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Led Lamp Harmonics Minimization

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Abstract- The cost of electricity is growing these days, and a lot of individuals have decided to reduce their emissions in order to conserve the environment and cut their living expenses. Reducing the electricity usage of the utilized electrical gadgets is the first step. A lot of firms redesign and enhance their products to meet the new requirements. Take the energy consumption of standby appliances, for instance.

In actuality, the first step in replacing our traditional (incandescent) light sources with more energy-efficient ones in our home is to install retrofit light-emitting diode (LED) or compact fluorescent (CFL) lamps. The classic incandescent lights, which typically have an energy efficiency level of E or G, are no longer allowed to be sold. The European Union supports this strategy by passing laws that forbid trading in light sources with an energy efficiency class of C or higher.

Because CFLs are reasonably priced in relation to their entire luminous flux, this has hastened the proliferation of alternate light sources. As LED technology has advanced over the past several years, more LED lamps are being used in homes. The major LED lamp problem, is the harmonic export to the grid. In this paper, the design of a cheap extra driving circuit to the lamp in order to reduce harmonic emissions.

Keywords- *LED, THD, pf*

I. Introduction

The current paper devoted to describe the design of a control system that uses a basic nonlinear switching power supply added to LED light sources to improve the power quality in low voltage networks. By using this technique, the harmonic distortion of line's voltage and current will be reduced and active power factor correction will also improve [1].

The upper harmonic controller, which uses an asynchronous parallel pattern search method in the frequency domain to decrease the amplitudes of the third, fifth, seventh, ninth, and eleventh upper harmonic components in the output voltage, is the innovative part of the suggested structure [2,3].

Recent changes to national power supply laws have made it possible to use grid tie inverter systems to feed surplus power into nearby low voltage mains in a number of nations. Additionally, these inverters' power injection results in a distorted current shape [4]. Because this power is used in the neighborhood close to the injection location, there is not much transportation loss. Furthermore, this kind of inverter's design allows it to be used for line conditioning, accurate voltage form correction, and reactive power repair in mains.

As a result, developing the capability of line conditioning just requires modifying the control strategies and regulators, not requiring costly building changes. Compared to the cost of the equipment, upgrading the controlling processor and control software is not very expensive.

Power injection into the grid is the subject of several publications; for a recent survey, see, for example, (Carrasco et al., 2006). While the nonlinear scenario has been studied, the possibility of power factor correction in conjunction with power injection has also been realized [5, 6]. Also investigated has been its relationship to nonlinear distortion reduction [7,8].

In order to compensate for an exact nonlinear load, the authors of this paper employ active power filters (APF) in conjunction with a DSP-based current management approach for distortion reduction. They inject the exact deviation current into the grid with drastic distortion reduction by using the phase locked loop (PLL) technology to sense the nonlinear current time function and the ideal sinusoid current. Although the price of these nonlinear power sources is not competitive, they can be balanced with careful circuitry design (e.g., Active Power Factor Correction, or APFC).

The work has focused on creating and examining devices and control strategies that can reduce the line's existent harmonic distortion and enable active power factor correction without requiring current measurement. This goal can be accomplished in addition to controlling the maximum power operating point from the renewable source (wind generator or photovoltaic panel) by adding new elements to the schematic construction intended for the built-in elements, as our previous paper and its further developed version demonstrate [9,10]. If a Grid-tie is present in the home, it illustrates the potential for compensating for the consequences of the nonlinear distortion [11, 12].

In the current paper, a new circuit part will be added, a specialized electronic ballast to the system without changing the cable structure and without the need for extra current

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sensors to accurately measure the distortion or time function of the electronic loads in the building or block.

II. Contribution

Through simulation in the MATLAB environment, the suggested controller was examined, and the output voltage and current waveform could be significantly improved as a consequence. Additionally, there has been a significant decrease in the overall harmonic distortion of the voltage and current. This drop contributes to a lessening of power loss in the transportation line's phase conductor and, to a greater extent, in the neutral conductor. Reducing greenhouse gas emissions from the production of electricity from fossil fuels will lessen the effects of climate change on the environment and social wellbeing.

Now aday, it's more and more common to employ low-power devices with straightforward switching power supply (in our case, LED light sources, but other examples include mobile phone chargers, laptops, networking items, small variable frequency motor drives, and consumer gadgets for telecommunication). These devices employ a diode bridge, a capacitive load with high nonlinearities, as their basic performance input arrangement. Significant 3rd and 5th upper harmonic current components are produced by these appliances, seriously distorting the voltage contour.

