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Microcontroller Based Power Consumption Monitoring and Warning System

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ABSTRACT

This paper attempts a solution to the problem of energy crisis in an indirect way. This project aim to design a circuit which helps consumer taking care regarding his electrical energy consumption and protect him/her from the extra charges incurred due to minor changes in slab categories, even though these changes are small but they affect the consumer's bill severely. To make him aware and to control the excess power consumption, this paper introduces, a **"MICROCONTROLLER BASED POWER CONSUMPTION MONITORING AND WARNING SYSTEM"**. This system will intimate the consumer about his usage rate. It will display the units he consumed and how many units he had been left with, in order to be in a minimum slab rate being fixed for a period of time by him/her. In this way we can make the consumer aware of the billing and make him to consume the power according to his use. It not only benefits the consumer, it also benefits the government as it is capable of reducing the power consumption and subsequently we can reduce the unusual power usage

Key words:-power consumption, slab rate, electrical energy crisis, consumer, warning system, micro controller.

I. INTRODUCTION

The price of electricity and demand for power is predicted to increase exponentially in the next several years. In fact, the world's demand for power is rising faster than the demand can be met. Consequently, industries, homes, and businesses are already taking power saving measures to save money and to become more environmentally friendly. Power saving techniques seems to have a small impact to each individual, but as the price and demand for electricity rises, the collective power saving actions of everyone will make a significant difference. This project aim's at building an electronic device which continuously monitor's ones energy consumption and warns consumer if he/she is expected to increase beyond him/her pre-fixed energy units.

This monitoring is done on a regular basis, so that if consumer is at the brink of exceeding his/her specified consumption limits, they will be warned.

This paper concentrates on two things,

1. Consumer's electricity bill.
2. Control on power consumption.

As mentioned above, by fixing ones consumption below a fixed slab rate category and continuously checking that the consumption has not exceeded this limit for a month, we can cut down the consumer's electricity bill as well as the load on the system, if we succeed in limiting the consumption below the slab rate. This project constantly alerts consumer if their consumption has reached nearer to the pre-planned units using an audio signal and/or an s.m.s on a regular basis, so that the consumer is aware of his consumption and voluntarily controls his consumption.

II. ENERGY CRISIS

Peak power shortage is shortfall in generation capacity when electricity consumption is maximum. The survey's shows that the resources currently allocated to energy supply are not sufficient for narrowing the gap between energy needs and energy availability. One of the reason for excess power demand is the consumer is using more power for his unwanted usage (voluntarily or involuntarily) beyond his need, there is a lot of power loss occurring in our state/country and the consumer is bearing more charges because of that unusual usage.

An energy crisis[1] is any great bottleneck (or price rise) in the supply of energy resources to an economy. In popular literature though, it often refers to one of the energy sources used at a certain time and place, particularly those that supply national electricity grids or serve as fuel for vehicles. There has been an enormous increase in the global demand for energy in recent years as a result of industrial development and population growth. Since the early 2000s the demand for energy, especially from liquid fuels, and limits on the rate of fuel production has created such a bottleneck leading to the current energy crisis.

An electricity shortage is felt most by those who depend on electricity for heating, cooking, and water supply. In these circumstances, a sustained energy crisis may become a humanitarian crisis.

If an energy shortage is prolonged a crisis management phase is enforced by authorities. Energy audits may be conducted to monitor usage. Various curfews with the intention of increasing energy conservation may be initiated to reduce consumption.

III. WORKING PRINCIPLE

The basic working principle of this project solely depends on one of the features of a digital energy meter. Every energy meter has a property of producing LED blinks these blinks are analogous to the energy meter disc which revolves specific no of times for a given energy consumption in analog energy meters. The speed of its revolutions depends on the power consumption at that given instant. In the similar way in a digital energy meter, the blinking rate of LED on digital energy meter corresponds to the energy consumption.

Every energy meter has its own constant which is termed as "ENERGY METER CONSTANT[2]", ex: 3200 blinks/kwh. So, by counting those blinks one can easily calculate power consumed by any unit. To count these blinks we use an micro controller which does this job automatically and calculates the power consumption on its own and regulates the consumption with a warning system.

We in this project are tapping out the information given by the LED via a light sensor (LDR) which detects the blinks of the LED without tampering energy meter .

IV. CALCULATIONS

Number of Blinks α energy consumption made So, number of blinks = energy meter constant x energy consumption made (in kwh)

So, $$\frac{B1}{B2} = \frac{E1}{E2}$$

Where B1 = energy meter constant.
E1 = 1 kWh.
B2 = blinks counted by the controller.
E2 = energy consumed by the user.

