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An Optimization Incremental Conductance MPPT on Grid Connected Photo Voltaic System

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***Abstract*— This paper presents simulation of incremental conductance (IncCond) maximum power point tracking (MPPT) used in solar array power system. IncCond algorithm is used to track MPPs because it performs precise control under rapidly changing atmospheric conditions. MATLAB and Simulink are employed for simulation studies and extract maximum power with the optimization method of maximum power point tracking. MPPT is done by using the incremental conductance algorithm and track the maximum possible output power with the help of boost converter. Maximum power is measured at the output side of the boost converter by adjusting the width of the pulse. For every instant of time, instantaneous voltage and current from solar is measured and compared with the reference values**

Index terms -Incremental Conductance (IncCond), Maximum Power Point Tracking (MPPT), Photo Voltaic (PV) system.

I. INTRODUCTION

RECENTLY, energy generated from clean, efficient, and environmentally friendly sources has become one of the major challenges for engineers and scientists.Among all renewable energy sources, solar power systems attract more attention because they provide excellent opportunity to generate electricity while greenhouse emissions are reduced..It is also gratifying to lose reliance on conventional electricity generated by burning coal and natural gas.[1,2] Regarding the endless aspect of solar energy, it is worth saying that solar energy is a unique prospective solution for energycrisis.Solar energy has the advantages of maximum reserve, inexhaustibleness, and is free from geographical restrictions, thus making PV technology a popular research topic. In this world 80 % of the green houses gases are released due to the usage of fossil fuel.The world primary energy demand will have increased almost 60% between 2002 and 2030, averaging 1.7% increase annually, increasing still further the Green House Gases [2,3,4].

In addition, the power scalability of PV generation facilitates itslarge-scale penetration and leads to grid-connected applications ranging from few kilowatts of small residential PV systemsprimarily installed on roofs to several megawatts of large-scalePV power plants.

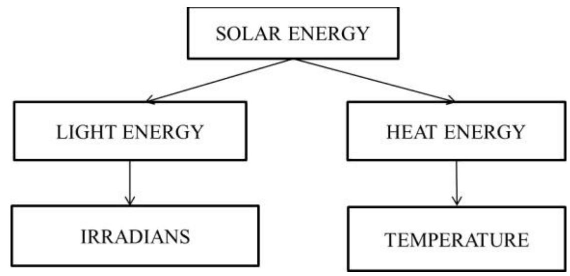

Figure 1.Block Diagarm of solar energy.

But the efficiency from PV Panel is poor in ranges between 20 to 30 % only due to 24-hr day, sunlight is only available for a limited time and depends heavily on weather conditions. There are two ways to increase the power coming from a photovoltaic array. One can add more panels to the array, which means an increase in area requirements and a great increase in cost for material. One can also attempt to make the existing array always work at its highest possible efficiency MPPT algorithm is included in charge controllers used for extracting maximum available power from PV modules under certain conditions. The voltage at which PV module can produce maximum power is called “Maximum Power Point” (or) Peak Voltage. Maximum Power varies with solar radiation, ambient temperature and solar cell temperature.

II. PV ARRAY

The Electrical Equivalent circuit of solar cell as shown in figure.2.aSolar energy is equivalent to a electrical source and a diode in anti-parallel in ideal case. With the practical case, resistance is connected in series and parallel. Practically resistance in parallel side is much greater than series resistance.

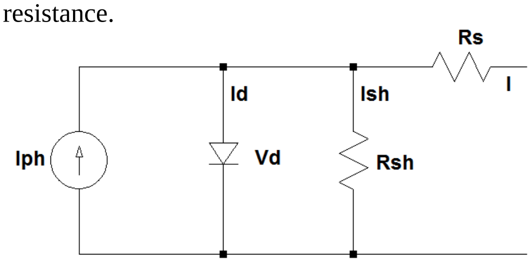

Figure 2.Electrical equivalent circuit of a solar cell.

