and time.

The operating voltage on each phase is varied with respect to the time shown in Figure 1. The connected load on phase 2 is low as compared to others shown in Figure 2. So that implements the proper load management in the industry. The true power and apparent power are equal whereas reactive power is zero shown in Figure 3. The total current harmonic distortion has exceeded IEEE Standard limits[14] as shown in Figure 4. Its because textile industries use many variable speed drive motors. Depends on speed variation it pollutes the fundamental frequency. Hence the suitable harmonic suppression technique is needed in all phases.

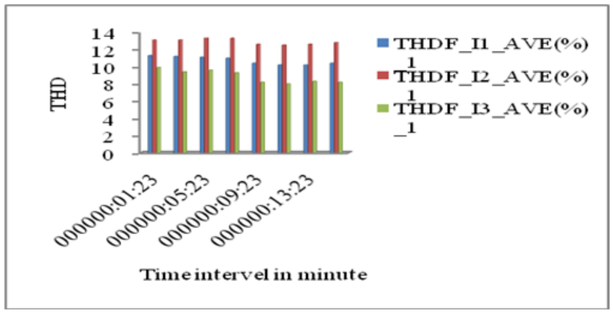

Figure 4. Relationship between THD vs. time.

5.2 Textile Industry 2

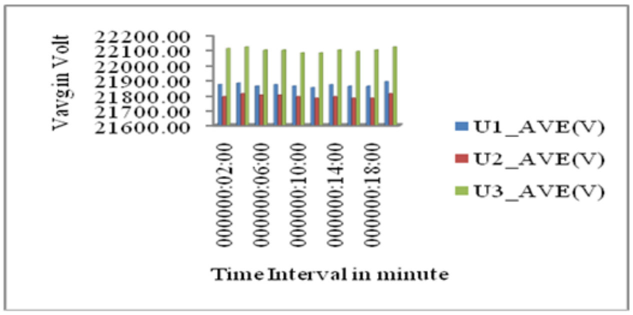

Figure 5. Relationship between system voltage vs. time.

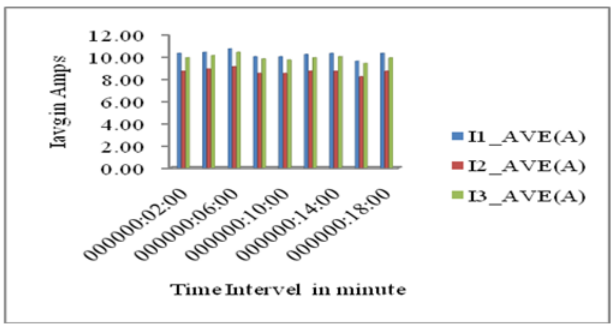

Figure 6. Relationship between load current vs. time.

The average voltage on each phase is not constant as shown in Figure 5. It is varied with respect to time. In addition, Phase 1 voltage is significantly higher phase 2 and phase 3. Average load current on each phase varied with respect to time as shown in Figure 6. The load is higher in phase 1 compared to others. The variation between true power and apparent power is small. Whereas, a significant quantity of reactive power appears on phase 2 as shown in Figure 7. It can be inferring that connected load on phase 2 is more inductive that of others. The average total current harmonics is exceeding the critical limit as as per IEEE standard[14]. Particularly, in phase 2 has higher harmonic content than others as shown in Figure 8. So that reforms the load management system as well as connect the suitable filter on each phase.

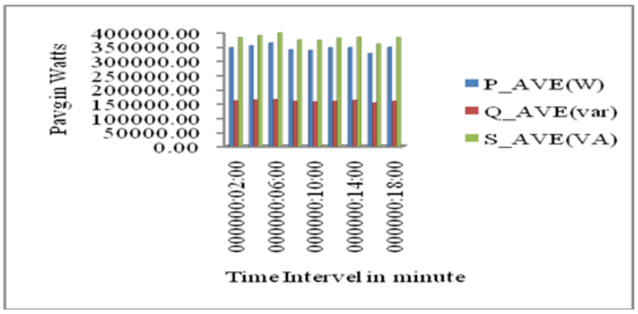

Figure 7. Relationship between average power vs. time.

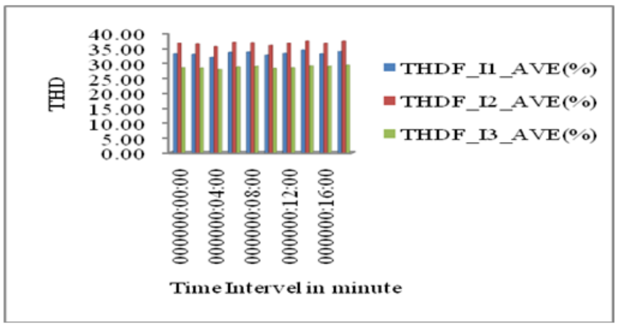

Figure 8. Relationship between total current harmonics vs. time.

