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# Design and Implementation of Low Power Devices Using Embedded System

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**ABSTRACT**

**Electric appliances consume electricity when they are in standby mode and sometimes even in off-mode. These "losses" of each appliance individually are not large but the sum over all appliances is no longer negligible. The standby losses of ten households are investigated. The standby power varies from 7 to 134 W and has an average of 40 W. The standby consumption is on average 274 kWh/year, representing 8% of the yearly consumption of an average household. With the 1-Watt plan, it is possible to reduce the standby losses to a significantly lower level. This project deals with a microwave oven, which consumes standby power of 3mW is reduced where a low standby power achieved. The microwave oven power consumptions monitored and it is connected to the analog input of the microcontroller. In this simulation we connected the Trim pot for adjusting the current input to the microcontroller. Current consumption goes below 3W the microcontroller turns off the relay. Then the microwave oven power shuts off.**

*Keywords*—Electric Appliances, Reduce Power, Power Consumption, Microwave

## I. INTRODUCTION

In most of the home appliances the standby power prevails in the circuit even when they are turned off/plugging state or in offstage. It is noticed that an electrical appliances consumes a power of 1to3W in its plugging mode or connected to a socket. This power is to be reduced, as the electrical appliance consumes about 10%of household total power. In this project a circuit is designed and implemented into any electrical appliances to reduce this standby power. The project deals with a microwave oven, which consumes standby power of 3mW is reduced where a low standby power achieved. The microwave oven power consumption is monitored and it is connected to the analog input of the microcontroller. In this simulation we connected the Trim pot for adjusting the current input to the microcontroller. Current consumption goes below 3W the microcontroller turns off the relay. Then the microwave oven power shuts off.

The door switch output signal is connected to the input of the MCU. If the door is opened, the MCU wakes up from its sleep mode and turns on the relay. So the microwave oven power switched on, thus enabling the oven and allowing the user to set the control panel. The keypad output is also connected to the input of the MCU. If the keypad is pressed, the oven power is switched on. This variation in its operating mode is indicated by the LED design circuit. Its power consumption and the implement results are compared and explained below. The circuit designed for low standby power consumption can be implemented in any of the future electrical appliances due to its low cost ,simple design and its flexibility.

## II. METHODOLOGY

In the proposed system, reduce the standby power consumption of a Microwave oven and the calculation of standby power consumption for various domestic appliances are performed. And this variation in the power stages is indicated by the LED indicator. This can be implemented by using the current sensor, switching circuit and limiting circuit.

The current sensor senses the current which is passing through the wire and if it is not necessary and it will be automatically switch off through the switching circuit. By using this proposed system power consumption will be reduced to great extend so that, the human effect also been reduced.

In general the touch panel microwave oven is plugged in to an ac power source. The standby power consumed by the oven is obtained by the ac/dc converter. The main concept of our design is that if there is no one using the microwave oven it should be completely cut off so it won't use any unnecessary power. All ac power can be turned off completely by means of a latching relay. If one wants to use the microwave oven, the ac power source is connected again. Our first action is to open the door, then to place food on the turntable and close the door, after which the control panel setting is done. So the first action of a user is opening the door. By just detecting whether the door is open or not the microwave oven would "know" if the user wants to use it or not.

If the door is not opened, it is not being used and thus the ac source power should be completely cut-off by the latching relay, thus reducing the standby power to zero. The output voltage of the ac/dc converter is denoted as $V_{DC}$, the ultra-capacitor (UC) voltage as $V_{UC}$, and the output voltage of the boost circuit as VCC.

The $V_{DC}$ is the UC charge source, and the $V_{UC}$ is the input of the boost circuit. The VCC is the required operation voltage that supports the MCU and the operation of other modules. In this design, a door switch module, a dc voltage module, a start button module, a MCU, an UC and a latching relay are used to reduce the standby power.

The door switch module detects the opening of the door. When the door is opened the operations like the display, the oven light, the keypad and a sound indicating that the oven is working are turned on, and if the door is not opened the operation functions are turned off as if the microwave oven were unplugged. The dc voltage module is designed to reduce the standby power consumption, the manufacturing cost and the volume size of the ac/dc converter. The start button module is designed to charge the dc voltage module when the oven is initialized.