The I-V characteristics of the equivalent solar cell model can be determined by following equations.The current through diode from schotky diode equation is given by:

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$I_d = I_s * [e^{(q*V / n.K.T)} – 1]$

$I_s = K*T^3*e^{(-Eg / k*T)}$

$I_{ph}= I_d + I_{sh}+ I$

$I_{Ph} = [I_{SC} + Ki(T - Tref)] * S/ 1000$

Ish = (V+I.Rs)/Rsh

I and V are the output current and voltage of the cell.

Iph is the generated photocurrent

Is is the reverse saturation current of the diode.

Id is diode current.

S is irradiation in W/m^2

q is the constant for the elementary charge (1.602*10^{-19} C)

K is Boltzmann’s constant (1.380*10^{23} J/K).

n is the Emission coefficient or Ideality factor

germanium n= 1;silicon n= 2

Eg is the band-gap energy of semiconductor

GermaniumEg= 0.744; silicon Eg= 1.17

T is the absolute temperature in Kelvin.

Tref is the reference temperature in Kelvin. [25 deg.c]

R_s: Solar cell series resistance (Ω)
R_{sh}: Solar cell shunt resistance (Ω)

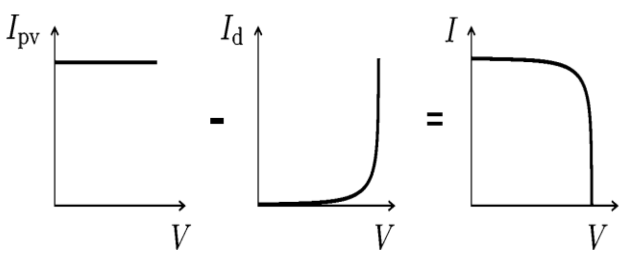

Figure 3.I-V characteristics of a PV cell.

III. MPPT ALGORITHM

In a 24-hr day, sunlight is only available for a limited time and depends heavily on weather conditions. There are two ways to increase the power coming from a photovoltaic array. One can add more panels to the array, which means an increase in area requirements and a great increase in cost for material. One can also attempt to make the existing array always work at its highest possible efficiency. The voltage at which PV module can produce maximum power is called “maximum power point”. In incremental conductance method the array terminal voltage is always adjusted according to the MPP voltage it is based on the incremental and instantaneous conductance of the PV module.

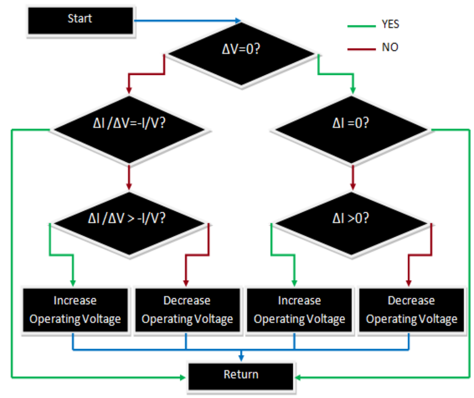

Figure 4.IC Algorithm-flow chart.

IV. BOOST CONVERTER

A DC-to-DC converter is an electronic circuit which converts a source of direct current from one voltage level to another. There are several different types of dc-dc converters, buck, boost, buck-boost and cuk topologies, have been developed to meet variety of application specific demands. The important requirement of any DC–DC converter used in the MPPT scheme is that it should have a low inputcurrent ripple. Buck converters will produce ripples on the PV module side currents and thus require a larger value of input capacitance on the module side. On the other hand, boost converters will present low ripple on the PV module side, so here in thisexperimental work, boost converter is used to verify the output power results.

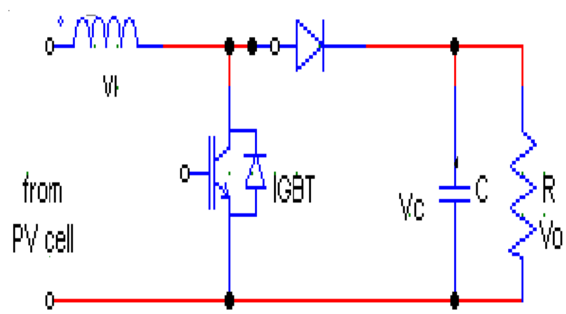

Figure 5. Boost converter representation.

