ISSN (Print) : 2320 – 9798
ISSN (Online): 2320 – 9801

International Journal of Innovative Research in Computer and Communication Engineering
Vol. 1, Issue 4, June 2013

Design & Development of a Microcontroller Based “Environment Decontamination System Controller”

Shuchi Garg[1], Narang N. Kishor[2]

M.Tech Scholar, Dept. Of ECE, Suresh Gyan Vihar University, Jaipur, India[1]

Mentor & Principal Design Architect, NARNIX TECHNOLABS, New Delhi, India[2]

ABSTRACT: EDSC (Environment Decontamination System Controller) is essentially a “Programmable Timer” that is designed for deployment in Hospitals, Nursing Homes, Laboratories, Sanitoriums, or Buildings/Premises which need to be De-Contaminated frequently. The patients who come to hospitals have their immunity already at low level, so they are more susceptible to catching infections. Extensive & frequent cleaning and decontamination requires extra manpower and scheduling, which adds to the fusillade of hospital’s operation & maintenance work. It’s not easy to keep track of Environmental Decontamination of Operation Theatres, ICUs & other Critical Areas of the Hospitals. Thus, Automation of this crucial work without manual intervention from time to time is the feature that makes EDSC extremely useful. With EDSC, you can comprehensively automate Decontamination of the hospital’s environment by setting time slots of switching ON respective Machines for the whole week, at one go, making the EDS Controller, Highly Versatile and Crucial in Hospitals.

Keywords: Environment Decontamination, Programmable Timer, Microcontroller, Controller Design, Automation Controller, RF Communication.

I. INTRODUCTION

EDSC (Environment Decontamination System Controller) is a Programmable Timer. It can be configured to work individually in “Independent Mode” with one load connected thru it, and also in a ‘Master-Slave Configuration” in which One BOX works as a Master with up to Three Boxes as Slave Controllers being controlled by the Master thru RF Communication. When working in independent mode, the Controller does not need the RF Communication Module.

While working in master mode, it behaves as a lead manager with all the slaves devices connected (through RF Communication and controlled by it. All the connected devices are monitored and controlled, using RF communication module, by the Master Controller itself. While working in Slave mode, the Controller sends its current working status to the Controller, which is configured in Master mode via handshaking process of RF communication. The programming and monitoring of slave Controllers is done by the Master only.

For the independent mode, each box is monitored and programmed independently and there is no connection present between them in terms of communication whereas master-slave mode allows all the boxes to be interconnected via RF communication and monitored by a single box (Master). For the security point of view, the Controller is inbuilt with password options and prevents any unauthorized user to disturb its settings. Hence, it is safe, when comes to its installation in hospitals or equally sensitive areas. Additionally, the timer if required can be set to be switched on and off at particular intervals on the selected days or even daily. So the overhead of programming it daily for every time slot is also efficiently resolved.

II. BASIC FEATURES

A. *Features Incorporated*

It comprises of a low cost micro-controller, a power supply block, power protection circuitry, a storage device, a device that defines and describes the real time, a block to view & feed in the time settings and a device for displaying the settings. Also for the communication between all the 3 boxes, it uses a communication module.

B. *Features & Specification*

EDSC is a Programmable Timer. It can support controlling of up to 4 Loads/Machines/Equipments. All the loads should be AC loads. Each load can be programmed for 8 time settings per day for a complete week. The system can work in independent and remote mode. The maximum duration for which any load can be kept ON at a time, can be set is up to 999 minutes. The device has the capability of communicating with its sub-units (slave devices) in sub GHz RF

ISSN (Print) : 2320 – 9798
ISSN (Online): 2320 – 9801

International Journal of Innovative Research in Computer and Communication Engineering
Vol. 1, Issue 4, June 2013

Band (typically 867MHz) using a radio frequency module. In independent mode, the devices are exempted from communication whereas in remote (master-slave) mode, they communicate via x-modem protocol of RF module.

