International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-3 Issue-3, August 2013

Smart Biogas Plant

Sunil MP, Ashik Narayan, Vidyasagar Bhat, Vinay S

Abstract*— *The project investigates the development of a low cost, efficient, portable biogas plant for the generation of energy from discarded kitchen wastes and food waste. The main purpose of the project is to cut down on the landfill wastes and generate a reliable source of renewable, decentralized source of energy for the future. Biogas generation does not require a complex technology and can be applied globally. Kitchen waste discarded causes public health hazards, the project also looks into prevention of various diseases including malaria, typhoid and also meets the social concerns in the society. Household digesters represent a boon for urban and rural people to meet their energy needs. These digesters help in two ways: one is to reduce waste and the other is to provide valuable energy.

***Index Terms*— *Biogas, Digesters,* GSM, *Kitchen waste, MQ5-Gas Sensor, PIC Microcontroller*.**

I. INTRODUCTION

Renewable energy resources such as solar energy, Biogas energy, wind energy, different thermal and hydro sources of energy. Biogas is the only sources on which the world can survive on in the future. Use of dung, firewood as energy is also harmful for the health of the masses due to the smoke arising from them causing air pollution. We need an eco-friendly substitute for energy. Biogas serves this, it does not have any geographical limitations nor does it require advanced technology for producing energy, also it is very simple to use and apply. Kitchen waste is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several orders of magnitude as said earlier. Hence we proposed system, with higher efficiency, compact size of digester and low cost of biogas production. Biogas refers to a gas produced by break down of organic matter in the absence of oxygen. Organic wastes such as kitchen wastes can be converted in to a gaseous fuel called as biogas. Biogas can be produced using anaerobic digesters. During the process, as an air-tight tank transforms biomass waste into methane producing renewable energy that can be used for heating, electricity, and many other operations that use any variation of an internal combustion engine. The process of generation of biogas depends on fermentation. Fermentation is the process in which chemical breakdown of a substance by bacteria, yeasts, or other microorganisms, typically involving effervescence and the giving off of heat. Typically fermentation process takes several weeks to complete and thus the energy generation is always a problem.

The basic idea of the project is to enhance the process of fermentation using eco-friendly chemicals thus making it a more reliable source to generate energy from portable equipment developed with minimal cost.

II. RELATED WORK

Appropriate Rural Technology of India, Pune (2003) has developed a compact biogas plant which uses waste food rather than any cow dung as feedstock, to supply biogas for cooking. The plant is sufficiently compact to be used by urban households, and about 2000 are currently in use – both in urban and rural households in Maharashtra. The design and development of this simple, yet powerful technology for the people, has won ARTI the Ashden Award for sustainable Energy 2006 in the Food Security category.

Dr. Anand Karve (ARTI) developed a compact biogas system that uses starchy or sugary feedstock (waste grain flour, spoilt grain, overripe or misshapen fruit, non-edible seeds, fruits and rhizomes, green leaves, kitchen waste, leftover food, etc). Just 2 kg of such feedstock produces about 500 g of methane, and the reaction is completed with 24 hours.

Shalini Singh[4] et al. (2001), laboratory studies were undertaken to evaluate the effect of microbial stimulants Aquasan and Teresan, on biogas yields from cattle dung and combined residues of cattle dung and kitchen waste, respectively. The addition of single dose of Aquasan at the rate of 10, 15 and 20 ppm to cattle dung on the first day of incubation resulted in increased gas yields ranging between 45.1 and 62.1 l/kg dry matter. Subsequent addition of Aquasan at 15 and 20 ppm dosage after a period of 15 days increased the gas yields by 15-16%. The gas production was found to be optimum at a dosage level of 15 ppm and was 39% and 55% higher with single and dual additions, respectively, than untreated cattle dung. In another bench scale study (1:1 dry matter) the addition of Teresan at 10 ppm concentration to the mixed residues of cattle dung and kitchen wastes at different solids concentration.

Hilkiah Igoni[5] proposed, Municipal Solid Waste (MSW) based system, which contains a relatively large amount of organic matter, which decomposes by the actions of microorganisms under anaerobic conditions to produce biogas. The total solids (TS) concentration of the waste influences the pH, temperature and effectiveness of the microorganisms in the decomposition process. This work investigated various concentrations of the TS of MSW in an anaerobic continuously stirred tank reactor (CSTR) and the corresponding amounts of biogas produced, in order to determine conditions for optimum gas production. Five laboratory-scale anaerobic batch digesters of 5 liters volume each were set up for the digestion of 2kg of shredded MSW diluted to a %TS concentration of 26.7%.

