HARMONIC REDUCTION AND POWER FACTOR IMPROVEMENT IN UPS

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Abstract – *Uninterruptible power supply, also uninterruptible power source UPS or battery/flywheel backup, is an electrical apparatus that provides emergency power to a load when the input power source, typically mains power, fails. This project presents an approach to minimize the harmonics contained in the output of a UPS. Proposed system considerably reduces the harmonics in the system by means of filter networks introduced in the system. An LC low pass filter is used which blocks the harmonics and undeniably passes almost sinusoidal output at the output terminal. Power Factor can also be improved almost near to unity with the help of shunt capacitors. This system helps to improve the electrical supply quality and hence increase the efficiency of the system. Thus the proposed system is a more efficient one and can reduce the load requirement of the user.*

***Key Words*: UPS, Harmonics, Power factor, Filter, Shunt capacitors**

1.INTRODUCTION

Upto the 1960s most of the electric loads were linear loads, in other words, the current flowing through the appliances was a perfect sine wave also. These appliance include induction motors, domestic lighting stoves and most other household appliances. With the advent of modern electronics, appliances became non-linear in the way they drew current through the mains electricity supply. The variable frequency drives and UPS systems are a major source of harmonics being injected into the electrical system and without proper protection, these harmonics can affect other parts of the plant and even the grid. Increasing demand for electrical energy by utilities has necessitated efficient utilization of available power. Most of the loads in the industry and domestic applications are inductive in nature causing a lagging power factor. This causes a reduction in the utilization of the power input. For the same power input the utilization can be improved by improving the power factor. Further the presence of harmonics results in poor quality of the power leading to losses. In present days, solid state electronics control electric motors are frequently used for drive control (speed and torque). This can introduce harmonics in current and voltages. The general opinion among technologists is that improvement in power factor reduces losses in an electrical system. Although this is true in a general way, it is not so in systems which use switched electronic devices that can introduce large amount of harmonics.

1.1 Concept of Harmonics

Harmonics have existed for many years in the power lines of plants and factories. However only over the last decade they have turned into a major problem to normal operations. This is largely due to the proliferation of harmonic producing equipment and the increased sensitivity of certain types of equipment to harmonics. The effects of harmonics can often be serious - computer systems may fail to operate properly. The presence of harmonics increases losses in the system. Harmonics are distortions to the voltage and current waveforms from their normal sinusoidal shape. At the power generating stations, a 50 Hertz (Hz) sine wave is generated and distributed to a large number of residential and industrial loads. Certain types of loads distort the 50Hz wave by injecting additional signals of various magnitudes and frequencies. These additional signals are also sinusoidal in shape but their frequencies are multiples of the original waves for example, 150, 250 and 350Hz. These waves are called harmonics. The frequency of the power systems parameter voltage and current waves are called the fundamental, which in our case is 50Hz. Harmonics are expressed as integral multiples of fundamental frequency i.e., 2nd, 3rd , 4th 5th etc orders. An important feature of harmonics is that the magnitude of the harmonics normally decreases with increasing frequency. Thus, only the first few orders usually need to be considered in examining the effects of harmonics on power system components or equipment.

1.2 Concept of Power Factor

Power factor is simply a name given to the ratio of actual power (active power) being used in a circuit, expressed in watts or more commonly kilowatts (kW), to the power which is apparently being drawn from the mains, expressed in volt-ampere or more commonly kilo volt-ampere(kVA). Causes overloaded generators, transformers and distribution lines within a plant, resulting in greater voltage drops and power losses, all representing waste, inefficiency and needless wear and tear on industrial electrical equipment. Reduces load handling capability of the plants electrical system. Increased authorities cost since more current has to be transmitted, and this cost is directly billed to consumers on maximum demand kVA systems. Most electrical supply authorities have changed to kVA demand systems from the inefficient kW demand system. Consumers are now billed and penalised for their inefficient systems according to the apparent power being used. In future, consumers will be penalised for plants with power factor below a pre-determined value.

