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Smart Metering and Home Automation using ARM Controller

Koduru Sriranga Suprabhath, Jami Sridevi

Abstract: ***This paper presents the controlling of household equipment from remote locations and to monitor the amount of power consumed by the equipment's using IOT platform. Smart grid is the major part of the smart city model and the smart grid are based on the bidirectional flow of communication between the consumer and the producer .This bidirectional flow is possible through the smart meter. The efficiency of power consumption can be improved by the consumer with the help of smart meter and alerts can be generated to the mobile phone of consumer. Our main emphasis will be to design a system which will increase the range of applications , this can be done by using advanced ICs and long range wireless communication technologies. In this paper we use the ARM controller to control the smart meter. Wireless communication is achieved by using GSM module and Bluetooth module. We are using two different communication modules to demonstrate the difference between their ranges of operation.***

Keywords—Internet of things, Smart meter, GSM module, Bluetooth module, ARM processor

I. INTRODUCTION

The Internet of Things is the revolution that changed the way of communication and operation of the devices completely. Internet of things is a giant interconnected network which is connected to many devices and share data about how they are used and the environment in which they are operating. This can be done using Sensors, sensors are embedded in every physical equipment that we come across in our day to day life. These sensors continuously emit data and these data is stored in the IOT platform. IOT platform provides the common platform for these data, the shared data is analyzed and retrieved back as per our requirement.

The retrieved data can be visualized in the devices and automation can be performed with improved efficiencies [1].Smart systems and Internet of things are driven by the combination of sensors & actuators, connectivity, people and processors. Sensors and actuators are directly connected to the electrical equipment we are using, they can sense the changes and control the equipment according to the instruction of the consumers. Connectivity will provide the path for the transfer of data from the consumer to system, connectivity may be wired or wireless.

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People and processors are the part of the system where the commands are given and further action is processed, we can program the processor to work according to our application. In this paper we are using the Relays as the sensors, GSM module and Bluetooth module as Wireless connectivity, ARM processor as the processing device.

To overcome the disadvantages of the conventional grid we are moving quickly towards the Smart grid [2][3]. In the conventional grid we are using the centralized power generation, which is the major disadvantage while the disturbances occur. As we are running out of fossil fuels we are looking forward for the renewable power generation. Smart grid is the solution for all the problems that the conventional grid provides. Smart grid is the decarbonized generation system, bidirectional flow of communication is possible. It also provides the interconnection between the conventional power generation and renewable power generation which helps to increase the reliability of the system [4]. The key technologies used for the better operation of smart grid are: Integrated communications, Sensing and measurement, advanced components, advanced control methods, improved interfaces and decision support. The four major components required for the better operation of smart grid are: Smart Meter [5], Phasor measurement, Information transfer, Distributed Generation.

The major equipment which makes the Smart grid standout from the conventional grid is the Smart meter. The advancement of meter in the electrical field is shown in figure.1. Smart meter uses the Advanced Metering Infrastructure (AMI) technology. AMI provides the two way communication between the consumer and the energy provider. Smart grid allows the flow of power from customer to grid if u have renewable power generation. It specifies the particular time for load shedding to the consumer in order to obtain the efficient power usage .Smart meter, communication network, Meter data acquisition system, Meter data management system are the building blocks of AMI .

Processor used in this paper is ARM (LPC2148). ARM stands for "Advanced RISC Machines" .ARM provides 32 bit and 16 bit processor core. RISC stands for reduced instruction set. ARM holdings is the British company that develops the

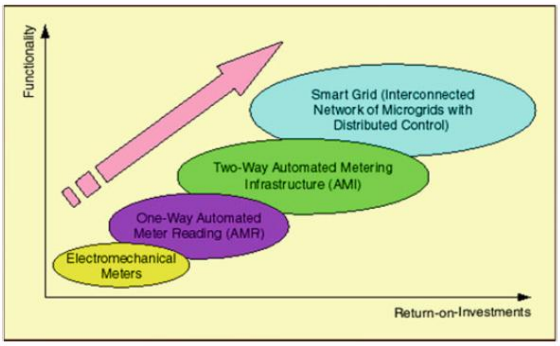


Figure 1. Comparison of Different Metering Techniques

Architecture and licenses it to other companies. Companies design their own products and implement one of these architectures including Systems-on-chips and cores. System –on- chips incorporate memory, interfaces, radios etc. the core designs will implement the architecture licensed by the ARM holdings and develop their own products.

