COMPARATIVE ANALYSIS OF ADIABATIC NAND GATE

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1

. Introduction of adiabatic

In CMOS circuit dominant source of power dissipation is due to the switching operation. During the switching operation power is dissipated in charging or discharging the parasitic capacitances during the voltage transition of the nodes.[4] A node capacitance C_L is charged from 0 to V_{dd}, and an amount

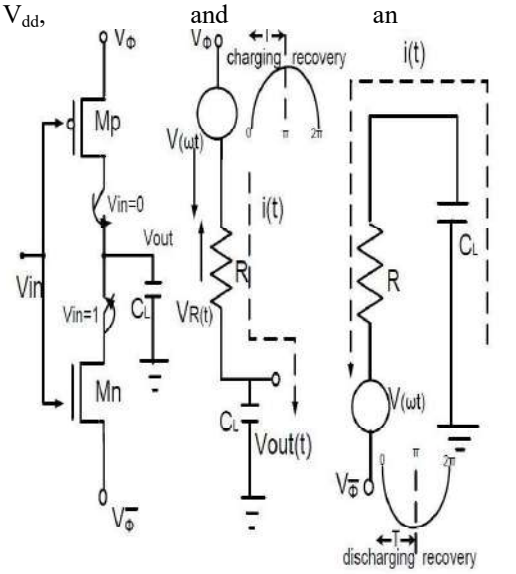

Fig1:Adiabatic Switching Principle

2.Conventional CMOS:

Conventional CMOS dissipates high power which is not desirable for portable devices. In this a constant power supply is used since power can not be reused. To overcome these problems adiabatic is developed with thermodynamics principle. devices but this affects the driving capability and speed.[11]In adiabatic switching for charge up phase, the output load is charged very slowly compared to its' time constant such that the voltage drop across the switching PMOS transistor is very small. [25]In this way the energy dissipation which occurs due to the finite rate of change of driving voltage is decreased[.8],[10]and physical capacitance. But there is a limitation, while reducing V_{dd}, sub threshold leakage current increases.[12] Physical capacitances may be decreased by reducing the sizes ofswitching energy dissipation by reducing the supply voltage In charge down phase instead of ejecting the charge to ground in each clock cycle, circuit is designed so that the charge can flow back to the power clock.[26],[28] In the circuit of Fig. 1 the supply V_Φ, swings gradually from 0 to V_{dd} .[20],[21]. $C_LV_{dd}/2$ is stored in load capacitances.[16]The energy which was stored in output load capacitance is dissipated in NMOS transistor in charge down phase.in conducting PMOS transistor, and other half energy i.e. One can reduce this The peak current can be significantly reduced by ensuring uniform charge transfers over the entire available time.of V_{dd} ($=C_LV_{dd}/2$) energy drawn from the supply. In charge up phase one half of this energy i.e. . $C_LV_{dd}/2$ is dissipated as heat Due to this there will be very little voltage drop across the channel of PMOS transistor, and hence very small amount of energy is dissipated.[1], [5], [6], [7], [9] A simple method to estimate the power dissipation in this case is:

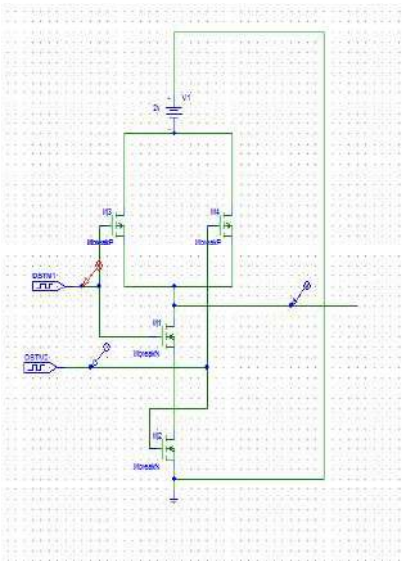

Fig2:Conventional NAND Gate

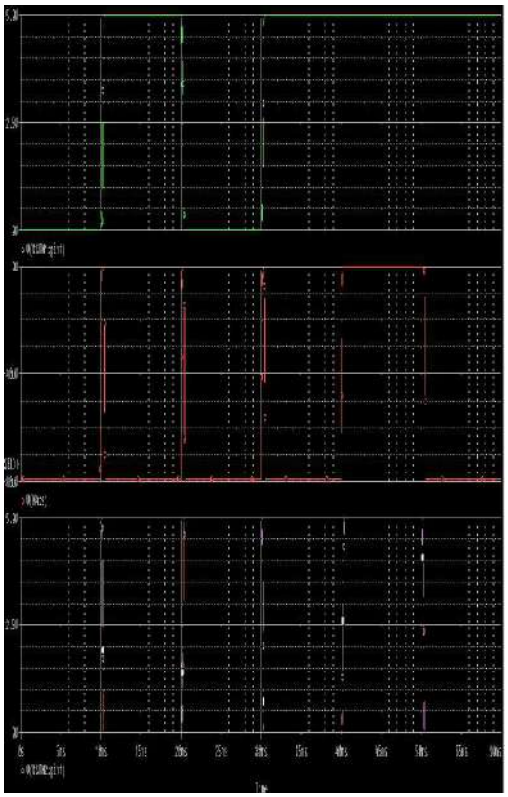

Fig3:Simulation Waveform

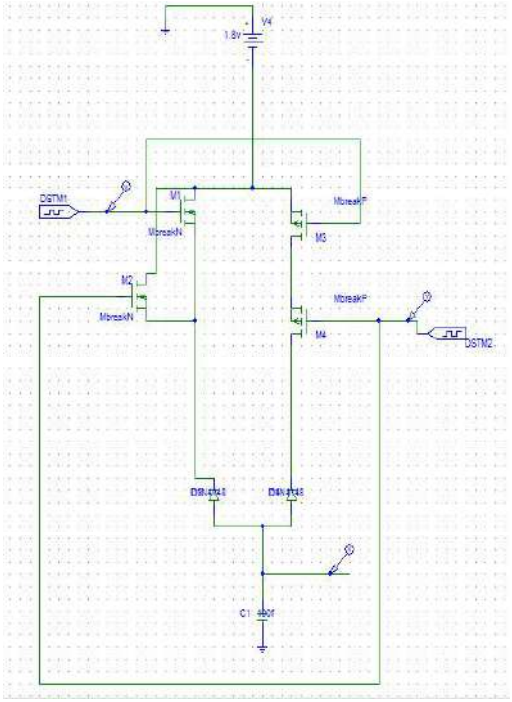

Fig4: GFCAL NAND Gate

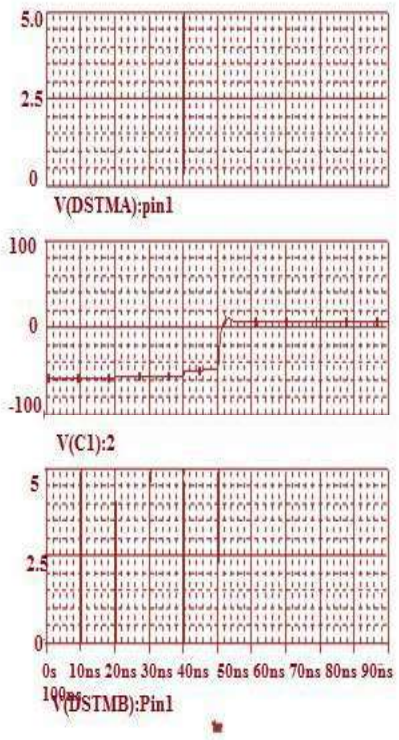

Fig5:Simulation Waveform

3.Logic Families:

3.1.GFCAL:

Glitch free cascadable adiabatic logic (GFCAL) circuit by replacing the triangular power supply with sinusoidal and trapezoidal power supplies (that control the charging and discharging of the capacitive load) and by sizing of transistors.[23] A simulative investigation and performance analysis of proposed approach based on GFCAL NAND gate. Circuit have also been done.[17] The triangular power supply produces very large delay at the outputs of GFCAL circuits thus it will be very difficult to cascade larger circuits. A solution to provide cascadability is optimization of the delay.[13],[14]

3.2.PFAL:

PFAL use power clock instead of normal one as it is also used to energize the logic networks i.e. no extra dc power source is used and time varying ac signal is uses to actuate the circuit elements along with the clock in control.[2] In PFAL 4 phase clock is uses namely ideal, evaluate, hold, recover stages, Ideal stage is inherently used for pipeline of different stages during evaluation phase the logic is evaluated as per the unit vectors which is kept retained during the hold stage.[3],[15] Charge is

recovered back but PFAL does not provide full recovery of charge and hence it is considered as partial recovery adiabatic logic family.[19]

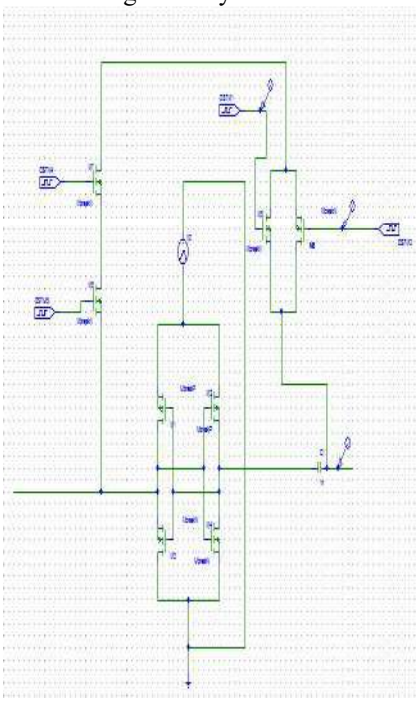

Fig6:PFAL NAND Gate

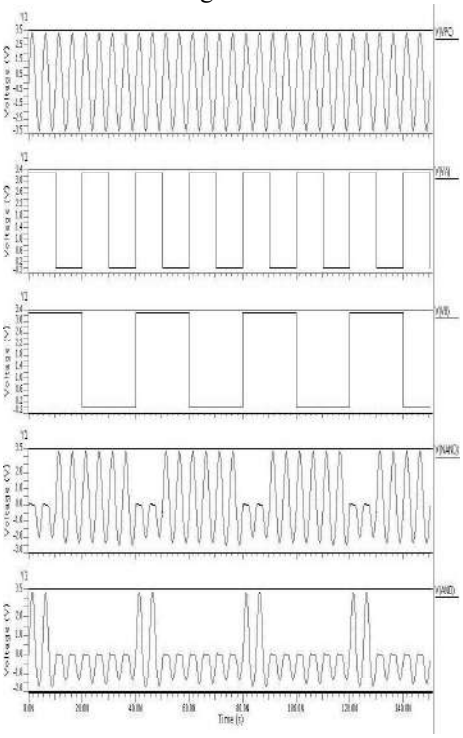

Fig7:Simulation Waveform

4.Comparision of CMOS and Adiabatic Logic circuits:[18]

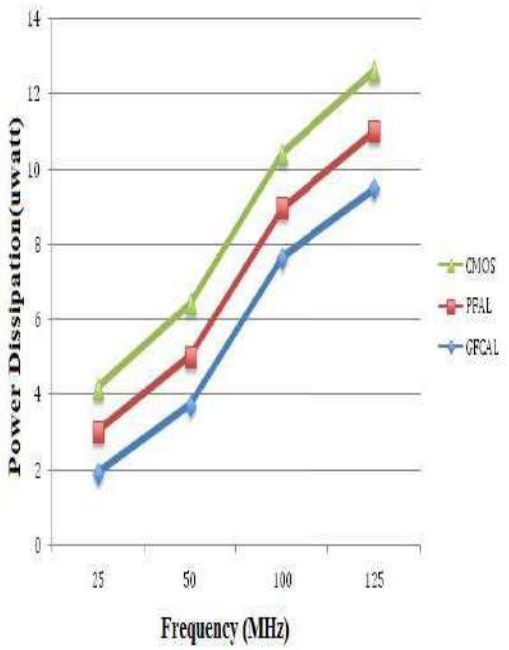

Fig8: Graph Representation of Power Dissipation vs Frequency

Frequency (MHz)	Static CMOS (µW)	GFCAL logic(µW)	PFAL logic (µW)
[]25	1.9138	1.1105	1.1655
50	3.8275	1.1007	1.4141
100	7.6543	0.932	1.4532
125	9.4858	0.817	1.6039

CONCLUSION

In this paper we have observed that replacement of dc supply with the power clock supply reduces the power consumption of adiabatic circuit. It is concluded that GFCAL based circuit with sinusoidal and trapezoidal power clocks have very less delay than the triangular power clock based circuits with a very small incremented power dissipation however overall power dissipation is very less compared to conventional CMOS circuits.

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LOW POWER DESIGN OF INVERTER USING ADIABATIC LOGIC

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Abstract- *Minimization of power dissipation is one of the major concerns in making any electronic device portable. Although there has been significant decrease in circuit operating voltages yet noticeable amount of power is lost in switching circuits. An answer to this never ending need of low power design has been given by adiabatic logic design. The adiabatic switching technique reuses the energy stored in the capacitances which is otherwise lost as heat. The loss of power is reduced by the use of time varying clock. This paper talks of the adiabatic logic design of inverter using different adiabatic logic families.*

Keywords: power dissipation, low power design, adiabatic logic design, adiabatic switching technique, time varying clock.

1.INTRODUCTION

The need of reduction in power dissipation in digital systems is gaining attention and importance as the demand of portable electronic devices is increasing. Factors such as battery life, weight and size depend on the power dissipation that occurs in the circuit. Increasing demands for low power designs has inspired the engineers to explore new methods in VLSI design in order to enhance the performance and capabilities of these systems. As circuit elements are getting smaller and circuit densities are growing, the problem of power dissipation minimization has become a real matter of concern. Power dissipation is mainly concerned with the switching that takes place in the transistors. This power dissipation is directly proportional to the input voltage squared (V_{dd}^2). Therefore one of the ways of reducing the power dissipation is to scale down the power supply. Although this definitely reduces the power loss, yet some power will be lost for every erased bit. This is governed by Launder's principle. Even though the magnitude is not so large as far as single transistor is concerned, one should not forget that modern era microprocessors and other integrated circuits make use of hundreds of millions of the transistors. Thus it is important for devices to make proper and wise use of the available energy. Some of the techniques in reducing power dissipation in conventional CMOS circuits other than reduction in the supply voltage include reduction in output capacitances, switching frequencies and shrinkage in transistor size. However transistor size shrinkage could not give significant benefits in energy dissipation.

2.BACKGROUND

Adiabatic logic design which is also known as energy recovery circuitry is a new approach in designing of VLSI circuits with low power dissipation which ideally performs as a reversible thermodynamic process with no loss or gain of energy. Reversible logic is a calculation approach in which the information that is no longer required is not allowed to dissipate as heat, rather saved so that the operations could be undone latter. It uses the basic energy and charge conservation principle in power dissipation reduction. Adiabatic switching operates by creating minute changes in energy levels in circuits, ideally leading in no power losses.

Power dissipation in CMOS transistors mainly takes place due to switching activities of the devices and can become easily understandable by studying CMOS inverter as shown in figure 1(a) and 1(b).

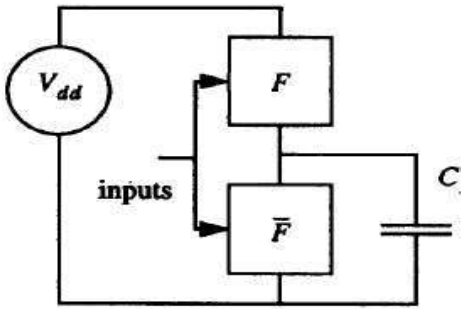


Fig. 1(a). Conventional CMOS logic gate with pull up and pull down network

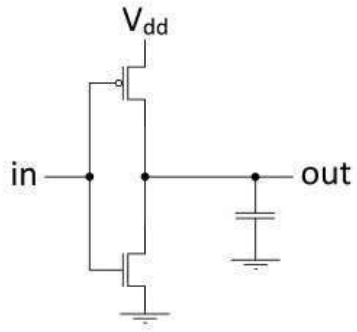


Fig. 1(b). CMOS inverter

The inverter consists of two transistors namely pull up and pull down transistors. These two transistors are nothing but pmos and nmos respectively. They are connected to the output capacitor having capacitance C. Here this capacitor acts as the fan out to the inverter. Figure 2 shows the equivalent simplified circuit of the CMOS inverter where R represents the channel resistance.

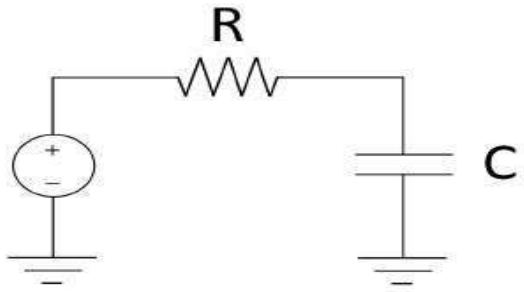


Fig. 2. Equivalent circuit of CMOS inverter

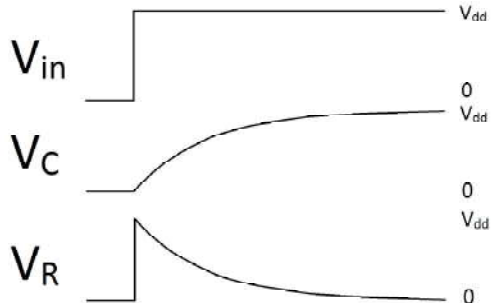


Fig. 3. Voltages at input, capacitor and resistance of equivalent circuit

The energy dissipated in the above given circuit can be calculated as

$$E_{app}=CV_{dd}^2 \quad (1)$$

When the voltage changes from 0 to V_{dd} then the amount of current flowing through the circuit is calculated as

$$i(t)=(V_{dd}^2/R)e^{-t/RC} \quad (2)$$

and the power used is

$$P(t)=(V_{dd}^2/R)e^{-2t/RC} \quad (3)$$

The energy stored in the capacitor C can be obtained by integrating the power over time and can be given as

$$E_{stored}=CV_{dd}^2/2 \quad (4)$$

From equation (4) it can be inferred that of the entire power supply half of the energy is stored in the capacitor while the other half is lost as heat across the resistance R during the charge cycle. The energy stored in the capacitor is lost during the discharge cycle. In order to minimize the power dissipation one should look towards the minimization of the energy lost in the transistor network. If f is the frequency needed to drive the circuit and T is the time period then the total power that is supplied to the circuit is calculated as

$$P_{app}=E_{app}/T=CV_{dd}^2/T \quad (5)$$

If the charging is done at the lower frequency f using a constant current source, the wastage of energy can be minimized. Therefore the dissipated energy can be calculated as

$$E_{diss}=Pt=(CV_{dd}/t)^2RCt \quad (6)$$

where t is the charging time. If this charging time is made infinitely long, from the equation (6) it can be inferred that the amount of energy dissipated will reduce to zero. The dissipated energy is directly proportional to the resistance. Thus the energy loss can be significantly reduced if this resistance decreases.

3. POWER CLOCK

Maximum part of the energy is lost during the rising edge of the square signal because at this stage the charge flows all of a sudden. If the clock is made as much linear as possible, depending on the logic family, the loss of energy can be minimized. Since the oscillator functions as power supply as well as clock, it is referred to as power clock.

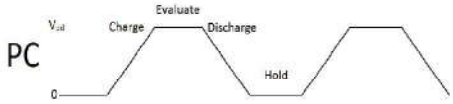


Fig. 4. Single phase trapezoidal clock

One of the basic adiabatic oscillators take trapezoidal shape which consists of four stages namely charge, evaluate, discharge and idle. The output capacitor gets charged during the charging stage, output is evaluated during the evaluation stage, capacitor gets discharged in adiabatic manner during discharge stage and the power clock is maintained at GND during the idle stage.

4. ADIABATIC LOGIC FAMILIES

Adiabatic logic families can be basically classified into two parts:

Fully Adiabatic: This family operates quite slowly and almost entire input energy is retrieved back.

Partially (Quasi) Adiabatic: In this family some part of the energy is recovered while some portion is lost in non adiabatic operations.

Adiabatic families can also be classified into two parts depending on the charge recovery:

- With diodes.
- Without diodes.

4.1 Adiabatic families with diodes

4.1.1. Adiabatic dynamic logic family (ADCL): Though similar to conventional CMOS inverter, yet this family shows differences from the conventional inverter. One of the major differences is the power clock is applied at the power supply. The diode is represented through it's equivalents which are nmos and pmos equivalents. The power clock is single phase sinusoidal pulse and is connected to ground connection as well. When the power clock swings from high to low, then it is called discharge phase and when the power clock swings from low to high it is called charging phase. If the input switches from low to high then the output follows the power clock during the discharge. This leads to the recovery of charge stored in the capacitor into the circuit. During the charging phase when the input switches from high to low, the output again follows the power clock and changes until

the power clock attains the value equal to V_{dd}. The speed of operation of this family is inversely proportional to the number of gates, thus this family is not suitable in implementation of larger circuits. This is one of the major drawbacks of ADCL family.

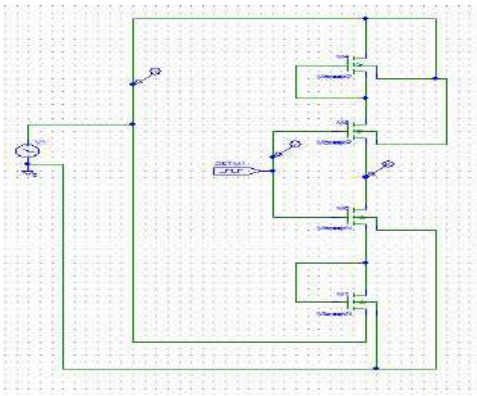


Fig. 5 Schematics of ADCL Inverter

Two phase dynamic CMOS logic family is the family which overcomes certain disadvantages of the ADCL family. The setup of 2PADCL is similar to that of ADCL with a difference that it uses two complementary power clocks connected at each end of the circuit. The operating speed of this family is greater than that of ADCL because the next stage of this family does not have to wait for the output from the current stage.

4.2 Adiabatic families without diodes:

4.2.1 1n1p: This family of adiabatic circuits is independent of diodes and is quasi adiabatic logic family. Its setup is similar to that of the conventional CMOS inverter but the difference arises when it uses single phase sinusoidal driver that oscillates between V_{dd} and GND. The nmos turns ON when the applied input is high and the corresponding output inverts and becomes low. When the input turns out to be low, the corresponding output then rises and reaches the maximum value of the power clock, say V_{pc}. The charge stored in the capacitor is recovered when the power clock ramps down from V_{pc} and the output follows it. One of the major drawbacks of this family is that it cannot be used in pipelining because the next stage will not give reliable output if the input changes. Thus care should be taken that the input remains constant while the computation of the output so as to obtain reliable data at the output.

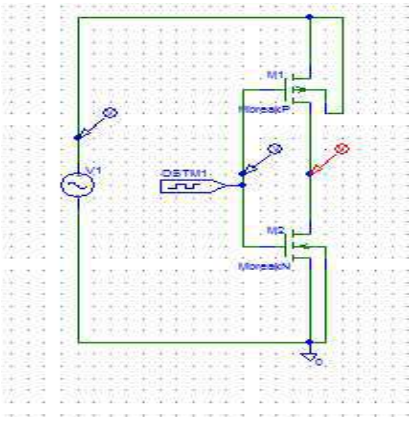


Fig. 6. Schematics of 1n1p inverter

4.2.2. 2n2p: This logic family consists of two nmos and two pmos. This family accepts two inputs where one of the inputs is the complementary of the other and gives two outputs such that one of the outputs is complementary of the other. The power clock used in this family is four phase trapezoidal clock. The beginning of the clock takes place from the reset stage. The inputs are kept low at this instant and the corresponding outputs obtained are complementary. The high output ramps down adiabatically because it is managed by the low output through a pmos transistor. The evaluation of the inputs happen during the wait stage of the power clock and the corresponding output is provided with GND values. Since the upper half and both the outputs are held at GND, the output values do not change anymore. During the evaluate stage the outputs get evaluated on the basis of the resolved inputs. At the end of the evaluate stage the two outputs become complementary of each other. One of the two stages remain at the GND by the nmos while the other gets charged up via pmos.

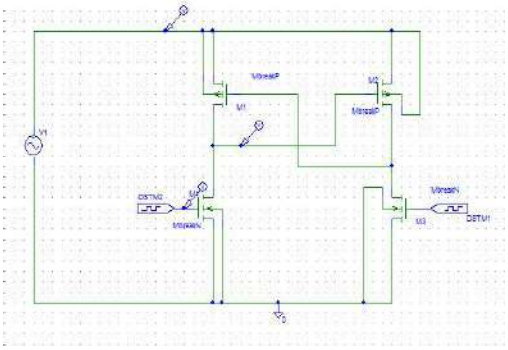


Fig. 7. Schematics of 2n2p Inverter

4.2.3. 2n-2n2p: This family is similar to that of 2n2p with the variation that it consists of two nmos transistors that are cross coupled and added in parallel to the two nmos transistors. The working of this family is same as that of 2n2p family. The presence of the new nmos proves to be advantageous as it eliminates the floating nodes of the circuit. Consequently, it restricts the leakage of charger. But it has certain disadvantages as well one of them being preventing the circuit from saving energy at the frequencies above 100MHz.

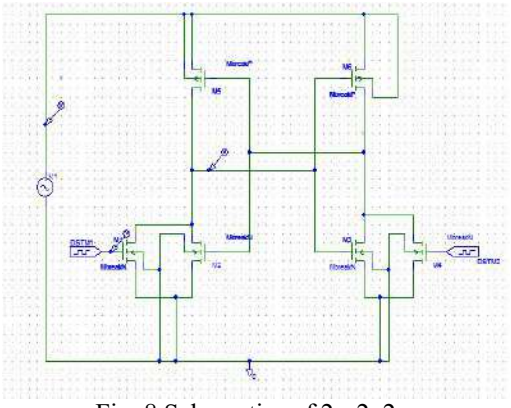


Fig. 8 Schematics of 2n-2n2p

4.2.4. Pass Transistor Adiabatic Logic: PAL is fully adiabatic family. PAL is also a variation of 2n2p family with a slight difference. The lower node of the circuit is connected to power clock, unlike the 2n2p family where it is connected to GND. It has certain advantages over 2n2p logic family as it uses two phase power clock which makes the implementation easier and is more power efficient.

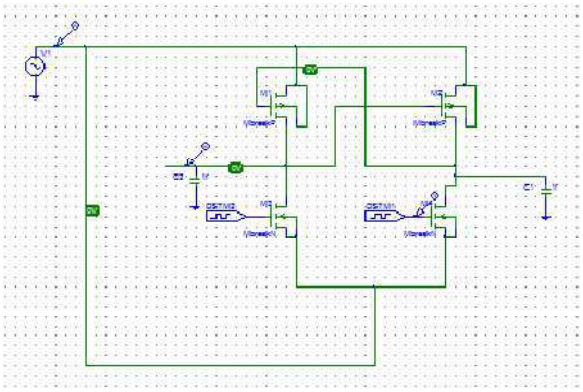


Fig. 9. Schematics of PAL Inverter

4.2.5. True Single Phase Energy Recovery Logic: TSEL is a quasi adiabatic logic family. It is similar to 2n-2n2p family. This family uses single phase sinusoidal power clock. TSEL inverters make use of reference voltages that work as bias voltages (V_{rp},V_{rn}). This is the distinct characteristic of this family. The pmos TSEL inverter operates in two stages, namely discharge and evaluate. During the discharge stage the energy stored in the output nodes gets recovered. When this stage begins then the power clock is high, and as it ramps down it is observed that both the outputs are pulled toward the threshold voltage of the pmos, V_{tp}. This transition is adiabatic when the difference between V_{tp} and V_{rn} is greater than V_{pc}. During the evaluation phase if the input is low, at the beginning V_{pc} is low which gradually starts rising and consequently P3 and P4 turn on, resulting in the switching on of P1 and P2. Until V_{pc} is less than difference between V_{rp} and V_{tp} P3 and P4 remain in conducting state. The cross coupled pmos amplify the difference between the two outputs. As soon as the output becomes greater than V_{pc}, P1 switches off as a result the complemented output gets adiabatically charged. P3 and P4 enter into non-conducting state when V_{pc} becomes greater than the difference between V_{rp} and V_{tp}. Once P3 and P4 turn off, the output becomes stable and does not varies if there is any variation in the input.

The operation of nmos TSEL is similar to that of pmos TSEL. Nmos TSEL operates in charge and evaluate phase. This family is more power efficient than any other family.

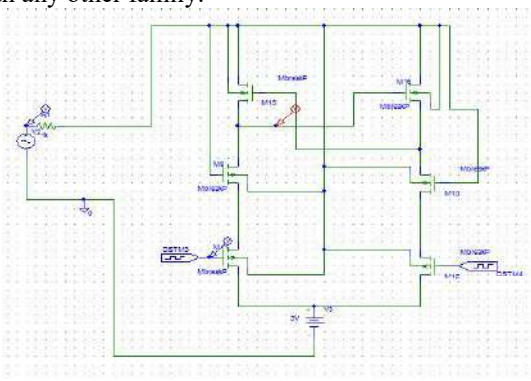


Fig. 10. Schematics of PMOS-TSEL

5.SIMULATION RESULTS

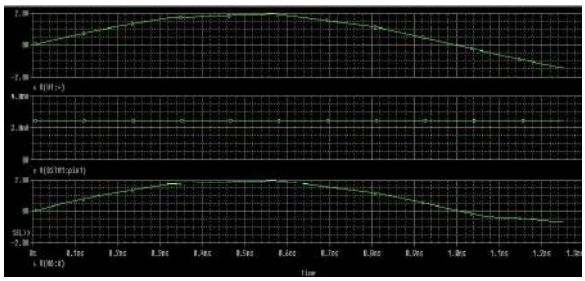
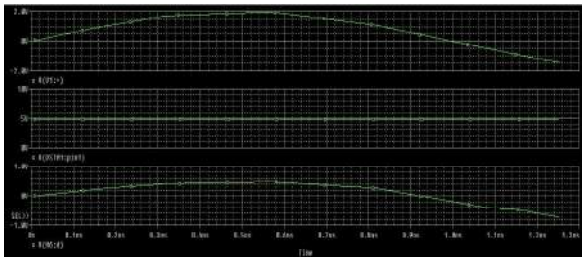


Fig.11. Simulation results of ADCL



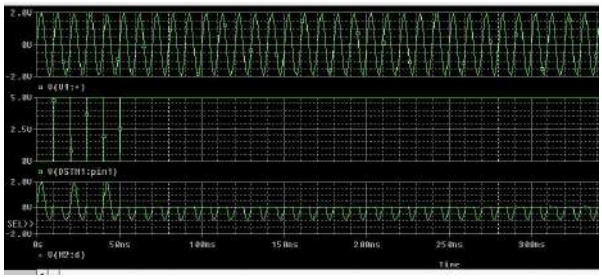


Fig. 12. Simulation result 1n1p

Fig. 13. Simulation result of 2n2p

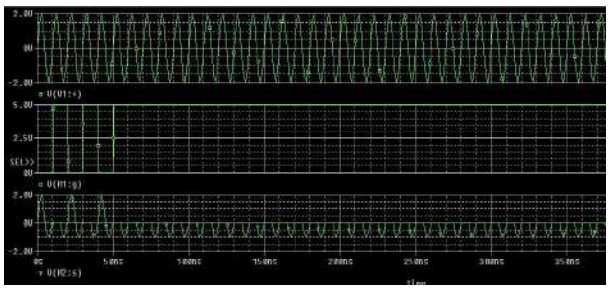


Fig.14. Simulation result 2n-2n2p

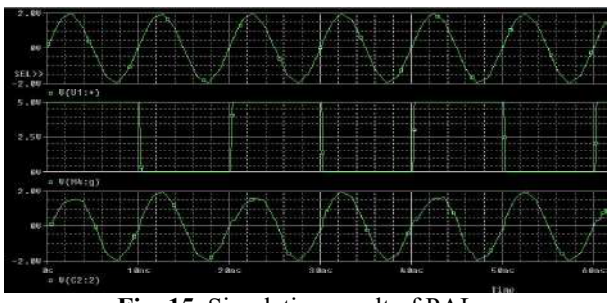


Fig. 15. Simulation result of PAL

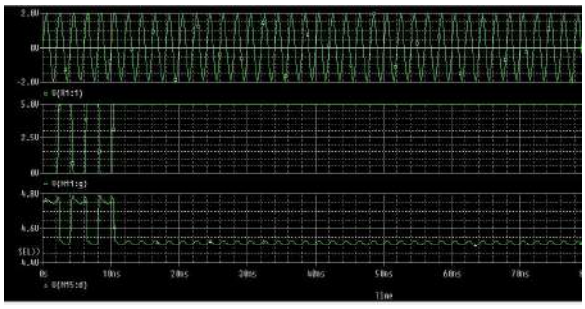


Fig.16. Simulation result of PMOS-TSEL

5. CONCLUSION

This paper gives the introduction of a new methodology used in low power design of inverter. Firstly the study of conventional CMOS has been done during which it was realized that dynamic losses i.e., the losses due to switching are the major causes of power dissipation in CMOS inverter. Power loss becomes a major issue of concern when increased chip density is the aim. Adiabatic logic is a power saving technique which can be implemented in design of chips with high chip density. This paper explains the logic behind adiabatic switching and provides the brief knowledge of various adiabatic logic families that have been classified on the basis of the use of diodes. The advantages of these families over each other have been discussed in this paper.

6.FUTURE WORK:

Future work includes the implementation and analysis of TSEL inverters and comparison of TSEL inverter with conventional CMOS and other logic families .

7. ACKNOWLEDGEMENT

We would like to express our heartfelt gratitude towards the Department of Electronics and Communication, Moradabad Institute of Technology, Moradabad, Uttar Pradesh, India. We would also like to thank our guide Mr. Amit Saxena, Assistant Professor, Moradabad Institute of Technology, Moradabad, for his constant support and encouragement.

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Pass Transistor Adiabatic Logic Circuit for Low Power Applications

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***Abstract*- The never ending need for the low power and low noise digital circuits has motivated the designers to explore new developments in the world of circuit design. This paper focuses on the Pass transistor adiabatic logic (PAL) as a new candidate for low power applications. Different digital circuits like Inverter, NOR, NAND gates were studied with conventional as well as with adiabatic logic principle and finally it was analyzed that adiabatic switching logic can reduce dissipated power to a large extent. The basic digital NOT Gate is simulated with a fully adiabatic PAL Logic. A Computer simulation results using P-spice carries out to analyze the circuit.**

***Keywords*- CMOS Circuit, Adiabatic Families, Adiabatic Logic, Pass transistor adiabatic Logic, Adiabatic Power Clock.**

I. INTRODUCTION

This paper has investigated novel circuit for low-energy VLSI systems. Its primary focus is on charge-recovering (a.k.a. adiabatic) circuits. By steering currents flowing across devices with low voltage drops and by recycling undissipated energy, these circuits can operate more efficiently than their earlier conventional digital counter parts. Early investigations have yielded that adiabatic circuits have very complex designs that are impractical for high-speed design. This project has led to the discovery of an extremely simple charge recovery circuits which achieve high energy efficiency at relatively high operating frequencies. The results of this research have been validated in P-SPICE simulation.

Adiabatic circuit architectures reduce the energy dissipation by steering currents flowing across devices with low voltage differences and by recycling the energy stored in the capacitors. Broadly speaking, the efficient operation of these designs is yet another manifestation of energy-speed tradeoffs. Adiabatic circuits that operate very efficiently at low operating frequencies stop functioning at high data rates.

Power consumption of digital circuits has become an important issue in high speed and applications. Several circuits have been proposed to reduce the power consumption but have their own shortcomings. “Adiabatic logic” has come with several methods to reduce power consumption.

The requirements of low power electronics have motivated the designers to explore new approaches and concepts to VLSI circuits. The classical approaches of reducing energy dissipation in conventional CMOS circuits included reducing the switching transients, supply voltages and node capacitances. Another approach used for reducing power dissipation is the usage of AC power supplies at the design level for recycling energy of node capacitances. This principle is known as adiabatic logic which is taken from the Thermodynamics. Such circuits achieve low power dissipation by recycling the energy stored on their capacitors and by restricting current to flow across devices with very low voltage drop. In literature, there are two kinds of adiabatic circuits present. One is full-adiabatic and other is quasi or partial adiabatic circuits.

The basic operation principles of adiabatic logic are:

Voltage or current ramps are used to prevent resistive power dissipation in parasitic resistance (asymptotically isentropic). The ramp rise and fall times (t_r, $t_f >> \tau$) = RC time constant of the circuit or block. Charge stored in the gate capacitors is feedback to the power supply (energy recovery). This requires an oscillating power supply that is in the proper phase to data load/discharge. The power supply can be realized by either LC resonance circuits, where C is the gate capacitance and L is an inductor at the power supply, or by phase circuits where the charge is circulating from phase to phase.

In section II, the classification of adiabatic families is listed. In section III, the concept and the operation of PAL is explained. In section IV, practical design approach of implementing different circuits using PAL is described. Simulation Results are shown in section V. Finally, Section VI is dedicated to the conclusion.

II. CLASSIFICATION OF ADIABATIC FAMILIES

In literature, there are two kinds of adiabatic circuits are there. One is full-adiabatic and other is quasi or partial adiabatic circuits which are further classified as follows:

A. *Full Adiabatic Circuits*

(i) Pass transistor adiabatic logic (PAL)
(ii) Split rail charge recovery logic (SCRL)
(iii) 2 Phase adiabatic Static CMOS logic

B. *Partially Adiabatic Circuits*

(i) Efficient charge recovery logic (ECRL)
(ii) Quasi Adiabatic Logic (QAL)
(iii) Positive feedback adiabatic logic (PFAL)
(iv) True single phase adiabatic logic (TSEL)
(v) NMOS energy recovery logic (NERL)

Quasi-adiabatic circuits have simple structure and power clock system. There are two types of energy loss incurred in this circuit, adiabatic loss and non-adiabatic loss. The adiabatic loss occurs when current flows through a non-ideal switch, which is directly proportional to the frequency of the power-clock. When the switch is turned on, and if there exist any voltage difference between the two terminals of a switch, non-adiabatic loss occurs. The non-adiabatic loss is proportional to the node capacitance and the square of the voltage difference and is independent of the frequency of the power-clock. Full-adiabatic circuits have no non-adiabatic loss, but they are much more complex in architecture than quasi-adiabatic circuits.

We propose the implementation of adiabatic logic to the power and extend battery life in these ultra low power applications. Adiabatic logic uses a periodic clock signal (power clock) in the circuit to charge and discharge the output capacitance of the logic blocks. The principle of adiabatic logic is to use the reversible logic to recycle energy back into the power clock rather than dissipate the energy as heat. In general, when input is at logic “0”, CMOS circuits charge a load capacitance from the dc supply rail and then, when the output transitions to logic “0” at input logic “1”, that energy discharges to ground and is dissipated. In most adiabatic designs, a power clock is used which allows the stored energy to flow back into it to be reused later.

There are primary two issues with adiabatic logic, which has severely limited its use in circuits. First, it is extremely difficult to design such complex circuits because of that miscellaneous noise spikes which develop in the propagating signals. Hence, very little work has been done on architectures other than basic gates, i.e. INVERTERS, AND, and OR. Second, many adiabatic logic families cannot operate at high frequencies while maintaining power savings over that standard CMOS methods.The most common adiabatic logic families fail between frequencies of the range on 200MHz – 500MHz, with significant power savings being obtained even lower than that frequency. These failure points occur only for basic gates, and not for larger structures. Hence, we want to look at all 3 facts of the design and improve in each area. Our primary focus is on power savings of electronics circuit for ultra low power applications.