Manuscript published on 30 August 2013.
*****Correspondence Author(s)

Mr. Sunil MP, Assistant Professor, Department of Electronics and Communication Engineering, School of Engineering and Technology, Jain University, India.

Ashik Narayan, Student, Department of Electronics and Communication Engineering, School of Engineering and Technology, Jain University, India.

Vidyasagar Bhat, Student, Department of Electronics and Communication Engineering, School of Engineering and Technology, Jain University, India.

Vinay S, Student, Department of Electronics and Communication Engineering, School of Engineering and Technology, Jain University, India.

The results from the batch experimentation were adapted to the design of a CSTR for the digestion of MSW.

Thomsen et al., [12] (2004 investigated anaerobic digestion of solid biowaste generally results in relatively low methane yields of 50−60% of the theoretical maximum. Increased methane recovery from organic waste would lead to reduced handling of digested solids, lower methane emissions to the environment, and higher green energy profits. The biodegradability of the waste was evaluated by using biochemical methane potential assays and continuous 3-L methane reactors. Wet oxidation temperature and oxygen pressure (T, 185−220 °C; O_2 pressure, 0−12 bar; t, 15 min) were varied for their effect on total methane yield and digestion kinetics of digested biowaste.

Jong Won Kang [14] et al (2010) studied the On-site Removal of H2S from Biogas Produced by Food Waste using an Aerobic Sludge Bio-filter for Steam Reforming Processing. They show that A bio-filter containing immobilized aerobic sludge was successfully adapted for the removal of H2S and CO2 from the biogas produced using food waste. The bio-filter efficiently removed 99% of 1,058 ppm v H2S from biogas produced by food waste treatment system at a retention time of 400 sec. The maximum observed removal rate was 359 g-H2S/m3/h with an average mass loading rate of 14.7 g-H2S/m3/h for the large scale bio-filter. The large-scale bio-filter using a mixed culture system showed better H2S removal capability than bio-filters using specific bacteria strains. In the kinetic analysis, the maximum H2S removal rate (Vm) and half saturation constant (Ks) were calculated to be 842.6 g-H2S/m3/h and 2.2 mg/L, respectively.

III. PROPOSED SYSTEM

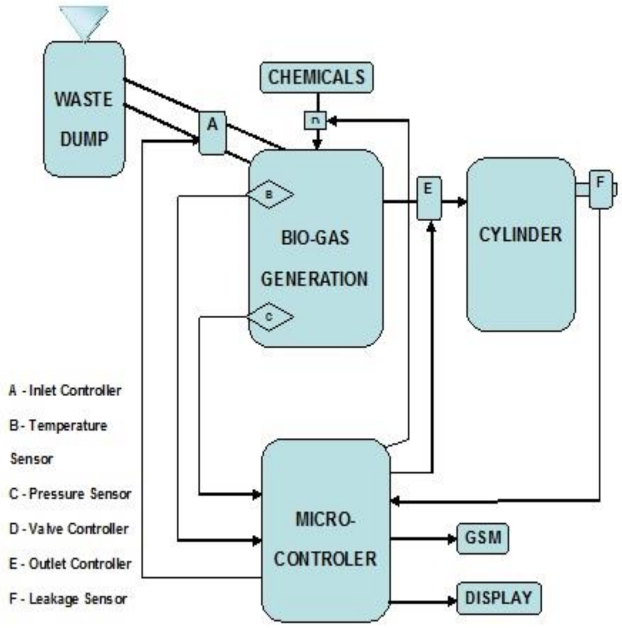

Fig 1: Basic Functional Block diagram

Kitchen wastes from daily uses are fed to the waste dump. These wastes are mixed with grinder to make fluid and chemicals are added in proper proportion to the biogas generation plant. The proportion of the chemicals is however controlled by the microcontroller. The produced biogas after the process of fermentation is stored in the cylinder. The temperature, pressure and gas of the system are monitored using sensors and displayed by the display unit. The sensors are controlled by using the microcontrollers. Using the microcontroller the input and the output valves are also controlled. If the gas produced in the generation plant reaches 80% or the pressure of digester reached 70 Kpa are detected, the system will send SMS intimation to the user using GSM modem by giving information to open the inlet valve of the cylinder to fill it.

