A Project report on

DESIGN AND PERFORMANCE ANALYSIS OF MPPT,BUCK BOOST CONVERTER/MODELLING OF SPV SYSTEMS

For the partial fulfilment of the requirements for the degree of B. Tech in Electrical Engineering

By

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Maulana Abul Kalam Azad University of Technology(MAKAUT)

CERTIFICATE

To HOD

This is to certify that the project work entitled "**Design and performance analysisof MPPT BUCK BOOST Converter/Moddeling of SPV systems**"is the bona fidework carried out by Srishti Chakraborty(11701617029),Swetneel Gupta(11701617022) ,Arpan Bhowmick (11701617069) Sibil Mandi(11701618003), thestudents of B.Tech in the Dept. of Electrical Engineering, RCC Institute ofInformation Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015,affiliated to Maulana Abul Kalam Azad University of Technology(MAKAUT), West Bengal, India, during the academic year 2020-21, in partialfulfillment of the requirements for the degree of Bachelor of Technology inElectrical Engineering and that this project has not submitted previously for theawardof anyother degree,diplomaand fellowship.

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RCC Institute of Information Technology
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Examiner:Name:

Designation:

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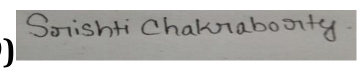
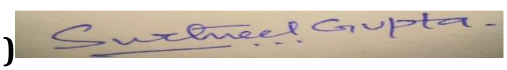
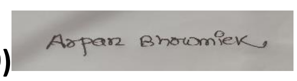
It is our great fortune that we have got opportunity to carry out this project workunder the supervision of . Prof. Dr. Ashoke Mondalin the Department ofElectrical Engineering, RCC Institute of Information Technology (RCCIIT) , CanalSouth Road , Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam AzadUniversity of Technology (MAKAUT), West Bengal, India. We express our sincerethanks and deepest sense of gratitude to our guide for his constant support,unparalleledguidanceandlimitlessencouragement.

Wewould alsoliketoconveyour gratitudeto allthefacultymembersandstaffsof the Department of Electrical Engineering, RCCIIT for their whole heartedcooperationto makethis workturn into reality

Signatureofthestudent

SrishtiChakraborty(11701617029) 

SwetneelGupta(11701617022) 

ArpanBhowmick(11701617069) 

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ABSTRACT

It is essential to convert the energy obtained withphotovoltaic panel from low efficiency withmaximum possible efficiency. So the concept of maximum power point Tracking (MPPT) basedisintroduced as it ensures energy conversion withhighest efficiency in the Buck-Boost converter . Inthis study, Buck -Boost converter fed by solar panels and controlled by MPPT techniques are examined and their performance analysis by hardware designing to observed. In this experiment when the output voltage can not require the fulfillment the charging requirement of battery then the boost converter will work and it will increase the level of voltage so that it can charge the battery. When we do not want that much high voltage level then the buck converter will operate and reduce the level of voltage. In this process MPPT will ensure that maximum power should always transfer to the load.

Table of contents:

INTRODUCTION

The past few years have been filled with news of fuel price hikes, oil spills, andconcerns of global warming. People are finding the benefits of having their ownrenewable energy system more attractive than they ever have before. The biggestform of renewable energy to benefit from this is solar PV systems. However, theoutput power of a PV panel is largely determined by the solar irradiation and thetemperature of the panel. At a certain weather condition, the output power of aPV panel depends on the terminal voltage of the system. To maximize the poweroutput of the PV system, a high-efficiency, low-cost DC/DC converter with anappropriatemaximumpowerpointtracking(MPPT)algorithmiscommonlyemployed to control the terminal voltage of the PV system at optimal values invarioussolarradiationconditions.BasicboostconvertersworkwellwiththeMPPTcontrol as long as the load can accept a voltage from the minimum output of thePV panel all the way up a certain value (e.g., 5 times) subject to practical limits ofthe duty cycle (e.g., 80%). The system needs to be robust enough that when theconsumer wants to expand their energy production by adding more panels, theydon't need to replace their entire system. The DC/DC converter and MPPT controlalgorithmproposedinthisworkwillimplementalloftheseimprovementsinhopescreating a highly efficient, low-cost, and highly reliable solar PV system for cleanandrenewablepowergeneration.Sincethepowergeneratedfromthephotovoltaic module depends on the temperature and the solar radiation, thesefactors must be taken into account while designing the maximum power pointtracker. The main goal of the MPPT is to move the module operating voltage closetothevoltageatwhichthePVproducesthemaximumpowerunderallatmosphericconditions. MPPT is very important in PV systems. Different techniques have beendeveloped to maximize the output power of the photovoltaic module. They haveadvantages and limitations over the others. These techniques vary in complexity,inthenumberof sensorsrequired,intheir convergencespeedand inthecost.

THEORY

MAXIMUM POWER POINT TRACKING

A MPPT system works just as it sounds it would. The system tracks the MPP undervarying conditions and then implements some sort of algorithm to adjust theconverter so it will hold the panels power output at the highest point for thatgiven time. In general, the tracking system completes this task using current andvoltage measurements to find the power output of the PV panel at the currenttime. The specific algorithm then takes this information and calculates theadjustments that need to be made to the circuit in order to allow the panel toproduce more power from outside the system, by using external data streamswhicharereadfromtheoutsideworld.

The adjustments made to the converter are usually in the form of a change in theduty cycle controlling the converter. The effect is that a change in duty cyclechanges the output voltage. In a converter not connected to a PV panel thisincrease in output voltage would be caused by the converter allowing more inputcurrent to pass through it. The characteristics of a PV panel coupled with thiseffectarewhatallowMPPTto occur.

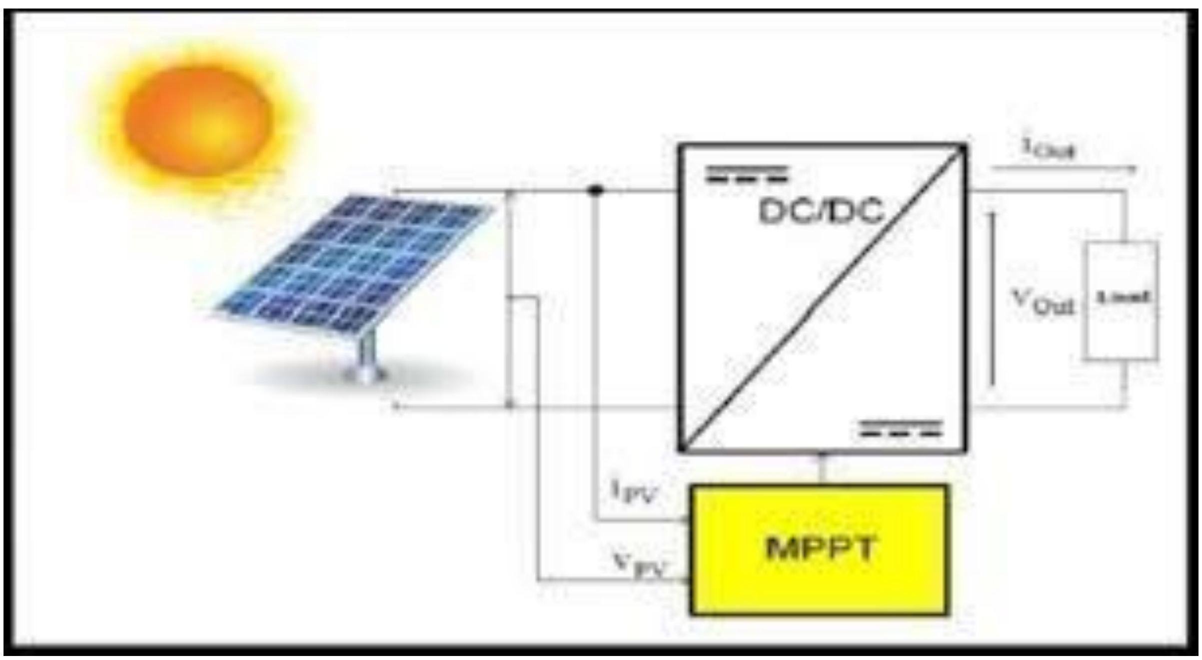


Figure1:-ImplementationofMPPT

When the current of a PV panel increases the voltage will eventually begin todecrease, and when the voltage increases the current will eventually decrease.When the duty cycle of the converter is increased the current allowed to passfrom the PV panel to the converter is increased. This causes the PV panel to movefrom the point it is currently operating at on the I-V curve to the next point with ahigher current output, moving left. This in turn decreases the voltage output bythe PV panel. Once the operating point of the panel is able to be changed analgorithm can be implemented to control this change, thus forming a MPPTsystem. Each algorithm may act differently but this is the basis for most all MPPTsystems

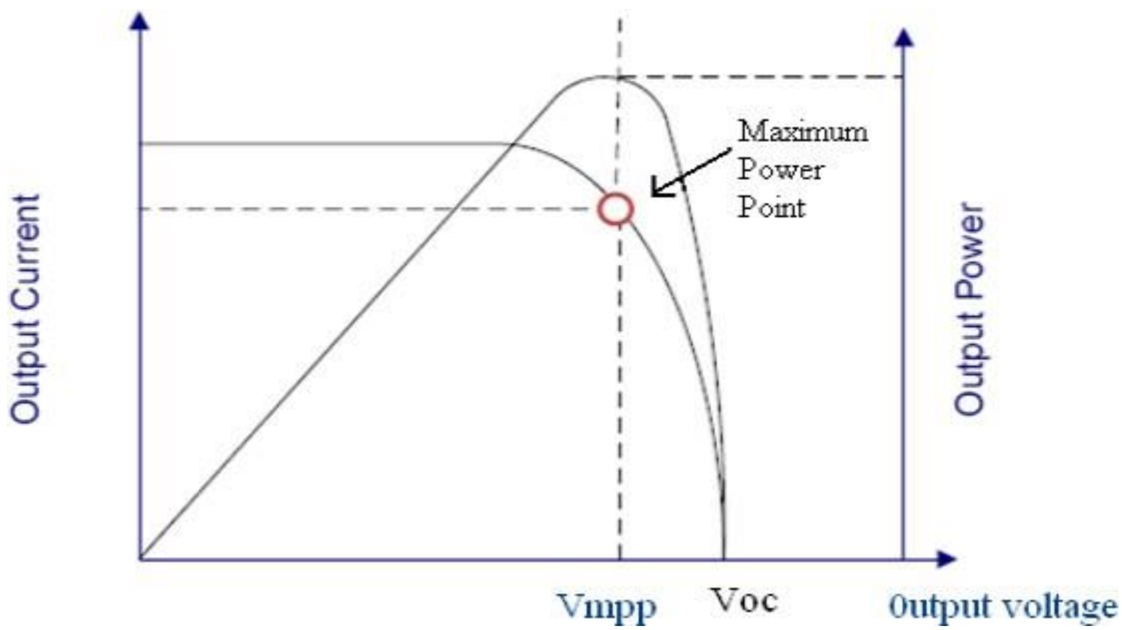


Fig2:-I-VandP-VcharacteristicsofMPPT

Different types of MPPT Logic

Renewable energy is an important and valuable tendency in the global market, asit answers the need for producing energy without harming the environment. Dueto a combination of factors, the demand for energy generated from photovoltaicsolarcellshasbeenincreased.Oneofthesefactors:loweroperationalandmaintenancecosts,noaudiblenoise,nofuelcost,andThegeneratedenergyisfreeof pollution. The photovoltaic solar cells for home applications are also a goodenergy solution in remote and developing countries and especially countries thatown a good amount of solar radiation. PV is indeed not just a good possibility forthe future, but already a profitable and promising solution for present energyneeds.However,thecurrentchallengeistofocusnotonlyontheenergyharvestedbutalsoontheefficiencyof theoverallprocess,whichincludesthecontrolofMPPT

Thedifferentways toimplementMPPTare: -

1. **PerturbandObserve(P&O).**
2. **IncrementalConductance.**
3. **FuzzyLogic.**
4. **ParasiticCapacitance**

Perturb and Observe(P&O)Method

The P&O algorithm based on increasing or decreasing the array terminal voltage,orcurrent,atregular period andthencomparingtheoutputpower ofthePVwiththose of the previous sample point . Based on the simple mathematical condition(dP/dV = 0). when the PV array operates to the left area of the MPP curve, theoutput power will be increased due to the increase in voltage and output powerdecreases on increasing voltage when the same operates to the right area of theMPP Curve. Hence if dP/dV> 0, the system keeps the disturbance, and if dP/dV<0, the disturbance should be reversed. The process repeats until the operatingpoint is across to the maximum power point. where P and V are power andvoltage at output of PV module respectively. The main advantage of the P&Oalgorithm is its simplicity. In general, this method shows a good operationprovided the solar radiation does not deviate too quickly. The classic perturb andobserve (P&O) method has the disadvantage of poor efficiency at steady stateand low irradiation, the operating point oscillates around the MPP voltage(usuallyfluctuates lightly) butnever reaches

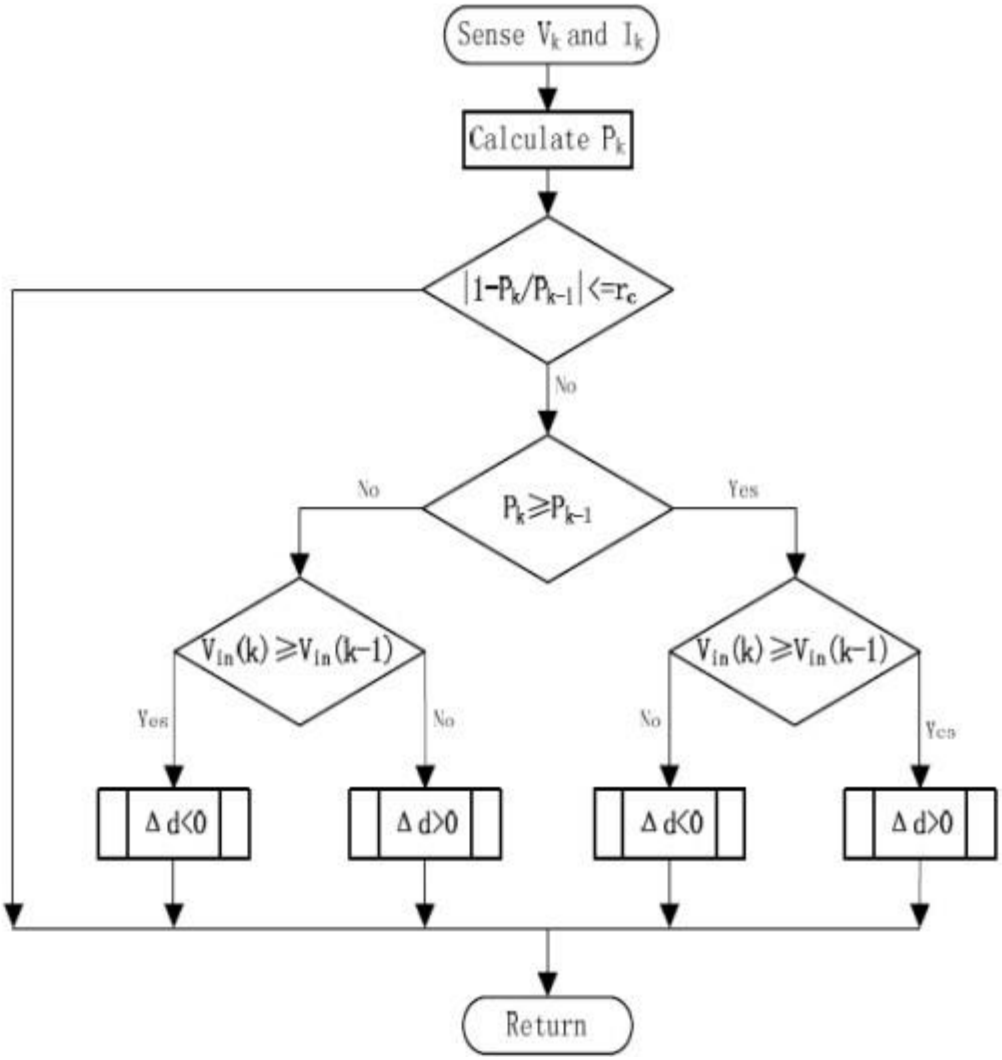


Figure3:PerturbandObserveAlgorithm

Incremental Conductance Method

The method of Incremental Conductance works when the dP/dV = 0, because thederivative of the power of the PV module is equal to zero at the MPP, the positiveresults off the left area of the MPP curve and negative results on the right of theMPPcurve

dP/dV=0	AtMPP
dp/dv>0	AtLeftareaofMPP
dp/dv<0	AtRightareaof MPP

Table1:-MathematicalpropertiesofIncrementalconductance

$dp/dV= dIV/dV \cong I+ V(\Delta I/\Delta V)$……………………… (1)For MPP,PuttingdP/dV=0

Itgives

I+($\Delta I/\Delta V$) =0……………………….(2)

So we have

$\Delta I/\Delta V = -1V$ At maximumpoint

$\Delta I/\Delta V > -1V$ Leftofmaximumpoint

$\Delta I/\Delta V < -1V$ Rightof maximumpoint

Accordingtoequation1and2,TheflowchartofICmethodisshowninFigure 4. The maximum power point of PV system can be tracked by comparing theI/V to ΔI/ΔV. $Vref$is the reference voltage of the PV array operation. When theMPPisachievedatthatmoment,$Vref$mustbeequaltoVmp.Whenithappens,thesystem keeps the output voltage at MPP until a change in is occur or the change inatmosphericconditions.TheICalgorithmdecidedtodecreasingorincreasingthe $Vref$toalways reachthenew MPP.

The advantage of this technique is its ability to track more accurately in extremelyvariable weather conditions and less oscillating behavior is shown around the MPPcompared to the Perturbation and Observation technique.

