

### Harmonics Reduction in Load control and Management system

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**Abstract :** This paper presents conservation of electrical energy in building with harmonics analysis and compensation which occur in electrical system. We use load controlling and management system in order to adjust load factor of system. The maximum demand limiting and controlling are used, then the system can acquire the prediction and compare it to the maximum demand set point. The electrical signal analysis based on FFT technique. The harmonics are compensated by using harmonic filters. This system consists computer which works as controller, processor, analysis and database unit together with digital power meter in form of multidrop network through serial communication via RS-485. The load control system uses PLC to control load via serial communication RS-485. The A/D converter is used for sampling the electrical signals via parallel port of computer. The harmonic filters are controlled by a computer. The data of measurement such as voltage, current, power, power factor, total harmonic distortion, energy, etc., can be saved as database and analysis. The load factor is adjusted by limiting and controlling maximum demand. The load factor adjustment can reduce the cost of electric consumption and energy generation together with harmonics compensation in order to increase high efficiency of electrical system.

**Keywords :** Harmonic analysis, Harmonic reduction system, FFT.

#### 1. INTRODUCTION

Presently, the energy conservation systems, use the load control and management system method, in building or factory level are more interesting. However, the most systems do not consider to harmonics, that occur from non linear load. These harmonics result in the efficiency of the electrical system is decreased. Thus, the harmonics reduction have an effect on the system that has more efficiency and do not damage to the other electrical devices.

In this paper, we present the development of harmonics reduction in load control and management system, which within the medium and small building, by increasing harmonic reduction system associate with the load control and management system that these whole systems are used with the computer which work as 12 bit A/D, digital powermeter, plc and harmonic filter. The information received from digital powermeter and 12 bit A/D can be show in data monitoring record to database system and forecast load demand and harmonics analysis. Demand forecast and load shedding are used in load control system. Harmonic reduction system base on the FFT technique in order to evaluate the occurring harmonics in the system and control filter to eliminate the harmonics.

#### 2. HARDWARE CONFIGURATION

All system consist of data acquisition system and control system, show in Fig.1. The data acquisition consist of the digital power meter and the 12 bit A/D, that install in building for measurement of electric signal, then link to the computer, with RS-485 and parallel port, respectively. The control system consist of computer, work as supervisory system. That is for monitoring of signal, harmonic filter control, communication, load control, demand forecast, database and Harmonic analysis. The load is controlled by PLC.

Harmonics filter is passive filter type. The induction of 5<sup>th</sup> and 7<sup>th</sup> are 1.84mH and 1.38mH, which a tuned at 240, 340, respectively.

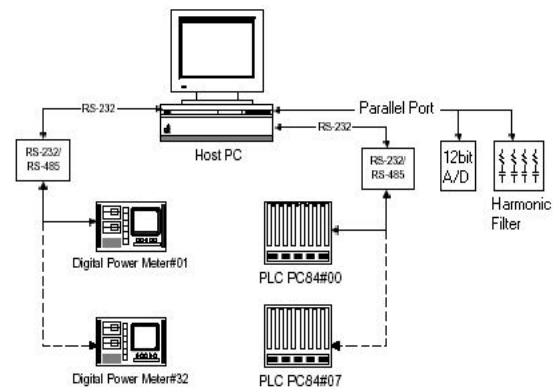


Fig. 1 All hardware configuration system.

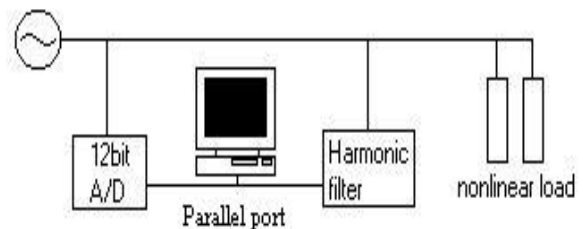


Fig. 2 Harmonic reduction system.

#### 3. SOFTWARE CONFIGURATION

The software is developed by Visual C++ Ver.6 program and can be used on the windows 98 operation system. The function of software is electric signal monitor, Spectrum graph from harmonic analysis, 12Bit A/D communication software

and Harmonic filter control. All function is inside the computer.

**3.1 The control system flowchart**

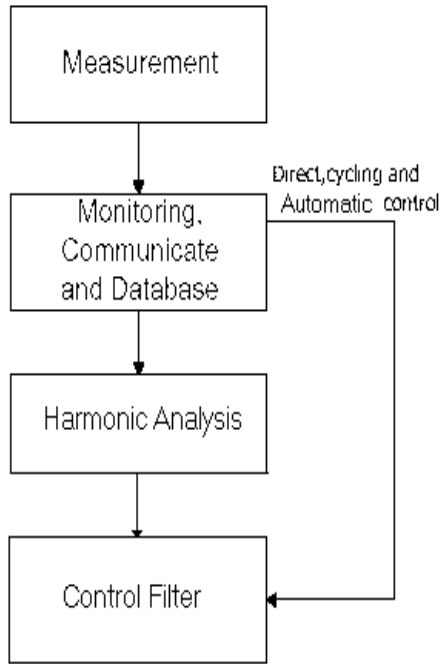


Fig. 3 The control system flowchart.