Wireless communications used in this paper are GSM and Bluetooth [06][07]. GSM is a mobile communication mode. It is abbreviated as Global System for Mobile communication (GSM). The GSM was developed at Bell Laboratories in 1970. It is a digital cellular technology extensively used for mobile communication system in the world and for transmitting mobile and data services which operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands. Bluetooth module we are using is HC05 module it will represented as AUBTM 22 HC05, this module will pair up with any devices which contains the Bluetooth facility to hare the information. The system will communicate with the module using UART with serial communication protocol SPP. The actuators used in this paper are Relays. Relays in our normal life are used to trip the circuit which are unhealthy or faulted, but in the embedded systems relays can be used as the switches to control the on/off of the device. This relay unit consists of relay, transistor and photo diode. Here we are using set of three relays which are individually connected each load.

II. BLOCK DIAGRAM

Figure.2 shows the connections of different components with each other and the flow of information. From the Energy source the supply is given to power supply block. Power supply block will step down the voltage to 12V and converts to DC using bridge rectifier circuit .This dc 12V is given to the ARM controller as the input power. The smart energy meter circuit consists of LED which usually blinks 3200 times so to calculate that impulse we fix LED which will indicate 1 Unit electricity consumption for 3200 blinks i.e. 3200 impulse = 1KW.

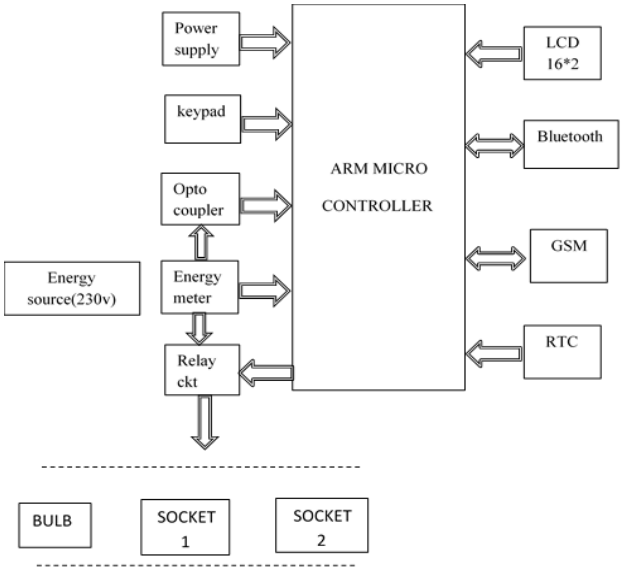


Figure 2. Block Diagram of Smart Meter using ARM

Opto coupler is to provide the electrical isolation between the energy meter and the controller. Opto-isolators prevent high voltages from affecting the system receiving the signal. Keypad connected to the ARM is used to enter the date and time of RTC it contains three switches increment, decrement and enter. By using these switches in keypad the details of date, time are entered into RTC. RTC is the Real Time Clock, RTC is inbuilt in the ARM LPC2148, and it keeps track of the present time and date even if the circuit is switched off. Relay circuit is connected to the ARM from which the commands of switch on/off are received, the power supply for relay circuit is from energy meter. GSM is connected to the UART port of ARM controller and Bluetooth module is connected to the general purpose I/O pins of the ARM. Both daily consumption units and status of the loads can be monitored in the webpage designed for the IOT platform.