III. BLOCK DIAGRAM AND CIRCUIT DIAGRAM

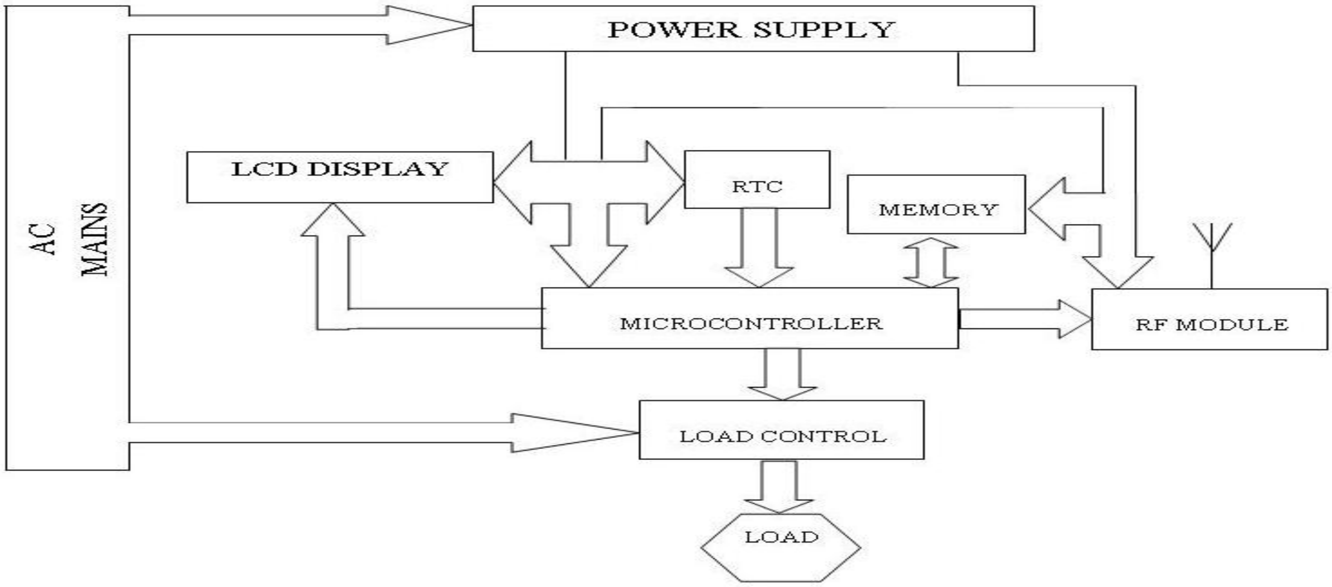

Fig.1 Block diagram for the EDSC system

It explains the flow of power and the connection of each block with other block. It also explains the flow of data. The block diagram also entails the circuit which will receive ac mains and the other receiving regulated supply. It also signifies the components that are directly controlled by microcontroller, hence defining the data and address busses.

