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# DESIGN, DEVELOPMENT AND PERFORMANCE EVALUATION OF LOW COST, LOW POWER INTERNET CONTROLLED HOME AUTOMATION SYSTEM (HASY) BASED ON 89C51CC03 - CAN NETWORKING MCU

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**ABSTRACT**

A home Automation System (HASY) automates the owner's house, triggers the events and keeps the watch on various routines involving light fixtures, security components and the heating or cooling the air-conditioning system. For example, when the owner enters the room, the sensor detects the user and automatically the home automation system turns on the home lighting system.

HASY controls a collection of "subsystems." Common subsystems include lighting, security, entertainment and heating or cooling the air conditioning systems. HASY uses one centralized controller along with one or more sub-systems. Hence with a single click, the owner can issue several command to different type of electronic components or products.

A smart home is an efficient way to monitor what is going on at house when the owner is away from home. This paper provides a way to program household appliances and track unwanted intruders from hampering security of home from remote distances. The present

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home automation product is costly enough. The cost varies from INR 50,000 to 2, 00,000. Due to high initial cost, the HASY is out of reach of many who really need it. Use of recent microcontroller can reduce the cost drastically while increasing its functionality manifolds. The severity of the accidents due to various home appliances can be reduced by the use of HASY.

## 1. INTRODUCTION

Home automation is needed heavily in almost every home due one or more of the following reasons,

### 1.1 Cost saving

Home owners, many times, forget to turn off the home appliances like television, fans, coolers, air conditioners, heaters, geysers, electric ovens, refrigerators and other electronic and electrical appliances. Even if a mobile charger is kept on in unloading condition for 8-10 hours, it consumes more power than small LED torch if kept on for two hours. Hence, keeping the electrical or electronics appliances turned on unnecessarily results in power wastage. The end user can lower utility bills by automatically turning the devices off when these devices are not intended to be used.

### 1.2 Convenience of operation

From remote places, the end user can monitor home appliances, which is especially useful for the handicapped persons or people who need to move from one place to another on daily basis.

### 1.3 Security

Home automation system can keep the trace of intruders and can place an automated call for help from nearby sources and protect the life and property of the end user from unwanted intruders, fire or any hazards. In case of an emergency, the end user can set an alarm and

also set some programs to take action automatically to decrease the damage caused by accidents to some extent.

## 2. HAYS EXISTING TECHNOLOGIES AVAILABLE

The various existing techniques for home control are discussed in this section.

### 2.1Remote Control

The remote control device makes use of the infrared signals which activate the sensors that are present on the control panel of the device under control. Upon activation, the appropriate programs are run for the adjustment of the parameter to be controlled. The basic limitation is that the control of the remote controllers can be exercised from small distances only and of no use when infrared signals are blocked due to some physical barrier.

### 2.2 X10 modules

X10 is a communication "language" that allows compatible products to talk to each other using the existing electrical wiring available in home.

## 3. INTERNET AS A MEDIUM OF COMMUNICATION

Due to the extraordinary pervading nature of the internet, the web based appliance controlled by internet provides a lucid, user friendly and cost efficient system for home automation with the long distance coverage. The internet provides the following advantages over other means of the data transfer.

- Improved access to data.
- Due to wide spread nature of the internet any authentic user can access the information on the web from any location in the world at any instant.
- High speed data transfer is possible using DSL (Digital Subscriber Line) or Cable Modems.

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## 4. HARDWARE DESCRIPTION

HASY addresses the specific needs of the user, without making the end user to pay for things that the end user doesn't find useful. It also must be flexible enough to be adapted as per the convenience and the need of the user which may change over time. Each automation system differs in its degree of intelligence, ease of programming, level of flexibility, intuitiveness of operation, communications media employed, price and other features. To help the end user make sense of the scores of viable options of home automation, the generalized home automation hardware components are represented here.