III. CONCEPT AND OPERATION OF PAL ADIABATIC LOGIC

Pass Transistor Adiabatic Logic is a dual-rail adiabatic logic with a relatively low gate complexity that operates with a 2-phase power clock. A PAL gate consists of a cross coupled PMOS latch and true and complementary pass transistor NMOS functional blocks. The power is supplied by a sinusoidal power-clock. When power clock starts rising from low, input states makes a conduction path from the power clock through one of the functional blocks to the output node and allow it to follow the graph of the power clock. The other node will be in the tri-state and kept close to 0V(LOW) by its load capacitance. This in turn causes one of the PMOS transistors to conduct and charge the node that should go to up to the peak of power clock. The output state is valid at the top of the power clock.

The power clock will then ramp down towards zero, while recovering the energy stored on the node capacitance. Pass Transistor adiabatic logic (PAL) family exhibits considerable improvements in terms of effective energy savings and switching noise characteristics but it has the disadvantages of lower speed of operation and higher supply voltage.

PAL is a full adiabatic logic which operates with a 2-phase sinusoidal power clock. PAL has proven superior to that static CMOS and other adiabatic logic types in NAND gate performance evaluations.

A. PAL Inverter:

The PAL gates consist of a cross coupled PMOS latch (M1, M2) and complementary NMOS functional blocks (M3, M4) as shown in Fig. 1. The Power is supplied with a sinusoidal power clock denoted by V_1, which is divided into 2 phases called the evaluation and the recovery phase. Let’s assume that initially In=1 and /In=0 and the load capacitors are discharged. In the evaluate phase, V_1 rises and begins to charge up C_1 through M4. When $V_1 > V_{TP,}$ M2 turns on and begins to charge C_2 also. M3 stays off since /In=0 and M1 stays off as the source voltage of M1 follows V_{PC}. When V_1 reaches V_{DD}, the output stages are at out and /out are valid. During the recovery phase, the value of V_1 ramps down to 0V and discharges C_l, returning the charge back to the power

supply. It is worth noting that some non-adiabatic loss occurs because C_l is only discharged until V_1=VTP, after which M2 turns off and no further discharge of /out occurs. PAL gates remains unchanged their output values for about half a cycle, they must be cascaded by using an alternate connection of PC that are inverted i.e., 180 degree phase shift. It is important to notice that extra energy is consumed in the complete circuit due to extra clock distribution network for clock supply V_1.

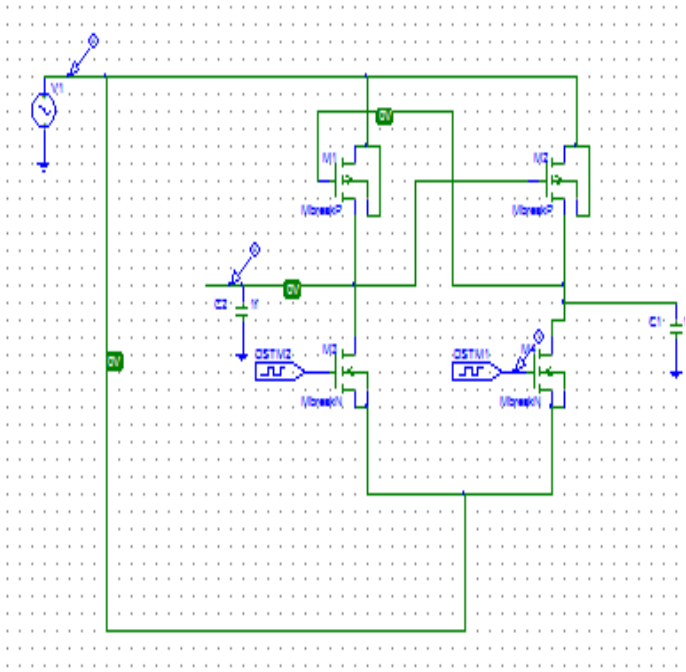

Fig. 1 Schematics of PAL Inverter

IV. DESIGN APPROACH

A Large part of dissipated power is lost because of the sudden flow of charge on the rising edge of the square-wave pulse. Adiabatic computing methods have worked to avoid this incurred loss by making the power clock as linear as possible, depending on the design style of that particular logic family. Since the oscillator works as both as a power supply reference voltage and a clock, it is also known as a power clock (PC).

The first proposed adiabatic oscillator has a trapezoidal waveform. This oscillator consists of 4 stages as shown in Fig. 3 (i.e., charge, evaluate, discharge and idle). The output capacitor is charged in the Charge stage, then evaluated during the Evaluate stage, and finally discharged adiabatically back to the power clock during the Discharge stage. The PC is then held at the ground (GND) during the Idle stage. This type of power clock allows the signal to stabilize better during the two plateaus (at V_{dd} and GND), but uses a 4, 6 or even 8-phase clock, which in larger clock gets very difficult to control. Additionally, new circuitry is also needed to generate a linear ramp voltage for charging/discharging.

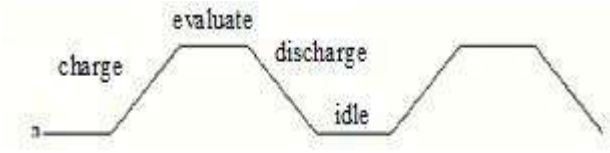

Fig.2 A single phase trapezoidal PC with stages

Another oscillator has sawtooth waveform output. This oscillator allows a more linear charge of load capacitance and hence could perform better than the trapezoidal oscillator. It can have a longer time to charge the outputs at the same frequency. But it is more difficult to samples the output at the peaks since there is no extra time allowed to stabilize. A sawtooth oscillator requires additional circuitry for its generation and hence most of the logic families using it to generate two phases.

The last kind of oscillator used in adiabatic has a sinusoidal waveform. This oscillator is used in compromise between linear voltage increase and circuit complexity. It is much easier and more energy-efficient to generate a sinusoidal waveform than a linear waveform. However the sinusoidal waveform does not provide the best approximation for a linear voltage. Most designs with sinusoidal waveform uses 2-phase clock oscillator, although there also exist designs with a single-phase clock. In PAL Inverter we have used the sinusoidal clock with frequency of 0.1 Ghz. Fig. 3 shows the waveform of the sinusoidal Power clock and its specifications.

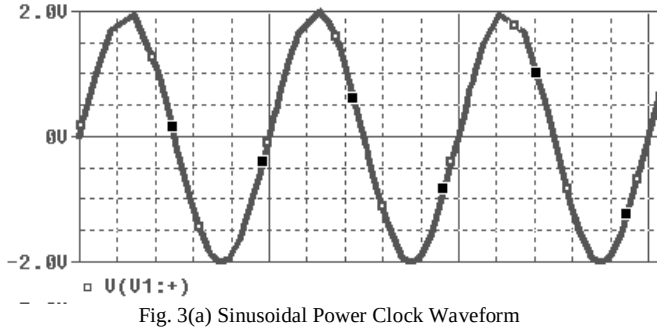

Fig. 3(a) Sinusoidal Power Clock Waveform

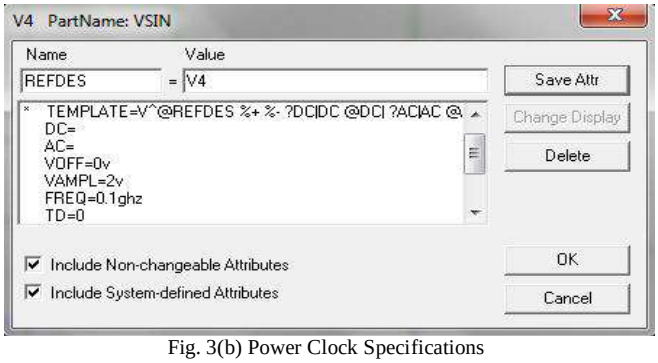

Fig. 3(b) Power Clock Specifications

V. SIMULATION RESULTS

Fig. 4 shows the curve for conventional CMOS Inverter circuit with its clock. We have used 5V DC supply in conventional CMOS circuit.

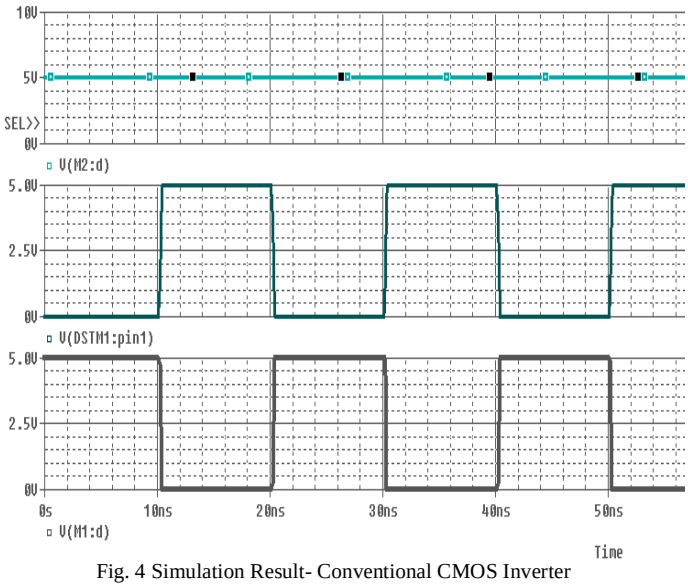

Fig. 4 Simulation Result- Conventional CMOS Inverter

Figure 5 shows the curve for PAL Adiabatic CMOS Inverter circuit with its clock. We have used 2V sinusoidal power clock with 0.1 GHz frequency.

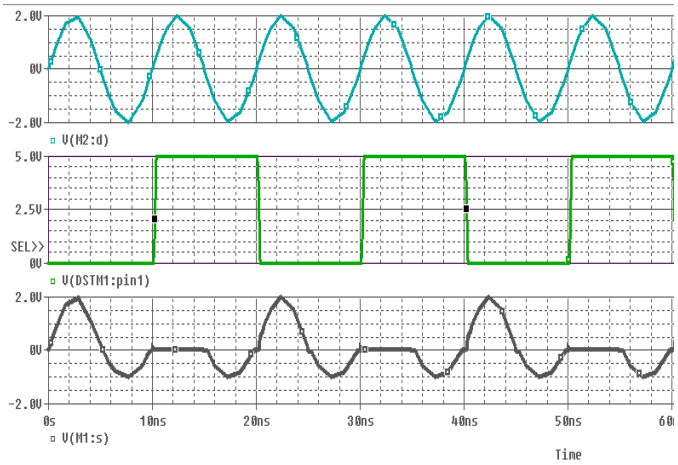

Fig. 5 Simulation Result- Adiabatic CMOS Inverter

VI. CONCLUSION

The paper primarily focuses on the review of the design of low power high speed CMOS adiabatic structure using PAL Logic. Firstly the basic knowledge regarding adiabatic logic is given in this paper. On the basis of those fundamentals, it was analyzed that the dynamic loss is the major cause of power loss in CMOS circuits. Later, it was analyzed that the Adiabatic logic design is an energy efficient way of design for low power applications. This paper mainly focuses on Pass transistor adiabatic logic behind the adiabatic switching and presented a way to minimize the dynamic power loss by changing the supply voltage. Adiabatic computing methods have worked to remove the incurred loss by making the clock as linear as possible, depending on the design style of the logic family. We have used the sinusoidal clock signal for gradual change in clock pulses. It was found that the adiabatic circuits can efficiently minimize the dynamic power to a large extent based on the simulation results. The simulation results were verified by the truth table of conventional CMOS inverter circuit. The output simulation file of PSPICE proves that the dynamic power loss is reduced to a large extent. The results shows the comparison between different adiabatic logic circuits with traditional CMOS circuit structure.

VII. FUTURE WORK

Future work includes the design of larger adiabatic Boolean gates and circuits using PAL Logic and dissipated energy analysis at that higher frequencies and its comparison with other adiabatic logic families.

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Optimization of universal logic gates using adiabatic technology

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Abstract*— in this paper comparison of power consumptions in Adiabatic and Conventional Universal Gates has been studied. The power saving of adiabatic circuit can reach more than 90% compared to conventional static CMOS logic. The clocking schemes and signal waveforms of adiabatic are different from those of standard CMOS circuits. In this work design of Adiabatic and Conventional Universal Gates NAND and NOR has been done on the Virtuoso Package of Cadence software using 180 nm CMOS technology.The proposed two phase clocked adiabatic static CMOS logic circuit utilizes the principle of adiabatic switching and energy recovery.First algebraic expressions for properties of power clocked signals are discussed. From the simulation results and comparisons with all technologies it shows that PFAL Adiabatic Logic gives lowest power dissipation at transition frequencies of 10 to 100 MHz's. The transient analysis of the circuit on Cadence Virtuoso at a supply voltage ranging 1.8V has been deployed. A constant output load capacitance of 1 femto Farad is used for power and delay measurements. Key Words- Adiabatic, PFAL, CMOS, femto NAND, NOR, Power clocked.

I. INTRODUCTION

In this era we cannot say a device to be portable unless it works with low power consumption. Power dissipation in CMOS circuits is related to the type of energy conversion they employ. In static CMOS circuits DC power supply is used, the signal power is calculated by charging and discharging of load capacitance, during this time energy converts from electric energy to thermal energy which is an irreversible process. Energy stored in the load is $1/2CV^2$ .Thus to reduce the energy dissipation switched capacitance has to be reduced. An Energy conversion is needed to represent a change in signal value. If energy exists only in one form, i.e., electric energy then there is only one-way conversion, researchers have introduced another energy form, i.e., magnetic energy, the irreversible conversion from electric energy to heat caused by dissipative elements, i.e. ,resistors, are largely avoided. For this reason, researchers have attempted to make a breakthrough in low-power CMOS circuit design, from basic circuit unit to microprocessor, by changing the mode of energy conversion.

Energy conversion from electric field to magnetic field and vice versa implies that circuit should be supplied with AC power. In this case signals in the circuits should also be alternating quantities. The latter has been extensively used in dynamic CMOS logic, such as clocked CMOS logic and domino logic. However those circuits still rely on DC power, and the energy conversion remains a conversion from electric energy to heat.

Therefore circuits supplied with AC power should be studied further. Since the AC power supply controls the working rhythm of the circuit and acts as the clock, it has been called power-clock. If the power clock is gradually changing less energy is dissipated when charging and discharging the load capacitance. The output of these circuits are only valid during a particular phase of the power clock cycle.

With increase in the density of transistors on a chip and high operating clock frequencies the design is getting very complex. To make a device portable for electronic consumer both the size and power consumption should be reduced. In the recent years several adiabatic or energy recovery architectures have been proposed. In this paper the adiabatic circuits are designed using PFAL method and same logic is implemented using conventional methods. Paper compares between adiabatic and conventional circuits for power consumptions and maximum operating frequencies.

II. ADIABATIC LOGIC

The word ADIABATIC comes from a Greek word that is used to describe thermodynamic processes that exchange no energy with the environment and therefore, no energy loss in the form of dissipated heat. In real-life computing, such ideal process cannot be achieved because of the presence of dissipative elements like resistances in a circuit. However, one can achieve very low energy dissipation by slowing down the speed of operation and only switching transistors under certain conditions. The signal energies stored in the circuit capacitances are recycled instead, of being dissipated as heat. The adiabatic logic is also known as ENERGY RECOVERY CMOS. In the adiabatic switching approach, the circuit energies are conserved rather than dissipated as heat. Depending on the application and the system requirements, this approach can sometimes be used to reduce the power dissipation of the digital systems. Here, the load capacitance is charged by a constant-current source (instead of the constant-voltage source as in the conventional CMOS circuits). Here, R is the resistance of the PMOS network. A constant charging

current corresponds to a linear voltage ramp. Assume, the capacitor voltage VC is zero initially.

The voltage across the switch = IR

P(t) in the switch $=I^2R$ ……....(1)

Energy during charge (E) = $(I^2R)T$

E = (CV/T)2 RT $=C^2V^2/T$ R …..……..……....(2)

Edis $=(RC/T)CV^2$ = $(2RC/T)(1/2CV^2)$ …….…....(3)

Where, the various terms of Equation (3) are described as follows:

E — energy dissipated during charging,

Q — charge being transferred to the load,

C — value of the load capacitance,

R — resistance of the MOS switch turned on,

V — final value of the voltage at the load,

T — time spent for charging.

Now, a number of observations can be made based on Equation (3) as follows:

The dissipated energy is smaller than for the conventional case, if the charging time T is larger than 2RC. That is, the dissipated energy can be made arbitrarily small by increasing the charging time,

Also, the dissipated energy is proportional to R, as opposed to the conventional case, where the dissipation depends on the capacitance and the voltage swing. Thus, reducing the on-resistance of the PMOS network will reduce the energy dissipation.

III. ADIABATIC LOGIC FAMILIES

Practical adiabatic families can be classified as either partially adiabatic or fully adiabatic. In partially adiabatic circuit, some charge is allowed to be transferred to the ground, while in fully adiabatic circuit all the charge on the load capacitance is recovered by the power supply. Fully adiabatic circuits face so many problems with respect to operating speed and input power clock synchronization. Different logic families are Efficient Charge Recovery Logic (ECRL), 2N- 2N2P Adiabatic Logic, Positive Feedback Adiabatic Logic (PFAL),NMOS Energy Recovery Logic (NERL), Clocked Adiabatic Logic (CAL),True Single-Phase Adiabatic Logic (TSEL),Source-coupled Adiabatic Logic (SCAL),Two phase adiabatic static CMOS logic(2PASCL) and fully adiabatic logic families are ,Pass Transistor Adiabatic Logic (PAL),Split- Rail Charge Recovery Logic (SCRL). In this project we are going with Positive Feedback Adiabatic Logic (PFAL).

IV. POSITIVE FEEDBACK ADIABATIC LOGIC

Positive feedback adiabatic logic was introduced in 1996 by Vetali and shows very positive aspects in addressing the power issues. The partial energy recovery circuit structure named Positive Feedback Adiabatic Logic (PFAL) has been used, since it shows the lowest energy consumption if compared to other similar families, and a good robustness against technological parameter variations. It is a dual-rail circuit with partial energy recovery. The core of all the PFAL gates is an adiabatic amplifier, a latch made by the two PMOS M1-M2 and two NMOS M3-M4, that avoids a logic level degradation on the output nodes out and /out. The two n-trees realize the logic functions. This logic family also generates both positive and negative outputs. The functional blocks are in parallel with the PMOSFETs of the adiabatic amplifier and form a transmission gate. The two n-trees realize the logic functions. This logic family also generates both positive and negative outputs.

V. DESIGN OF CONVENTIONAL GATES

A. NAND gate

The structure of a conventional NAND gate is shown in fig 1.

The circuit consists of two P-channel MOSFET‘s (M3, M4) connected in parallel and two N channel MOSFET‘s (M1, M0) connected in series.

Operation of circuit:-

When the input Y1 is 0 and Y2 is 0 MOSFET‘s M3, M4 are on and M1, M0 are off due to which the current flows from supply through M3 and M4 therefore Vout gets on logic high.

When the input Y1 is 0 and Y2 is 1 MOSFET ‘s M3, M0 are on and M4, M1 are off due to which the current flows from supply through M3 and Vout gets on logic high.

When the input Y1 is 1 and Y2 is 0 MOSFET‘s M3, M1 are on and M4, M0 are off due to which the current flows through supply and Vout gets on logic high.

When the input Y1 is 1 and Y2 is 1 MOSFET’s M3, M4 are off and M1, M0 are on due to which the terminal Vout is connected to the ground and is at logic 0.

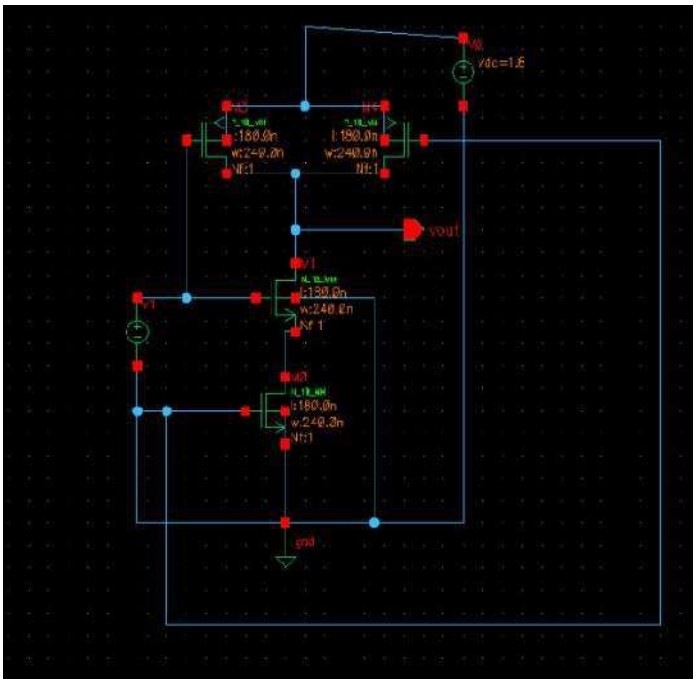

Fig 1. Conventional CMOS logic NAND.

CALCULATED VALUES FROM TRANSIENT ANALYSIS

The following values have been calculated from Fig2.

1. CURRENT=2.531514E-7
2.POWER= 4.5567252 E-7
3.DELAY = 1.820891 E-11
4.RISE TIME= 49.59ps
5.FALL TIME =34.096ps
6.Tphl=24.8125ps
7.Tplh=30.273ps

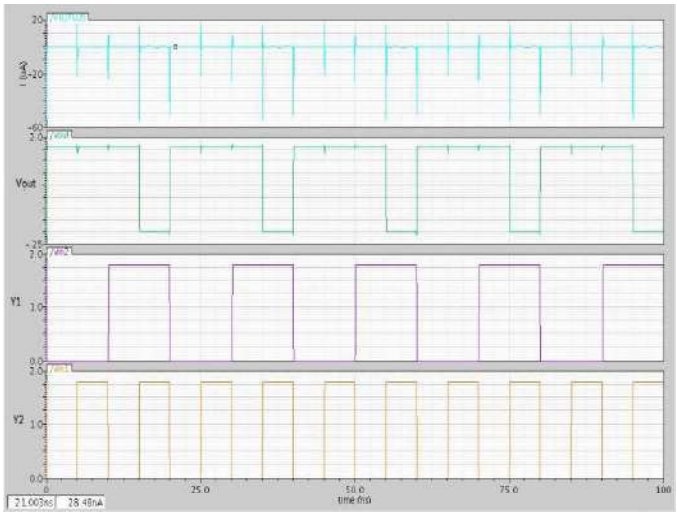

Fig 2. Transient Response of conventional NAND gate

B. NOR gate

The structure of a conventional NOR gate is shown in fig. The circuit consists of two P-channel MOSFET‘s (M0, M1) connected in parallel and two N channel MOSFET‘s (M2, M3) connected in series.

Operation of circuit:-

When the input A is 0 and B is 0 MOSFET‘s M1, M0 are on and M2, M3 are off due to which the current flows from supply through M0 and M1 therefore Out Terminal gets on logic high.

When the input A is 0 and B is 1 MOSFET‘s M1, M3 are on and M0, M2 are off due to which the out terminal gets shorted through M3 and gets grounded.

When the input A is 1 and B is 0 MOSFET‘s M0, M2 are on and M1, M3 are off due to which the out terminal gets shorted through M2 and gets grounded.

When the input A is 1 and B is 1 MOSFET’s M0, M1 are off and M2, M3 are on due to which the terminal Out is connected to the ground though M2 and M3 and is at logic 0.

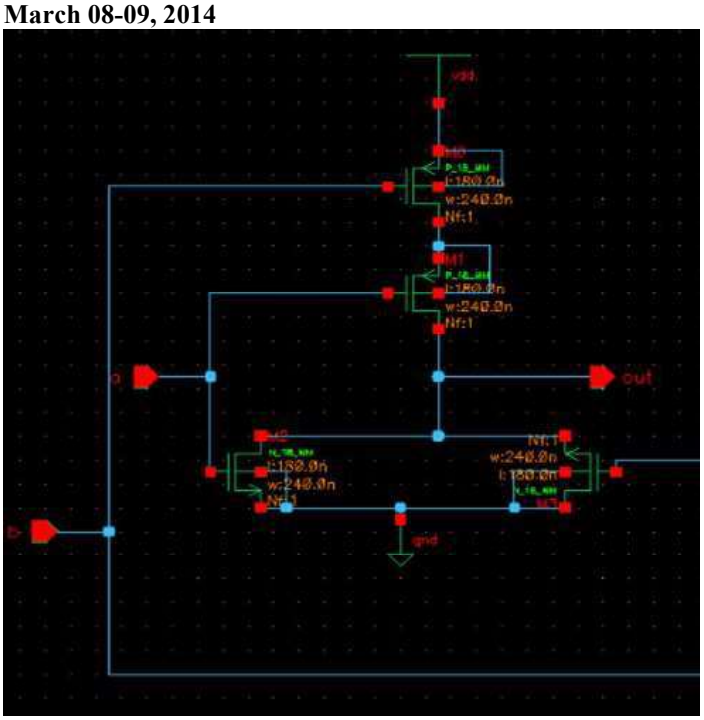

Fig 3. Conventional CMOS logic NOR.(PFAL)

CALCULATED VALUES FROM TRANSIENT ANALYSIS

The following values have been calculated from following Fig4.

1. CURRENT = 3.5900735218 E-7
2. POWER =6.46213233 E-7
3. RISE TIME =106.3ps
4. FALL TIME =28.94
5. DELAY=1.012077 E-10
6. Tphl=28.47ps
7. Tplh=64.36ps

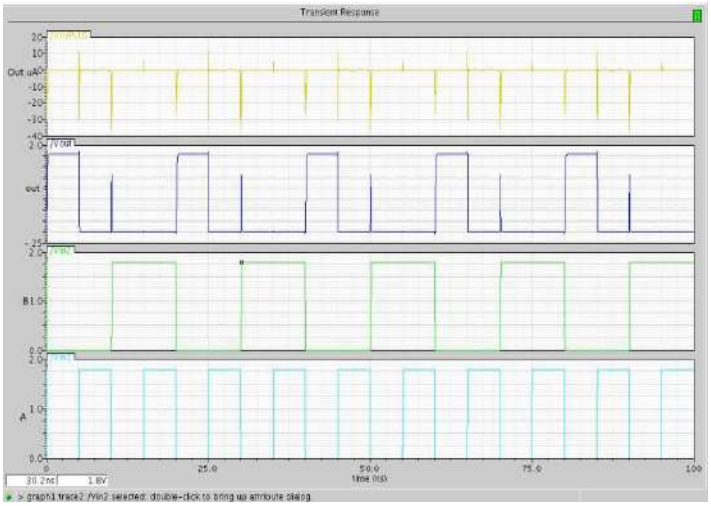

Fig 4. Transient Analysis of Conventional NOR gate.

VI. DESIGN OF ADIABATIC GATES

A.NAND Gate

The structure of an adiabatic NAND gate proposed by us is shown in fig5., illustrates NAND Adiabatic circuit with the 2 N-MOS diodes M7 and M6 added to the conventional logic NAND gates. And the structure of adiabatic NOR gate proposed illustrates conventional NOR gates with 2 N MOS diodes shown below:-

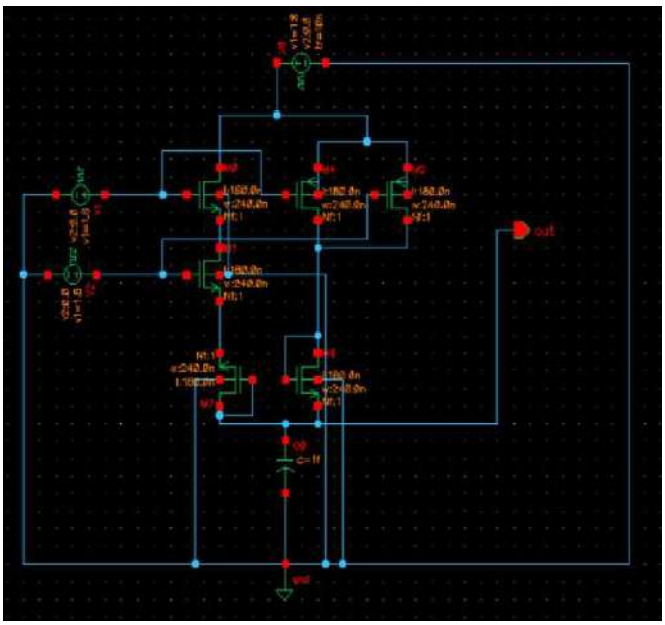

Fig 5. Adiabatic CMOS Logic NAND (PFAL).

The 2 N MOS Diodes helps in charging and discharging of the capacitor C0 and feeding back the power from capacitor to the power supply when the output logic has to be pulled down to 0.

Thus the circuit consumes the power on the positive cycle of the triangular wave and when not needed, it can provide it back to the supply pulse to convert the pulsating power to the dc form. This wave of course carries some ripple and is not pure DC as we can see from the output waveform but it helps in decreasing the power consumption of the circuit. . The Transient analysis is shown below:-

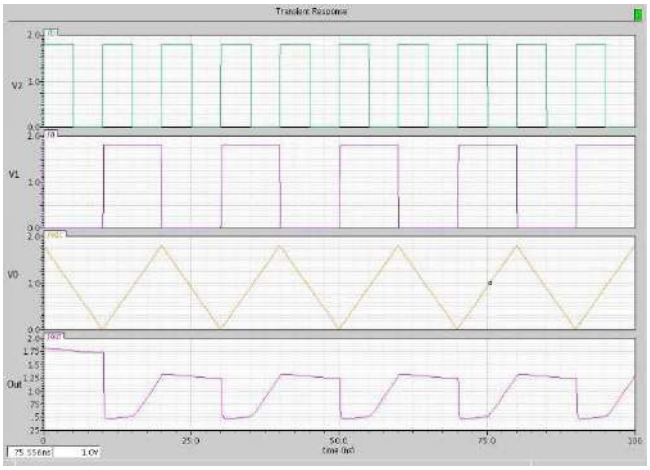

Fig 6. Transient Response of Adiabatic CMOS NAND.

As seen from figure the input power supply is Y0 input logic levels are Y1 and Y2, and Out is the output waveform.

The output is high when any one of the input logic levels are low else it's low.

As for Adiabatic circuits the input power has to be non-DC therefore only transient analysis is possible.

CALCULATED VALUES FROM TRANSIENT ANALYSIS

The following values have been calculated from following Fig4.

Calculated Delay:

V1 = 1.020814713744333E-8

V2 =1.0183147137419063E-8

Current =1.251854360E-8 A

Power = 2.253337848E-8 W

B.NOR Gate

The structure of an adiabatic NOR gate proposed by us is shown in fig 7.

Like the case of Adiabatic NAND here also the power will be recycled to the supply by the help of two NMOS diodes M5 and M7 while discharging the capacitor C0.

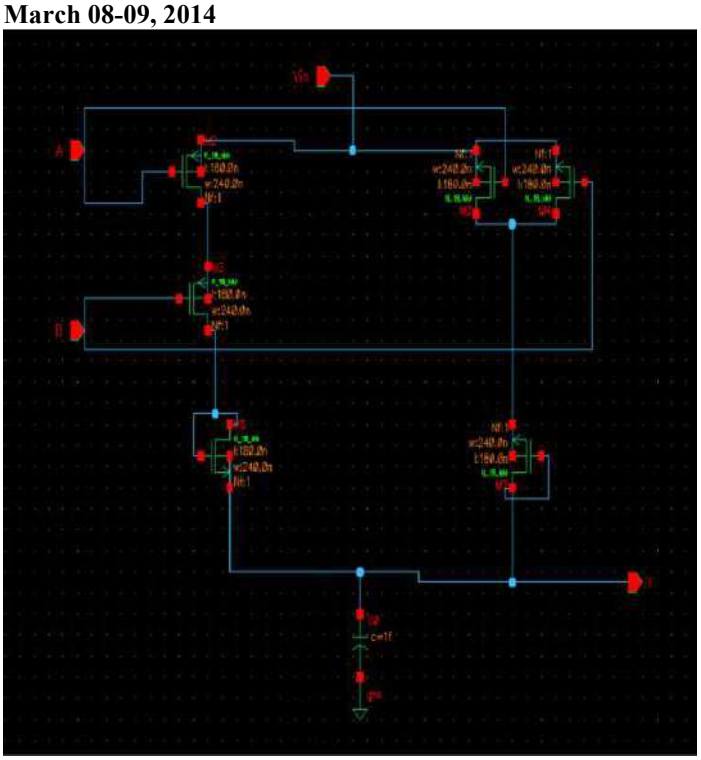

Fig 7. Adiabatic NOR gate Schematic Diagram.

The Output Waveform is:-

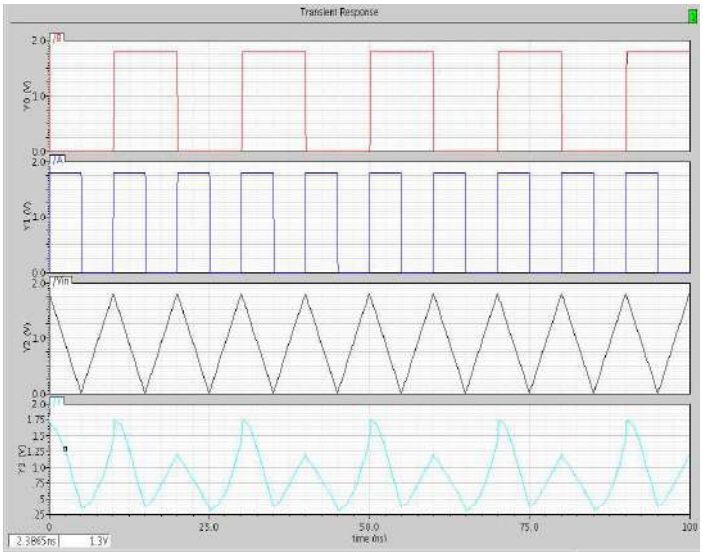

Fig 8. Transient response for adiabatic NOR gate.

As seen from the waveform the inputs are Y0 and Y1 Input power supply is Y2 and the output power supply is Y3. The output is low when any one of the inputs is high.

CALCULATED VALUES FROM TRANSIENT ANALYSIS

The following values have been calculated from following Fig4.

Calculated Delay:

V1 = 1.050734913744383E-8

V2 = 1.048315613748706 3E-8

Current =1.354855390E-8 A

Power = 2.543337349E-8 W

VII. COMPARISON BETWEEN ADIABATIC AND CONVENTIONAL CIRCUITS

A. **Adiabatic Circuits** are low power circuits which use "reversible logic" to conserve energy. Unlike traditional CMOS circuits, which dissipate energy during switching, adiabatic circuits attempt to conserve charge by never turning on a transistor when there is a voltage potential between the source and drain. Secondly never turning it off when current is flowing through it. Fully adiabatic operation of a circuit is an ideal condition. It may be only achieved with very slow switching speed.
In practical cases, energy dissipation with a charge transfer event is composed of an adiabatic component and a non- adiabatic component.

B. **In Conventional Circuits** during charging process of the output load capacitance constant voltage source is replaced with the constant current source to charge and discharge the output load capacitance. These can be used over high switching speed circuits

VIII. CONCLUSIONS AND FUTURE WORK

This paper has described a simulation of NAND and NOR logic gates based on adiabatic technology and conventional technologies. By implementing the adiabatic charging and energy recovery theory, PFAL NOR and NAND gives the lowest result in power dissipation of all the

Simulated Universal Gates. It has been seen that at different frequencies power dissipation for NAND and NOR gates using 2pascl Technology have the lowest power reduction. In future these logics can be designed at other technologies to further reduce the power consumption and voltage swing can be improved and future work on minimization of chip area can also be done on various technologies.

Acknowledgment

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OBJECT REJECTION AND COUNTING MACHINE

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Abstract—
nowadays, with the advancement of technology, particularly in the field of Microcontrollers, all the activities in our daily living have become a part of Information technology and we find microcontrollers in each and every application. Image processing is any form of signal processing for which the input is an image, such as photographs or frames of video, the output of image processing can be either an image or a set of characteristics or parameters related to the image. Most image processing techniques involve treating the image as a two dimensional signal and applying standard signal processing techniques to it. Image processing generally involves extraction of useful information from an image. This project aims at the separation of a particular coloured object moving in a conveyor belt from others, after scanning each object using webcam. Using MATLAB programming technique, each object is scanned and compared with our desired colour specification. If the desired specification is met, then that particular object will be separated from the others.
KEYWORDS : Microcontroller ,Conveyor ,Object sensor.

1. INTRODUCTION

This project aims at the separation of a particular coloured object moving in a conveyor belt from others, after scanning each object using webcam. Using MATLAB programming technique, each object is scanned and compared with our desired colour specification. If the desired specification is met, then that particular object will be separated from the others. Many of the current applications of machine vision are inspection tasks that do not involve the use of an industrial robot. A typical application is where the, machine vision system is installed on a high-speed production line to accept or reject parts made on the line. Unacceptable parts are ejected from the line by some mechanical device that is communicating with the vision system.
The objectives of machine vision inspection include checking of gross surface defects, discovery of flaws in labelling (during final inspection of the product package) ,verification of the presence of components in the assembly, measuring for dimensional accuracy, and checking for the presence of holes and other features in a part. When these kinds of inspection operations are performed manually, there is a tendency for human error. Also, the time required in most manual inspection operations requires that the procedures be accomplished on a sampling basis. With machine vision, these procedures are carried out automatically, using 100% inspection, and usually in much less time.

1.1.SOFTWARE

This system uses two software packages, the C programming and Embedded Coding. The hardware programming is done in the Keil Micro vision 3 compiler which programs the Microcontroller to initiate the different actions.

2.BLOCK DIAGRAM DESCRIPTION

In the block diagram the conveyor system is made to run with the help of two motors The motors are synchronised and driven by a relay driver circuit, which is controlled by the PIC microcontroller. An actuator motor is connected to the conveyor which is having forward and reverse motion control relay circuit which is also controlled by the PIC Microcontroller. An object sensor is also connected to the conveyor system which detects the presence of any object moving through the conveyor. If it detects any object, it gives the output to the microcontroller. The serial communication between the PIC microcontroller and the PC is done using RS232 Data Interface. A webcam is connected to the PC for taking the pictures.