***Standby Power & its Necessity***

Most experts agree that standby power is electricity used by appliances and equipment while they are switched off or not performing their primary function. That power is consumed by power supplies (the black cubes—sometimes called "vampires"—converting AC into DC), the circuits and sensors needed to receive a remote signal, soft keypads and displays including miscellaneous LED status lights. Standby power use is also caused by circuits that continue to be energized even when the device is "off".

That definition is attractive to a lay person but inadequate for technical purposes. An international technical standards committee is developing a definition and test procedure.

Almost any product with an external power supply, remote control, continuous display (including an LED), or charges batteries will draw power continuously. Sometimes there is no obvious sign of continuous power consumption and you need a meter to be certain.

TABLE 1

| **Microwave Ovens** | **Average (W)** | **Min (W)** | **Max (W)** | **Count** |
|---|---|---|---|---|
| Ready, door closed | 3.08 | 1.4 | 4.9 | 18 |
| Ready, door open | 25.79 | 1.6 | 39 | 17 |
| Cooking | 1433 | 966.2 | 1723 | 18 |

***Necessity of Standby Power***

Some times. Certain appliance functions do require small amounts of electricity include:

- Maintaining signal reception capability (for remote control, telephone or network signal)
- Monitoring temperature or other conditions (such as in a refrigerator)
- Powering an internal clock
- Battery charging
- Continuous display

Good design can make the power requirements for these functions very low (but not yet zero).

***Power Consumption of Standby Power***

Many new technologies can improve the efficiency of power supplies, manage power use more carefully, and limit power use of displays. We believe that it is technically feasible to reduce standby power by 75% overall. Most savings will be less than a watt, but other cases will be as large as 10 watts.

## III. BLOCK DIAGRAM

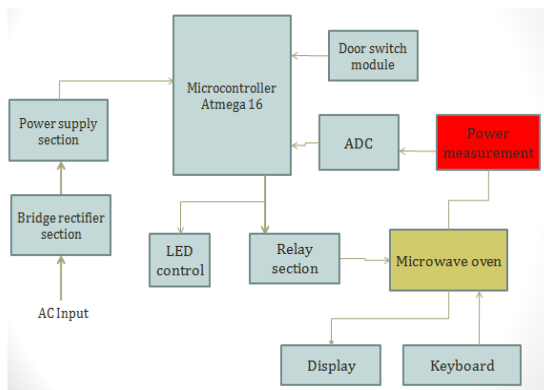



Fig.3.1: Block diagram for microwave oven Standby power consumption reduction

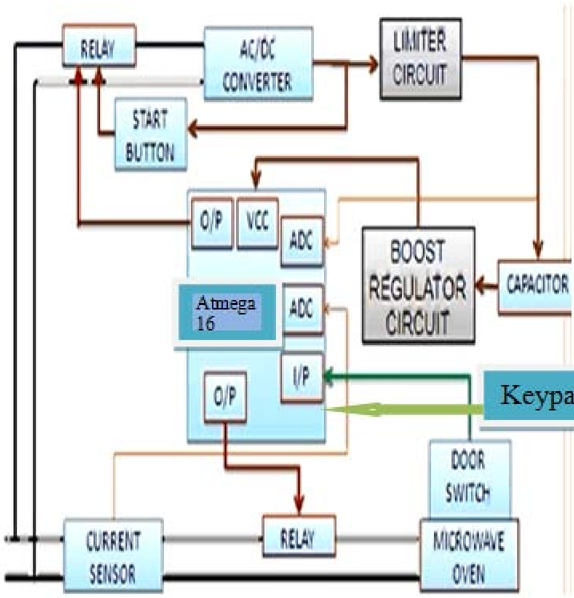



Fig.3.2 Block diagram for standby power consumption in microwave oven

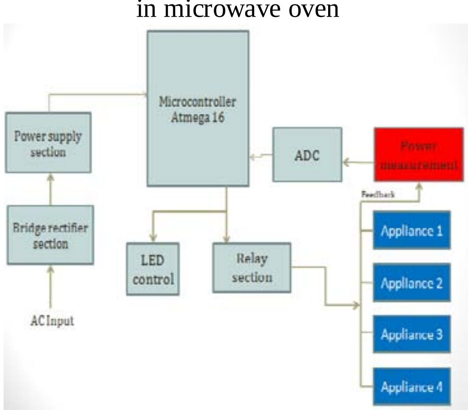
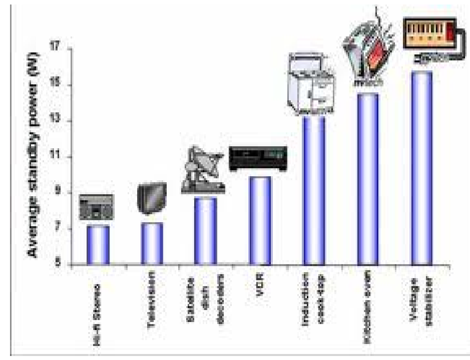