**3.2 Electric signal and harmonic analysis monitoring**

Monitoring software can be shown electric signal and harmonic analysis in the graph format another values such as total harmonic distortion(THD) to show in monitor. Show in Figs.2~ 3 .

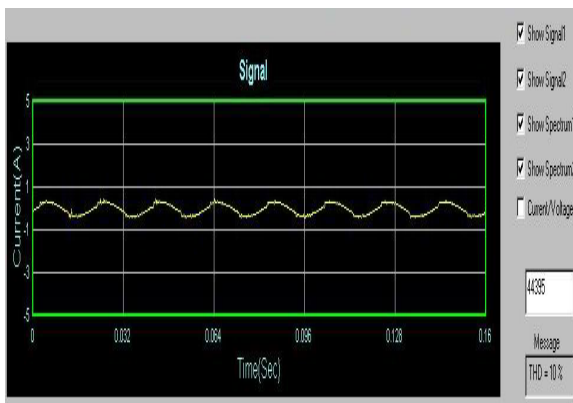


Fig. 4 show electric signal monitor.

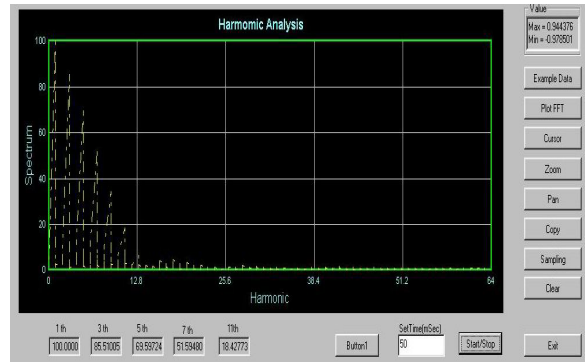


Fig. 5 Show Harmonic analysis monitor.

**3.3 Communication software**

The communication software in this paper is interfacing between computer, A/D and harmonic filter by via parallel port .Using address 0379H and 037AH for receive data of electric signal from 12Bit A/D and address 0378H is used for sent data to 12Bit A/D and harmonic filter ,show in table 1.

Table 1 Parallel port communication address

Address	Bit0	Bit1	Bit2	Bit3	Bit4	Bit5	Bit6	Bit7
0378H	Bit0-3 use for control A/D				Bit 4-7 use for control Filter			
0379H	-	-	-	-	Bit 4-7 use for receive data from A/D			
037AH	Bit0-3 use for receive data from A/D				-	-	-	-

**4. HARMONIC ANALYSIS**

Harmonic analysis program in this paper use FFT method. This method can sharply convert the measured signals from A/D converter on the time domain to the frequency domain. Diagram is show in Fig.6 . The signals are represented with spectrum lines and these lines indicate the occurring harmonics in the measured system .

We can calculate total harmonic distortion (THD) from Eq(1) and Eq(2).

$$THD_I = \frac{\sqrt{\sum_{n \neq 1} I_{n,rms}^2}}{I_{1,rms}} \tag{1}$$

$$THD_V = \frac{\sqrt{\sum_{n \neq 1} V_{n,rms}^2}}{V_{1,rms}} \tag{2}$$

where

THD is Total Harmonic Distortion.

$I_n$  is  $n^{th}$  harmonic current.

$V_n$  is  $n^{th}$  harmonic voltage.

This program analyzes the harmonics every 50 ms and every time the load control system operate with the non-linear loads. The computer will select filter for reduction harmonics after it analyzes the harmonics. Function of harmonic analysis and control filter can be direct and automatic control.

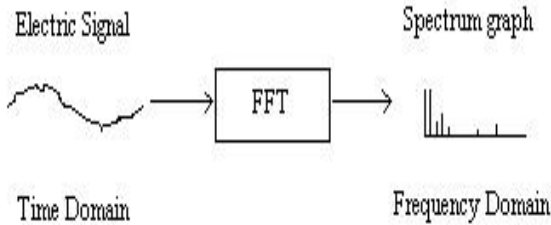


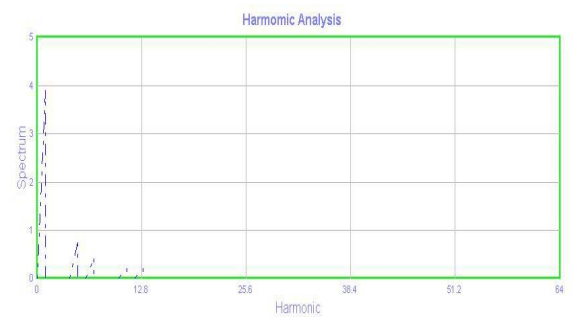
Fig.6 Harmonic analysis diagram.

