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# SMART CITY: POWER GENERATION FROM THE FOOT STEP

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## ABSTRACT

The usefulness of most high technology devices such as cell phones, computers, and sensors is limited by the storage capacity of batteries. In the future, these limitations will become more pronounced as the demand for wireless power outpaces battery development which is already nearly optimized. Thus, new power generation techniques are required for the next generation of wearable computers, wireless sensors, and autonomous systems to be feasible. Piezoelectric materials are excellent power generation devices because of their ability to couple mechanical and electrical properties. For example, when an electric field is applied to piezoelectric a strain is generated and the material is deformed. Consequently, when a piezoelectric is strained it produces an electric field; therefore, piezoelectric materials can convert ambient vibration into electrical power. Piezoelectric materials have long been used as sensors and actuators; however their use as electrical generators is less established. A piezoelectric power generator has great potential for some remote applications such as in vivo sensors, embedded MEMS devices, and distributed networking. Developing piezoelectric generators is challenging because of their poor source characteristics (high voltage, low current, high impedance) and relatively low power output. This paper presents a theoretical analysis to increase the piezoelectric power generation that is verified with experimental results.

***Keywords-*** *Piezoelectric materials, piezoelectricity, power generation, PZT ceramics.*

## I. CHAPTER 1

### *1.1INTRODUCTION*

As human population is increasing tremendously so by using human powered transportation many of the use full things can be made to happen. This project mainly includes such mechanism which uses human transportation for the purpose of power generation. Walking is the most common activity in day to day life. When a person walks he loses energy to the road surface in the form of impact, vibration, sound etc, due to the transfer of his weight on to the road surface, through foot falls on the ground during each and every step. So this energy can be converted in the electric power.

An average person, weighing from 55 to 60 kg, will generate only 0.1 watt in the single second required to take two steps across the tile. But in the case of when we covering a large area of floor space and thousands of people are stepping or jumping on them, then we can generate significant and large amounts of power. The same system can be implemented where we find large number of people locomotion or heavily populated stations.
In this system we use piezoelectric effect. In which certain material are used to build up electric charge from pressure applied on it. The term piezoelectricity means ability of material to generate electric pulse from the applied pressure.

The same system can be implemented for making any city to become a smart city where a single step of a person in crowded area is been used for some significant purpose of producing electricity. For the prototype purpose here we are using bulb as a load. But in real application we can generate large amount of energy to run number of appliances.

### *1.2 Problem Defination*

In our day to day life we locomote from one place to many other places. A scientific study says that lot more amount of energy is transmitted to the ground when we place a single foot step. This energy can be used for many more applications.

As this is non-conventional energy system and which is very essential at this time to our country. It is very important for very populated countries like India, china.

Consumption of non renewable energy has become the major problem in every developing and developed countries.

***1.3 Relevance of work***

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[5] Andrew Townley, Electrical Engineering, University of Pennsylvania.
[6] Jedol Dayou, School of Science and Technology, University Malaysia Sabah, 88999 Kota Kinabalu, Sabah, Malaysia. [7] Man-Sang, Faculty of Science, Art and Heritage, University Tun Hussein Onn Malaysia,
86400 Parit Raja, Batu Pahat, Johor, Malaysia.
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## II. CHAPTER 2

***2.1 LITERATURE SURVEY***

The idea to produce electricity is not entirely unique. There have been attempts by several individuals and groups to generate energy from different ways.

1) The most impressive earlier method was electricity generation from dynamo and the same paper has been published in the year of March 2013 1 ISSN 2250-3153 by English persons Tom Jose V, Binoy Boban, Sijo M here they used dynamo for the electricity generation.

2) Another attempt is made in the same year of April 2013 by Bruce Champagnie
Geatjens Altenor Antonia Sims here they used the wind turbines for the generation of electricity. They published the same paper as wind turbines electricity generation. Here they used the turbines and placed it on highways for generation of electricity from the wind flown by vehicles.

3) There is another attempt has been made in the year of 2014 by
Piyush Bhagdikar, Shubham Gupta, Navneet Rana, R. Jegadeeshwaran
School of Mechanical and Building Sciences, VIT University Chennai Campus students and they published the paper in the same year. They used the roller mechanism for the electricity generation.