III. HARDWARE DESCRIPTION

The power supply unit is designed to convert high voltage AC to a suitable low voltage supply for the operation of electronic circuits and other devices. Power supply block consists of step down transformer, Rectifier, Filter, Voltage regulators. Form the supply step down transformer is used to step down the ac voltage from 230V to 12V .Bridge rectifier converts the AC voltage to DC voltage and the filters are used to minimize the ripple content present in the dc supply .voltage regulator is used to maintain the voltage to the specified value here. The major equipment in this technology is Micro controller .We are using LPC2148. ARM based microcontroller. ARM stands for Advanced RISC Machines .ARM supports high code density, whenever we are coding some complex programs we definitely go for high code density. ARM has low power consumption, whenever we are using an embedded system we do not have luxury of high power operation most are battery operated hence we need low power consumption which is provided by ARM. It has smaller size (smaller silicon foot print), it occupies very less space on the board.

Any architecture is characterized by two things, one is data path and other is control path. We have two types of architectures namely CISC (complex instruction set computer) and RISC (reduced instruction set computer). ARM uses the RISC .In the ARM the operands are fetched from the registers but not the memory location and the result is also stored in the registers, the barrel shifter present in the data path will perform the preprocessing work. [08]

ARM LPC2148 microcontroller consists of two ports named as PORT0 and PORT1 each port consisting of 32 pins each. In PORT0 we have 32 pins in which 31 pins (0.0-0.30) can be used as the general purpose input output pins GP I/O, 0.32 pin is only for the output purpose. In PORT1 we have 32 pins in which 16 pins (1.16-1.31) are general purpose input output pins GP I/O, the remaining 16 pins of PORT1 (1.0-1.15) are reserved for some specific operations such as V_{ref}, V_{sat}, V_{dd}, Reset , RTC etc. as shown in figure.3

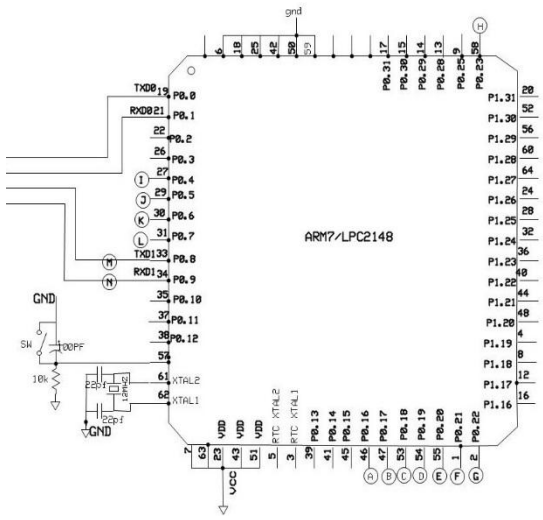


Figure 3. Pin Description of ARM LPC2148 controller

Architecture used in the ARM7 is load store architecture, here the data operations are only involves registers, and memory locations are not involved. ARM register bank contains 16 registers and 2 status registers.

CPSR - Current program status register

SPSR - Saved program status register

CPSR

31	30	29	28		7	6	5	4	3	2	1	0
N	Z	C	V		I	F	T	M 4	M 3	M 2	M 1	M 0

N, Z, C, V are the conditional flags. I, F, are the interrupt enable bit. If T=0 (ARM state) and if T=1(THUMB state). ARM supports two modes of operation one is privileged mode and other is non privileged mode .according to the modes the mode bits (M) are decided in the CPSR, the following table represents the mode bits for different mode of operations. By observing the mode bits and other flags in the CPSR we can determine the state of the ARM controller.

