Automatic ballast tester

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Abstract — With the interest to minimize electrical loading by using energy efficient lighting systems has resulted into a replacing conventional incandescent lamps with Compact Fluorescent Lamps(CFL).CFLs are significantly more efficient and economical than incandescent lamps, and are expected to be used in 100% of residential lighting in the future. However CFLs are a nonlinear load which injects harmonics and it produces highly distorted currents. Large number of customers uses CFLs for domestic, commercial and industrial. The CFL use electronic ballasts and the design of these have an enormous impact on the electrical performance of the CFL .This paper presents automatic ballast tester for large and medium scale manufactures. This work describes the design and development of ballast tester using PIC (Programmable Interface Controller) microcontroller chip. This involves measuring all power quality parameters of CFL that are, power factor, frequency, RMS values of current and voltage, input and output power, efficiency, input current THD. These kinds of tester can test thousands of units in a very short time with fully computerized documentation, achieving very good accuracy and high reliability, delivering 24hrs of operation.

Keywords—*compact fluorescent light; electronic ballast; power quality; harmonic distortions*

I. INTRODUCTION

One of the best ways of energy conservation strategy is to promoting modern technologies that consumes less energy but providing better quality in all electric power utilities. Consumption of electricity more efficiently is by using energy efficient lamps such as Compact Fluorescent Lamps (CFL) to replace conventional incandescent lamps. CFL has a great importance in lighting since it can provide significant energy saving and last longer than incandescent lamps. CFLs operate at a low power factor consuming less active power, providing comparable luminous output to that of incandescent lamps [1]. However, the ballasts of compact fluorescent lamps are nonlinear which injects higher order harmonic components in current waveform. These lamps induce distorted current waveform which influences the quality of the supplied power as well as the electrical appliances [2, 3].This harmonic current flowing in the network causes a power quality issue as these harmonic currents flowing through the system will distort the voltage waveform. The impact of harmonics flowing in electrical networks is diverse and often subtle.

The study presented in this paper is completely based on measurements of power quality parameters of electronic ballast of CFL. The research is started by knowing the harmonics produce by electronic ballast in electrical network with the help of readily available meters [5, 6 and 7].This meters are parameters specific and also for the setup of this experiment required technically sound person who knows all the measurements ways and connections. This method time consuming as we can measure the power parameters of only single unit and also costlier. Automatic ballast tester is fully functional power quality tester with advanced features like RMS measurements, power factor and frequency detection, harmonic analysis, active and reactive power calculations. The proposed system uses Microchip's powerful 16-bitds PIC33F Microcontroller Unit (MCU). Design is unique as it performs all calculations and takes advantage of the dsPIC33F DSP engine. All output quantities are calculated in the frequency domain through the use of direct Fourier transforms (DFT) or through fast Fourier transform (FFT). It can test thousands of ballast in a very short time, fully computerized documentation, with very good accuracy and high reliability, delivering 24hrs of operation. It can declare "pass" when all the test result are within the limit or declare "fail "when any of measure parameter is out of the limit. All the test result (pass/fail) is recorded in a data base file with date and time stamping. The setups parameters are initially fed in the system. Test parameters are stored for different types/models. During the test, the particular model selected based on the selected model the tester automatically runs the test sequence as per listed parameter, compare the recorded readings with reference and display the results.

The paper is organized in six different sections. They are such as section II describes Literature review, section III gives system design which describes block diagram of proposed system with the overview of different block and section IV software implementation which includes analog part simulation results. It ends with section VI conclusion drawn.

II. LITERTURE REVIEW

The electronic ballast circuit block diagram shown in Fig.1 includes the AC line input voltage (typically 120 VAC/60 Hz), an EMI filter to block circuit-generated switching noise, a rectifier and smoothing capacitor, a control IC and half-bridge inverter for DC to AC conversion, and the resonant tank circuit to ignite and run the lamp[4]. The additional circuit block required for dimming is also shown; it includes a feedback circuit for controlling the lamp current.