The output voltage equation is given as follows
Output voltage [Vo] = Vin / (1-D) volts.
Where,

Vin- Input voltage applied from PV cell
D-Duty cycle.

V. INVERTER

Here three phase inverter is used to convert DC power from chopper into AC power and integrated to the grid. Symmetrical modulation PWM technique is used to drive the inverter circuit. As shown in fig.5 below the usual sinusoidal waveform is sampled at every interval of time. This symmetrical modulated technique shows the results compare with ordinary sinusoidal PWM technique with the help of MATLAB simulation as follows.

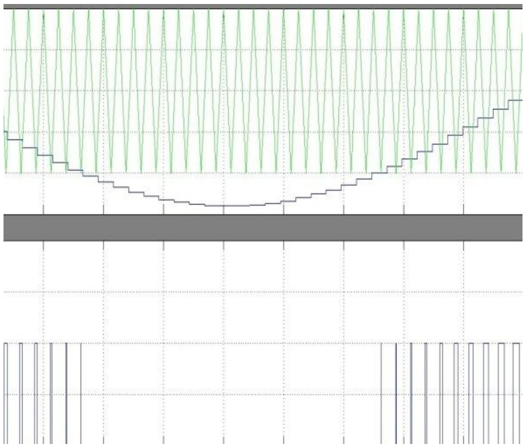

Figure 6. Symmetrical modulated PWM technique.

VI.MATLAB SIMULATION

Fig 7shows the simulation circuit ofIncCond MPPT of PV panel with inverter circuit. PV panel varies with respect to solar irradiation and temperature. Outputof PV panel is given to MPPT controller. Triggering pulse of MPPT controller is given toIGBT switch. Then the output is fed to the inverter.The entire system has been modeled onMATLAB™ 2010a.

S (irradiation) = 1000 W/m^2

T(absolute temperature) = 298 Kelvin.

R_s (Solar cell series resistance) =0.002 (Ω)
R_{sh}(Solar cell shunt resistance) = 500 (Ω).
L=0.2 mh; C= 1mf; R= 8 Ω.
Reference signal: f= 50 Hz
Carrier signal: f=4000 Hz

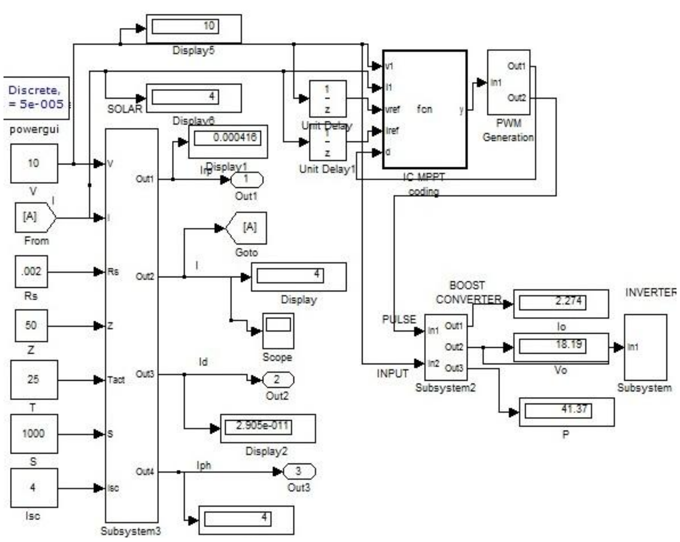

Figure 7. Simulation of PV system.