Table: ARM Modes of Operation

User Mode	10000
Fast Interrupt Request Mode	10001
Interrupt Request Mode	10010
Supervisor Mode	10011
Abort Mode	10111
Undefined Mode	11011
System Mode	11111

In the meter circuit we use LED, LED produces pulses according to the load. If the LED gives 3200 pulses then it is understood that 1KW of energy is consumed. To detect the pulses we place a photo diode next to the LED, the signals of the photo diode are weak so connect a transistor which amplifies the the signal from the photo diode. So the micro controller will count the pulses from the optical sensor and the equivalent electrical reading to the web server [09]. Universal Asynchronous Receiver and Transmitter (UART) provide the serial communication. Here we use UART0 and UART1 for serial communication.

Real Time Clock (RTC) measures the passage of time to maintain the clock and calendar. It Provides Day of Week, and Day of Year. RTC can be clocked by a separate 32.768 KHz oscillator, or by a programmable presale divider based on the VPB clock. Also, the RTC is powered by its, connected battery The RTC includes four set of registers based on functionality. The first set are Miscellaneous Register Group (8). The second set are Time Counter Group (8). The third set are Alarm Register Group (8). Rest of the registers control the Reference Clock Divider.

GSM is one of the wireless technology used in this paper for the communication [10][11]. With the wide spread use of cellular networks, this approach is popular when small amount of data is to be transferred through the network. We are using SIM800L miniature cellular module which is shown in figure.4. It allows GPRS transmission, sending and receiving messages, making calls. Specified voltage for this module is in the range of 3.8V-4.2V. Recommended supply voltage is 4V. Sim card type is micro sim slot .status of the signal is detected using LED.

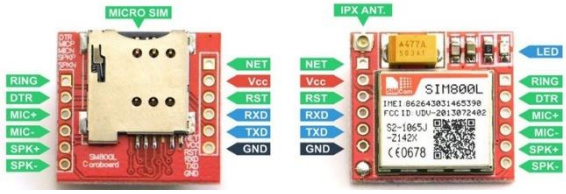


Fig 4. SIM800L GSM MODULE

RING is in low state while receiving calls. DTR is the sleep mode (serial communication is disabled), default it is HIGH whenever the module is setup it becomes LOW and module wakes up. IPX is the antenna connector and NET is the antenna. Bluetooth HC-05 is another wireless communication module used shown in figure.5. This Bluetooth module is used for short range applications like within the vicinity of our home. The range of Bluetooth module normally ranges from 100m to 120m depending upon the transmitter,

receiver and geographic conditions. Bluetooth module works with the android application "BLUETOOTH TERMINAL". The input commands for this Bluetooth module is from the smart phone, before giving the commands this module should be paired with the smart phone [12]. HC-05 is provided with red LED it indicates the connection status, whether the Bluetooth is connected or not. This Bluetooth module voltage range is 3.3V. It contains On-board 5V-3.3V Voltage regulator.

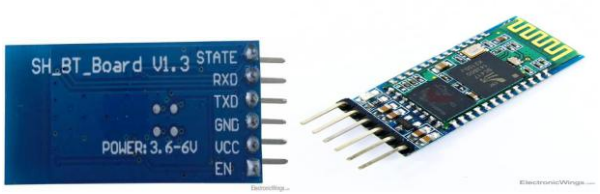


Fig5. HC05 BLUETOOTH MODULE

RXD and TXD are the receiver and transmitter pins respectively. EN enable pin is set to high the module I in command mode. STATE pin indicates whether the module is connected or disconnected.

Relay unit acts as the actuator which will turn on/off the load according to the commands received from the controller .Relay is the is electro mechanical device shown in figure.6 , current flowing through the relay coil will generate the magnetic field and this field attracts the lever and changes the position of the switch. For 12V relay the amount of current passed will be 30mA

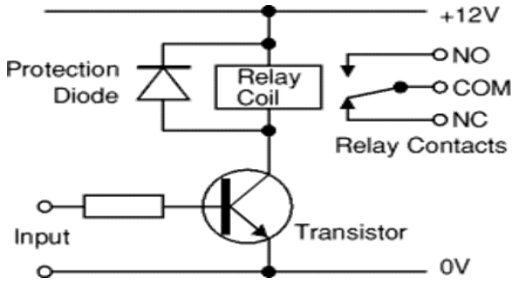


Fig6. Relay Circuitry

Relay produces the high voltage spikes for very less time which may damage the transistors, to avoid this we are connecting the Protection Diode.