HASY usually is comprised of 4 main parts,

- Main Controller
- Interfaces
- Sensors
- Control methods

### 4.1 Main Automation Controller

This is an era of SOC (System-on-Chip) based computing. Embedded systems play an important role in representing computing power in the smallest possible device that too in the most liberal way. Microcontroller is now known as a major embedded system product and is responsible to carry computing power on any-time-any-where basis. Use of microcontroller is now termed as affordable intelligence. The outcome of the comparative study and timing simulation analysis is now available and useful for the designers and first generation entrepreneurs to encourage low power and low cost designs. Majority of the first generation entrepreneurs, especially in India and the other third world countries, are unaware of the important features of the recent 8-bit microcontrollers and timing simulation analysis and hence, are unable to compete in the global consumer electronics and strategic electronics production market [IJCA/SAA2] . In the developing countries, such as in India, electronics hardware production went from Rs. 50,500 crore in 2004-05 to Rs. 97,260 crore in 2008-09,

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with a cumulative annual growth rate of 17.3%. The production of electronics hardware in India has grown from Rs. 97,260 crore in 2008-09 to Rs. 109,940 crore in 2009-10, registering a growth of 13%, slightly low due to global slowdown. The control, instrumentation and industrial sector of electronics industry use critical hardware technologies and systems with built-in software [IJCA/SAA2]. Low cost and low power microcontroller based system design can play a significant role to increase employability and the export in this sector, particularly, in the developing country [IJCA/SAA2]. The controller description is given below. Fig. 1 and 2 show the CAN controller block diagram and internal architecture of AT89C51CC03, respectively.

**4.1.1 Description of AT89C51CC03**

The AT89C51CC03 is a member of the family of 8-bit microcontrollers dedicated to CAN network applications. In X2 mode a maximum external clock rate of 20 MHz reaches a 300 ns cycle time. Besides the full CAN controller AT89C51CC03 provides 64K Bytes of Flash memory including In-System Programming (ISP), 2K Bytes Boot

Flash Memory, 2K Bytes EEPROM and 2048 byte ERAM. Primary attention is paid to the reduction of the electro-magnetic emission of AT89C51CC03.

**4.1.2 CAN Protocol**

The CAN protocol is an international standard defined in the ISO 11898 for high speed and ISO 11519-2 for low speed.

**4.1.3 CAN Principles**

CAN is based on a broadcast communication mechanism. This broadcast communication is achieved by using a message oriented transmission protocol. These messages are identified by using a message identifier. Such a message identifier has to be unique within the whole network and it defines not only the content but also the priority of the message.

The priority at which a message is transmitted compared to another less urgent message is specified by the identifier of each message. The priorities are laid down during system design in the form of corresponding binary values and cannot be changed dynamically. The

identifier with the lowest binary number has the highest priority. Bus access conflicts are resolved by bit-wise arbitration on the identifiers involved by each node observing the bus level bit for bit. This happens in accordance with the "wired and" mechanism, by which the dominant state overwrites the recessive state. The competition for bus allocation is lost by all nodes with recessive transmission and dominant observation. All the "losers" automatically become receivers of the message with the highest priority and do not re-attempt transmission until the bus is available again.

**4.1.4 Message Formats**

The CAN protocol supports two message frame formats, the only essential difference being in the length of the identifier. The CAN standard frame, also known as CAN 2.0 A, supports a length of 11 bits for the identifier, and the CAN extended frame, also known as CAN 2.0 B, supports a length of 29 bits for the identifier.

**4.1.5 CAN access**

The CAN Controller accesses are made through SFR. Several operations are possible by SFR:

• Arithmetic and logic operations, transfers and program control (SFR is accessible by direct addressing).

• 15 independent message objects are implemented; a pagination system manages their accesses.

Any message object can be programmed in a reception buffer block (even non-consecutive buffers). For the reception of defined messages one or several receiver message objects can be masked without participating in the buffer feature. An interrupt is generated when the buffer is full. The frames following the buffer-full interrupt will not be taken into account until at least one of the buffer message objects is re-enabled in reception. Higher priority of a message object for reception or transmission is given to the lower message object number. The programmable 16-bit Timer (CANTIMER) is used to stamp each received and sent message in the CANSTMP register. This timer starts counting as soon as the CAN controller is enabled by the ENA bit in the CANGCON register. The Time Trigger Communication (TTC) protocol is supported by the AT89C51CC03.