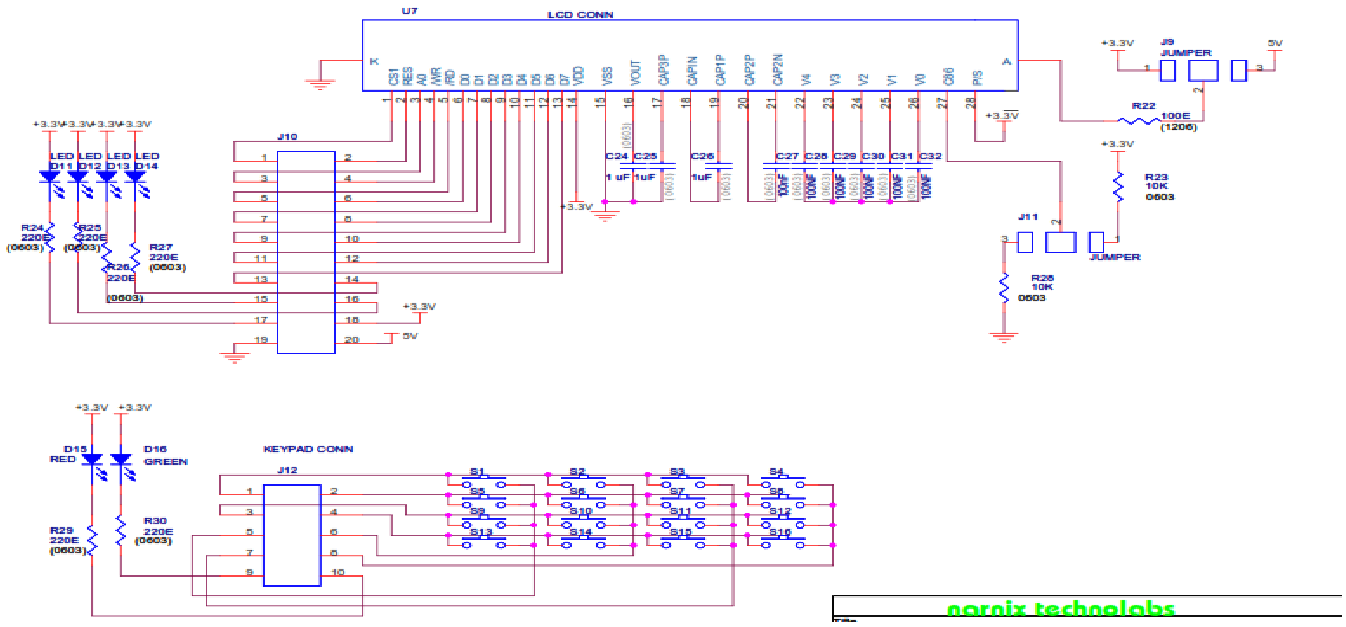

Fig.2 Display PCB schematic

This is the schematic for PCB-2 which shows the connection and placement of display components. The TIANMA LCD module ‘foot print is embedded along with connector, j10, to connect it to the main PCB. Jumpers (j11 and j9) , that are responsible for intensity control of backlight and display, are also shown. The keypad connector and footprints for mechanical switches are also connected, giving a complete schematic for display PCB

ISSN (Print) : 2320 – 9798
ISSN (Online): 2320 – 9801

International Journal of Innovative Research in Computer and Communication Engineering

Vol. 1, Issue 4, June 2013

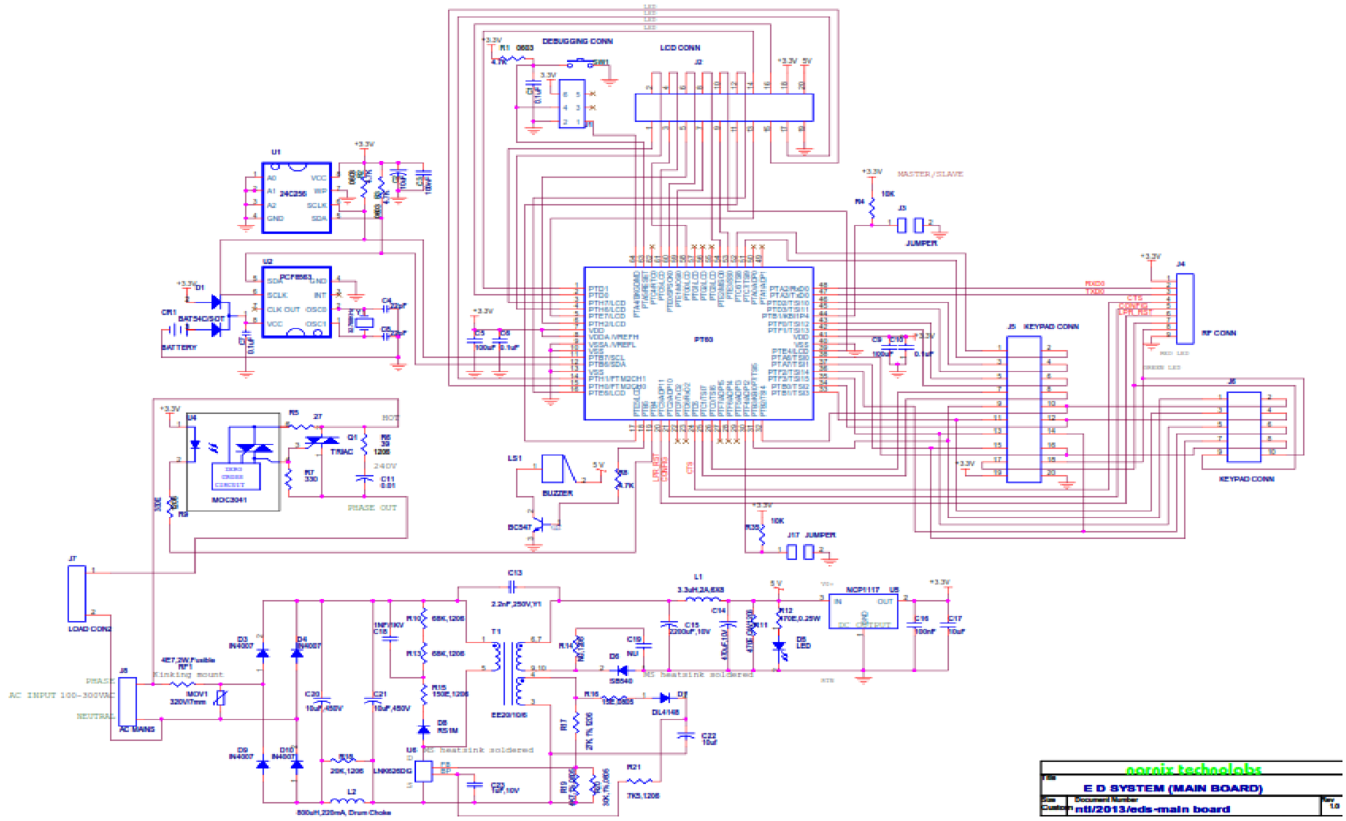

Fig.3 Main PCB schematic

This is the circuit for main PCB-1. It includes all the main components like microcontroller, memory, RTC, power section, TRIAC, LDO and all essential connectors. The connectors are connected with other present on PCB-2 and PCB-3 with the help of flat cables. This circuit shows how all the implementation of design is done. The block diagram of fig.1 is an overview of this schematic.