## III. CHAPTER 3-METHODOLOGY

***3.1 INTRODUCTION***

At present, electricity has become a lifeline for human population. Its demand is increasing day by day. Modern technology needs a huge amount of electrical power for its various operations. Electricity production is the single largest source of pollution in the whole world. At one hand, rising concern about the gap between demand and supply of electricity for masses has highlighted the exploration of alternate sources of energy and its sustainable use. On the other hand, human population all over the world and hence energy demand is increasing day by day linearly. Accordingly, it is an objective of the present invention to provide a method of electrical power generation from this ever increasing human population that does not negatively impact the environment. This technology is based on a principle called the piezoelectric effect, in which certain materials have the ability to build up an electrical charge

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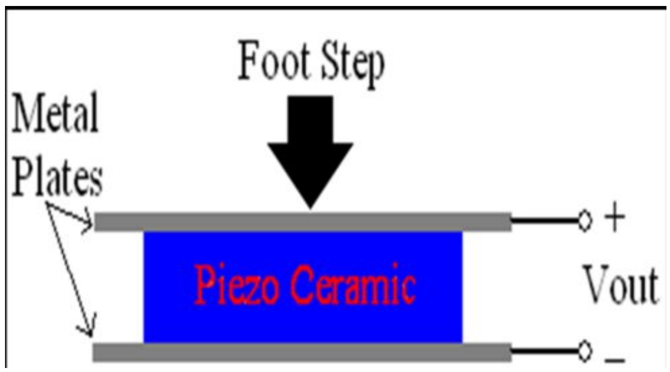
from having pressure and strain applied to them. Piezoelectricity refers to the ability of some materials to generate an electric potential in response to applied pressure. Harvesting of energy which means energy is already available, but is going to waste if not utilized.

