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Design of PV cell power system for Rural Areas (5 village) of C.G India

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Abstract - *Sun is the most promising option available as a renewable source for electricity generation. The paper study and demonstrates, the behavior of the power system which is connected directly to solar energy. In the proposed scheme Solar PV cell will be used to supply 5 villages of District Gariyaband (C.G) India in which PV module will capable of producing that amount of electricity which required by 5 villages at day and night, the amount of electricity required at night will also generated and given to grid and those 5 villages by pv module in day time but at night time it will taken only from the grid. So that approximately zero billing can done for the those villages. The whole system is designed and simulated in MATLAB (simulink).*

***Key Words*: *IGBT, Photovoltaic, Matelab, Grid ,filter*…**

I. Introduction

As in developing country the demand of electricity is increasing day by day. To have sustainable growth and social progress it required to generate more electricity. Now a day, we are using a large amount of non renewable sources like fossil fuels to meet the heavy demand of electricity. But the burning of fossil fuels emits large amount of harmful gases in the atmosphere which directly or indirectly affects environment and living creatures around us. And decreasing quantity of fossil fuel push us in the search of alternate source for energy . So in this we are using renewable energy sources in addition to non renewable sources in order to meet the increasing demand of electricity and reduce the dependency on non renewable sources. By this the affect of dangerous gases can also be limited to a safe extent.

Solar PV system is connected to grid act as inverter that convert direct current electricity from PV module into AC PV system connected to grid extra energy is transfer to grid after fulfilling 5 village of C.G. If PV module is not capable to full fill the local demand extra required energy is taken from grid .PV system act as alternative resource of energy and local as increasing demand is full fill. First electrical power is generated from PV panels irradiance is fed to pv array panel with convert solar energy into electrical energy.

The electrical energy which is generated from pv array panel is in dc nature to convert it from dc to ac universal bridge is use with contain three pair of IGBT and IGBT is given a gate pulse with the help of voltage source converter which is used for enforcing ac voltage by matching frequency and phase of the grid. And with the help of step up transformer voltage is match and supply to utility grid by connecting a circuit breaker for protection.

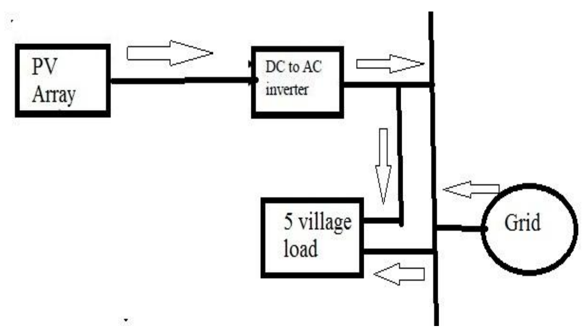

Fig. 1 :- Basic structure of load connected PV system

Model of PV module with a diode

PV cell basic structure is given

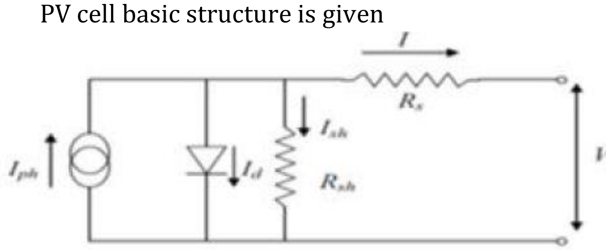

Fig. 2: Electric model of solar cell

$$I = -I_{ph} + \frac{V-RsI}{Rsh} + Is\left(\exp\left(\frac{q(V-RsI)}{AKT}\right) - 1\right) \quad (1)$$

With:
I → Current supplied by the cell .
V →The terminal voltage of the cell [V].
Iph→ The photo-current , which is proportional to the irradiance.
Is → Saturation current of diode , the temperature dependent.
Rs → Series resistance [Ohm].
Rsh → Shunt resistance (or parallel) [Ohm].
q → Electron charge = 1,602.10-19 Coulomb.
k → Boltzmann constant = 1,38. 10-23 J/K
A → Ideality factor of the diode.
T → Effective temperature of the cell taken as 30^0C

