Reduction of Harmonic in phase-cutting Dimmers

H. Fathabadi

***Abstract*—In this paper, we consider a designed and implemented dimmer. The dimmer is closed loop and phase-cutting type. In fact, a microcontroller calculates and then regulates the firing delay angles of eight triacs. Depending on the firing angle, the harmonic distortion in the input current will not comply with international standards, such as IEC 61000-3-2(class C equipments). For solving this problem, eight harmonic compensators will be designed and added to the dimmer. So, the proposed dimmer has a little harmonic distortion in the input current whereas conventional phase-cutting dimmers are not so.**

***Index Terms*—Dimmer, compensator, harmonic, dimming.**

I. Introduction

As we know electrical energy is expensive. So, when the luminosity of environment is higher than enough, the electrical power is become useless. In order to economize of electrical energy, we must turn off or decrease the luminosity of lamps. In this way, a lot of electrical power will be economized. As we know, a dimmer can do this. Recently, dimmers have attracted considerable attention [1]-[8]. Most results addressing this subject, available in power electronic literature. As we know, phase-cutting dimmers are two types, open loop and closed loop. In open loop dimmers, the luminosity of environment is regulated manually. Conversely, in closed loop dimmers, luminosity is regulated automatically. So the economy of energy is higher.

In fact, in open loop dimmers, the firing delay angles of triacs or thyristors are regulated manually whereas they are calculated and regulated by a CPU or logical circuits in closed loop dimmers. The dimmer which is presented in this paper, is closed loop. This dimmer regulates the luminosity of eight locations synchronously. Also eight harmonic compensators are added to system. In order to economize the electrical energy, the outputs of compensators are connected to resistances (elements) of the water heaters or boilers in houses or industrial centers.

II. Block Diagram Of The Dimmer

The block diagram of the dimmer has been shown in Fig. 1. As we see, the system consists of the following units:

1) Eight sensors in eight locations. These sensors generate eight feedback signals which are changed by varying in the luminosities of the eight locations.
2) Analog to digital converter. The output signal of each sensor must be converted to digital signal. These digital signals can be used by C.P.U. or microcontroller.
3) A multiplexer. Eight digital signals must be multiplexed in order to transmit on one data bus.
4) A cross-over zero detector. This unit generates a negative edge pulse, when AC power line passes from negative alternation to positive alternation. In fact, this unit generates the origin of time.
5) A CPU or microcontroller. This unit is necessary, because it calculates and regulates the firing delay angles of eight triacs base on the eight feedback signals.
6) Eight isolators and couplers. Power section of circuit is isolated from the control section of circuit by these elements.
7) Eight controlled power drivers. Controlled power drivers are electronic elements such as triac or thyristor that operate as controlled switches.
8) Eight harmonic compensators.
9) Twenty four lamps (three lamps for each location or channel). In fact, they are the output of the system.

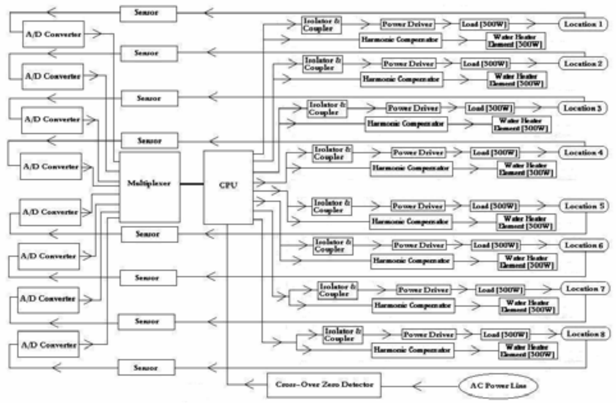

Fig. 1. Block diagram of the dimmer.

III. Harmonic Compensators

As shown in Fig. 1, the harmonic compensator of each channel is parallel with the driver and the load (lamps) of that channel. So, total current of each channel is the sum of its' driver and compensator currents. The circuit of the harmonic compensator for one channel is shown in Fig. 2. As we see, the compensator is dynamic type and Gate turn-off thyristor (GTO) has been used for implemented circuit. For economizing the electrical energy, the load of compensators is the resistance (element) of the water heater or boiler in houses or industrial centers. Note that,

Manuscript received Nov. 25, 2007.

Hassan Fathabadi is with the Electrical Engineering of Islamic Azad University (south tehran branch), Ahang Blover, Tehran, Iran. (tel: 00989123773748; e-mail: h4477@hotmail.com). **Preferred address for correspondence:** Hassan Fathabadi- No. 27 - Ghazanfar Khavand Alley - 30 Metry Jey Blover- Tehran-Iran .P.O.Box: 13517-53593.

in order to remove all of the harmonic distortion, the load of each compensator must be equal to the load of each channel. So, the load of each compensator is a 300W resistance (element) of electrical water heater or boiler. Since the loads of each compensator and its' channel are not exactly equal, a little harmonic distortion will exist in system. In fact, the GTO of each channel is turned on by cross-over zero detector when AC power line passes from negative alternation to positive alternation. Also it is turned off at the moment that the driver (triac in proposed dimmer) of that channel is turned on. The currents of channel, driver and harmonic compensator for one assumed channel with firing angle $\alpha = 90^{\circ}$ has been shown in Fig. 3. As we see the total current of that channel is completely sinusoidal form. Thus, that channel doesn't generate any harmonic distortion in the input current and also other channels. As described above, in practice, the system will have a little harmonic distortion because of mismatching between each compensator and its' channel.