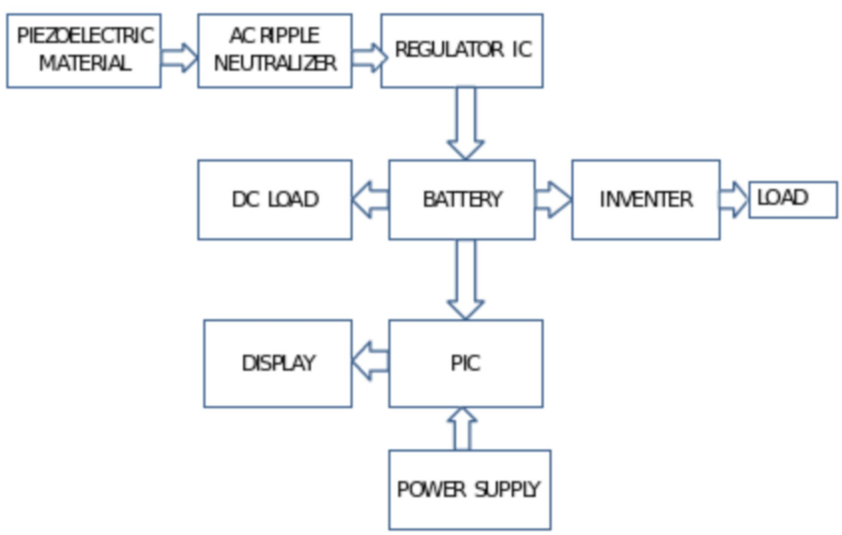
### *3.2 PROPOSED METHODOLOGY*




***piezoelectric principle***

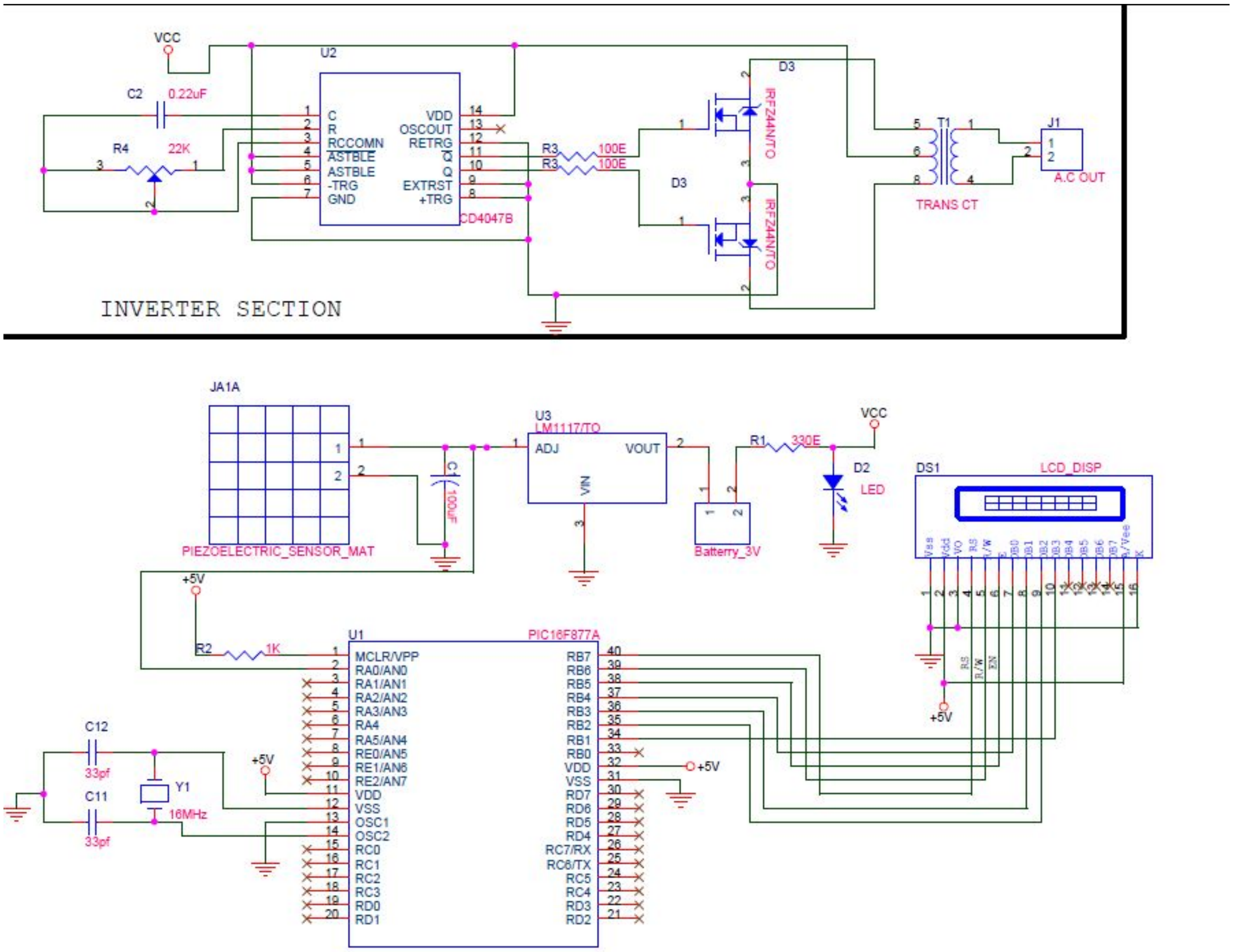
When an asymmetrical crystal is elastically deformed along its specific axes, an electrical charged is developed on its sides. The value of the charge developed is proportional to the applied pressure on the crystal and the same can be displayed on the screen.

### *3.3 BLOCK DIAGRAM*




***block diagram***

### 3.4 CIRCUIT DIAGRAM




*circuit diagram*

### 3.5 WORKING

The piezoelectric material converts the pressure applied to it into electrical energy. The source of pressure can be either from the weight of the moving vehicles or from the weight of the people walking over it. The output of the piezoelectric material is not a steady one. So a bridge circuit is used to convert this variable voltage into a linear one. Again an AC ripple filter is used to filter out any further fluctuations in the output. The output dc voltage is then stored in a rechargeable battery. As the power output from a single piezo-film was extremely low, combination of few Piezo films was investigated. Two possible connections were tested - parallel and series connections. The parallel connection did not show significant increase in the voltage output. With series connection, additional piezo - film results in increased of voltage output but not in linear proportion. So here a combination of both parallel and series connection is employed for producing 40V voltage output with high current density. From battery provisions are provided to connect dc load. An inverter is connected to battery to provide provision to connect AC load. The voltage produced across the tile can be seen in a LCD. For this purpose microcontroller PIC16F873A is used. The microcontroller uses a crystal oscillator for its operation. The output of the microcontroller is then given to the LCD which then displays the voltage