Fig.3.3 Block diagram for other electrical appliances standby power consumption reduction.

**Estimating standby power**

Standby power consumption can be estimated using tables of standby power used by typical devices, although standby power used by appliances of the same class vary extremely widely (for a CRT computer display standby power is listed at a minimum of 1.6 W, maximum 74.5 W). Total standby power can be estimated by measuring total house power with all devices standing by, and then disconnected, but this method is inaccurate and subject to large errors and uncertainties.




## IV. CIRCUIT DESIGN OF THE ULTRA-LOW STANDBYPOWER MICROWAVE OVEN

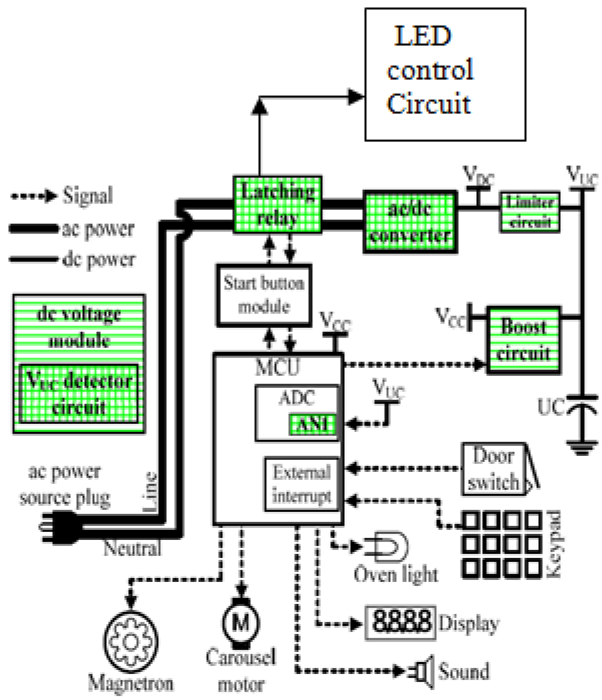



Fig 3.4 Circuit design for ultra low standby power Microwave oven

### *A.POWER SUPPLY*

In general the touch panel microwave oven is plugged in to an ac power source. The standby power consumed by the oven using ac/dc converter. The converter consists of a line frequency step-down transformer, a bridge diode and a buck regulator which together accommodate the loosely regulated secondary voltage, as depicted in the figure 3.5

The primary wirings of the transformer always cause power consumption to be many times more than the power used for the internal functions in the standby state.

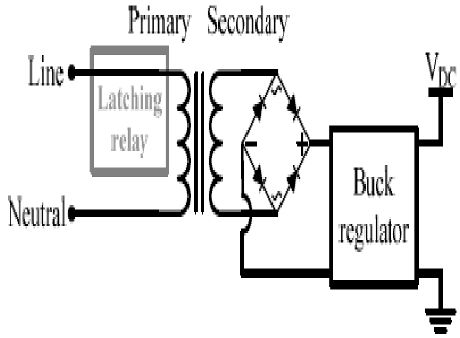



Fig. 3.5 Power Supply

In the secondary side the bridge rectifier and the buck regulator is which is connected to the VDC is used. Hence to reduce this standby power the converter must be turned off. The circuit needs an ac/dc converter to support the dc operation voltage VCC.

***Power shuts off***

Power Relay is connected in the PD2 pin of MCU. Power to the oven is connected through the relay COM, NO contacts. If power consumption goes below 4W, the microcontroller turns off the relay. Now the microwave oven power shuts off.

### *B. CURRENT SENSOR*

A current sensor is a device that detects electrical current (AC or DC) in a wire, and generates a signal proportional to it. The generated signal could be analog voltage /current or even digital output. It can be then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purpose. Microwave oven current consumption is monitored through the current sensor. And it is connected to the analog input (PA0) of the microcontroller.