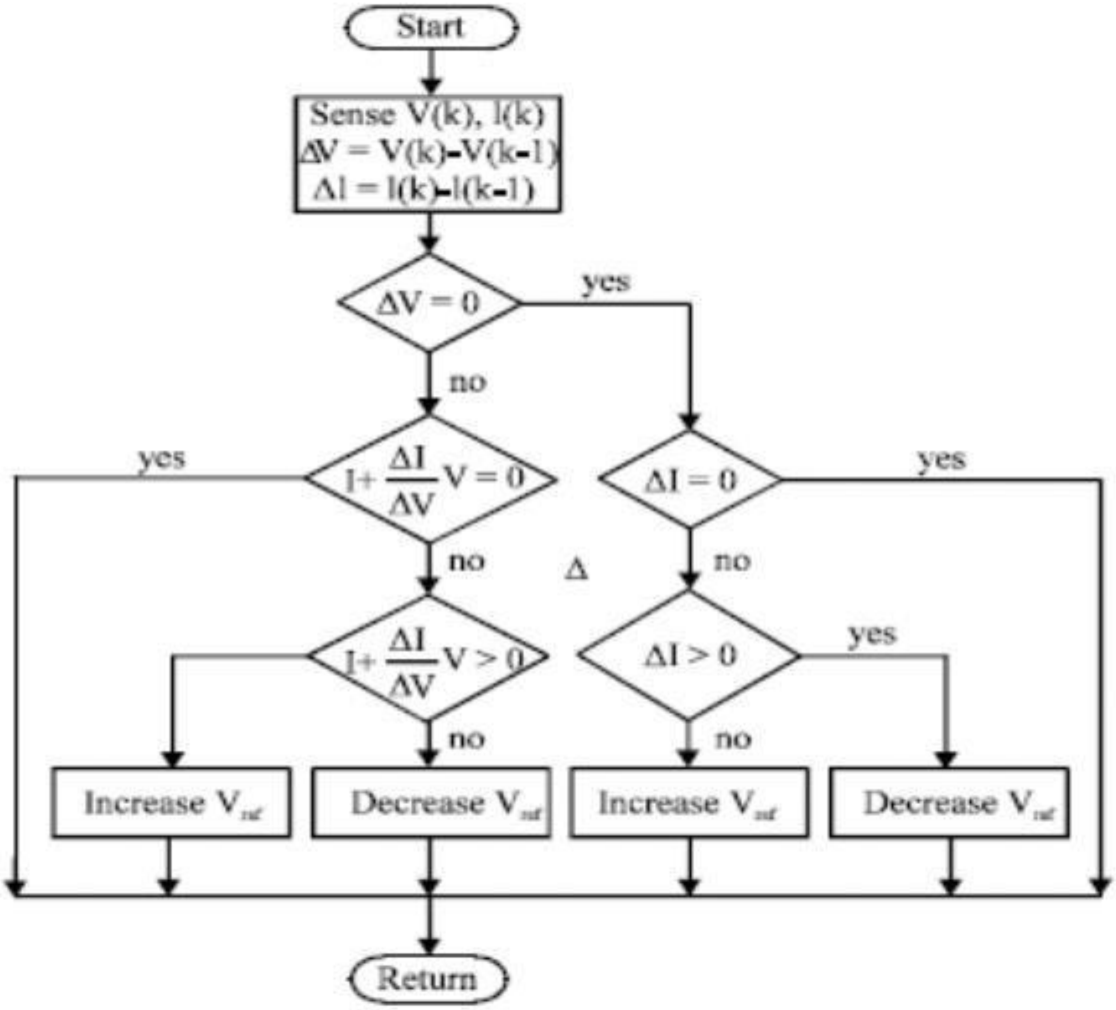


Fig4:-IncrementalConductanceMethod

FUZZY LOGIC METHOD

Fuzzy logic based intelligent MPPTs have been gained more attention because oftheir capability to handle nonlinearity associated with the system. Due to lack ofprecise modeling of PV modules and uncertainty in the performance of PV systemduetovaryingirradianceandtemperature,thefuzzyMPPT(FMPPT)isfoundtobemore suitable for tracking of MPP than conventional algorithms in PV Systems.FMPPTcandealwithuncertaintysuchasunmodeledphysicalquantities,nonlinearity and unpredictable changes in operating point of the PV system. ThisMPPTtechniqueenhancesthechoiceofthevariablestepsizeofthedutycycleandtherefore improves the performances of photovoltaic system. The concept of thisalgorithm is to compute the variable step according to the slope value of Power-Voltage characteristic for photovoltaic module. Then, it provides the appropriatevalueof dutycycle.

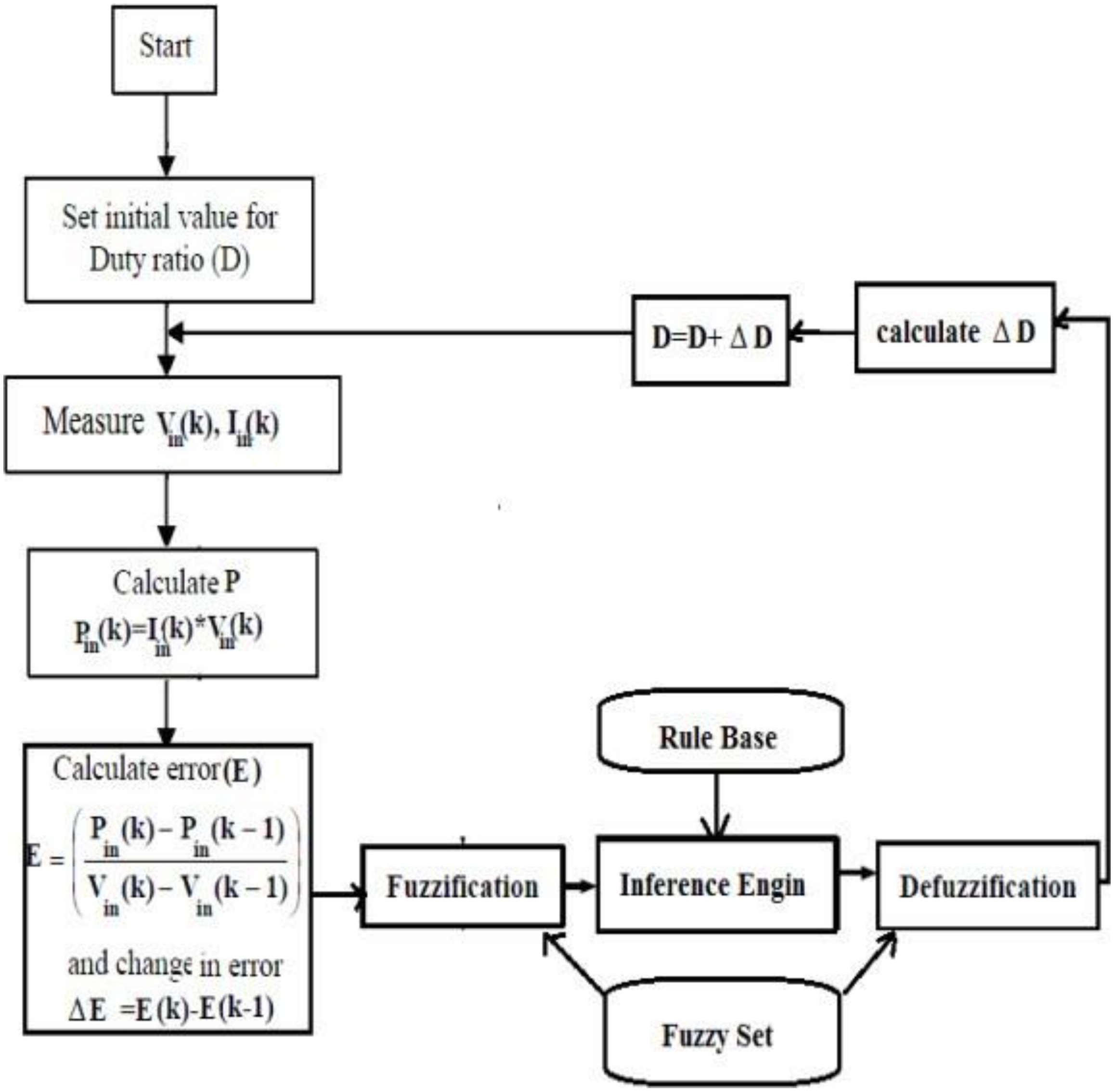


Fig5:-FuzzyLogicmethod

Parasitic Capacitance Method

Parasiticcapacity(PC)methodshowssimilaritieswiththeICmethod.However,changing of parasitic junction capacity (PJC) value is taken into account in thismethod. PJC occurs as result of charge accumulation in p-n junction area andthe inductance associated to the connections of PV cells. Actually, there aretwo main components (parasitic capacitance and inductance) called thereactive parasitic components. It is determined that the parasitic capacitancereduces the error signal when the PV panel is operating outside the MPP,slowing down the system dynamic [41]. But these unavoidable losses are usedasan importantparameterindeterminingtheMPP.Byaddingthe current i(t)=c(dv/dt) demanded by this capacity to (1), the following equation isobtained:

$$I = I_{\text{ph}} - I_0 \left(e^{(q \cdot V)/(k \cdot T_c)} - 1 \right) + C\frac{dv}{dt} = F(v) + C\frac{dv}{dt}.$$

Derivativeofmultiplyingthisequationbythepanelvoltage canbewritten as

$$\frac{dF(v)}{dv} + C\left(\frac{V'}{V} + \frac{V''}{V'} \right) + \frac{F(v)}{v} = 0.$$

Three terms in this expression represent the instantaneous conductance, voltageoscillations due to parasitic capacities, and incremental conductance,respectively.First-and second-orderderivativesof arrayvoltagehavetakenthe A.C. ripple components into account. If the capacity value is assumed as zero inthe equation of IC algorithm is obtained. Parasitic capacity is modeled as acapacitor that is parallel connected to each cell in a PV module. Therefore,parallel connection of modules increases the amount of parasitic capacity forMPPT. As a result of this, the efficiency of PC method is reached to maximumvalueinhigh-powerPVsystems thatincludenumerousparallel-connected

A typical PV Panel

PV panels, also known as solar panels capture the **sun's energy** and **convert itinto electricity**. Electricity generated by PV panels is mostly used for **poweringhouseholdappliances**and equipment.

The most typical PV panel system is the **grid-connected system**, which as its nameindicates, is connected to the national grid. This means that at night, when thesolarpanelsdonotwork,youcan useelectricityfromthegrid.

Moreover, if your solar system produces more electricity than what you need, youcan sell the surplus back to the grid, and effectively **make money by having solarpanels** at home if you make use of solar panel grants, like the Smart ExportGuarantee(SEG).

The second type of PV panel system is the **stand alone system,** which is notconnected to the grid. In this case you can add solar batteries to the system tohave electricity when it gets dark. This system can be really **convenient in remoteareas** where there is no alternative for other sources of electricity. Nowadays,thousands of people power up their homes and business with the help of PVpanels.

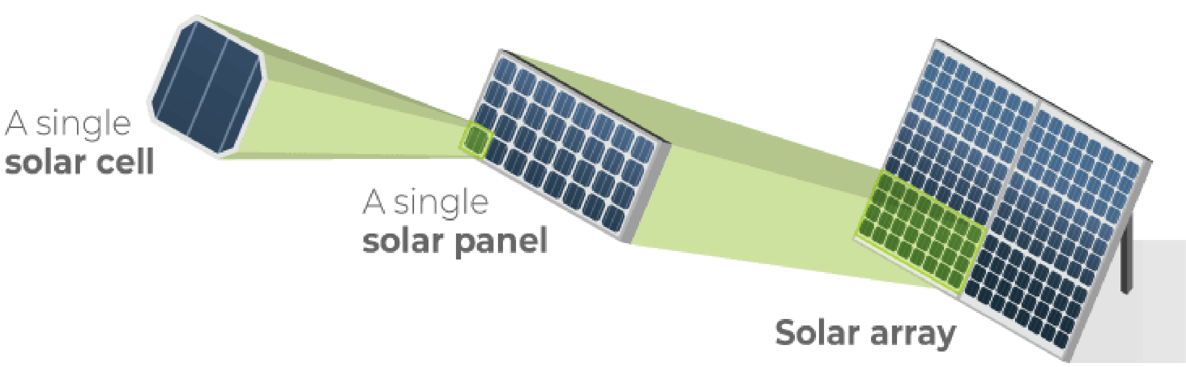


Fig6:-Differenttypesofsolarcellandsolarpanel

Solar cells output power in what is called an I-V curve. A typical I-V and P-V curveofasolar cellcanbeseenin Figure1. Thiscurverepresentswhatthecurrent output by the solar cell would be as the output voltage is varied and vice versa.Thiscurvecan beeasily obtained fromtheI-Vcurvethroughtheequation

P=V xI.

There are three other important aspects of a solar cell also shown in Figure 1. Thefirst two are the open circuit voltage (Voc) and the short circuit current (Isc) of thecell. The open circuit voltage is the voltage that is output to the cell terminalswhen the cell is exposed to light and there is no current flowing between theterminals. This is also the maximum voltage that can be produced by the cell,which makes knowing this number useful when designing a circuit or load toconnect to the cell terminals. The short circuit current is the current that will flowwhen the cell is under light and the terminals are shorted together. This is themaximumcurrentthatcanbeoutputbythespecificsolarcell.Thethirdimportant aspect of a solar cell is the MPP. This is the point where the cell isoperating at maximum efficiency and outputting the highest power available. TheMPP also has voltage at maximum power (Vmp) and current at maximum power(Imp) pointsassociatedwithit.Eachindividualcellisrelativelylittleinsizeandcan only produce a small amount of power. The Voc of an individual solar cell isusually approximately 0.6 V. The cells become much more useful when combinedin an array to create a PV panel. When connected together the cells propertiesadd together to create an I-V curve that has the same appearance as that of anindividual cell but is larger in magnitude. The cells in an array are usuallyconnectedinseriestoobtainahigherandmoreappropriateterminalvoltage

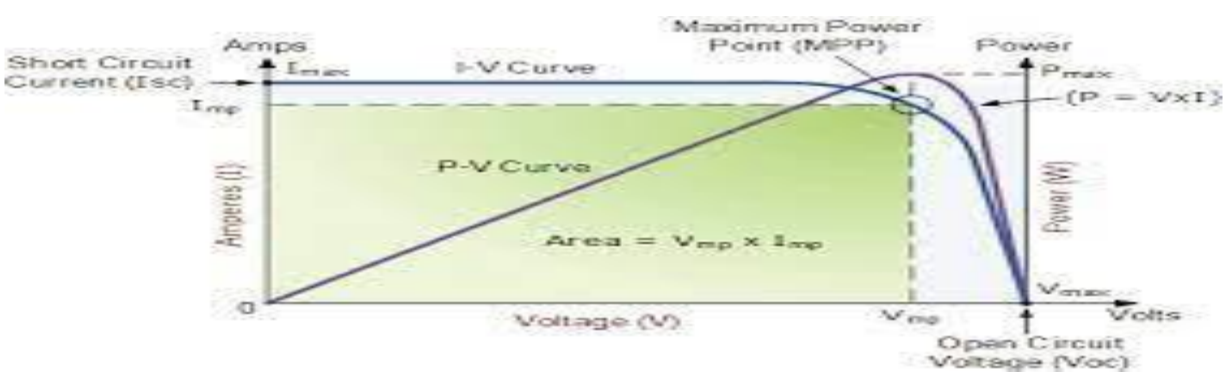


Fig7:-ArepresentativeI-VandP-VcurveforasolarcellshowingtheMPPandA PVcell

CHARACTERISTICS OF SOLAR MODULE

Short Circuit Current of Solar Cell

Themaximumcurrentthatasolarcellcandeliverwithoutharmingitsownconstriction. It is measured by short circuiting the terminals of the cell at mostoptimizedconditionofthecellforproducingmaximumoutput.Thetermoptimizedconditionused because for fixed exposed cell surface the rate of production ofcurrentinasolarcellalsodependsupontheintensityoflightandtheangleatwhichthe light falls on the cell. As the current production also depends upon the surface area of the cell exposed to light, it is better to express maximum current densityinsteadmaximumcurrent.Maximumcurrentdensityorshortcircuitcurrentdensityratingisnothingbutrationofmaximumorshortcircuitcurrenttoexposedsurface area of the cell.

Where

I_{sc}= shortcircuitcurrent

J_{sc} =maximum current densityA= thearea of solarcell.

1.1 Open Circuit Voltage of Solar Cell

It is measured by measuring voltage across the terminals of the cell when no loadisconnectedtothecell.Thisvoltagedependsuponthetechniquesofmanufacturing and temperature but not fairly on the intensity of light and area ofexposedsurface.Normallyopencircuitvoltageofsolarcellnearlyequalto0.5to 0.6volt.Itis normallydenotedbyV_{OC}.

Maximum Power Point of Solar Cell

Themaximumelectricalpoweronesolarcellcandeliveratitsstandardtestcondition. If we draw the v-i characteristics of a solar cell maximum power willoccuratthebendpointofthecharacteristiccurve.Itisshowninthev-icharacteristicsofsolarcellbyP_m.

Current at Maximum Power Point

Thecurrentatwhichmaximumpoweroccurs.CurrentatMaximumPowerPointisshowni n thev-icharacteristicsof solarcellbyI_m

Voltage at Maximum Power Point

The voltage at which maximum power occurs. Voltage at Maximum PowerPoint is shown in thev-icharacteristicsofsolar cellbyV_m.