2.1.RELAY

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be

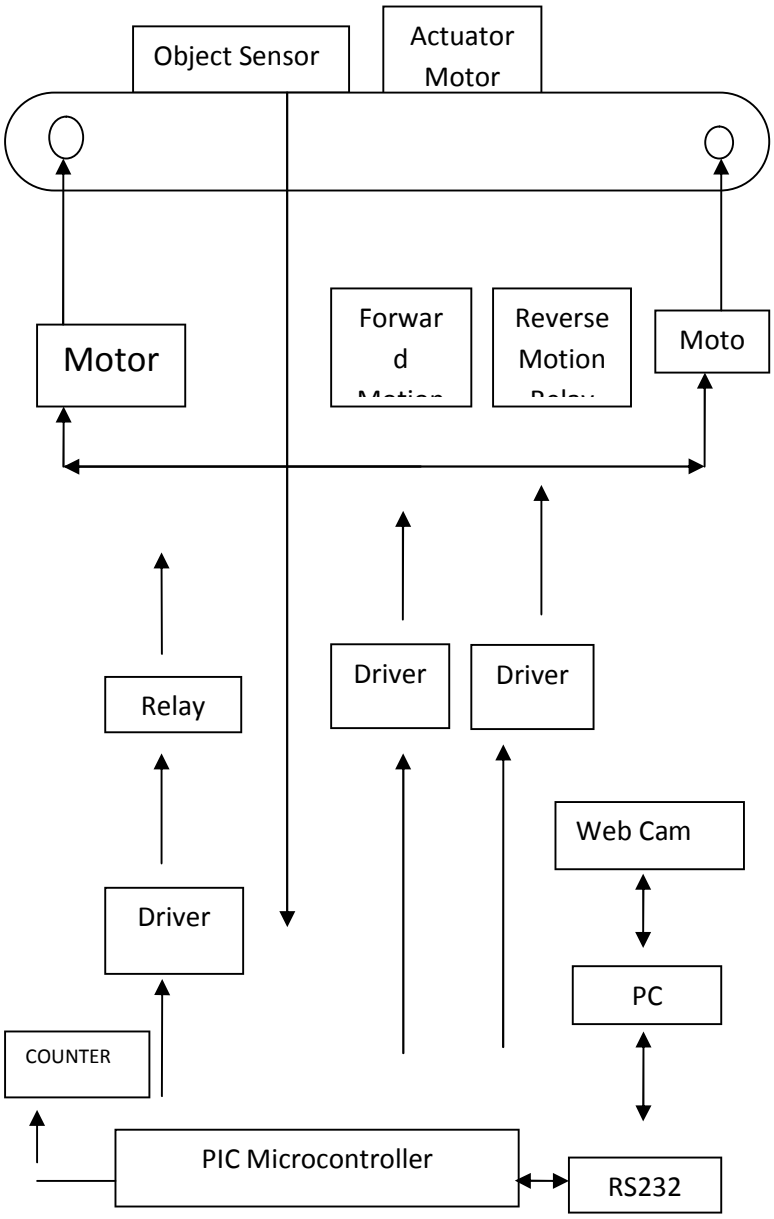


Fig.1.block diagram

completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

Fig.2. Relays

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

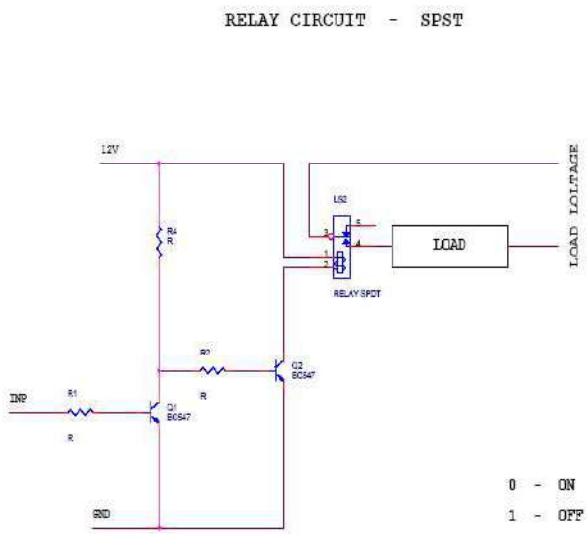


Fig.3.Relay Circuit

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay.

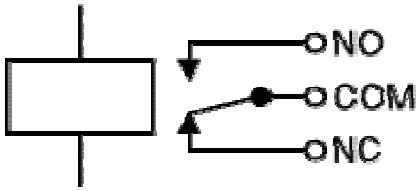


Fig 4. Relay Connections

The relay's switch connections are usually labeled COM, NC and NO:

- **COM** = Common, always connect to this, it is the moving part of the switch.
- **NO** = Normally Open, COM is connected to this when the relay coil is **on**.
- **NC** = Normally Closed, COM is connected to this when the relay coil is **off**.

2.2.PIC

The microcontroller that has been used for this project is from PIC series. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques.

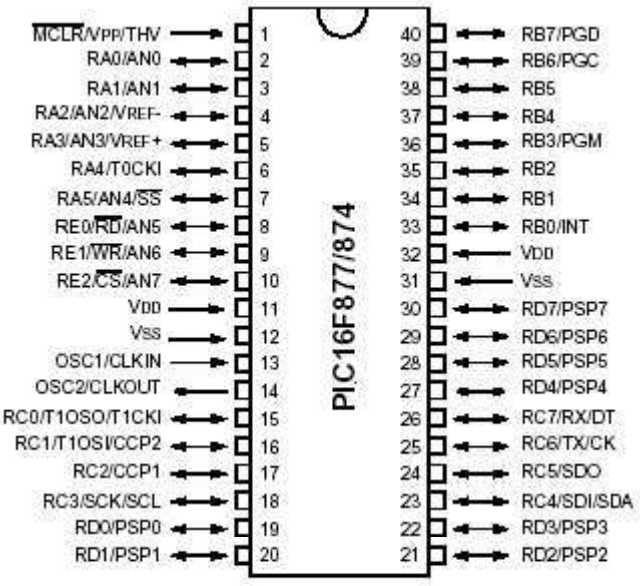


Fig .5. Pin diagram of PIC16F877

2.3.CONVEYOR SYSTEM

The conveyor system has 60cm length and about 8 cm breadth. Two dc motors working at 12V/10rpm is used to rotate the conveyor belt. The motors are given control from the relay circuit activated or deactivated by the PIC microcontroller. Special provisions for fixing the actuator motor, the object sensor and the webcam have been provided in it. Two boxes are attached to it for collecting the objects moving through the conveyor. One box is kept opposite to the actuating motor for collecting the objects that are pushed by it. Another box is kept at the end of the conveyor for collecting the objects that are left by the actuating motor.

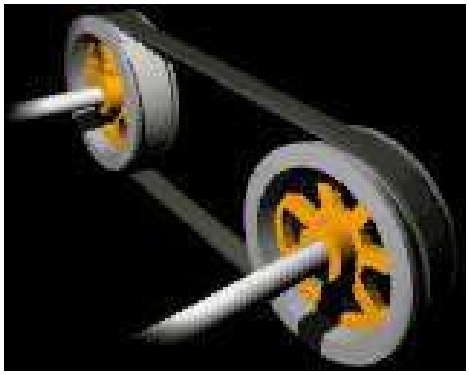


Fig.6. conveyor

A conveyor belt (or belt conveyor) consists of two or more pulleys, with a continuous loop of material - the conveyor belt - that rotates about them. One or both of the pulleys are powered, moving the belt and the material on the belt forward. The powered pulley is called the drive pulley while the unpowered pulley is called the idler. There are two main industrial classes of belt conveyors; Those in general material handling such as those moving boxes along inside a factory and bulk material handling such as those used to transport industrial and agricultural materials, such as grain, coal, ores,fines,and lumps material.

The belt consists of one or more layers of material. They can be made out of rubber. Many belts in general material handling have two layers. An under layer of material to provide linear strength and shape called a carcass and an over layer called the cover.

2.4. OBJECT SENSING CIRCUIT

This circuit is used to sense the object for different application. clock generator is used to generate 38 KHZ carrier The 4046 signal which is transmitted through the sensor TSOP1038.

The CD4046 micro power phase locked loop consists of a low power, linear, voltage controlled oscillator, a source follower, a zener diode, and two phase comparators. The two phase comparators have a common signal input and a common comparator input. The signal input can be directly coupled for a large voltage signal, or capacitive coupled to the self biasing amplifier at the signal input for a small voltage signal.

Phase comparator 1, an exclusive OR gate, provides a digital error signal and maintain 90 phase shifts at the VCO center frequency between signal input and comparator input, it may lock onto the signal input frequencies that are close to harmonics of the VCO center frequency.

Phase comparator 2 is an edge controlled digital memory network. It provides a digital error signal to indicate a locked condition and maintain the a 0 phase shift between signal input and comparator input.

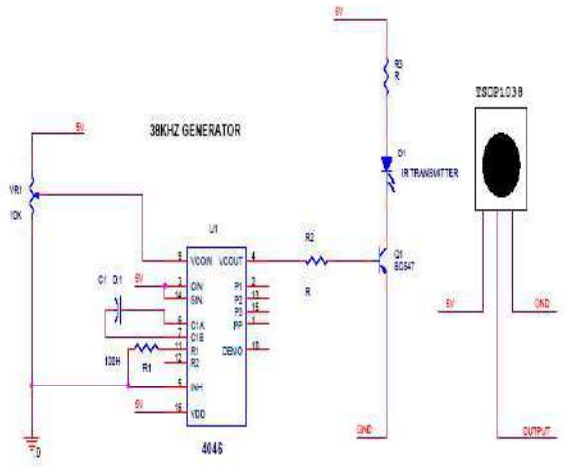


Fig. 7.object sensor circuit

3.WORKING

The normal voltages needed for the working of the entire system are +5Volt DC and +12 Volt DC; 5Volt for the working of the PIC Microcontroller and object sensor,12 Volt for the working of the 2 dc motors and actuator motor. 230 Volt main is stepped down using two separate transformers, (0-9 V, 0-15V). The proximity sensor's normal output is 5V, but when it senses an object, it becomes 0V. This is given to the active low input of the PIC microcontroller. Whenever the active low input of the PIC becomes zero, the conveyor motor is stopped and it sends information to the webcam to take snap.

Here, we are sending 'A' to PC when an object is detected. Snapshot is taken by using MATLAB coding. PIC microcontroller communicates with the PC through RS232. RS232 is operating at 12V logic level and PIC is working at 5V logic level. So bidirectional logic level conversion is needed for proper communication. This is done by Max232 logic level converter. After taking the snapshot, the colour of the image is processed by using MATLAB coding. Colour identification is done by matrix evaluation, i.e., by calculating the mean value of the matrix. Initially we will be selecting the colour of the object to be separated. After the colour is identified, it checks with the set colour and proper control signals are given back to the PIC microcontroller circuit to hit the object or to allow it to pass through the conveyor. Here, a 'C' will be sent if the desired specifications are met and if it is not met, 'B' is sent. Then the conveyor motor is again started and the process continues.

4.POWER SUPPLY

A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

4.1.TRANSFORMER : The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier,

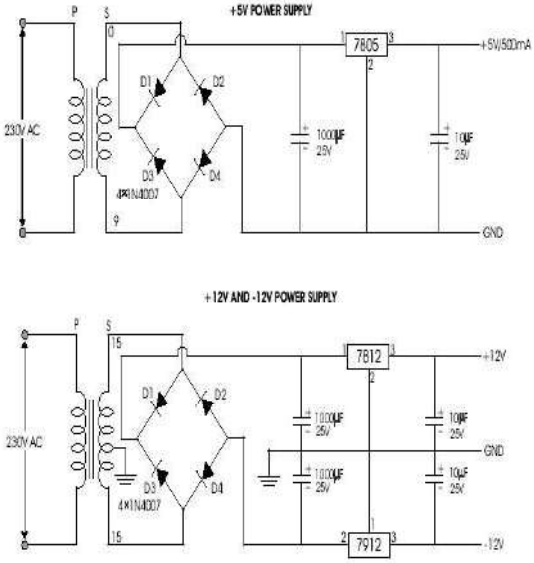
Fig 8. Circuit diagram (Power supply)

4.2.BRIDGE RECTIFIER: When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.

4.3.IC VOLTAGE REGULATORS: Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage.

5.CONCLUSION

This project plays an important role in the industries. We have devised a method to separate objects by its colour only. Our project is only a miniature model of



the actual conveyor system. By increasing the size of the conveyor system and including more paths and actuating motors, all coloured objects can be separated to different paths. By proper design and calibration and using higher quality cameras, even multi coloured objects can be separated. Instead of using an actuating motor, we can also design a robotic arm to pick the

objects on the path of the conveyor and place it to another path.

6.APPLICATION

- Object sorting finds its applications in various manufacturing industries as well as in airports to sort out luggage on the security basis.
- Used to identify defective objects or products in mass production.
- The same system or mechanism can be used for Textile printing, which involves the production of a predetermined coloured pattern on a fabric, usually with a definite repeat.
- Colour printing in paper industry is yet another application, which involves the reproduction of an image or text in colour.
- Reduced man-power accomplishment in industries related to mass production.
- Pattern recognition can also be done, which aims to classify data (patterns) based either on *a priori* knowledge or on statistical information extracted from the patterns.

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Motorcycle Ignition Using Fingerprint Recognition

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Abstract- **Motorcycle enthusiasts do not have as many security options for their bikes and they must work very hard to protect their vehicles. A motorcycle stays in the open, and most bar locking systems are not very effective. And nobody wants to lose the massive investment to a thief who knows how to break the bar lock.**

Thus there is a need for more security options to be available for the motorcycle. Biometrics system can be used as a good and effective security option. An important and very reliable human identification method is fingerprint identification. As fingerprint of every person is unique thus it can be used in various security options.

In this paper we are focusing on the use of finger print recognition to start or ignite the motorcycle against the use of conventional methods of key locks. Also a keypad is present in alternate to the finger print module in case of emergency. Thus in this project there will be a need of : R305 finger print module(to store the authentic person finger print record and for matching), a 4*3 keypad (as an alternate way to unlock and ignite the motorcycle in case of emergency), ATMEGA-16 microcontroller (to drive the whole circuitry comprising of the input methods and the ignition system of motorcycle), 16*2 LCD (for display unit), a relay (circuitry used to interface the output of microcontroller to the ignition switch), and an alarm (to alert about the unauthorized person).

Keywords-Fingerprint module R303A, Microcontroller, Keypad, Relay, Ignition system

I. INTRODUCTION

According to a recent survey on an average 80000 motorcycles are stolen in a year. These records are very less in number than of the actual motorcycle stolen because most of the bike theft is never reported. In reality this number will be in a huge quantity. Out of the entire bike stolen only 5-10% of the bikes are recovered in reusable condition. This is somewhat because of the old and traditional locks available in the motorcycles which are not very tough to crack

.This creates the demand of such type of lock which is new and provides an additional security level. The new and modern lock must be unique in itself i.e. it must be only unlocked by special and specific key. This type of feature is available in the biometrics locks i.e. the lock which can only be locked and unlocked by the human body features. Biometrics can include: face recognition, voice recognition, fingerprint recognition, eye (iris) recognition. Of all these type of special biometric recognition techniques the fingerprint recognition is the most widely used because fingerprint of every person on the earth is unique and can provide good reliability. Also the implementation of the fingerprint recognition system is easy and cheap than the other ones. Thus fingerprint recognition locking system can provide better reliability than the traditional locks and is also cheaper and easy than the other biometric locking system.

Thus here we are proposing a model which utilizes the concept of fingerprint recognition in the motorcycles to enhance the security level of the vehicle. Some other related work to this model is also reviewed in the next section.

II. DESIGN IMPLEMENTATION OF THE PROPOSED MODEL

Basically Skin of human fingertips consists of ridges and valleys and they mixing together form the distinctive patterns and these patterns are called fingerprints. From different researches it has been observed that no two persons have the same fingerprints, so they are unique for each individual .because of the above mentioned characteristic, fingerprints are very popular for biometrics applications.

Fingerprints have remarkable permanency and uniqueness throughout the time. From observations we conclude that the fingerprints offer more secure and reliable personal identification than passwords, id-cards or key can provide.

Thus in this paper we are providing an extra security option to the motorcycle by adding a fingerprint module to the bike by which only the valid or authorized user can access the motorcycle. The ignition system of the bike is connected to the controlling unit i.e. the microcontroller. Following are the basic terminologies that are used in the model.

Fingerprint: A finger prints are the most important part of human finger. It is experienced from the research that all have their different finger prints and these finger prints are permanent for whole life. So fingerprints have been used for the forensic application and identification for a long time. A fingerprint is the composition of many ridges and furrows. Finger prints cant distinguished by their ridges and furrows. It can be distinguished by Minutia, which is some abnormal points on the ridges.

Minutia is divided in to two parts such as: termination and bifurcation. Termination is also called ending and bifurcation is also called branch. Again minutia consists of ridges and furrows; valley is also referred as furrow.

Fingerprint recognition: The fingerprint recognition problem can be grouped into two sub-domains such as:-

i) fingerprint verification
ii) fingerprint identification

Fingerprint verification is the method where we compare a claimant fingerprint with an enrolled fingerprint, where our aim is to match both the fingerprints. This method is mainly used to verify a person's authenticity. For verification a person needs to his or her fingerprint in to the fingerprint verification system. Then it is representation is saved in some compress format with the person's identity and his or her name. Then it is applied to the fingerprint verification system so that the person's identity can be easily verified. Fingerprint verification is also called, one-to-one matching.

Fingerprint identification is mainly used to specify any person's identity by his fingerprint. Identification has been used for criminal fingerprint matching. Here the system matches the fingerprint of unknown ownership against the other fingerprints present in the database to associate a crime with identity. This process is also called, one-to-many matching. Identification is traditionally used for solve crime and catch thieves.

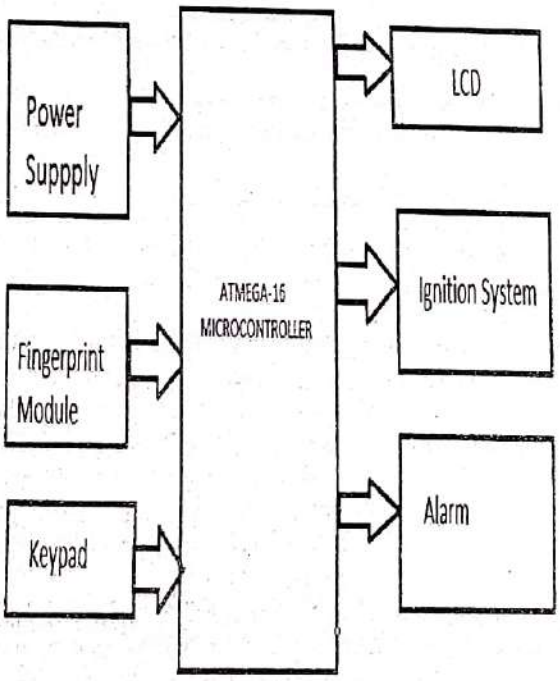

Fig.1 Block Diagram

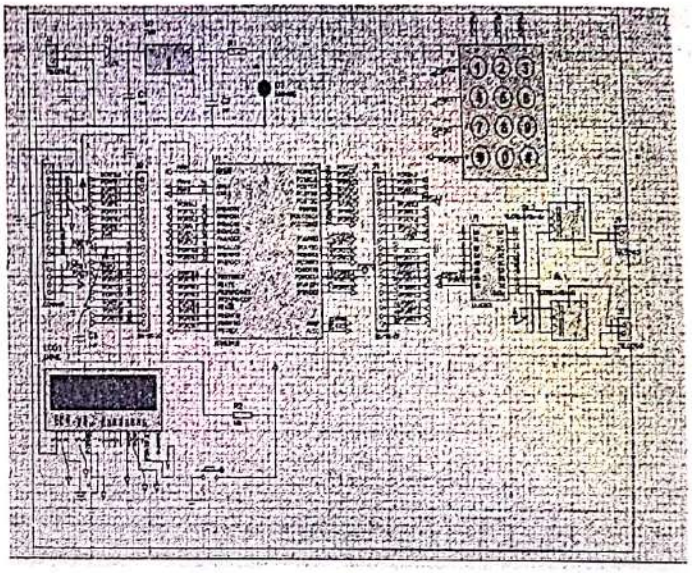

Fig.2 Circuit Diagram of the Model

III. WORKING

Initially the data of authorized user(s) should be entered in finger print module. With the help of this stored data we will provide excitation to the ignition system of the motorcycle. There are four pots in the microcontroller each comprising of 10 pins. Port B of the microcontroller is interfaced with the LCD.

The pins 14 and 15 of the microcontroller are the defined for the USART. Thus the fingerprint module can be directly interfaced with these two pins of the microcontroller. The receiving pin (RD) of the module will be connected to the transmit pin (TXD) of the microcontroller and the transmit pin (TD) of the fingerprint module is connected to the receiving pin (RXD) of the microcontroller. The port C and D are utilized to control the output circuitry i.e., the interfacing circuitry comprising of relay which is used to drive the ignition system of motorcycle.

Ignition system of the bike will only be ignited if the person is authorized i.e. the record of the person's fingerprint is stored in the module.

When any person scans his finger in the fingerprint module then the scanner will search its library and if the scanned fingerprint template is found in the database of the fingerprint module then it will provide an acknowledgement signal to the microcontroller. Microcontroller activates the relay circuitry which in result will drive the ignition system of the motorcycle. But if a mismatch occurs then the microcontroller sends active signal to the alarm to alert the authorized user about the threat to the motorcycle.

IV. CONCLUSION

Fingerprint identification enhances the security of a vehicle and makes it possible only for some selected people to start the vehicle.

The expected result by implementing this model on the motorcycle is that only the authorized person will be able to ignite the motorcycle. Not every person with the key will be able to start the bike. There will be matching of the person's data with the stored one and only in the case of match the bike will start otherwise not. Thus by implementing this relatively cheap and easily available system on a vehicle one can ensure much greater security and exclusivity than that offered by a conventional lock and key. The thief would have to do a great deal of homework to steal the bike, and it is unlikely that they have the fingerprint technology needed to fake your fingerprint.

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SHRI RAM MURTI SMARAK
Women's College of Engineering & Technology

National Conference
Advances & Research Trends in Electronics & Communication
April 25, 2015

Certificate of Participation

This is to certify that Prof./ Dr./Mr./Ms. SARTHAK SHARMA of MORADABAD INSTITUE OF TECH., MORADABAD has presented paper titled. MOTORCYCLE IGNITION USING FINGERPRINT RECOGNITION in National Conference on **"Advances & Research Trends in Electronics & Communication (ARTEC-2015)"** organized by Department of Electronics & Communication Engineering, Shri Ram Murti Smarak Women's College of Engineering and Technology, Bareilly.

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Anti-Theft System for Mobile Phones Using Zigbee Modules

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Abstract: **In present world, costly items such as mobile phones, Tablets, Laptops are prone to theft are required to be monitored to ensure safety. Monitoring the phones within a short distance by the use of wireless security system is implemented using modules which are capable of communicating with each other. The LED and buzzer attached to the modules sounds instantly when thephone moves approximately eight meters away from the owner to the fixed location. The modules are designed with two ATMEGA8 microcontrollers and MAX232 Zigbee modules. A wrist band on which a receiver is mounted with a vibrator, vibrates when phone cross the eight meter margin.**

Keywords: *Wireless Security, MAX232, Zigbee Technology, Microcontroller*

I. INTRODUCTION

The theft of valuable phones or valuable goods is increasing every day. There is a tremendous increase oftheft in public places in the previous years. In the current situation how to protect the phones such as mobile phones, laptops and tablets has become a tough task. These phones are easy forthieves to steal and resale. According to statistics, for everyfifty three seconds a phone is stolen. Checkingthe physical presence and location of these devices is an importanttask needed at all times. There can be number of ideas to protect thephones from being stolen. We can reduce the amount of theft byusing an antitheft alarm system. A buzzer is present at the transmitting or cover of the phone in which LED is attached, it is having a wrist band or receiving portion which vibrates when phone is out of range. The owner of the phone is alerted by analarm if the phone is moved eight meters away. In wirelesscommunication, data is broadcasted by radio frequencies.As a result, data may be captured when it is broadcasted. Thereare many wireless communication technologies such Zigbee,WI-FI, RF, Bluetooth, etc. Various wireless technology hasdifferent communication range from centimeters to severalhundred meters. In this project a range approximately eightmeters is used because it is easy to protect the phone from beingstolen. Eight meters range is an accessible range and can be more effective than others.

II. EVOLUTION OF ANTI THEFT SYSTEMS FOR MOBILE PHONES

The design of anti-theft alarm systems is an important safety measure to keep a mobilephone safe. The main idea of this design is to give information or any kind of alarm or warning to the owner of the phone when the phone is moved from its original position. A personal phone alarm device is designed which works on a position sensing principle and gives out an audible alarm ,starts blinking of LED and vibration on wrist band in case of theft. The device is housed in a sealed box with an opening for the sound signal to come out and is comprised of an alarm, sensing switch and a battery source. It also has a receiving section on the owner wrist which vibrates when the phone is out of range. The device has two position sensitive switches which are employed in the design to overcome any faulty errors that may occur with the use of the single switch. Zigbee modules have high accuracy than normal RF modules as number of other RF devices can be working the region which can interrupt the signal but Zigbee has high frequency than RF which makes it more efficient and accurate. Previous models of anti theft system consist of position sensing of mobile phones using timers .It was consisting a pulse generator at transmitter end and a timer at receiver end when there is any delay in the receiving of the signal the buzzer starts beeping and the theft is indicated. After this, a frequency receiving anti theft device was made in which frequencies are compared simultaneously and if there is any weak signal found then it triggers alarm.

III. WHAT IS ZIGBEE?

Zigbee is an IEEE 802.15.4 standard for data communications with business and consumer devices. It is designed around low-power consumption allowing batteries to essentially last forever. The Zigbee standard provides network, security, and application support services operating on top of the IEEE 802.15.4 Medium Access Control (MAC) and Physical Layer (PHY) wireless standard. It employs a suite of technologies to enable scalable, self-organizing, self-healing networks that can manage various data traffic patterns. Zigbee is a low-cost, low-power, wireless mesh networking standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries, and the mesh networking provides high reliability and larger range.Zigbee has been developed to meet

the growing demand for capable wireless networking between numerous low power devices. In industry Zigbee is being used for next generation automated manufacturing, with small transmitters in every device on the floor, allowing for communication between devices to a central computer. This new level of communication permits finely-tuned remote monitoring and manipulation.

Comparison among various technologies:

TABLE I

Category	Zigbee	Bluetooth	Wi-Fi
Distance	5-15m	3m	50m
Extension	Automatic	None	Dependsonnetwork
Power Supply	Years	Days	Hours
Complicity	Simple	High	Complicated
Freq. Range	2.4GHz	2.4 GHz	2.4GHz
Linking Time	30ms	Up to 10 s	Up to 3s
Prime Cost	Low	Low	Normal
Ease of use	Easy	Normal	Hard

Zigbee Device Types

Zigbee devices are of three types:

1) Zigbee coordinato r(ZC): The most capable device, the coordinator forms the root of the network tree and might bridge to other networks. There is exactly one Zigbee coordinator in each network since it is the device that started the network originally. It stores information about the network, including acting as the Trust Center & repository for security keys.

2) Zigbee Route r(ZR): As well as running an application function, a router can act as an intermediate router, passing on data from other devices.

3) Zigbee End Device (ZED): Contains just enough functionality to talk to the parent node (either the coordinator or a router); it cannot relay data from other devices. This relationship allows the node to be asleep a significant amount of the time thereby giving long battery life. A ZED requires the least amount of memory, and therefore can be less expensive to manufacture than ZR or ZC.

IV. DESIGN OF SYSTEM

A RS232 communication protocol was used to interface Universal Asynchronous and Receiver and Transmitter in ATMEGA8 microcontroller and the Zigbee transceiver. The R1OUTandT1INprovides a transmit/receive data lines with standard rates. An R1OUTandT1IN provides transmit and receive first in first out (FIFO) for transfer of data between ATMEGA8 to MAX232 Zigbee transreciever. The microcontroller-based embedded device along with MAX232 Zigbee transceiver in one module will maintain full duplex communication with another module. MAX232 Zigbeetransceiver in both modules provides extensive hardware support for effective RF communication in eight meters of distance. When any of the modules move eight meters away from the fixed location, the communication between two modules will be lost and it generates a buzzer sound and LED blinking at cover end and at band end the vibrations occurs, which is connected to pin 40 of the microcontroller. When the circuitry is in range then there is no functioning the circuit is in idle state. The Oscillator is connected to XTAL1 and XTAL2. A reset switch RST is used to reset the circuitry. Power supply was made of 9V to 5V using a transformer and diodes. It was consisting of two IN4001 diodes,threecapacitors of 1000μF,10μF, 0.01μF respectively and IC 7805 is used as avoltage regulator to covert 9V to 5V.

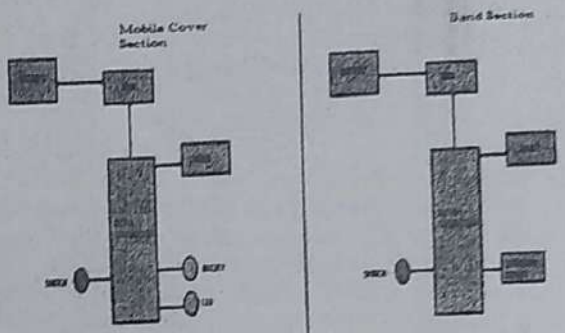

Fig1. Block Diagram of Anti-theft system using Zigbee Technology.

V. BUILDING THE SYSTEM

In order to meet the project, the building system is developed in various phases. In the initial phase, the required system criteria, such as inputs are identified,established and the Power supply was made. The next stage was simulation of circuit. In the next phase, all hardware components are configured for proper operation. The RS232 communication protocol is used to interface ATMEGA8 microcontroller R1INANDT1OUT and the MAX 232transceiver .ATMEGA8 and MAX 232 interface The MAX 232 transceiver is configured for obtaining optimum register settings and to meet the design aspects of the communication channel. MAX 232 transceiver is interfaced to an ATMEGA8 microcontroller and this controller is able to:

(i) RD/WR buffered data to and from MAX 232 for lossless communication.
(ii) ProgramMAX 232 in different modes to meet therequirements of the communication channel.

In transmit mode, the circuit gets triggered when the band or the cover moves away from the distance of eight meters.In the final phase, the project of the wireless security system using Zigbee technology is evaluated by three factors in consideration, such as effective distance, time delay, and noise associated with the system. The distance between two modules

can be varied depending on the application selected. MAX 232 transceiver is specifically used for short distance communications at lower power levels in a frequency range of 2.4GHz. By practically testing the system, the buzzer and LED blinking is observed in mobile cover sectionand vibration on band section when any of the modules is moved eight meters from the fixed location. Some minimum time delay is observed due to the interference of the communication channel between modules.The initial processing of the system with getting started and initialization of the registers of MAX 232 requires some time. Noise is tested by placing the modules in a vacuum environment and when the modules are in the external environment. There was more noise effect when modules are tested in external environment.

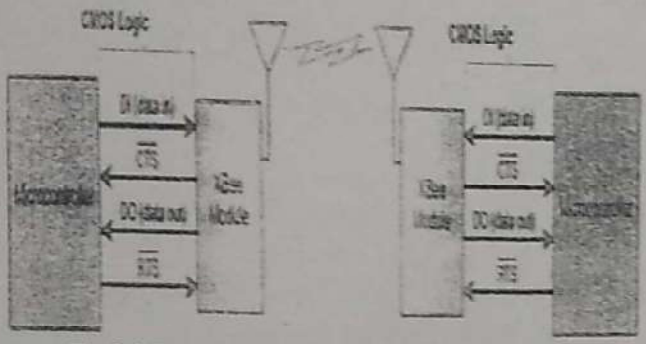

Fig 2. Microcontroller and Zigbee Communication.

VI. IMPLEMENTATION OF THE SYSTEM

A Zigbee enabled wireless security system is built around MAX 232 RF transceiver and an ATMEGA8 microcontroller. A MAX 232 Zigbee transceiver is interfaced to microcontroller using T1INANDR1OUT. A RS232 communication protocol is used to interface ATMEGA8 microcontroller and the MAX 232 Zigbee transceiver. In MAX 232 Zigbee transceiver, first it is set in TX mode which is initiated in one module and data is transferred completely. After completing data transfer, it is automatically changed to RX. These modules are set to default settings from the factory and can communicate to one another without any configuration. The MAX 232 Zigbee transceiver supports up to 250 kilobytes per seconds of data variable packet length mode. Here the channel number is selected as 0 which is a default number in both modules of MAX 232 Zigbee transceiver.The MAX 232 Zigbee transceiver supports amplitude, frequency and phase shift modulation formats. Frequency shift keying (FSK) modulation is used in both modules with symbol encoding as 0 for negative deviation and 1 for positive deviation. The T1IN AND R1OUT in ATMEGA8 microcontroller has a transmitter and receiver which communicate with MAX 232 Zigbee transceiver using RS 232 communication protocol by the use of START and STOP pulses. When the power is turned ON, microcontroller initializes the code in flash memory and resets all the registers. The instructed program in ATMEGA8 microcontroller executes the required function (transmitting and receiving of an ASCII value to ensure communication between the modules) through RS 232 with a baud rate of 250kbps and make communication establishment with MAX 232 Zigbee transceiver. The R1INANDT1OUT receives the acknowledgement from MAX 232 Zigbee transceiver and updates the test flag, which is used to monitor the continuous communication process ensuring security. When there is continuous communication between two modules of MAX 232 Zigbee transceiver, the buzzer, LED, Vibrator is in off condition. And when two modules move away eight meters, the communication is lost and this results in a buzzer sound LED Blinking and Vibration at wrist band.

VII. CONCLUSION

An Antitheft security system attached with the phone in consideration was proved to be an efficient way to alert the user in case of theft. The wireless communication between two Zigbee modules is achieved through MAX232 and microcontroller ATMEGA8. The size of the system can be reduced or minimized by decreasing the battery sizes, making it more accessible, secure and compact to install on many portable devices.

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Contact Dynamics Emulation Using Leap Motion Controller

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Abstract. Recent developments in Human-Computer Interaction technologies can be harnessed effectively to facilitate better cognitive learning and this is what this project aims to achieve in the field of Contact Dynamics. The project aims to enable a better comprehension of the concepts of Contact Dynamics to a layman through a technology that has been developed to foster interactive learning viz. the Leap Motion Controller. The project involves the usage of the Leap Motion Controller, a hand motion sensing device, to understand 'Dynamics' i.e., a branch of classical mechanics associated with the application of forces on bodies and the effect they have on their motion, along with the help of a conventional personal computer.

Keywords: Human-Computer Interaction · Leap Motion · Contact Dynamics · Hand-motion sensing · Newtonian Mechanics

1 Introduction

Theoretical knowledge pertaining to the concepts of Contact Dynamics is difficult to grasp at first glance. Also, for senior high school and varsity students, practical research and analysis in the field of Contact Dynamics are hard to conduct because of:

- High costs incurred in the construction of a physical prototype.
- Risks that involve collateral damage to people and property in the vicinity of the physical prototype due to erroneous calculations, unforeseen environmental conditions etc.

Therefore, a virtual model is not only instrumental but imperative for better understanding systems comprising of singular or multiple bodies upon which a variety of forces are applied. The goal is to study about the motion of these bodies under the application of various forces. So, the target of the project is to design a virtual simulation environment on the host computer which emulates the theoretical concepts of Contact Dynamics in particular and Newtonian Mechanics in general.

Another reason why various virtual prototypes are required because they assist in visuospatial constructive cognition [1]. Visuospatial constructive cognition is the

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ability to visualize an object in the form of its constituent segments and build a model of the object using these segments. Hence, this project helps students conceptualize the prototypes and interact with them through hand gestures so as to promote both easy learning and a better understanding of the same while simultaneously providing them with a fun way to improve their visuospatial skills. Exploration into interactive learning through Leap Motion Controller has been explored in Australian Sign Language Recognition [2] to support the hearing impaired. This interactive framework can be used to treat, if not heal altogether, people afflicted by conditions like Attention Deficit Hyperactivity Disorder (ADHD) [3]. Also, it can be used to examine skeletal muscles using Electromyography (EMG) [4].

To achieve an interactive configuration, a sensor device called Leap Motion Controller is connected to a computer. This device is used to track the movements of a user's hands and fingers, in order to recognize the hand gestures being performed as the user glides their palm/fist/pointed finger(s) just over the Leap Motion device in a defined pattern. If the Leap Motion device is able to recognize a hand gesture, an operation corresponding to that gesture will be performed on the computer system to which the sensor device is connected. Several types of gestures can be customized using the device and operations corresponding to each gesture can be defined on the computer. By performing these hand gestures in the vicinity of the Leap Motion device, a user can operate a simulated virtual environment. For instance, the Leap Motion has been found to be rather dynamical in simulating musical instruments like piano as it has a vast gesture repertory [5]. The Leap Motion device is able to track the motion of hands hovering above it with the help of infrared radiation emitted by its sensors as well as with the help of 2 built-in cameras.

The Leap Motion Detector tracks the fingers and palm of the user when their hand moves within the range of the infrared radiation emitted by the device. This tracking data can be obtained from the Leap Motion API through an object called *frame*. The *frame* object contains data pertaining to the position of the user's hand like the velocity of the fingertip and its spatial position. This data can then be retrieved in the form of coordinates and manipulated upon to perform various operations like pushing a button, moving a static bar on the screen, taking input values on the host computer by the gestures of the fingers etc. In order for the operations to be performed on the computer through gestures, the gesture frames are fed to the LeapGesture library [6] which contains previously defined gesture recognition functions. If the frame data matches one of the previously defined gesture recognition functions in the LeapGesture library, then the operation corresponding to the gesture will be carried out on the computer. However, besides the use of predefined gestures, users may also be able to customize new gestures according to their convenience to interact with the framework, much like sensor gloves which have been used in applications involving the use of custom gestures [7]. But some additional pattern recognition functions may need to be incorporated into the project to recognize the new gestures. For instance, a 3D surface rendering software: OsiriX [8], which is used to process images produced by imaging techniques like MRI, CT, PET, Ultrasounds etc., makes use of gestures in which a circular motion is performed with the index finger of the right hand in clockwise and anti-clockwise motions to navigate through a data set.

Although other motion tracking devices that have depth sensors like Kinect from Microsoft could alternatively be used, a device is preferred that is compact, cost-effective, robust, and has high-resolution sensors. Kinect has been found to generate imprecise and low resolution depth maps [9]. This can cause discrepancies in the measurement of the distances of fingertips from the depth sensor. Since the Leap Motion Controller was found to be better in all the aforementioned parameters than Kinect, the former was incorporated in the project. Also, only the utility of hand gesture recognition suffices for the project as opposed to full-body motion detection that is provided by Kinect. Another alternative to the use of the Leap Motion Controller could be the Data Glove which was developed by Zimmerman [10]. The Data Glove has a major limitation, i.e., it is equipped with tactile switches, optical goniometer and resistance sensors besides a variety of other sensors to detect flexion of the fingers [11] which makes it a cumbersome device to use lest one forgets that the device comes with a hefty price tag which is several times the price of the Leap Motion Controller.

2 Project Configuration

A brief description of the tools and the technologies utilized in the project are given as follows:

2.1 Leap Motion Controller

Leap Motion Hardware. Leap motion controller is a cuboidal hand-motion gesture detection device (dimensions: 13 mm × 13 mm × 76 mm). It consists of 3 infrared sensors and 2 cameras which simultaneously detect the movements of a user's hand(s) in general and the fingers in particular in a 3-Dimensional conical space above the device [12] with sub-millimeter accuracy [13] for up to 10 fingers. The area in the vicinity of the Leap Motion device in which the hand gestures are accurately detected is 2 feet above the device, by 2 feet wide on each side along the length of the device covering an angle of 150°. And up to 4 feet across the device covering an angle of 120°. The fingers' position, velocity and direction coordinates are recorded by the device at a rate of up to 200 fps [14] (Fig. 1).

The below figure shows that the Leap Motion device has the best frame rate from among other popular gesture detection devices. Hence our predilection for the Leap Motion Controller.