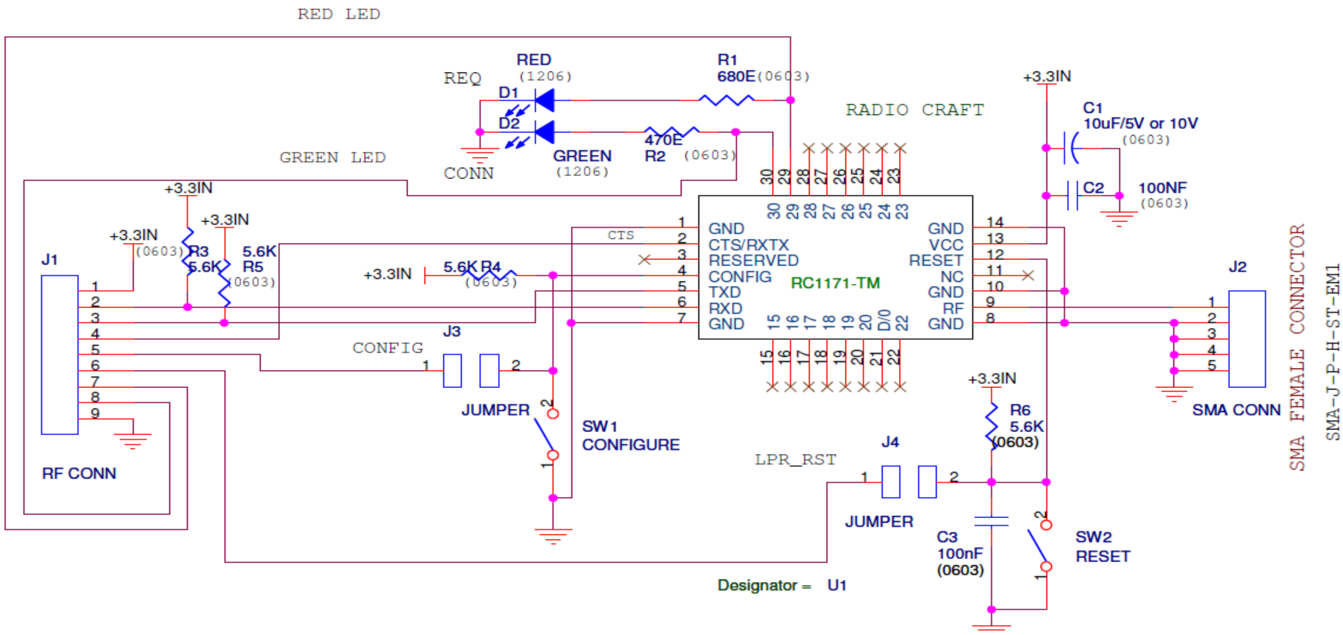

Fig.4 RF Module PCB schematic

This is the schematic for PCB-3. This shows how the wireless communication module (RC1171) is implemented in the design. It is responsible for the communication of EDSC in different modes. The SMA connector shown is for connecting the RF antenna. This PCB is connected with PCB-1 with connector J1 via flat cables.

IV. DESIGN METHODOLOGY

ISSN (Print) : 2320 – 9798
ISSN (Online): 2320 – 9801

International Journal of Innovative Research in Computer and Communication Engineering
Vol. 1, Issue 4, June 2013

The project was executed applying the "Water-fall" methodology. At each step of the Design Development, verification and validation was done. The preperation of Design document, Design specs and component selection executed after a Detailed & Comprehensive Market Research on various relevent aspects like: what older version of any such system are available in the market and the problems faced by the users of those systems, based on these inputs, preparing a "Market Requirement Specification" Document. Then, each and every aspect of the MRS Document was analysed for feasible options to achieve the requirements and address the prevailing problems in the existing systems, if any. Based on the conclusion of the research and analysis, each block of the system was designed based on availibility of components that could help realize the needed functions from the corresponding System Block. The detailed documentation was done to keep a track of what features are required and what could actually be implemented on practical grounds.