E2 = (E1 x B2)/B1

From the above equation if we know B2 (blinks counted by the controller) we can directly calculate the power consumption and compare it constantly with the pre-set units and whenever the consumption reaches close to the pre-set units it automatically sets the alarm and sends a message to the mobile number fed into the controller[2].

We initially set fixed units to be consumed in a given period of time and the consumption starts the micro controller counts the blinks and indirectly counts the energy left to be consumed. The setting of initial consumption depends on the past history of consumer and his consumption pattern for the last few years or months and additional equipment he had installed in his house hold.

V. CIRCUIT DESCRIPTION

- Power supply circuit
- Control unit (AT89S52)
- LCD module
- GSM module(sim 900)
- MAX 232
- Crystal oscillator
- LDR
- Relay
- 555 timer as switch

Power supply circuit:

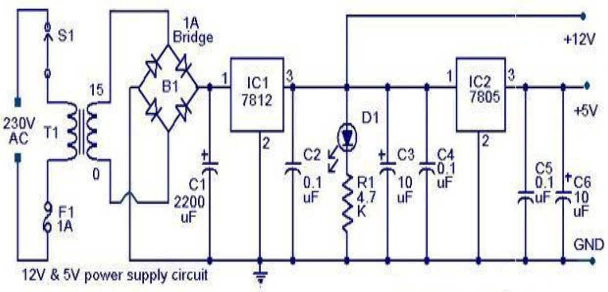

Fig 5.1 Power supply circuit

Initial stage of every electronic circuit is power supply system which provides required power to drive the whole system. The specification of power supply depends on the power requirement and this requirement is determined by its rating. The main components used in supply system are:

- transformer
- rectifier
- input filter
- regulator
- output filter
- output indication

5.1.1 Transformer:

The main source of power supply is a transformer. The maximum output power of power supply is dependent on maximum output power of transformer. We determine power from its current and voltage rating. e.g.: if there is a transformer of

12V, 500mA then maximum power delivered by transformer is 6Watt. It means we can drive a load from this transformer up to 6w. In our project our maximum power requirement is 1watt. So to provide this power we use 12V/250mA transformer. The maximum output power of this transformer is 4watt.it means it can easily drive load up to 4 watt.

5.1.2 Rectifier:

Rectifier is a circuit which is used to convert ac to dc. Every electronic circuit requires a dc power supply for rectification. We have used four diodes.

5.1.3 Input filter:

After rectification we obtain dc supply from ac but it is not pure dc it may have some ac ripples .To reduce these ripples we use filters. It comprises of two filters low frequency ripple filter and high frequency ripple filter. To reduce low frequency ripples we use electrolytic capacitor. The voltage rating of capacitor must be double from incoming dc supply. It blocks dc and passes ripples to ground.

5.1.4 Regulator:

Regulator is a device which provides constant output voltage with varying input voltage. There are two types of regulators-
(a) Fixed voltage regulator
(b) Adjustable regulator
We have used fixed voltage regulator LM78XX last two digits signify output voltage. The voltage for our system is 5V that is why we have used 7805 regulator which provides 5V from 12V dc.

5.1.5 Output filter:
It is used to filter out output ripple if any.

5.1.6 Output indication:

We use LED to observe the functioning of our system. If the LED glows it confirms proper functioning of our supply. We have used four power supply units.

Control circuit (AT89S52 microcontroller)