Leap Motion Software. Leap Motion software comprises of the Leap Motion Software Development Kit (SDK). This SDK consists of the LeapGesture library which, in turn, provides the developers with the Application Programming Interfaces (API) of Leap Motion Controller. The Leap Motion API is a set of functions, classes and objects which allow the developer to use predefined gestures as well as standard commands from the Leap Motion library in order to interact with the system using the Leap Motion Device. The following figure explains the process through which hand gestures are recognized by the Leap Motion device (Fig. 2).

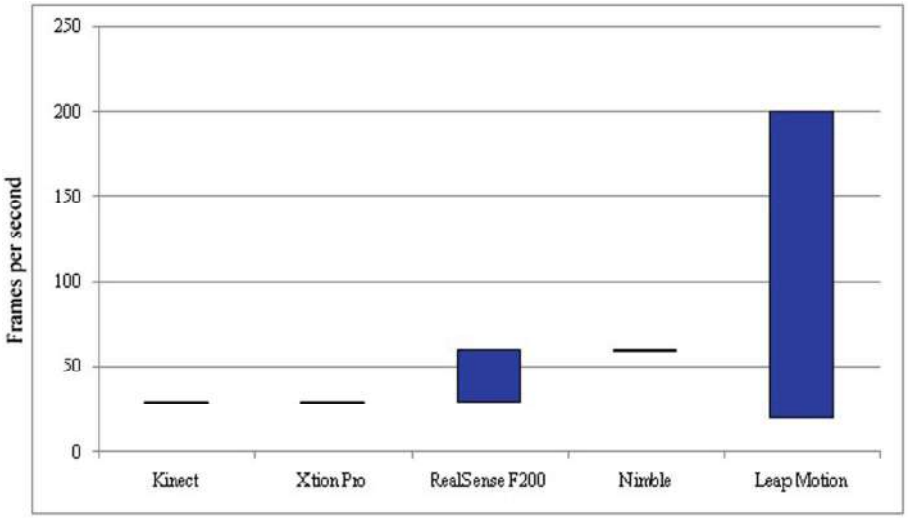

Fig. 1. Frame rates of different gesture recognition devices

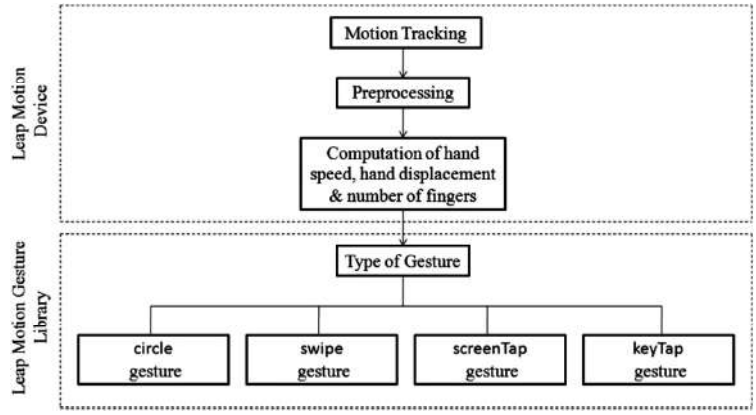

Fig. 2. A diagram presenting the recognition process implemented in the LeapGesture library

2.2 Programming Languages Used

HTML5 and CSS3. The <canvas> element of HTML5 is most extensively used in this project because not only does it allow for differentiating multiple objects like buttons on a webpage, but also facilitates easy interaction of hand gestures with those objects. Besides, this element of HTML5, along with CSS3, can also be used to draw graphics and 2D pictures on a webpage [15].

JavaScript. JavaScript is best suited for developing projects involving the Leap Motion device. This language is particularly used to extract as well as manipulate the coordinates of fingers/hands to interact with the objects in the webpage and to design the animations of the project. These animations provide a visually stimulating experience for students to learn the concepts of Contact Dynamics.

3 Methodology

The user opens the HTML file of the project through a web browser and is presented with an interface that prompts them to select one case from among four different cases of Contact Dynamics, namely:

- LM (linear motion) of a single block
- SMIP (sliding motion along an inclined plane) of two blocks
- DMHP (dragging motion along a horizontal plane) of two blocks
- FPVL (fixed pulley with vertical loads) (Fig. 3, Table 1)

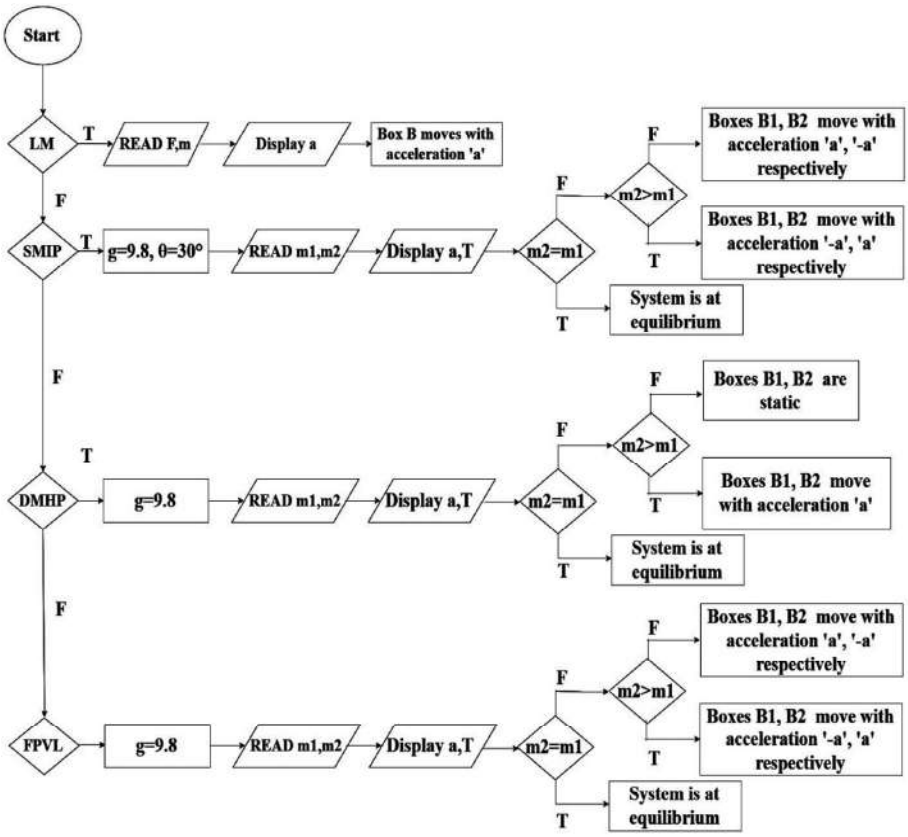

Fig. 3. Procedure to select and run a case of Contact Dynamics

Table 1. Abbreviations of the terminology used and their corresponding definitions

Abbreviation	Definition
F	Force acting on a block
m	Mass of a block
a	Acceleration with which a block moves
T	Tension in the rope connected to a box
g	Acceleration due to gravity (9.8 m/s$^{2)}$

Initially, the user needs to perform a *screenTap* gesture to select a case. The *screenTap* gesture is a pointing movement which is equivalent to a mouse-click. This gesture is recognized when the index finger rapidly prods forward and draws backward into its original position with a velocity of at least 40 mm/s [16]. Then, the user must move their finger over to the *Input* button and perform the same gesture again. This opens up a new HTML page which prompts the user to input several values corresponding to the case that the user selected, via a numeric keypad. The numeric keypad allows a user to input values, by performing the *screenTap* gesture, into the text fields that appear on the webpage of the browser's window (Table 2).

Table 2. The input requirements and outputs of different cases of Contact Dynamics taken in this project

Case	Prerequisite data	Input	Output
LM	Nil	Mass of the block and force applied on the block	Block moves with acceleration 'a'
SMIP	G (acceleration due to gravity) = 9.8 m/s^2 and Θ (angle of inclination of wedge) = 30°	Masses of both the blocks	Both blocks move along the direction of the block, the net force acting on which is greater, with acceleration 'a'. If the net force acting on each block is equal, the system remains stationary
DMHP	G = 9.8 m/s^2	Masses of both the blocks	Both blocks move along the direction of the suspended block, if the net force acting on the suspended block is greater, with acceleration 'a'. Otherwise, the system remains stationary
FPVL	G = 9.8 m/s^2	Masses of both the blocks	Both blocks move along the direction of the block, the net force acting on which is greater, with acceleration 'a'. If the net force acting on each block is equal, the system remains stationary

Upon entering the values in the requisite text fields, the net acceleration 'a' with which the system must move is calculated on the basis of the entered values and displayed. After a delay of about 4 s, the output is generated in the form of an animation which corresponds to the case that the user had previously selected. The animation shows the system moving with an acceleration of 'a' m/s^2. The animation was made using HTML5, CSS3 and JavaScript.

4 Results

The *screenTap* gesture is performed to select a case from among 4 different cases of Contact Dynamics taken in this project. To implement the *screenTap* gesture, *Pointable* class method *touchDistance* of Leap Motion API is used. This method creates an adaptive touch plane at the central axis of the device. The *touchDistance* values range from −1 to +1 on the transverse axis of the Leap Motion device. The adaptive touch plane is at value 0. If the fingertip position coordinates lie within the range [+1, 0), then this implies that the fingertip is hovering over the object. As soon as the fingertip position coordinates come within the range (0, −1], then the *screenTap* gesture will be performed and the case will be selected.

To select a single object out of multiple objects on a webpage, *pointable* and *interactionBox* objects of class *Frame,* and *normalizePoint()* method of class *InteractionBox* are used. These objects and the *normalizePoint()* method help map the finger coordinates to the canvas. These mapped coordinates are then displayed in the textual form on the canvas using the method *strokeText()*.

The following algorithm shows how the retrieved positional data coordinates of the fingertip can be manipulated to interact with the objects on a webpage that lie within different grids of the HTML canvas:

```
SELECT_CASE(case,X,Y)
if canvasX > x1 & canvasX > x2 & canvasY > y1 & canvasY >
y2
  thenimgChange("image.png")
  if touchDistance < 0
  then     canvas.strokeText(case,X,Y);
                    imgtype ←"image"
```

Following images depict the results of implementing the previously described methodology (Fig. 4).

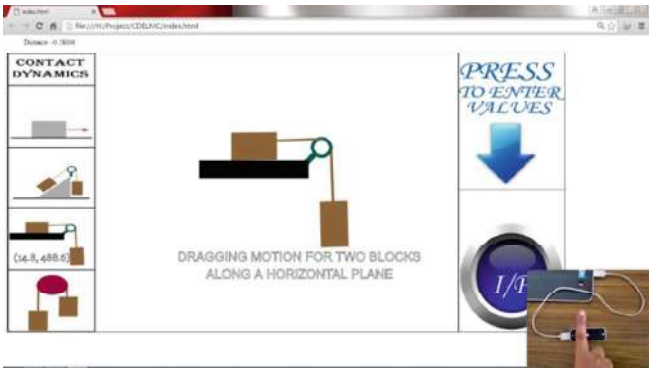

Fig. 4. Selecting a case of Contact Dynamics through *screenTap* gesture

The above image shows the 'DMHP' case being selected from the left menu (3rd from top) (Fig. 5).

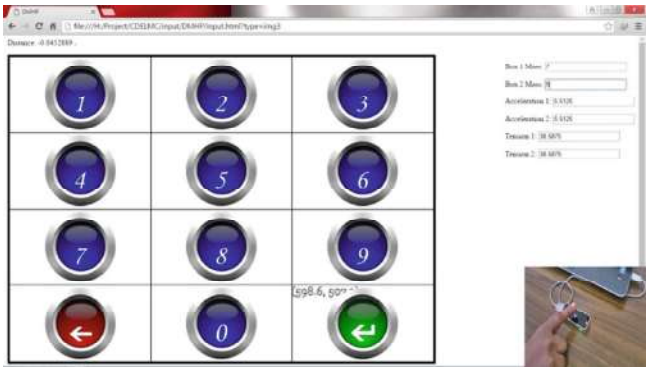

Fig. 5. A keypad to enter values into the requisite text fields through *screenTap* gesture in order to calculate the net acceleration of the blocks in the system

The above image shows the use of a virtual keypad to input values such as masses of the boxes, for the previously selected case, in the text fields by performing the *screenTap* gesture (Fig. 6).

Fig. 6. The resultant animation of the selected case of Contact Dynamics showing the acceleration of the blocks in the system

An animation pertaining to the selected case of Contact Dynamics will be played wherein the boxes may move with a certain acceleration depending upon the values which were input by the user in the antecedent stage using a keypad.

5 Conclusion

In this paper, we have attempted to establish a novel approach to discerning, comprehending, analyzing and evaluating a very small portion, viz., Contact Dynamics, of a Brobdingnagian field, viz., Newtonian Mechanics. This project has the potential to be a viable and plausible alternative to the orthodox 'black-board' teaching methodology which, apparently, is insufficient to elucidate intricate concepts. This project has tremendous scope in academics as it can be used to incorporate concepts pertaining to various fields including, but not limited to: Defense, Automotive, Aeronautics and Biomechanics. This new alternative has already begun showing promise, so much so that the Leap-Motion SDK which comes with the Leap-Motion Controller shows the working of the human heart in 3-D and the process of pumping of blood through all 4 valves of the heart in a way that can easily be understood by a layman.

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Support Vector Machine Based Gender Identification Using Voiced Speech Frames

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***Abstract*—Gender of the speaker can easily be identified by his or her voice. Identification of gender is required in restricted areas where only specific gender is allowed. Gender identification may also play important role in speaker recognition as this can be used to reduce search space. In this paper gender of the speaker has been identified using support vector machine (SVM).Two features- Pitch and Mel Frequency Cepstral Coefficients (MFCCs) are used as components of feature vector. Voiced frames are extracted from speech signal using Short Term Energy (STE) and Zero Crossing Rate (ZCR). Pitch value is calculated by cepstral analysis method applied on extracted voiced frames. MFCCs are also calculated from voiced frames. Experiments have been performed on the database obtained from IIIT-Hyderabad consisting of 5000 speech signals having voice of males and females in multilingual (Hindi, Telugu, Tamil, Marathi and Malayalam). For training the proposed model, 200 male and 200 female speech signals are taken arbitrarily from the above database. Evaluation of the proposed model has been performed using other 200 speech signals (males and females both) from same database. Without separating voiced and unvoiced frames, the accuracy of gender identification claimed in the literature is 99%. Using pitch and MFCCs that are calculated from extracted voiced frames, the accuracy of gender identification has gone up to 99.5%.**

Keywords—STE, ZCR, Cepstral Coefficients, Pitch, MFCCs, SVM

I. INTRODUCTION

Speech signals are the most common means of communication. Today, speech signals are used in many real life applications like speech recognition, speaker identification, gender identification and speech pre-processing for hearing aid devices [5]. Speech signals consist of both voiced and unvoiced sounds. Voiced sounds are produced when the vocal cord vibrates. Hence, voiced speech signals generate quasi periodic waveforms. Vocal cord does not play an important role for producing unvoiced sounds. Pitch can be easily calculated from periodic waveforms. It can be extracted accurately from speech signals considering only voiced frames [4]. In real life, background noise is acoustically added with clean speech and degrades the performance of the speech signal processing systems [1] [2]. To enhance the performance of such systems, speech enhancement and silence removal techniques are applied to the input speech. Speech enhancement techniques reduce the noise from the noisy speech [13].

The proposed approach in this paper, speech signals are divided into frames. Each frame is multiplied with hamming window to correct the discontinuity at the beginning and end of the samples of the frame. Features like ZCR and STE are calculated from input speech, Pitch and MFCCs are extracted from voiced frames of speech. Cepstral analysis method is used to find out the pitch from voiced frames of speech signal. ZCR is the measure of number of times the amplitude value of the speech signal changes the sign either from positive to negative or negative to positive. STE is calculated by summing the squares of the amplitude of each speech sample present in the frame.

Speech signal contains the information of excitation source and vocal tract. Pitch values of the speech signals are calculated by extracting the excitation source information. These two informations are separated out easily in frequency domain as compared to time domain. So, first we convert the speech signal from time domain to frequency domain and then apply Cepstral Analysis method to separate out these two information. Cepstral Analysis method converts these two convolved information as linear combination in cepstral domain.

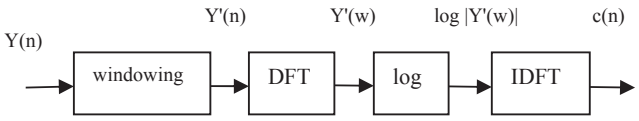

Fig.1 Block diagram of Cepstral Analysis method

Fig.1[1] describes the steps involved in converting the given voiced speech frames from time domain to cepstral domain. Y(n) is the voiced frame, Y'(n) is windowed frame, Y'(w) is spectrum of voiced frame and c(n) is the vector containing cepstral coefficients. First 15 values of cepstral vector are used for extracting vocal tract parameters like formant frequencies and remaining values are used to extract excitation source parameters like pitch [3][12].

Fig.2 describes the steps involved in extracting MFCC coefficients [14] from speech signal. MFCC are the

representation of the short-term power spectrum of speech signal.

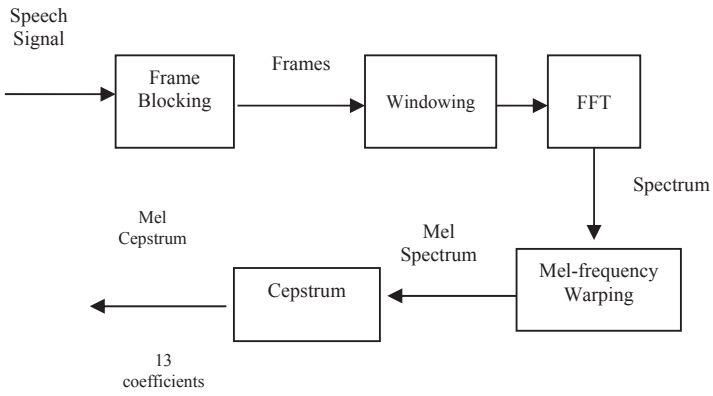

Fig.2 Block Diagram for extracting MFCC coefficients

Support Vector Machine performs well for linear binary classification. Gender identification problem is also a binary classification problem because gender is classified into two classes either male or female. In case of nonlinearly separable data, SVM can be used by selecting suitable kernels– Radial basis function, polynomial and multilayer perceptron. SVM maps inputs into a high dimensional space and then separate classes with a hyper plane. The kernel uses an explicit expansion into SVM feature space.

In 2003, H. Harb, and L. Chen [6] have proposed the gender classification system based on neural networks as classifiers by using 1 second of speech utterance. They claimed the accuracy for gender classification to be 92%. In 2006, Yu-Min Zeng et al. [7] have proposed the gender classification system using Gaussian Mixture Model (GMM). They used pitch and Relative spectral perceptual linear predictive coefficient (RASTA-PLP) as features. This model is claimed as language independent, it performs well in low signal to noise (SNR) condition. The minimum classification accuracy is 98% for all clean speech and 95% for noisy speech as claimed in the paper. In 2009, M.H. Sedaaghi [8] performs a comparative study of gender and age classification algorithms using speech signals. He studied the performance of different classifiers like Probabilistic Neural Networks (PNNs), Support Vector Machines (SVMs), K nearest neighbor (K-NN) and Gaussian Mixture Model (GMM). The Bayes classifier using sequential floating forward selection (SFFS) technique is also used for feature selection. He observed that the accuracy of gender classification is 95% . In 2009, M.Abdollahi et al. [9] proposed a novel approach for gender identification based on adaptive Multi Resolution (MR) classification of spectro-temporal maps. In this approach speech signals are converted into images by using inspired spectro-temporal representations. These spectro-temporal representations include mel-spectrogram, cochleagram and auditory spectrogram. The 2-D representation of a segment of a speech utterance is used as the input to the system. The accuracy claimed in the paper is 99%. In 2012, Yakun Yakun Hu *et al*.[10] proposed a novel pitch-based gender identification system with a two-stage classifier. The first stage of the classifier identifies the gender of the speaker based on pitch. The speech signals that are not classified by the first stage are known as suspicious speech signals. These suspicious speech signals are forwarded to second stage classifier. It uses Gaussian Mixture Model to classify the suspicious speech signals. The accuracy of the system is 98.65% as claimed in the paper.

Rest of the paper is organized as follows: Section II, describe the proposed algorithm and its block diagram. Section III describes the parameters used for measuring the performance. Section IV describes the experimental results of the proposed approach.

II. Proposed Approach

Voiced frames play an important role for extracting the pitch value from the speech signals [11]. Pitch value extracted from voiced frames is more accurate. Therefore, pitch value used in this paper is extracted from voiced frames only. First of all voiced frames are extracted from speech signal by using ZCR and STE. Then pitch values are obtained from these extracted voiced frames using cepstral analysis method. Pitch value is not sufficient for gender identification because it overlaps for some male/female persons. In this paper, pitch value and MFCC coefficients are used as feature vector for training and testing the SVM classifier.

Assumptions and Notations used in Algorithm:

i. Variables with superscript"$\widehat{\ }$" indicate that their values lie in frequency domain, otherwise in time domain.

ii. $|\hat{A}|$ represents the magnitude of spectrum $\hat{A}$.

iii. *fft (A)* represents fast fourier transform of vector *A*.

iv. *ifft*$(\hat{A})$ represents inverse fast fourier transform of spectrum $\widehat{A}$.

v. *fs* represents the sampling frequency.

vi. *Y(n)* represents the voiced frame and n is the number of samples present in the voiced frame.

vii. F_n represent number of frames in speech signal and F_s represent number of samples in particular frame.

viii. th_z *and* th_s represents the threshold values for the ZCR and STE.

ix. Each vector is assumed as a column vector.

A. Proposed Algorithm

Let S be a speech signal vector having dimension ($\boldsymbol{N\times 1}$) with sampling frequency ***fs***. The speech signal contains some silence region that has to be removed by using silence removal approach. We divide the speech signal into frames of duration 20 ms each with 10 ms overlap and compute the STE and ZCR value of each frame. Each frame has been further categorized as voiced or unvoiced on the basis of threshold value of STE and ZCR . During this approach two thresholds (th_z and th_s) have been calculated experimentally by using mean value of ZCR and STE of all the frames of speech sample. Frames having ZCR values less than th_z and STE values higher than th_s are known as voiced frames.

Steps involved in proposed approach are as follows:-

Step 1: Calculate the mean m of given speech signal

$$m = \frac{1}{N} \times \sum_{i=1}^{nN} S(i) \quad (1)$$

Step 2: Remove the differential coefficient (DC) component as follows

$$S = Si - m \qquad \forall i \text{ where } i = 1 \text{ to } N \quad (2)$$

Now, the signal S has no DC component.

Step 3: Remove the silence part from the speech signal

A frame whose short term energy value is less than 5% of average short term energy of the speech signal; that frame will be categorized as silence frame.

Step 4: Divide the speech signal into frames of size 20 ms each. Calculate the frame size F_s and number of frames F_n

$$F_s = \frac{fs}{1000} \times 20 \quad (3)$$

$$F_n = \frac{N}{Fs} \quad (4)$$

F_i denotes the i^{th} frame where $1 \le i \le F_n$.

Step 5: Calculate the zero crossing rate value of each frame

$$Z_i = \sum_{j=1}^{F_s} \frac{1}{2} \left[abs\left(sign\left(F_i(j)\right) - sign\left(F_i(j+1)\right) > 0 \right) \right]$$

$\forall_i$ *where i=1* to F_n .

Z_i represents Zero crossing rate of i^{th} frame and is stored in vector Z of size $F_n \times 1$.

Step 6: Calculate the short term energy value of each frame

$$E_i = \sum_{j=1}^{Fs} (Fi(j))^2 \qquad \forall_i \text{ where } i=1 \text{ to } F_n . \quad (5)$$

E_i represents Short term energy of i^{th} frame and is stored in vector E of size $F_n \times 1$.

Step 7: Set the threshold values for ZCR and STE

$$th_z = \frac{1}{Fn} \times \sum_{i=1}^{Fn} Z_i \quad (6)$$

$$th_s = \frac{1}{Fn} \times \sum_{i=1}^{Fn} E_i \quad (7)$$

Z_i represent the ZCR value of i^{th} frame

E_i represent the STE value of i^{th} frame

Repeat step 6 and step 7 for i=1 to F_n.

Step 8: Estimation of voiced frames based on ZCR and STE value of each frame and threshold values

i^{th} frame is voiced if $Z_i < th_z$ & $E_i > th_s$ otherwise unvoiced frame

Step 9: Apply Cepstral Analysis method to calculate the pitch value for all the voiced frames.

Step 10: Take the average pitch value of voiced frames and this is treated as pitch value for particular speech signal.

Step11: Calculate 13 MFCC coefficients of each voiced frames and take the average value of 13 MFCC coefficients and this is treated as MFCC coefficients for particular speech signal.

Step12: Combine pitch and 13 MFCC coefficients for each speech signal. Create a model by using these combined features and train the model by using speech signals (Using SVM as classifier).

Step13: Test the model by using speech signals.

B. Proposed Block Diagram

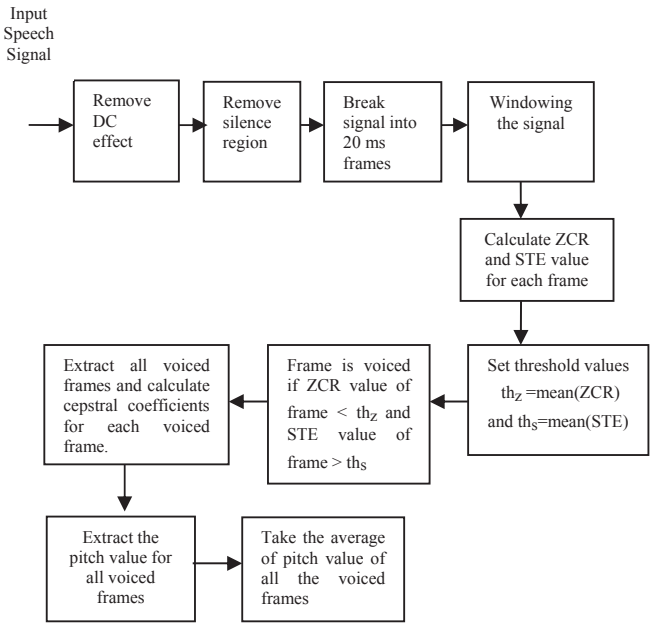

Fig. 3 Block diagram for calculating pitch frequency

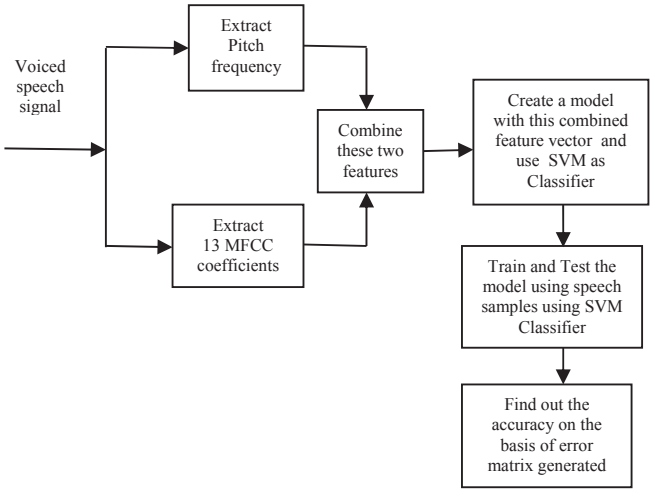

Fig. 4 Block diagram for Gender Identification using SVM as classifier

III. PARAMETERS USED FOR PERFORMANCE MEASURES

The error matrix (also often called the confusion matrix) is used for evaluating model performance. Error matrix compares the decision made by model with actual facts. Columns of the

matrix represent the instances in predicted class while rows represent the instances in an actual class. It shows the number of false positives (FP), false negatives (FN), true positives (TP), and true negatives (TN).

TP defines number of hits. TN defines number of correct rejection. FP defines false alarm. FN is defines number of misses.

Sensitivity or True Positive Rate (TPR) measures the proportion of positives that are correctly identified. It is equivalent to hit rate.

$$TPR = \frac{TP}{TP+FN} \quad (8)$$

Specificity or True Negative Rate (TNR) measures the proportion of negatives that are correctly identified.

$$TNR = \frac{TN}{FP+TN} \quad (9)$$

The false positive rate (FPR is the proportion of all negatives that still yield positive test outcomes.

$$FPR = \frac{FP}{FP+TN} \quad (10)$$

The false negative rate (FNR) is the proportion of events that are being tested for which yield negative test outcomes with the test.

$$FNR = \frac{FN}{FN+TP} \quad (11)$$

The accuracy is the degree of closeness of measurements of a quantity to that quantity's true value.

$$Accuracy = \frac{TP+TN}{Size\ of\ data\ set} \quad (12)$$

IV. Simulation and Results

IIIT-H database is used for the performance evaluation of the proposed approach. It contains 5000 speech samples in five Indian languages i.e. Hindi, Marathi, Telugu, Tamil and Malayalam. 200 male speakers (40 Hindi, 40 Marathi, 40 Telugu, 40 Tamil and 40 Malayalam) and 200 female speakers (40 Hindi, 40 Marathi, 40 Telugu, 40 Tamil and 40 Malayalam) are used for the training purpose of the model. 100 male speakers (20 Hindi, 20 Marathi, 20 Telugu, 20 Tamil and 20 Malayalam) and 100 female speakers (20 Hindi, 20 Marathi, 20 Telugu, 20 Tamil and 20 Malayalam) are selected randomly to test the trained model. The sampling frequency of all speech signals are 16 kHz and each sample contains 16 bits. The pitch and 13th order MFCC coefficients are extracted from every 20 ms frame. The dimension of feature vector is 14 (1 for pitch and 13 for MFCC coefficients).The proposed approach has been applied to all speech signals for gender identification. It is observed that gender identification is possible with high accuracy by using voiced frames. Our proposed approach is very robust and language independent.

Fig. 5 represents the original waveform of input speech signal. Fig. 6 represents the original speech waveform without DC effect and silence region. Fig. 7 represents the 20 ms voiced frame of the waveform. For this voiced frame ZCR=9 and STE = 2.120. The threshold values are th_Z= 12.83 and th_S= 1.98. The speech waveform contains total 62 frames of size 20 ms each. It is found that total 24 voiced frames are found and rest 38 frames are unvoiced. Fig. 8 represents cepstrum coefficients of the voiced frame. Table 1 shows the range of pitch values obtained by using our proposed approach for male and female speech signals.

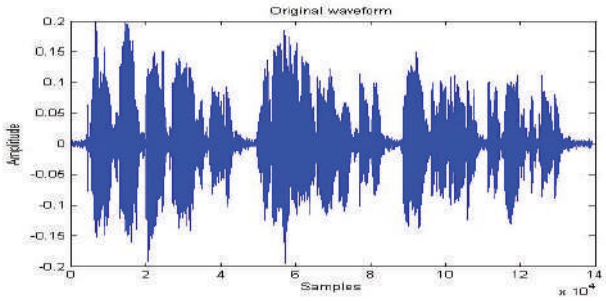

Fig. 5. Speech waveform

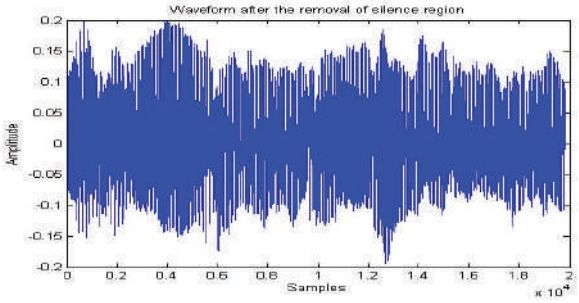

Fig. 6. Speech waveform without silence region

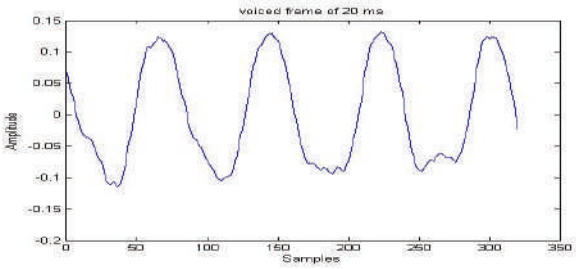

Fig. 7. 20 ms voiced speech frame

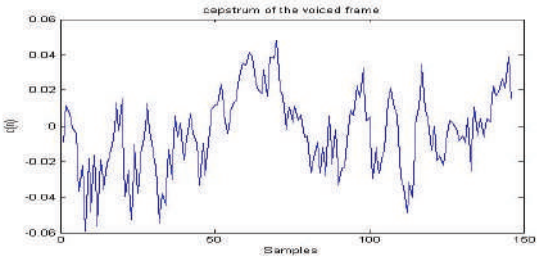

Fig. 8. Cepstrum coefficients of voiced frame

TABLE1: Pitch values obtained from speech samples using proposed Approach

	Min pitch value	Max pitch value
Male speaker speech samples	116.3	238.02
Female speaker speech samples	254	380.16

The file "gender3.xls" contains training data with combined features. The file "gender3_test_score_idents.csv" contains test data with combined features. The test outcome can be positive (classify the speaker that is female, represented by 0) or negative (classify the speaker that is not female i.e. male, represented by 1). Table 2 represents error matrix generated only taking pitch as feature. Table 2 shows that 96 out of 200 speakers are correctly identified as female speakers and 80 speakers out of 200 are correctly identified as male speakers. 20 male speakers incorrectly identified as female and 04 female speakers incorrectly identified as male speakers.

TABLE2: Error Matrix for the SVM model on gender1_test_score_idents.csv (counts):

Count		**Predicted**	
		0	***1***
Actual	0	96	4
	1	20	80

TABLE3: Error Matrix for the SVM model on gender1_test_score_idents.csv (proportions):

Count		**Predicted**		
		0	***1***	***Error***
Actual	0	0.48	0.02	0.04
	1	0.1	0.4	0.2

$$Accuracy = \frac{96+80}{200} = 88\% \quad (13)$$

Overall error: 12% it means that accuracy is 88% .

Table 4 represents error matrix generated when pitch and MFCC coefficients together taken as feature vector. Table 4 shows that 100 speakers out of 200 are correctly identified as female speakers and 99 speakers out of 200 are correctly identified as male speakers. 01 male speakers incorrectly identified as female and none female speakers incorrectly identified as male speakers.

TABLE4: Error Matrix for the SVM model on gender3_test_score_idents.csv (counts):

Count		**Predicted**	
		0	***1***
Actual	0	100	0
	1	1	99

TABLE5: Error Matrix for the SVM model on gender3_test_score_idents.csv (proportions):

Count		**Predicted**		
		0	***1***	***Error***
Actual	0	0.5	0	0.0
	1	0.005	0.495	0.01

$$Accuracy = \frac{100+99}{200} = 99.5\% \quad (14)$$

Overall error: 0.5% it means that accuracy is 99.5%

By taking pitch only feature, accuracy of gender identification is 88% while combining it with MFCC coefficients accuracy has improved to 99.5% .This accuracy is better than accuracy that calculated considering both voiced and unvoiced frames during features extraction.

CONCLUSION

In this paper, a new approach for gender identification of speakers using only voiced speech frames is proposed. This approach of gender identification can be used for real time applications like specific gender entry systems or gender specific survey. It can also be used for speaker recognition system by reducing search space.

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Technological Scopes in Nurturing Smart India (TSNSI-2017) organized at MIT MORADABAD

ANYBODY CAN DO DATABASE MANAGEMENT(ABCDM)

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ABSTRACT

Interaction with standard databases are possible only if we know about the standard SQL queries. This paper focuses on interacting with the DBMS with speech. Automatic speech recognition is becoming famous now a days and it is widely used in many applications. Here users can interact with the database with their voice for retrieving details from it. Hence it is not necessary that user must have a prior knowledge about the SQL queries, they could retrieve details with their knowledge. The main purpose of this paper is that novice users who have no knowledge about the sql queries can use it for retrieving the details from the database.

INTRODUCTION

Speech is one among the way of exchanging information among people. Many interfaces are being developed for human-machine interaction. Voice/speech recognition is one of the widely developing area now. Automatic speech recognition (ASR) is becoming famous nowadays. Many speech recognition systems can recognize lot of words. ASR, is has a lot of applications in many aspects of our daily life, for example, telephone applications, applications for the physically handicapped and illiterates and many others in the area of computer science.

OVERVIEW OF PROPOSED SYSTEM

We propose an interactive database system approach in which speech is recognized using speech recognizer and the recognized voice is converted into text .Now the text is converted into a standard sql query. For the constructed sql query necessary details are retrieved from the database. This process is repeated until the user is satisfied with the retrieval results.

LIST OF MODULES

1. Automated speech recognition module

2. Text to Sql Converter Module
3. Database Interaction Module

Automatic Speech Recognizer Module

Speech recognition is the inter disciplinary sub-field of computational linguistics that develops methodologies and technologies that enables the recognition and translation of spoken language into text by computers. It is also known as "automatic speech recognition" (ASR), "computer speech recognition", or just "speech to text" (STT). It incorporates knowledge and research in the linguistics, computer science, and electrical engineering fields. Some speech recognition systems require "training" (also called "enrollment") where an individual speaker reads text or isolated vocabulary into the system. The system analyzes the person's specific voice and uses it to fine-tune the recognition of that person's speech, resulting in increased accuracy. Systems that do not use training are called "speaker independent" systems. Systems that use training are called "speaker dependent" The automatic speech recognizer takes user voice as the input and produces the corresponding text as the output. It is a speaker independent continuous speech recognition system. It accepts voice input from the user as SQL or NON-SQL commands and converts into text. In order to implement this module, the voice of the user is taken as the input. This input is recorded using the microphone. The voice of the users are stored as wav file. This wave file is taken as the input for processing. Here we to consider the configuration file for processing the user voice input. The configuration file contains the required details for processing a wav file ,the sampling rate for processing the speech signal is stored in that file.

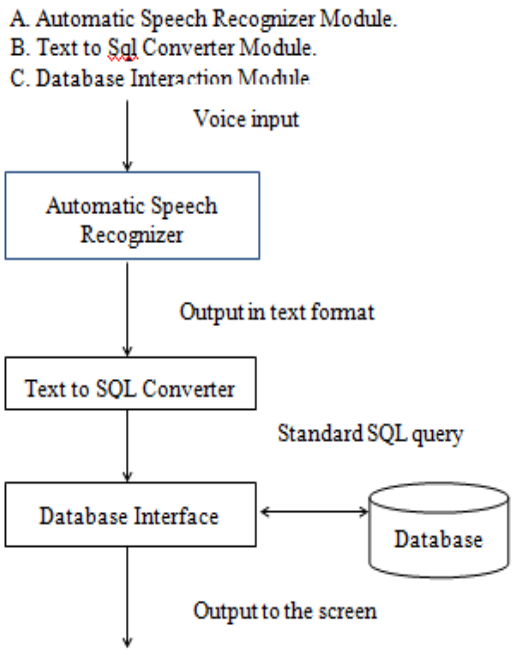
Text to Sql Module

Input recognized in the module1 is converted into a standard text format in this module. The administrator have to write an xml configuration file for the created database. Once the configuration file is written, it is taken as an input for processing module2. Here the xml configuration file is converted into a adjacency list like structure. Each line of the configuration file is processed and the required details are taken to produce the output for text to SQL converter. Initially parsing is done to separate each word in the sentences and now we get different set of tokens as the output. Now in this tokens we have to remove the stop words such as a, the, for, is. Once the stop words have been removed, now we have to categorize the tokens in to different labels

Database Interaction Module

In this module, we have to consider the sql query obtained in the previous module as the input and it is used to retrieve the necessary details from the database. It is similar to normal database interaction, but here we are not using any keyboard to give the query, rather we just use the queries said by the user through their voice. Finally, the result is displayed into the screen.