Fill Factor of Solar Cell

The ratio between product of current and voltage at maximum power point totheproductofshortcircuitcurrentandopencircuitvoltageofthesolarcell.

$$Fill\ Factor = \frac{P_m}{I_{sc} \times V_{oc}}$$

Efficiency of Solar Cell

Itisdefinedastheratioofmaximumelectricalpoweroutputtotheradiationpowerinputtothecellanditisexpressedinpercentage.Itisconsideredthattheradiationpower on the earth is about 1000 watt/square metre hence if the exposed surfacearea of the cell is A then total radiation power on the cell will be 1000 A watts.Hencetheefficiencyof asolar cellmaybeexpressed as

$$Efficiency(\eta) = \frac{P_m}{P_{in}} \approx \frac{P_m}{1000A}$$

Theoutputcurrenttotheloadcanbeexpressedas

$I = IPV - Io((V+)nkTa - 1)$

Where:

- Iis theoutputcurrent ofthesolarmodule(A),

- Vistheoutputvoltageofthesolarcell(V),whichcanbeobtainedbydividingthe outputvoltageof thePVmodulebythenumber ofcells inseries,

- IPVis thecurrentsourceofthesolarmodulebysolarirradiance(A),
- Ioisthereversesaturationcurrentofadiode(A),NSistheseriesconnection numberof thesolarmodule,
- n is the idealfactorofthediode(n=1~2),
- qistheelectricchargeofan electron(1.6×e−19c),
- kistheBoltzmann’s constant(1.38×10−23j/K),
- Tis theabsolutetemperatureof thesolarcell.

BUCK BOOST CONVERTER

Buck – boost converter is "a DC to DC converter which either steps up or stepsdown the input voltage level". The step up or step down of input voltage leveldepends on the duty ratio. Duty ratio or duty cycle is the ratio of output voltageto the input voltage in the circuit. Buck – bust converter provides regulated DCoutput.

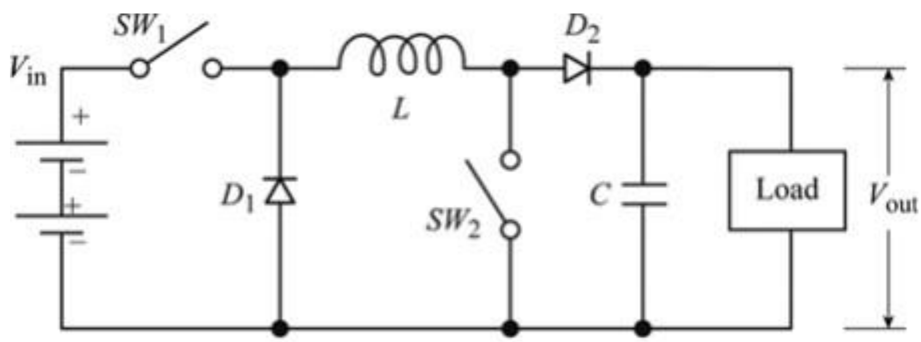


Fig8:-CircuitofBUCK-BOOSTCONVERTER

When it is in buck mode, the output voltage obtained is less than input appliedvoltage. In this mode, the output current is more than input current. However,the output power is equal to the input power. When it is in boost mode, theoutput voltage obtained is more than the input applied voltage. In this mode, theoutput current is less than input current. However, the output power is equal tothe input power. To operate the buck – boost converter, the two switches willoperate simultaneously. When switches are closed, inductor stores energy in amagnetic field. When switches are open, the inductors get discharged and givethe supply to the load. The inductors in the circuit do not allow sudden variationsinthecurrent.Thecapacitoracross theloadprovidesaregulated DCoutput.

Thereareseveralformatsthatcanbeusedforbuck-boostconverters:

+Vin, -Vout: This configuration of a buck-boost converter circuit uses the samenumber of components as the simple buck or boost converters. However thisbuck-boostregulatororDC-DCconverterproducesanegativeoutputfora positiveinput.Whilethismayberequiredorcanbeaccommodatedforalimitednumberof applications,itisnotnormallythemostconvenientformat.

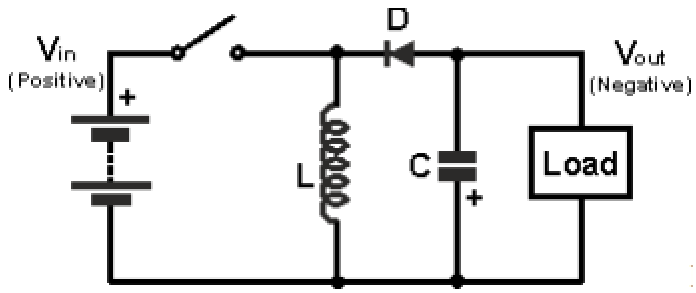


Fig9:-Whenswitch1isopen

When the switch in closed, current builds up through the inductor. When theswitchisopenedtheinductorsuppliescurrentthroughthediodetotheload.

+Vin, +Vout: The second buck-boost converter circuit allows both input andoutput to be the same polarity. However to achieve this, more components arerequired.Thecircuitforthisbuckboostconverteris shownbelow

In this circuit, both switches act together, i.e. both are closed or open. When theswitches are open, the inductor current builds. At a suitable point, the switchesare opened. The inductor then supplies current to the load through a pathincorporatingbothdiodes,D1and D2.

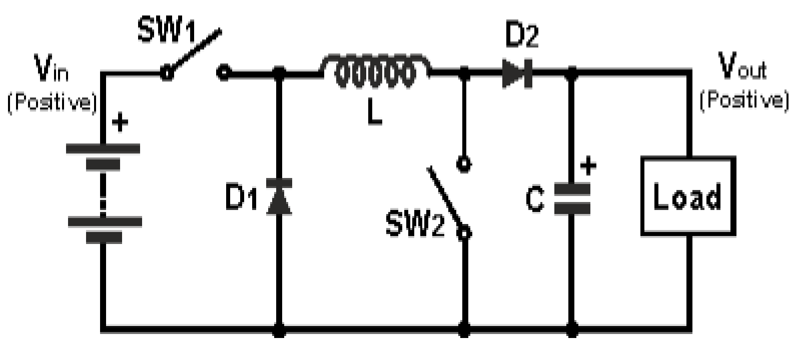
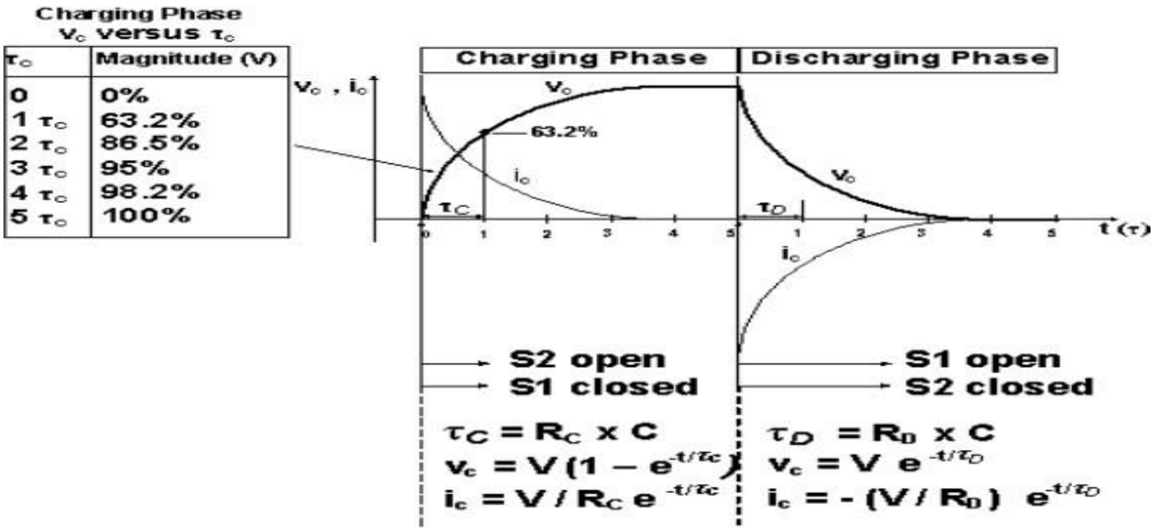
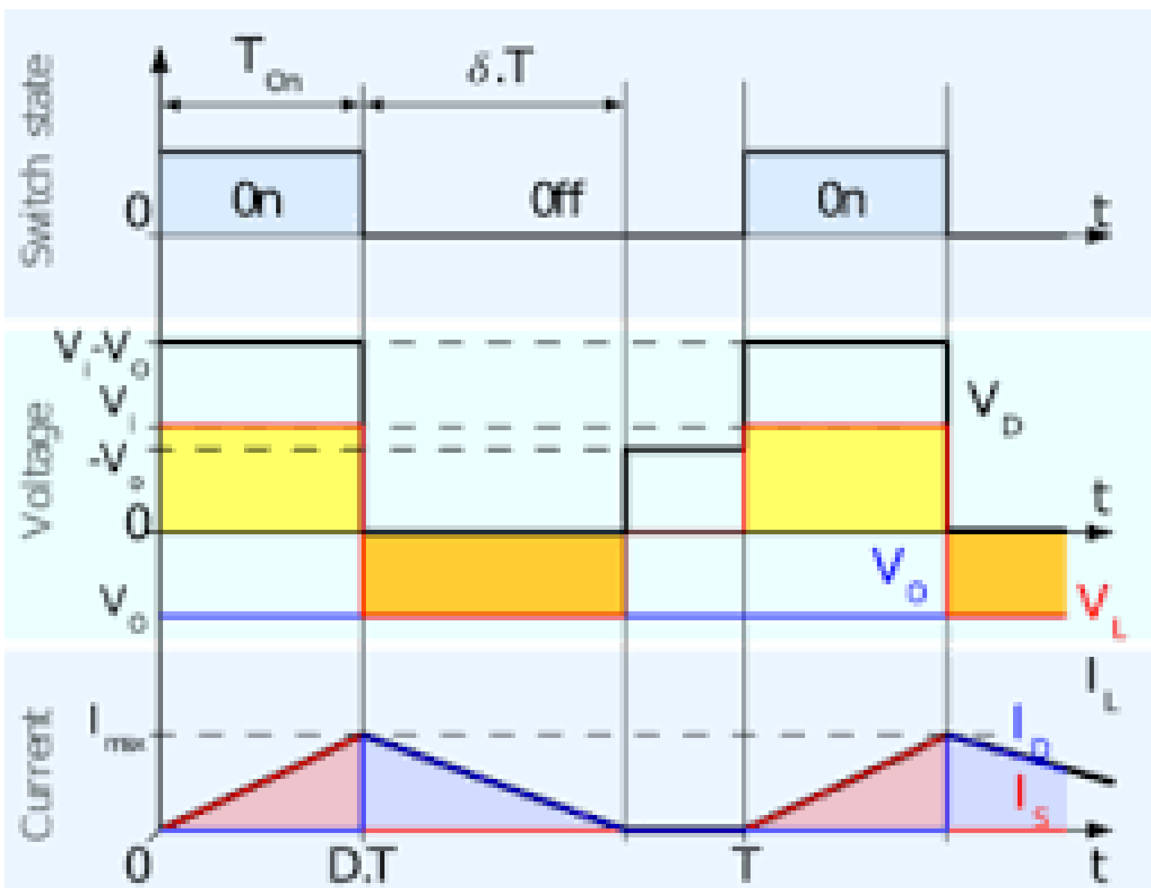
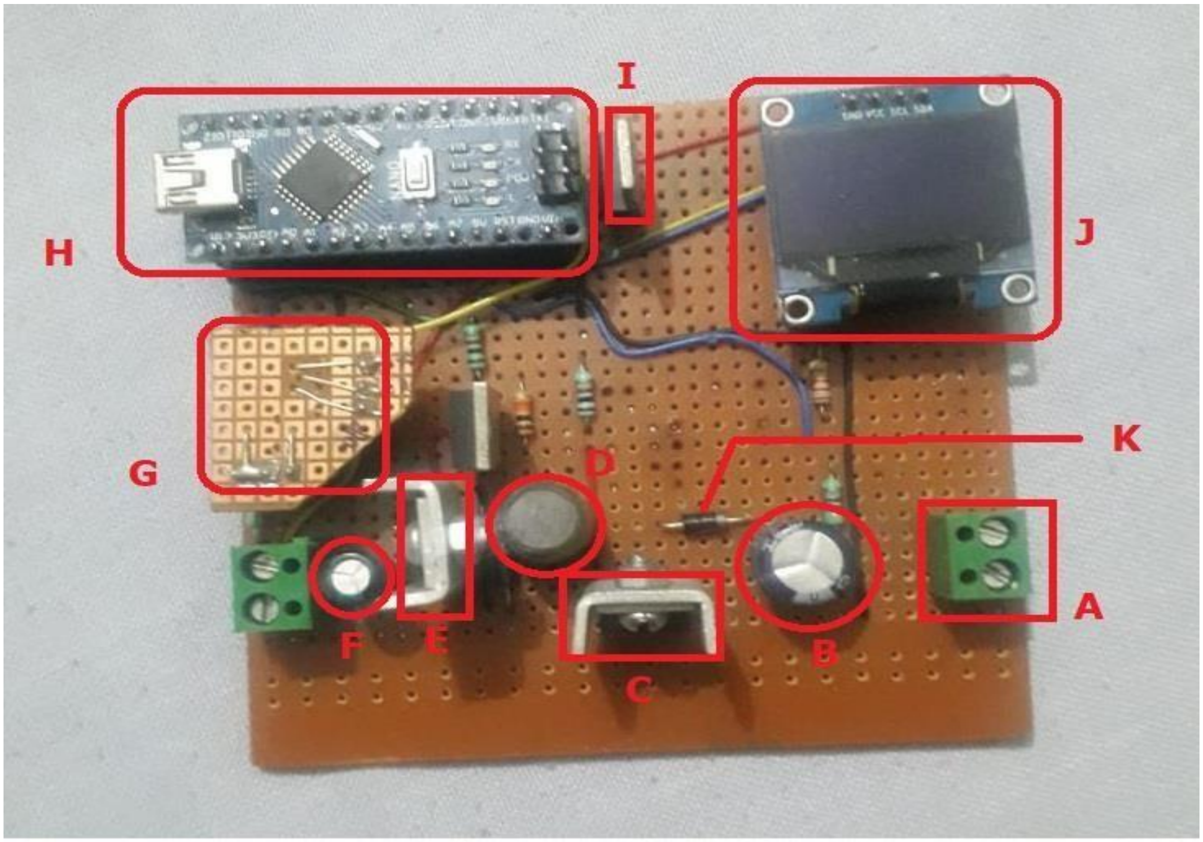


Fig10:-Whensw1andsw2bothareopen


Charging Phase
Vc versus τc
τc | Magnitude (V)
0 | 0%
1 τc | 63.2%
2 τc | 86.5%
3 τc | 95%
4 τc | 98.2%
5 τc | 100%
Charging Phase
Discharging Phase
vc , ic
vc
63.2%
ic
τC
τD
t (τ)
S2 open
S1 closed
S1 open
S2 closed
τC = RC x C
vc = V (1 – e^-t/τC)
ic = V / RC e^-t/τC
τD = RD x C
vc = V e^-t/τD
ic = - (V / RD) e^t/τD


Switch state
Voltage
Current
TOn
δ.T
On
Off
On
0
t
Vi-Vo
Vi
-Vo
VD
Vo
VL
Imax
IL
ID
IS
0
D.T
T
t

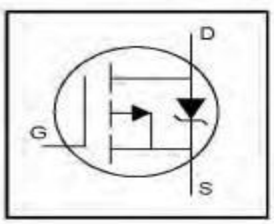
Components



A - 2 Pin Terminal Block
B - 220uF 50V Capacitor
C - IRF 540 n-MOSFET
D - 100uH Power Inductor
E - IRF 9Z24N p-MOSFET
F - 10uF 25V Capacitor
G - Hall Current Sensor
H - Arduino Nano
I - 7809 Voltage Ragulator
J - 0.96" OLED Display
K - 1N4819 Schottky Diode
L - Dot Vero Board

IRF9Z24N

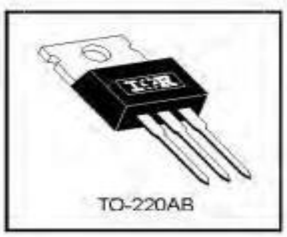
1. Lead-Free
2. AdvancedprocessTechnology
3. Dynamicdv/dtrating
4. 175°COperatingTemperature
5. Fastswitching
6. P-channel
7. FullyAvalancheBreakdown



$V_{DSS} = -55V$

$R_{DS(on)} = 0.175\Omega$

$I_D = -12A$



Source-Drain Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Conditions
I_S	Continuous Source Current (Body Diode)	—	—	-12	A	MOSFET symbol showing the integral reverse p-n junction diode.
I_{SM}	Pulsed Source Current (Body Diode) ①	—	—	-48		
V_{SD}	Diode Forward Voltage	—	—	-1.6	V	$T_J = 25°C$, $I_S = -7.2A$, $V_{GS} = 0V$ ④
t_{rr}	Reverse Recovery Time	—	47	71	ns	$T_J = 25°C$, $I_F = -7.2A$
Q_{rr}	Reverse RecoveryCharge	—	84	130	µC	di/dt = -100A/µs ④
t_{on}	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by L_S+L_D)				

Absolute Maximum Ratings

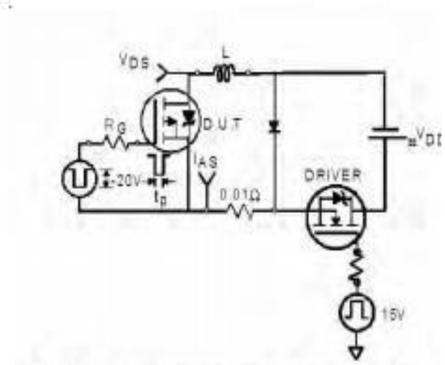
	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ -10V	-12	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ -10V	-8.5	
I_{DM}	Pulsed Drain Current ①	-48	
P_D @T_C = 25°C	Power Dissipation	45	W
	Linear Derating Factor	0.30	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulse Avalanche Energy②	96	mJ
I_{AR}	Avalanche Current①	-7.2	A
E_{AR}	Repetitive Avalanche Energy①	4.5	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-5.0	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to + 175	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting torque, 6-32 or M3 screw	10 lbf•in (1.1N•m)	

Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	—	3.3	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient	—	62	