IV. HARDWARE IMPLEMENTATION

Whole System design can be divided into following sections:-

Electronic Hardware Design ii) Mechanical Design

i) Electronic Hardware Design:

A. Power supply modules

This module is basically designed to achieve 12V, 1A and 5V, 500mA. This consists of a transformer which is used to step down the AC voltage, IN4007 diodes used to form a bridge rectifier to convert AC to DC, capacitor 1000uF which used as a filter circuit, 7812 regulator to obtain a 12V and followed by 7805 regulator to obtain a 5V at the output of the regulator, 330 ohm resistance and LED as indicator is as shown in figure 2.

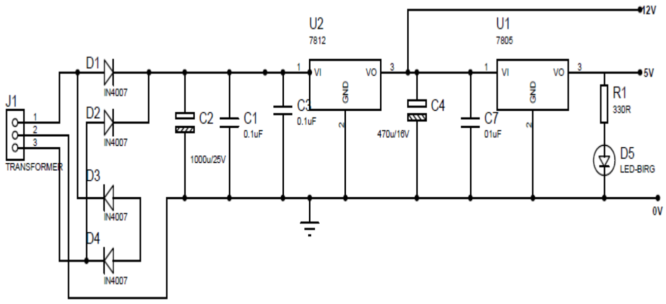

Fig 2: Diagram of Power Supply section

B. PIC Microcontroller

Controller is the heart of the design. It controls I/O devices connected to board. It controls an LCD display which is used to display purpose. PIC microcontroller is RISC architecture. The PIC microcontroller was originally designed around 1980 by General Instrument as a small, fast, inexpensive embedded microcontroller with strong I/O capabilities. PIC stands for "Peripheral Interface Controller". A microcontroller is an integrated chip that is often part of an embedded system. The microcontroller includes a CPU, RAM, ROM, I/O ports, and timers also supports serial protocols SPI, USART, USB and I^{2}C. They are much smaller and simplified so that they can include all the functions required on a single chip PIC18F452 is one of the most advanced microcontroller from Microchip.

C. GSM Modem

The Global System for Mobile (GSM) communication is the Second Generation of mobile technology. Although the world is moving towards Third and Fourth generation but GSM has been the most successful and widespread technology in the communication sector.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

GSM technology paved a new way for mobile communication. In our design we have interfaced GSM Module with a PIC microcontroller, when there is detection of 80% of biogas in the reactor the GSM module will send SMS to the user by intimating gas has been detected and also it will display on LCD. A line converter MAX232 is employed to convert the RS232 logic data of GSM Module to TTL logic so that it can be processed by the microcontroller.

To Send a SMS using GSM Modem

- Enter "AT" in the HyperTerminal, the board will echo "OK" if everything is properly setup
- To send SMS send the command -> AT+CMGF=1
- Modem will acknowledge by sending the text -> OK
- Then send -> AT+CMGS="NUM" Where NUM is the number you want to send the SMS to.
- Modem will acknowledge by sending the text - TYPE THE MESSAGE>
- Enter the message and then press ctrl+z to send SMS.

D. LCD Display

LCD is a type of display used in digital watches and many portable computers. LCD displays utilize sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. LCD technology has advanced very rapidly since its initial inception over a decade ago for use in lap top computers. Technical achievements has resulted in brighter displace, higher resolutions, reduce response times and cheaper manufacturing process. This LCD can be used to display 20 characters in 4 rows. It has the ability to display numbers, characters and graphics. It has an inbuilt refreshing circuit, thereby relieving the CPU from the task of refreshing. The figure 3 shows the interface of PIC microcontroller with LCD using parallel multi bit output. Data is sent serially into shift register at a very faster rate whereas the register transmits the same data to the LCD parallel data lines using D0 to D7.