OUTPUT



FUTURE SCOPE

This software is use in many places for managing the database such as collages, schools, small shops, etc… where the non technical worker can handle the system with simple knowledge of Sql commands.

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Technology Behind Air Quality Meter with Warning System

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***Abstract*-Automobiles are a 'necessary evil', while they have made living easy and convenient they have also made Human life and environment more complicated and vulnerable to both toxic emissions and increased risk factors. Hence air pollution monitoring is extremely important as air pollution has a direct impact on human health and environment. Urban people are most affected and amongst the worst sufferers are traffic policemen who are particularly close to the fumes of automobile exhaust. Studies made in India, indicate that there is high rate of occurrence of respiratory, digestive, ocular and skin problems amongst the traffic policemen and a significant number of them become victims of lung disorders in the very first few months of their posting to a traffic department. Traditionally, pollution measurements are performed using expensive equipment at fixed locations or dedicated mobile equipment laboratories. This is a coarse-grained and expensive approach where the pollution measurements are few and far in-between. In contrast to traditional air pollution monitoring stations, we present the design, implementation, and evaluation of low power, low cost Air Pollution Monitoring System which provides real time monitoring of polluted materials at proper locations by using distributed (real time) air pollution monitoring systems. In the present paper a microcontroller based embedded system is developed for awaking people about the air pollution at each square. This system indicates the toxic gases status in air with real time on LCD displays. This work modifies the existing safety model installed in industries and this system also be used in homes and offices. In case of delay in message delivery of warning system installation of voice module is done to make it more reliable and efficient for altering purpose. This system will be definitely going to be useful for mankind and will serve in regaining the healthy environment for the people by monitoring continuously the level of toxic gases in the atmosphere.**

Keywords: Microcontroller, Embedded System, Pollution, LCD display, low cost, low power consumption

[I] INTRODUCTION

Pollution can be defined as presence of minute particles that disturbs the functioning of natural processes and also produces undesirable health effects. In other word pollution can affect the natural cycle and also can disturb the health of human being [1]. As industrialization is growing very extensively pollution is also getting introduced at large manner. At present there is Air pollution, Water pollution, Soil pollution worldwide. Air pollution is the presence of contamination or minute particles that interfere with human health and environment. These pollutants basically results from vehicles, industries [2].

Quality air is fundamental to people's health and well-being. Air quality is an important issue from both a social and economic point of view. Continual advances in medicine and technology necessitate constant reevaluation of the air-conditioning needs of humans. Most of us spend major portion of our time indoors in homes, schools, the workplace, shopping malls or hospitals. The average person will use typically 15kg of air a day through breathing compared with 1kg of food and 2kg of water, yet there are no clear guidelines to ensure good air quality in buildings available.

Urban air pollution is an essential environmental issue due to its direct effect on human health. It is fast becoming a grave threat as levels of toxicity in urban centers increase beyond safe limits. This is especially true for many low and middle income nations, where the rapid pace of industrialization and

development coupled with fast growing urban population are leading to increased environmental constraints. Due to the trans-boundary nature of airborne pollutants, a single organization cannot seek to control or take responsibility for international pollution issues. Therefore, the control of air pollution is entirely inter-country dependent and relies heavily on the local legislation. The passing of new legislation can only take place once accurate figures on current pollution trends are in place and may only be effectively executed if the airborne compounds can be monitored accurately.

The World Health Organization states that 2.3 million people die each year due to causes directly attributed by air pollution. Based the fact above mentioned, the human should focus on air pollution monitoring [1].Many organizations and countries around the world have set up urban environmental monitoring systems to provide the data needed to maintain orimprove air quality. In Paris, AIRPARIF (2012), an organization tasked by the French government to monitor air quality is operating a network of 42 automated monitoring stations spread over a 100-kilometre radius. Likewise, in Australia, the Office of Environment and Heritage (OEH) (Environment Protection Authority of New SouthWales 2012) is responsible for monitoring and reporting air quality. OEH collects data on real-time concentrations of ambient air pollutants from over 30 monitoring sites within the Air Quality Monitoring Network, located around the metropolitan areas. It aims on informing the public about prevailing environmental conditions by updating the regional air quality index on an hourly basis, i.e. providing 24-hour, monthly and annual reports. On a larger scale, the United States Environmental Protection Agency manages the nationwide air quality monitoring program called AIRNOW (2012), which monitors a specific set of air pollutants, called criteria air pollutants across the United States. AIRNOW offers daily AQI (Air Quality Index) forecasts as well as real-time AQI conditions for over 300 cities across the United States. India however, like most polluted country, lacks an urban air pollution monitoring infrastructure as it is difficult for the public sector to dedicate the resources necessary for this. What is required is a system that is comprehensive in terms of spatial and pollutant coverage and is relatively inexpensive and autonomous.

[II] LITERATURE REVIEW

Sunithaa.Jetal [1] explained that the design of a wireless LPG leakage monitoring system is proposed for home safety. The system detects the leakage of the LPG and alerts the consumer about the leak and as an emergency measure thesystem will switch on the exhaust fan and also checks the leakage. An added feature of the system is that theapproximate consumption is indicated in terms of the total weight. The proposed system makes use of GSM module in order to alert about the gas leakage via an SMS. Whenever the system detects the increase in theconcentration of the LPG it immediately alerts by activating an alarm and simultaneously sending message to the specified mobile phones. The exhaust fan is switched on and an LPG safe solenoid valve fitted to thecylinder is given a signal to close avoiding further leakage. The device ensures safety and prevents suffocation andexplosion due to gas leakage**.**

V.Ramyaetal [2] mentioned that safety plays a major role intoday's world and it is necessary that good safety systemsare to be implemented in places of education and work.This work modifies the existing safety model installed inindustries and this system also be used in homes andoffices. The main objective of the work is design inmicrocontroller based toxic gas detecting and alerting system. The hazardous gases like LPG and propane weresensed and displayed each and every second in the LCD display. If these gases exceed the normal level then analarm is generated immediately and also an alert message (SMS) is sent to the authorized person through the GSM.The advantage of this automated detection and alertingsystem over the manual method is that it offers quickresponse time and accurate detection of an emergency andin turn leading faster diffusion of the critical situation.

Sagar Shindeetal [3] explained that the former systems can not react in time, even cannot obtain data from an accident andlocate accurately. This system gives real time detective of potential risk area, collect the data of leak accident andlocate leakage point. This system having protection circuitry consists of exhaust fan and an LiquefiedPetroleum Gas Safe Solenoid Valve. The hazardous gasses like Liquefied Petroleum Gas and Propane were sensedand displayed each and every second in Liquid Crystal Display. If these gasses exceed normal level then alarm isgenerated immediately. In this system MQ-6 gas sensor used to sense poisonous gas and has high sensitivity toLPG and also response to natural gas. This work modifies the existing safety model installed in industries. It offers quick response time and accurate detection.

Jen-Hao Liu et al [4] Introduced micro-scale air quality monitoring system for urban areas in 2012.This System monitors the concentration of carbon monoxide co caused by heavy vehicles emission. Sensor nodes were deployed in highly

populated areas. System was integrated with the GSM for data transmission.Gateway collected the data from all sensor nodes and sends to control centre by GSM network.

Anuj Kumar et al [5] in 2013 conducted a review on environmental monitoring system. The review discussed different techniques and various hardware used in the environment monitoring systems. It also considered the parameters like low cost, low power consumption, reliability, and signal to noise ratio and RF interference.

Ayushi Gupta et al [6] explained the version of measurement device which is made of sensor unit, A/D converters and microcontroller to convert sensor's electric response to gas concentrations. Microcontroller is also responsible for linking measurement results with geographic coordinates from GPS and sending these data to servers using GSM/GPRS link. The gas concentration sensors together with temperature and humidity sensors are put inside manifold Air flow inside manifold is forced by fan, which rotate speed is controlled by microprocessor because change in flow rate will change gas sensor's substrate temperatures as air is cooling the casings of sensors. Electrical response of gas sensors is converted into voltage signals using very high impedance operational amplifier (for EMF output) or by resistive voltage divider (for resistive output)

Nisha Parveen et al [7] mentioned the technique that monitor the quality of air, a new framework is proposed that monitors the parameters of the environment around us such as NH4, CO, presence of smoke, alcohol, LPG, temperature and humidity and dust with the help of GSM. Various gas sensors are used here to detect air pollutants, LPG and alcohol. Few of them are detect the amount of gases and displayed these amount on LCD display at every 10 sec. There is an additional feature in this project, the system continuously level reaches below the threshold limit of gas then alerts the consumer about the leak by sending SMS to the authorized person through the GSM and an alarm is generated immediately. The software package PROTEUS has been used for testing the microcontroller program and its functionality virtually through a simulation environment. Once the program has been tested successfully via the PROTEUS simulator, it is subsequently embedded into the microcontroller.

[III] PROBLEM IDENTIFICATION

During past decades, as result of civilization and urbanization there is a huge growth in Polluting industries, open burning of refuse and leaves, massive quantities of construction waste, substantial loss of forests and vehicles (particularly diesel driven cars) on roads that give rise to health endangering pollution. Therefore, it is necessary toregularly monitor and report the hazardous impacts from air pollution.

Clean air is vital need for every human being. Polluted air causes many health problems and several damages. Therefore to make any step ahead of controlling the pollution rate it is necessary to monitor the air quality which may help us to make a right decision at right time. There are various causes of increasing the pollution such as smoke automobile exhaust, chemical discharge from industries, radioactive substance etc.these are main reason of decreasing the quality of air. The main gases which directly affect the human health are carbon monoxide (CO), hydrogen sulphide, sulphur dioxide (SO2), Nitrogen dioxide (NO2) and the main contribution of these gases are traffic related pollutant emission. Huge efforts are required to improve the quality of air in both outdoor and indoorenvironment. Monitoring of environment has beencontrolled from manual to the automatic control step bystep. There are various improvement in the instrument ofenvironment monitoring but still cannot meet the harsh environment.

[IV] DESIGN AND IMPLEMENTION

Heart of the circuit is ATmega328P. Other components used are 16×2 LCD display (LCD1), temperature and humidity module DHT11, gas sensor MQ135, MQ5, MQ7, PM2.5/PM10 sensor and a few others which is shown in fig.1

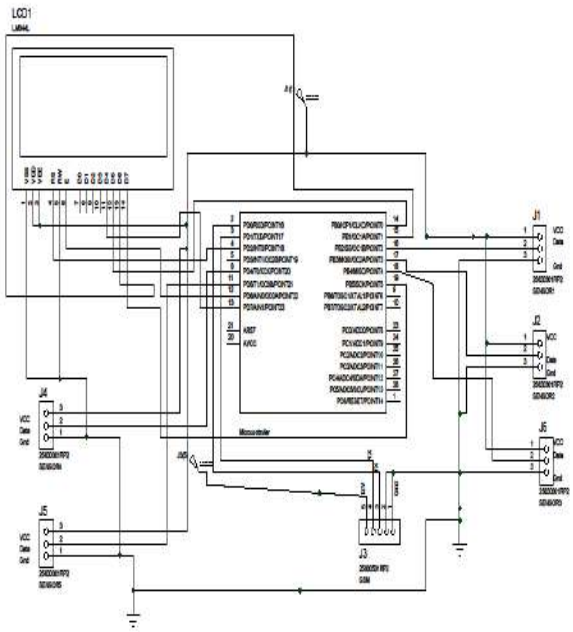

Fig.1: Circuit diagram of the system

In this circuit diagram.Atmega328p is used. Reason behind using Atmega328p is that we're using large no. of sensor that is not compatible with ATmega.Gas sensor modules are connected to the Arduino Uno board using jumper wires.The Analog pin of the sensorsis connected to the analog pin on the Arduino board,while the +5V and GND pins on the sensor module are connected to the 5V Vcc and GND (ground) pin respectively on the Arduino board. The Arduino Uno board is thenconnected to a LCD display and GSM module. The working can be explained as 5v regulated supply is given to the circuit and all the sensor present in the circuit continuously sense the atmosphere and the output from all the sensors goes to the input of programmed controller. The output from sensor is in analog form. We set some threshold value for particular gas and also for particulate matter which depicts the digital voltage level 5V. All the values of gas that are below threshold value are denoted as voltage somewhere between 0-5V. As the output from sensor is in analog form so this analog data is converted in digital form by the help of AD convertor and microcontroller. This digital output which is in the form of voltage is converted into different levels of gases in the atmosphere and are displayed on the LCD.As soon as the value of any gas in the atmosphere increase more than threshold level then a message is sent to the authorized person with the help of GSM interfaced with microcontroller with the help of RS232 cable and also the voice module will be turned on and a message will be aired to notify the people of that particular locality.

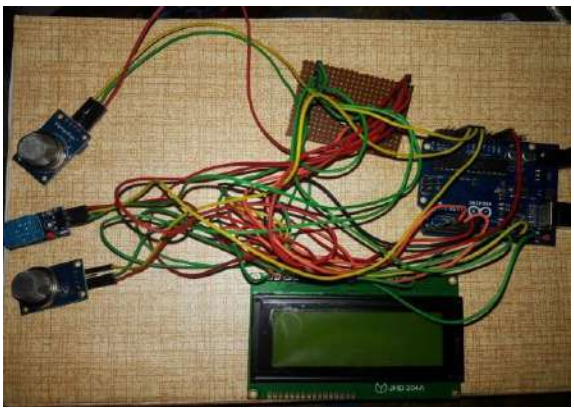

Fig.2: One module of the system

One of the modules of the given system is shown in fig.2. In this system only two gas sensors MQ135 and MQ7 having capability to sense smoke and alcohol respectively are used. For measurement of temperature and humidity there is temperature and humidity sensor, called DHT11. These sensors generate voltage signals in proportions to the percentage amount of the detectable gas, temperature, humidity. Voltage data from sensors is converted into digital form using arduino board and displayed on LCD display.

[V] RESULT

In the present system data display on 16X2 LCD in the given format successfully as shown in Fig.3 in the first row, humidity is displayed in percentage. In second row temperature reading is displayed in Celcius.In the following rows, reading of MQ135 and MQ7 are displayed.

Fig.3: Data displayed on LCD display

[VI] CONCLUSION

We have shown the construction and working of ArduAir which is a small, portable and low-cost air pollution monitoring system. This system can be used easily at a large scale and domestically by a large number of people. We used Arduino to monitor CO, NO2, smoke alcohol, LPG and Particulated matter etc. using different sensors. This system can thus be utilized effectively by the general public for monitoring the quality of air around them.These sensors offers many advantages like long lifetime, low cost, reliable and high sensitive to their respective gases.

The proposed Wireless Air Pollution Monitoring System provides real-time information about the level of air pollution in these regions, as well as provides alerts in cases of drastic change in quality of air.

[VII] FUTURE SCOPE

This system has an advantage such as low power consumption, inorder monitor quantity in different site, future work can be focused on establishing a system with more sensor node and more base station connection between node and base station. This system can also be used in cotton industries.

[VIII] ACKNOWLEDGEMENT

We express our deepest sense of gratitude towards our guide Ms. Ekta Agarwal (Assistant Professor), Department of Electronics & Communication Engineering, Moradabad Institute of Technology, Moradabad for his patience, inspiration, guidance, constant encouragement, moral support, keen interest, and valuable suggestions during preparation of this research paper. Our heartfelt gratitude goes to all faculty members of Electronics & Communication Engineering Dept., who with their encouraging and caring words and most valuable suggestions have contributed, directly or indirectly, in a significant way towards completion of this paper. We are indebted to all our classmates for taking interest in discussing our problem and encouraging us. We owe a debt of gratitude to our father and mother for their consistent support, sacrifice, candid views, and meaningful suggestion given to us at different stages of this work. Last but not the least we are thankful to the Almighty who gave us the strength and health for completing our report

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ADVANCE AND INTELLIGENT BIOMETRIC OPTICAL LINK SYSTEM

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ABSTRACT

With the explosion of information traffic due to the Internet, electronic commerce, computer networks, multimedia, voice, data, and video, the need for a transmission medium with the bandwidth capabilities for handling such vast amounts of information is paramount. Fiber optics, with its comparatively infinite bandwidth, has proven to be the solution. The security inherent in optical fiber systems is a major benefit. The increasing rate of crime, attacks by thieves, intruders and vandals, despite all forms of security gadgets and locks, still need the attention. To make optical link more secure many devices can be used for transmission and reception purpose. These devices may be DNA sensor lock, card sensor lock, electronic eye lock, thumbprint sensor lock and electronic combination lock. In this research paper we are focusing on a secure communication where biometric system can be used as a good and effective security option. An important and very reliable human identification method is fingerprint identification. As fingerprint of every person is unique thus it can be used in various security options. Fingerprint recognition at the transmitter side allows only valid person to transmit the signal. At the receiver side code lock security can be economic and good option to allow only valid user to receive the information which has been sent through secure optical link. During communication over the optical link, automation can also be achieved at the receiver end from the transmitter end. With the help of automation, energy consumption at the receiver end can be reduced upto a great extent from the transmitter end.

KEYWORDS: *Automation, Biometric security, Code-lock security, Optical fiber link.*

I INTRODUCTION

Data transmission through unguided transmission media leads to less security availed in the transmission therefore data is lost easily during transmission. Data transmission through guided media leads to a point to point communication which is comparatively more secure than unguided media transmission. There are multiple examples of guided media transmission such as coaxial cable, twisted pair and optical fiber transmission. These media have their own data transmission capacity. Optical fiber cable has the largest data transmission capacity among them. The usual rate for optical fiber cable systems is 2.4 Gbps or even 10 Gbps. While giving high data transmission rate optical fiber is also provides secure data transmission.

There is a consequent increase in the rate and sophistication of crime. As a result, it is necessary to ensure security of oneself and one's valuable belongings. This creates demand of a new and modern lock that must be unique. This type of feature is available in the biometric locks i.e. the lock which can only be locked and unlocked by the human body features. Fingerprint of every person on the earth is unique and can provide good reliability. Also the implementation of the fingerprint

recognition system is easy and economic than the other ones [14]. Biometric security can be used at transmitter end so no unauthorized person is able to send any kind of wrong information to the receiver end. Receiver end requires a security system too. So a code-lock security system protects the receiver end. Only a person who has valid password can be able to unlock the received data. With the increase in consumption of energy, there is a great need to conserve energy in every way possible. The inability to access and control the appliances from remote locations is one of the major reasons for energy loss. So automation is also introduced in the project to control energy consumption [12].

II LITRATURE SURVEY

Nick Massa [9]: This paper states that optical fiber must be protected from the environment. Cabling provides the fiber protection from the elements, added tensile strength for pulling, rigidity for bending, and durability. In general, fiber optic cable can be categorized into two types:

1) Indoor Cables:

• Simplex cable-contains a single fiber for one-way communication

• Duplex cable-contains two fibers for two-way communication

• Multi fiber cable-contains more than two fibers. Fibers are usually in pairs for duplex operation.

• Breakout cable-typically has several individual simplex cables inside an outer jacket. The outer jacket includes a zip cord to allow easy access.

• Heavy, light, and plenum-duty and riser cable:

− Heavy-duty cables have thicker jackets than light-duty cable, for rougher handling.

− Plenum cables are jacketed with low-smoke and fire-retardant materials.

− Riser cables run vertically between floors and must be engineered to prevent fires from spreading between floors.

2) Outdoor Cables: Outdoor cables must withstand harsher environmental conditions than indoor cables. Outdoor cables are used in applications such as:

• Overhead-cables strung from telephone lines

• Direct burial-cables placed directly in trenches

• Indirect burial-cables placed in conduits

•Submarine-underwater cables, including transoceanic applications.

Fiber Optic System Design Considerations:

1) Power Budget: The power arriving at the detector must be sufficient to allow clean detection with few errors. The power at the detector must be above the threshold level or receiver sensitivity.

2) Bandwidth and Rise Time Budgets: The transmission data rate of a digital fiber optic communication system is limited by the rise time of the various components, such as amplifiers and LEDs, and the dispersion of the fiber. The cumulative effect of all the components should not limit the bandwidth of the system.

3) Connectors: Many types of connectors are available for fiber optics, depending on the application. The most popular are:

SC-snap-in single-fiber connector

ST and FC-twist-on single-fiber connector

FDDI-fiber distributed data interface connector

4) Fiber Optic Couplers: A fiber optic coupler is a device used to connect a single (or multiple) fiber to many other separate fibers. There are two general categories of couplers:

a) Star couplers b) T-couplers

5) Wavelength-Division Multiplexers: The couplers used for wavelength-division multiplexing (WDM) are designed specifically to make the coupling between ports a function of wavelength. The purpose of these couplers is to separate (or combine) signals transmitted at different wavelengths. Essentially, the transmitting coupler is a mixer and the receiving coupler is a wavelength filter.

Annie P. Oommen, Rahul A P, Pranav V, Ponni S and Renjith Nadeshan [1]: This paper explained how to create a micro-controller based Digital Code Lock that serves the purpose of security. The microcontroller based Digital Code Lock is an access control system that allows only authorized persons to access a restricted area. The system comprises of a push button keypad connected to the 8 bit microcontroller. The system will allow you to preset a password. The lock will open if and only if the entered password matches the preset one. If the entered password is wrong a buzzer will be activated.In our project digital code lock comprises of 8 bit microcontroller AT89s52.

Adamu Murtala Zungeru [2]: In his paper, he explained that the use of electronic combination locks in modern day technology cannot be overemphasized. They prevent losses to theft,

carelessness etc. Also being that they are electronically powered, they provide a better and safer security system than all other locks. The block diagram of the electronic lock contains power supply unit, the input, control and the output units as shown in fig. 1.

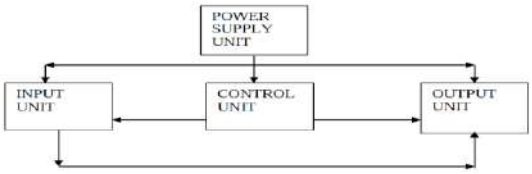

FIGURE 1: Block diagram of Electronic Switch

Vaclav Matyas and Zdenek Rıha [10]: He proposed the classification of biometric on different parameter in his paper. Biometric systems falling into the level four should be able to resist even professional and well-funded attacks.

TABLE I: classification of biometric on different parameter [10]

Level	Liveness	Temper resistance	Secure comm.	Traditional auth method
1	No	No	No	Sufficient/ Anytime
2	No	No	Yes	Sufficient/ Malfunction
3	Yes	Moderate	Yes	Not sufficient
4	Multiple	Advanced	Yes	Not sufficient/ Required

Artur Balanuta Ricardo Lopes Pereia and Carlos Santos Silva [6]: In his paper he proposed a novel system to address the energy consumption problem and inadequate habits of people in office buildings. It's a highly flexible distributed office management system that can scale from an individual node in an office to the whole building. The goal is to reduce global building energy consumption without significantly affecting the user's comfort level. An approach is used where the building services are adjusted to its occupancy level and user's needs based on their location. Users are driven to better energy usage habits through access to information and feedback.

Ravi Subban and Dattatreya P. Mankame [8]: In his paper he focused on knowledge on the diverse area of FP biometric systems envisage the importance of FP biometric system to provide strong authentication. The FR is having edge over other biometric traits. Our project uses fingerprint security.

TABLE II: Performance of different biometric technologies based on EER, FAR and FRR [8]

Biometric	EER	FAR	FRR
Face	NA	1%	10%
Fingerprint	2%	2%	2%
Hand geometry	1%	2%	2%
Iris	0.01%	0.99%	0.94%
Key Strokes	1.8%	7%	0.1%
Voice	6%	2%	10%

Anil K. Jain, Arun Ross and Salil Prabhakar [3]: In his paper he explained the practical biometric system should meet the specified recognition accuracy, speed, and resource requirements, be harmless to the users, be accepted by the intended population, and be sufficiently robust to various fraudulent methods and attacks to the system. In this paper, he provided a brief overview of the field of biometrics and summarized some of its advantages, disadvantages, strengths, limitations, and related privacy concerns.

Ritesh A. Jadhav and Dattatraya S. Shitole [5]: This paper explained the implementation of fiber optics in electronic communication network with development in optical fiber communication. Its high bandwidth capabilities and low attenuation characteristics make it ideal for gigabit transmission. Using fiber optic cable, optical communication have enabled communications links to be created over much greater distances and with much lower levels of losing the transmission medium and possibly most important to fall, fiber optical communications has enabled much higher data rates to be accommodated.

Satish Palaniappan, Naveen Hariharan, Naren T Kesh, Vidhyalakshimi S and Angel Deborah S [7]: He explained in his paper that remotely accessible environment is an environment in which each appliance can be remotely accessed and controlled. Such remotely accessible systems are already available in the market, but have a number of drawbacks as well. So we are providing automation in our project using optical fiber, which is comparatively much better than other.

Neha Chaudhary Sangeeta Singh, Shubham Pandey and Shivani Gupta [11]: This paper showed the study of optical fiber and different types of security which can be used while transmitting or receiving data. The single mode fiber optic cable provides much better performance with lower attenuation. She explained different types of biometric security e.g. Voice Recognition, Signature Recognition, Face Recognition, Palm scan, Iris-scan, Retina-scan, Hand geometry, Signature-scan, Fingerprint Recognition etc. This paper introduced a proposal in which one

can use advance technologies like biometric, code lock and optical link for the safe and secure transmission of information. She explained in her paper that Optical Fiber Link is very secure medium for voice and data transfer. The finger print module helps to transmit the data from an authorized person only whereas code lock at the receiver end is used for receiving information by an authorized person. At receiver end the lock will open only if entered password matches the preset one otherwise not. The brief study in this paper has shown how code lock security works. The advantage of this code lock is that the password will be in encrypted form so that no other person will be able to understand the password.

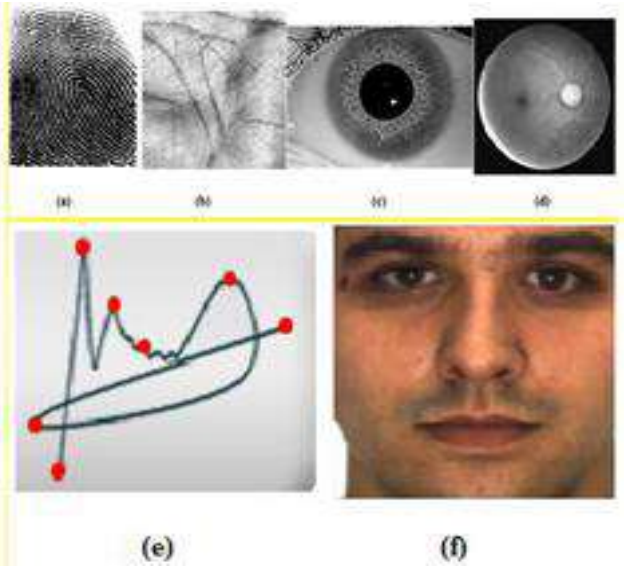

FIGURE 2: Biometrics traits (a) Fingerprint (b) Palm (c) Iris (d) Retina (e) Signature (f) Face [11]

Shubham Pandey, Shivani Gupta, Neha Chaudhary and Sangeeta Singh [12]: He focused on advancement of neha chaudhary et al proposal. Further study is carried out by him in this paper. This paper showed the study of different types of biometric security and how biometric security works in real time world. He explained how biometric is depending upon the application context, a biometric system may operate either in verification mode or identification mode. He also provided the study of optical fiber link and code lock security. He discussed the evolution and advantages of the optical fiber. He further introduced an automation process in previous proposal so that energy consumption can be reduced. Study of automation is also shown in this paper. He also introduced the proposed model of the project in his paper and explained the modes of project. The project can be classified into following modes-

A) Biometric:

1) Data base mode
2) Valid casting mode
3) Checking mode

B) Optical Link Mode: In this mode optical fiber is used for communication purpose.

1) Voice communication
2) Data communication
3) Fail mode of optical link

C) Code Lock: Code lock security is used at receiver end, when any person enters code, system will check condition and operate the optical link.

D) Automation: As the name suggests for getting something done automatically. This project proposal is to achieve automation at the receiver end and get it done from the transmitter end.

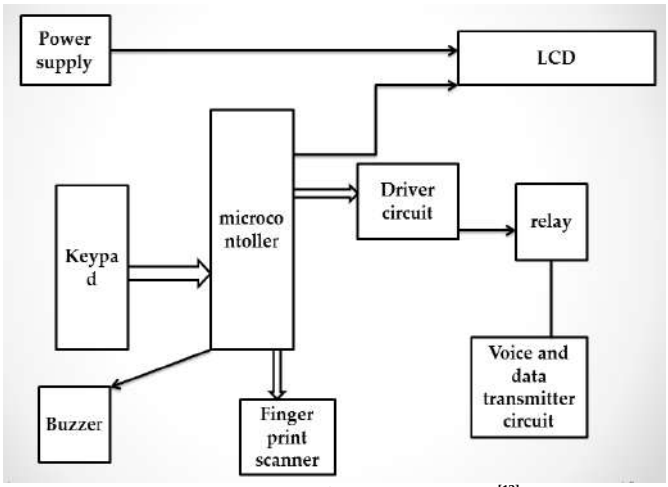

FIGURE 3: Block diagram of proposed project [12]

Sangeeta Singh, Neha Chaudhary, Shubham Pandey and Shivani Gupta [13]: She further carried out research on the project proposed by Shubham Pandey et al. She explained more modifications in the proposed block diagram and further introduced the circuit diagram of the transmitter and its working in her paper. She explained that the heart of the circuit is microcontroller at89s52. Other components used are voltage regulator 7805, LCD display 16x2, matrix keypad, relay, buzzer, and finger print scanner. First of all, step down transformer and rectifier together converts 220 AC voltage into 12V DC supply and capacitor is used to reduce the harmonics those are introduced during rectification

and regulator 7805 IC provides fixed five volts. Data can be sent either using keypad or using mic.

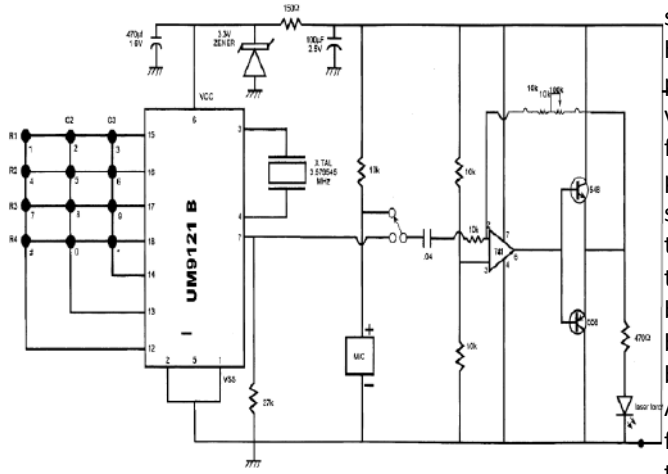

FIGURE 4: Circuit Diagram of Transmitter [13]

III PROBLEM IDENTIFICATION

The problem for which this project idea is demonstrated is consequent increase in the rate and sophistication of crime. As the result of increment in crime it is highly demanding to make communication more secure. So to provide security biometric, code lock and RF-ID etc. technologies can be used.

While demonstrating this project we have faced some problems. Some problems occurred designing the circuit and others occurred implementing the project. The problem faced in designing are listed below:

1) Components availability.
2) Deciding value of components.
3) Circuit designing.

The problems faced during implementing the project are listed below:

1) How to give the effort of soldering properly.
2) Programming of sensor.
3) Signal sending.
4) LCD interfacing.
5) Buzzer interfacing at receiver end.
6) Finger print module interfacing at transmitter end.

IV DESIGN AND IMPLEMENTATION

Optical fiber cable has the largest data transmission capacity. The usual rate for optical fiber cable systems is 2.4 Gbps or even 10 Gbps. While giving high data transmission rate optical fiber is also provides secure data transmission. An important and very reliable human identification method is fingerprint identification. As fingerprint of every person is unique thus it can be used in various security options. Fingerprint recognition at the transmitter side allows only valid person to transmit the signal. At the receiver side code lock security can be economic and good option. Automation can also be performed through optical link in this project. The block diagram of this project is shown in the figure 5. After verifying the biometric ID proof that is fingerprint of an authorized person, the optical transmitter sends the analog or digital signal through optical fiber cable, which is then received by the optical receiver. In case of invalid person at the transmitter end, system will beep and doesn't provide access to an unauthorized user. This optical link can also be used for controlling different devices at receiver end. After reception of the signal at the receiver end, the user would be able to access the data and the transmission would be successfully done with higher security.

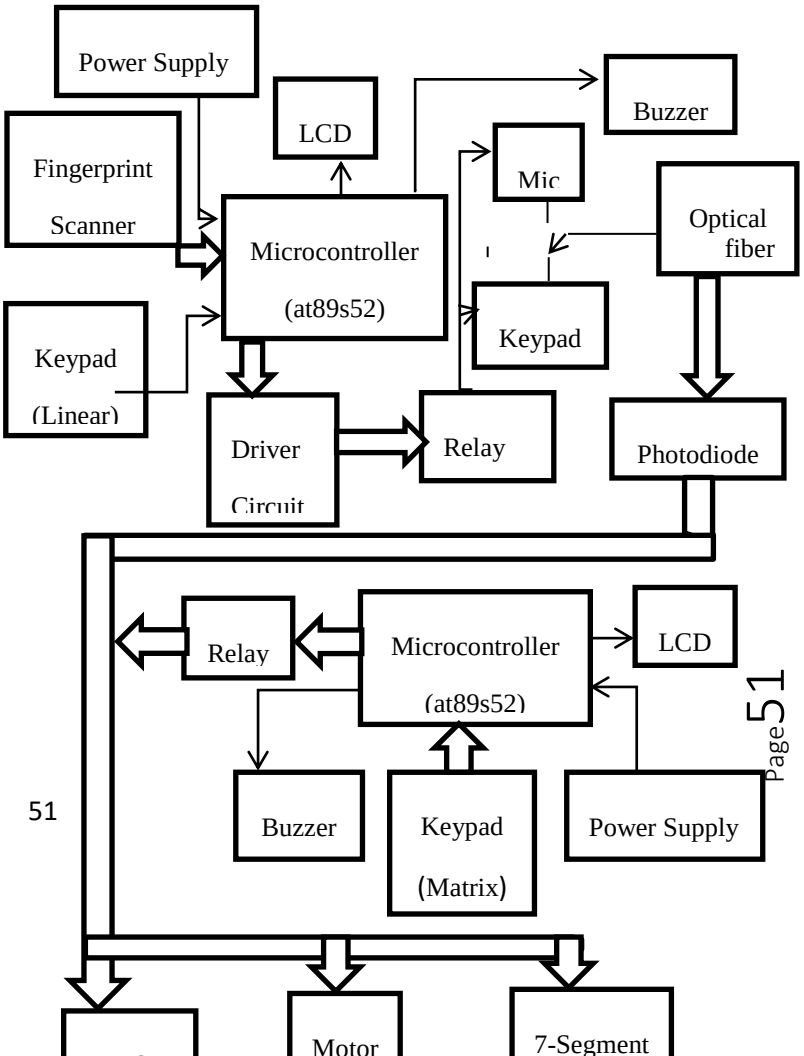

FIGURE 5: Block Diagram Of The Project

A regulated power supply of 5 volts is needed in this project. When user wants to send the data and voice with the help of optical fiber, system will demand for fingerprint scanning. Then system will check the fingerprint condition and operate the relay in case of valid fingerprint and allow communication of voice and data. Microcontroller then allows driver circuit to activate the relay; this will create an optical fiber link. In case of invalid user the buzzer gives indication and it gets displayed on LCD display that the user is unauthorized and the link will not be created. Photodiode at the receiver receives the information. Only when the valid password is entered through keypad (matrix), microcontroller will allow relay to operate. Then received information can be gained through speaker/ motor or 7-segment display. If user enters wrong password then buzzer will beep and "INVALID USER" gets displayed on LCD display.

Working:

First of all, step-down transformer and rectifier are used to convert 220 AC voltage into 12 volts DC supply. Capacitor is used to remove the harmonics those are introduced during rectification and regulator 7805 IC is used to provide fixed 5 volts.

Biometric Module: We enter the database in the biometric module with the help of keypad (linear) and fingerprint scanner. All conditions are displayed on LCD display. Through fingerprint scanner the condition of valid user will be checked and be displayed on LCD display. In case of valid user microcontroller (at89s52) then allows driver circuit to activate the relay; this will create an optical fiber link. In case of invalid user the buzzer will give indication.

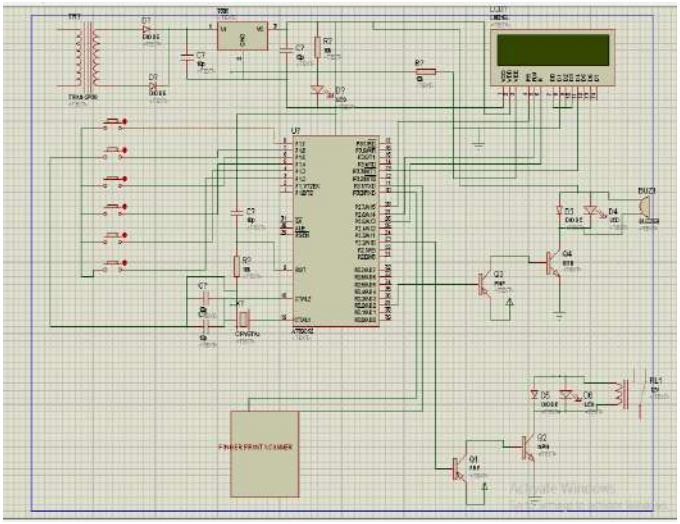

FIGURE 6: Simulation of Biometric Module

Optical Fiber Communication: The optical fiber communication involves two types of data transmission that are analog and digital data transmission. In our project we are using both types of data transmission. First one is analog signal i.e. voice signal using mic and other one is digital signal using numeric keypad. We use switch to change over data transmission type. An optical fiber data transmission basically involves three components: an optical transmitter, an optical fiber cable and an optical receiver.

Transmitter: For digital input we use DTMF signal generator (UM91514) for generating a signal in the form of PWM (pulse width modulation.). All the nine switches are connected to the input of this IC as a matrix network. All the switches are divided in four rows and three columns. Pin no 6 of this IC is connected to the positive supply. This IC is very sensitive to voltage and requires only 3.3 voltage. Zener diode regulated supply is used for this requirement. 150Ω resistance is used to limit the current. One crystal is connected to the 3rd&4th pin of this IC to provide a carrier frequency to the IC. Output is available on the 7th pin of this IC which is directly connected to the 2nd pin of OP-AMP IC. Switch is provided to change the input to either digital or analog. Voice data is fed through mic as an analog input which converts this mechanical signal into electrical signal and coupled at the 2nd pin of OP-AMP IC (741). Pin no. 3 acts as a comparator. 7th pin of 741 IC is connected to the power supply and 4th pin is grounded. 741 IC is used as amplitude amplifier. The amplification factor depends upon the negative feedback which is connected between 2nd

and 6th pin of this IC. The amplified output is taken from 6th pin of OP-AMP IC. For further power amplification transistor circuit is used. Here we use two transistors one is NPN and second is PNP. Collector of the NPN is connected to the positive supply and collector of the PNP is connected to the negative supply. Output is available from the emitter of the both transistor. The output of this transistor circuit is connected to the semiconductor laser diode. Working voltage of this diode is approx. 3.6 volt. This diode is very sensitive and on high voltage it is immediately burnt out. Here Ga-As laser is used. Output from the amplifier is further converted into regulated 3.6 voltage with the help of one 3.6 volt zener diode. Zener diode is used with laser light to protect them from high voltage. Data is now super imposed on the laser light and we focus this laser light towards the receiver.