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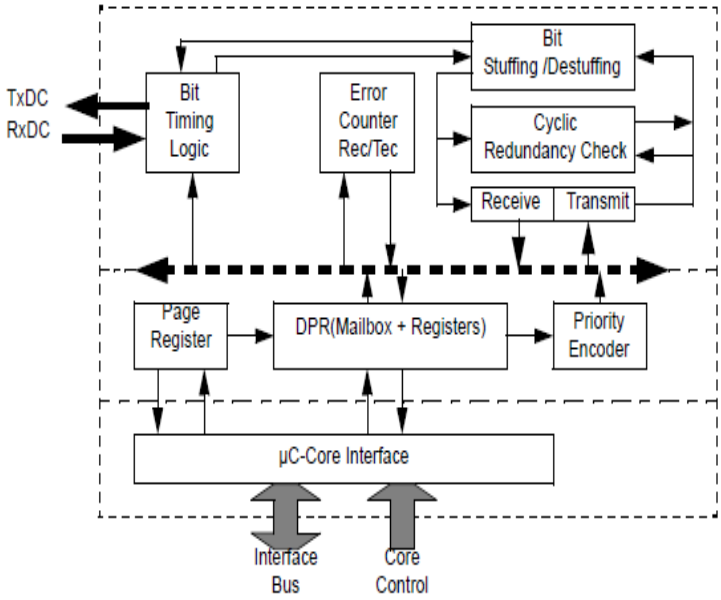


Fig.1 CAN Controller Block Diagram

**4.1.6 Block diagram**

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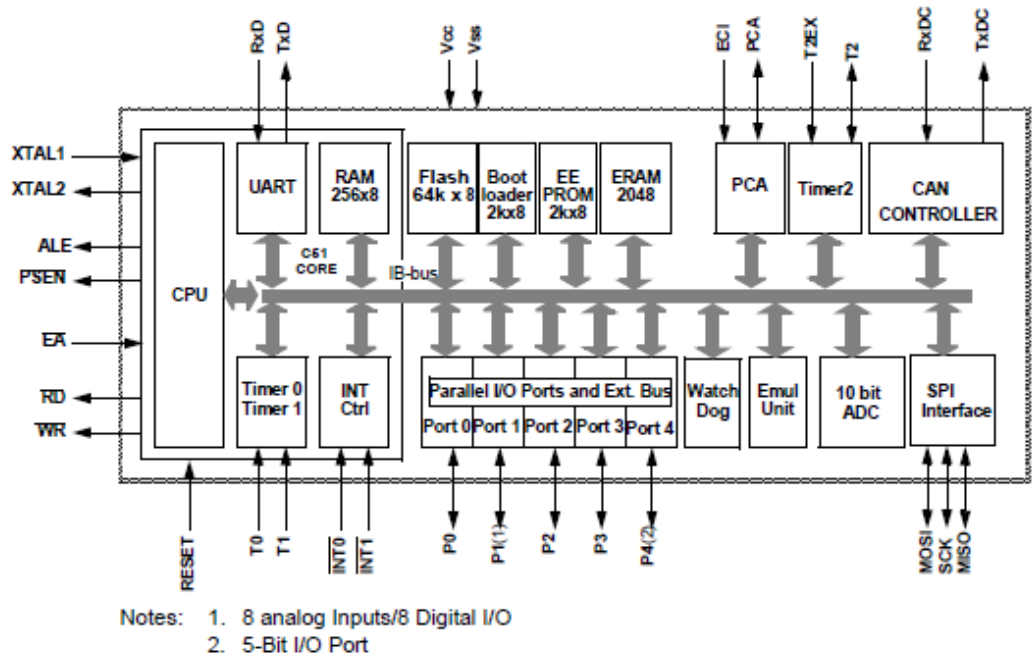


Fig. 2 Internal architecture of Atmel 89C51CC03

### 4.2 Interfaces

An Interface is the way user interacts with the HASY Controller. There are many types of interfaces as described below,

#### 4.2.1 Touch Panels

Touch panels can range from hardwired 4 inches screens to larger 10 inches screens.

#### 4.2.2 Keypad

It is a 2, 3, or 6 button device which is mounted on the wall. These buttons can be programmed to have different functions or to control different parameters when pressed twice instead of once.

#### 4.2.3 Remote Control

Remote control device is normally used with the TV set as the parameters to be controlled are displayed on the TV screen.

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#### 4.2.4 Mobile Devices

The most popular mobile device is the I-pod. One can even use the touch screen of the I-pod to operate the home automation system.

### 4.3 Sensors

Sensors are tiny gadgets that can detect whether something is in a current state. Home Automation System may have a contact sensor on the door or window which can tell the controller if that door is open or closed. Another type of sensor is a motion sensor that which detects the motion. For example this system could be used by the controller to turn lights on in a room when motion occurs. There are many other types of sensors, such as light, temperature, humidity etc. Few sensors are listed below which are preferred in the HASY.