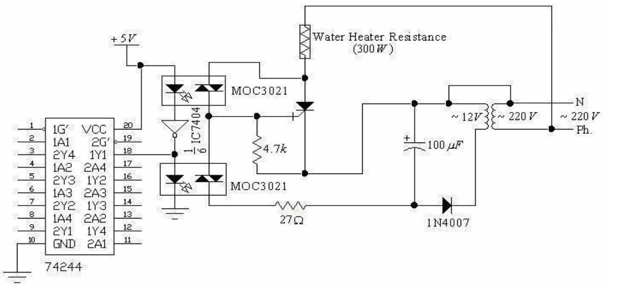

Fig. 2. The circuit of the harmonic compensator.

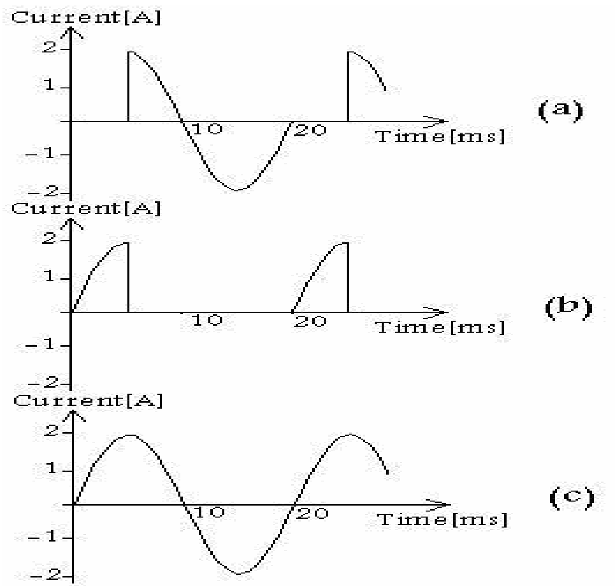

Fig. 3. For $\alpha = 90^{\circ}$: (a) Current of driver. (b) Current of harmonic compensator. (c) Current of channel.

IV. Hardware And Flow Chart Of Software

Based on previous sections, hardware of the dimmer and added compensators is shown in Fig. 4. A flow chart for the software of the dimmer has been shown in Fig. 5. Based on this flow chart, the software for the dimmer has been written.

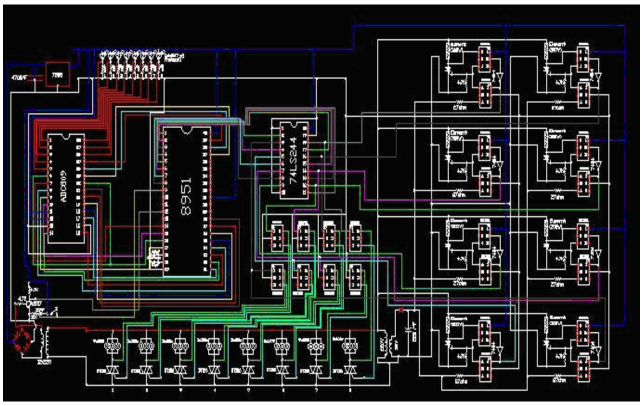

Fig. 4. Hardware of the dimmer.

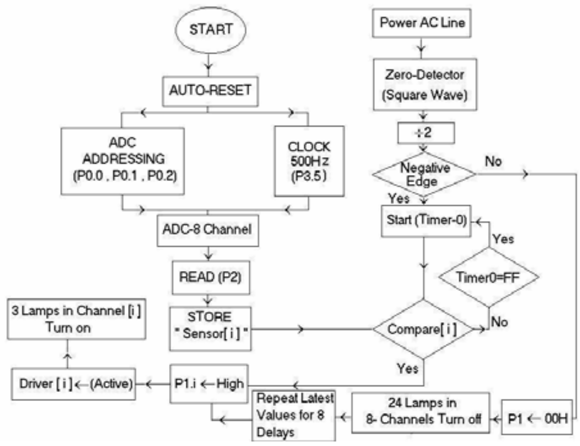

Fig. 5. Flow chart for software of the dimmer.

V. Conclusion

In this paper, the designed and implemented phase cutting dimmer was considered. The proposed dimmer was closed type. The harmonic of the dimmer was reduced and limited to zero with using eight dynamic compensators. Hardware and software of the compensated dimmer were presented.

Acknowledgment

Implementation of the project has been done in Islamic Azad University (south tehran branch).

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