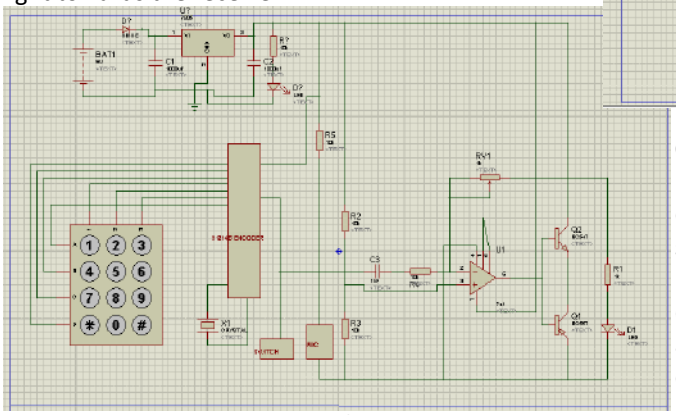

FIGURE 7: Simulation of Transmitter

Receiver: The laser light is received on the photodiode at the receiver section. Photodiode converts this light into electrical signal. This small voltage is amplified by OP-AMP IC. The output of 741 IC is further amplified by the transistor pair, this amplification is power amplification. Then voice output is available at the speaker or in case of digital signal, it is further fed to the DTMF decoder (CM8870C). DTMF decoder converts this signal into a BCD signal. This is a 18 pin IC. Pin no. 10 and 18 is connected to the positive supply. One crystal is connected to the pin no. 7 and 8 to demodulate the frequency. Signal from the operational amplifier is applied to the pin no 2 and 3 of this IC. The demodulated frequency is available on the pin no 11, 12, 13, 14 in the form of BCD signal. This BCD signal is used to control many other appliances, so with the help of this BCD signal automation is achieved at the receiver end. This BCD signal is also used to display the digital data on 7-segment display. IC 7447 is used as a seven segment decoder circuit. IC 7447 receives the BCD signal from the 8870 and convert this signal in the numeric display.

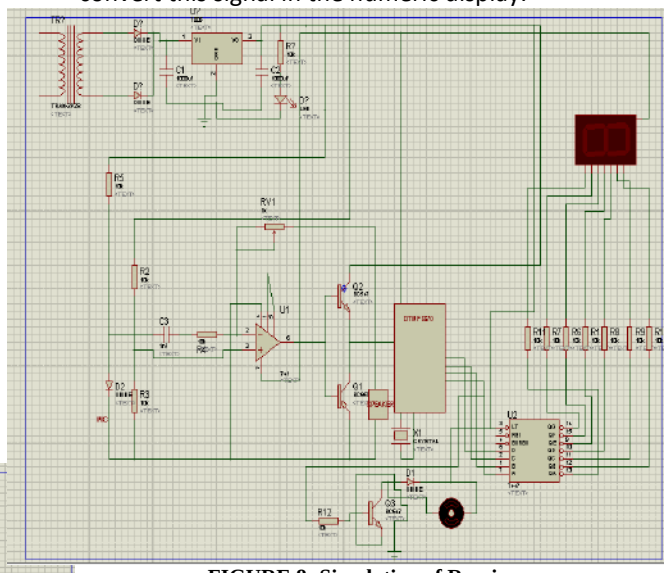

FIGURE 8: Simulation of Receiver

Code-Lock: At the receiving end user needs to verify his identity to access the received data. User has to enter valid password to obtain information from the system. In case of invalid password the buzzer will beep and “INVALID USER” gets displayed on the LCD display. Or in case of valid user microcontroller will allow relay to operate. Then according to the signal either it is displayed on 7-segment display or can be heard by speaker. Automation can also be shown by applying any appliance at the receiver end.

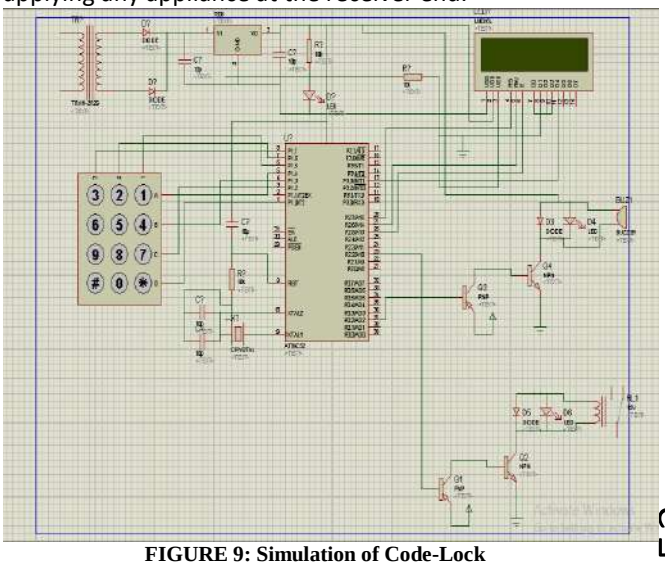

FIGURE 9: Simulation of Code-Lock

V RESULT AND DISCUSSION

The result of this project came as expected. Result of the project is that by using this advance and intelligent optical link system we can transmit and receive the data through an authorized person only, no other person can send and receive the data through this link and hence this device can do wonders in the field of communication. After working upon this we achieved more advancement in security system and with the help of this project optical link automation can also be performed that means user can control different appliances from one place (from transmitter end). Fingerprint module provides higher security for the data transmission. Code lock is another way to secure the data. Optical fiber link provides high speed in transmission. It is clear that every technology has its advantages as well as limitations. So it is better to merge the technologies to reach a desired goal as a group of technologies when used together can overcome each other's limitations and hence it results in a better project. This project may find a great use in field of communication and automation as it is fulfilling many tasks that include secure digital and analog data transmission and automation.

This project has a drawback of not having a storing element to record the data for receiving it after some time at the receiver side.

VI CONCLUSION

Based on all the systems surveyed and their advantages and drawbacks studied, this paper presents an integrated technology that can enable a user to communicate in a secure way. Through optical link user can send data at very high rate and in a secure manner. Optical link provides analog and data transmission both. The biometric technology enhances the security so we conclude that it would be used at transmitter side so that only a valid person, whose data has been stored in data base, can transmit the data. Fingerprint identification is reliable security device. Code-lock is also a good and economic option for security purpose. Therefore it is used here at the receiver side. Hence this device can do wonders in the field of communication.

Automation is also provided from the transmitter end. Hence many tasks can be performed easily from the transmitter end with less physical effort and therefore energy consumption can be reduced upto a great level. This technique will be very useful for colleges, banks, and other important places.

VII FUTURE SCOPE

Whether it's a technology, human, device or machine, there is always a place for improvement to make it better; same is in the case of this proposed work. As we are merging different technologies, more advancement can be achieved in the future. First of all we can add a storing element in this technology so that at receiver data can be received by the user even after some time too. Multi – Terabit Optical Networks Dense Wave Division Multiplexing (DWDM) can be used to provide higher bandwidth for data transmission. More understanding of the interactions between the electromagnetic light wave and the transmission medium is necessary to proceed towards an infrastructure with the most favourable conditions for a light pulse to propagate. Improvement in laser technology can also be introduced here. The use of ultra-fast photonic sections is expected to further improve the capacity and speed of telecommunication networks.

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Technology Entrepreneurship Capability Development in Indian Automotive Industry

Mohd Talha Khan and Niraj Kumar

Abstract Technology entrepreneurship comprises of technical aspects and ability of entrepreneurship skills and competency. The four interrelated and complementary factors of entrepreneurship technology are: context, firm, technology, and entrepreneur. The merging of these four factors is necessary to create a competitive edge in the present scenario. The Indian automobile industries are well equipped with local firms having natural design and development capabilities. These local firms are not only well established global brands but also have a good marketing presence in India and other emerging markets. This study focuses primarily on technology entrepreneurship capability development in the Indian automobile industry and reveals the key attributes that shaped the innovative capabilities developments.

Keywords Entrepreneurship capability development · Indian automotive industry

1 Introduction

Entrepreneurs are the drivers of the economy in almost all of the nations. It is the effort of entrepreneurs that create job opportunities for the people of the nation [1]. Defined entrepreneur as one who moves economic resources from an area of lower productivity into an area of higher productivity with greater yield. When this term becomes entrepreneurship, it is the globalization and liberalization phenomena that are running the economy of the world towards rising competitiveness. Today, the major focus is on technology-based industries such as information technology, biotechnology, automobile industries, and the electrical & electronics industries [2]. The global trend is, therefore, moving toward entrepreneurial activities that are technology-oriented, also termed as 'technology entrepreneurship'. In the last 10 years, the

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Indian automotive industry is one of the fastest growing industries with increasing levels of technological understanding amongst various other emerging countries.

It provides employment in mass for local populations in the country. Also, its export revenues help to increase foreign trade [3]. It is quite clear that the Indian automotive industry also followed the same track of development followed by other emerging countries such as Brazil, Mexico, and Thailand [4]. It started with an assembly of automotive components, after that gradual increase in local content to full-scale manufacturing and after that finally to export promotion phase [5]. In 2006, the Government of India declared Automotive Mission Plan of 10 years from 2006 to 2016 for supporting strongly to the automobile industry, thus, aiming to boost production and increase export of vehicles [6]. As a result of this, in 2008 the Indian firm Tata Motors designed and developed the world's cheapest car named 'Tata Nano' which is against all the expectations of global car makers. Similarly, in the same year, Mahindra and Mahindra launched a sports utility vehicle, named 'Scorpio', which is against the product of the indigenous design and development effort. In 2010, Maruti Suzuki's car named 'Alto' became the world's largest car sold by volume [3]. In Indian car export, Hyundai and Maruti Suzuki share more than 90% of the total sales. Hyundai has located its production sites in Chennai and shipped to 95 countries in the year 2009 [7]. For Hyundai, India is a global automobile hub for production and sales both in India as well as the global market. These developments of the Indian automotive industry surprised other auto firms as their expectation of Indian success in the global market were low due to a perceived disorder between the scale of the challenges and existing capabilities of the Indian automobile companies [8].

2 Technological Capability in Indian Automobile Industry

Technological capability is defined as the ability to make trained manpower for

- Carrying out initial research work.
- Testing general facilities available in the industry.
- Acquire and accept new technologies.
- Provide information, supportive and networking system [9].

Technological capability in general can be best described in terms of three levels:

- Basic level means the ability to operate and maintain a new production plant which is based on imported technology i.e. production capability.
- Intermediate level means the ability to copy and accept the design and technique of an imported plant anywhere else in the country or abroad, i.e., investment capability.
- Advanced level means a capability to adopt new designs and develop new production systems and components, i.e., innovation capability (Table 1).

Table 1 Elements of technology capability

Level	Components
Basic level, i.e., production capability	Production engineering, production management, maintenance of capital equipment, and marketing of output produced
Intermediate level, i.e., investment capability	Project engineering, project management, capabilities to procure and training of manpower
Advanced level, i.e., innovation capability	Generates new technical possibilities for the purpose of profit making

Source Author

Most of the Indian manufacturing firms like food processing, metal forming and forging, steel, machine tools, pharmaceuticals, etc. appear to beat the basic or intermediate level of technological capability, whereas Indian automobile industry is at an advanced level [2, 10]. The industrial policy of the Indian government leads to the development of basic capabilities but on the other side, it restricted technology capability development in Indian automobile manufacturing. The key attributes of firm ownership, such as managerial vision and diversified nature of the business, helped Indian firms in the development of technological capabilities [3].

3 Salient Features of Indian Automobile Industry

The performance of Indian Automobile Industry is measured in three contexts: Automobile Production Trends, Automobile Domestic Sales Trends and Automobile Exports Trends.

3.1 Automobile Production Trends

A growth of 5.41% has been registered in industrial production in the year from April–March 2016 to 24,016,599 over April–March 2017 to 25,316,044 of vehicles which includes two wheelers, passenger vehicles, three wheelers, and commercial vehicles. [11]. The industrial production growth in the past 6 years is shown in Fig. 1.

3.2 Automobile Domestic Sales Trends

In the same time frame of last year, i. e., from April–March 2016 to April–March 2017, sales of passenger vehicles increased by 9.23% during April–March 2017.

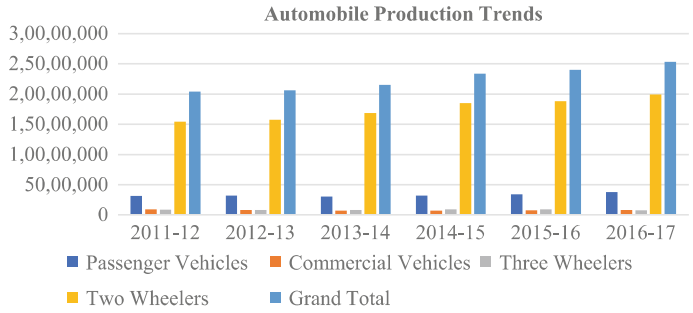

Fig. 1 Automobile production trends in the past 6 years. *Source* [12]

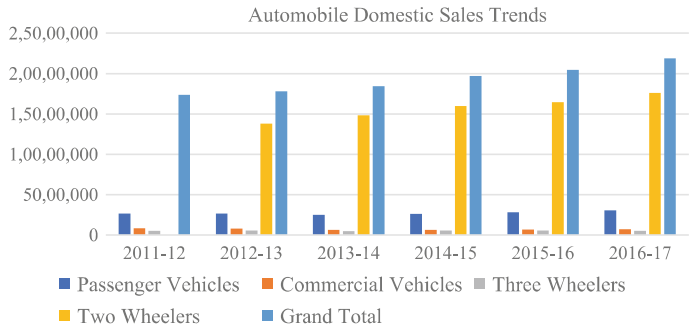

Fig. 2 Automobile Domestic Sales Trends in the past 6 years. *Source* [13]

Similarly, in this time period amongst all passenger vehicles, around 3.85% rise was in passenger cars, a 2.37% rise was in vans and 29.91% rise was in utility vehicles. In April–March 2017 net commercial vehicle segment represented 4.16% growth over the past 1-year period. Light commercial vehicles rise by 7.41% and M & HCVs (Medium and Heavy Commercial Vehicles) grown up by 0.04% in April–March 2017 over the past 1-year span. There is a decline of −4.93% in three wheelers during April–March 2017 over the last 1-year period. Sales of goods carrier increase by 12.75%, while sales of passenger carrier reduce by −8.83% during April–March 2017 over the last 1-year span. A rise of 6.89% has been registered in the sales of two wheelers during April–March 2017 over April–March 2016 which includes a 23.02% increase in mopeds, an 11.39% rise in scooters and 3.68% hike in motorcycles within two wheelers segment has been registered in April–March 2017 over April–March 2016 [11]. The industry domestic sales trend of the last six years is shown in Fig. 2.

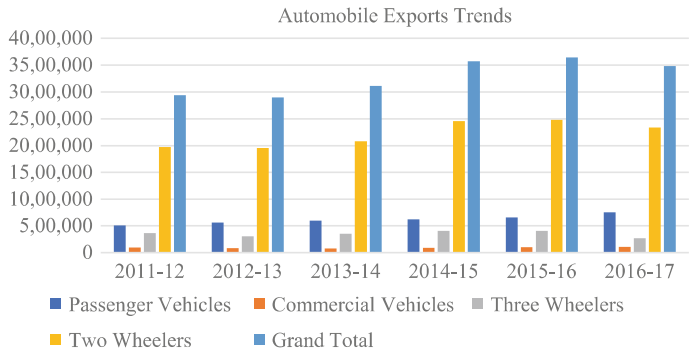

Fig. 3 Automobile Exports Trends in the past 6 years. *Source* [14]

3.3 Automobile Exports Trends

There is a reduction of −4.50% of overall automobile exports in April–March 2017 over April–March 2016. The rise of 4.99%in commercial vehicles and 16.20% in passenger vehicles has been registered within the same time period. Exports of two wheelers dropped by −5.78% and three wheelers dropped by −32.77% in April–March 2017 over April–March 2016 [11]. The industry exports trend for the past 6 years is shown in Fig. 3.

4 Analysis of Technology Entrepreneurship Capability Development in the Indian Automobile Industry

The analysis found that factors for Technology Entrepreneurship Capability Development in Indian Automobile Industry are growing demand, policy support and support infrastructure and high investments [15] (Table 2).

5 Indian Automotive Market 2020

India is a key pillar of the world's automotive market. Strategies, policies, and actions of India automotive market will have core impact on the worldwide auto landscape. It is thus expected that India automotive sales lead the US market around the mid-2030s. The global automotive game will be pretty much decided by the twin forces for China and India. With global economic shift, automotive sales are resonating towards the India market in the Asian region [16]. Passenger vehicle sales distribution

Table 2 Factors of technology entrepreneurship capability development

Growing demand	• Key driver of technology entrepreneurship capability development due to the rise in income of the individual and a large youth population
	• Enough availability of credit and finance related support
	• Rise in demand for commercial vehicles which results due to the high level of activity work in the infrastructure sector
Policy support	• Indian government adopted the Public Private Partnership model with Maruti Udyog Limited and Suzuki to make India as an automobile manufacturing hub
	• Missions like Make in India, Automotive Mission Plan 2026, NEMMP 2020 etc. all are going to improve the automobile sector to triple, i.e., 9.4 million units of passenger vehicles by 2026
Support in infrastructure and high investments	• Developing road infrastructure is one of the key segments of technology entrepreneurship capability development and India at present has the second largest road network in the world
	• Recognized firm ownership and managerial vision of Indian Automobile Industry thus providing necessary support to encourage the growth of the sector
	• 5% of total Foreign Direct Investment inflowing to India went into Indian Automobile sector which resulted in higher supplier productivity, better and cheaper products

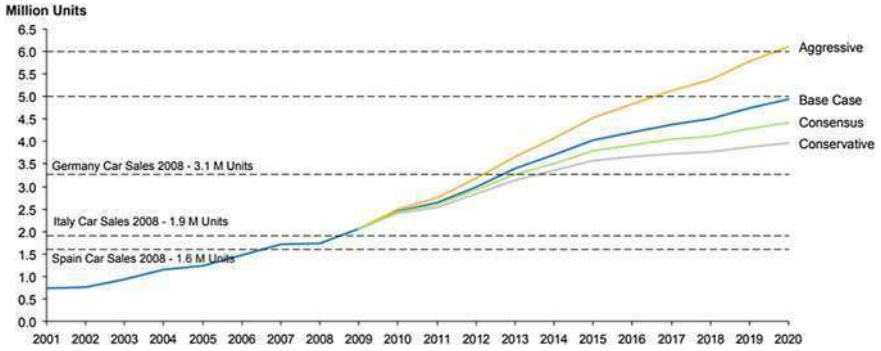

Fig. 4 Growth of passenger vehicles sales in India from 2001 to 2020. *Source* [16]

is represented in Fig. 4 shown below thus indicating the potential for rapid growth of the Indian car market to 6+ millions of units annually by 2020.

Self-governing cars are expected by 2020 to be on the roads. Amongst consumers efficiently performing hybrid cars will be most populous [17]. As India is moving towards Smart Cities Mission smart transportation is its key element.

6 Conclusion

In India, the automotive industry has a prominent future. Technology Entrepreneurship Capability Development in Indian Automobile Industry is presented in this paper. The three levels of Technology Capability, i.e., basic level (production capability), intermediate level (investment capability), and advanced level (innovation capability) are described. The performance of Indian Automobile Industry for the past 6 years is analyzed. Important growth factors of the automobile industry, i.e., growing demand, policy support and support infrastructure and high investments are identified. India's automobile market is penetrating the International automobile market and apart from this also meeting the advancing national automobile demands. Technology Entrepreneurship Capability development in the Indian Automobile Industry is also emphasized with the future scope of Indian Automotive Market by 2020.

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Green Energy: A Building Block for Smart City in India

Mugdha Mishra, Mohd. Talha Khan and Niraj Kumar

Abstract India by 2022 would be ranked as number one in densely populated nation by overtaking the China, due to population explosion in this century. That yields to acceleration in the urbanization, 30 people per minute moving from village regions to cities takes place for better living standard. Hence, stress is imposed over the existing system. For such critical issue Indian Government already initiated sustainable remedy Smart City Mission. Smart city includes following main features: uninterrupted power supply, clean environment, transportation, waste recycling, etc. Electrical power is its key domain so this paper focuses on the power challenges and region-wise power potential for green energy for the smart city mission of India.

Keywords Green energy · Solar power · Smart city · Wind power

1 Introduction

Inculcating various technologies in the existing system the quality of livelihood and efficiency of services can be enhanced along with urban development that yields to inculcating various technologies in the existing system livelihood quality and efficiency of services can be enhanced along with urban development that yields to smart city. The objective of the smart city is to upgrade the urban flows management and real-time responses allowed for the challenges. Electricity is the major factor in the smart city concept and renewable energy is its basic building block. The Renewable sources (such as Solar Energy, Wind Energy, etc.) are not extinguishing resource of energy, this energy always accessible and will not run out hence named

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Green Energy with a lot of power potential if properly utilized. Heat generated and light radiated by Sun utilized by various technologies as photovoltaic, solar thermal, artificial photosynthesis, solar architecture, and solar heating constitute to Solar Power [1].

70% of carbon emissions are due to cities as per the UN calculation. Electricity demands of Indian cities are growing every year and still, reliable energy wait is going on by 400 million people of our nation. By 2035, there will be 132% hike in electricity demand that takes place with only 112% rise in power generation as stated by British Petroleum's Energy Outlook. (ISA) between France and India for the purpose to boost Solar Energy generation in developing nations is signed. The aim of this solar alliance is proper utilization of solar power and to reduce dominion over the conventional resources. There is an extensive need of India to become the smart nation by articulating techniques such as energy-efficient city, low-carbon emitting and power-secure cities. Numerous opportunities are available with multiple cleaner options such as rooftop solar and bio-methane from sewage, the demand integrated action by all the governing bodies of private and government sector. "International Solar Alliance fossil fuels (primary objective of ISA). High capital is also invested in the renewable energy sector in India and Africa [2].

Green Energy Sources use local sources to generate electricity with negligible greenhouse gases emissions and negligible air pollutants emissions. By green technology, natural sources are converted into electricity, i.e., marketable energy future substitute to conventional power [3]. In India the calculated green energy potential is around 900 GW with Solar energy 750GW, small hydro energy 20 GW, Wind energy 102 GW (80 m height) and Bio-energy 25 GW. This paper clearly demonstrates the current and future scope of Indian states in Green Power, which is the main building block of smart city mission. Smart cities need smart electricity which is a sustainable one and at low cost. Under the smart city mission of India 100 cities were selected from various regions. In the proposed infrastructure of smart cities approved by the Indian Government, the key integrators of this project are Smart House, Environment-Friendly buildings, Intelligent Transportation System, Electric Vehicles, etc. Each of these integrators requiring energy for which needs to install solar, biofuels, windmills and other green power plants. Green clean resources of power (such as wind, solar) are smart solutions for smart cities. The shift toward distributed energy and implications for the entire electricity value chain is something that to understood and implemented [4]. In India's primary energy consumptions renewable energy have percentage share and initiating major steps for clean air, reducing carbon emission and adding renewable power technologies all these leads towards sustainable tomorrow [5]. The smart solution for smart city, i.e., Solar Rooftop plant for Bhopal has been presented and the Solar rooftop potential of the city has been estimated [6]. The business market history, how entrepreneurial opportunities are created for Solar Power from the time before World War II to modern era has been highlighted [7]. The rapidly decreasing carbon footprints is the target of our nation by adopting Nuclear, Wind and Solar power green resources use government have signed various agreements [8]. By 2020, 40 GW 50 Solar Parks have been approved and budget is sanctioned for 60 Solar Cities, also off-shore Wind Power and Hybrid

Table 1 MW-installed capacity region wise.

Region	Northern	Western	Southern	Eastern	Northeastern	Islands	Total
Hydro	19753.77	7447.50	11808.03	4942.12	1342.00	0.00	45293.42
Nuclear	1620.00	1840.00	3320.00	0.00	0.00	0.00	6780.00
Renewable	12873.22	20446.38	34369.28	1038.40	282.56	12.56	69022.39
Coal plant	52939.20	70608.62	45782.02	27321.64	520.02	0.00	197171.50
Gas plant	5781.26	10806.49	6473.66	100.00	1736.05	0.00	24897.46
Diesel	0.00	0.00	761.58	0.00	36.00	40.05	837.63
Total MW	92967.45	111148.99	102514.57	33402.16	3916.63	52.61	344002.39

Source [12]

Solar-Wind National scheme has been launched by the government to enhance the GDP [9]. For the promotion of Green Resources, the Government of India under MNRE (Ministry of New and Renewable Energy) initiated steps such as Incentives (Generation, Subsidies, funding) and government welcomes foreign investments in this domain. To make solar power capable of replacing fossil fuels, National Solar Mission has been started. To accomplish all these targets and promote such activities, a separate Solar Energy Corporation of India (SECI) has been set up [10]. The design and performance of solar devices and all solar power applications such as distillation of water, biogas, air and water heating systems, drying of crops with cost analysis has been comprehended [11].

2 Current Energy Scenario of India

As per diversification of power resources, the electricity production varies from region to region. Table 1 indicates the current energy scenario of various regions of our country. The western region of our country has the highest thermal power as well as the largest nuclear power generation while Northern regions are leading in Hydropower generation and the Southern region has strength in Renewable Energy generation. It is clearly seen that India's major power production contribution is from thermal plants as compared to other resources.

In the past decade, the power share of renewable resources is increased, MW-installed capacity of renewable energy in India is 69022.39 MW with the description given in Fig. 1.

3 Green Energy Potential of India Region Wise

India's population is rapidly increasing since there is a scarcity of coal, diesel, and other fossil fuel. In the upcoming decade, Electricity shortage problem will arise in India due to power insecurity and energy cost. Conventional fuel use causes environmental problems. India is moving toward smart city mission that leads to smart country so this problem can be rectified. The solution which nature itself provided is green energy, Fig. 2 represents the MW Green Energy Prospective of Indian States.

Green power resources available in India are Solar, Wind, Small Hydro and Bio-energy (biomass, biogas cogeneration, and waste to energy), as per the data compiled by MNRE MW green power potential of Indian states and union territories are listed below in Table 2 [3].

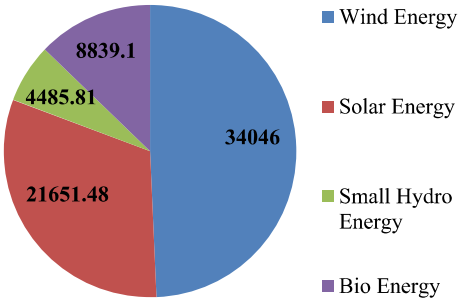

Fig. 1 MW-installed capacity of renewable energy in India. *Source* [12]

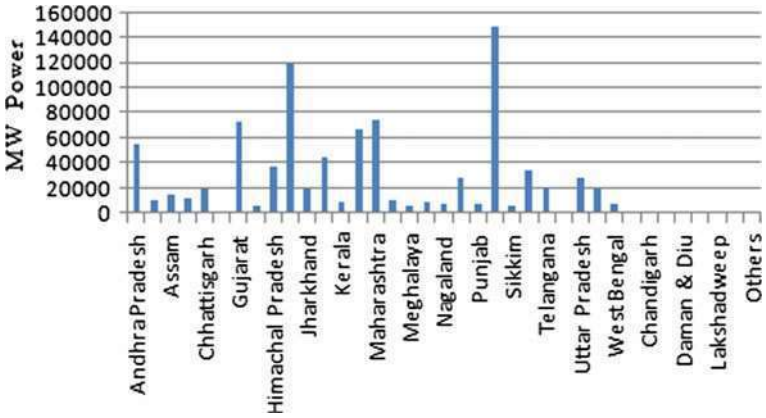

Fig. 2 MW green energy prospective of Indian states. *Source* [3]

Table 2 MW power potential of India's States and Union Territories

S.No.	Indian States	Bio-Energy	Small Hydro	Solar Power	Wind Power	Total MW
1	Andhra Pradesh	1001	978	38,440	4497	54,916
2	Arunachal Pradesh	8	1341	8650	236	10,236
3	Assam	520	239	13,760	112	14,330
4	Bihar	692	223	11,200	144	12,559
5	Chhattisgarh	260	1107	18,270	314	19,951
6	Goa	376	7	880	0	912
7	Gujarat	1683	202	35,770	35,071	72,726
8	Haryana	1357	110	4560	93	6470
9	Himachal Pradesh	144	2398	33,840	64	36,446
10	Jammu & Kashmir	43	1431	111,050	5685	118,208
11	Jharkhand	550	209	18,180	91	18,580
12	Karnataka	1131	4141	24,700	13,593	44,015
13	Kerala	1080	704	6110	837	8732
14	Madhya Pradesh	2692	820	61,660	2931	66,853
15	Maharashtra	2174	794	64,320	5961	74,500
16	Manipur	15	109	10,630	56	10,811
17	Meghalaya	13	230	5860	82	6185
18	Mizoram	3	169	9090	0	9261
19	Nagaland	10	197	7290	16	7513
20	Orissa	268	295	25,780	1384	27,728
21	Punjab	3517	441	2810	0	6768
22	Rajasthan	1101	57	142,310	5050	148,518
23	Sikkim	2	267	4940	98	5307
24	Tamil Nadu	1671	660	17,670	14,152	34,152
25	Telangana	0	47	20,410	0	20,410
26	Tripura	5	1260	2080	0	2131
27	Uttar Pradesh	3043	61	22,830	1260	27,593
28	Uttarakhand	29	1708	16,800	534	19,071
29	West Bengal	544	396	6260	22	7222
30	Andaman & Nicobar	0	8	0	365	373

(continued)

Table 2 (continued)

S.No.	Indian States	Bio-Energy	Small Hydro	Solar Power	Wind Power	Total MW
31	Chandigarh	6	0	0	0	6
32	Dadra and Nagar Haveli	0	0	0	0	0
33	Daman and Diu	0	0	0	4	4
34	Delhi	131	0	2050	0	2181
35	Lakshadweep	1001	0	0	0	0
36	Pondicherry	8	0	0	120	123
37	Others	520	0	790	0	1812
Total		692	19,749	748,990	102,772	896,602

Source [3]

3.1 Wind Power Potential in India

Most of the Indian regions are having low wind velocity while the regions of Jammu & Kashmir, Himachal Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Telangana, Andhra Pradesh, Karnataka, Tamil Nadu, and West Bengal have wind velocity which is capable of power production. MW wind power potential of Indian states and Union territories listed in Table 2, the highest wind power potential is of Gujarat state of 35071 MW.

3.2 Solar Power Potential of India

India has around 300 sunny clear days per year, 5 EWh/yr (5000 trillion kWh) amounts of solar power strikes on the Indian land. Energy output from conventional fossil fuel power reserves in a year led by available Solar Power in our country. 1500–2000 maximum rated capacity operating hours in a year is the daily average generation capacity of the solar plant in India which is approximately 0.25 k Wh per meter of used earth's surface with existing proved technologies [1].

Indian government approved schemes for increasing solar power capacity by the development of Ultra Mega Solar Energy Projects and approval for installing solar parks. It is planned that the setting of around 50 solar parks of capacity greater than equal to 500 MW. In the hilly states like Himalayan region, where difficult terrain, contiguous land smaller solar parks will be incorporated under this scheme. As per the report 2016–17 given by Ministry of New and Renewable Energy the solar energy

potential of Indian states and Union Territories given in Table 2, Rajasthan is leading in this perspective with the generation of 142,310 MW.

3.3 Small Hydro Power Potential

Apart from conventional hydro plants, the hydro plants are subclassified on the basis of electrical capacity as

- Micro Hydro Power plant has power capacity less than 100 kW
- Mini Hydro Power plant has the power capacity of 100–1000 kW
- Small Hydro Power plant has the power capacity of 1–50 MW

In the smart city concept, these small projects also sanctioned MW Small Hydro Power Potential of India's States and Union Territories as per MNRE's report for regions of India. Karnataka state is having maximum small hydropower potential of 4141 MW.

3.4 Bio-Energy Potential

India is an agriculture-based country and with an abundance of crop waste, bio-energy is also adopted as a green resource of power. Urban and rural energy markets grow exponentially in India for green energy systems and the bio energy is the prominent one in this regard. It is found from the data given in Table 2 that the Punjab state is having highest bio-energy potential of around 3517 MW.

4 Government Initiatives for Green Energy

The Indian government has started multiple projects to promote green power and collaborated with Industries also to take part in the smart city project.

Rooftop solar panel over the government building is started by Azure Industry to solve the energy problem. To meet carbon footprint reduction targets and to reduce the electricity bills of industrial and commercial customers Azure roof power is providing its solution by solar power. Customers of Azure projects include DMRC(Delhi Metro Rail Corporation), Indian Railways, warehouses, commercial real estate companies, the chain of premium hotels, government ministries, the water utility company in Delhi and Distribution Companies in smart cities [13, 14]. Also the implementation of Grid-Connected Rooftop Solar Projects for 152 Schools by the company Azure Power [15].

Indian Smart city project has the following building pillars:

- Smart Power System: Smart Power system includes Smart Power Storage units, Smart Grid, and Smart Metering. Creating Smart grids and electrification of all houses, Smart grid pilot projects of US$ 10 million investment. 130 million smart meters installation until 2021 has been planned. Investment of US$ 26 billion planned by the Power Grid Corporation of India in the energy sector.
- Sustainable development incorporated by the growth of Renewable Power, Government focus toward setting up public transport for the growing population by promoting the Green Transport. US $ 4.13 billion sanctioned by the Indian government for investment in 2020 electric and hybrid vehicles (with 6 million targets of such vehicles) and Electric Vehicle Charging Stations. US$20 billion sanctioned on the metro rail projects, 534 km Mumbai–Ahmedabad high-speed rail project of approx. US$10.5 billion and Monorail.
- In Smart Governance around US$1.2 trillion investment required for the next 20 years in the domains such as energy, public security, and transportation to design smart city.
- Infrastructure is the next key element, Smart Buildings which save up to 40% of energy usage, reduction of building maintenance costs by 10–30% and decreases 30% of water usage [16].

World's biggest Solar Parks is shaping up in India in the place Pavagada of Karnataka under Solar Power Development Corporation which managed to acquire 12,000 acres of the 13,000 acres [17]. Solution to the extra power supply for sustainable and smart city small-scale distributed generation systems is incorporated with Renewable Energy Sources (RES) [18].

5 Conclusion

Indian government provided many opportunities by initiating smart cities mission. The objective of this mission is decreasing the carbon footprint and energy intensity of the economy. India is now at the stage to transform into the smart nation with optimized power supplies, maximum recycling, and efficient transportation. Smart cities with world-class facilities: 24 h electricity, smart grid system, smart metering system, and manageable energy consumption system. In this paper, region-wise green energy potential of India is presented, the government initiatives and schemes to promote green energy started also mentioned. Green energy is the main building block for the smart city. The green energy capacity of Indian regions/states is identified.

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Framework the Food Supply Chain Network in the Present Indian Scenario

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Abstract. In India, agriculture sector always takes priority over the other leading areas as the maximum population is dependent on it for their bread and butter. It contributes the major proportion to the Indian economy & most significantly provides nutritional security to the country. Despite of all these facts, the issues like food security, post-harvest losses & socio-economic status of the farmers are the major challenges which create barriers to the development of the country. Recently numerous studies have been found in the concern of food waste and losses along the supply chain. Even so, the 40% of the food is wasted in India according to a report of United Nations Development Programme. In this study, causes of food waste and losses along the supply chain network are identified and weighted based on the survey of previous literature. The aim of this study is to categorize the major causes as a superset and the minor causes as its subset and is represented through fishbone diagram for its clear vision. Secondly the initiatives regarding the reduction in food waste are identified and prioritized using the weighted prioritization matrix approach. This study helps to give an idea about the most significant initiative that government should adopt at large scale in the context of reducing food waste and losses. It is concluded from the results that the linkages between farmers and industries require prior attention over the other initiatives to improve the efficiency and profitability of food supply chain.

Solar Food Processing and Cooking Methodologies

Abhishek Saxena, Varun Goel and Mehmet Karakilcik

Abstract In this study, a theoretical analysis of food processing (e.g., solar drying), worldwide cooking pattern, and cooking methods by using the solar energy has been reviewed. Solar food processing method is applied as direct absorption, air heater, and a combination of direct and indirect drying by solar radiation. Therefore, this process is one of the most accessible and hence the most widespread processing technologies. Traditional solar drying involves keeping products in the direct sunlight. Solar drying and cooking processes take place at different temperatures and timescales, and it depends on the nature of the food or substance. The amount of solar energy that reaches to the system and design parameters determines the performance of food processing and cooking systems. The time duration of drying and cooking depends on the temperature of heated air and environment. The temperature distributions, mass, and ingredient of food have an important role in the performance of dryers and cooker boxes. For a better understanding of the system parameters, the concept of solar food processing has been discussed thermodynamically. Energy saving by using solar systems has also been discussed.

Keywords Solar food processing · Solar drying · Cooking methodologies Energy analysis

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Nomenclature

Symbols

PBP	Payback period
x	Interest rate
y	Inflation rate
Z	Manufacturing cost of cooker
M	Maintenance cost
E	Energy saving per year
FC	Fuel combusted per year
OF_{fc}	Fuel oxidation factor
HHV_{fc}	Fuel higher heating value
CCC_{fc}	Carbon content coefficient
MW_{CO2}	Molecular weight of CO_2
MW_c	Molecular weight of carbon
E	Energy
zdT	Drop in temperature
MC	Heat capacity
Q	Heat
F	Heat exchanger efficiency factor
L	Latent of heat vaporization
W	Weight of water evaporated
LCV	Lower calorific value of fuel
P_f	Power of fan
Mb	Mass of fuel consumed
Asc	Crop surface area
K_f	Thermal conductance of air
K_m	Mass transfer coefficient of vapor
P_v	Vapor pressure

Subscripts

o	Output
in	Input
avg	Average
w	Water
wf	Final
if	Initial
th	Thermal
amb	Ambient
pm	Plate mean
i	Insulation
p	Plate
c	Glass cover
w	Wind

L Loss
a Air
d Dried substance
sc Solar collector
e Equilibrium

Greek letters

ε Emissivity
τ Drying time
η Efficiency
λ Latent heat evaporation

1 Introduction

Sun is a very large, inexhaustible source of energy. The power from the sun intercepted by earth is approximately 1.8×10^{11} MW which is many thousands of times larger than the present consumption rate on earth of all commercial energy sources. Smoke caused by cooking and heating is the main cause of many respiratory diseases altogether with environmental pollution. The World Bank's Development Report—1993—reports that eliminating indoor smoke could cut childhood pneumonia by half and reduce the burden of other diseases by 5%. It has been estimated that at present more than 15 million hectares of forest are lost per year in developing countries mainly due to consumption of firewood. According to UN Food and Agricultural Organization, some 2400 million people are expected to face acute fuelwood shortage by the end of century with serious nutritional and health consequences. So we need to move to renewable sources of energy in which solar energy is the most promising one. Thus, in principle, solar energy could supply all present and future energy needs of the world on a continuing basis. Also in India, energy subsidies are provided for petroleum products including kerosene, diesel, and LPG as well as for electricity. In 2010–2011, this accounted to more than ₹ 25,000 crores in total LPG subsidies (IISD 2012). So, this huge amount of money can be utilized to develop and improve methods to harness solar energy, i.e., solar cell, solar cooker, solar drier.