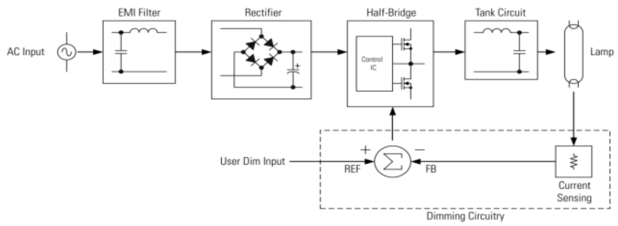

Fig.1 Overview of electronic ballast

Compact fluorescent lamps have high total current harmonics due to control circuit use for limiting discharge current [5].The magnitude of harmonics generated by the CFL vary between different manufactures and also between the ratings of lamps. The study was done on the power quality based comparison of two identical systems modeled , one comprising CFLs as lighting load and the other has fluorescent lights as lighting source(see Fig .2). Current waveforms along with its spectrum for the HTs (High Tension side) and LTs (Low Tension side) of distribution transformers, voltage waveforms and their spectrum at different buses have been compared in terms of THDv and THDi at various locations.

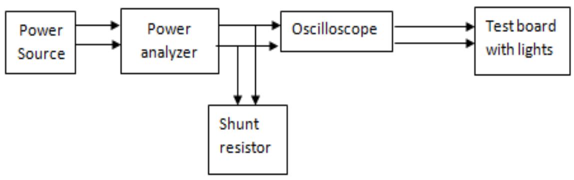

Fig.2 Block diagram of power quality parameter measurements of CFL

The research study made to evaluate the harmonic distortion in the distribution systems caused by the various non-linear residential loads (see Fig.3). The experimentally developed harmonic spectrums of several home appliances are implemented for the simulation of a typical UK distribution system using Electrical Transient Analyzer Program (ETAP) [6].

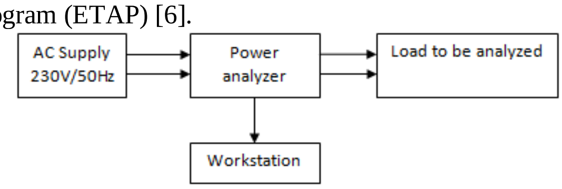

Fig.3 Analysing harmonic distorsion in distribution system

Thousands of compact fluorescent lamps are manufacture by manufacturing companies of CFL, so it is not feasible them to check all quality parameters of each CFL by using power analyzer. At present they are doing testing at sampling basis because of which too many bugs in circuit gets transfer from different stages of manufacturing and also testing of this sample CFL is very tricky. It requires technically sound and very train operator to record all the quality parameters of it.

Instead of testing quality parameters of each CFL, manufacture do hundred percent checking of only electronic ballast drives the corresponding load or not. They give input 230v/50Hz supply to electronic ballast and check its output drives corresponding load or not.

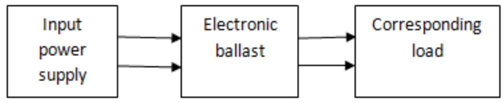

Fig.4 Present system

Power quality parameters recoreded using present system on the sampling basis.recorded parametrs for 15Watt electronic ballast are as follows(see Table I).

TABLE I. RECORDED PARAMETERS FOR 15WATT ELECTRONIC BALLAST

Parameters	Ratings	Practical Recordings
Input voltage	230V+/-10%	230.1V
Input Current	75mA(Max)	0.064A
Operating frequency	43.5+/-5% KHz	42.98Khz
Power Factor	0.85	0.946
Total Current THD	<40%	31.9%
Lamp power	11.8+/-10?%Watt	12Watt
Lamp voltage	78.8V+/-10%	73.4V
Lamp current	0.166A+/-10%	0.176A