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	-55	—	—	V	V_{GS} = 0V, I_D = -250μA
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	-0.05	—	V/°C	Reference to 25°C, I_D = -1mA
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	—	0.175	Ω	V_{GS} = -10V, I_D = -7.2A ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	—	-4.0	V	V_{DS} = V_{GS}, I_D = -250μA
g_{fs}	Forward Transconductance	2.5	—	—	S	V_{DS} = -25V, I_D = -7.2A
I_{DSS}	Drain-to-Source Leakage Current	—	—	-25	μA	V_{DS} = -55V, V_{GS} = 0V
		—	—	-250		V_{DS} = -44V, V_{GS} = 0V, T_J = 150°C
I_{GSS}	Gate-to-Source Forward Leakage	—	—	100	nA	V_{GS} = 20V
	Gate-to-Source Reverse Leakage	—	—	-100		V_{GS} = -20V
Q_g	Total Gate Charge	—	—	19	nC	I_D = -7.2A
Q_{gs}	Gate-to-Source Charge	—	—	5.1		V_{DS} = -44V
Q_{gd}	Gate-to-Drain ("Miller") Charge	—	—	10		V_{GS} = -10V, See Fig. 6 and 13 ④
$t_{d(on)}$	Turn-On Delay Time	—	13	—	ns	V_{DD} = -28V
t_r	Rise Time	—	55	—		I_D = -7.2A
$t_{d(off)}$	Turn-Off Delay Time	—	23	—		R_G = 24Ω
t_f	Fall Time	—	37	—		R_D = 3.7Ω, See Fig. 10 ④
L_D	Internal Drain Inductance	—	4.5	—	nH	Between lead, 6mm (0.25in.) from package and center of die contact 
L_S	Internal Source Inductance	—	7.5	—		
C_{iss}	Input Capacitance	—	350	—	pF	V_{GS} = 0V
C_{oss}	Output Capacitance	—	170	—		V_{DS} = -25V
C_{rss}	Reverse Transfer Capacitance	—	92	—		f = 1.0MHz, See Fig. 5



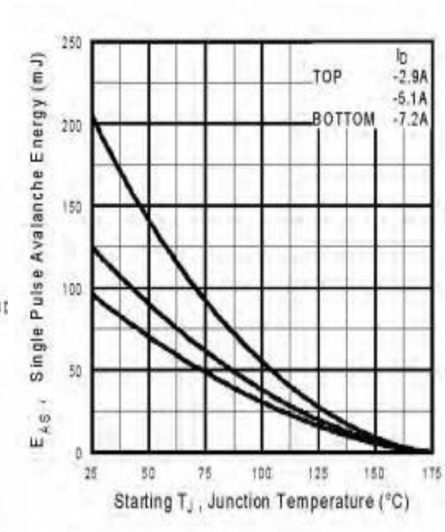
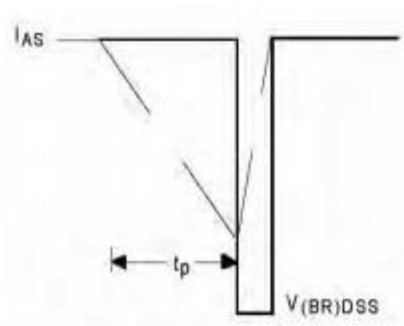


Fig13a:-UnclampedInductiveTestCircuit



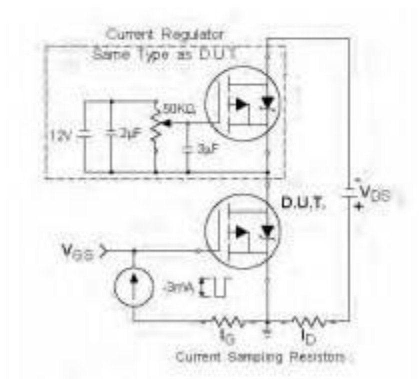


Fig13b:-UnclampedInductiveWaveforms

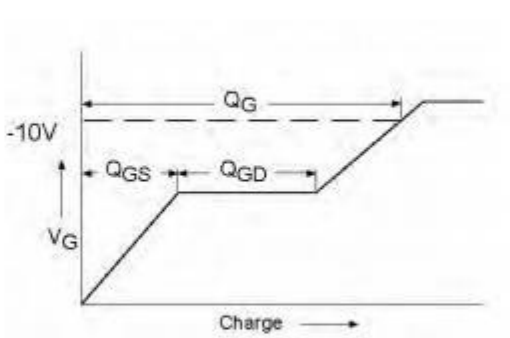
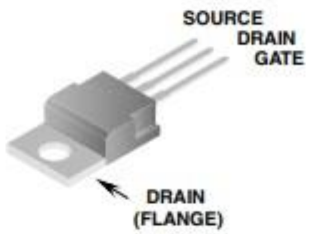


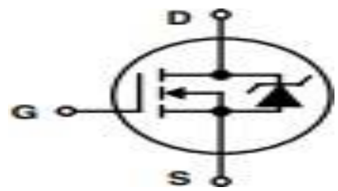
Fig14a:-BasicGateChargewaveform

IRF540N

JEDEC TO-220AB



IRF540N



Absolute Maximum Ratings $T_C = 25^oC$, Unless Otherwise Specified

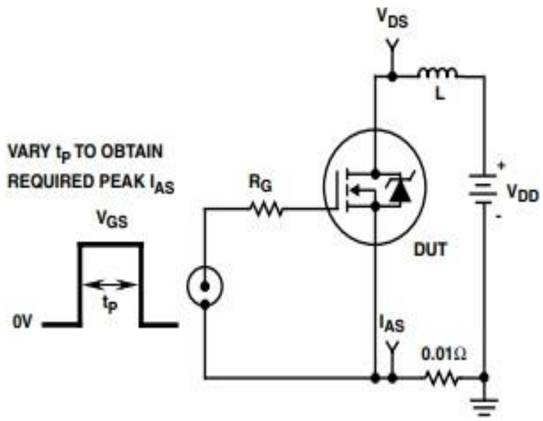
		IRF540N	UNITS
Drain to Source Voltage (Note 1)	V_{DSS}	100	V
Drain to Gate Voltage (R_{GS} = 20kΩ) (Note 1)	V_{DGR}	100	V
Gate to Source Voltage	V_{GS}	±20	V
Drain Current			
Continuous (T_C= 25^{o}C, V_{GS} = 10V) (Figure 2)	I_D	33	A
Continuous (T_C= 100^{o}C, V_{GS} = 10V) (Figure 2)	I_D	23	A
Pulsed Drain Current	I_{DM}	Figure 4	
Pulsed Avalanche Rating	UIS	Figures 6, 14, 15	
Power Dissipation	P_D	120	W
Derate Above 25^{o}C		0.80	W/^{o}C
Operating and Storage Temperature	T_J, T_{STG}	-55 to 175	^{o}C
Maximum Temperature for Soldering			
Leads at 0.063in (1.6mm) from Case for 10s	T_L	300	^{o}C
Package Body for 10s, See Techbrief TB334	T_{pkg}	260	^{o}C

Electrical Specifications $T_C = 25^oC$, Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS		MIN	TYP	MAX	UNITS
OFF STATE SPECIFICATIONS							
Drain to Source Breakdown Voltage	BV_{DSS}	$I_D = 250\mu A$, $V_{GS} = 0V$ (Figure 11)		100	-	-	V
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = 95V$, $V_{GS} = 0V$		-	-	1	μA
		$V_{DS} = 90V$, $V_{GS} = 0V$, $T_C = 150^oC$		-	-	250	μA
Gate to Source Leakage Current	I_{GSS}	$V_{GS} = \pm 20V$		-	-	±100	nA
ON STATE SPECIFICATIONS							
Gate to Source Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}$, $I_D = 250\mu A$ (Figure 10)		2	-	4	V
Drain to Source On Resistance	$r_{DS(ON)}$	$I_D = 33A$, $V_{GS} = 10V$ (Figure 9)		-	0.033	0.040	Ω
THERMAL SPECIFICATIONS							
Thermal Resistance Junction to Case	$R_{\theta JC}$	TO-220		-	-	1.25	$^oC/W$
Thermal Resistance Junction to Ambient	$R_{\theta JA}$			-	-	62	$^oC/W$
SWITCHING SPECIFICATIONS ($V_{GS} = 10V$)							
Turn-On Time	t_{ON}	$V_{DD} = 50V$, $I_D = 33A$, $V_{GS} = 10V$, $R_{GS} = 9.1\Omega$ (Figures 18, 19)		-	-	100	ns
Turn-On Delay Time	$t_{d(ON)}$			-	9.5	-	ns
Rise Time	t_r			-	57	-	ns
Turn-Off Delay Time	$t_{d(OFF)}$			-	40	-	ns
Fall Time	t_f			-	55	-	ns
Turn-Off Time	t_{OFF}			-	-	145	ns
GATE CHARGE SPECIFICATIONS							
Total Gate Charge	$Q_{g(TOT)}$	$V_{GS} = 0V$ to $20V$	$V_{DD} = 50V$, $I_D = 33A$, $I_{g(REF)} = 1.0mA$ (Figures 13, 16, 17)	-	66	79	nC
Gate Charge at 10V	$Q_{g(10)}$	$V_{GS} = 0V$ to $10V$		-	35	42	nC
Threshold Gate Charge	$Q_{g(TH)}$	$V_{GS} = 0V$ to $2V$		-	2.4	2.9	nC
Gate to Source Gate Charge	Q_{gs}			-	5.4	-	nC
Gate to Drain "Miller" Charge	Q_{gd}			-	13	-	nC
CAPACITANCE SPECIFICATIONS							
Input Capacitance	C_{ISS}	$V_{DS} = 25V$, $V_{GS} = 0V$, f = 1MHz (Figure 12)		-	1220	-	pF
Output Capacitance	C_{OSS}			-	295	-	pF
Reverse Transfer Capacitance	C_{RSS}			-	100	-	pF

Source to Drain Diode Specifications

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Source to Drain Diode Voltage	V_{SD}	$I_{SD} = 33A$	-	-	1.25	V
		$I_{SD} = 17A$	-	-	1.00	V
Reverse Recovery Time	t_{rr}	$I_{SD} = 33A$, $dI_{SD}/dt = 100A/\mu s$	-	-	112	ns
Reverse Recovered Charge	Q_{RR}	$I_{SD} = 33A$, $dI_{SD}/dt = 100A/\mu s$	-	-	400	nC



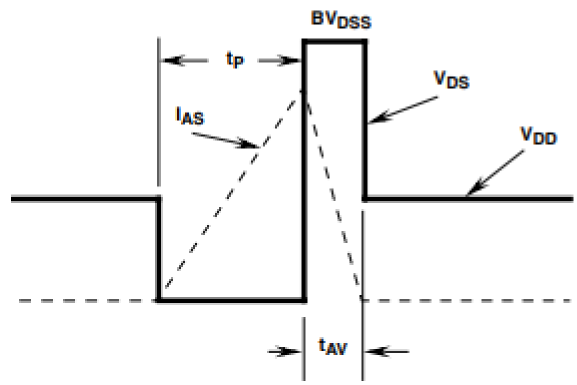
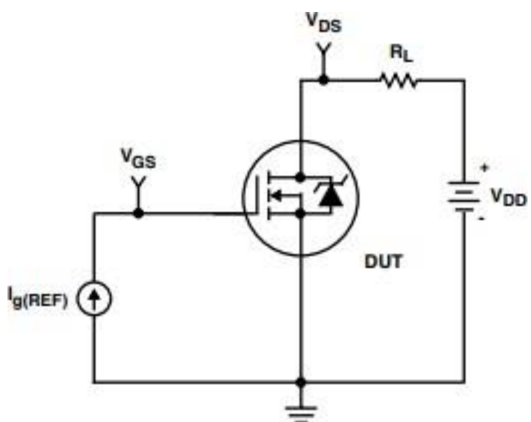


Fig15a:-UNCLAMPEDENERGYTESTCIRCUIT **Fig15b:-UNCLAMPEDENERGYWAVEFORMS**



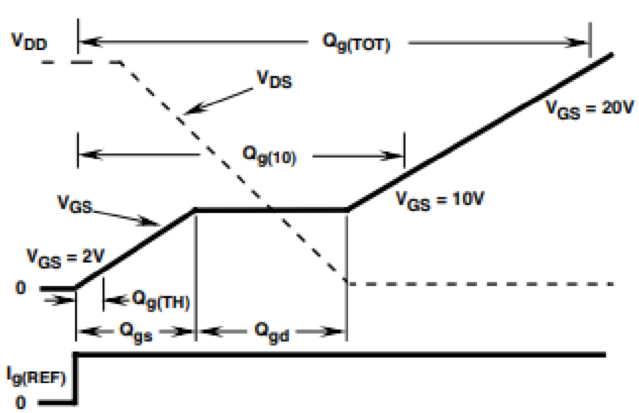
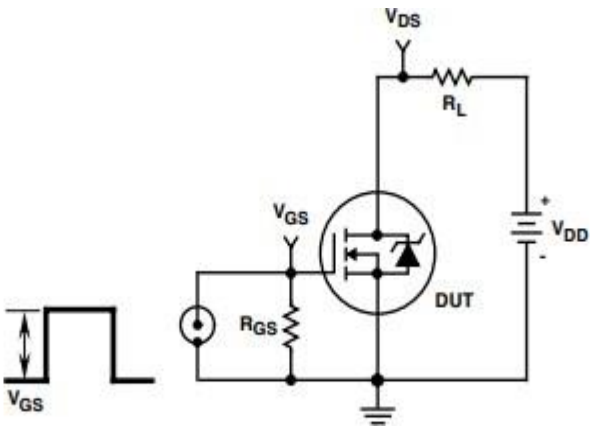


Fig15c:-GATECHARGETESTCIRCUIT **Fig15d:- GATECHARGEWAVEFORMS**



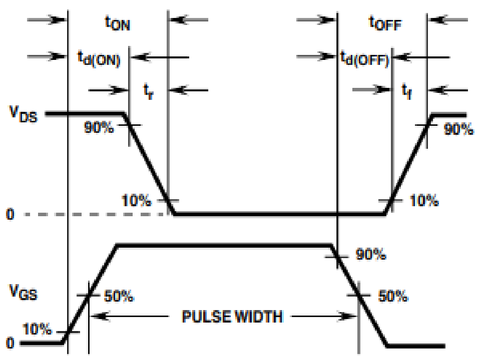


Fig15e:-SWITCHINGTIMETESTCIRCUIT **Fig15f:-SWITCHINGTIMEWAVEFORM**

Microcontroller

Arduino Nano is a small, compatible, flexible and breadboard friendlymicrocontrollerboardbasedonATMEGA328P.Itcomeswithanoperatingvoltageof5V,however,thepowerinputpin (Vin)voltagecanvary from7to12V.

ArduinoNanoPinoutcontains

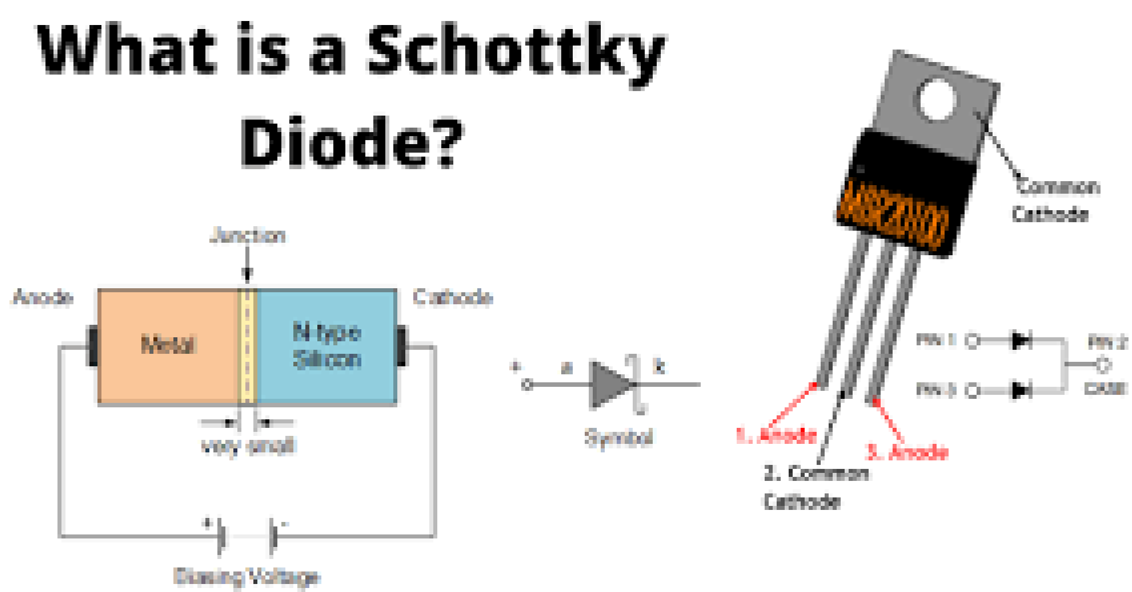
14digitalpins D0-D13

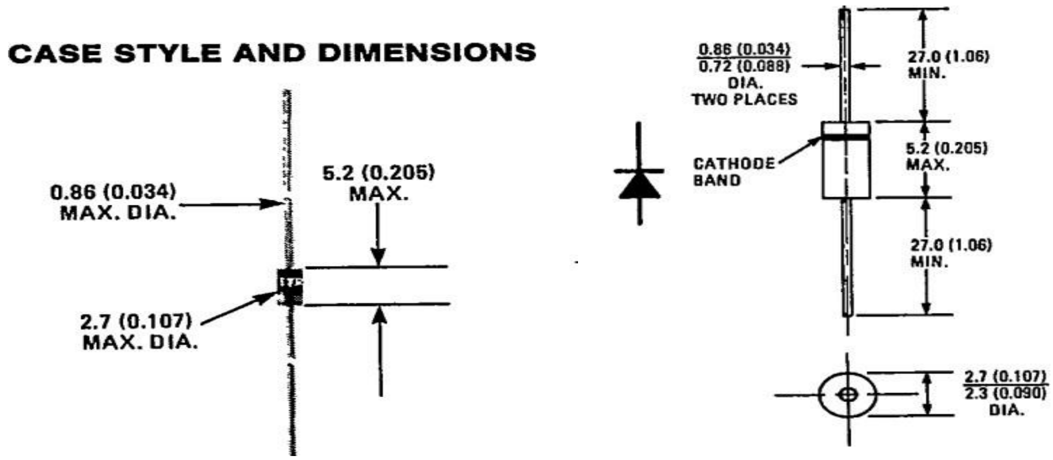
8analogPins………………………………….A0-A72Reset Pins&6Power Pins

It has built in 8channel, 10-bit ADC that can measure approx. 5mV minimum. Pin A0-A5 can beusedas digitalpinifrequired.