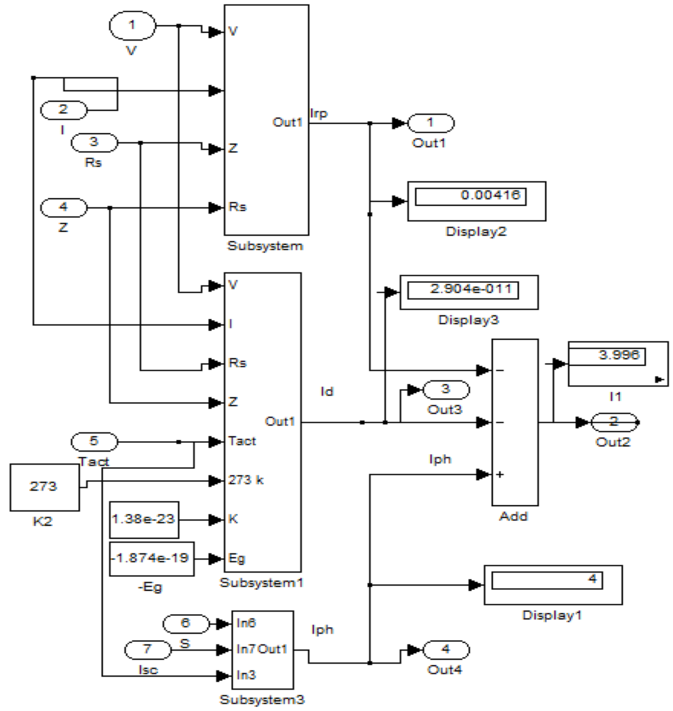

Figure 8. Simulation of PVModule.

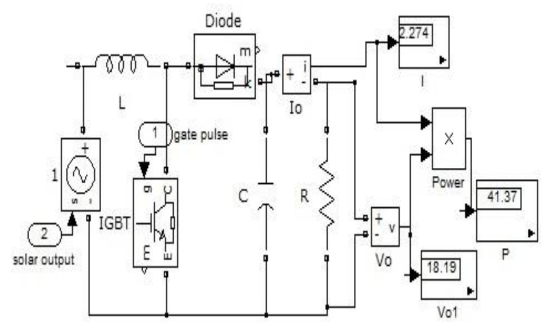

Figure 9. Simulation of Boost converter.

Table.1 COMPARISON TABULATION

S. NO	IRRADIANS [WATTS/M^2]	OUTPUT POWER	
		WITHOUT MPPT	WITH MPPT
1	1000	35.91	43.2
2	900	32.31	41.4
3	800	28.71	39.8
4	700	24.39	35.7
5	600	21.51	31.2
6	500	17.91	25.65

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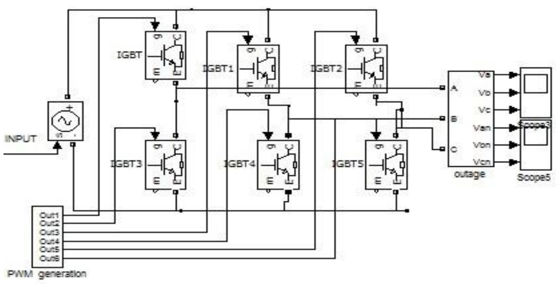


Figure 10. Simulation of Three Phase Inverter.

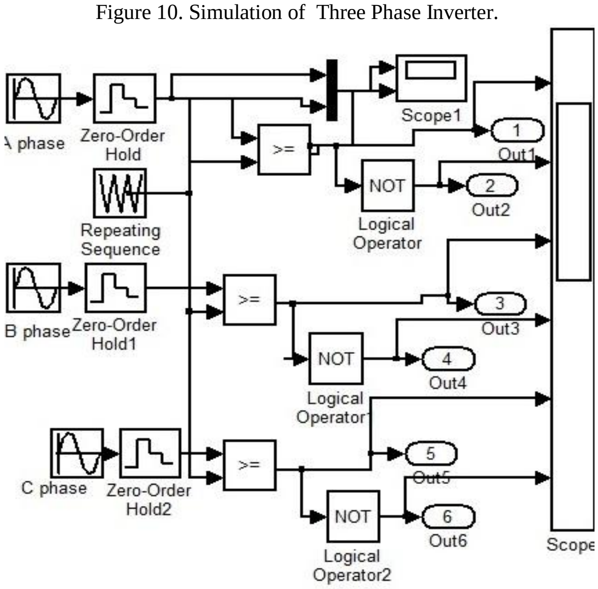


Figure 11. Simulation of PWM generation.