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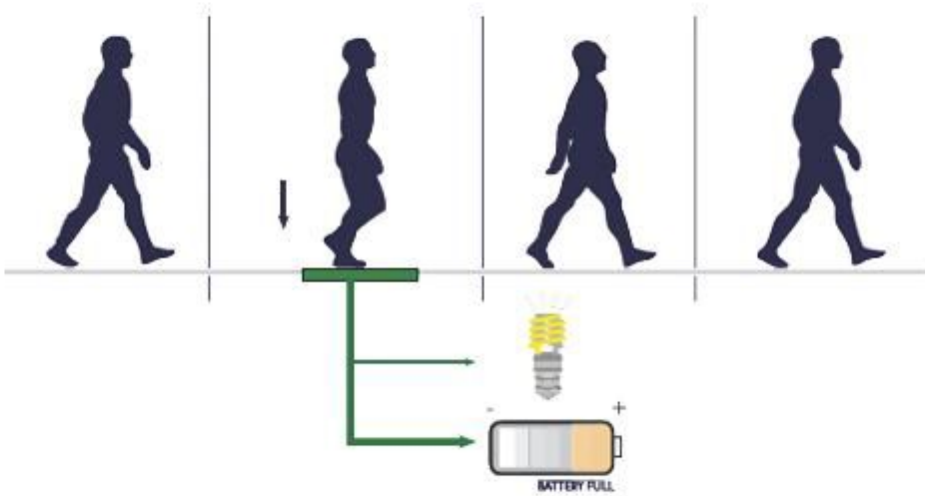


***Schematic representation of the working model***

The inverter used in this circuit uses the IC CD4047. It is used to convert the DC voltage stored in the battery to AC voltage. IC CD4047 produces two pulse trains phase shifted by 180°. These pulse trains are used to switch transistors configured in common emitter mode producing pulse trains of 12V, which is capable of switching a MOSFET. The sources of the two MOSFETs used in the inverter circuit are supplied with a 12V supply. When the MOSFETs are switched on by the outputs of the transistors, two output pulses of 12V are obtained. These pulses are connected to a step up transformer from whose high voltage side; we obtain the 220V AC supply.

## IV. CHAPTER 4 SYSTEM DESCRIPTION

### *4.1 HARDWARE REQUIRED*

1) Piezoelectric transducer
2) Ac neutralizer
3) Regulator IC
4) Rechargeable battery
5) PIC16F877A
6) LCD display
7) Inverter circuit
8) Load

Piezoelectric transducer

In this system we use piezoelectric effect. In which certain material are used to build up electric charge from pressure applied on it. The term piezoelectricity means ability of material to generate electric pulse from the applied pressure.

Piezoelectric ceramics are the group of ferroelectric materials like PbTiO3, PbZrO3, PVDF and PZT. The main component of the project is the piezoelectric material. The proper choice of the piezo material is of prime importance. For this, an analysis on the 2 most commonly available piezoelectric material - PZT and PVDF, to determine the most suitable material was done. The criterion for selection was better output voltage for various pressures applied. We find that ideal voltage from PZT is around 2 V where as that of PVDF is around 0.4V.We can thus conclude that better output is obtained from the PZT than the PVDF.

A piezoelectric sensor is a device that uses the piezoelectric effect to measure pressure, acceleration, strain or force by converting them to an electrical signal.

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***Piezoelectric Crystal***

4.1.2 Battery

An electrical battery is a combination of one or more electrochemical cells, used to convert stored chemical energy into electrical energy. Here we are using the battery for storage purpose. We are using lead acid battery in the project just because of its initial cost and the easily availability everywhere in the world.

There are many different sizes and designs of lead-acid batteries. Lead-acid batteries are available in both wet-cell (requires maintenance) and sealed no-maintenance versions. Exceptional long life is another advantage of lead acid battery.