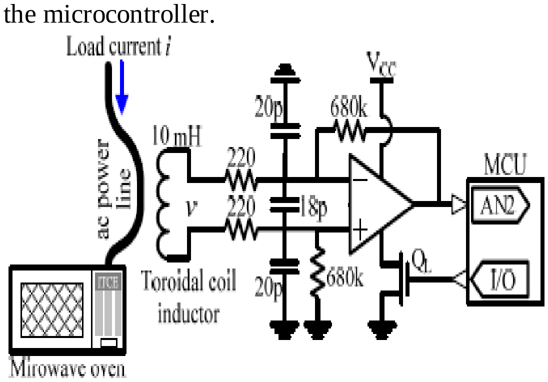



Fig.3.6 Load current sensor module circuit

The sensed current and the output signal can be:

*AC current input*

- analog output, which duplicates the wave shape of the sensed current
- bipolar output, which duplicates the wave shape of the sensed current
- unipolar output, which is proportional to the average or RMS value of the sensed current

*DC current input*

- unipolar, with a unipolar output, which duplicates the wave shape of the sensed current
- digital output, which switches when the sensed current exceeds a certain threshold.

### *C. AC/DC CONVERTER OR AC ADAPTER*

The AC adapter, AC/DC adapter or AC/DC converter is a type of the external power supply, often enclosed in a case similar to an AC plug. Other names include plug pack, plug-in adapter, adapter block, domestic mains adapter, line power adapter, wall wart, or power adapter. Adapters for battery-powered equipment may be described as chargers. AC adapters are used with electrical devices that require power but do not contain internal components to derive the required voltage and power from mains power. The internal circuitry of an external power supply is very similar to the design that would be used for a built-in or internal supply.

### D. LCD DISPLAY MODULE

A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock.

They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones, and have replaced cathode ray tube (CRT) displays in most applications. LCDs are, however, susceptible to image persistence.

The LCD screen is more energy efficient and can be disposed of more safely than a CRT. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically modulated optical device made up of any number of segments filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome.

## E. MICROWAVE OVEN

A microwave oven is a kitchen appliance that heats food by bombarding it with electromagnetic radiation in the microwave spectrum causing polarized molecules in the food to rotate and build up thermal energy in a process known as dielectric heating. Microwave ovens heat foods quickly and efficiently because excitation is fairly uniform in the outer 25–38 mm of a dense (high water content) food item; food is more evenly heated throughout (except in thick, dense objects) than generally occurs in other cooking techniques.

Microwave ovens are popular for reheating previously cooked foods and cooking vegetables. They are also useful for rapid heating of foods otherwise slowly prepared cooking items, such as hot butter, fatsand chocolate. Unlike conventional ovens, microwave ovens usually do not directly brown or caramelize food, since they rarely attain the necessary temperatures to produce Maillard reactions.

## *F. RELAY*

A relay is an electrically operating switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

## *G. DOOR SWITCH MODULE*

The door switch is set on the doorframe of the oven to sense when the door is open, as depicted below in the figure 3.7

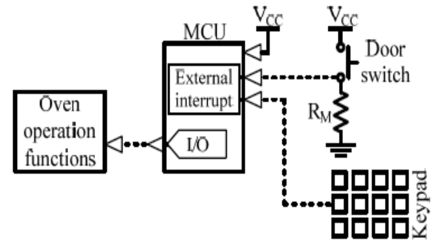



Fig 3.7 Door switch module

In the door switch output signal is connected to an external interrupt input of the MCU. If the door is opened, the MCU wakes up from its sleep mode and turns on the oven operation functions, thus enabling the oven and allowing the user to set the control panel. The delay from opening the door to the operation functions being turned on is less than 1msec, which the user never notices.

The door switch is a normal close (NC) switch. If the door is opened and the switch is turned on, the output signal is high; otherwise it is low. For convenience the keypad output is also connected to the interrupt input of the MCU. If the keypad is pressed, the oven is started. The power consumption of the module is presented. In addition to the touch panel microwave ovens,besides the three power states this design has one additional power state, the “enable state”, which enables the oven operation functions.Fig4.3 shows the state transition of the ultra-low standby power microwave oven.