VII. SIMULATION RESULTS

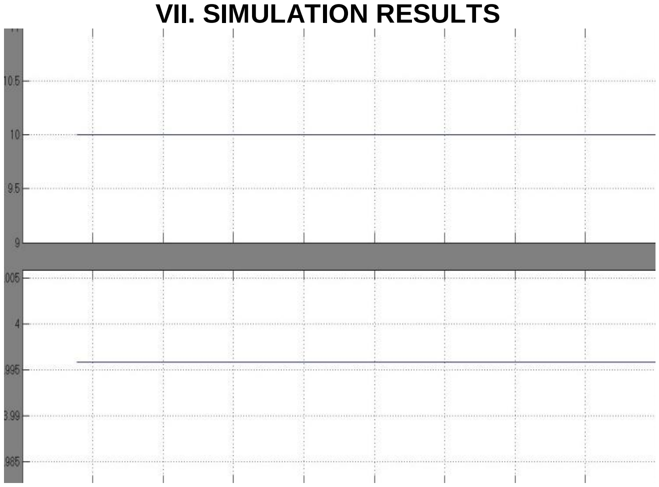


Figure 12. Simulation results of photo voltaic system

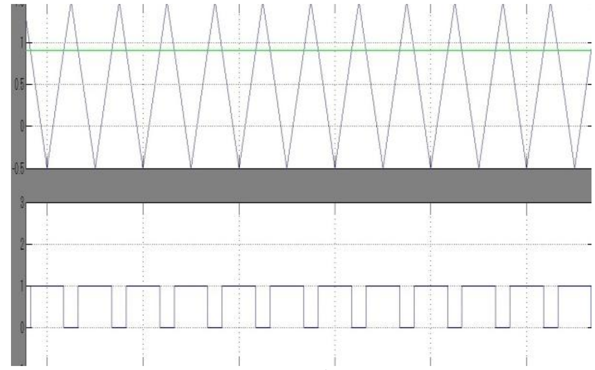


Figure.13. simulation of pulse generation.

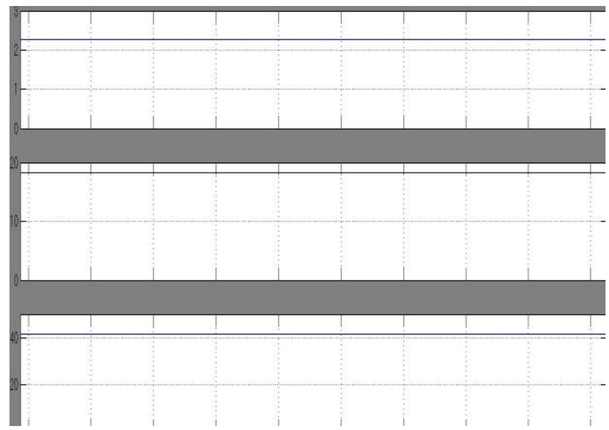


Figure 14. Simulation results of boost converter output.

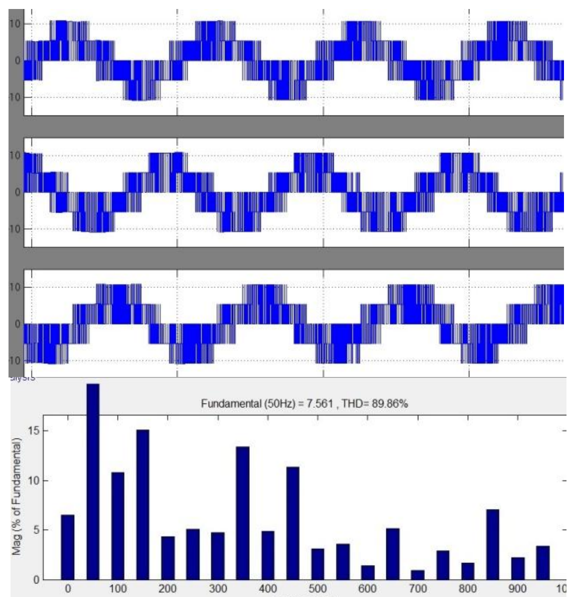


Figure.15. Inverter output& FFT Analysiswith
modulation index = 0.8 (without filter).