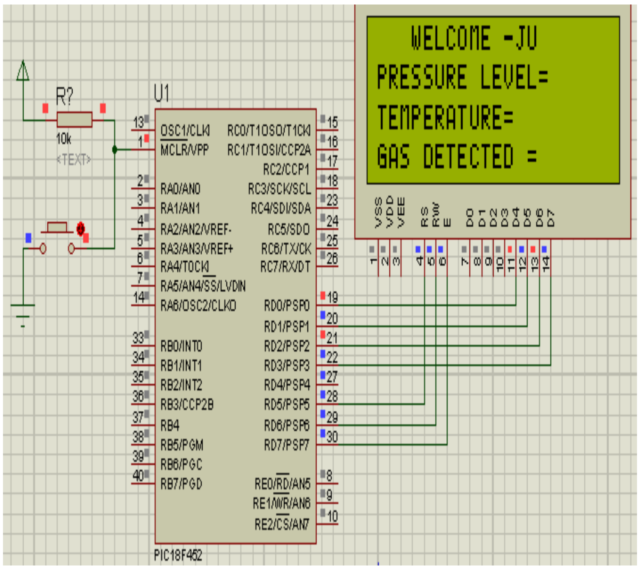

Fig 3: Interface of 20x4 LCD with Microcontroller

E. Sensors

MPX4115 pressure sensor integrates on-chip, bipolar op amp circuitry and thin film resistor networks to provide a high level analog output signal and temperature compensation.

MQ5 (Gas Sensor)-The presence of dangerous LPG leakage in the cars, service station or in the storage tank environment can be detected using the Ideal Gas Sensor. This unit can be easily integrated into a unit that can sound an alarm or give a visual suggestion of the LPG concentration. The sensor has both admirable sensitivity and rapid response time. This sensor can also be used to sense other gases like iso-butane, propane, LNG and even cigarette smoke.

Temperature Sensor (LM35) - The LM35 series are precision integrated-circuit temperature sensors, with an output voltage linearly proportional to the Centigrade temperature. Thus the LM35 has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The device is used with single power supplies, or with plus and minus supplies. As the LM35 draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 is rated to operate over a −55°C to +150°C temperature range.

V. SOFTWARE IMPLEMENTATION

A. Microcontroller Programming with Embedded C

MPLAB IDE is a software program that runs on a PC to develop applications for Microchip microcontrollers. It is called an Integrated Development Environment, or IDE, because it provides a single integrated "environment" to develop code for embedded system. The MPLAB C18 compiler is a full-featured ANSI-compliant C compiler for the Microchip Technology PIC18CXXX family of PICmicro® microcontrollers (MCUs).MPLAB C18 is fully compatible with Microchip's MPLAB Integrated Development Environment (IDE), allowing source level debugging with both the MPLAB ICE 2000 In-Circuit Emulator and the MPLAB SIM simulator.

B. Proteus Simulator

Proteus VSM for PIC18 contains everything you need to develop; test and virtually prototype your embedded system designs based around the Microchip Technologies™ PIC18 series of microcontrollers. The unique nature of schematic based microcontroller simulation with Proteus facilitates rapid, flexible and parallel development of both the system hardware and the system firmware. This design synergy allows engineers to evolve their projects more quickly, empowering them with the flexibility to make hardware or firmware changes at will and reducing the time to market.

C. PIC Kit 2 Programmer

The PICkit 2 Development Programmer/Debugger is a low-cost development tool with an easy to use interface for programming and debugging Microchip's Flash families of microcontrollers. With Microchip's powerful MPLAB Integrated Development Environment (IDE) the PICkit 2 enables in-circuit debugging on most PIC microcontrollers.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

VI. RESULTS AND DISCUSSION

Table 1 shows the two weeks data for the quality of the biogas produced at the plant. As mentioned above Kitchen waste is organic material having the high calorific value and nutritive value to microbes that is why efficiency of methane production can be increased by several orders of magnitude. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences: It not only leads to polluting surface and groundwater through leachate and further promotes the breeding of flies, mosquitoes, rats and other disease bearing vectors. Also, it emits unpleasant odour & methane which is a major greenhouse gas contributing to global warming. This fact can be seen in current practices of using low calorific inputs like cattle dung, distillery effluent, municipal solid waste (MSW) or sewage, in biogas plants, making methane generation highly inefficient. We can make this system extremely efficient by using kitchen waste/food wastes.

Table 1. Results of two weeks.