Door switch signal is connected as an input to the MCU (PD3 pin). If the door is opened PD3 pin gets low signal and MCU switch on the Relay. Through the Relay Microwave oven gets AC power.

## *Key Pad*

Key press is also monitored. Key pad is connected in PORT A. If any one of the key is pressed the MCU Switch on the relay. So that microwave oven gets power.

The standby state in Fig. 3.8 means that if the microwave oven is not in use the ac power source is completely cut-off as if the unit had been unplugged.

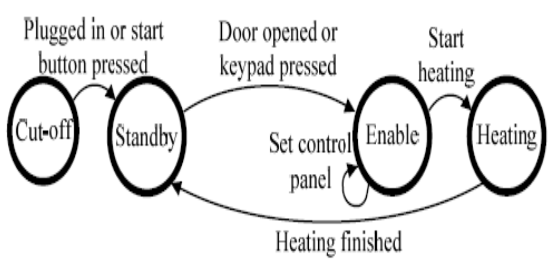



Fig 3.8 State transition of this design.

TABLE 2

**Power Consumption of Door Switch Module**

| Situation | Power (VCC=3.3 V) |
|---|---|
| Door closed, switch turned off and keypad not pressed, MCU in sleep mode, Oven operation functions turned off (Nobody wants to use it) | 3.3 V×0.4 µA =1.32 µW |
| Door opened, switch turned on or keypad pressed, MCU in active mode Oven operation functions turned on(User wants to use it)(The oven operation power is not included) | 3.3 V×4.9 µA =16.17 Mw |

## V. SOFTWARE IMPLEMENTATION

AVR Studio 6
ISIS Profession Release 7.7
The simulation is done through Proteus Software

### *5.1 PROTEUS SOFTWARE PACKAGE*

This package splits into three parts very conveniently namely: -

ISIS -Intelligent Schematic Input System - for drawing circuit diagrams etc.

ARES-Advanced Routing and Editing Software - for producing PCB layout drawings.

LISA -Labcenter Integrated Simulation Architecture - for simulation of circuit diagram. Separate handout.

### *5.2 ISIS PROFESSIONAL RELEASE*

Proteus is software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design. It is developed by Labcenter Electronics.

### *5.2.1 SYSTEM COMPONENTS*

- ISIS Schematic Capture - a tool for entering designs.
- PROSPICE Mixed mode SPICE simulation - industry standard SPICE3F5 simulator combined with a digital simulator.
- ARES PCB Layout - PCB design system with automatic component placer, rip-up and retry auto-router and interactive design rule checking.
- VSM - Virtual System Modelling lets cosimulate embedded software for popular micro-controllers alongside hardware design.
- System Benefits Integrated package with common user interface and fully context sensitive help.

### *5.3 AVR STUDIO*

Atmel® Studio6 is the integrated development platform(IDP) for developing and debugging Atmel ARM® Cortex™-M and Atmel AVR® microcontroller-(MCU-) based applications. The Atmel Studio 6 IDP gives seamless and easy-to-use environment to write, build and debug applications written in C/C++ or assembly code.

Atmel Studio 6 is free of charge and is integrated with the Atmel Software Framework (ASF)—a large library of free source code with 1,600 ARM and AVR project examples. ASF strengthens the IDP by providing, in the same environment, access to ready-to-use code that minimizes much of the low-level design required for projects. Use the IDP for wide variety of AVR and ARM Cortex-M processor-based MCUs, including broadened portfolio of Atmel SAM3 ARM Cortex-M3 and M4 Flash devices.

The Atmel Studio 6 IDP also:

- Facilitates reuse of existing software and, by doing so, enables design differentiation.
- Supports the product development process with easy access to integrated tools and software extensions through Atmel Gallery.

## VI. RESULTS

### *6.1 MICROWAVE OVEN OFF CONDITION*

In this project microwave oven Power consumption is monitored and it is connected to the analog input of the microcontroller. In this simulation we connected the Trimpot for adjusting the current input to the microcontroller. Current consumption goes below 3W the microcontroller turns off the relay. Then the microwave oven power shuts off relay. Then the microwave oven power shuts off.