III. Power System Model

It is well-known that it is difficult to compensate the reactive power of this type of nonlinear distorted voltage shape with traditional shunt capacitances (compensator). The distortion of the voltage shape is commonly characterized by the total harmonic distortion (THD) which is defined as [13]:

$$THD = \sqrt{\frac{\sum_{k=2}^{\infty}|V_k|^2}{|V_1|^2}}$$

Where V_1 equals to the voltage amplitude of the fundamental frequency and V_n is the voltage amplitude of the nth harmonic. In applications with capacitive input stage, THD > 0 holds.

This type of distortion occurs in all mains plug in every home. In the near future this distortion, this nonlinear reactive power and the THD will probably increase because of the growing rate of simple switching type power sources in household appliances [14, 15].

Increasing luminous efficacy and long lifetime make them suitable to be used for lighting in rural villages. Unlike other technologies, LEDs started showing their applicability in lighting in developing countries before coming to the markets in developed countries. Nowadays, thanks to rapidly developing solid state technologies, the use of LED light sources increases widely in almost all lighting application areas to ensure sustainability in terms of energy efficiency [16].

The behavior of different LED lamp types was examined in a low voltage network with approximately 3% distorted voltage shape. Measurement results show power factor values ranged from 0.4334 to 0.999, and the current total harmonic distortion varies from 2.7% to 192.7%. The exact measuring of the optimal and the worst-case results can be seen in Fig. (1). The 192.7% value is rather alarming, spreading this type or similar electrical designed ones, can rather make the low voltage network behaves as a nonlinear circuit.

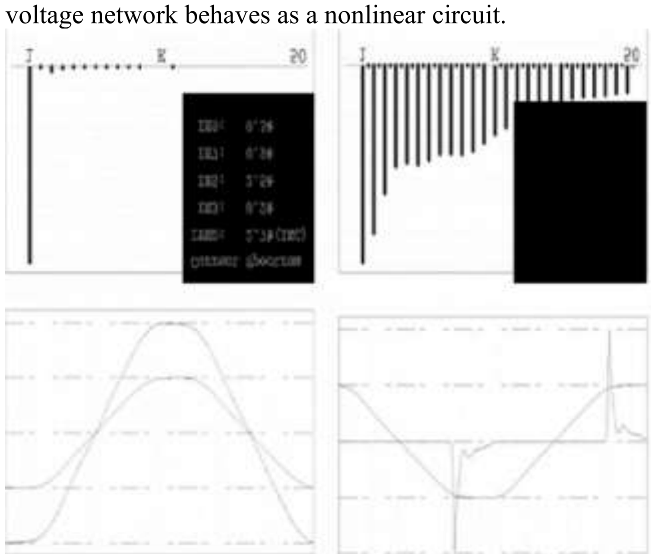

Fig. (1): Incandescent lamp (left) and 4 W LED lamp (right) measured values

IV. Power Quality Analysis

Boost overall grid dependability, prevent costly equipment failures, and settle conflicts over energy supply electric power is a product, just like any other, and its quality matters. Electric utilities benefit greatly from power quality analysis because it allows for ongoing monitoring, early excursion detection, root cause investigation, and prompt corrective action, all of which increase overall grid dependability.

Major energy consumers are also interested in power quality in order to reduce the frequency of power quality events and prevent costly equipment failures. Thus, the adoption of high-performance power quality is motivated by the shared interest in power quality between energy suppliers and energy consumers.

High performance power quality monitoring is offered by SATEC devices, which come equipped with integrated IEEE1159 or EN50160 monitoring, statistics, and reports. Direct access and a comprehensive toolkit for recording and evaluating power quality events are offered by Expert Power TM Pro, SatEC's online solution for complete system Power quality analysis.

The S series is an active harmonic filter device that lowers expenses by removing harmonic oscillations. The S series keeps an eye on the current signal and modifies the measured current to remove undesirable components. As a result, the filter guarantees harmonic suppression regardless of how many power factor corrections are made, increasing system

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efficiency and lowering harmonic pollution loads. Additionally, it recorders and analyzers for resolving disputes.

Power systems inspection to evaluate issues like: Power factor, Voltage / Current unbalance, Harmonic distortion, Scrambled data, Memory loss, Interrupted communications, Frozen OS, System crashes, and Over-heated transformers.

V. LED Lamp Benchmarks

The construction of LED lamps is as shown in Fig. (2). It consists of the base, driving circuit (Brown colour intermediate circuit), LEDs and the outer envelope.

Fig. (2): LED bulb construction

The driving circuit is the part in the bulb responsible for harmonics and power factor. Really, the two items are highly correlated. A harmonic is a component of a periodic wave having a frequency that is an integer multiple of the fundamental power line frequency that proliferate by power semiconductor devices. Characteristic harmonics are the predominate harmonics seen by the power distribution system. The main result of harmonics is the current, voltage and hence power waveforms harmonic distortion.