5.3 Textile Industry 3

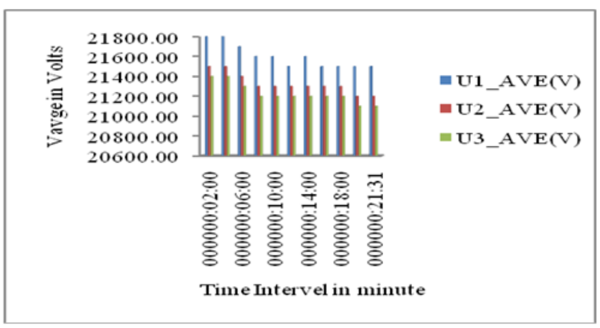

Figure 9. Relationship between average voltage vs. time.

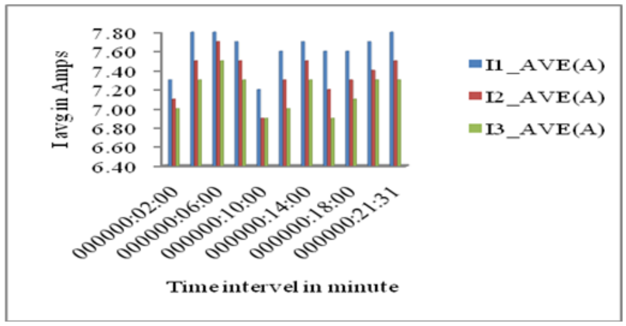

Figure 10. Relationship between average load current vs. time.

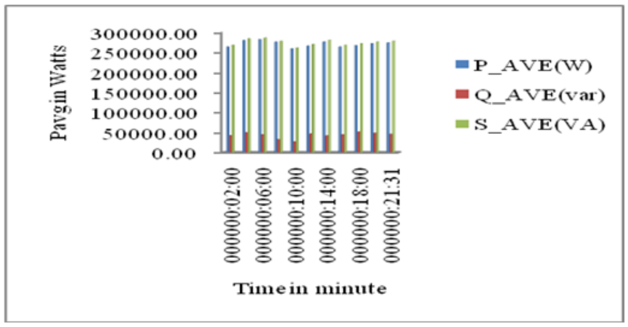

Figure 11. Relationship between average power vs. time.

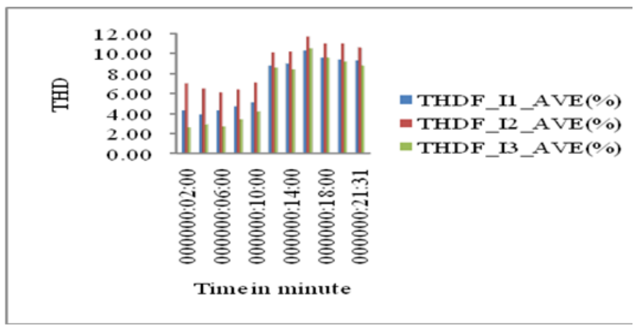

Figure 12. Relationship between total current harmonics vs. time.

The average voltage, current on each phase is not constant . It is continuously varied with respect to time shown in Figure 9 and Figure 10. The reactive power is very low on compared to the real power and apparent power shown in Figure 11. Also, Load current on each phase is varied with respect to time. Total harmonic distortion in phase 2 is higher as compared to others. The harmonic distortion on phase 2 increases with time as shown in Figure 12. For first five consecutive measurements the current harmonic distortion is low. It is gradually increased with time.

Also, it exceeds IEEE Std 519 limit[14]. Hence the suitable harmonic suppression technique is needed in all phases.

5.4 Textile Industries 4

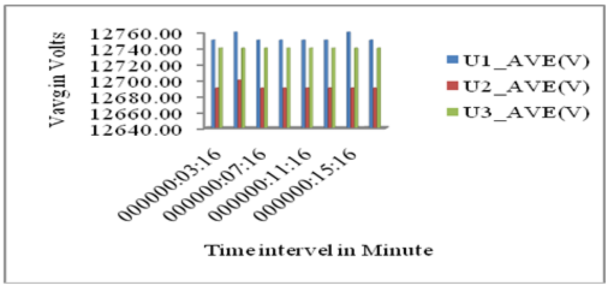

Figure 13. Relationship between average voltage vs. time.

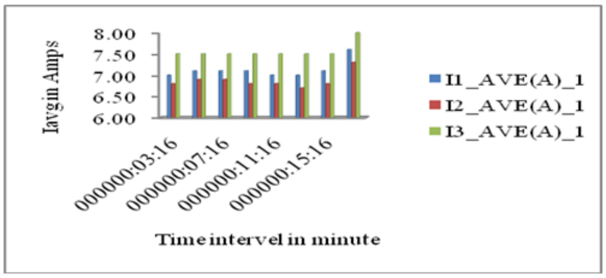

Figure 14. Relationship between average load current vs. time.

The average voltage, load currents are varied with respect to time. as shown in Figure 13 and Figure 14. The difference between real power and apparent power is very low as shown in Figure 15. Whereas, measured reactive power is a negative value due to continuous variable speed drive motors. Total current harmonic distortion is much higher than the IEEE Std limit[14] as shown in Figure 16. Hence the harmonics suppression technique is needed.