Specifications
1) 12V 1.3Ah sealed lead acid battery.
2) CE and Ro Hs high quality and reliability.
3) Maintenance free
4) Long life cycle

battery

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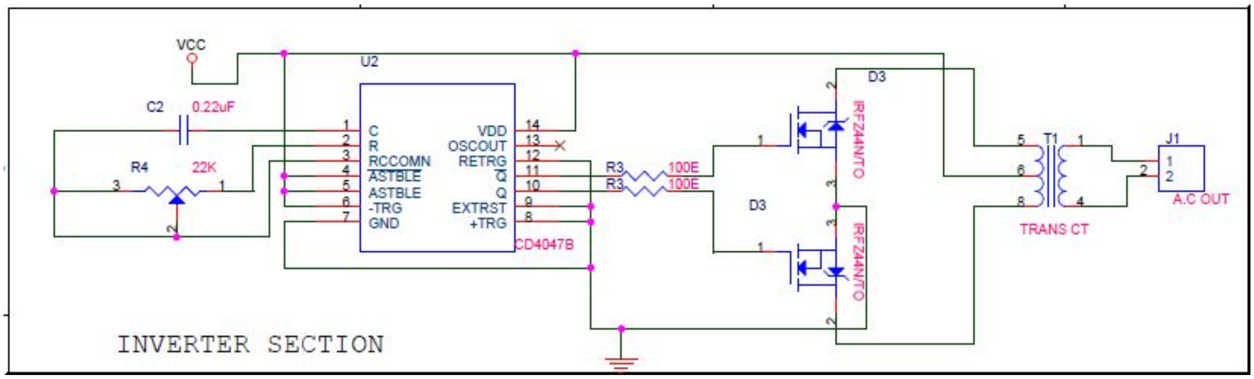
4.1.3 Inverter

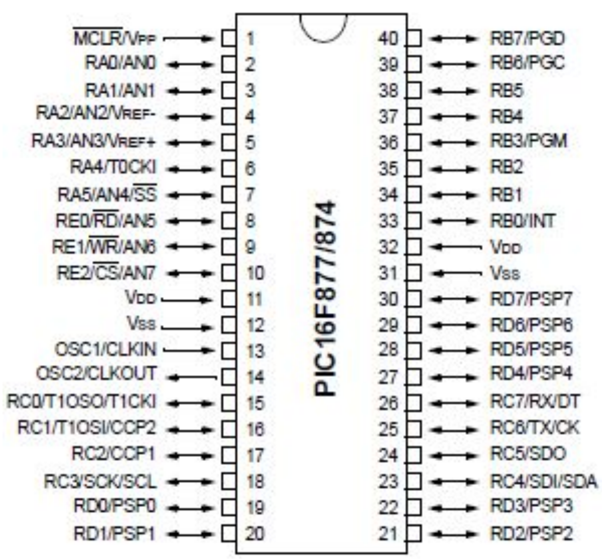
An inverter is an electrical device that converts direct current (dc) to alternating current (ac); the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits. There are main two types of inverters. Output of modified sine wave inverter is same as square wave inverter except as some volt it goes to zero.




***inverter circuit***

4.1.4

4.1.4 MICROCONTROLLER AND LIQUID CRYSTAL DISPLAY INTERFACE




***Pin diagram***

Liquid crystal display is thin, flat panel used for electronically displaying information such as text, image and moving pictures.

Its use include monitors for computer, televisions, instruments panels, and other devices ranging from industrial displays to day to day consumer devises

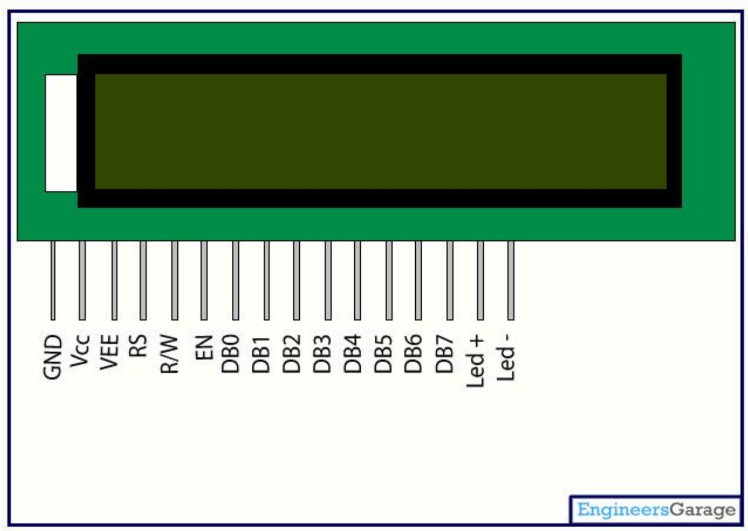
.