2. PROPOSED SYSTEM

The block diagram of the system includes current transformer, potential transformer, relays, LC filters, capacitors, battery, inverter and microcontroller.

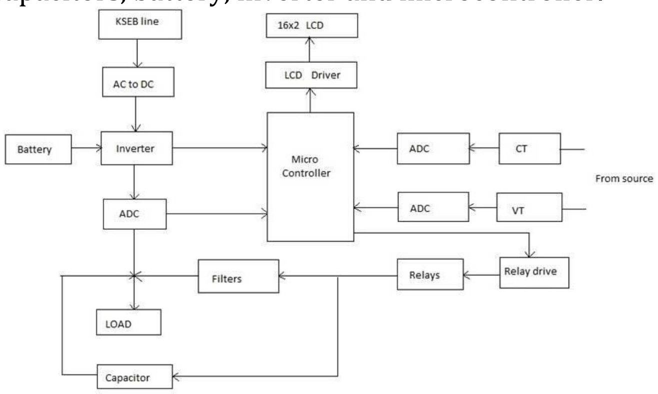

Fig -1: Block diagram of proposed system

Here we use ATMEGA32 as the microcontroller. The whole section can be divided into two main sections, Zero crossing detection section for power factor improvement and harmonic reduction section. For zero crossing detection a current transformer and a voltage transformer is used. If there is any correction in power factor is required, capacitors will be automatically added to the circuit using SPDT relays. Likewise if harmonics are present in the output of inverters, LC filters are added to the circuit using relays.

2.1 Inverter

The inverter circuit is the main part of the project. The circuit drawn in PROTEUS software is shown in figure 2

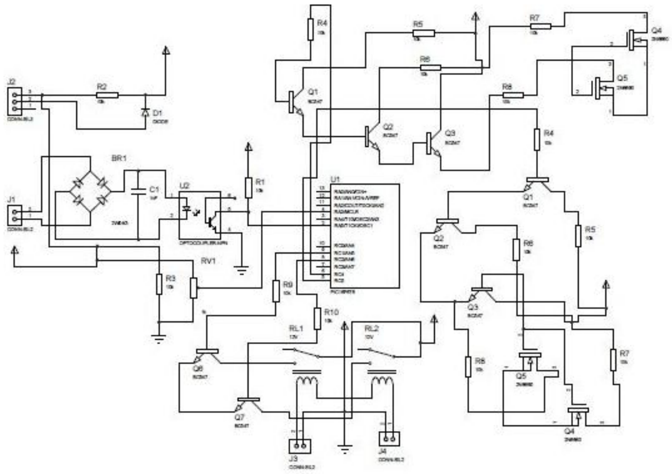

Fig -2: Inverter circuit

DC voltage from a battery converts into AC voltage by an oscillator, but it provides low current. So power switching such as power transistors or power MOSFET has to be used. In this inverter circuit two MOSFETs are used, where only one can conduct at a time. The gate triggering of a single MOSFET is given through the base of three NPN and one PNP transistors. The switching speed is controlled by a PIC microcontroller. The PIC microcontroller has a very high operating frequency when compared to Atmega32, that is why it is used in inverter circuit. When the MOSFET Q4 is on, the current flows through the transformer primary coil in one direction and when the MOSFET Q5 is on, the current flows through the same coil in reverse direction, which causes electromagnetic induction and so transformer action takes place.