III. SYSTEM DESGIN

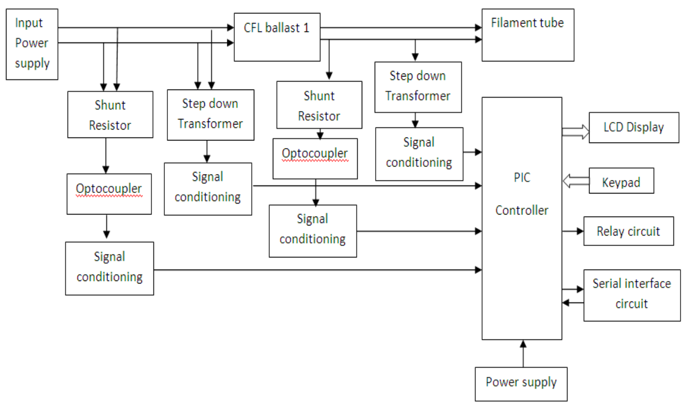

Fig. 5 Block diagram of proposed system

Figure shows the basic hardware block diagram of the automatic ballast tester Reference Design. The hardware includes the dsPIC33F, current and voltage sensors, analog signal conditioning using op-amp, UART interface to PC, power supply circuits, LCD for displaying measured parameters and keyboard for user interface.

Electronic ballast is powered by ac supply 230v/50Hz.To sense the input and output voltage we are using voltage step down transformer. Output from step down transformer requires signal condition so that it can feed to ADC channels of microcontroller. As the input current supply to electronic ballast is very small which is in miliampere, so we are using shunt resistor to sense the input current. Similar to voltage input signal, input current also requires signal conditioning.RMS values of input and output current and voltage is calculated by microcontroller. Zero crossing detectors is used to detect power factor between current and voltage. From the recorded RMS values of input signal and power factor, active power, reactive power efficiency is calculated.THD is obtained from number of harmonics present other than fundamental frequency component. All these calculated parameters are transferred to PC through serial interface. Recorded parameters are display on LCD screen. Keyboard is used as user interface so as to enter the reference data of all models and also to select specific model which user wants to check. Recorded parameters of specific model which is under test by microcontroller are compared with the reference data store in the PC , if all readings are within tolerance with the reference data then "PASS" results displayed on LCD else "FAIL" displayed in LCD screen.

Features of proposed system

- Very fast - low cycle time
- No special skill required
- Human error free
- Computerized documentation
- High accuracy
- Very high reliability
- Economic

A. *Microcontroller*

High performance, 16 bit digital signal controller dsPIC33F is main block of proposed system. It has modified Harvard architecture with 16bit timer/counters. Its Flash program memory is up to 128 Kbytes and Data SRAM up to 16 Kbytes.ADC is 10-bit, 1.1 Msps or 12-bit having 500 Ksps conversion. It also has a 4wire SPI (Supports 8-bit and 16-bit data), Full Multi-Master Slave mode I2C, UART port (up to two modules).It permits real time sampling of current and voltage signal sampling and all power quality parameters measurements. It drives, control and monitor all peripheral circuitry.

B. *Signal conditioning circuit for voltage*

Voltage input signal is sense by voltage step down transformer 220/5v then this signal is pass through the voltage divider circuit so as to avoid the saturation of an op amp. To adjust the gain of an input signal inverting amplifier is used. Output of signal conditioning circuit is fed to RA0 channel of ADC for sampling of input signal.

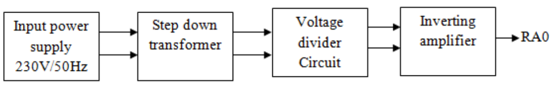

Fig. 6 Signal conditioning circuit for voltage

C. *Signal conditioning circuit for current*

Input current of electronic ballast is in milliamps so we used shunt resistor to sense the input current. Then optocoupler is used to separate input and output signal. Similar to voltage signal conditioning input current signal also needs signal conditioning to adjust gain. Then this signal is passing to RA1 of ADC for further processing.

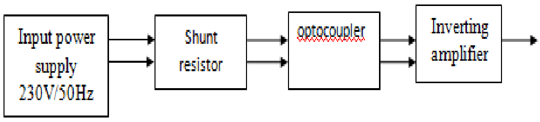

Fig. 7 Signal conditioning circuit for current

D. *Relay circuit*

Relay circuit is used for the selection of the targeted device. The relay circuit allow the isolation of two different sections of a system with two different voltage sources i.e., a small amount of voltage/current on one side can handle a large amount of voltage/current on the other side with assurance of no chance of mix up of these two voltages.