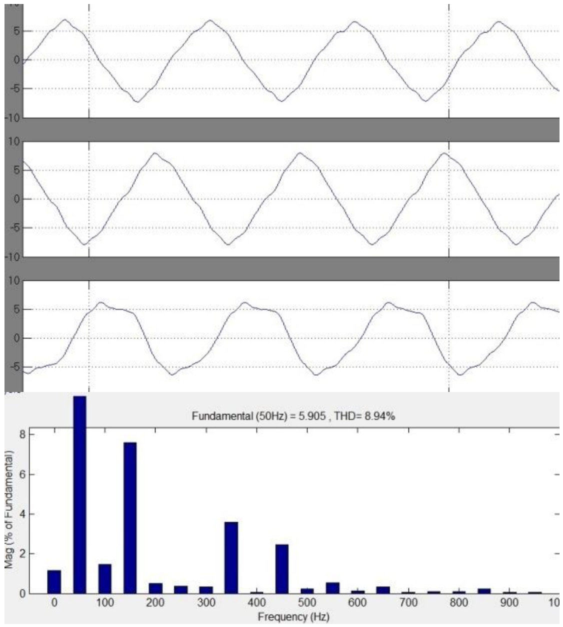


Figure.16Inverter output & FFT Analysis with modulation index = 0.8 (with filter)

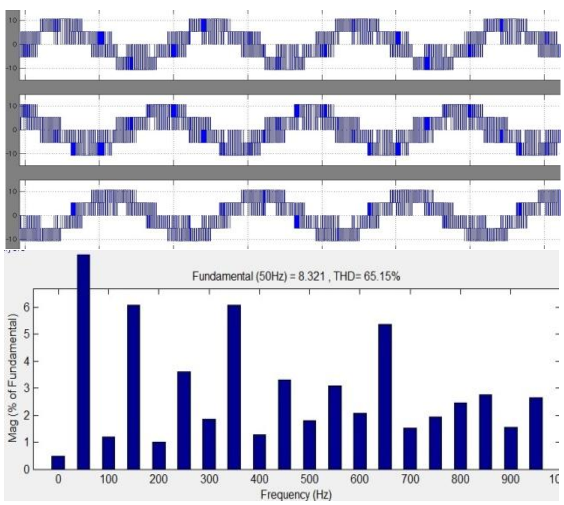
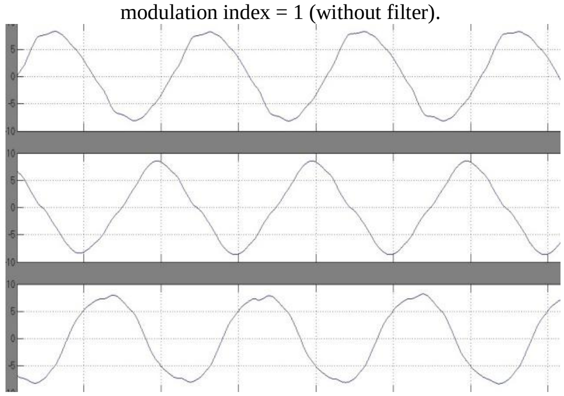


Figure.17Inverter output & FFT Analysis with modulation index = 1 (without filter).