A web page is created which shows the status of our payment, no of units consumed, status of the loads which are ON and OFF. Web page is a kind of documented which is written in HTML (Hypertext mark-up language). The web page is accessed by entering a URL. Whenever any changes are made in the load operations we can monitor that changes through the webpage. It is the User interface available to monitor the device condition. . This will make the process easy for the customer to monitor the bill payment and the power consumption. Only threat is there is a chance of hacking which should be taken care by proper security measures. Bluetooth module works with the android application "BLUETOOTH TERMINAL".

IV. SOFTWARE REQUIRED

Software required for this project are KEIL µVision using Embedded C programming [14]. KEIL can be used to create source files, compile the code. , we can simulate and perform debugging of the hardware by accessing C variables and memory. Simulator or debugger can be used to perform a detailed simulation of the controller, it will indicate the execution time of the instructions precisely. By the help of debugger quick trouble shooting can be obtained, a window is opened for each peripheral of the device, indicating the state of the peripheral. In addition to this we can also get view of every register, we can have the detailed view of all the microcontroller operations. KEIL is a common platform to build, compile, simulate and debug the controller.

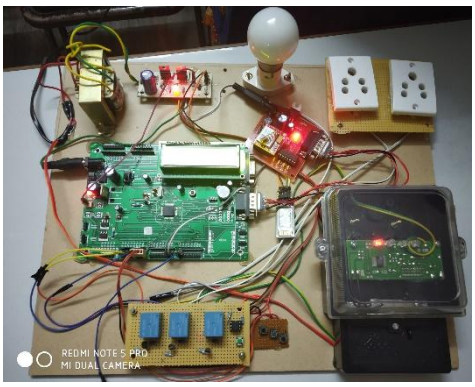
For dumping the code into the microcontroller we use FLASH MAGIC software. Flash Magic is a PC tool, it used for programming microcontrollers using a serial communication to the targeted hardware.

V. RESULTS AND DISCUSSIONS

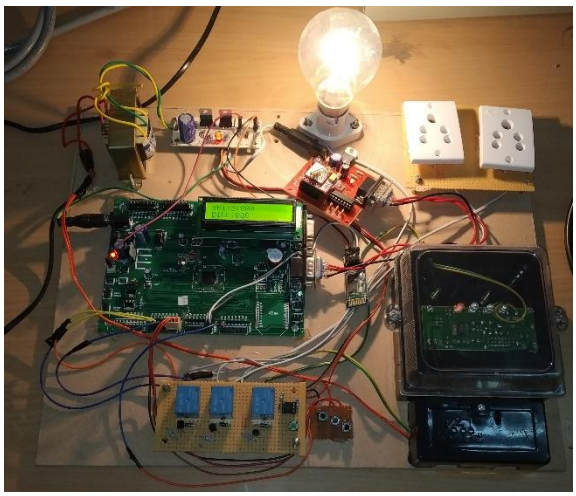
ONLINE	SERVICE
USAGE	STATUS
METER	564223
UNITS	000
BILL:	000Rs/-
BULB1	ON
BULB2	OFF
BULB3	OFF

(a)

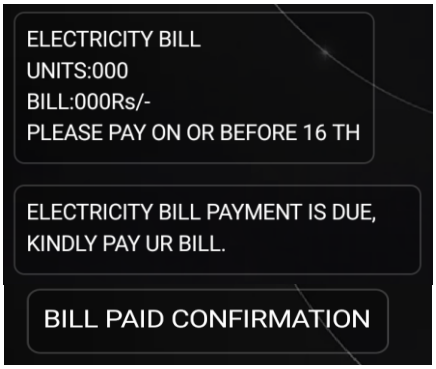
(b)