After this stage, the "Design Goal Specification" Document was prepared, which helped in developing the Schematic Diagram design, BOM preperation and arranging and procuring the needed components. In designing EDSC Schematic we have used ORCAD Capture-CIS tool from "CADENCE". The finalizing of Schematic comprises of all the necessary components, their respective footprints and part numbers to be embedded in the Diagram, followed by verification as per the respective DRCs (Design Rules Checks) and generation & Verification of Netlist. After this the Design was divided into Hardware and Firmware (Embedded Software) sections and executed by the respective design engineers accordingly. The hardware part and designing the logic of EDSC' Firmware/Software was my scope of study and not the Coding part. After the PCB's mechanical fitting and component Placement was finalised, it was sent for lay-outing and fabrication, which was again out of scope of my work. Then, the components were mounted on the PCBs and tested for hardware functioning and bugs, if any. Meanwhile the code was developed using the logics and flowcharts with the help of "CODE WARRIOR" the Integrated Development Environment from FREESCALE, because, we used an 8 bit MCU from FREESCALE. The Code was then built/compiled and debugged in the IDE and then ".s19" file (the Programming File) was generated and burnt into the microcontroller. The final system was then tested for functions and operations, as per the MRS Document. The design was comprehensively validated and optimized as per the features & specifications defined.

V. DESIGN AND IMPLEMENTATION

A. *Designing*

For EDSC, firstly the power consumption/supply was worked upon. As the different sections of EDSC require different operating voltage, so a low dropout was also incorporated with this section. Selecting switched mode over linear mode solved the objective of having an Efficient & Optimized Power Supply to Convert Input Mains AC to Low Voltage DC. The reasons for selecting switched mode are low power dissipation, smaller size of transformer and high efficiency. This makes it a popular active power supply used in embedded designing now days. Secondly the load control concern was addressed. So, an Opto-isolator device was identified and used. It is a device which blocks the unnecessary voltage to destroy the components of the circuit and takes the required input signal and converts it into light, with the help of an inbuilt photodiode, which is then further converted to output signal.

TRIAC's (triode for alternating current) are bidirectional devices. Because of the physics of the device they are best suited as AC switches. TRIACS belong to silicon controlled rectifiers (SCR) family and can be triggered by either a positive or negative supply of pulse at the gate terminal. To prevent the unwanted triggering of TRIACS snubbed circuit is used.

TRIACS along with Opto-isolator is a perfect combination to be used as the switch in order to control the switching of large AC powered devices. Opto-isolator is unidirectional and TRIAC being bidirectional complements each other in successful functioning of the device being connected to it as load or output. A real time clock is incorporated in the system using IC PCF8563[2] designated as U2. To continue keeping time even when the power is off, the RTC is supplied with an alternate battery CR2032. The RTC used here has a crystal oscillator Y, which oscillates at a frequency of 32.768 kHz and feeds the corresponding oscillations to the RTC Chip.

An EEPROM memory is used here for recording these time values .The EEPROM is microchip 24C256[3] designated as U2, has a maximum clock frequency of 400kHz.The serial data and serial clock data output of the I2C [14]Bus from the MCU is fed into the corresponding SDA and SCLK ports of the memory chip. A 3.3 V power supply is used to provide V_{cc} for the memory.

As the EDSC is essentially a programmable timer to control the 3 loads programmed for different time slots in a day for all the days of the week. So an RTC caters to this need of time keeping in the EDSC. The time slot data input by the user is calibrated with the RTC data and stored in the EEPROM memory. RF [13] module RC1171-TM is used here and a standard 3.3 v power source is provided to it. The RF module deployed works in the frequency range of 867.0-870.0 MHz

The main purpose of the RF [13] module in the Environment Decontamination System Controller is to provide an easy way of communication between the 3 Slave Loads Controllers using radio frequency regime. It works basically on

ISSN (Print) : 2320 – 9798
ISSN (Online): 2320 – 9801

International Journal of Innovative Research in Computer and Communication Engineering
Vol. 1, Issue 4, June 2013

the master-slave rule. The load settings are checked from the master settings and if they match then the system proceeds forward. There is also provision for editing these settings. In case there is an error in the communication system between the three loads then the RF module sends the signal to microcontroller and the corresponding "communication error" message is displayed on the display during a self-diagnostic test.

Next challenge was to select a controller, which besides being low in Cost, could also support the no. of features that were to be incorporated. So we considered taking the FREESCALE's 8bit microcontroller of low cost, high performance HCS08 family. All microcontrollers in the family use enhanced HCS08 central processor unit and are available with a variety of modules, memory sizes, types and packages. Out of all microcontrollers, the one matching our specifications and requirement was MC908PT60 [1]. The flash size of PT60 is 60K and the inbuilt memory (EEPROM) is of 256 bytes. The RAM includes 4096 of bytes. PT60 has bus frequency of 20MHz, which was fast enough to support RF communication feature and support the "PROGRAMMABLE TIMER" concept of EDS.