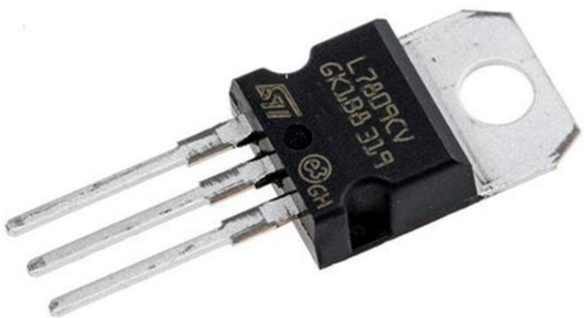
It hasDAC of8-bitthatcan giveoutputfrom0to5 V.PWMPins3,5,6,9,10,&11doesthisoperation.

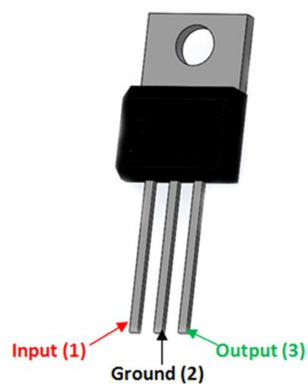
1N4819 Schottky Diode





<u>7805 Voltage Regulator</u>





<u>LM7805PinoutConfiguration:-</u>

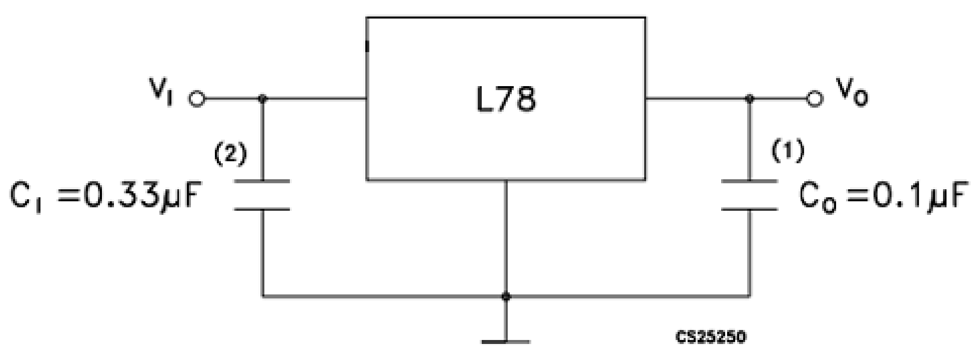
PinNumber	PinName	Description
1	Input(V+)	UnregulatedInput Voltage
2	Ground	ConnectedtoGround
3	Output(VO)	OutputsRegulated+5V

L7805RegulatorFeatures

1. 5VPositiveVoltageRegulator
2. MinimumInputVoltageis11V
3. MaximumInput Voltageis 35V
4. OutputCurrent:1.5A
5. PSRR/RippleRejection:55dB
6. OutputType: Fixed
7. InternalThermalOverloadandShortcircuitcurrentlimitingprotectionisavailable.
8. JunctionTemperaturemaximumof125degreeCelsius
9. AvailableinTO-220,TO-3 andKTEpackage

L7805as+5VVoltageRegulator

This is a typical application circuit of the 7809 IC. We just need two capacitors of value 0.33ufand 0.1uf to get this IC working. The input capacitor 0.33uF is a ceramic capacitor that deals withthe input inductance problem and the output capacitor 0.1uF is also a ceramic capacitor thatadds to the stability of the circuit. These capacitors should be placed close to the terminals forthem to work effectively. Also, they should be of a ceramic type, since ceramic capacitors arefasterthan electrolytic.



7805Applications

1. Constant+5Voutputregulatortopowermicrocontrollersandsensorsinmostoftheprojects
2. AdjustableOutputRegulator
3. CurrentLimiterforcertainapplications
4. RegulatedDualSupply
5. OutputPolarity-Reversal-ProtectionCircuit

0.96’’OLEDDisplay

1. ThinOLEDDisplay
2. 0.96"OLEDDisplay,OLED0.96"
3. Suitableforwearabledevice
4. Type:Graphic
5. Structure:COG
6. 128x 64DotMatrix
7. Built-incontrollerSSD1306
8. 3VPowersupply
9. 1/64duty
10. Interface:6800,8080,SPI,I2C
11. DisplayColor:White/Yellow /Blue

Capacitor

Capacitorswhichhavebeenusedinthisprojectare

1. 220u F50V Capacitor
2. 10u F25V Capacitor

Power Inductor

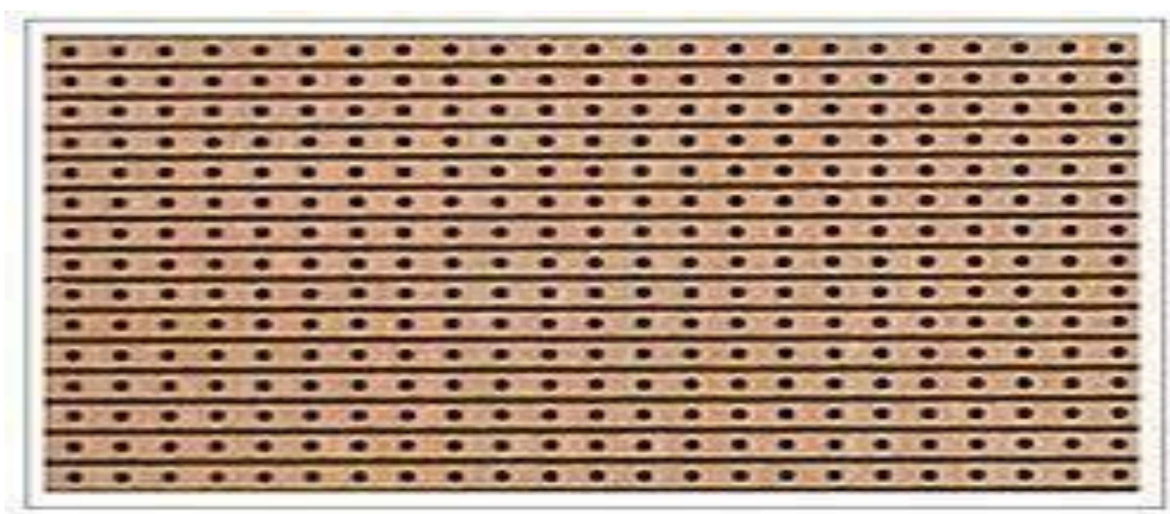
Theonlyinductorusedinthisexperimentisof100uH

2Pin Terminal Block

Duallevelterminalblocksusetwolevelsofcontacts.Thishelpssimplifywiringandsavespace.

Dot VeroBoard

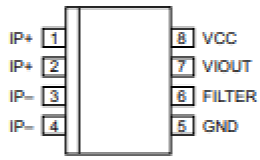
It was introduced as a general-purpose material for use in constructing electroniccircuits - differing from purpose-designed printed circuit boards (PCBs) in that avarietyofelectronicscircuitsmaybeconstructedusingastandardwiringboard



HallCurrent Sensor

ACS712provideseconomicaland precisesolutionsforACor DCcurrentsensing inindustrial,commercial, and communications systems. The device consists of a precise, low-offset, linear Hall sensorcircuitwith a copperconductionpathlocatednear thesurfaceofthedie.

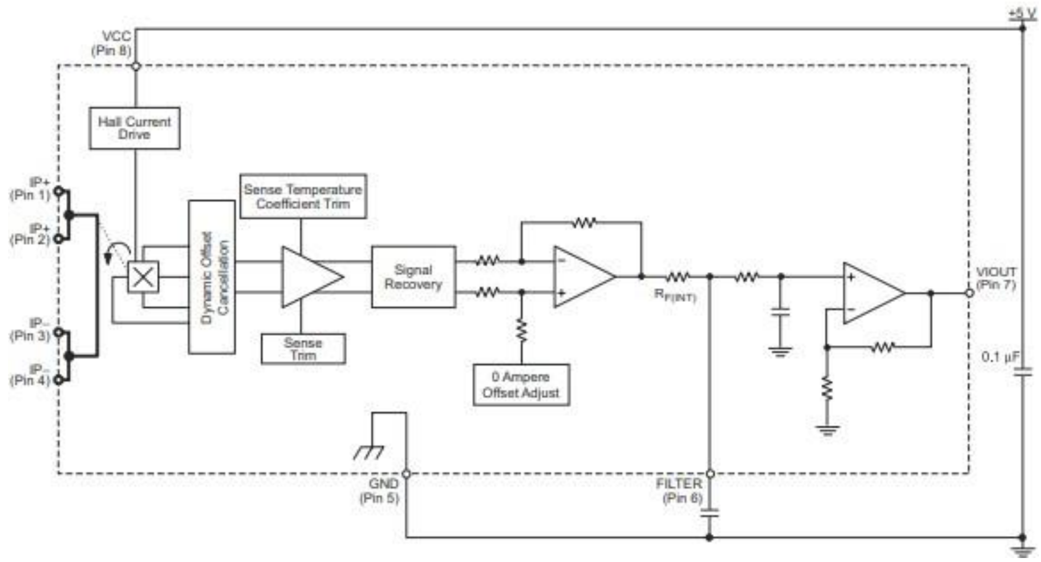
Pin-out Diagram



Terminal List Table

Number	Name	Description
1 and 2	IP+	Terminals for current being sensed; fused internally
3 and 4	IP–	Terminals for current being sensed; fused internally
5	GND	Signal ground terminal
6	FILTER	Terminal for external capacitor that sets bandwidth
7	VIOUT	Analog output signal
8	VCC	Device power supply terminal

Functional Block Diagram



COMMON OPERATING CHARACTERISTICS[1] over full range of T_A, C_F = 1 nF, and V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Supply Current	I_{CC}	V_{CC} = 5.0 V, output open	–	10	13	mA
Output Capacitance Load	C_{LOAD}	VIOUT to GND	–	–	10	nF
Output Resistive Load	R_{LOAD}	VIOUT to GND	4.7	–	–	kΩ
Primary Conductor Resistance	$R_{PRIMARY}$	T_A = 25°C	–	1.2	–	mΩ
Rise Time	t_r	$I_P = I_P(max)$, T_A = 25°C, C_{OUT} = open	–	5	–	µs
Frequency Bandwidth	f	–3 dB, T_A = 25°C; I_P is 10 A peak-to-peak	–	80	–	kHz
Nonlinearity	E_{LIN}	Over full range of I_P	–	1.5	–	%
Symmetry	E_{SYM}	Over full range of I_P	98	100	102	%
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A, T_A = 25°C	–	V_{CC} × 0.5	–	V
Power-On Time	t_{PO}	Output reaches 90% of steady-state level, T_J = 25°C, 20 A present on leadframe	–	35	–	µs
Magnetic Coupling[2]			–	12	–	G/A
Internal Filter Resistance[3]	$R_{F(INT)}$			1.7		kΩ

COMMON THERMAL CHARACTERISTICS[1]

			Min.	Typ.	Max.	Units
Operating Internal Leadframe Temperature	T_A	E range	–40	–	85	°C
					Value	Units
Junction-to-Lead Thermal Resistance[2]	$R_{\theta JL}$	Mounted on the Allegro ASEK 712 evaluation board			5	°C/W
Junction-to-Ambient Thermal Resistance	$R_{\theta JA}$	Mounted on the Allegro 85-0322 evaluation board, includes the power consumed by the board			23	°C/W

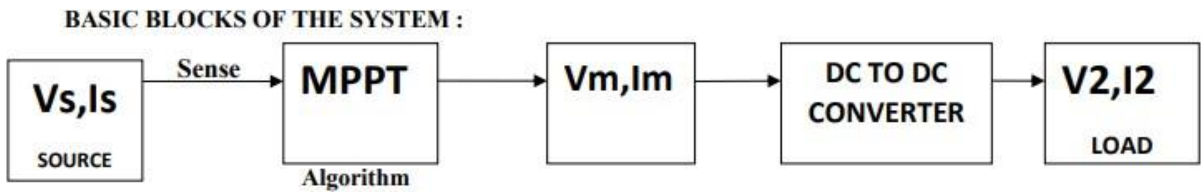
A Typical pv module

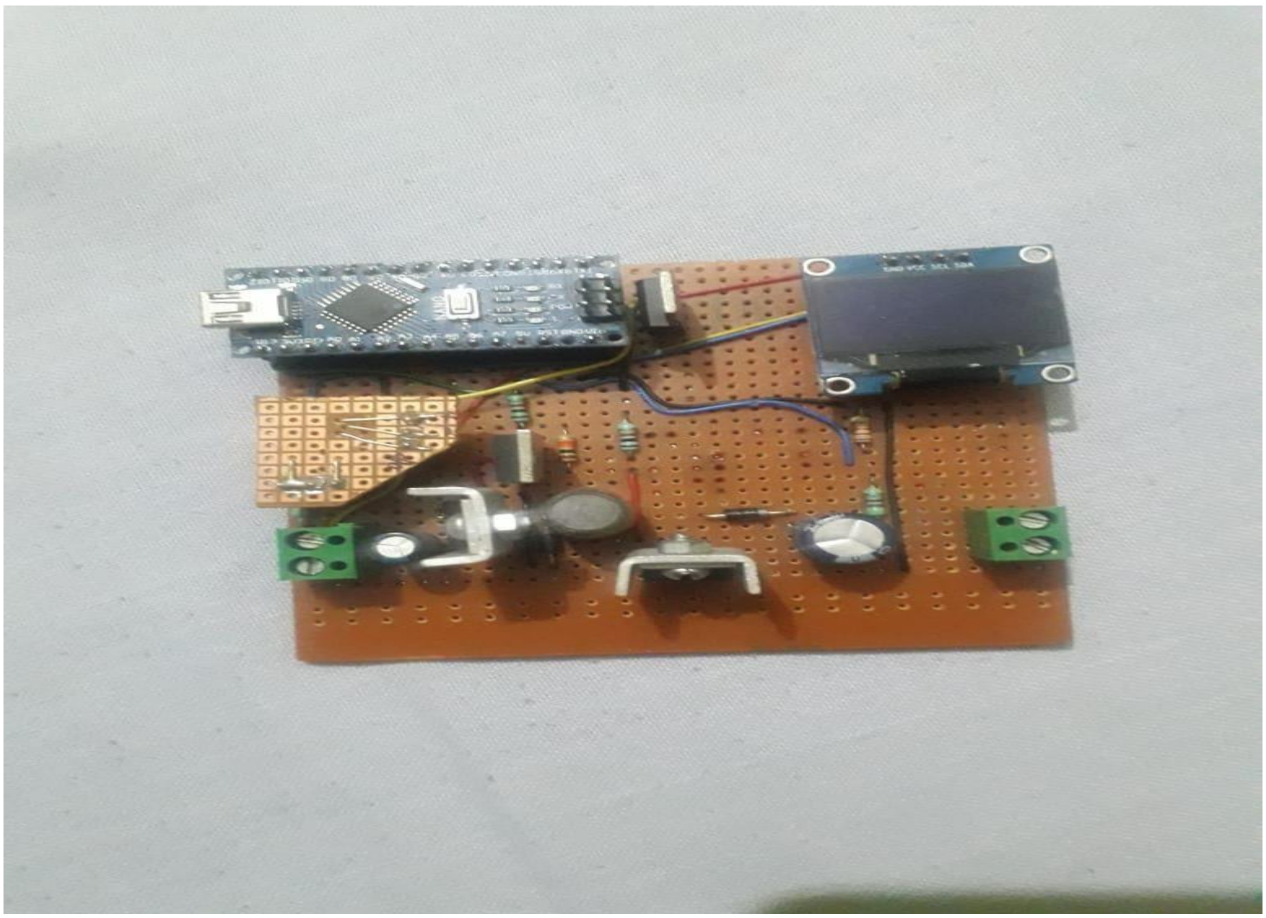
Thespecificationisgivenbelow:-

Specefication	Value
Wattage	10 watt
VoltageatMaxpower,Vmp	16.85 volt
CurrentatMaxpower	0.59 Amp
OpenCircuitvoltage(Voc)	20.9 volt
ShortCircuitCurrent(Isc)	0.65 Amp
Numberofcells	36