(c)



(d)



(e)

Fig7. (a) Web Page (b)GPRS connected (c) Circuit Of Smart Meter (d) Result Of Smart Meter (e) Payment Alert

When we switch on the Power supply, controller, GSM and Bluetooth modules are powered up. LCD is switched on and displays the text "Welcome to the Project" as we specified in the embedded c code. In the next step we should set the date and time in the RTC by using the linear keypad which contains the increment, decrement and enter switches, by pressing that switches we can set the date and time. When the GSM module is switched on, the LED in the module glows very fast and after brief period of time the blinking will become very slow that indicates that the GSM module is connecting to the internet service provider, once the connection is established the LED blinking will steady. Now it is ready to use. GPRS connecting status will be appeared on LCD as shown in figure 7(b). Similarly the Bluetooth module is connected to the controller, when the controller is switched on the Bluetooth module is active and ready to use. In GSM and Bluetooth modules the receiver port is connected to the transmitter port of the controller and transmitter port is connected to the receiver port of the controller to permit the bidirectional flow of the information.

A web page is created which shows the status of our payment, no of units consumed, status of the loads which are ON and OFF as shown in figure 7(a). Web page is a kind of documented which is written in HTML (Hypertext mark-up language). The web page is accessed by entering a URL. Whenever any changes are made in the load operations we can monitor that changes through the webpage. It is the User interface available to monitor the device condition.

In this project we are using three loads .These three loads can be controlled by SMS (short message service) to the mobile number of the service provider that is incorporated in the GSM module. In the Embedded code written we will use particular text to switch on/off the loads, the same should be used while we are giving SMS to the GSM. In our project to switch ON the BULB1 we should text message as "@BULB1 ON*" , immediately the message is received by the GSM module and sent to the transmitter to the controller then the controller will give the HIGH output to the relay pin and relay operates and turns ON the load. The same thing happens to the other two loads. By the start of the month we receive the Bill payment request SMS from the controller .After the payment of the Bill, We will text as "@PAID*", then we will get the return message as "BILL PAID CONFIRMATION" as shown in figure 7(e). The Due date for the bill payment can be modified in the code. This will make the process easy for the customer to monitor the bill payment and the power consumption. The operation of Bluetooth module is pretty similar to the operation of GSM module except that we cannot control the bill payment here. Bluetooth module works with the android application "BLUETOOTH TERMINAL". After installing the application then scan for the Bluetooth devices, it detects Bluetooth module HC05 then pair with the Bluetooth module .After pairing the communication between your mobile and the module is enabled. In the message section we should enter our command to control the loads. To switch on the BULB1 we will text as "@B1ON*". This message is received by the module and sent to controller which in turn changes the relay position and load turns on. This whole process of loads switching on/off can be monitored from the webpage. The project is designed as shown in figure 7(c) and results are obtained when we operate using different modules it can be seen in figure 7(d)

VI. CONCLUSION

We have presented an architecture, implementation and demonstration of the "SMART METERING AND HOME AUTOMATION USING ARM CONTROLLER" which is customer centric and distribution centric allowing the bidirectional flow of information. This proposal have unique sense of novelty and advantages as we are using the advanced ICs. Previous works are based on home automation and controlling of equipment's using normal ICs and low range of wireless communication. In this paper we implemented the home automation using maximum possible range and this increases the applications, in addition to this we can monitor the live status of the equipment from remote location using GPRS, apart from household equipment we can find it application in agriculture. As a Future work we can extend this proposal to the transmission level by controlling the transmission of power generated by renewable energy sources This will serve the purpose of Smart Grid to establish a meshed network. This project has been successfully designed and tested. Integrating features of all the hardware components used have developed it. Presence of every module has been reasoned out and placed carefully thus contributing to the best working of the unit.

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