The display system used in the EDSC is basically a FSTN positive type LCD displays with white background colour and LED backlighting capable of 8 Bit parallel/SPI 4 data transfer. The TM12864A8CCWGWA[8], Graphics LCM unit designated as U7 consists of 128×64 dot-matrix LCD panel, LCD driver and controller LSI on a single IC. Incorporating display data RAM in the controller LSI, the unit can efficiently display under microprocessor control. It offers a Wide range of Operating temperature (-20 to 70 ºC). It is compliant with the Requirements on environmental protection: RoHS. The jumper J9 is used to control and monitor the intensity of backlight of the display. All the data and input signals from the main PCB are connected to the display using a connector J10. It is basically connected to the jumper J2 of the main PCB using flat cables. J10 feeds the data values into data bits namely D0 to D7 along with chip select input CS1, reset input RES, write signal (WR) and read signal (RD). A 3.3V power supply provides the required VDD to the display, various LCD driver supply voltages viz. V0 to V4 are supplied through capacitors C27 to C32.Now the master display provides easy input and display for providing various time related parameters. The main menu has options for selecting self-diagnostic test, setting mode and mode select.Setting mode offers options to change load settings, PIN settings, Set clock and reset settings. Load settings menu further provides the option of editing the load like loads name and time control of the load for various days of the week. Bypass mode settings can also be altered, the system factory settings can be restored and PIN changes can be made using the display and input panel keypad.

B. *Implementation*

The Hardware is divided into 3 parts or PCB's (fig 1):

- Main PCB consisting of Power supply, memory, RTC, Switches, Triac, Opto-isolator, SMPS, PT60 microcontroller
- Display and keyboard PCB with 6 LED's
- RF Module

We now adopt/follow a systematic approach to explain/ elaborate the various components of the system explaining their implementation in system.

- The power supply (fig. 3) is required to run the system at 3.3 V so the power supply section of EDSC is Switched Mode type. This power supply is designed to deliver 5V/2A output utilizing LNK626DG IC. The AC mains is rectified by the diode and converted to DC supply [5]. Next IC NCP1117 [5], which is a low dropout voltage regulator IC, is used to convert the 5V to required 3.3V. The net output voltage of 3.3V is supplied to the microcontroller, RTC, RF module; memory and LCD display [9].
- As the load is required to be switched according to different conditions so an Opto-coupler Triac Driver IC MOC3041 [4] is used a load driver integrated circuit. It drives the load along with TRIAC. IC MOC 3041 is an Opto-isolator acting as a Triac driver IC. It controls the switching of load thru the TRIAC.
- For Time keeping purposes pertaining to real time specification needs for different days of the week , A real time clock is incorporated in the system using IC PCF8563[2] and To continue keeping time even when the power is off, the RTC is supplied with an alternate battery CR2032.
- An EEPROM memory is used here for recording these time values .The EEPROM selected for this purpose is microchip 24C256[3].
- The problem statement states that the master and 3 slave units of the EDS system should interact and communicate among themselves and slave should only work on the master's command, So an RF module (fig. 4) RC1171-TM[7] is deployed which works in the frequency range of 867.0-870.0 MHz and Radio frequency antennas.
- An LCD display (fig. 2) system is required for displaying various menu functions such as load settings, time settings etc. The TM12864A8CCWGWA [8], Graphics LCM unit with 128×64 dot-matrix LCD panel is used for this purpose.
- A 64 pin 8 Bit microcontroller (fig. 1) MC9S08PT60 [1] is used in the system to regulate and control all the different components of the system. It provides the system with necessary computing power required. The

ISSN (Print) : 2320 – 9798
ISSN (Online): 2320 – 9801

International Journal of Innovative Research in Computer and Communication Engineering
Vol. 1, Issue 4, June 2013

main task of a microcontroller is to achieve and maintain the integrity between the various subsystems so that required goal can be achieved.

- A keypad System (fig. 2) is required for inputting the various parameters and performing different menu functions. This panel is provided on the second PCB under the display panel. It is basically a mechanical keypad with 16 tact switches.
- Small standard Buzzers (fig.1) are also provided to give a better sound feel to the user while using the system and pressing the keys on the keypad. Security is very essential in such systems as these are to be used in hospitals etc. So a PIN based security system is envisioned for the panel. An administrator PIN system is also provided for additional security and also there is a provision for changing these PIN's at will.
- In such systems a common problem encountered is the leakage of charge across the components of the circuit, which reduces the efficiency of the system. To combat this problem a 320V Metal Oxide Varistor (MOV) is incorporated in the main circuit. This is mainly for the extra voltage surge protection that happens within the circuit.