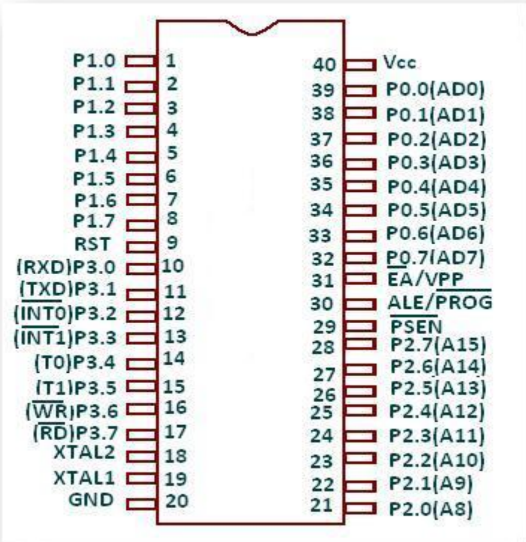

Fig:5.2 *AT89S52 microcontroller*

Features
- Compatible with MCS-51™Products
- 8K bytes of In-System Reprogrammable
- SPI Serial Interface for Program Downloading
- Endurance: 1,000 Write/Erase Cycles
- 4.0V to 5.5V Operating Range
- Fully Static Operation: 0 Hz to 33 MHz
- 256 x 8 bit Internal RAM
- 32 Programmable I/O Lines
- Three 16 bit Timer/Counters
- Eight Interrupt Sources
- Full Duplex UART Serial Channel
- Low Power Idle and Power Down Modes
- Interrupt Recovery from Power Down Mode

Advantages
- Less power consumption
- Low cost
- Less space required
- High speed

5.2 Pin Description:

5.2.1 VCC: Supply voltage.

5.2.2 GND: Ground.,

5.2.3 Port 0: Port 0 is an 8-bit open drain bidirectional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high impedance inputs. Port 0 can also be configured to be the multiplexed low-order address/data bus during accesses to external program and data memory. In this mode, P0 has internal pull-ups. Port 0 also receives the code bytes during Flash programming and outputs the code bytes during program verification. External pull-ups are required during program verification.

5.2.4 Port 1: Port 1 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 1 output buffers can sink/source four TTL inputs. When 1s are written to Port 1 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. In addition, P1.0 and P1.1 can be configured to be the timer/counter 2 external count input (P1.0/T2) and the timer/counter 2 trigger input (P1.1/T2EX), respectively, as shown in the following table .Port 1 also receives the low-order address bytes during Flash programming and verification.

5.2.5 Port 2: Port 2 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 2 output buffers can sink/source four TTL inputs. When 1s are written to Port 2 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that uses 16-bit addresses. In this application, Port 2 uses strong internal pull-ups when emitting 1s. During accesses to external data memory that uses 8-bit addresses, Port 2 emits the contents of the P2 Special Function Register. Port 2 also receives the high order address bits and some control signals during Flash programming and verification.

5.2.6 Port 3: Port 3 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs,
Port 3 pins that are externally being pulled low will source current (IIL) because of the pull-ups. Port 3 receives some control signals for Flash programming and verification. Port 3 also serves the functions of various special features of the AT89S52.

5.2.7 RST: Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device. This pin drives high for 98 oscillator periods after the Watchdog times out. The DISRTO bit in SFR AUXR (address 8EH) can be used to disable this feature. In the default state of bit DISRTO, the RESET HIGH out feature is enabled.

5.2.8 ALE/PROG: Address Latch Enable (ALE) is an output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming. In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external data memory. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode.

5.2.9 PSEN: Program Store Enable (PSEN) is the read strobe to external program memory. When the AT89S52 is executing code from external program memory, PSEN is activated twice each machine cycle, except that two PSEN activations are skipped during each access to external data memory. EA/VPP: External Access Enable. EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH.
Note, however, that if lock bit 1 is programmed, EA will be internally latched on reset. EA should be strapped to VCC for internal program executions. This pin also receives the 12-volt programming enable voltage (VPP) during Flash programming.

5.2.10 XTAL1: Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

5.2.11 XTAL2: Output from the inverting oscillator amplifier.

16x2 LCD Display[5] Unit:

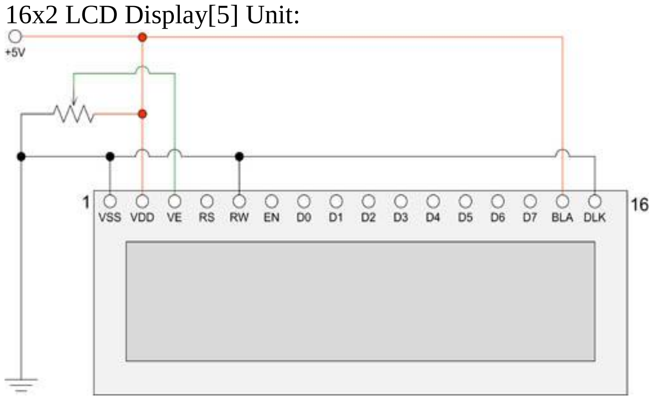

Fig:5.3 16x2 LCD Display

TABLE 5.1 LCD description

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

Liquid crystal displays (LCD) is an alphanumeric display and widely used in recent years as compared to LEDs. This is due to the declining prices of LCD, the ability to display numbers, characters and graphics, incorporation of a refreshing controller into the LCD, their by relieving the CPU of the task of refreshing the LCD and also the ease of programming for characters and graphics. We have used JHD162A advanced version of HD44780 based LCDs.