1.1 History

Food processing times back to the early age when the crude processing containing different types of cooking, such as over biomass firing, smoking, baking and

steaming, fermenting, solar drying, solar cooking and preserving with some salts was in practice. Food preserved in this manner was a mutual part of 'soldiers' and 'sailors' diets. These crude processing methods were continued to be the same until the initiation of the industrial revolution [1]. In 1809, Nicolas Appert had developed a vacuum bottling practice by using heat energy for supplying food to the troops in the French army, which was ultimately led to sacking in tins by Peter Durand in 1810. He developed the theory of food preservation in airtight jars and containers by applying sufficient heat energy, and by this, food would last longer safe from bacterial spoilage. In 1864, Louis Pasteur discovered pasteurization which improved the quality of preserved food. In the nineteenth century, food processing technologies were developed on a large scale to fulfill military needs [2]. Later on, in the twentieth century, the major changes in food habits (eating and cooking both) and the quality awareness of the humans toward the development of food processing have been observed [3]. Apart from this, at present, the trends of cooking and the demand of food have quite changed. Now, ready-to-eat foods are available across the globe with a possibility of cooking/baking or roasting, at almost all locations [2–4]. Some common techniques of food preservation are shown in Fig. 1.

In technical aspect, heating is a common and reliable practice for food treatment. Thermal processing of foods, such as heating, pasteurizing or boiling, drying, baking or roasting, frying and grilling, affects the quality of the food (nutritional values). Thermal processing can be done by both conventional methodology and modern techniques for a quality food [5]. During heating of food (based on Millard reaction), all bacteria, inactive enzymes, and microorganisms are died, while the vitamins, flavors, colorants, and quantity are less affected [6]. In the present modern techniques

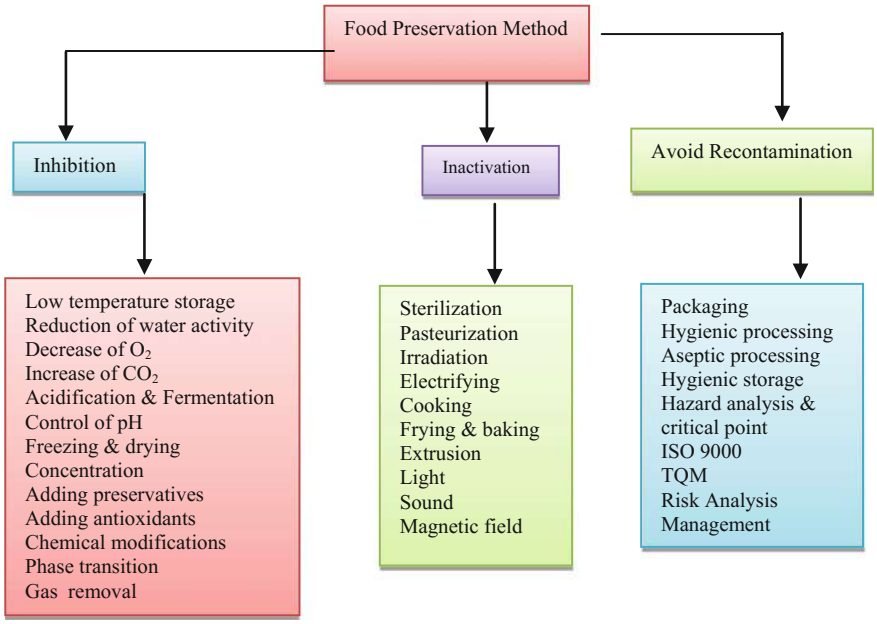

Fig. 1 Major food preservation techniques [5]

or food processing methods, there is no risk of toxicity, bacterial or allergic reactions. Heating also improves palatability, microbiological safety, and shelf life [7].

1.2 Solar Food Processing

Solar food processing is a developing technology which provides quality foods almost at negligible or minimum cost. There are a number of drying techniques for various substance or chemicals [as shown in Table 1]. Solar drying is a common practice for the drying of vegetables, fruits, or chemicals without losing their useful properties [8]. Different designs of solar dryers are used globally according to the substance. Besides this, open sun drying is also used for some foods with low moisture such as chili, pepper, pickle. Forced convection-type solar dryers are comparatively better to open sun drying for dehydration [9]. In general, solar food processing fetches in two emergent concepts together to resolve the two major issues of the twenty-first century: First one is how to produce sufficient energy for global population, and second is how to meet their demands of feeding and living. Obviously, the reason is population blast and unequal wealth distribution in different nations [9, 10]. Food production per capita above poverty line is necessary for a sustainable life. But, the problem still prevails in major portions of the different countries because of lack of education and unemployment [11]. By knowing the easy and a safe way of food preservation and full utilization of reliable energy sources (such as solar energy), people can sort out this problem at their end, especially in rural areas.

If one can talk about the effect of heat on microorganisms, then it is notable that the preserving result of heat dispensation is just because of denaturation of proteins, which terminates enzyme commotion and enzyme-controlled absorption in microorganisms. The level of demolition is a first-order reaction, i.e., when food is heated up to a temperature at which contaminating microorganisms destroy; the same proportion of microorganism decease in a particular period of heating [5]. The demolition of microorganisms depends upon the temperature; cells decease more swiftly at peak temperatures. There are many factors that control the heat resistance of microorganisms, but common reports of the result of a assumed variables for heat resistance are not continuously conceivable [13]. Given factors are acknowledged for significance.

(i) Nature of microorganisms,
(ii) Cultivation conditions during cell evolution or spore development (temperature, age of the culture, and culture mediocre used),
(iii) Improper heat treatment (i.e., pH value of the food, water activity of the food, composition of the food, and the growing media and cultivation conditions).

Knowledge of the temperature resistance of the different enzymes or microorganisms found in particular food can be used to estimate the temperature conditions desired for destruction of them. In common practice, the most heat-resilient enzyme or microorganism in a specified food is generally used as a base of calculating process conditions. It is supposed that supplementary less heat-resistant species will also be destroyed [14].

Table 1 Summary of novel and conventional drying techniques for food [12]

Technique	Suitability/current usage	Advantages	Disadvantages
Microwave drying and dielectric drying	High value-added products	Low temperature, batch or continuous operation, good quality	Slow and expensive
Microwave-augmented freeze drying	High value-added products	Low temperature, rapid, good quality	Expensive
Centrifugal fluidized bed drying	Small particles, vegetable pieces, powder	Rapid, easy to control	Loss of product integrity, noisy
Ball drying	Small particles, vegetables pieces	Relatively low temperature, rapid continuous	Loss of product integrity, difficult to control
Ultrasonic drying	Liquids	Rapid	Requires low fat solutions
Solar open drying	Fruit, meat, fish plant	Simple, low cost	Large space required, slow, labor intensive, difficult to control
Smoking	Meat, fish	Added flavors	Difficult to control, slow
Convection drying	Low value-added products	Continuous	Difficult to control
Drum drying	Liquids, gelatin	Continuous	Modification of liquid
Freeze drying	Value-added products	Continuous, no restriction particle size, low temperature	Slow, expensive
Fluidized bed drying	Small uniform particles, small vegetables	Usually batch operation, uniform drying, rapid	Restriction on particle size
Osmotic drying	Sugar infused fruit	High quality	Two-step process

Besides this, if one takes a look in typical mechanism of irradiance, then ionizing radiation takes the form of gamma rays from isotopes or from X-rays and electrons. It has already been acceptable in 38 countries to preserve foods by devastation of microorganisms or reserving of biochemical variations [13, 14]. The irradiation procedure includes exposing foods either prepackaged or in bulk, to a determined level of ionization heat. The application of solar irradiance [Table 2] to organic materials has a direct/indirect effect, in which the direct effect is a result of energy deposition by the irradiance in the object molecule, while the unintended effects transpire as a significance of sensitive diffusible free extremists fashioned from the radiolysis of water. Solar irradiance has a very wide scope in food disinfection, shelf life allowance, refinement, and substance quality improvement. All the details are thoroughly investigated through a comprehensive review by Wilkinson and Gould [15] with an importance of solar irradiance. The common benefits of solar irradiance are as follows:

(i) There is only marginal heating of the substance and thus negligible change to physical characteristics.

Table 2 Applications of food irradiation [15]

Application	Dose range (kg)	Examples of foods	Countries with commercial processing
Sterilization	7–10	Herbs, spices	Belgium, Canada, Croatia, Denmark, Finland, Israel, Korea, Mexico, South Africa, USA, Vietnam
	Up to 50	Long-term ambient storage of meat	None
Sterilization of packaging materials	10–25	Wine corks	Hungary
Destruction of pathogens	2.5–10	Spices, frozen poultry, meat, shrimps	Belgium, Canada, Croatia, USA, Denmark, Finland, Israel, Korea, Mexico, South Africa, Vietnam
Control of molds	2–5	Extended storage of fresh fruit	China, South Africa, USA
Extension of chill life from 5 days to 1 month	2–5	Soft fruit, fresh fish, and meat at 0–4 °C	China, France, South Africa, USA, the Netherlands
Inactivation of parasites	0.1–6	Pork	–
Disinfection	0.1–2	Fruit, grain, flour, cocoa beans, dry foods	Argentina, Brazil, Chile, China
Inhibition of sprouting	0.1–2	Potatoes, garlic, onions	Algeria, Bangladesh, China, Cuba

(ii) Packed and freezing foods may be treated.
(iii) Fresh foodstuffs may be conserved in a single process and without using chemical preservers.
(iv) Energy demand is very low.
(v) Variations in nutritive value of foodstuffs are comparable with other approaches of food conservation.
(vi) Processing is habitually organized and has low functioning costs.

1.2.1 Concepts of Thermal Processing

Concepts of thermal processing clearly show that the traditional thermal food processing depends on certain old ideas and keys, which are employed well, while current food study has raised some queries in contradiction to those perceptions. The traditional theory of the D value and of the z value is illustrated in Fig. 2a, b. To define a D value of a specific strain of microorganisms, illustrations of these microorganisms are bare to a higher temperature for a figure of time steps. The

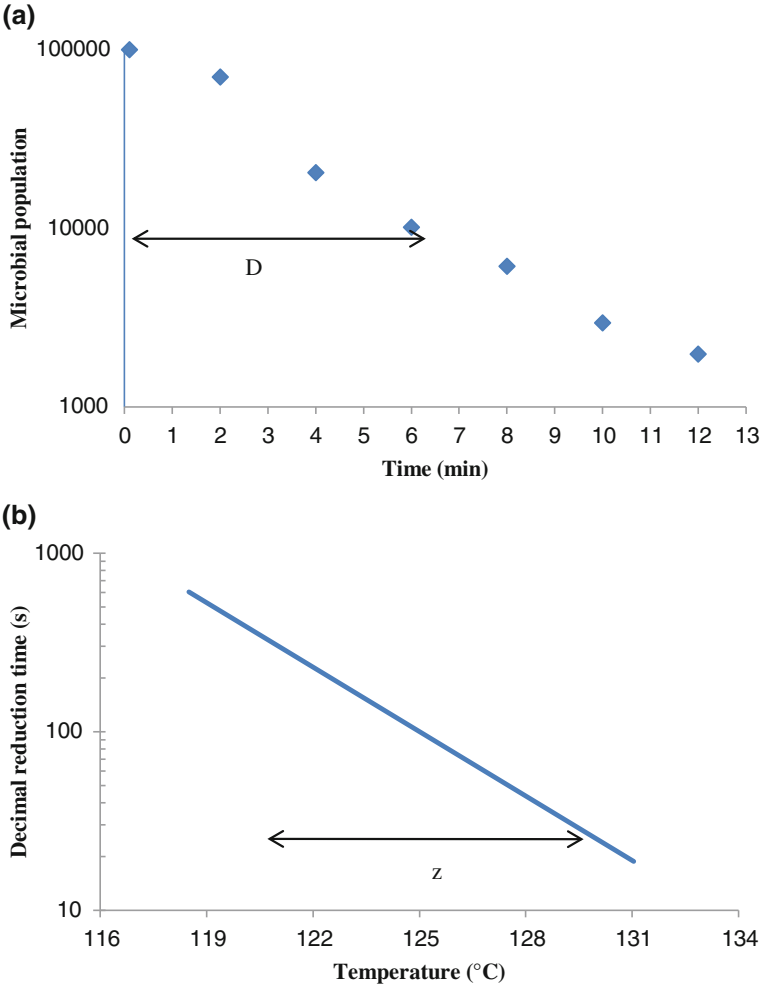

Fig. 2 **a** Microbial survivor curve on semi-logarithmic coordinates (D value) [10], **b** A plot of logarithm of D versus temperature used to determine the thermal resistance constant (z) [10]

residual amount of microorganisms is plotted on a log-scale versus treatment phase, and the data points bring into line linearly. The *D* value can be defined as the time required for reducing the sum of microorganisms at that particular temperature by one log cycle. The *z* value defines the necessity of the *D* value on a fixed temperature [16]. These standards are usually used to define the heat inactivation of bacteria.

Yet, all thermal falling-off reactions, including the obliteration of heat-sensitive food constituents, follow these laws. Figure 2b shows a mutual concept of thermal food processing, i.e., a high-temperature short-time treatment (HTST). Besides this, as per the '*D*' and '*z*' values, various time–temperature configurations can be established, which are really adequate to attain the same consequence of pasteurization.

1.2.2 Effect of Heat on Nutritional and Sensory Characteristics

The obliteration of various vitamins, aroma amalgams, and stains by heat follows a similar first-order reaction to microbial demolition. Commonly, both the values are greater than those of microorganisms and enzymes. As an outcome, nourishing and sensory properties are improved and retained by the usage of high heat (temperature) and short span of time during heat treating [17]. It is thus conceivable to select specific time–temperature permutations from a thermal death time curve (all of which attain the same degree of enzyme or bacterial demolition), to optimize a method for nutrient preservation of desired sensory potentials. This conception forms the basis of specific rapid blanching, high temperature, short-time pasteurization, high heat sterilization, extrusion, etc. [18].

Heat treatment is an important method, generally used in food processing, due to the desired belongings on eating quality (different eatables are consumed in cooking processes such as baking yield flavors which cannot be produced by other method), but due to a preserving effect on diets by the annihilation of enzymes, microorganisms, pests, and organisms. Some other main advantages of heat treatment of foods are as follows [16]:

(i) Relatively a simple mechanism of dispensation conditions,
(ii) Competence to develop shelf-stable foods which do not need freezing,
(iii) Obliteration of anti-nutritional issues (e.g., trypsin inhibitor in some pulses),
(iv) Improvement in the obtainability of certain nutrients (e.g., better digestibility of proteins, gelatinization of starches).

Besides this, the some common nutritious benefits of thermal treatment of food are [10]:

(i) Removal of harmful constituents (bacterial contamination, venom, enzyme inhibitors, or allergens protection of food);
(ii) Modifications in food environment erection and texture (advancement in digestion, improved bioavailability);
(iii) Generation of valuable new combinations (smell, antioxidants, etc.).

1.3 Cooking Scenarios in Different Countries

Cooking is a primary need, or it is a major activity of every household and commercial places (such as hotels, hostels, hospitals, restaurants, small roadside shops) and in some common transportation models such as trains and airplanes. It is also notable that nowadays, ready-to-eat meal (light and heavy stuffed food) is available in the market, which is usually carried by various persons to their working places, and through a heating process, this will be ready within few minutes for eating. This is the actual practice for eating and selling of different kinds of food, across the globe [4, 19]. Also in some countries like, India, Pakistan, Nepal, Bangladesh, Bhutan etc., where some religious trends such as celebrations of festivals (Diwali, Holi, Eid, Lohri, X-Mas, etc.), marriages, other functions/parties or even a funeral gathering, when food is

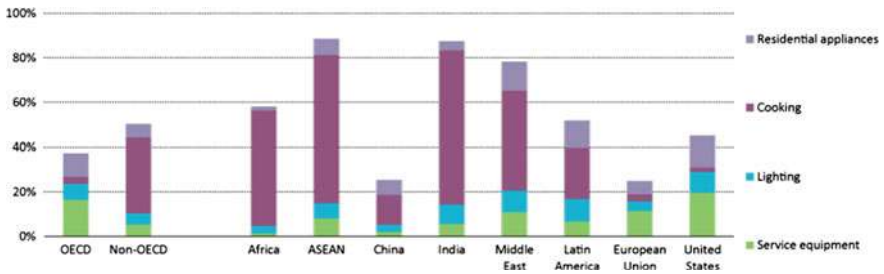

Fig. 3 Energy consumption of different households for some different countries [19]

cooked and served to all gathered people [20]. The food in these activities is generally cooked in open or closed places (like an open field or ground and a banquet hall) for a long time through various cooking fuels such as LPG, firewood, or coal.

In this section, the efforts have been made to highlight the present scenario of cooking foods with their methodologies and obviously the fuel used for cooking in different countries or region.

In emerging countries, at present around 2.6 billion people rely on biomass in rural areas to meet their daily energy needs for cooking or heating [19]. Figure 3 shows the energy consumption for different household activities in which energy consumption for cooking is much higher than other activities, across the globe. Apart from this, it is also notable that these resources account for more than 90% of household energy consumption in many countries. If the problem remain same, i.e., lack of certain new policies, then the number of people depending on biomass will rapidly increase to over 2.7 billion by 2030 due to unstoppable population growth. Statistics shows clearly that one-third population of this world will still be depending on these conventional fuels [21].

There are few corresponding methods which can improve this condition [19–21]:

(i) Encouragement of more effective and sustainable use of conventional biomass (fuel) as well as encouraging people for switching to updated cooking fuels and skills.
(ii) Dynamic and rigorous government plan and action is required to accomplish this target, organized with improved funding from both the public and private sectors/sources.
(iii) Strategies to encourage, more efficient cleaner fuels and technologies for cooking necessity to report barriers to access, adoptability or affordability and supply chain, and to formulate a dominant module of larger development policy.

Lack of new policies for the development of cleaner fuels and new technologies of cooking is the major components in consumption of conventional fuels, while another major issue is world's population blast and continuously increasing daily higher energy demands for cooking and heating across the globe. The government of different countries (or state-wise) should develop new policies for cleaner fuels such as LPG, electricity.

1.3.1 Household Cooking Patterns, Fuel Switching, and Policies

Commonly, there are three types of household in every country that are categorized according to particular household income, viz higher income household (HIH), medium income household (MIH), and lower income household (LIH), and they can also be categorized as rural or urban households in some developing countries. Each household has their own choice of fuel for cooking and heating according to their need and affordability [22]. According to the energy ladder [23], LIHs generally use the wood (including wood chips, straw, shrubs, grasses, and bark), charcoal, agricultural residues, and dung, while MIHs use wood, residues, dung, kerosene, and biogas and lastly HIHs use wood, kerosene, biogas, LPG, natural gas, electricity, and coal for cooking in developing countries [24].

Available literature and reports by World bank, IEA (International Energy Agency), WHO, and energy outlooks show that households normally use a combination of different fuels for cooking and heating (see Table 3 for example) which can be characterized as traditional (such as dung cakes, crop residues, and fuelwood), transitional (such as charcoal, lignite, and kerosene), or modern (such as LPG, biogas), while electricity is used for small appliances for cooking and heating but mainly for lighting. The share of population relying on the traditional biomass for cooking in 2012 was: 67% for Africa, 80% for sub-Saharan Africa, 51% for developing Asia, 15% for Latin America, and 4% for Middle East. Table 4 shows the traditional biomass consumption for cooking in different countries [26, 27].

The excessive dependence on solid fuels for cooking is an indicator of energy deficiency. It is familiar that access to modern energy facilities (clean fuels such as electricity) is important to the success of Millennium Development Goals. The burden on women and children for collecting fuelwood (wood pellets) can be reduced by applying the modern energy services (MES). By this, not only the time will save, but also one can be educated or get some other employment opportunities. There will also be a notable effect on child mortality [28]. It is also well known that traditional biomass fuels generate a bundle of pollution. These harmful pollutants have a poor effect on our health and sometimes become a major cause of death [29]. Jain [30] had discussed the energy security issues for all types of households by focusing on clean energy fuels for cooking in India. It was mentioned that the clean energy fuels (LPG, electricity, and kerosene) must be affordable for LIHs for cooking and heating and the policies should be revised for the same.

Pandey and Chaubal [31] had developed a logit model for rural household (India) fuel choices for cooking by using database of around 403, 207 observations. Authors focused on some major indicators such as females and children's education, regular income of the particular household, and possession of ration card (BPL—below poverty line type, especially). It was concluded that clean fuel such as kerosene should be provided in sufficient quantity for cooking and lighting. Akpalu et al. [32] had discussed that the almost all energy policies in Ghana or other developing countries are focused primarily on industrial energy consumption instead of household energy use. The socioeconomic factors such as household income and fuel switching cost were considered. It was concluded that a good subsidy on LPG and kerosene is a better and effective option to a LIH and MIH for fuel switching option. It was noticed that LPG is primarily chosen for cooking in Ghana's households.

Table 3 Combination of cooking fuels in Nigeria (2015) [25]

Fuels used	Population share (%)
Wood + Kerosene	17.71
Wood + Kerosene + Charcoal	3.21
LPG + Kerosene + Solar	8.21
LPG + Kerosene	1.04
LPG + Electricity	4.27
Kerosene + Electricity + Wood	4.27
LPG + Wood + Charcoal	3.13
LPG + Wood	5.21
Wood + LPG + Kerosene + Charcoal	10.42

Table 4 People using traditional biomass for cooking [28]

Region/Country	2009	2015	2030
	(Millions)		
Africa	657	745	922
Sub-Saharan Africa	653	741	918
Developing Asia	1937	1944	1769
Other developing Asian countries	659	688	709
India	855	863	780
China	423	393	280
Latin America	85	85	79
Total	2679	2774	2770

Wickramasinghe [33] had carried out a research project in Sri Lanka to extend the appreciative of human aspect of energy access. A questionnaire was prepared to survey around 2269 households for gathering a data on socioeconomic situations and matters influencing a transition toward clean cooking services. The results of the present study show that to develop a transition (switching of fuels), two domains must be addressed: risk capability and livelihood (Fig. 4).

The results have also shown that the transition is hampered by the following aspects:

(i) Lack of motivation and financing;
(ii) Burden for switching over to cleaner fuels;
(iii) Lack of updates of energy technology options and other supports;
(iv) The financial risks (the results also reveal that there is a need for a policy agenda linking the stakeholders, funding, and standardized technologies).

Foell et al. [34] had discussed the use of biomass fuel by the people of world and the impacts of biomass burning used for household cooking systems (China). This chapter focuses on the framework and policy development for clean cooking accesses, to develop a strategy for suppliers of clean fuels, and to revise the failures policies to improve the program. Maes and Verbist [35] had reviewed the biomass cooking literature and discussed the sustainability of domestic cooking pattern in

developing countries and how this can be improved. As a solution to air pollution, the use of energy ladder and switching of fuels (traditional to cleaner) was discussed with a result-oriented fashion, in which it was shown that the health damages can be reduced, and time and money can be saved as well as the green environment. Duan et al. [36] had focused on same points and discussed that the household fuels are intensely associated with numerous effects comprising the air quality, health, and a district environment change. The study reveals the results of first Chinese environmental exposure-related human activity patterns survey (CEERHAPS), carried out among 91,121 households located in 9745 villages and towns. The objective of the study was to investigate the cooking and heating pattern in China. It was observed that the LPG and biomass fuels are principal energy fuels for cooking, used by 45% (approximately) and 32% of households, respectively. Biomass (47.6%) has been observed as a main fuel for cooking in rural households, while urban population was more likely to cook with gas (65.8%). A model was developed to WHO for indoor air pollution (IAP), health effects, and burden of disease.

There are numerous data available on cooking fuel choice and modern stoves [37–43], fuel switching theory and models [44–51], energy ladder [52–55], IAP [56–60], respired illness, and burden of disease and death [61–72] in developing countries. As reference to the above literature, the daily demand of cooking energy fuels with increasing world's population is very tough to adopt the clean cooking fuels by MIHs and LIHs, while the new improvements in cookstoves are introducing day by day to achieve more efficient performance of cooking systems.

Government of different nations are promoting the clean fuels and providing various offers (subsidies, special discounts, etc.) on them. According to a report of the World Bank, different designs/types of cookstoves are used by different households (here for MIH and LIH) which are commonly associated with particular fuel types such as a three-stone type for biomass fuel, a traditional clay pot/simple ceramic liner-type stove for dung cakes or wood pellets, a round cylindrical stove for charcoal, and gasifier stoves. For a HIH or a rural area population, modern

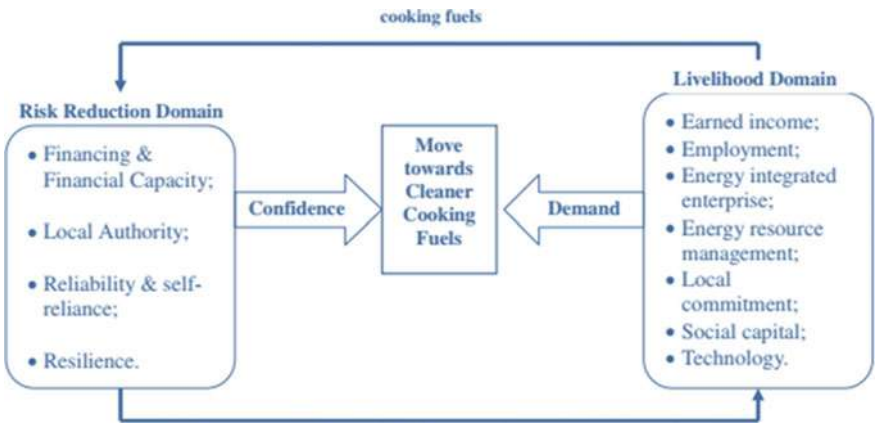

Fig. 4 Risk capacity and income for switching cleaner cooking fuels and stoves [33]

Fig. 5 Different designs of modern cooking stoves for clean cooking: **i** microwave oven, **ii** LPG stove (5 burners), **iii** electricity induction stove, **iv** modern coal stove (Angeethi), **v** modern kerosene stove, **vi** large wood pellets stove (big Chulha), **vii** modern single burner small family LPG stove, **viii** compact wood pellets stove for grilling and roasting, **ix** solar box cooker, **x** solar dish cooker, **xi** modern biomass stove, **xii** solar evacuated type cooker for roasting [139]

cooking stoves (see Fig. 5) are used in developing countries because of using clean cooking fuels such as LPG (1–5 burner type cooking stove), natural gas, electricity (a microwave oven, induction stove, or an electric kettle). The conversion efficiency of these stoves is much better over previous designs of cooking stoves. Apart from this, in modern era, biogas cookstoves and solar cookers are also getting a good attention in rural areas of emerging places. It is notable that solar cookers are not popular in only rural area but some urban households are using them well in both developing and developed countries because of their simplicity, low maintenance, no carbon emissions, and obviously performing on free fuel from the sun. Apart from this, by using of solar cookers one can save the limited fossil fuels and power energy for a fair amount annually.

2 Solar Drying Technologies

Solar drying is simple and an economic way to preserve the food since nineteenth century. This treatment removes water or heavy moisture presents in various ingredients and prevents fermentation. Solar food dryer (SFD) presents a significant progress upon this primeval method of drying foods. SFD has an initial expense, but it provides a better taste and a safe nutritious food and their marketability. They perform a fast and safe drying process more efficiently than other traditional sun drying methodologies. Solar drying can be categorized into two simple categories: open sun drying and cabinet solar drying. Solar cabinet dryer produces a high-quality dried foodstuff more quickly in humid or arid climates. Dried stuffs contain a high value of vitamin C content [73].

In recent years, several attempts have done across the globe to design or develop novel solar dryer for various activities such as for agriculture or industrial sector. The previous research shows that the efforts has been made not only to improve the efficiency of the SFD but also for cost and design optimization as well as to improve the year-round performance by making a hybrid SFD. In the next section, the discussion is made on various types of solar dryers and their performance.

2.1 Types of Solar Dryers

Solar dryer simply utilizes solar radiant energy to heat the air which flows over the substance placed inside the SFD. Warm or dry air that flows through the system carries away the moisture contents from the different substances through evaporation. A solar dryer generally consist of a solar air collector or air heater [74], a drying unit and an air handling unit. The main components of a solar drying are shown in Fig. 6. It is notable that the efficiency of the SFD majorly depends on the efficiency of air heater. Classification of the solar dryers is shown in Fig. 7, and some commonly used solar dryers are discussed in Table 5.

Fig. 6 A solar chimney fruit dryer with a solar air heater (consisting of single or double glazing, a solar collector, an air blower, ducts for air supply, and sometime a PV module in case of hybrid solar dryer)

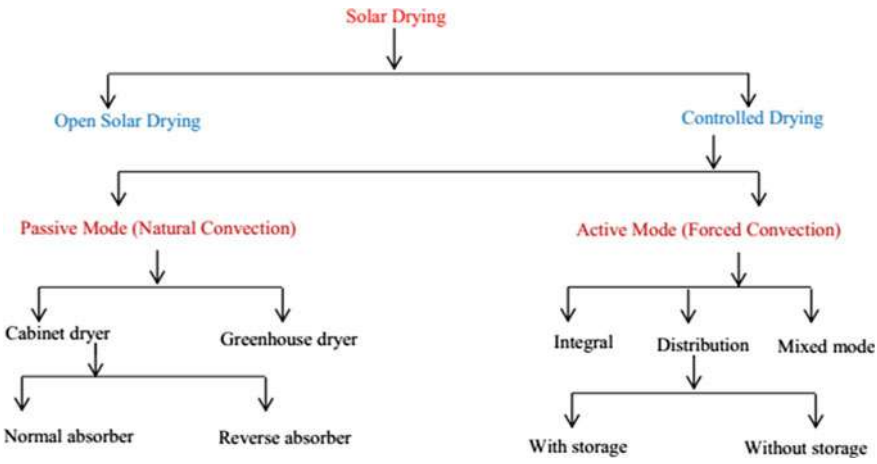

Fig. 7 Classification of solar drying [75]

Table 5 Types of solar drying

Types	Working
Open sun drying	In this, the substance is spread in the form of a thin layer on the ground. Solar radiant energy directly incident on the substance, and the moisture contents removed through the natural convection with low wind velocity. In this phenomenon, the present substance also absorbed radiation which results in a high vitamin C value. This drying is still most common drying in rural areas. The ambient parameters have a major significant effect on open sun drying
Cabinet solar dryer	A cabinet solar dryer is a hot box-type dryer in which fruits, herbs, spices, vegetables, etc., can be dehydrated. It consists of a long rectangular basin, an insulated base, and a single or doubled glazing. Irradiance passes through the glazing and absorbed by blackened surface (absorber) and raises the internal temperature. Small holes are made in the cabinet for providing ventilation to induce fresh air inside the cabinet
Greenhouse dryer	It is a low cost, simple in design, and easy to fabricate. It is used across the globe for crop dehydration. It has a parabolic shape and covered by a polycarbonate sheet. The base of the dryer is generally a concrete floor. The substances are placed in a thin layer on the black concrete floor. Solar irradiance passing through the polycarbonate sheets heats the air and stuffs inside the dryer, as well as the absorber floor. The heated air, when pass over the stuffs, absorbs moisture from the stuffs. A direct exposure to irradiance of the stuffs and the heated air augment the drying rate
Hybrid solar dryer	A hybrid solar dryer generally performs on two or more fuels for drying. This is because the said systems become more efficient by operating on two or more fuels, simultaneously. This system is capable of generating an adequate and continuous flow of hot air for a higher temperature range. Likely hybrid dryers used biomass or electricity along with solar energy

2.2 Solar Open Drying

Solar drying is an important application of the sun energy. Earlier farmers were fully dependent on solar energy for drying agriculture crops, herbs, or spices. For this, a ground or a bed of concrete was prepared to achieve a high temperature range through solar energy. The ambient temperature and wind velocity support this as natural convection. Obliviously, the process is much slow; therefore, it generally took 3–4 days to dry the substance. The initial and operation cost of open sun drying is almost negligible. Volume wise and despite a very simple process, the open sun drying is still a most common technique of drying [76]. Table 6 shows the various studies conducted on open sun drying of commonly used crops.

2.3 Solar Cabinet Drying

It is a single- or double-glazed rectangular cabinet (Fig. 8). Solar irradiance directly incident on the substance, and interior surface is blackened to enhance the heat

Table 6 Various studies conducted on open sun drying of commonly used crops

Reference	Research work outcome
Anwar and Tiwari [77]	An attempt had been made to estimate the value of 'hc' for six different crops, such as green chillies and green peas under open sun drying conditions. The value of 'hc' was varied from crop to crop because of differences in their properties such as moisture content, porosity, shape, and size of the crop
Mulokozi and Svanberg [78]	In the present work, 8 vegetables commonly consumed in the living areas were traditionally sun-dried and the pro-vitamin 'A' carotenoid was counted. It was remarked that the amount of pro-vitamin A-carotenes in conventionally dried vegetables was much reduced by open sun drying
Kabasa et al. [79]	The present work focused on the availability of vitamins A and C in vegetables and fruits. These vitamins were found out for a major cause of blindness for 54% in Uganda. The government of Uganda promotes solar drying as an economic and reasonable substitute. The effect of 3 drying methods (open sun drying, visqueen-covered solar dryer, and greenhouse solar drying) was investigated for vitamins A and C contents in fruits and vegetables
Jain and Tiwari [80]	In the present work, open sun drying was carried of green pea and chillies, white gram, potatoes, cauliflower, and onions to investigate the thermal behavior of the said vegetables. A mathematical model was developed to estimate the temperature and moisture removal rate from species. The value of 'hc' was estimated for different drying times with respect to different vegetables under open sun drying, and a significant variation was found in this with a change of species. The moisture removal rate for cauliflower and potato slices was significantly high in comparison with other crops
Akpinar and Cetinkya [81]	In the present work, drying response of parsley leaves was carried with forced and natural convection (open sun drying) conditions. It was observed that no constant drying falling rate was occurred during performing on both the modes
Prasad et al. [82]	The efforts have made to investigate the drying characteristics of ginger under open sun drying and a hybrid drying system (biomass based). It was concluded that drying depends upon the product thickness and ambient conditions of the drying place under open sun drying. In comparison with open sun drying, the hybrid solar drying system was found better for drying other stuffs, vegetables, and fruits
Al-Mahasneh et al. [83]	The open sun drying and forced convection drying have been carried of sesame hulls at Jordan University of Science and Technology. In total, six mutual thin-layer drying prototypes were tailored to the experimental data. The experimental results were compared with theoretical models, and it was found that open sun drying took place in nearly 180 min while forced convection drying needed 120–250 min. Both the drying techniques were found adequate for drying sesame hulls
Kooli et al. [84]	The open sun drying and greenhouse drying of red pepper were carried out inside a laboratory by using a 1000 W lamp for radiant energy. The effect of drying was investigated for moisture contents and drying rate by repeating the experiments under open conditions. It was

(continued)

Table 6 (continued)

Reference	Research work outcome
	concluded that experiments carried out in laboratory overestimate the drying process with respect to time
Tripathy and Kumar [85]	In the present article, the experiments have been conducted for drying of potato slices to find out the optimum fast rate drying methodology. The testing was carried out for open sun drying and mix-mode sun drying to observe the drying characteristics such as surface color, texture, and drying rate. It was concluded that the water captivation ability of done product is partial mostly by the variation in rehydration temperature tracked by sample geometry
Gudapaty et al. [86]	An LPG-based drier has been developed for drying of 50 kg of Indian gooseberry, and the comparisons were made with open sun drying of the same. The quality and rehydration characteristics of LPG-based dried stuff were higher and free from impurities. Beside this, the value of vitamin C in the dried product was high rather than dried by open sun technique
Akpinar [87]	Drying characteristics of mint leaves were was studied and investigated in a chimney type solar dryer and under open sun drying. Energy and exergy analysis was performed for both conditions. It was concluded that there was no change in dried mint leaves either by open drying or by solar cabinet drying
Hande et al. [88]	In the present work, the study of drying characteristics for open sun drying of Kokum rind was carried out. The important parameters were the temperature of crop surface, moisture removal rate, and drying time. The value of 'hc' was estimated on the value of constants 'C' and 'n' which were calculated by regression analysis. Some other important parameters were also considered for study such as acidity, pH value, non-reducing sugar contents, carbohydrates, protein ash, calorific value, and color, before and after open sun drying of kokum rind

transfer. For ventilation, small holes are drilled to the bottom surface to induce the fresh air inside the box. Opening ports are positioned on the top segments of the sideways and rearmost panels of the cabinet frame. As the box temperature rises, the hot air passes out of these openings by means of natural convection. In this process, both the heat and mass transfer take place [89]. The heat is transferred to the stuff through radiant energy or energy from any other heating source, while the mass transfer of moisture is from the entire stuff to the surface and then to the surrounding air. The objective of the cabinet drying is to supply the more heat to the crop than open sun drying. A cabinet dryer can also be a forced convection or hybrid SFD, which results in a fast moisture removal rate, less drying time, quality drying characteristics of the matter, and an economic process. Some novel designs of cabinet-type solar dryers are shown in Table 7.