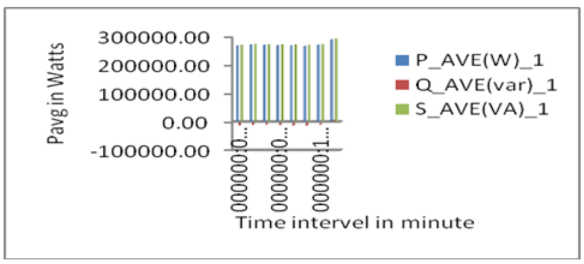

Figure 15. Relationship between average power vs. time.

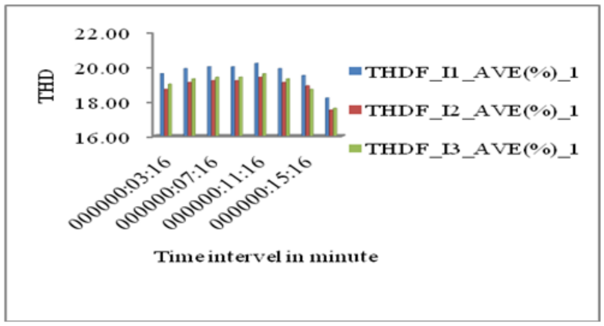

Figure 16. Relationship between THD vs. time.

5.5 Coffee Industry

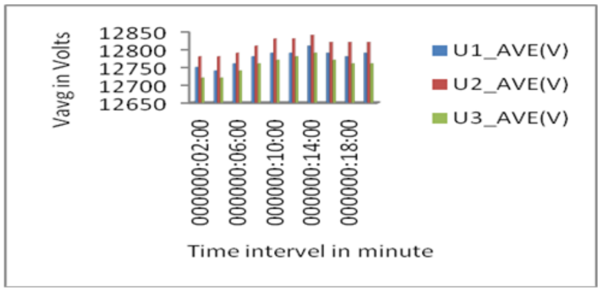

Figure 17. Relationship between average voltage vs time.

The average voltage on phase 2 is higher than phase1and phase 3. Load current on phase 2 is higher than others which is followed by phase 1, phase 3 as shown in Figure 17 and Figure 18. Reactive power is low on compared to others as shown in Figure 19. This is a coffee industrypower quality analysis data. This type of industries is used burrgrinders for crushing coffee seeds and so transmitting further process through belt conveyers, these are content speed motor so that the total harmonic distortion is low as compared to textile industries as shown in Figure 20.

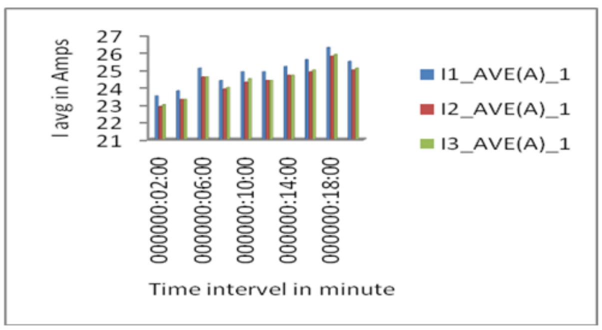

Figure 18. Relationship between average current vs. time.

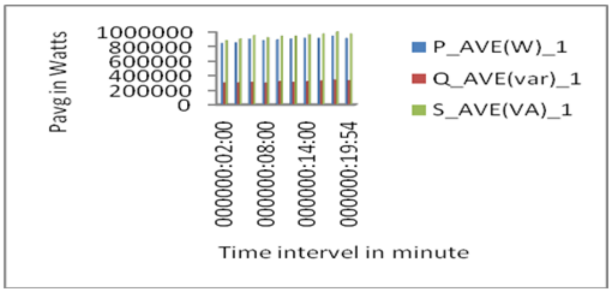

Figure 19. Relationship between average power vs. time.

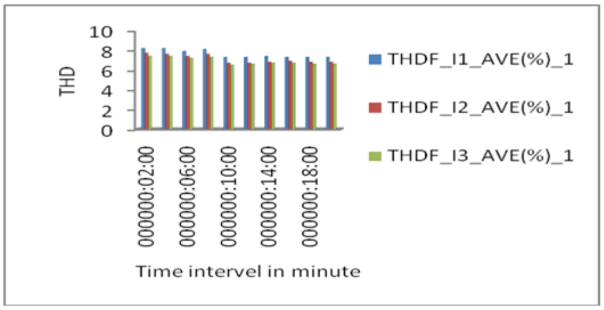

Figure 20. Relationship between THD vs. time.

6. Conclusion

At first effect of harmonic distortion on transformers, mitigation technique of harmonic distortion and important terms related to power quality issue were discussed. From the analyze it was found that active filter is simple and cheapest. Passive filter do harmonic suppression and power factor correction. The hybrid filter technique is best choice for harmonic suppression, but the cost is higher than other two technique. Subsequently, the power quality measurement has been performed on industries. From the measurement found that, total harmonic distortion in textile industries exceeding the IEEE standard limit. Hence its very essential, to implement the effective current harmonic suppression technique.

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