3.HARDWARE IMPLEMENTATION

3.1 Flow Chart

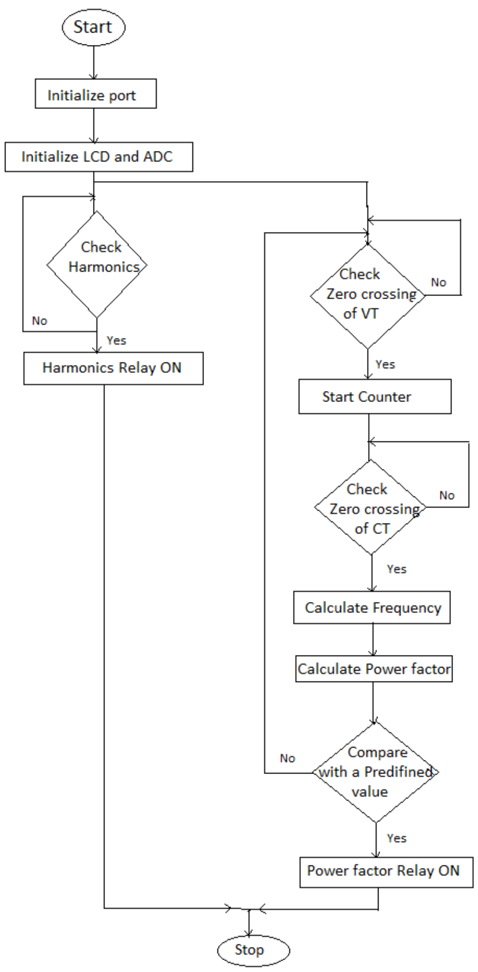

Fig -3: Flow Chart

Once the hardware is completed, software required for its effective working has to be implemented. For that, the microcontroller is programmed using AVR studio and the flowchart of the program is shown below. At first, initialise all the ports and display the project name. For harmonics reduction, the output of the inverter is monitored continuously. For filtering out the harmonics in the inverter output, it is passed through an inductor load. A relay is operated which will include the inductor unit to the output. Another relay operation is involved in the correction of power factor. VT and CT values are monitored continuously. At first the instant at which VT reading becomes zero is noted. A counter starts and the time upto which the CT value also becomes zero is found. The microcontroller is so programmed to convert the counted time into frequency value. Then the value of power factor of the line is calculated by suitable equations. For low power factor values the microcontroller is programmed to include the capacitor to the input line by means of a relay mechanism.

3.2 - : Project Hardware

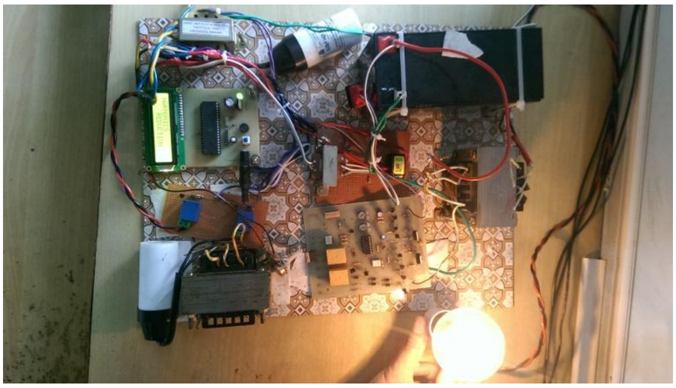

Fig -4: Experimental Setup

Project is fully completed by combining the software and hardware part. Thus the proposed project was designed as shown above. The inverter circuit and control unit are separately made on two different PCB boards. A dc source ie;12V battery is given to operate the inverter. The current transformer and potential transformer are wired on the board and their values are monitored by the microcontroller. Two relay units are present in the hardware. One is for including the capacitor for power factor improvement and the other one for including the filter circuit to reduce the harmonics in the inverter output. An LCD unit giving different display is also part of the hardware.

4. CONCLUSION

Proposed system considerably reduces the harmonics in the system by means of filter networks introduced in the system. The use of appropriate filters with the circuit at output and input results in reduction of Total Harmonic Reduction in input current. Power Factor can also be improved almost near to unity with the help of Shunt capacitors. Thus the proposed system is a more efficient one and can reduce the load requirement of the user. The effects of harmonics is often serious and especially in medical applications, aircrafts etc, these disturbances are be taken into concern lot. The addition of filter circuit is a cost effective method to reduce the harmonics.

Improvement of power factor makes the utility companies get rid from the power losses while the consumers are free from low power factor penalty charges. By installing suitably sized power capacitors into the circuit the Power Factor is improved and the value becomes nearer to 0.9 to 0.95, thus, capacitor banks used for power factor correction reduce losses and increases the efficiency of the power system and also increases stability. By using this system the efficiency is highly increased.

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