Property	Existing model	Proposed model
Type of waste processed	Mainly gobar	Kitchen waste and Food waste
Waste feed	Direct	After making slurry in mixer
Handling waste	Direct	Needs segregation
Processing time	20-25 days	8 days
Methane	60-65%	70-75%
Scope	Rural mainly	Urban and rural
Gas generated	90 gms of biogas	100-120 gms of biogas

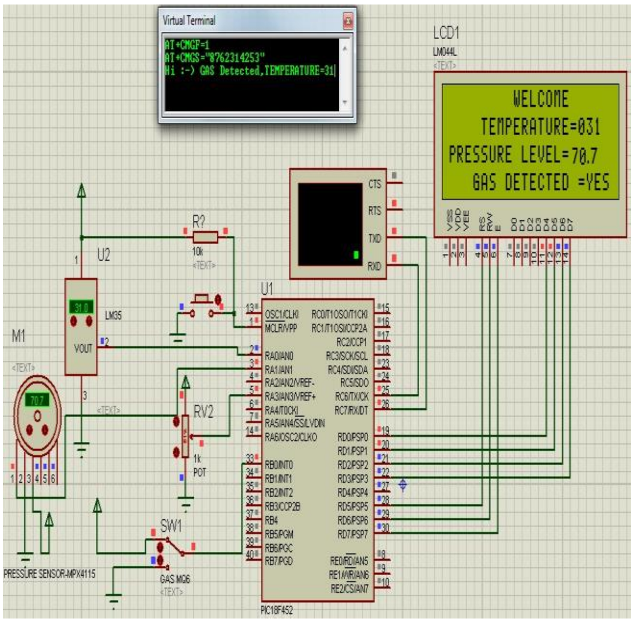

Fig 4: Complete System Simulated Results

As shown in above figure 4, when there is 80% of gas level detection from MQ5 gas sensor or 70 Kpa Pressure level detection from MPX4115 pressure sensor, the system will send an auto SMS intimation to the user by using GSM modem, here we can see it on virtual terminal is as shown in figure 4. The complete hardware design setup is shown in figure 5.

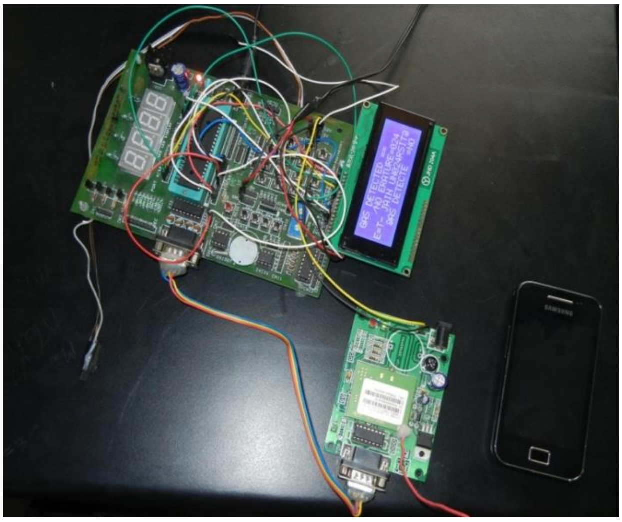

Fig.5: Hardware design

VII. CONCLUSION

Household digesters represent a boon for urban and rural people to meet their energy needs. These digesters help in two ways: one is to reduce waste and the other is to provide valuable energy. Although they have been used for many years, modernization is needed to overcome the drawbacks in the long run system. Hence we proposed system, the new modernized model with higher efficiency, with compact size of reactor and low cost of biogas production. In most of cities and places, kitchen waste is disposed in landfill or discarded which causes the public health hazards and diseases like malaria, cholera, typhoid. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences: It not only leads to polluting surface and groundwater through leachate and further promotes the breeding of flies, mosquitoes, rats and other disease bearing vectors. Also, it emits unpleasant odour & methane which is a major greenhouse gas contributing to global warming, so by using this we can avoid causes and reduce waste.

The future work to proposed system, in the present energy crisis, after biogas utilization it can be upgrade to power generation applications such as lightening & electricity. The proposed system is partially automated hence we can build fully automated system by using electronic valve and suitable motors. And other enhancement is that, still the processing time of biogas generation can be minimized by using highly reactive chemicals and also we can build hot reactor in order to maintain a temperature of 37°C to make constant biogas production and increase production rate.