GSM MODULE(SIM 900):

Fig: 5.4 SIM 900

GSM[5] module is base on SIM900A Quad-band GSM/GPRS module. SIM900 is a complete Quad-band GSM/GPRS module in a SMT type and designed with a very powerful single-chip processor integrating AMR926EJ-S core, allowing you to benefit from small dimensions and cost-effective solutions. GSM module is an compact and reliable wireless module. This module is compatible with Arduino and other MCU's. It is configured and controlled via its UART using simple AT commands.

The GPRS Shield provides you a way to use the GSM cell phone network to receive data from a remote location. The shield allows you to achieve this via any of the three methods:

- Short Message Service
- Audio
- GPRS Service

Features:

- Can interfaced via RS232 as well as TTL.
- Power, RING, STATUS and Network LEDs for easy debugging.
- Onboard buzzer for general audio indication.
- Control via AT commands - Standard Commands: GSM 07.07 & 07.05 | Enhanced Commands: SIMCOM AT Commands.
- Short Message Service - so that you can send small amounts of data over the network (ASCII or raw hexadecimal).
- Speaker and Headphone connector - so that you can send DTMF signals or play recording like an answering machine.
- SIM Card holder and GSM Antenna - present onboard.

Specification:

TABLE 5.2 Voltage Characteristic

Minimum	Nominal	Maximum
6.5 V	9V - 12V	15V

TABLE 5.3 Current Characteristic

Minimum	Nominal				Maximum
	standby	Tx	Rx	Peak surge current	
46mA	50 - 55 mA	100 - 180 mA	140 - 300 mA	500 mA (Non-Repitative)	500 mA

Max 232 IC:

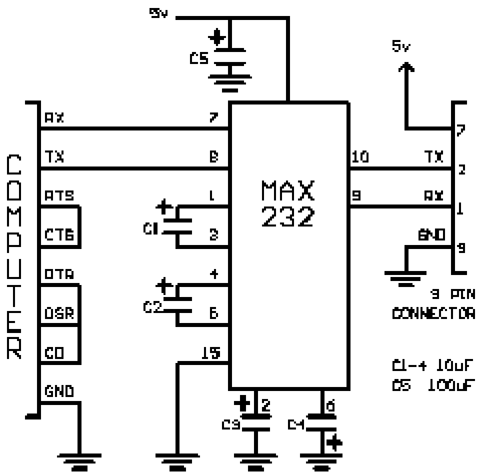

Fig:5.5 Max 232 IC

The MAX232 is an IC, first created in 1987 by Maxim Integrated Products, that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals.

The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case.

The receivers reduce RS-232 inputs (which may be as high as ± 25 V), to standard 5 VTTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V.

Voltage levels:

It is helpful to understand what occurs to the voltage levels. When a MAX232 IC receives a TTL level to convert, it changes a TTL logic 0 to between +3 and +15 V, and changes TTL logic 1 to between -3 to -15 V, and vice versa for converting from RS232 to TTL. This can be confusing when you realize that the RS232 data transmission voltages at a certain logic state are opposite from the RS232 control line voltages at the same logic state. To clarify the matter, see the table below. For more information, see RS-232 voltage levels.

TABLE 5.4 Voltage levels in max 232

RS232 line type and logic level	RS232 voltage	TTL voltage to/from MAX232
Data transmission (Rx/Tx) logic 0	+3 V to +15 V	0 V
Data transmission (Rx/Tx) logic 1	-3 V to -15 V	5 V
Control signals (RTS/CTS/DTR/DSR) logic 0	-3 V to -15 V	5 V
Control signals (RTS/CTS/DTR/DSR) logic	+3 V to +15 V	0 V

Crystal oscillator:

A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. This frequency is commonly used to keep track of time (as in quartz wristwatches), to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is the quartz crystal, so oscillator circuits incorporating them became known as crystal oscillators but other piezoelectric materials including polycrystalline ceramics are used in similar circuits.

Quartz crystals are manufactured for frequencies from a few tens of kilohertz to hundreds of megahertz. More than two billion crystals are manufactured annually. Most are used for consumer devices such as wristwatches, clocks, radios, computers, and cell phones. Quartz crystals are also found inside test and measurement equipment, such as counters, signal generators, and oscilloscopes.