4.1.5 LIQUID CRYSTAL DISPLAY

Here we are using LCD to display the amount of power generated by the foot step. This LCD is interfaced with the PIC microcontroller.

Features of PIC microcontroller 16F877A:

- Operating frequency - DC 20MHz
- Flash Memory - 8K
- Data Memory - 368 bytes
- Timer - 3
- Interrupts - 14
- Instruction set - 35
- 10 bit Analog to Digital module - 8 input channels
- Input output ports - Ports A,B,C,D,E




***LCD PIN CONFIGURATION***

Here we are using PIC microcontroller 16F877A to display the amount of battery get charged whenever we place our foot on piezoelectric transducer.

These components are "specialized" for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits. They are used for writing

different messages on a miniature LCD A model described here is for its low price and great possibilities most frequently used in practice. It is based on the HD44780 microcontroller (*Hitach)* and can display messages in two lines with 16 characters each . It displays all the alphabets, Greek letters punctuation marks, mathematical symbols etc. In addition, it is possible to display symbols that user makes up on its own. Automatic shifting message

There are pins along one side of the small printed board used for connection to the microcontroller. There are total of 14 pins marked with numbers .

The Analog-to-Digital (A/D) Converter module has five inputs for the 28-pin devices and eight for the other devices. The analog input charges a sample and hold capacitor. The output of the sample and hold capacitor is the input into the converter. The converter then generates a digital

result of this analog level via successive approximation. The A/D conversion of the analog input signal results in a corresponding 10-bit digital number. The A/D module has high and low voltage reference input that is software selectable to some combination of VDD, VSS, RA2, or RA3. The A/D converter has a unique feature of being able

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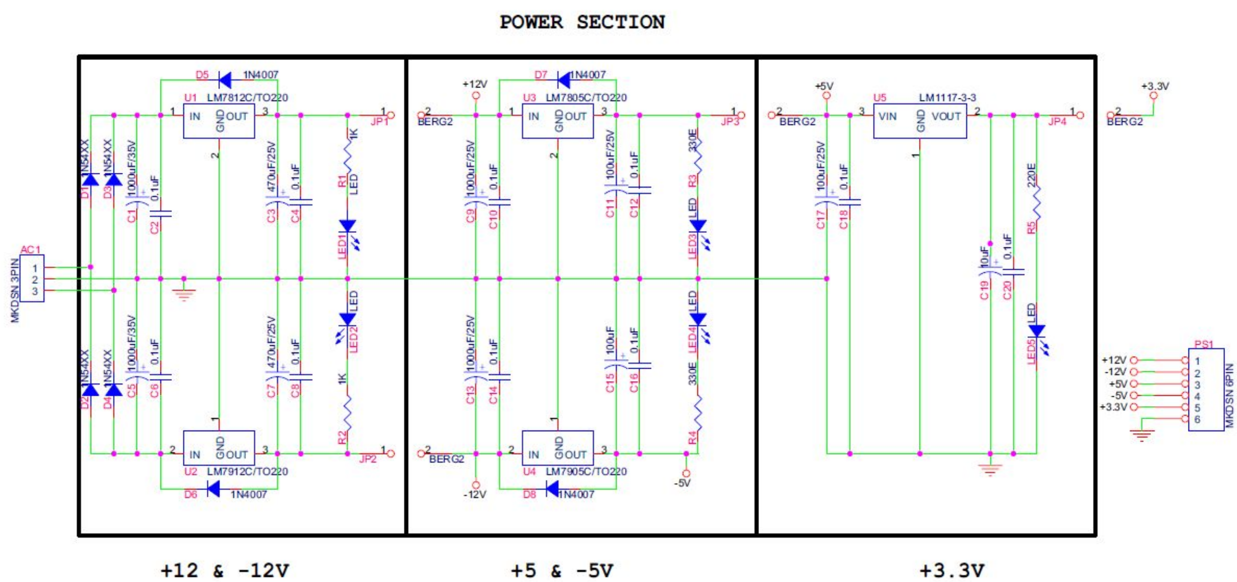
to operate while the device is in SLEEP mode. To operate in SLEEP, the A/D clock must be derived from the A/D's internal RC oscillator.