#### 4.3.1 Temperature Sensors

- SMT16030 Digital Temperature Sensor
- DS18B20 Digital Temperature Sensor
- HS-2000V Digital Temperature Sensor
- VR IN 64/78 Temperature Sensor
- HF 3223/HRF3223 Temperature Sensor

#### 4.3.2 Humidity Sensors

- SHC180 Capacitive Humidity Sensor
- EDS Humidity Sensor
- HIH-4000 Humidity Sensor
- SHT7x Humidity Sensor
- HS1100/HS1101 Humidity Sensor

The main purpose of these sensors it to send the message to the controller that a specific situation is happening.

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### 4.4 Control Methods

Controllers communicate and control nearly all the different components of a HASY in a variety of ways. Some of the control methods are IP (Internet Protocol), Wi-Fi, Zig-bee, Infrared, Serial Data Communication and Relays (for motorization).

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#### 4.4.1 IP/TCP

This is used when the users are interacting with their controller over the Internet, and can be also used to allow the communication between the controller and its wired touch panels, contacts, security systems, thermostats etc. It is a standard way of communicating with the controllers.

#### 4.4.2 Wi-Fi

Wi-Fi is a great option when the end user cannot get Ethernet wiring to locations. It is really a very good medium for streaming music to different locations in the house, and will allow large bits of information to be passed back and forth with no wires. Internet access without wires is possible and hence the device control. Wi-Fi based control may have few limitations such as no access to the internet due to large building nearby.

#### 4.4.3 Zig-bee

It's a new form of wireless communication. Zig-bee allows two- way communication of devices but can only transmit very small bits of information.
The Zig-bee is basically a mesh network and hence the signal rerouting is possible.

#### 4.4.4 IR (infrared)

It is a low but focused beam of infrared LED light that is used to send commands one way. It is the cheapest option available for communication. IR pairs are needed to realize the communication.

#### 4.4.5 Serial Data Communication (SDC)

IR control is unidirectional but SDC is biredirectional. Almost all the controllers have SID and SOD pins available for serial communication. SDC is preferred to send the command words. SDC is not suitable for to and fro transfer of large data volumes.

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### 4.4.6 Relays

Relays are used to send electrical signals to actuate the electromechanical or motorized devices. Common uses of relays include opening and closing the shades, lowering a projection screen, camera motion control etc.

## 5. HARDWARE WORKING

The fig. 3 shows the block diagram of HASY.

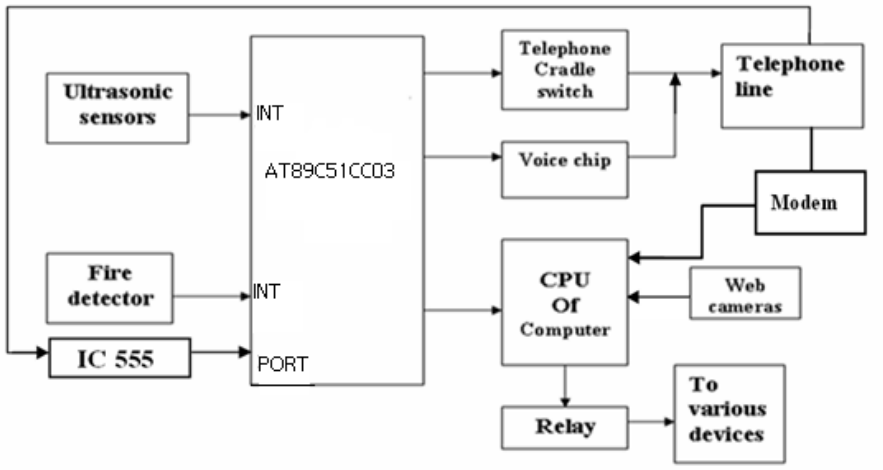


Fig.3 Block diagram of HASY

The purpose of “Home security controlling through networking” is to provide complete monitoring and control of domestic appliances. It includes the local PC to remote PC interfacing for providing security to home and appliances inside it from distant areas via internet facility. Initially the infrared proximity detectors which are placed at the entrance provide an interrupt to the microcontroller AT89C51CC03 whenever any intruder cuts the transmission path of rays emitted by the sensor. At this instant, a high to low pulse is generated by the sensor receiver. This is applied as input interrupt signal to microcontroller. Hence the main execution process gets diverted.