**5. EXPERIMENT AND RESULT**

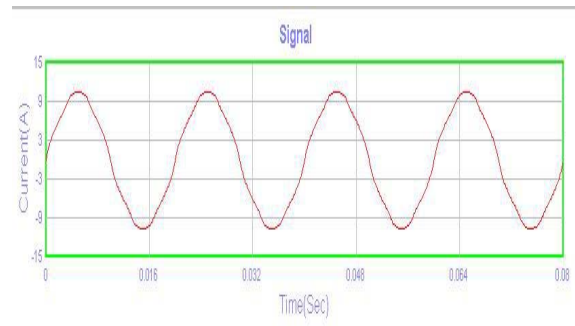
The harmonic reduction system is tested in the small model system which has a non-linear load(converter). In experiment, we measure the signal of current from system that has a non-linear load and the signal of current is shown in Fig. 7(a). It can be seen that the signal is non-sinusoidal. The occurring harmonics in current of system consist of 5<sup>th</sup>, 7<sup>th</sup>, 11<sup>th</sup>, 13<sup>th</sup> of harmonics that shown in Fig 7(b). The measured total harmonic distortion (THD) of the current before the filter operate is 23.40%. The results, after filter operate in system, are shown in the Figs. 7(c) and 7(d). Then, the total harmonic distortion (THD) of the current is 4.16%.

In Figs. 8(a)~8(b) show signal and spectrum of voltage from system before filter operate. The total harmonic distortion (THD) of voltage is 5.49%. In Figs.8(c)~8(d) show signal and spectrum of voltage from system after filter operate. The total harmonic distortion (THD) of voltage is 1.04%.

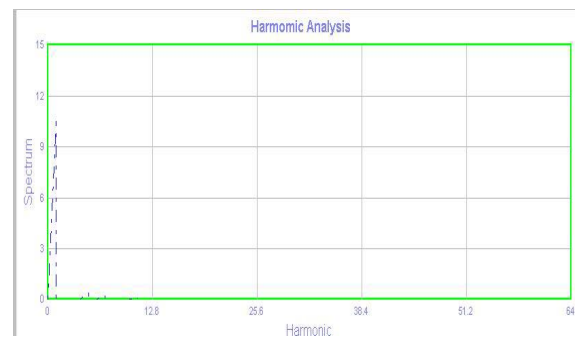
Fig. 9 show demand graph of load control system while harmonic reduction system is operate. It can be seen that the load control usually work by can control the demand in the limitation of set point.



(b)



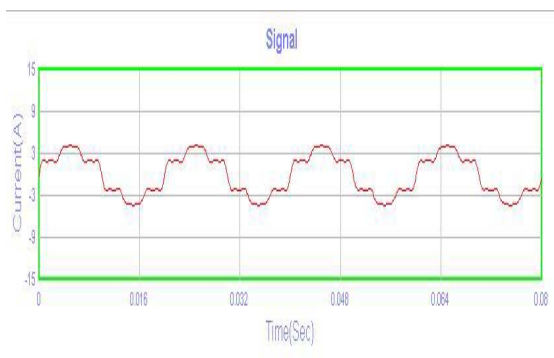
(c)



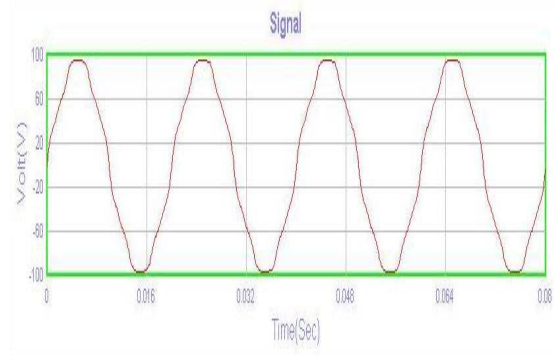
(d)

Fig. 7 show waveforms and spectrum of current.

- (a) signal of current before filter operate.
- (b) current harmonics before filter operate.
- (c) signal of current after filter operate
- (d) current harmonic after filter operate.