Fig. 8 Different designs of solar dryers [95, 135, 140, 141]

Table 7 Research outcome of some novel solar cabinet dryers

Reference	Research work outcome
Datta et al. [90]	In the present work, a solar cabinet drier has been developed and transient analysis of the SFD was carried out with some applied assumptions. The model was feasible to predict the instant temperatures inside the cabinet, the drying rates, and the moisture contents. Experiments were conducted for no load and for load conditions (10–40 kg of drying substance). It was concluded that up to 20 kg/m^2 of wheat can be dried per day
Sharma et al. [91]	A SCD was fabricated, and thermal performance was carried out with help of energy balance equations at New Delhi. The collector temperature was observed around 85 °C on no load, while around 50 °C was observed for load conditions (20 kg of wheat). The cauliflower, turnip, and green peas were also dried for a comparison at small load conditions. It was concluded that the cabinet dryer was much efficient than a open sun dryer and the product dried in cabinet dryer was superior in quality
Ampratwuma and Dorvlo [92]	In the present work, a reverse FPC has been used for air heating for drying of agriculture stuffs inside a SCD in climatic conditions of Delhi. Energy balance equations were developed for thermal modeling of the system. The design optimization of SCD was done for parametric studies over ambient conditions. It was concluded that new type SCD was much efficient than conventional SCD

(continued)

Table 7 (continued)

Reference	Research work outcome
Goyal and Tiwari [93]	A prototype SCD was fabricated and tested at no load as a solar air-heating system. The system was operated for 28 days of May 1996 in Oman. During the testing, the SCD achieved a temperature around 81.3 °C. The system was observed for temperature variations inside SCD during the duration of 28 days, but no significance difference was observed in inside temperature of SCD during 10:00–15:00 h. The rate of solar radiant energy absorbed by SCD was approximately 0.90 kW sq/m
Adapa et al. [94]	An SCD integrated with a dehumidifier loop was designed and fabricated to study the drying characteristics of a highly moisture content (70%) alfalfa. The stuff was spread on the trays inside the SCD and operated for 10% of moisture content alfalfa. The system was operated on the forced convection for a temperature range of 25–45 °C. The drying time for alfalfa chops was observed from 4 to 5 h. The explicit moisture removal rate was observed from 0.35–1.02 kg/kWh
Srikumar et al. [95]	A new type of SCD has been developed and tested for drying fruits and vegetables. In this design, the stuff was placed beneath the absorber to avoid the problem of discoloration due to irradiance. Two small fans used for forced convection accelerate the drying rate. The system was found adequate for solar drying by removing 90% moisture from the stuff (4 kg) within 6 h. The economic analysis has also been done, drying cost was found around Rs. 17.52 for 1 kg of bitter gourd, and the payback was estimated around 3.26 years
Rawat et al. [96]	The energy analysis of an economic, simply designed, natural convection SCD was studied for India. Present work focused on manufacturing sectors who wish to know energy requirement and to reduce greenhouse emissions. Grown chillies were taken as drying object. Energy payback period was estimated for different conventional fuels. The overall energy input to the system was estimated around 2744.61 MJ, while the energy payback was found in the range of 1–2 years (i.e., depended on the drying characteristics of object)
Signh and Pandey [97]	In the present work, the drying properties of sweet potato (*Ipomoea batatas* L.) were investigated in a SCD. The convective drying has been carried out under the five different temperatures and the air velocities for different sample thicknesses of sweet potatoes. Results shown that the drying of samples took place in the falling rate phase and the diffusivity was observed to be increased with increasing temperature. The effective moisture diffusivity of the taken samples was observed for a range 1.26×10^{-9} to 8.80×10^{-9} m^2/s, while the activation energy was estimated around 11.38 kJ/mol
Demiray and Tulek [98]	In the present work, the effect of the drying behavior of garlic slices has been investigated in a SCD at a constant velocity (2 m/s) and a temperature range of 55–75 °C. The effective moisture diffusivity of the taken samples was observed for a range of 2.22×10^{-10} to 2×10^{-10} m^2/s, while the activation energy was estimated around 30.58 kJ/mol

(continued)

Table 7 (continued)

Reference	Research work outcome
Sallam et al. [99]	In the present work, two similar solar dryers (direct and indirect) were used for drying the mint by operating it on natural and forced convection. In the case of forced convection, velocity of the air was around 4.2 m/s. The effect of flow mode was investigated with the significant effect on drying kinetics of the object. The results shown that the drying of mint was occurred in a falling rate period with different climatic conditions (with no constant rate period of drying). The drying rate was observed to be high in forced convection operation. The effective moisture diffusivity of the taken samples was observed for a range of 1.2×10^{-11} and 1.33×10^{-11} m^2/s
Yahya et al. [100]	In the present work, a solar-assisted pump dryer (SAHPD) and a SCD were investigated for solar drying of cassava chips. The moisture content of cassava was notified to be reduced from 61 to 10.5% with a flow rate of 0.125 kg/s. Results shown that drying rate by using SAHPD was quite higher than SCD. Thermal efficiencies were notified as 25.6% for SCD and 30.9% for SAHPD with an average solar fraction as 66.7% for SCD and 44.6 for SAHPD

3 Solar Cooking

Food is the prime need of humans. Various types of fuels are used to cook the food worldwide. Due to limitations of using the fossil fuels for cooking as well as to reduce the environmental pollution and need of safe cooking, the concept of solar cooking was generated in 1951. But, the efforts toward solar cooking were successfully evaluated in 1767 by H.D. Saussure, a French-Swiss Physicist [101]. After this, efforts were continued by various pioneers of the field toward the effective solar cooking in eighteenth century and later. At present, various designs are available for solar cookers for efficient solar cooking across the globe. These solar cookers are not only simple in design but economic, accident, and pollution-free cooking, easy to maintain and feasible to perform round the year even in low ambient conditions. Indian government programs like Jawaharlal Nehru National Solar mission (JNNSM) ambitious target to generate 100 GW solar energy by 2022. Also Off-grid and Decentralized Solar Cooker Program (phase 2, JNNSM) promotes off-grid cooking application such as cooking/baking/frying using solar device with central financial assistance from Ministry of New and Renewable Energy (MNRE).

3.1 Types of Solar Collector and Solar Cookers

Solar collector—a solar-type collector is a flat wooden or metallic box which generally composed of a transparent glass cover, some glass or metallic tubes carrying coolant or heat-carrying working fluid, and an insulated back plate. The working principle is a simple greenhouse effect; whenever solar beams incident

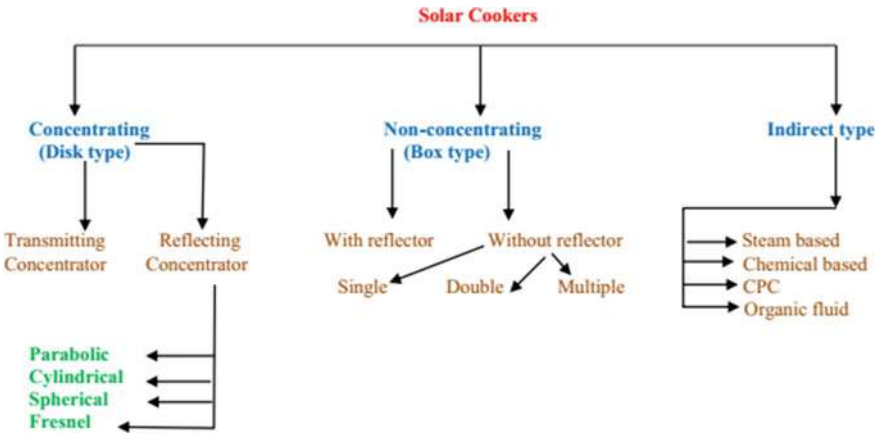

Fig. 9 Types of solar cookers

upon the glazing, the direct radiation strikes on the blackened surface of solar collector through passing the transparent cover and the heat energy is trapped by the collector. There are mainly two types of solar collector, i.e., flat plate collector and concentrating collector. Concentrating collector can further be classified as:

(a) Flat plate collector with plane reflectors;
(b) Compound parabolic collector;
(c) Cylindrical parabolic collector;
(d) Collector with fixed circular concentrator and moving receiver;
(e) Fresnel lens concentrating collector;
(f) Parabolic dish collector.

From the design prospects, solar cookers can generally be categorized into two types: tracking solar cookers and non-tracking solar cookers (Fig. 9). But, in present scenario, the research on solar cooking and standard of solar cookers have broaden the categories of solar cooker as following.

3.1.1 Tracking Solar Cookers

It is a solar cooker which consists of a parabolic dish (combination of small reflectors), a pressure cooker, a continuous tracking mechanism, and a rigid stand for holding both the elements. The sun beams incident on the cooker directly, and reflectors reflect the energy to the cooking vessel placed at focal point. The said cooker requires a continuous movement to follow the sun (each 10 or 15 min) and to retain the focus image on the object. These types of cookers give the highest cooking efficiency (Fig. 5i).

3.1.2 Non-tracking Solar Cookers

It is a simple box-type solar cooker which consists of a rectangular or square well-insulated blackened box, 2–4 cooking utensils, and single or double glazing with a reflector mirror booster. The stuff is placed inside the cooking vessel, and the glazed cover is then easily closed. The sunlight directly falls on the blackened surface (aperture area), on the top surface of vessel, and on the mirror booster. In this manner, conduction and convection take place inside the cooker through the solar radiant energy and the stuff get cooked. These cookers are used on a large scale around the world because of less time taken in quality cooking (Fig. 5j).

3.1.3 Indirect-Type Solar Cookers

These cookers are quite different in design and use. In these types of solar cooker, obviously the heat source is solar radiant energy but it is utilized indirectly for cooking purpose. Generally, they consist with a solar collector integrated with heat pipes, a solar boiler, etc. The food is cooked with the help of steam produced through the solar boiler inside the cooking chamber. The use of PCM has been observed effective in these types of cookers. Sometimes, Fresnel lens or additional mirror boosters can also be used to enhance the thermal performance of the unit (Fig. 10).

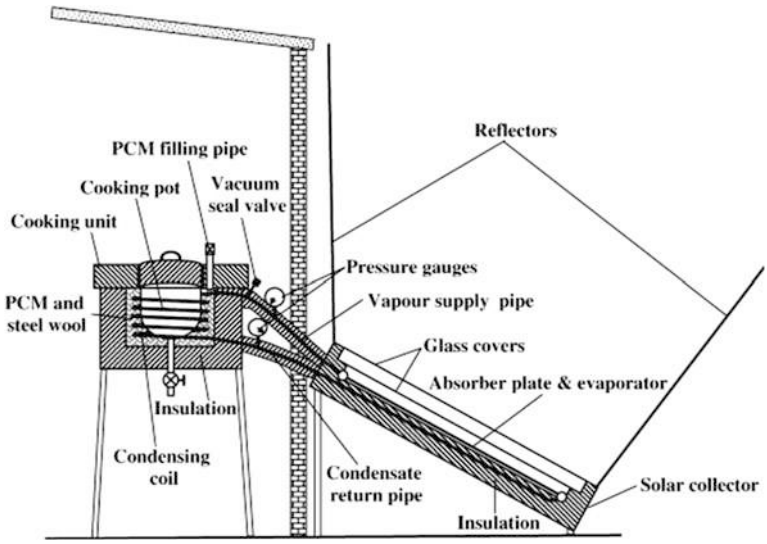

Fig. 10 Schematic diagram of indirect solar cooker [102]

Fig. 11 Experimental setup of a hybrid solar cooker [103]

3.1.4 Hybrid Solar Cookers

These types of solar cookers are more efficient in comparison with other solar cookers because of operating on dual fuel. These cookers are operated on dual inputs, say solar energy and electricity or solar energy and LPG or any other fuel along with solar energy. The system decently performs on solar energy, when the ambient conditions are good, but as they became low or poor, the other fuels initiate and maintain the cooking speed without any interruption. It results in timely and safe cooking (Fig. 11). They often provide a fast thermal response of solar cooking.

3.2 Cooking Methodologies and the Use of Solar Cookers

Cooking is a major end-use activity in which we find robust and frequently high specific energy carrier priorities. The extent and the form of energy carrier used by an individual family depend on the capability of the household to recompense the subsequent fuel costs as well as the lifestyle. The cause of this change is simple; i.e., low-income families cannot invest in high energy efficiency technology because of unawareness toward the costs of energy and poor information barriers. Accessibility and cost of the cooking fuels clearly demonstrate the reason of fuel choice for cooking and heating. Households that change the cooking fuels for a clean environment were much aware, and this also shows their capability toward paying a higher cost for the replacement (especially shifting to LPG from kerosene). Besides this, the cooking methodology is adopted by the various households by taking into account the economical use of food and resource fuel as well as the safety of food. Following are cookery methods for different households of different countries (Fig. 12).

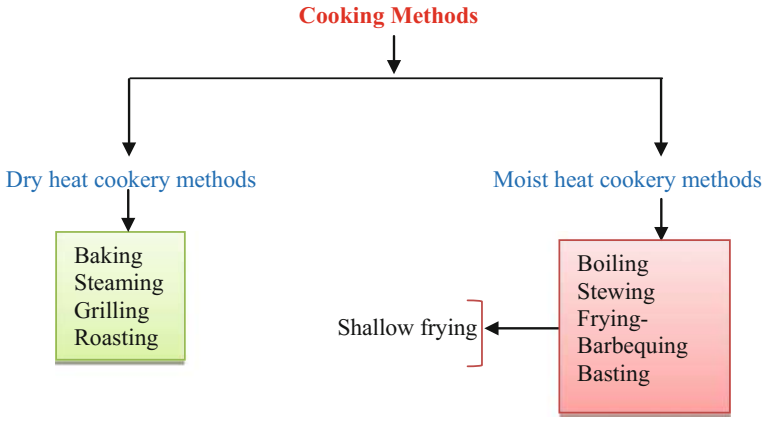

Fig. 12 Cooking methodologies across the globe

No doubt that a large figure of households instantaneously uses a different cooking pattern or variety of fuels for cooking, but another considerable factor is the choice of cooking fuels according to their cost that suits their family budget. If one can talk about the fuel choice for cooking than in rural households, biomass (wood pellets, charcoal, dung cakes, dry grass, etc.) is common fuel for these activities. On the other hand, LPG and kerosene are used for the same purposes in urban households. Besides this, clean energy fuels such as electricity and solar energy are also used for cooking at different locations of the various countries in the present era.

However, it is difficult to measure the exact involvement of solar energy in cooking or heating activities in developed or developing countries, but people from different countries are aware about this source of free energy. Countries such as China, India, Turkey, South Africa are paying attention toward solar energy applications and continue for promoting it by launching new schemes and by providing attractive financial aids. People from these countries are using solar cookers along with LPG and electricity in urban areas while along with kerosene and biogas in rural areas. Still that biomass fuel is used by some rural households for cooking and heating. Both the households (rural and urban) have a different pattern for cooking and use the cooking fuels accordingly. Both the households use solar cookers for cooking pulses and rice, to boil eggs and potatoes, and other light meals or the meals which require less time for cooking. It is also notable that the use of solar cookers is not limited to rural or urban households in different countries but they are also used in hospitals, institutes, hotels, hostels, and many other places where the sunshine is available in plenty [104–108].

Generally, rural households start their routine life early in the morning with preparing breakfast. At this time, solar radiant heat is not available in appropriate amount. During the solar noon (from 11:00 AM to 15:00 PM), one dish for the lunch and one dish for dinner (such as pulses or rice) are prepared by solar cooking.

Table 8 Cooking schedule of different households in Moradabad [109]

Family	Time of cooking	Cooking by solar cooker
A (05 members)	Breakfast (7:30–8:00 h), lunch*2 (12:30–14:00 h), dinner*2 (19:00–20:15 h)	lunch*2 (10:00–13:00 h) and (13:15 h–up to the finishing of one dish for dinner)
B (07 members)	Breakfast (7:30–8:15 h), lunch*2 (12:30–14:15 h), dinner*2 (19:00–20:15 h)	lunch*2 (10:00–12:45 h) and (13:00 h–up to the finishing of one dish for dinner)
C (07 members)	Breakfast (7:30–8:15 h), lunch*2 (12:30–14:15 h), dinner*2 (19:00–20:15 h)	lunch*2 (10:15–12:45 h) and (13:10 h–up to the finishing of one dish for dinner)
D (06 members)	Breakfast (7:30–8:00 h), lunch*2 (12:30–14:00 h), dinner*2 (19:00–20:15 h)	lunch*2 (10:00–12:30 h) and (13:00 h–up to the finishing of one dish for dinner)
E (08 members)	Breakfast (7:30–8:25 h), lunch*2 (12:30–14:15 h), dinner*2 (19:00–20:15 h)	lunch*2 (10:15–13:15 h) and (13:30 h–up to the finishing of one dish for dinner)

*shows the number of dishes to be cooked for both lunch and dinner

For this, a dish cooker, a box cooker, or an especially designed solar cooking unit can be used. A solar dish cooker is more efficient than a box cooker to cook the stuff which requires high temperature (potatoes, eggs, meat). On the other hand, box cooker is used for pasteurization of milk or water, for cooking rice or pulse, etc. Other cooking materials are prepared by biomass or kerosene (such as chapatis, some dry vegetables, or other stuff required hard boiling or deep frying).

Table 8 shows the cooking schedule of five different families in which three from rural area (families A, B, and C) 'Naya-Gaon' and two from the town (families D and E) in Moradabad district. This table demonstrates the time of cooking and use of solar cooker by particular family. It is also clear from Table 8 that the people from rural and urban areas use the solar cooker only for cooking two dishes, i.e., one for the lunch and one for dinner.

3.3 Energy Savings Through Solar Cooking

Estimation of energy savings through the use of solar cookers is a simple exercise in which the amount of fuel saved per year by solar cooking is calculated. These savings depend on the efficiency of solar cooker, design parameters of cooker, ambient parameters during solar cooking as well as the nature of substance to be cooked inside the cooker. For this exercise, a survey-based research is necessary by considering some basic assumptions with the effective cooking time. Let us assume that a simple household of 5 family members uses an electric oven (1200 W) for

cooking, then what would be the amount of electricity consumed for cooking? This can be simply estimated by knowing the cooking pattern of the same household.

Assumptions are as follows:

1. For a single dish, the amount of electricity is consumed 0.25 kW.
2. For a single dish, the amount of LPG is consumed 0.20 L.
3. A single dish means 600 g of vegetables or cooking substance (not non-veg).
4. Solar cooking is performed during the sunshine hours.

Now, for the estimation of electricity consumption by considering the cooking pattern of the said household:

Electricity consumed for cooking breakfast, the lunch, and dinner by oven = 1 kW,

Electricity consumed for cooking the light snacks by oven = 0.25 kW.

Electricity consumed on ideal conditions by oven = 0.10 kW.

Total electricity consumed for cooking by oven = 1 kW + 0.25 kW + 0.10 kW = 1.35 kW.

If the electricity connection is through the hydel board of electricity, then the cost of total electricity consumed is (by ₹ 4.40/unit) around ₹ 6.00. It means that the monthly bill is around ₹ 180 for cooking on electricity.

Similarly in the case of LPG, the estimation of LPG consumption by considering the cooking pattern of the said household is:

LPG consumed for cooking breakfast, lunch, and dinner by LPG stove = 0.50 L.

LPG consumed for cooking the light snacks by stove = 0.10 L.

Total LPG consumed for cooking by stove = 0.50 ltr + 0.10 ltr = 0.60 L.

If the LPG connection is through the authorized gas agency by government, then the cost of total LPG consumed is (by ₹ 32.50/unit) around ₹ 19.50/-. It means that the monthly bill of LPG is around ₹ 604.50/- for cooking.

From Table 8, it is shown that a solar cooker is feasible to cook the two dishes per day, i.e., one for lunch and one for the dinner. Now, one can accept that the electricity consumption for cooking -two dishes is 0.50 kW (from the assumptions) and the price for this amount is ₹ 2.20/day which can be ₹ 66.00/month or ₹ 742.00/year. Similarly, for the LPG the saving amount will be ₹ 13.00/day and this will around ₹ 390/month or ₹ 4680/year. But these savings are not the actual because it includes the PBP of the cooker. If one has to estimate the net savings of fuels or the amount which is spent to buy the cooking fuels, then the PBP of the cooker has to also be estimated and subtracted from this savings amount.

The PBP of the cooker can be calculated by considering some economic factors as follows [110]:

$$N = \frac{Log\left[\frac{(E-M)}{(x-y)}\right] - Log\left[\frac{(E-M)}{(x-y)} - Z\right]}{Log\left[\frac{(1+x)}{(1+y)}\right]}$$

Alternatively, the PBP of the cooker can also be estimated by a simple formula without considering the various additional cost such as inflation rate, interest, maintenance cost [111]:

$$Payback\ Period = \frac{Manufacturing\ cost\ of\ solar\ cooker}{Cost\ of\ energy\ saved\ per\ year}$$

By this way, the net savings can be easily estimated through the solar cooking at any place. By this way, people who used biomass fuel for cooking and heating can not only save the limited fossil fuels but also some amount of money, some amount of time, and obviously their health also. Besides this, one can also estimate the annual CO_2 emission by using the different conventional fuels with the help of following formula [112], which produced while cooking on conventional fuels:

$$CO_2 emission = FC \cdot OF_{fc} \cdot CCC_{fc} \cdot HHV_{fc} \cdot \left(\frac{MWco_2}{MW_c}\right)$$

4 Hybrid Systems for Solar Drying and Cooking

Solar hybrid systems are those systems which operate on more than one fuel or input. The optimum design has been selected according to the need and ambient conditions to get desired output. In solar energy systems, electricity (AC or DC) is commonly used as second fuel in most applications. The great advantage of the system is that it can also work in night or under poor climatic conditions. These systems are more efficient in comparison with pure solar thermal systems and can be used at any location of developed or developing countries. Although many households use more than one cooking fuel for cooking such as LPG + kerosene, LPG + electricity, electricity and biomass, LPG + electricity + solar energy, LPG + solar energy, as the people are convenient or due to availability of fuels or resources in their particular region.

Another advantage is that the baking, frying, water or room heating, and high-level drying are also possible with these systems. If we talk about solar cookers, then this practice is more convenient to box cookers in comparison with dish-type solar cookers. Dish-type solar cookers require a continuous tracking of the sun; therefore, the position of the cooker is changed repetitively, but box cookers are installed at one place and there is no need to change the position; hence, second fuel is easily supplied than a dish cooker. Heat is supplied through an electric coil (sufficiently of 10 W) beneath the solar collector from the grid supplied electricity or from the photovoltaic modules by means of battery storage. In designing solar thermal hybrid cookers or dryers, the metal of solar collector is generally copper. The heat in this system is highly controllable, and around 91% heat is supplied to the substance in the cooking vessel (in case of cooker) or around 80% supplied to the

substance to be dried (in case of dryer). Overall, solar hybrid systems are more convenient to operate as well as for savings of fuels or to reduce CO_2 emissions.

In daily practice of solar cooking and drying, it has been observed that the using solar cooking or drying, systems alone are low in efficiency and fully depend on sunshine conditions. To overcome this problem, a hybrid solar cooker-cum-drying system was developed in Costa Rica by Nandwani [113] for cooking and baking of almost all edibles. As per the convenience of the consumer, the cooker can be shifted to the electrical input during or before the cooking. An electric back plate of 1500 W was used for heating up the cooking vessels to cook the food. Hussain et al. [114] had carried out experiments in cloudy days for cooking by incorporating an electrical coil beneath the solar collector plate inside a solar hybrid cooker. Through this mechanism, the cooking was possible in low ambient conditions in Bangladesh. In comparison with Nandwani's model, the present model consumed only 900 W of electricity. The model also satisfied the figures of merit for box cookers [115]. Later on, Chaudhuri [116] had estimated the required electrical back for a SBC. However, BIS does not specify any standard for hybrid solar cooker, but it was concluded that 160 W of electrical backup is sufficient for cooking in a SBC. Besides this, all of the authors [113–116] did not specify the design specifications of cookers, cooking methodologies, cooker size, or anything about the cooking stuffs that were considered for performance evaluation of hybrid model (Fig. 13).

Later on, Nandwani [117] had designed and tested a multipurpose (four in one) solar hybrid device for cooking, drying, and water heating-cum-distillation unit in Costa Rica. This device uses the electrical energy and solar energy to operate. Experimental studies were carried out for each one operation of the said device such as; cooking, drying, pasteurization and distillation and obtained thermal efficiency of the box as a cooker was 23% as a dryer it was 32.3% and as a still it was come out to around 27%. Ali et al. [118] had developed a hybrid solar cooker as a substitute to conventional energy and to reduce the environmental pollution. The cooker was operated on electricity and solar energy simultaneously. A matrix of parabolic reflectors was used to boost up the solar irradiance and thereby thermal efficiency. The performance of the hybrid cooker was evaluated with the help of

Fig. 13 A Hybrid solar multipurpose device [117]

energy balance equations. The system was feasible to reduce the cooking times in low ambient conditions. Joshi and Jani [119] had developed a small PVT box hybrid cooker with the help of five solar panels of 15 W each. During the experimentation, the value of first figure of merit (as per BIS) was found to close as per standard. Efficiency of the cooker was around 38%, and the estimated cost was around ₹ 7200/-, which can be reduced for consumers who already have solar panels for solar lights, etc.

Solar food drying is another form of solar food processing in which the heated air by solar energy is used to dehydrate food for storage and consumption. In conventional method, some thin slices of the substance are placed outdoor on a well-ventilated surface or on the rooftop of buildings for drying through hot air produced by solar irradiance. The heated air flows over the surface of the food stuff and carries a large amount of heavy moisture contents present in food through natural convection. For an advance option, these thin slices are placed in an enclosure or closed drying cabinets that utilize solar energy with forced convection methods in which mass flow rate is controllable (because the system operated on electricity or on PV modules). This method of drying is more effective in comparison with open sun drying, the system is easy to design and maintain, and food is quite safe from animal and birds attacks. By this, the substance or food got dehydrated with a high rate in less time. The quality of food stuff is not affected anyhow.

About storing of the dried stuff, clean plastic freezer bags (or glass jars with tight lids) are quite safe and promising for a heavy duty and can be simply transported. They can also be labeled or tagged with a code or date. All the packed stuff should be periodically checked special for weevils (a small and clean insect) or webbed cocoons. If the insects found, then pasteurization method can be adopted to kill the weevils. Before cooking the dried and stored food stuff, it should be hold for 15 min in hot water (70–80 °C) for a safe and healthy cooking (Fig. 14).

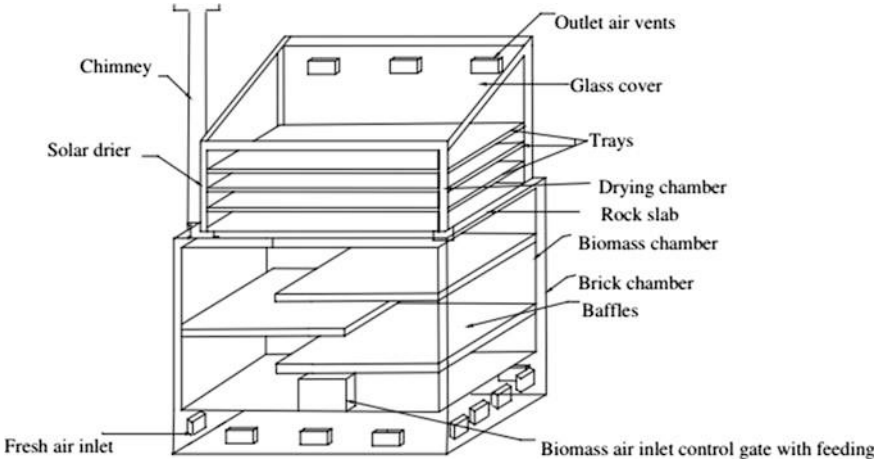

Fig. 14 A solar-cum-biomass drier (hybrid dryer) [121]

Akyurt and Selcuk [120] had developed a prototype solar food dehydrator (tunnel type) in which bell peppers and sultana grapes were dried at various mass flow rates. An additional auxiliary heating system was integrated with drying unit for a continuous operation. Economic analysis also showed that the present system can also be undertaken for an effective drying of fruits and vegetables. Prasad et al. [121] had developed a solar-cum-biomass hybrid dryer which performed on natural convection for drying of turmeric rhizomes. The objective of the experiment was to reduce the consumption of petroleum fuel or electricity, especially in rural areas. The system was found adequate to supply the hot air around 60 °C. The system was found for a good satisfaction comparatively with open sun drying. The overall efficiency of the drying unit was around 29%.

Ferreira et al. [122] had experimentally discussed that hybrid solar dryers are good option to reduce the drying costs of food in comparison with conventional solar dryers. It was also discussed that hybrid dryers (solar energy + electricity) improve the quality of dried product because of the controlled thermal drying state. Obtained results were in the favor of solar hybrid dryer for drying of banana slices in comparison with natural sun drying and artificial drying. Hossain et al. [123] had developed a hybrid solar dryer which consists of a concentrating collector, heat storage, drying unit with auxiliary unit. The system was tested in different operating conditions for drying 20 kg fresh tomato slices for different physical characteristics and flavonoids. The maximum efficiency was achieved around 29%. It was observed that this efficiency can be increased by 5–6% by using a solar reflector. It was recommended that if tomato is dried at 45 °C of the hot air, then no pre-treatment is necessary to prevent infectious growth. Amer et al. [124] had designed and constructed a new hybrid solar dryer with a heat exchanger. Water was used as heat storage media which release the stored heat at night or in poor ambient conditions for drying light substances with the help of electric heaters. The maximum efficiency of the drier was achieved by recycling around 65%. The system was feasible to provide the hot air about 40 °C more than ambient air. The experiments were conducted for drying of 30 kg of banana slices. The physical characteristics were found better in comparison with open sun drying (Fig. 15).

Lopez-Vidana et al. [125] had developed a solar-LPG hybrid drier with an auxiliary heating mode. The significance of design parameters was noticed to be affected through variations in input to the system. Mass flow rate was measured as a major parameter that affects energetic efficiency very much. The thermal efficiency was noticed as 26%, while the drying efficiency was noticed maximum for 71%. It was concluded that the system was found satisfactorily operating for drying tomatoes. Reyes et al. [126] modified and tested a solar hybrid dryer integrated with PV panels and a phase change material. The system was tested for mushroom drying in the form of thin slices (8–12 mm). The thermal efficiency was noticed as between 22 and 62%, while the efficiency of accumulator panel was noticed maximum for 21%. The PCM had a significant effect on the thermal efficiency of the system. Yaseen and Al-Kayiem [127] had utilized the thermal energy of flue gas from a biomass unit to develop a hybrid solar thermal drying unit. The system was tested for a day and night performance through a hybrid mode and thermal mode alone. The system was integrated

Fig. 15 Hybrid dryer test rig [127]

with an additional recovery drier for an optimum design and effective performance in poor ambient conditions. The results showed that the overall drying efficiency was around 13% with recovery drier. The novelty of the hybrid system was its recovery unit which enhances the overall efficiency of the system to be 30%.

5 Thermal Analysis of Solar Cookers

Thermal performance of solar cookers depends on many parameters: climatic parameters such as solar irradiance, wind velocity, ambient temperature, as well as design parameters such as shape, size, material of collector, number of glazing, vessel design, insulation, selective surfaces; in general terms, three parameters are essential for experimentation:

1. Time–temperature curve of cooker at ideal conditions (i.e., no load);
2. Cooking duration for variety of foods;
3. Time required for a fix volume of water up to boiling temperature.

A complete thermal analysis of solar cooker is quite complex because of 3D transient heat transfer involved. Solar energy cookers are the topic of research for

the last 160 years but yet now there is no standard thermal rating is available for solar cookers.

5.1 Thermal Performance of Box Cooker

With the help of the first law of thermodynamics and the energy balance equations for the box cooker [101], energy input can be estimated as:

$$E_{in} = I_{avg} \cdot A_{sc}$$

while the energy output (on load conditions) for the SBC can be estimated through above equation as:

$$E_o = \frac{m_w c_{p-w}(T_{wf} - T_{if})}{t}$$

Now, having the value of above parameters in above two equations, one can easily estimate the value of thermal energy efficiency of the present system by:

$$\eta_{th} = \frac{m.c_p \cdot \Delta T}{t.I_{avg} \cdot A_{ap}}$$

Along with this, the cooking power has been estimated by [128]:

$$P_{sbc} = m.c_p \frac{(T_{wf} - T_{iw})}{600}$$

Equation for cooking power is divided by 600 to account for the number of seconds in each 10-min interval as per recommendation [128]. The figures of merit (F_1 and F_2) for the box cooker suggested by Mullick et al. [129] had computed by:

$$F_1 = \frac{(T_p - T_{amb})}{I}$$

where I (W/m^2) is the insolation on a horizontal surface (taken at time of stagnation testing)

$$F_2 = \frac{m_w c_{p-w}}{A_{sbc} t} F_1 \ln \left[\frac{1 - \frac{1}{F_1}\left(\frac{T_{wi} - T_{amb}}{I}\right)}{1 - \frac{1}{F_1}\left(\frac{T_{wf} - T_{amb}}{I}\right)} \right]$$

Now, heat transfer coefficient can be obtained by:

$$h = \frac{Q_U}{A_p\left(T_p - T_f\right)} = \frac{\tau . I_{avg} . A_p}{A_p\left(T_p - T_f\right)}$$

Overall heat loss coefficient has been obtained by summing the top loss coefficient and bottom loss coefficient [130], while the side losses are assumed negligible:

$$U_L = \left[\frac{2.8}{\frac{1}{\varepsilon_P}\left(\frac{1}{N_c^{0.025}+\varepsilon_c} - 1\right)} + 0.825(x_m)^{0.21} + aV_{win}^{b} - 0.5\left(N_C^{0.95} - 1\right)\right]\left(T_{pm} - T_{amb}\right)^{0.2} + \frac{k_i}{t_i}$$

5.2 Thermal Performance of Dish Cooker

During the experimentation on dish-type solar cooker, examining over a minute time interval during the sensible cooling of fluid or water, the total time taken dτ for a drop of d$\underline{T_w}$ (–ve) in water temperature is [131, 132]:

$$d\tau = -\frac{(MC)_w^{'} dT_w}{Q_L} = -\frac{(MC)_w^{'} dT_w}{A_t F^{'} U_L (T_w - T_a)}$$

Now assuming U_L and T_a are constant during the cooling test, the equation for total time taken can be integrated over the 'τ' during which the T_{wo} falls to T_w:

$$\tau = -\frac{(MC)_w^{'}}{A_t F^{'} U_L} In\left[\frac{(T_w - T_a)}{(T_{wo} - T_a)}\right]$$

Now rewriting the equation, we get

$$(T_w - T_a) = (T_{wo} - T_a) e^{-\tau/\tau_o}$$

where the time constant for cooling can be obtained by:

$$\tau_o = (MC)_w^{'} / A_t F^{'} U_L$$

Now, during the sensible heating, the time taken (dτ) for a temperature rise (dT_w) of water is:

$$d\tau = \frac{(MC)_w^{'} dT_w}{\dot{Q}_u} = \frac{(MC)_w^{'} dT_w}{F^{'}[A_p I_b \eta_o - A_t U_L (T_w - T_a)}$$

Now, if the insolation (I_b) and T_{amb} are constant over a fixed interval of time (τ), then the above equation can be integrated over (τ) for a water temperature rise from T_{w1} to T_{w2} and given as

$$\tau = -\tau_o In\left[\frac{F'\eta_o - \frac{F'U_L}{C}\left(\frac{T_{w2}-T_a}{I_b}\right)}{F'\eta_o - \frac{F'U_L}{C}\left(\frac{T_{w1}-T_a}{I_b}\right)}\right]$$

Now, with the help of above equation, the cooker parameter ($F'\eta_o$) can be obtained as:

$$F'\eta_o = \frac{F'U_L}{C}\left[\frac{\left(\frac{T_{w2}-T_a}{I_b}\right) - \left(\frac{T_{w1}-T_a}{I_b}\right)^{e^{-\tau/\tau_o}}}{1-e^{-\tau/\tau_o}}\right]$$

Now, the time required for sensible heating can be obtained by rewriting the equation for the cooker parameter ($F'\eta_o$) as:

$$\tau_{boil} = \tau_o In\left[\frac{1}{1-\frac{F'U_L}{F'\eta_o}-\frac{1}{C}\left(\frac{100-T_a}{I_b}\right)}\right]$$

6 Thermal Analysis of Solar Dryers

There are various design and types of solar dryers such as natural circulation dryers, mixed mode solar dryers, and forced convection-type solar dryers. Energy balance equations are much helpful for the thermal modeling of the system or to estimate the necessary parameters such as heat transfer coefficient, heat loss coefficient, food temperature, moisture evaporation rate, heat utilization factor, coefficient of performance [133, 134]. One can easily estimate all those parameters if the design of system is known, say if the system is a solar cabinet dryer or shelf-type dryer.

The efficiency of a solar energy dryer can be obtained through the ratio of energy consumed for moisture evaporation by the substance (to be dried) to net input supplied energy to the system as [135]:

$$\eta_d = \frac{m_d[M_o - M_\tau].\lambda}{S.A_{sc}.\tau}$$

The system efficiency for a natural convection solar dryer can be obtained by [136]:

$$\eta_s = \frac{WL}{IA_{sc}}$$

The system efficiency for a forced convection solar dryer can be obtained by [136]:

$$\eta_s = \frac{WL}{(IA_{sc} + P_f)}$$

The system efficiency for a hybrid convection solar dryer can be obtained by [136]:

$$\eta_s = \frac{WL}{(IA_{sc} + P_f) + (m_b.LCV)}$$

Specific energy consumption is another major factor and can be obtained by the given relationship between useful thermal energy for evaporation and unit mass of moisture [135]:

$$\text{Specific energy consumption} = \frac{Q_u}{[m_d(M_o - M_\tau)]}$$

Now, for the estimation of annual thermal energy that is required for drying the substance, the following equation can be used

$$Q_{u,ann} = 365\left(\frac{f.N_d}{\tau}\right).Q_u$$

Another important characteristic for solar food drying process is the drying rate. When a food product is continuously heated at constant moisture content, then its vapor pressure is increased. The moisture flow rate is proportional to its vapor pressure transformation with environment due to crop resistance to moisture flow. Following are the two main drying rate regimes [137]:

(a) Constant drying rate—In this, drying of the object takes place from the surface (simply the evaporation of moisture contents from free water surface). This drying rate mainly depends on the environmental or surrounding conditions, and only the nature of the substance (hard or light stuff) affects this.

$$\frac{dw}{dt} = \frac{K_m A_{sc}}{R_o T}(P_v - P_{va}) = K_f \frac{A(T_a - T_s)}{L}$$

(b) Thin-layer drying—It can define as the drying rate that is only dependent on the physical characteristics of seed, i.e., type and size of seed, moisture contents,

and drying temperature. Now, by rewriting the constant drying rate equation, we get

$$\frac{dM}{dt} = -\frac{(P_v - P_{va})}{(1/K_m A_{sc})R_o T} = -\frac{K_m A_{sc}(P_v - P_{va})}{R_o T}$$

Drying rate may also be expressed from the equation of thin-layer drying, such as [138]

$$\frac{dM}{dt} = -k(M_t - M_e)$$

Now, the moisture contents present in the food substance or product to be dried at any time 't' can be expressed as:

$$M_t = \left[\frac{W_i - W_d}{W_d}\right]$$

7 Conclusion

The present chapter focuses on the solar food processing and cooking methodologies in some developing and developed countries. Many types of cooking fuels are available, but still biomass covers a major portion of various households which generates a lot of pollution and cause fire accidents. To overcome problem, solar cooking is a good option that not only saves the fossil fuels but also a promising candidate for safe cooking. Also, solar food processing found to be the most accessible option for the people and hence the most widespread processing technology. Solar energy is used for drying the food or other products by keeping them under open sun conditions or some cabinet or greenhouse-type dryer. Under the sunlight, some notable thermodynamically or chemically process takes place and the moisture of the product is evaporated by means of solar irradiance and natural or forced convection.

In the present work, various models of solar food processors, solar dryers, and solar cookers have investigated theoretically and their testing analysis. A solar cabinet dryer has been found superior among the various models for a fast drying of products, while the box cooker was found a more appropriate solar energy application for clean cooking because of low thermal losses in comparison with dish cooker. Solar air heater has been observed as an important key element for large size of solar dryers where the high mass flow rate is essential for the product for drying. The natural convection-type solar dryer is found suitable in remote rural areas because of economic and easily accessible. Hybrid-type solar dryers or solar

cookers are found more efficient (multipurpose, high efficiency, minimum losses, and working in low ambient conditions) in comparison with conventional systems because of performing on additional energy source along with solar energy.

The performance analysis of both the systems shows the thermal behavior of both the systems under various testing conditions. This analysis is very helpful for the readers to design an efficient solar dryer, food processor, or solar cooker. Besides this, the energy saving analysis will also support the readers to develop a cost optimized solar system.

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