A start pulse is generated by the microcontroller which makes the local PC “on”, after 25 seconds the booting process is started and a startup program is automatically run which is loaded onto the RAM. During the execution/running of the program, the cradle switch of

telephone will operate and automatically dial the stored number in its internal memory; this number is generally of the owner, administrator, fire brigade or police to inform regarding any problem such as burglar theft or accidental fire at a particular place where the system is installed. When the call message is received, the voice chip is played. In the voice chip, various voices are pre-recorded which will be heard to the user at remote end. Upon receiving the message, the user can go to nearest cyber cafe (remote PC) and log on by entering the password and necessary IP address. By doing this process, the complete view of the house or institution could be observed with the help of rotating web cameras which are used for monitoring function that is video conferencing.

The same process will be repeated if an event of fire occurs at any place in that particular area. For controlling the various appliances, a relay switch is used which is connected to the printer port of CPU. The user can give commands to the PC which will operate the relay and complete the particular action or task through software approach via internet.

**6. SOFTWARE DESCRIPTION**

Anyplace Control is Window based software that allows user to securely control remote computer and transfer files via the Internet or LAN. The program displays the desktop of the remote computer on user's local screen to facilitate user to control the PC remotely. Fig. 4 shows the screen of the remote PC during testing.

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Fig.4 .Screen remote PC during testing

The built-in file transfer feature allows users to transfer files between the computers. With Anyplace Control, user can restart and shutdown a remote PC or locks a remote mouse or keyboard. The program also includes the remote installation feature, which provides user with the facility to install and configure user program on multiple remote PCs without the need to visit each PC individually. The software has many distinct features such as displaying the remote computer screen on local screen in real-time.

The Admin module displays desktop of remote computer (in separate window) on screen and allows user to use own mouse and keyboard to control the other PC remotely (via LAN or Internet). User can monitor exactly what is happening on networked workstations and servers. Fig. 5 shows the main window of the Admin module which is after the application starts up.

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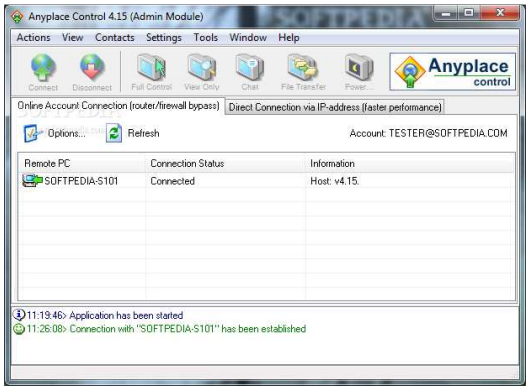


Fig. 6 Main window of Admin module

## 7. CONNECTIVITY MODES

Connection between local and remote computers can be established in two ways,

- Direct connections: via IP address or DNS name.
- Account connection: Firewall-friendly access to remote computer over the Internet using an Account and nickname (IP address is not used).

### 7.1 Direct Connections mode

Direct Connections mode enables user to connect to the remote computer using its IP address or a DNS name. This connection mode makes remote control possible both via LAN and via Internet. For a successful connection the host computer should have a static external IP address and proper firewall or router configurations.

### 7.2 Account Connections mode

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This mode is used when there is no possibility of establishing direct connection. It provides access via internet to the computers, that don't have external static IP address. User can easily connect to the computers with internal (192.168.x.x) or dynamic IP address without any network configurations. User connects via account name and computer nickname instead of IP address.

## 8. PERFORMANCE EVALUATION

Fig. 7 and 8 show the actual hardware implementation of HASY.