### *6.2 MICROWAVE OVEN ON CONDITION*

The door switch output signal is connected to the input of the MCU. If the door is opened, the MCU wakes up from its sleep mode and turns on the relay. So the microwave oven power switched on, thus enabling the oven and allowing the user to set the control panel. The keypad output is also connected to the input of the MCU. If the keypad is pressed, the oven power is switched on.

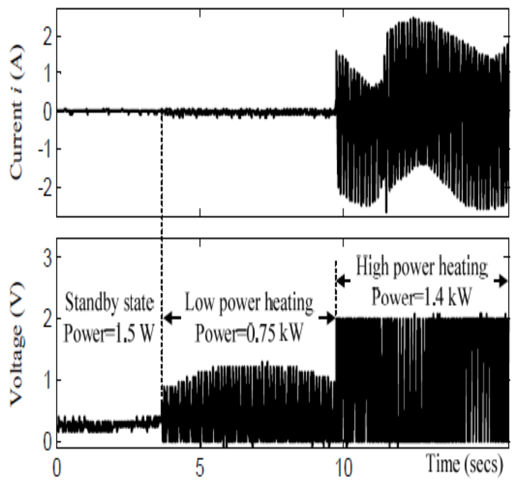
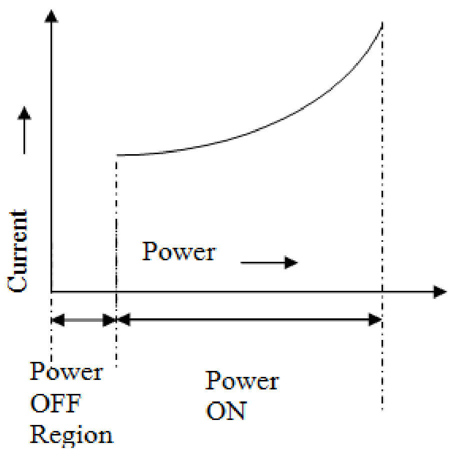



Fig6.2.Load current and output signal

**Power output signal**



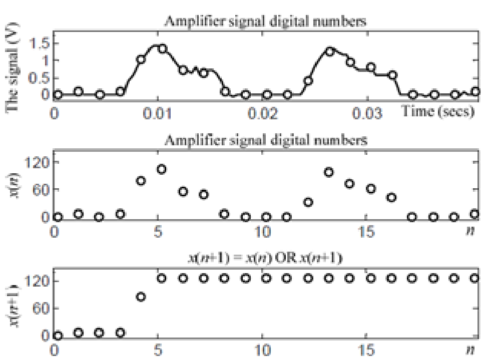
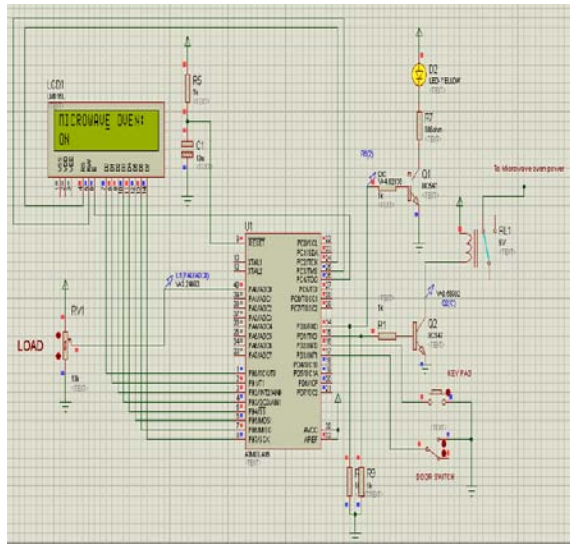




Fig6.3 Load current digital number procedure

# VI. SIMULATION IMPLEMENTATION

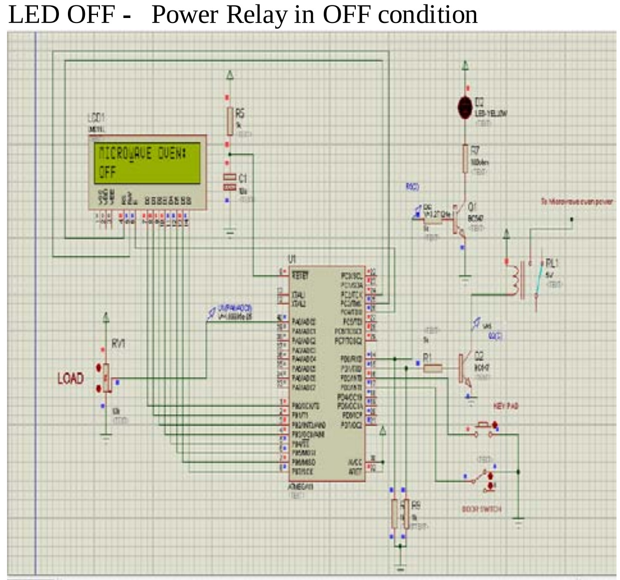
### 7.1 Microwave oven in ON condition:

LED ON - Power Relay in ON condition



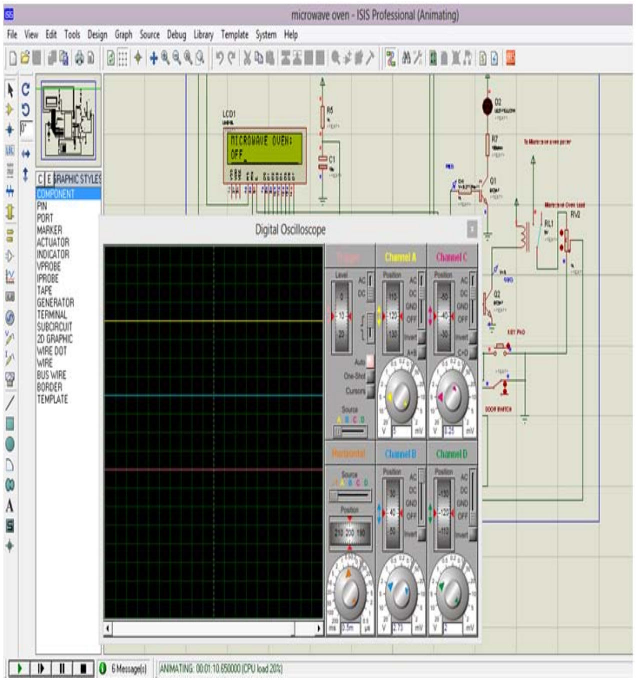

### 7.2 Microwave oven in OFF condition:

LED OFF - Power Relay in OFF condition

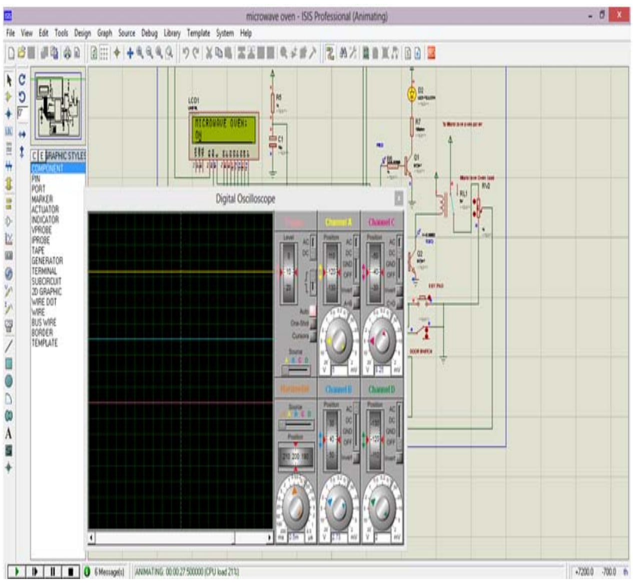


## VIII. SIMULATION RESULT

### 8.1 When Microwave Oven is in Standby mode




### 78.2 When Microwave Oven is in Power on Condition




## IX. CONCLUSION

This project proposes a new circuit design which substantially reduces the standby power to much less than that of other touch panel microwave ovens and also indicate the condition of the microwave oven. This new ultra-low standby power microwave oven, which consumes 3mW, is both easy to set up and inexpensive. In the long run this oven saves more power while at the same time the performance ofthe oven is unchanged. Furthermore, this design could be made into a socket and LED indication connected to the existing touch panel microwaveoven. Although the standby power of a touch panel microwave oven is not great, it not only affects the electricity bill in the long run, but because this power is converted into heat it also increases the indoor temperature. In some scenarios, the resulting heat places a greater load on the air conditioning system. Therefore, in reducing the standby power we reduce a further item of electricity cost as well.

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