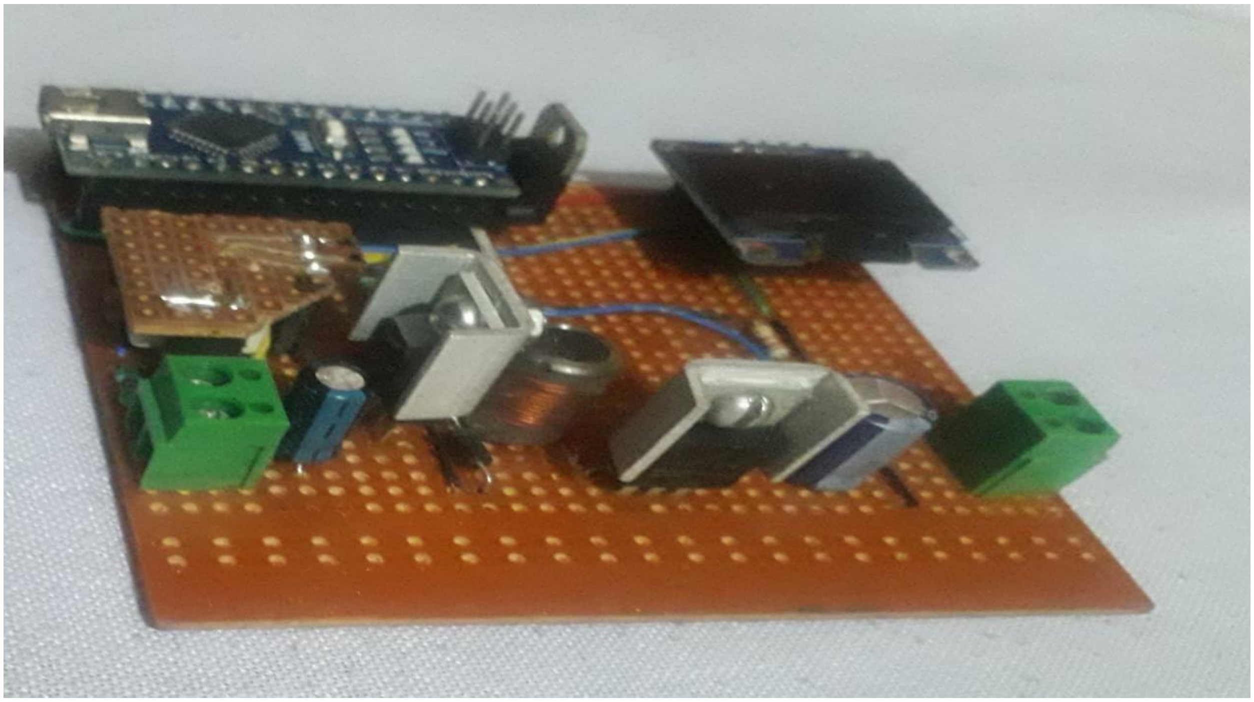
Hardware Section

BasicBlockDiagram

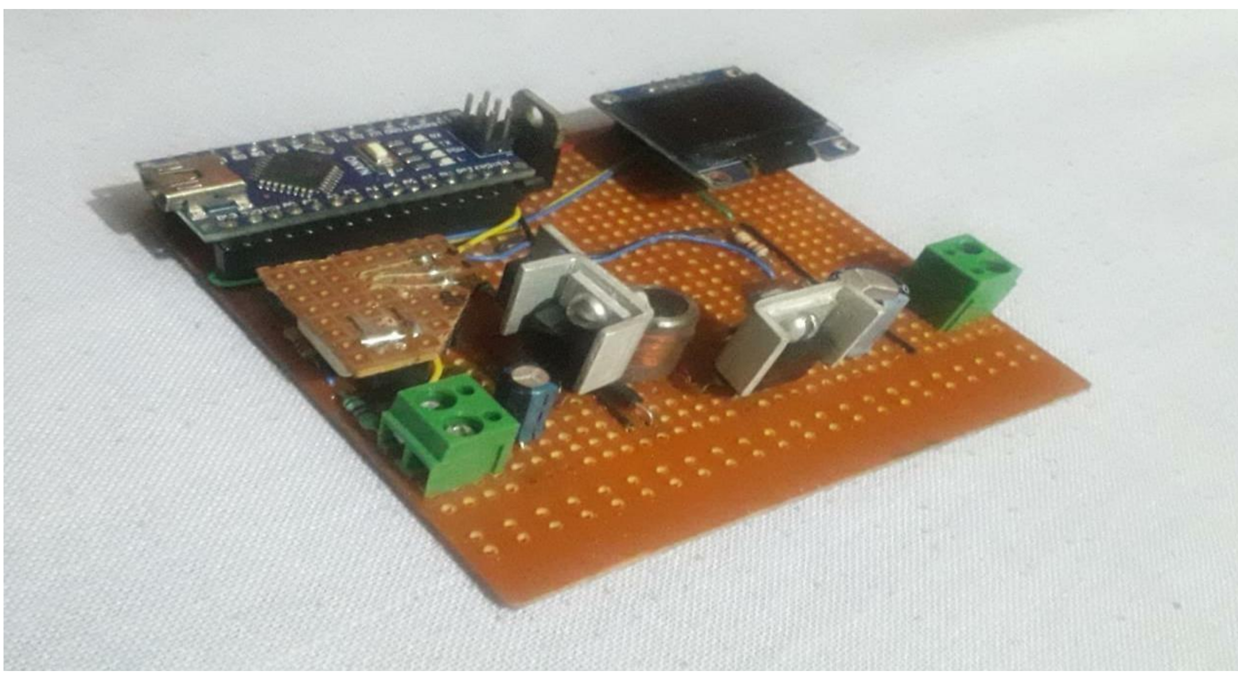




TopviewoftheHardwarecircuit

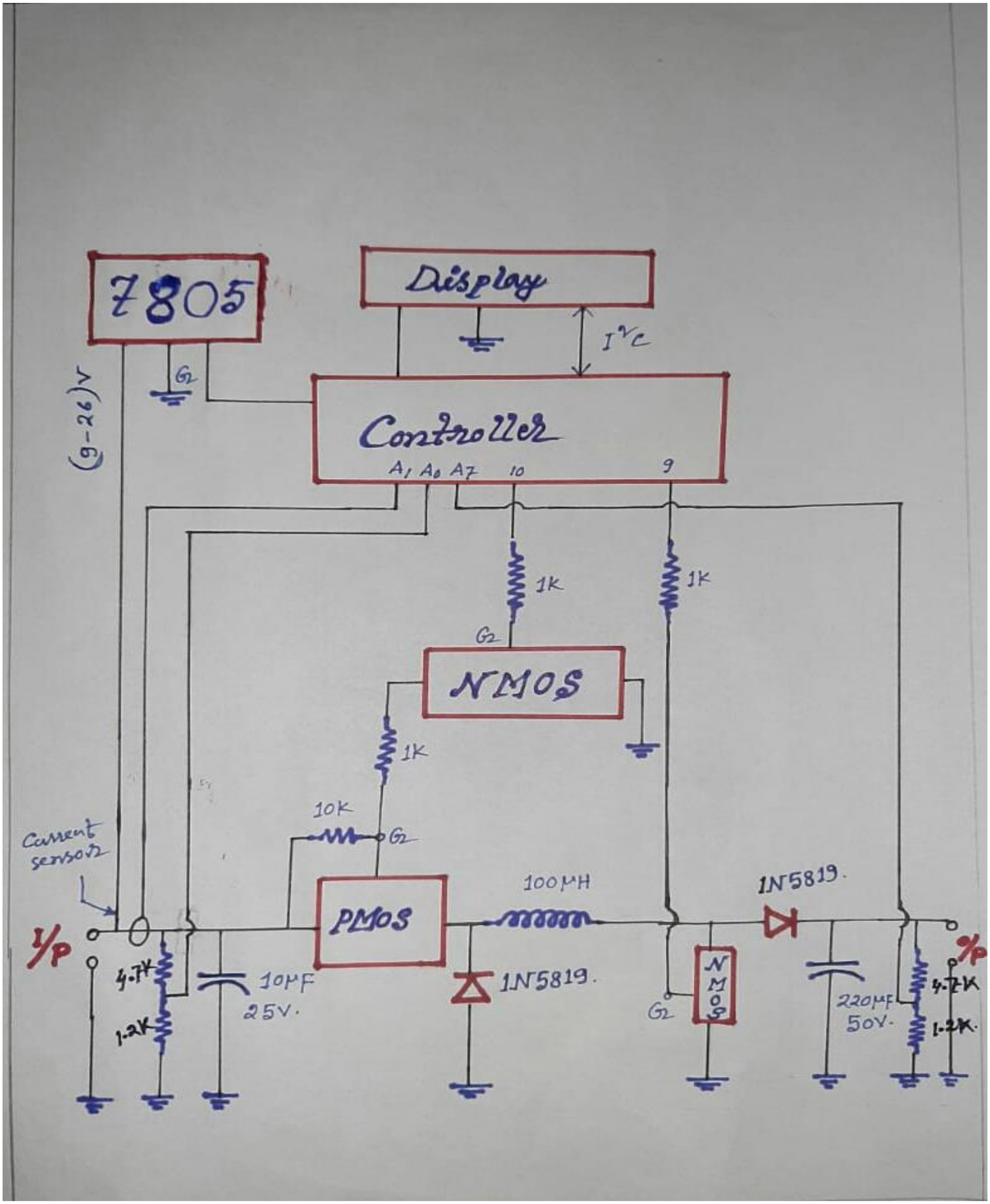


Sideviewofthecircuit



Anothersideviewofthe circuit

Circuit Diagram and their operation



For easy understandingwe are separating the parts and try to understand theworkingof each part

Communication Protocol

The proper descriptions of digital message formats as well as rules are knowncommunicationprotocols.

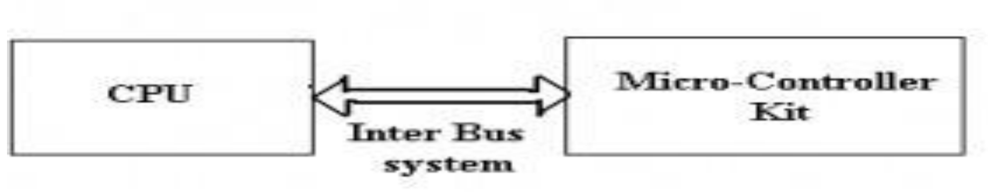
1. **Protocol**:Asetofrulesandregulationsiscalledaprotocol.
2. **Communication:** Exchange of information from one system to anothersystemwith amedium iscalledcommunication.
3. **Communication Protocol:** A set of rules and regulations that allow twoelectronicdevicesto connectto exchangethedatawith oneand another.

Therearetwotypesofcommunicationprotocolswhichareclassifiedbelow

1. InterSystemProtocol
2. IntraSystemProtocol

Inter System Protocol

The inter-system protocol using to communicate the two different devices. Likecommunication between computer to microcontroller kit. The communication isdonethroughan inter bussystem



Inter Bus System Protocols

.

Thedifferentcategoriesofintersystemprotocolmainlyincludethefollowing

1. UARTProtocol
2. USARTProtocol
3. USBProtocol

Intra SystemProtocol

TheIntrasystemprotocolisusedtocommunicatethetwodeviceswithinthecircuitboard. While using these intra system protocols, without going to intra systemprotocolswewillexpandtheperipheralsofthemicrocontroller.Thecircuitcomplexity and power consumption will be increased by using the intra systemprotocol. Using intra system protocols circuit complexity and power consumption,thecostis decreasedand itis verysecuretoaccessingthedata.

Thedifferentcategoriesofintrasystemprotocolmainlyincludethefollowing.

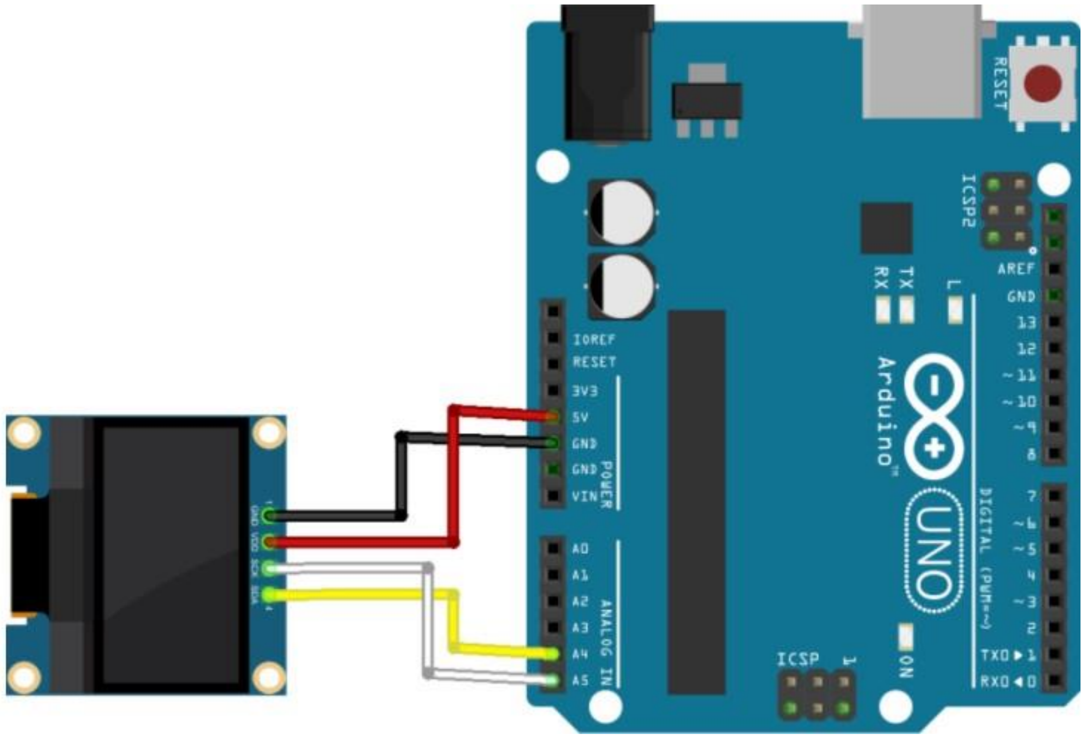
1. I2CProtocol
2. SPIProtocol
3. CANProtocol

HerewehaveusedI2CProtocolsoourmain discussionwillbeonI2Cprotocol

I2C Protocol

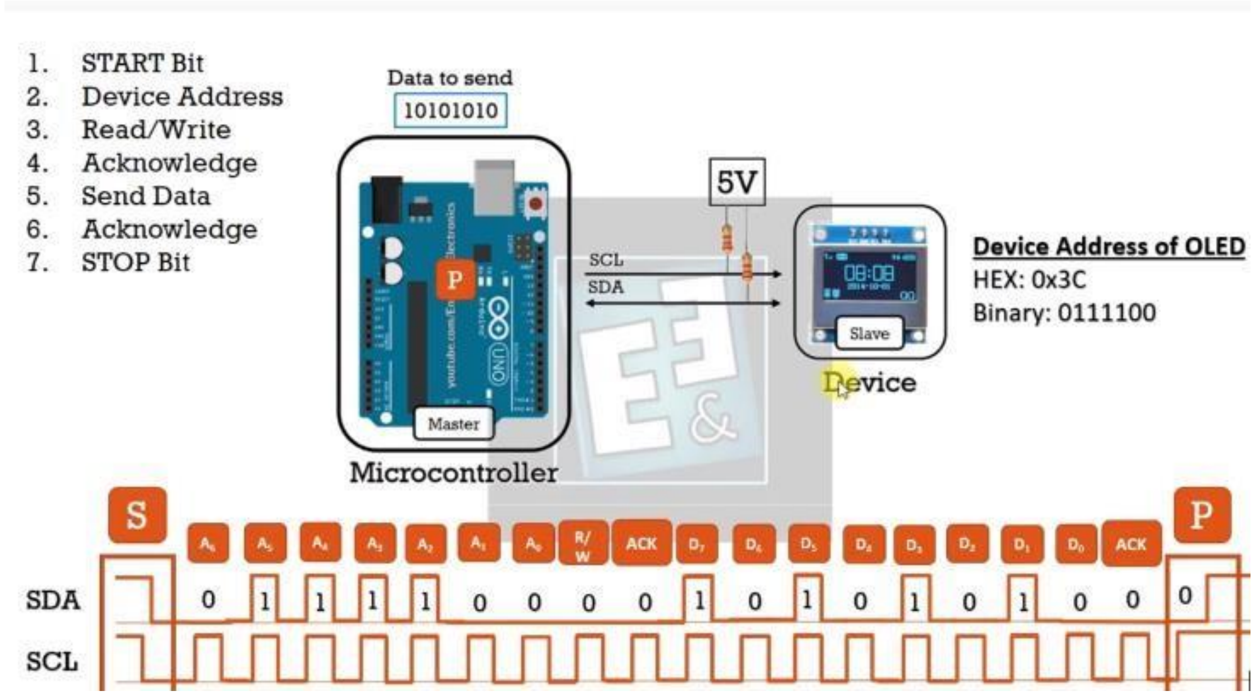
I2C stands for Inter Integrated circuit and it requires only two wires connecting allperipheralstothemicrocontroller.I2CrequirestwowiresSDA(serialdataline)andSCL(serialclockline)tocarryinformationbetweendevices.Itisamastertoaslavecommunicationprotocol.Eachslavehasa uniqueaddress.Themasterdevicesendsthe address of the target slave device and reads/writes the flag. The addressmatches any slave device that the device is ON, the remaining slave devices aredisabled mode.

Once the address is match communication proceed between the master and thatslave device and transmitting and receiving the data. The transmitter sends 8-bitdata, the receiver replies 1-bit of acknowledgment. When the communication iscompletedmasterissuesthestopcondition.