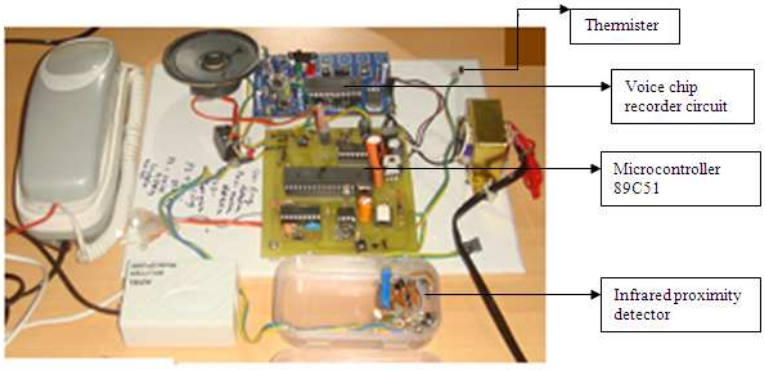


Fig. 7 Hardware circuit

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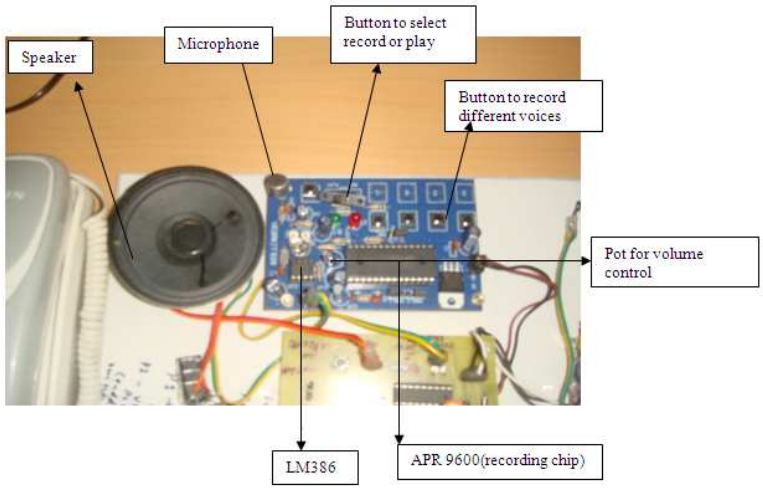


Fig. 8 Voice chip recorder APR9600

As the intruder cuts the path of transmission of infrared detector the following sequence of events were automatically executed,

- A high to low pulse was generated by the sensor receiver. This was applied as input interrupt signal to microcontroller 89C51CC03.
- A start pulse was generated by the microcontroller which in turn made the local PC ON.
- The cradle switch of telephone was thus operated and automatically dialed the stored number in its internal memory.
- When the call message was received, the voice chip is played & the message “someone is there in home” was heard.
- The user logged by entering the password and necessary IP address as shown in the following window (fig.9).

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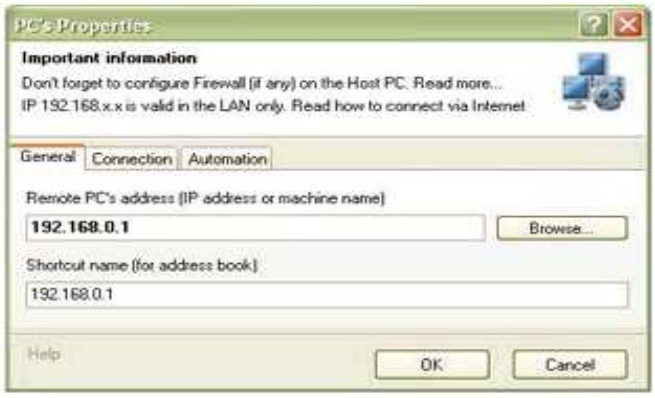


Fig. 9 Window for entering IP address

- The Main window of the Admin module was seen (fig.10).


Fig. 10 Window of the Admin. module

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- To work with the Remote Screen window and to operate a remote computer a convenient toolbar was designed as seen in fig. 11.

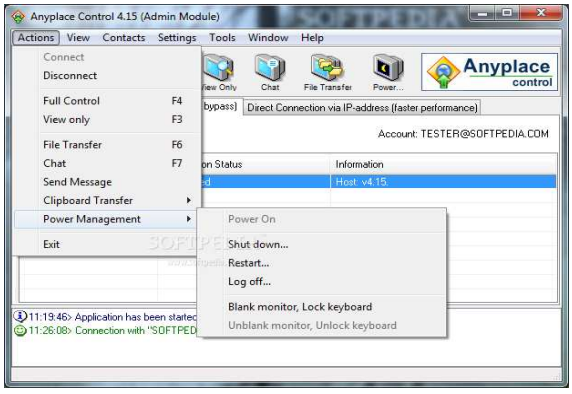


Fig. 11 window showing Toolbar to operate remote window

## 8. CONCLUSION

The paper describes the low cost approach for home automation system design using the combination of hardware and software to provide the access to the security aspects from remote places. Prevention of accidents is greatly possible. With Anyplace control software it is possible for user to control remote PC. The built-in file transfer feature allows transferring files between the computers. The remote installation feature provides user the facility to install and configure the program on multiple remote PCs without the need to visit each PC individually.

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