REFERENCES

1. Biogas Plant based on Kitchen Waste by S. P. Kale and S. T. Mehetre, Nuclear Agriculture and Biotechnology Division.
2. Karve .A.D. (2007), Compact biogas plant, a low cost digester for biogas from waste starch. http://www.arti-india.org.
3. Karve of Pune A.D (2006). Compact biogas plant compact low-cost digester from waste starch. www.bioenergylists.org.
4. Singh, Shalini ; Sushil Kumar, ; Jain, M. C. ; Kumar, Dinesh (2001), *Increased biogas production using microbial stimulants* Bioresource Technology, 78 (3). pp. 313-316. ISSN 0960-8524

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

5. A.H. Igoni, M.F.N. Abowei, M.J. Ayotamuno and C.L. Eze. "Effect of Total Solids Concentration of Municipal Solid Waste on the Biogas produced in an Anaerobic Continuous Digester". Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 07 010. Vol. X. September, 2008.
6. Tanzania Traditional Energy Development and Environment Organization (TaTEDO),
7. BIOGAS TECHNOLOGY- Construction, Utilization and Operation Manual.
8. The University of Southampton and Greenfinch Ltd. - Biodigestion of kitchen waste A comparative evaluation of mesophilic and thermophilic biodigestion for the stabilisation and sanitisation of kitchen waste.
9. Ranjeet Singh, S. K. Mandal, V. K. Jain (2008), Development of mixed inoculum for methane enriched biogas production.
10. Kumar, S., Gaikwad, S.A., Shekdar, A.K., Kshirsagar, P.K., Singh, R.N. (2004). Estimation method for national methane emission from solid waste landfills. Atmospheric Environment. 38: 3481–3487.
11. Jantsch, T.G., Matttiason, B. (2004). An automated spectropphoyometric system for monitoring buffer capacity in anaerobic digestion processes. Water Research. 38: 3645-3650.
12. Thomsen, A.B., Lissens, G., Baere, L., Verstraete, W., Ahring, B. (2004). Thermal wet oxidation improves anaerobic biodegradability of raw and digested biowaste, Environmental Science and Technology, 38 (12), pp 3418–3424, 2004
13. Meres, M., Szczepaniec-Cieciak, E., Sadowska, A., Piejko, K., Oczyszczania, M.P., Szafnicki, K. (2004). Operational and meteorological influence on the utilized biogas composition at the Barycz landfill site in Cracow, Poland. Waste Management Resource. 22: 195–201.
14. Jong Won Kang, Chang Moon Jeong, Nag Jong Kim, Moon Il Kim, Ho Nam Chang. (2010). "On-site removal of H 2 S from biogas produced by food waste using an aerobic sludge biofilter for steam reforming processing", Biotechnology and Bioprocess Engineering - BIOTECHNOL BIOPROCESS ENG , vol. 15, no. 3, pp. 505-511, 2010.

AUTHOR PROFILE

Mr. Sunil MP, currently working as an Assistant Professor in the department of Electronics & Communication Engineering, School of Engineering and Technology, Jain University, Karnataka, India. He has received B.E degree in Electronics and Communication from VTU in 2009. He has received M.Tech degree in Electronics Design and Technology from National Institute of Technology, Calicut, Kerala in 2011. His research interests include Network Security, Embedded Systems Design, Analog and Mixed signal VLSI Design, Ultra-Thin Gate insulators for VLSI Technologies, RF VLSI Design, Microelectronics System Packaging, Microelectronics, Micro/Nano Sensor Technology, High-speed CMOS analog/RF-wave integrated circuits and systems.

Ashik Narayan received B.E degree in Electronics & Communication from School of Engineering and Technology, Jain University, Karnataka, India. He is working at Design Esthetics as a Web Developer.

Vidyasagar Bhat received B.E degree in Electronic & Communication from School of Engineering and Technology, Jain University, Karnataka, India. Currently working at Pyrodynamics-India for strain measurement system design and his areas of interest include network security, VLSI and Embedded System design, Digital system design and Power Electronics.

Vinay S received B.E degree in Electronics & Communication from School of Engineering and Technology, Jain University, Karnataka, India. His areas of interests include VLSI Design, Embedded Systems, Microelectronics and Nanotechnology.

.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)