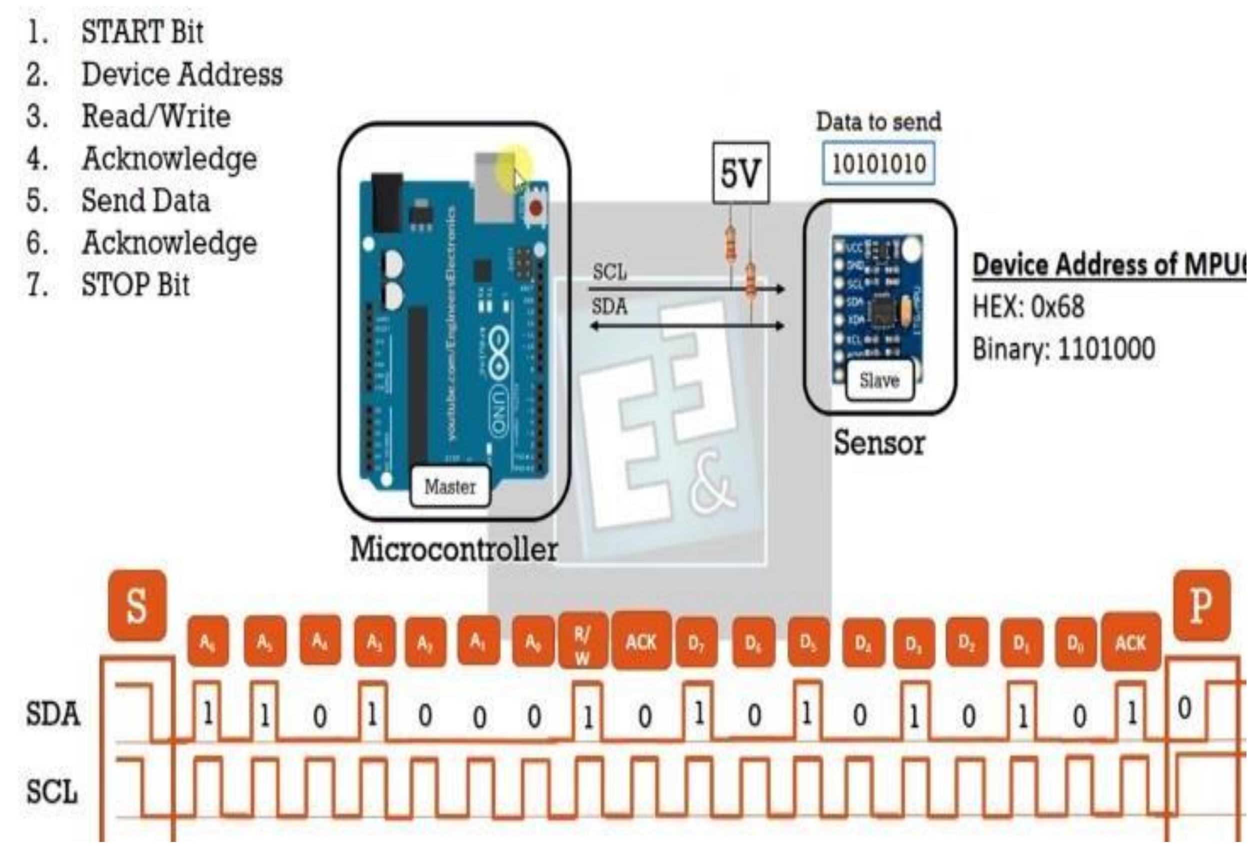


Sending DATA from Master to slave

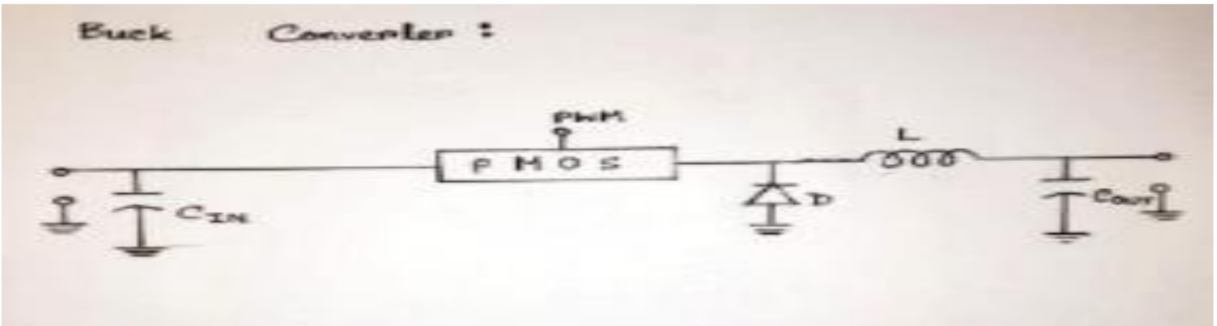
For communication we require only two pins SCL(Serial Clock) and SDA(SerialData). SCL and SDA pins will remain high initially, and by using SCL and SDA notonly single device but multiple devices can be connected. Over here todifferentiatethedevicesdeviceaddress areused.Everydevicehasitsowndeviceaddress,which weused toreceiveorsenddatafromthatdevice.



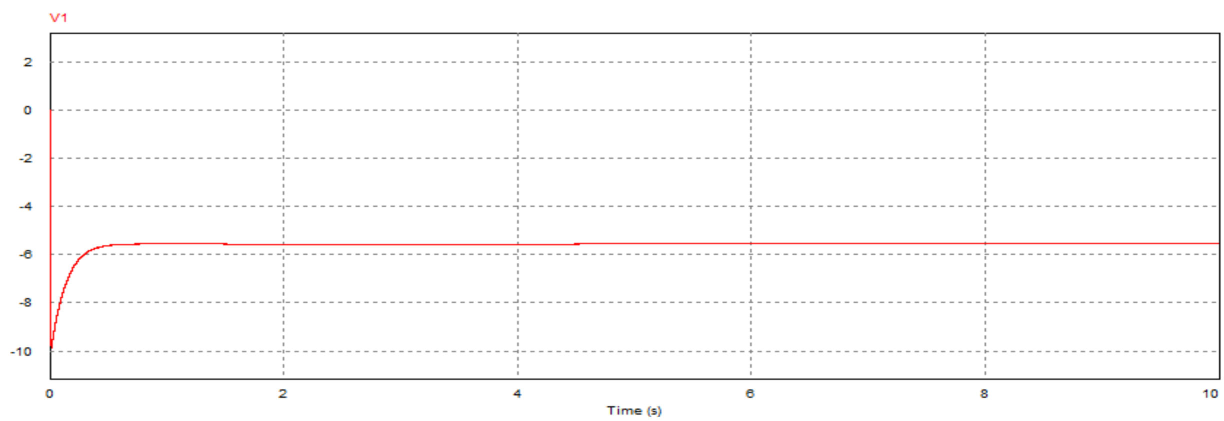
Receving DATA from Slave to Master



BUCK Converter Circuit



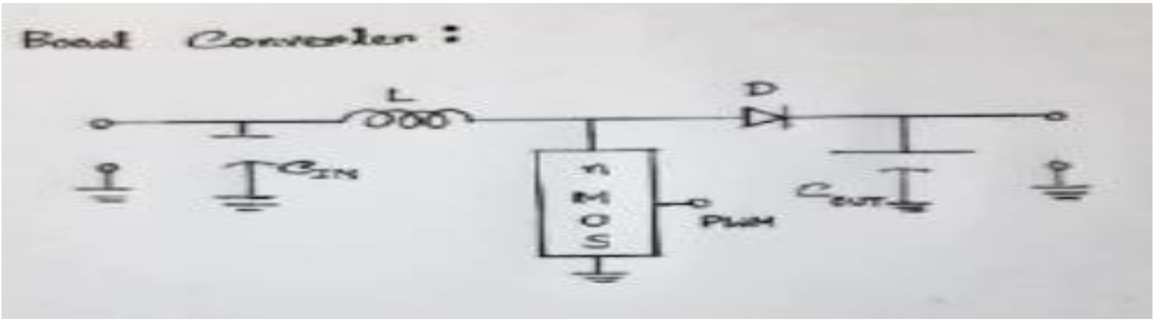
For easy understanding we are separating the circuit partwise and try to understand the operation ofeach part.



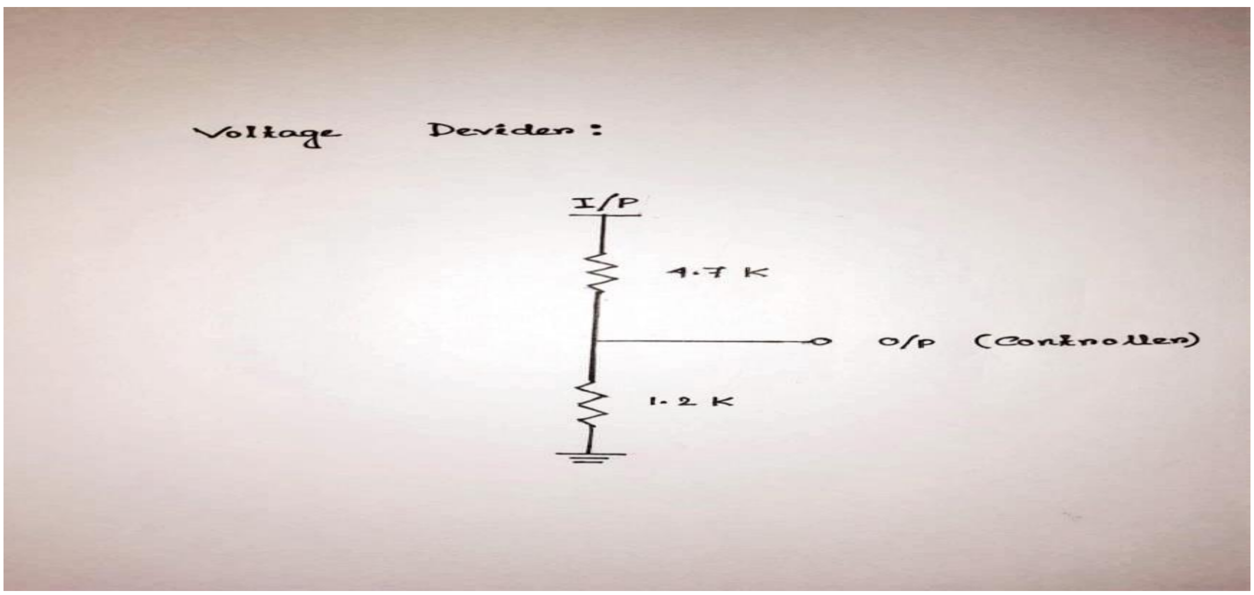
OutputvoltagewaveformwhenoperatingasBUCKConverter

The gate of PMOS is connected through 1kohm resistor to NMOS toground.Thistypeofarrangementisdonebecauseforahighinputatthegate terminal the NMOS becomes on and operates as switch, so it willconnect to the ground. By using voltage divider rule the voltage acrossthethePMOSwillbeverylessandthePMOSwillbeONandBUCKmodewilloperate.Thisarrangementisdonesothatthevoltagetothecontrollercanbe within5volt sothat it operates safely.

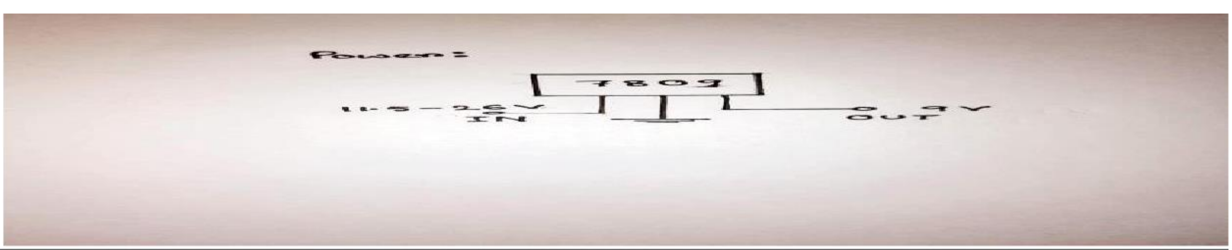
BOOST Converter



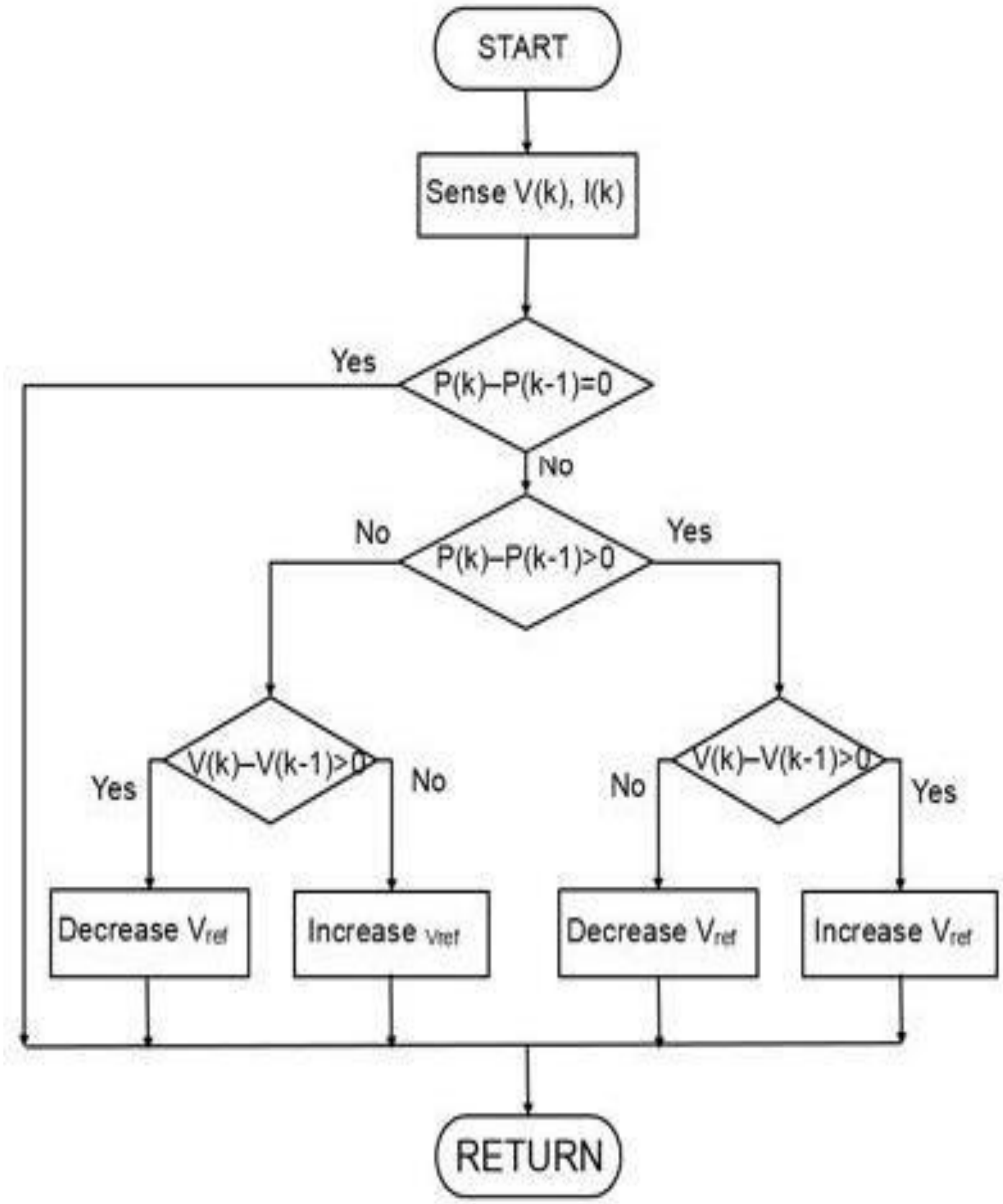
Voltage Divider



Power



FLOW CHART



START
Sense V(k), I(k)
P(k)–P(k-1)=0
Yes
No
P(k)–P(k-1)>0
No
Yes
V(k)–V(k-1)>0
Yes
No
V(k)–V(k-1)>0
No
Yes
Decrease Vref
Increase Vref
Decrease Vref
Increase Vref
RETURN

Result and Discussion

MPPT(Maximum power point tracker) logic is mainly usedis mainlyused to ensure the maximum power flow.So when the output voltageis less than the input voltage then the boost mode will on and increasetheoutputvoltagesosothatmaximumpowercantransfertotheload.Similarly when the output voltage is more than the input voltage thenthe buck mode will on and decrease the output voltage level so thatmaximumpowercan transferred totheload.