## V. CHAPTER-5 -WORK IMPLIMENTED

### *5.1 POWER SUPPLY DESIGN*




***power supply***

Theory:-

- A Power Supply is an electronic device that supplies electric energy to an electrical load.
- The primary function of a power supply is to convert one form of electrical energy to another and known as a electric power converters.
- Every student project requires a regulated DC power supply to be used. The power supply requirement is generally 12V, 5V and 3.3V DC output with about 3 Amp (Max) current capacity.
- Power supply required for different controller

a) 8051 = 5 V b) PIC Controller = 5 V c)AVR = 5 V d) ARM = 3.3 V

Parts of a power supply:
Universal Power Supply Design Specification.

**INPUT :-**

Nominal RMS AC voltage = 230 V.

Frequency= 50 Hz.

Frequency variation tolerance = +1 Hz

Single phase, 3 Wire = Live, Neutral and ground

Angular rate = 314.1593 Radians / sec.

Voltage variation = +10%

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Minimum RMS AC voltage = 207V.

Nominal RMS AC voltage = 230V.

Maximum RMS AC voltage =258V.

**OUTPUT:-**

1) Nominal D.C Voltage = +12 Volt
a) Output Current –1 Amp (With Full Load)
b) Output Current –1Amp(With Full Load)
3) Nominal D.C Voltage =3.3 Volt
a) Output Current –100 m Amp.

4) Nominal D.C Voltage =-5 Volt
a) Output Current –1Amp(With Full Load)

5) Nominal D.C Voltage =12 Volt
a) Output Current –1Amp (With Full Load)
Selections of Transformer
Transformer design:-
Np= No of Turns at Primary Winding. Ns No of Turns at Secondary Winding.
Vp = Primary Winding Input Voltage. Vs = Secondary Winding Output Voltage.
Ip = Primary Current. Is = Secondary Current.
L1= Inductance of Primary WindingL2 = Inductance of Secondary Winding.
Rp = Primary Resistance .Rs = Secondary Resistance.
M = Mutual Inductance. K = Coupling Factor. (0.996)
**(Np/Ns) = (Vp/Vs) = (Is/Ip).**
**(Np/Ns) = K.Sqrt(L1/L2).**
a) The current rating of the transformer depends upon the current required for the load to be driven.

b) This system requires +/-12 V, +/-5 V & +3.3 V D.C Output .

Input Voltage (Peak) = Dropout Voltage + D.C Output Voltage i.e 12,5,3.3 V.

Dropout voltage across each Regulator IC,
7812/7912 = 2V.
7805/7905 = 2V
LM1117-3V3 = 1.2 V
But Transformer Secondary output voltage is RMS value.
Vpeak (secon)= (1.414) * Vrms.
Vpeak ( secon)= (1.414) * 15Volt.
Vpeak (secon)= 21.45 Volt.
In Bridge Rectifier total Voltage drop across two diode considered i.e.1.4 Volt.

**For regulator ICs required peak input voltages according to above formulae,**
For 12V Output, Input = 15.4 Vpeak.
For 5V Output, Input = 8.4Vpeak.
For 3.3V Output, Input = 6.7Vpeak.
Hence we choose 15-0-15Volt transformer which is Sufficient to Give input peak voltage as per mention above.
So choose 15-0 -15transformer with current rating 3Amp
Since 15*√2 = 21.45Vpeak .
We can select transformer which sufficient to give secondary output signal upto Max 35Vpeak , and Min . 16 Vpeak .
Transformer Rating given are all in RMS need to convert into Peak by using

Vpeak = Vrms * 1.414 this Formulae.

**Rectifier Circuits**

Depending upon Output current rating we choose Rectifier diodes.

Current rating for Bridge Rectifier should be suitable with load current, also, the designer should consider the Voltage Drop across each diode, which is normally equal to 0.7 V.

Only two diodes are required when using Centre Tapped Transformer.