VI. FIRMWARE DESIGNING

A. *Software used*

The CADENCE' ORCAD Capture CIS and FREESCALE'Codewarrior IDE are the main software that were used during design and implementation of EDS.

Cadence Capture CIS is designing software for making schematics when the problem statement is finalized and documented. It enables us to draw a proper wiring diagram and circuit diagram of project. We can place all the electronic components already present in the CIS library. We can also make new parts and components as per our requirement and save it by updating the library. To beautify the project, option for color selection of text and their size points is also available. Page setup can also be customized as per the size of the schematic. The components can also be embedded with their footprints and complete part numbers. We can show/hide details of components which ever is required. Complete annotation of the schematic can also be done in either incremental or decremented order. The net list of the schematic can also be generated using CIS which is further used during verification of schematic at PCB lay outing step. The schematic can also be checked for design rules violation and errors, the errors are highlighted by the software itself. Finally the bill of material is also generated using Capture CIS which is an important document for monitoring the budget of the project and arranging and procuring the components of the schematic.

FREESCALE Code warrior is an Integrated Development Environment. It can create, build and debug the project. It has the ability to support all the FREESCALE microcontrollers starting from 8bit to 32bit. Its "PREPROCESSOR EXPERT" option enables the user to just understand the logic of software and implement it directly. It has two perspective of debug mode and c/c++ mode. The user can do the coding part in c/c++ mode and see the debug report in debug mode. IDE generates the complete error report. It gives the complete memory allocation and that used by variables and that which is free for use. We can navigate in to the coding by inserting breakpoints. We can check/ compile the code using these breakpoints which evaluates the code errors at steps defined by the user. Another software "PADS LAYOUT" from "MENTOR GRAPHICS" was also used for PCB lay outing process. The use of PADS LAYOUT is beyond the scope of this work.

ISSN (Print) : 2320 – 9798
ISSN (Online): 2320 – 9801

International Journal of Innovative Research in Computer and Communication Engineering
Vol. 1, Issue 4, June 2013