LDR:

A photoresistor or light-dependent resistor[5] (LDR) or photocell is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photoresistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits.

A photoresistor is made of a high resistance semiconductor. In the dark, a photoresistor can have a resistance as high as a few megaohms (MΩ), while in the light, a photoresistor can have a resistance as low as a few hundred ohms. If incident light on a photoresistor exceeds a certain frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free

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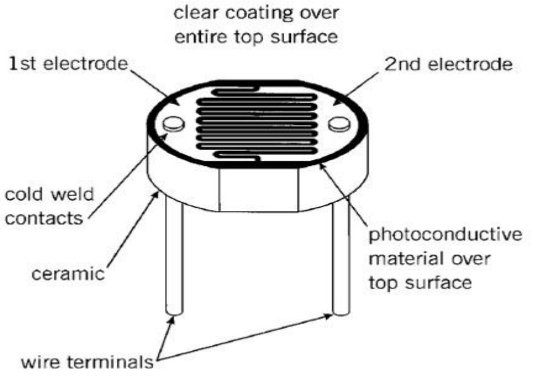
electrons (and its hole partners) conduct electricity, thereby lowering resistance. The resistance range and sensitivity of a photoresistor can substantially differ among dissimilar devices. Moreover, unique photoresistors may react substantially differently to photons within certain wavelength bands.



fin

Fig:5.6 LDR

Relay:

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays[4] 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 as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

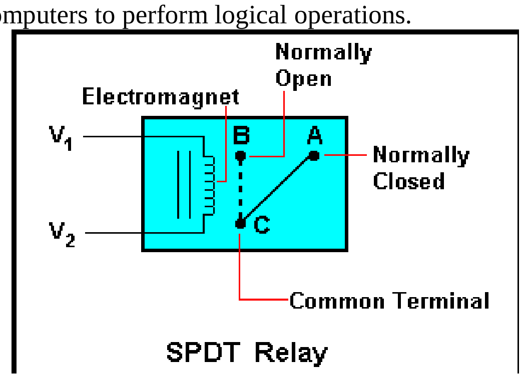


Fig:5.7 relay

555 timer as switch:

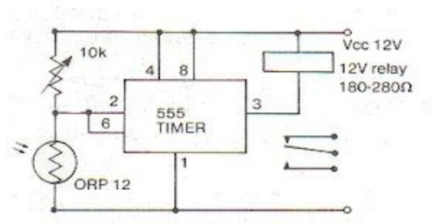


Fig:5.8 555 timer as switch

The use of the 555 timer [5] 1C with an LDR provides a high performance light switch. An LDR is a Light Dependent Resistor and is a very low cost way of detecting light. The 555 is used with its trigger and thresholds tied together to provide a Schmitt trigger with a very low input current but which can drive a relay taking up to 200mA of current. The trigger is activated when the light level on the LDR falls below a predetermined level.

VI. FEATURES

6.1 Automatic load shedding

As the power consumption reaches nearer to the set units, the controller automatically sheds/shuts down the least priority loads through an electromagnetic relay and hence reduces the power consumption and slows down the rate of consumption, if and only if the consumer has requested for this kind of feature

6.2 Warning system

When the units consumed reaches to some value which is not the set units but it is set forefront of the actual limit, it warns the consumer by constantly beeping an alarm and hence makes the consumer cautious about his consumption and prompts him to slow down his consumption.

6.3 Messaging system

If in case no one is present in the home, this unit sends a text message via a gsm module present in this circuit. And hence intimates the user that the limit is about to cross.

VII. FUTURE SCOPE

7.1 Union with maximum demand controller:

This unit can be united with a maximum demand controller to control both the maximum demand and the consumer's electricity bill.

7.2 Solar panel as its power house:

As this unit consumes some power from the supply mains, to nullify this effect we may use a solar panel which powers this circuit by charging a lithium ion battery so that the running cost of this device is drastically reduced.

7.3 Extension with a alphanumeric keypad:

This keypad will enable the user to enter his own consumption and also the units at which he/she wants to get the warnings. This can be set twice, thrice or any number of times in a specific time.

VIII. CONCLUSIONS

By successful implementation of such a kind of hardware project at every house hold it can be expected to cut down the electricity bill of a consumer as well as to reduce the load fluctuations on the system. The maximum demand can be brought into tolerable limits and hence the extra charges incurred from the maximum demand as well as changes in rates from one slab rate to another slab rate can be suppressed.

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