As we have to carry 3 amps current we are using 1N5408diodes in bridge configuration.

**Selections of Filter Capacitors**

1. Filter Capacitors: -

C = Filter Capacitors.
IL = Load Current.
Vr = Ripple Voltage.
Fr = Ripple Frequency
(For Bridge Rectifier= (2 * Line Frequency) i.e. 100 Hz).
Vsec = Secondary Output Voltage of Transformer.
Vr = Vsec * 1.414 –( Output D.C Voltage + Dropout Voltage of IC + Bridge Rectifier Drop Voltage)
**C = IL / ( Fr * Vr)**

Filter Capacitor also calculate by use of above formulae ,
But according To A.C Current, A.C Voltage Theory.
This is standard that Smoothing or Filter Capacitor value always selected based on,
**1 Ampere= 1000uFarad**
For in our power supply design we required full load current rating are
For 12 V, 1 A, we choose 1000uF Capacitor
For 5 V, 1A , we choose 1000uF Capacitor
For 3.3 V, 100 mAmp, we choose 100uF Capacitor
As Filter capacitors i.e 1000uF, 1000uf, 100uF at input sides.
On output side Load capacitors are used , and its value always half of Input Filter/Smoothing Capacitors.
Hence,
For 12 V = 500 uF, but availability of 470 uF in market so we choose 470 uF.
For 5 V = we can choose 500 uF ( 470uF)but output of 5 V is used as input of LM1117 which have drive maximum load upto 100 m Amp. So instead of 500uF (470 uF)we choose 100uF Capacitors.
For 3.3 V, =100 uF used for100 m Ampere, for load purpose we used load capacitor which are suitable to drive only 10 m Amp current from IC. i.e 10uF.

**Hence finally we get ,**
For +/-12 Volt Output

C1,C5 = 1000uF.

C3,C7 =470uF.

For +/-5 Volt

C9,C13 = 1000uF.

C11,C15 = 100uF.

For 3.3 Volt

C17 = 100uF.

C19 = 10uF.

Minimum Voltage rating of every capacitor depend on 5* output voltage of regulator IC acrosswhich we used Capacitorfor filtering/Smoothing or Load Purpose.
According that we choose 25V, 35V,50 V rating capacitors.

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Capacitor 0.1uF(Ceramic Capacitor) used to avoid Transient change in voltage due to changein Load.

1N4007Diode used as Safeguard of IC also called Protection Diode.

**Selections of Regulators ICs**

+12 V D.C Output –IC LM7812.
Input Voltage :-Min =14.5V Max = 30V,

Output Currents = 1.5Amp.

Dropout Voltages = 2Volt.

-12 V D.C Output –IC LM7912.
Input Voltage :-Min =14.5V Max = 30V.

OutputCurrents = 1.5Amp.

Dropout Voltages = 2Volt.Typically =1.1 V.

o +5V D.C Output –IC LM7805.
InputVoltage :-Min =7V Max = 25V.

Output Currents = 1.5Amp.

Dropout Voltages = 2Volt.

-5V D.C Output –IC LM7905
Input Voltage :-Min =V Max = 25V.

Output Currents = 1.5Amp.

Dropout Voltages = 2Volt.Typically = 1.1 V.

3V3 D.C Output –IC LM1117-3.3
Input Voltage :-Min =4.5V Max = 20V

Output Currents = 1.5Amp.

Dropout Voltages = 1.2Volt.

**Output Side**

For 12V :-
Load Resistance = 1K .
ILoad = 12 mAmp.

For 5V:-
Load Resistance = 330E .
ILoad = 13 mAmp.

For 3.3V:-
Load Resistance = 220E .
ILoad = 11 mAmp.

## VI. CHAPTER NO. 6

### *6.1 ADVANTAGES*

- Easy construction.
- Less number of equipments required for power generation.
- Reliable, economical, eco-friendly.
- No moving parts, long service life

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- Extremely wide dynamic range almost free from noise
- Compact yet highly sensitive
- Self generating_no external power supply needed.

### *6.2 APPLICATIONS*

- In street light.
- Emergency power failure stations.
- Can be used as power supply for traffic light
- In malls and railway platform.
- Any station where emergency electricity is required.

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