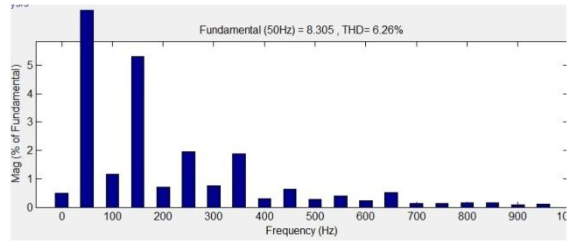


Figure.18 Inverter output & FFT Analysis with modulation index = 1 (with filter)

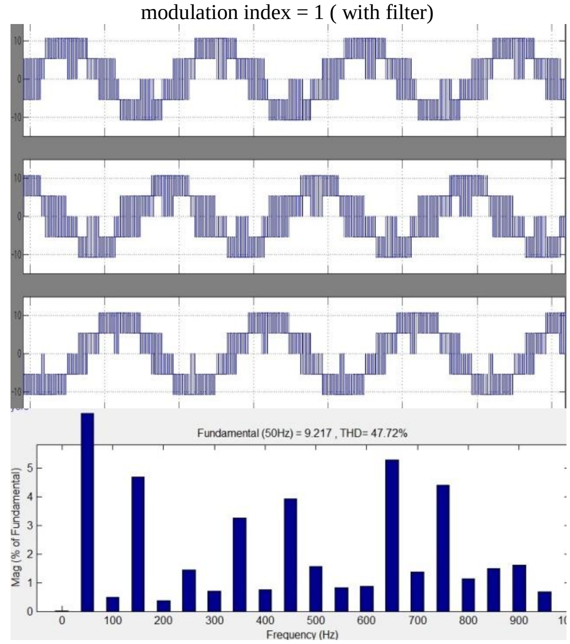


Figure.19 Inverter output & FFT Analysis with modulation index = 1.2 (without filter)

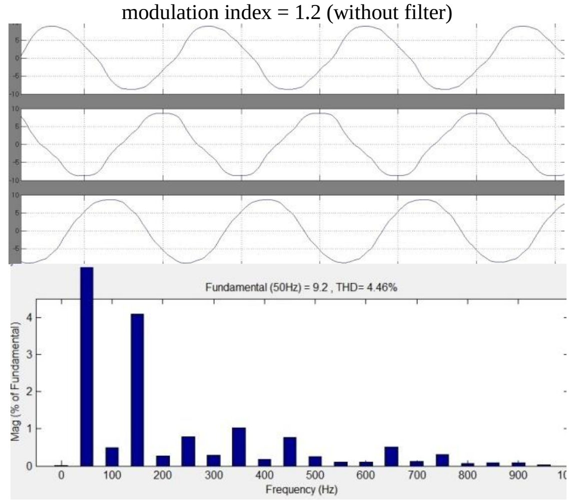


Figure. 20 Inverter output & FFT Analysis with modulation index = 1.2(with filter).

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Table.2 COMPARISON TABULATION OF INVERTER WITH FFT ANALYSIS

S. NO	MODU LATION INDEX	WITHOUT FILTER		WITH FILTER	
		FUNDA MENTAL RMS (VOLTS)	THD (%)	FUNDA MENTAL RMS (VOLTS)	THD (%)
1	0.6	4.74	121.6	4.73	10.3
2	0.8	7.56	89.86	5.9	8.94
3	1	8.32	65.15	8.3	6.26
4	1.2	9.21	47.72	9.2	4.46
5	1.4	9.602	46.21	9.58	3.21

VIII. CONCLUSION

This paper has presented analysis of MPPT Incremental Conductance Controller. This paper mainly focuses on analysis of solar panel with standard values of insulation and temperature has been included in the simulation circuit. Thus the simulation results were verified for the output power of solar with and without using the MPPT (incremental conductance algorithm) technique and the power is increased. Under rapidly changing atmospheric conditions the algorithm perform better results. But the convergence time taken by this algorithm is higher than P & O method.In SMS-PWM, inverter operated in over modulation region, shape of the waveform was improved [reduced the harmonic level] and increases the RMS output voltage. The drawback is that, THD will be higher with the modulation index is less than 1.[Ma < 1]. The comparison tabulation shows the FFT analysis of three phase inverter with and without using the filter. With the development of multi level inverter THD will be reduced.

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