The relays are interfaced with microcontroller using their respective drivers which are used for current amplification. The output current of µc (500mA) is amplified to 600mA at the output of the drivers. Thus the driver for relay is ULN2004. This is simply a 16 pin chip that contains 7 Darlington transistors. The "chip" also contains internal back EMF suppression diodes and so no external 1N4001 diodes are required.

E. *User interface*

Keyboard and LCD driver is provided for easy user interface. All the different types of models which are user want to check with its reference power quality parameters are enter in the system using keyboard. Keyboard will be also necessary in case of user wants any modifications in the present system. All the measured parameters are displayed on LCD screen. It is consist of two lines with 16 characters each.

F. *Algorithm of propsed system*

To record all power quality parameters required steps to follow in the proposed system are as follows.

Step1: Select the targeted model.
Step2: Give the supply to first electronic ballast.
Step3: Convert the input signal into square wave to find out zero crossing.
Step4: When high to low edge of square wave is detected start the sampling.
Step5: Check for next high to low pulse if it detected stop the sampling, else continue till next high to low pulse.
Step6: Square the each value of sample.
Step7: Add the all squared value of samples.
Step8: Divide it by number of sample to find average value.
Step9: Take the square root of average value.

Step10: Store the RMS values of input/output for further calculation.
Step11: Calculate active and reactive power from RMS values.
Step12: Calculate power factor as it is as the ratio of active power to apparent power.
Step13: Calculate the operating frequency.
Step14: Calculate total harmonic distortion.
Step15: Calculate the efficiency as it is proportion of all energy dissipated in the circuit that is dissipated in the load.
Step16: Transfer all the power quality parameters to PC through serial interface.
Step17: Compare the recorded parameters with reference parameters stored in the PC.
Step18: Display the results.
Step19: Select next unit of ballast using relay circuit.
Step20: Repeat step 2 to 18.
Step21: Stop.

IV. SOFTWARE IMPLEMENTAION

Analog part of circuit simulated in proteus software. Proteus is best simulation software for various designs with microcontroller. It is mainly popular because of availability of almost all microcontrollers in it. So it is a handy tool to test programs and embedded designs. We can simulate your programming of microcontroller in Proteus Simulation Software. We are simulating only analog part of circuit in Proteus. Zero crossing detector output is given channel A of digital oscilloscope, so we are getting square wave at output. Output of inverting amplifier for current is given to the channel B we are getting amplified current waveform and Output of inverting amplifier for current is given to the channel C we are getting amplified voltage waveform.

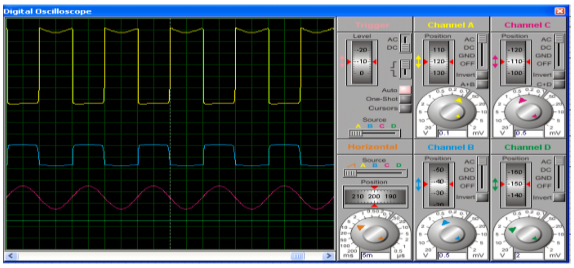

Fig.8 Simulation of analog circuit

Software MPLAB C30 will be use as compiler and debugging tool. It provides platform for developing C code. MPLAB C30 compiles C source files, producing assembly language files. These compiler-generated files are assembled and linked with other object files and libraries to produce the final application program in executable COFF or ELF file format. The COFF or ELF file can be loaded into the MPLAB IDE, where it can be tested and debugged, or the conversion utility can be used to convert the COFF or ELF file to Intel® hex format, suitable for loading into the device programmer.

V. CONCLUSION

Power quality parameters are critical factors in all types of lighting systems. In order to avoid injections of harmonic components in the electrical network there is need of high speed automatic ballast tester. In this tester there is provision to define the model which user wants to test and can wide variety of model. It will possible for small and large manufactures to test each unit of electronic ballast and maintain their standard in the market as well as avoid the passing of faults carrying ballast in different stages of manufacturing. It provides cost effective solution with communication facility. It reduces the testing time of ballast by reducing number of connection and increasing the number of testing units at time. The proposed tester gives high accuracy, stable performance, gives fool proof results and it is easy to operate as it can be possible to handle by nontechnical person. Its software based design gives easy up gradation of system.

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