(a)



(a)

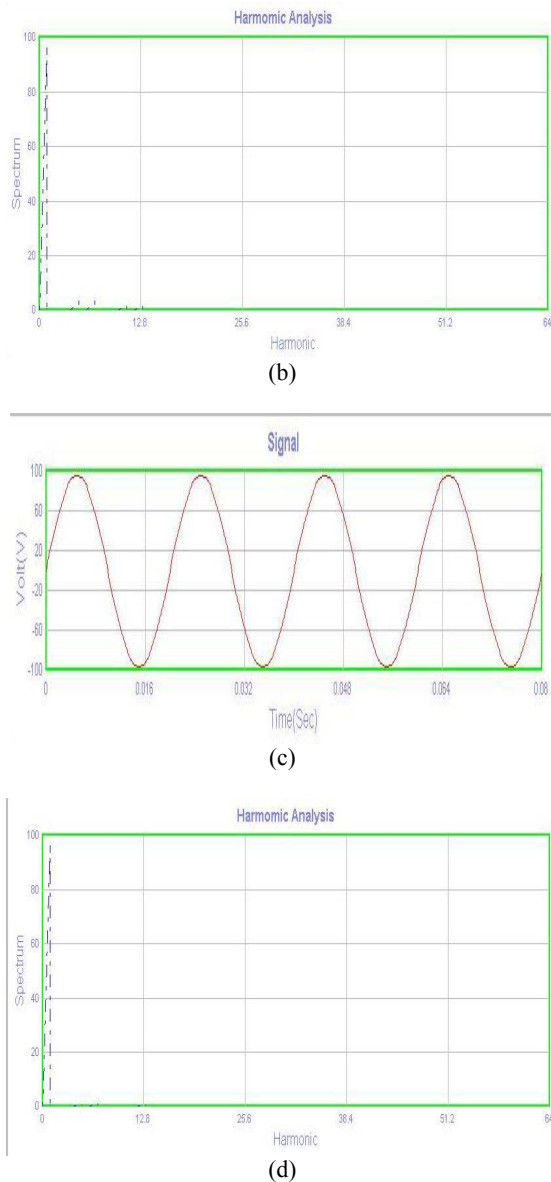


Fig.8 show wave form and spectrum of voltage.  
 (a) signal of voltage before filter operate.  
 (b) voltage harmonics before filter operate.  
 (c) signal of voltage after filter operate .  
 (d) voltage harmonic after filter operate.

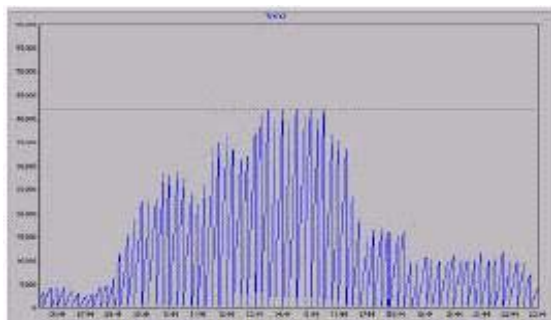


Fig. 9 Show Demand value from Load control system.

6. CONCLUSION

In this paper we present the harmonic reduction in load control system for reducing the total harmonic distortion (THD) by computer which work as 12Bit A/D and harmonic filter. The harmonic reduction system select and control filter by analyze signal from system .On computer was show electric signal ,hamonic analysis,function direct and automatic filter control .And the harmonic reduction in this paper can work with load control system.

REFFERENTS

- [1] Tain-Syh Luor; " Influence of load characteristics on the applications of passive and active harmonic filters" *Harmonics and Quality of Power, 2000. Proceedings. Ninth International Conference on* , Volume: 1 , 1-4 Oct. 2000 Page(s): 128 -133 vol.1.
- [2] INTERSIL, "HI-574A 12 Bit A/D Converters datasheet" www.intersil.com.
- [3] Tipsuwanporn, V. ; Srisuwan, K. ; Kulpanich, S. ; Suesut, T. ; Numsomran, A. .; "Development of load control and management system" *Transmission and Distribution Conference and Exhibition 2002: Asia Pacific. IEEE/PES* , Volume: 3 , 6-10 Oct. 2002 Page(s): 2139 -2142 vol.3.
- [4] Chen, Z.; Blaabjerg, F.; Pedersen, J.K.; "A study of parallel operations of active and passive filters" *Power Electronics Specialists Conference, 2002. pesc 02. 2002 IEEE 33rd Annual* , Volume: 2 , 23-27 June 2002 Page(s): 1021 -1026 vol.2.
- [5] Wilson E. Kazibwe, Musoke H. Sendaula. *Electric Power Quality Control Techniques*. New York: Van Nosteand Reinhold, 1993.
- [6] E.O. Brigham, "The Fast Fourier transform", Prentice-Hall, 1974.
- [7] L.H. Thomas, "Using A Computer to Solve Problems in Physics, Application of digital Computer ," Boston. Mass. :Ginn, 1963.
- [8] Acha, Enrique "Power system harmonics: Computer modelling and analysis" Chichester : John Wielely & Sons, c2001.