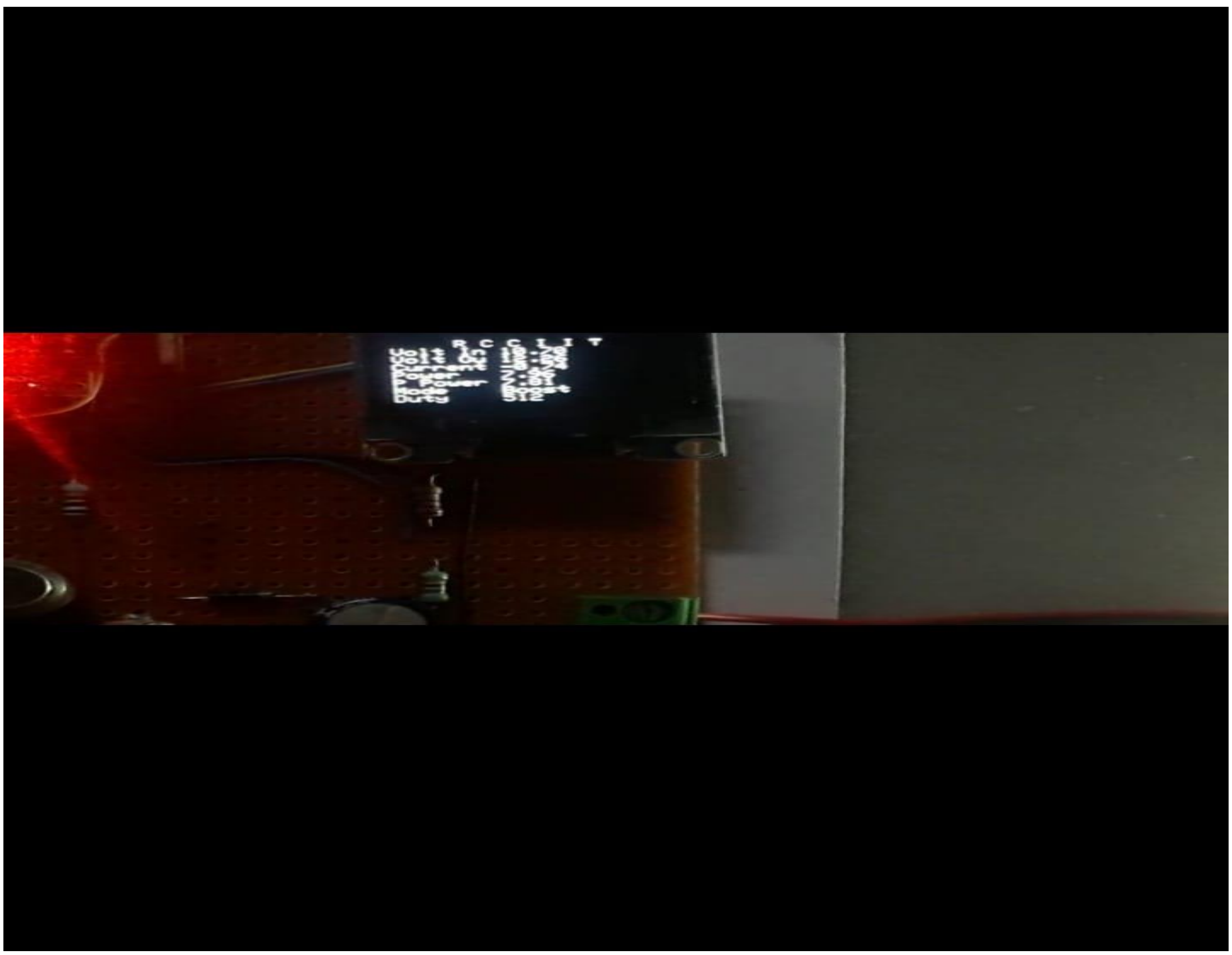


Fig:-Result showing the BOOST mode operation

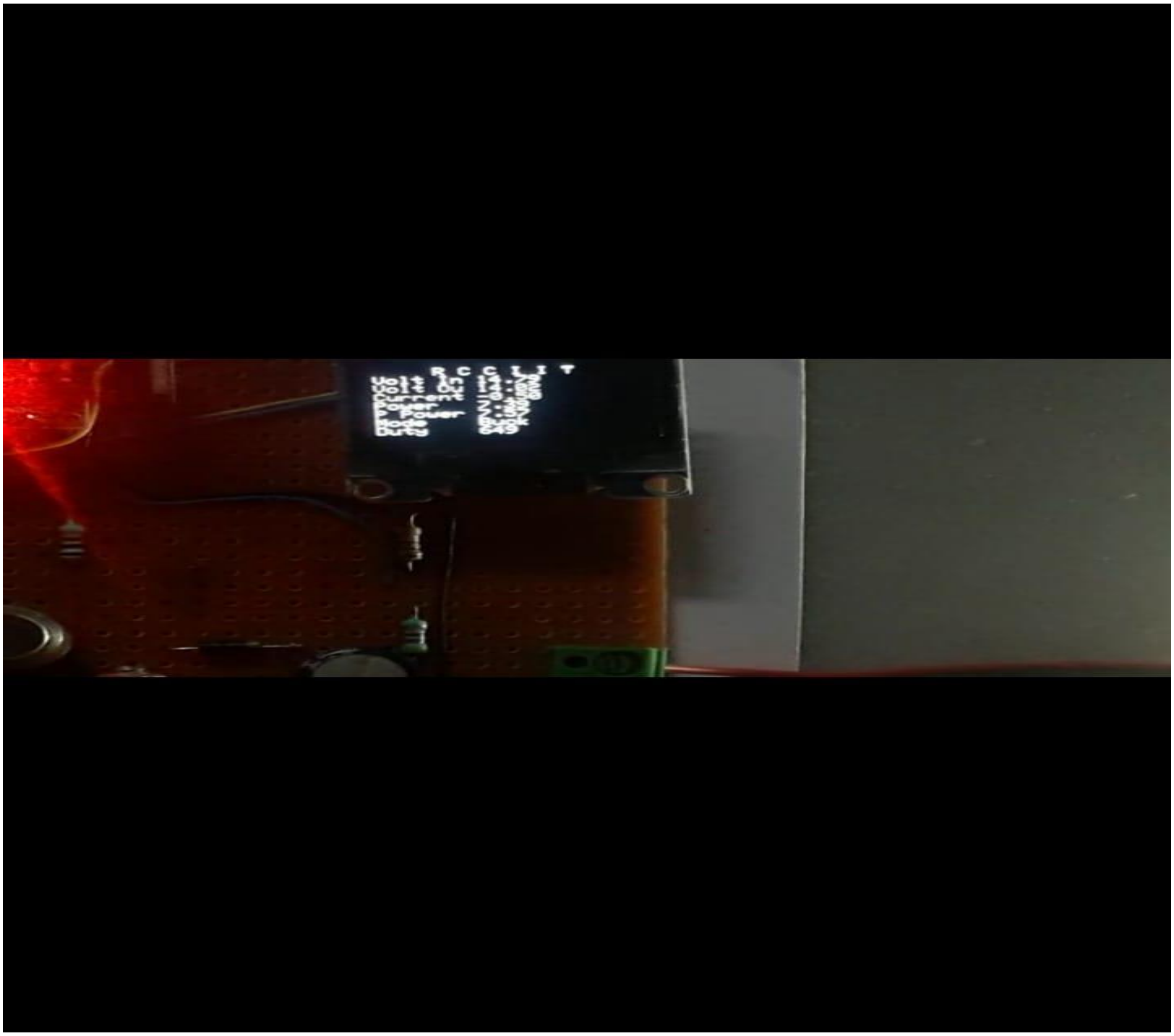


Fig:-Result showing the BUCK mode operation

Software Simulation ckt

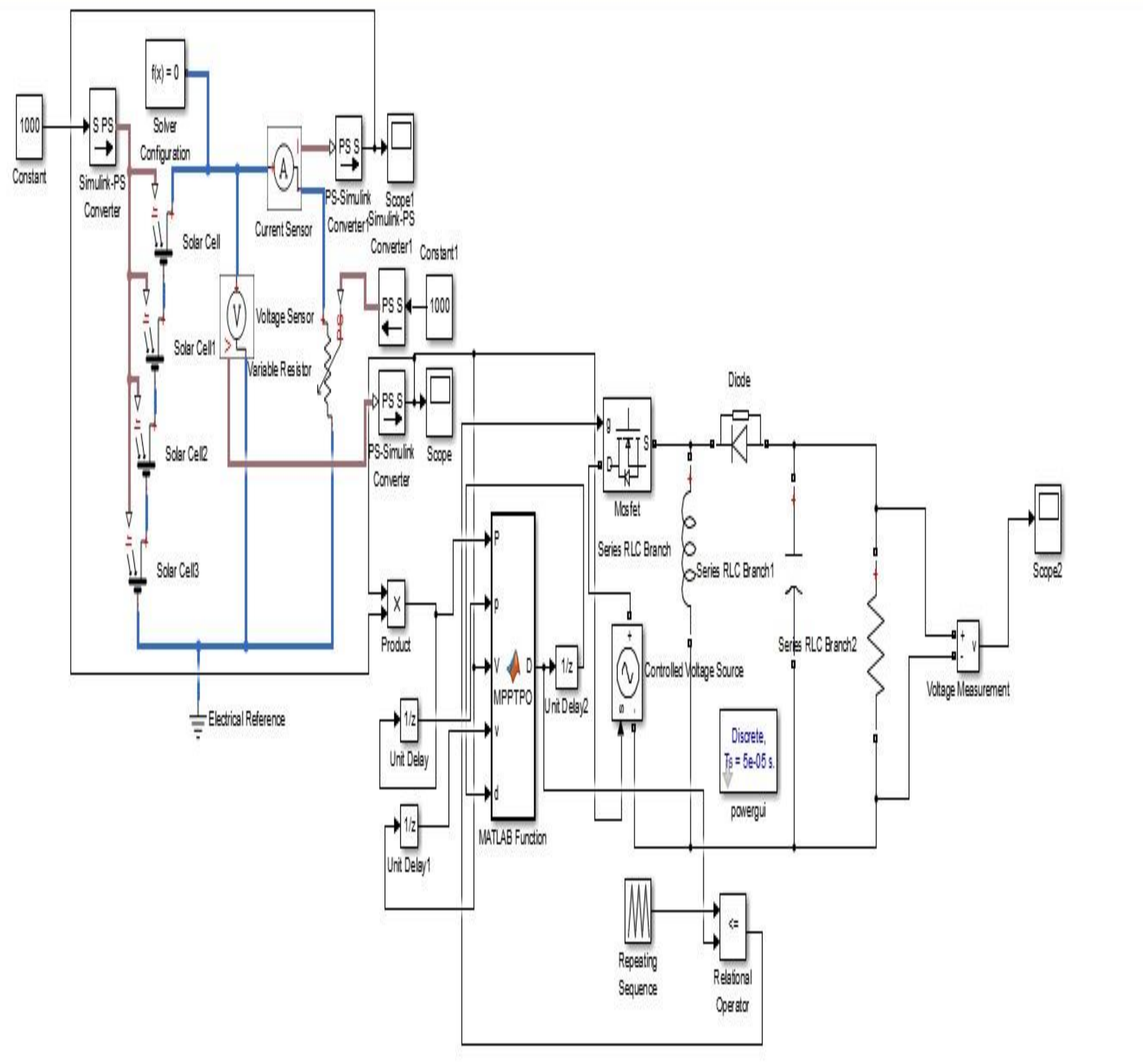


Fig:-Matlab Simulation ircuit Diagram

Simulation Components

MATLAB:- MATrixLABoratory is basically popularwith thenameMATLAB.InonesentenceMATLABis theLanguageof TechnicalComputing.

TheMATLABplatformisoptimizedforsolvingengineeringandscientific problems. The matrixbased MATLAB language is the world's most natural way toexpress computational mathematics. Built-in graphics make it easy to visualizeand gain insights from data. A vast library of prebuilt toolboxes lets us get startedright away with algorithms essential to our domain. The desktop environmentinvites experimentation, exploration, and discovery. These MATLAB tools andcapabilitiesareallrigorouslytestedanddesigned to worktogether.

Features of Matlab:-

Simulink:-Simulink® is a block diagram environment for multidomainsimulation and Model-Based Design. It supports simulation, automatic codegeneration,andcontinuoustestandverificationofembedded systems.

LanguageFundamentals:Syntax,operators,datatypes,arrayindexingandmanipulation

Mathematics: Linearalgebra,differentiationandintegrals,Fouriertransforms,andot hermathematics

Graphics: Two-andthree-dimensionalplots,images,animation,visualization**Data Import and Analysis**: Import and export, preprocessing, visualexploration

Programming Scripts and Functions: Program files, control flow,editing,debugging

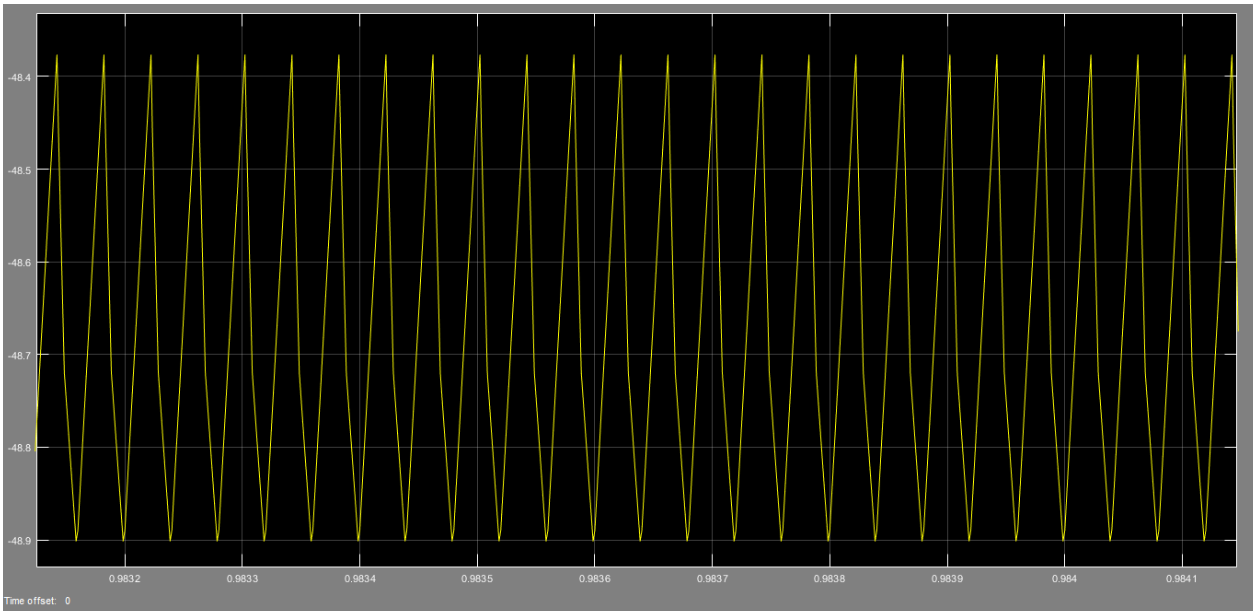
AppBuilding:AppdevelopmentusingAppDesigner,GUIDE,oraprogrammatic23| Pageworkflow

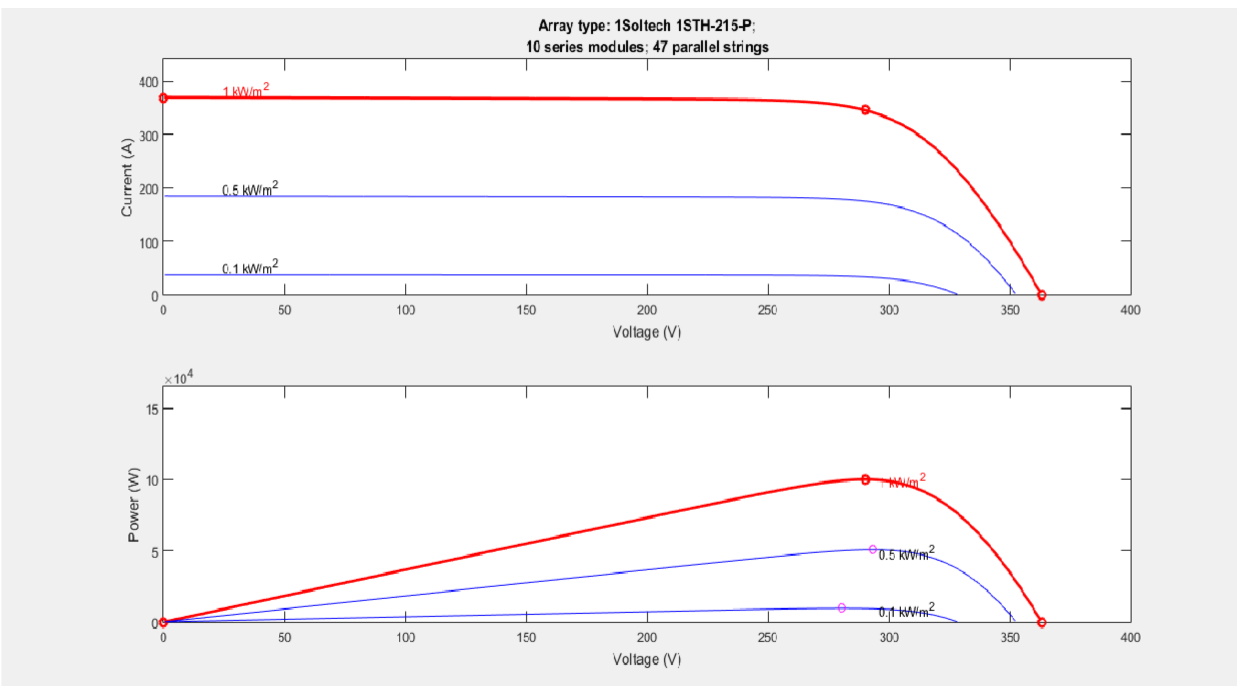
Advanced Software Development: Object-oriented programming; codeperformance; unit testing; external interfaces to Java®, C/C++, .NET and otherlanguages

Desktop Environment: Preferences and settings, platform differences**Supported Hardware**: Support for third-party hardware, such as webcam,Arduino®, and Raspberry Pi™ hardware. Also the MicroLab box can be used to gettherealtimeoutputfromtheSimulinkfiles

About Simulink: Simulink® is a block diagram environment for multidomainsimulation and Model-Based Design. It supports simulation, automatic codegeneration, and continuous test and verification of embedded systems. Simulinkprovides a graphical editor, customizable block libraries, and solvers for modelingand simulating dynamic systems. It is integrated with MATLAB®, enabling us toincorporate MATLAB algorithms into models and export simulation results toMATLAB for further analysis. To run the model in real time on a target computer,we made use of the Simulink RealTime™ for HIL simulation, rapid controlprototyping,andotherreal-timetestingapplications.Inthisproject,ourHardware and Software part both are based on Simulink. In the software part thewhole thing is simulated in Simulink and in the hardware part the control signal isalsogeneratedusingtheSimulinkfilebygettingarealtimeoutputusingMicroLabBoxand dSPACEsoftware

Simulation wave forms:-





Future Scope

The work that had been carried out by the researchers,the designing of MPPT controller, should be extended bytrackinglargernumberofinput parameterswhicharevaryingwithrespecttothetimesuchasparametersvariations of the system. In order to get accurate MPPTpoint,therecentmathematicalalgorithmssuchasZ-infinity algorithmsshouldbeimplemented.

There are several application of this project like Batterycharging. It is used in Hybrid power plant so that overallefficiencycanbeincreased.ThebuckmodecanbeusedinInverterapplication.Itisalsousedtoena bletheIOTmode.

Conclusion

From this project on Design and analysis of MPPT BUCK BOOSTConverter / Modelling of SPV system we can learnt about MPPTtheory,different typeofMPPT logic.We gatherclear
knowledge on BUCK BOOST converter, it's operation duringswitch on and switch offand can analyze the waveformsclearly. We get a clear vison on the hardware componentswhich have been used in this experiment. Different types ofcommunication protocols and their uses are now clear to us.WebecomefamiliarizeaboutI2Ccommunicationprotocol.Ourknowledge have been enhanced a lotby doing this projectUndertheguidanceofourmentorProf.Dr.AshokeMondal.
We are very much honoured to have him as a mentor and weare alsoverymuch thankfulto theentireElectricalDepartmentofRCCIITforgivingus thechanceto workonthisproject.

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