Total Harmonic Distortion (THD) of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. Lower THD, for example, allows the components in a loudspeaker, amplifier or microphone or other equipment to make a violin sound like a violin when played back and not a cello or simply a distorted noise

The power factor (pf) is the cosine of the angle between current and voltage waveforms. Power factor is affected directly by THD. The ideal (displacement) power factor is defined as:

$$pf_{ideal} = 0 \le \frac{Active\ power}{|V_{rms}|.\,|I_{rms}|} \le 1 \qquad (2)$$

Real pf can be defined as:

$$pf_{real} = pf_{ideal}\cdot\frac{1}{\sqrt{1+\left(\frac{THD}{100}\right)^2}} \le pf_{ideal} \qquad (3)$$

To reduce the LED lamp THD and hence increase the real power factor, an active harmonic filter will be proposed as a system problem solution. It can be applied to one or many nonlinear loads at the same moment. Can provide pf correction. More cost effective for multiple loads. Needs low space. A simple circuit will be tested and installed for different experiments. A calibrator is used in order to measure the THD and pf, power quality analyzer, as shown in Fig. (3).

Fig. (3): LED lamp measurements

The results were measured and recorded. The results are as follows: THD =110%, I = 42 mA, V = 223 V, P = 8.96 W, Q = - 3.71 Var, S = 14.66 VA, pf = + 0.611 and φ = - 22˚. It's clear that there is about 3,24 W power losses. Then we gave up the whole circuit and looked inside the light bulb itself and the circuit inside it; i.e. the bulb was broken and the circuit was removed as shown in Fig. (4).

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Fig. (4): The bulb base

The driving circuit inside the bulb was found that was broken and the circuit was removed as shown in Fig. (5) consists of: bridge, A4c, diode, capacitors resistance to reduce the voltage, transistor and fuse.

Low pass filter is one of the best filters used in those cases. It will reduce THD and increase pf. Low pass filter is shown in Fig. (6). The filter was tested outside of the experiment to ensure that it works in a good condition, as shown in Fig. (7). The filter is connected with the driving circuit and final measurements was carried out as shown in figures (8) and (9).

Ther re-measurements is to recognize the decrement of THD and increment of pf. The results are as follows: THD =52.82%, I = 36 mA, V = 221 V, P = 8.57 W, Q = - 3.71 Var, S = 14.66 VA, pf = + 0.885 and φ = - 22˚. It's clear that power consumption will be a power loss will decrease to about 1.53 W.

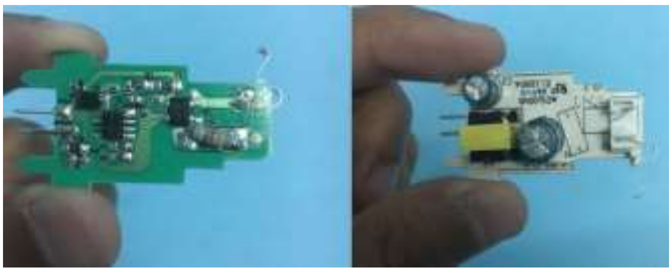

Fig. (5): Driving Circuit

Fig. (6): Low pass filter

Fig. (7): Low pass filter testing

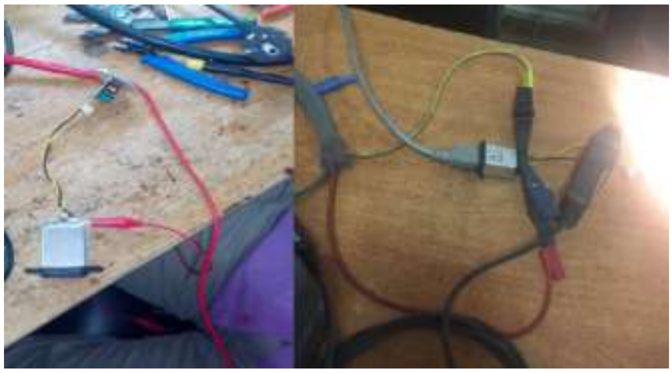

Fig. (8): Low pass filter connection

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Fig. (9): Final measurements

Conclusion

In conclusion, the shift toward energy-efficient lighting solutions, driven by rising electricity costs and environmental concerns, marks a significant step in reducing household energy consumption. With regulations such as those from the European Union banning inefficient incandescent bulbs, alternatives like CFLs and LEDs have become more widespread. CFLs offer a cost-effective option, but the rapid advancement of LED technology has made it the preferred choice for many, due to its superior energy savings and longevity. This transition not only lowers living expenses but also supports broader efforts to reduce emissions and conserve the environment. In this paper, a trial of a new design for the LED lamp driving circuit is succeeded in decreasing the THD generated from the lamp operation, and hence enhance the lamp power factor.

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