B. *Logic diagram*

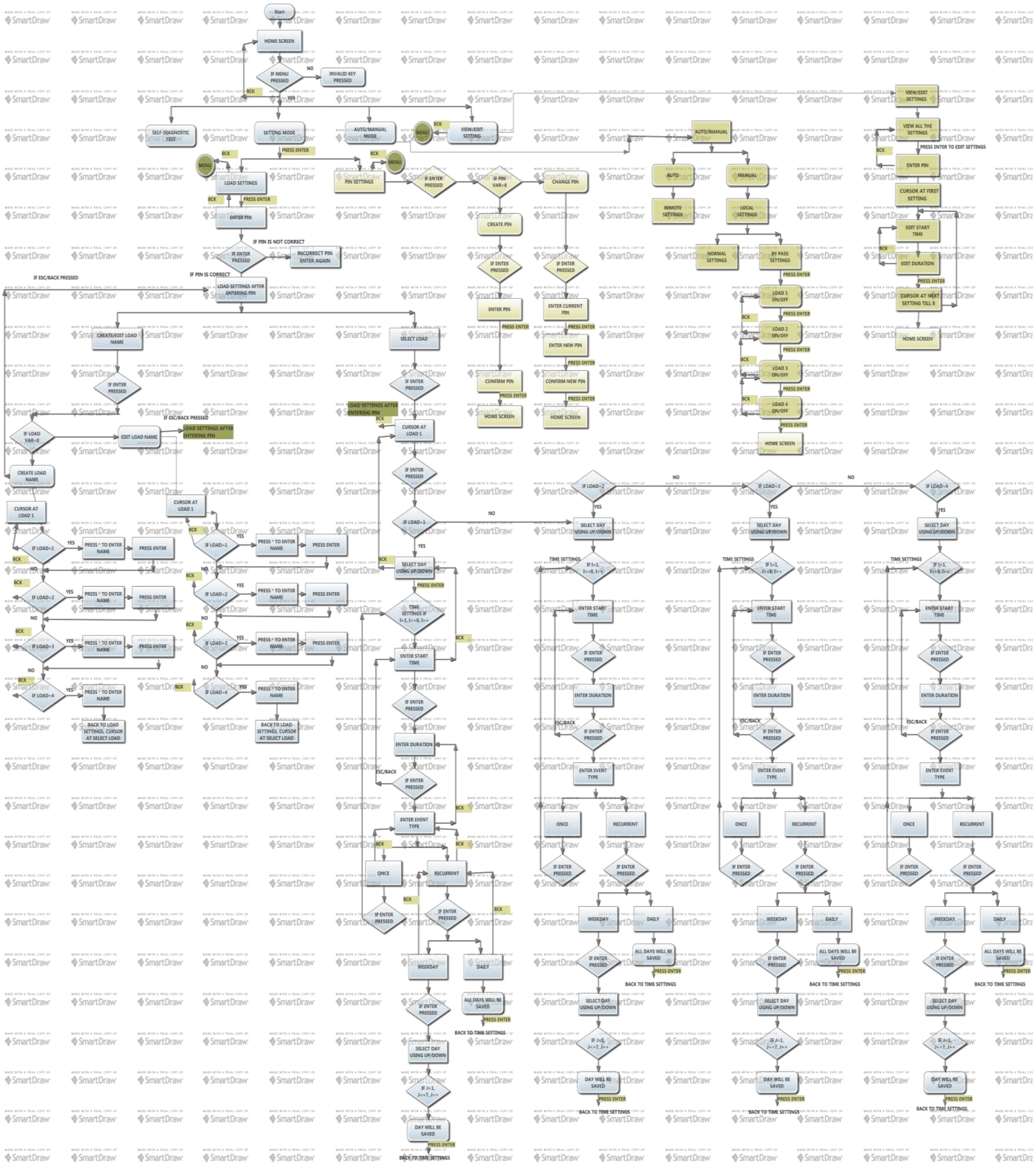

Fig.5 Logic Diagram of Firmware

This is the logic flow of EDSC. It represents how the firmware of EDSC is designed and functions. It includes the functions to be incorporated in the firmware and the sequence of their implementation

VII. Applications and Further Scope

The EDSC that was designed essentially as a “programmable timer” in master-slave configuration to communicate between master and slave low power RF signals.

- This programmable timer/ controller has unlimited application where it could be used to remotely automate any operation and control of any machinery or equipment in different application environments. This can be used in schools and colleges to automate bell ringing as per classes time scheduling.

- It could also be used in a home or a building to operate various lightning and appliances as per pre-configured weekly schedule.
- It can also be deployed in industrial environment to control the operation of different equipment and machinery in accordance with pre-programmed weekly schedule.
- It could be deployed in hotels and restaurant to remotely control the fumigation operation as well as spraying perfumed aerosols to enhance the guest experience with a soothing ambience.
- It could be deployed to automate the water boosting pumps in homes/hotels and in commercial and institutional areas.
- It could also be deployed in agricultural farms to automate the irrigational process by automating the operation tube wells as per pre-configured routines or schedules.

ACKNOWLEDGMENT

We take this opportunity to express our deepest gratitude and appreciation to all those who have helped us directly or indirectly towards the successful completion of this paper.

REFERENCES

1. Freescale semiconductor inc., mc9s08pt60, mc9s08pt60 reference manual (supports PT60 and PT32), document no. mc9s08pt60rm,rev.3, pg 1-666, 2012.
2. NXP semiconductors, real time clock/calendar, PCF8563 product datasheet, rev 10, 2012.
3. ATMEL/ST/MICROCHIP, CMOS Serial EEPROM,24AA256/24LC256/24FC256 datasheet, rev.1, 2007.
4. MOTOROLA Semiconductor, optoisolator TRIAC Driver output, MOC3041/D technical datasheet, rev. 1.3, 2000.
5. ON Semiconductor, Low Drop Out positive fixed and adjustable voltage regulators, NCP1117/NCV1117 datasheet, rev. 25, 2013.
6. Power Integrations, offline switcher, LNK626 link switch-cv family datasheet, ver1.5, 2007.
7. RADIOCRAFT embedded wireless solutions, rc11xx/25xx-tm datasheet, tiny mesh^{TM} RF transceiver module, rev1.35, pg 1-52,2012
8. Tianma microelectronics corporation ltd., tm12864a8ccwgwa datasheet, specifications for LCD module, v1.0,pg1-32, 2011
9. Power integrations, 10w enclosed adapter using lnk626dg, engineering report, rev.1.2,pg 1-29,2012
10. Mazidi Muhammad ali,Janice Gillispie, Rolin D. Mckinlay, 8051 real world interfacing, The 8051 Microcontroller and embedded systems, vol.2, pg 528-617, 2008
11. Wayne Wolf, High-Performance Embedded Computing: Architectures, Applications, and Methodologies, Computers as components; principles of embedded computing system design,vol.2, pg 213-389,2008
12. Fairchild Semiconductor, Schottky Diode, BAT54C/A/S datasheet, rev5.2, 2012.
13. Texas instrument, data file on RF basics, Advance technical conference on RF basics, 2006.
14. Texas Instrument, I2C Serial bus devices, I2C application note clip, rev 2.7,2004.