Table 1

Model parameter for module

Rs	0.037998 Ohm
Rp	993.51 Ohm
Is	$1.1753*10^{-3}$ A
Iph	5.9602 A
Qd	1.3

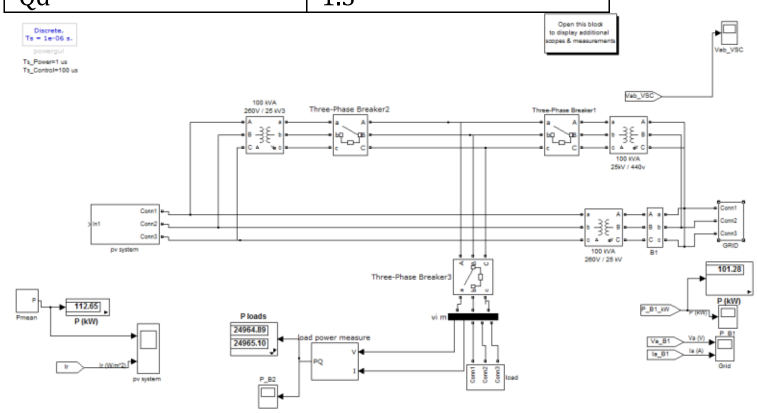

Fig 3: MATLAB DIGRAM FOR DESIGNED SYSTEM

II. Design of system step by step

PV system

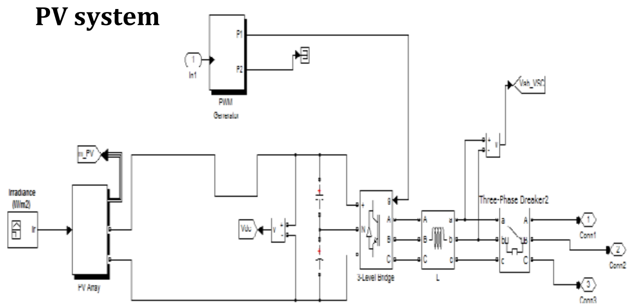

Fig 4: MATLAB DIGRAM FOR PV SYSTEM

LOAD OF 5 VILLAGE

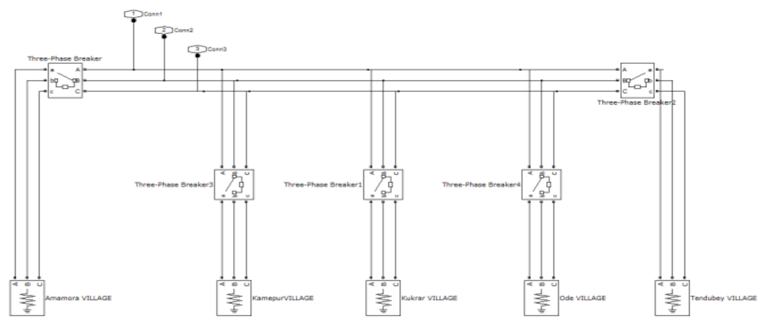

Fig 5 : MATLAB DIGRAM FOR LOAD SUB SYSTEM

GRID

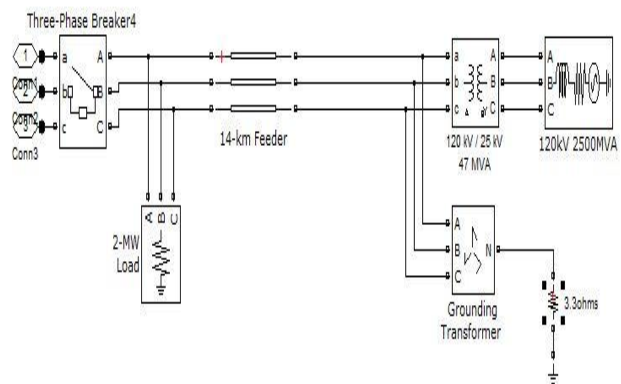

Fig 6: MATLAB DIGRAM FOR GRID SUB SYSTEM

The design Parameter for the above figure are

fig 3: (MATLAB DIGRAM FOR DESIGNED SYSTEM)Show the Simulation of system made in MATLAB in which pv SYSTEM generate 100 KW of electrical energy which is at 260 volt and then with the help of a transformer 260 volt AC in converted to 25KV which is connected to grid on the other hand PV module is also connected to a 260/440 volt transformer with the help of circuit breaker to supply load and a power measurement is done so that we can calculate supply load.

An another transformer is connected to grid which convert 25/440 volt so at night time when PV system is not capable to supply load energy is taken from grid.

fig 4:(MATLAB DIGRAM FOR PV SYSTEM) Show that PV module generate100 KW energy and it is fed to inverter the output of the inverter is 260 V AC

The 100 KW solar voltaic system is designed. For this ,the solar module of nominal voltage 54.7 volt is used so 8 solar panel are required in series to attain 450 volt .Hence the series string offer nominal voltage of 450 volt to be in safer side the system design is done for 100 KW.

Table 2

Model parameter for PV module

Power	100KW		
Voltage at peak power	500 V		
Current	200 A		
PV module Specification			
P_m(Max power)	305.2 W		
Vmax	54.7 V		
Imax	5.58 A		
$V_{o.c}$	64.2		
$I_{s.c}$	5.96		
Max Power of PV Module($P_{max} = v_{max} * I_{max}$)	54.7*5.58= 305.2 W		
PV Module Parameter	Symbol	Value	Unit
PV Array power requirement	P_{max}	100	KW
PV Module Array open circuit voltage at peak power	V_{max}	500	v
PV Module array current at peak power	I_{max}	200	A
No of PV Module to be connected in series and parallel			
No of PV module to be connected in series	8	Ns	
No module connected in parallel	66	Np	
New value of PV array voltage	Vmax new=Vmax*Ns=8*54.7=437.2 Volt		
New value of current	Imax new=Imax *Np=66*5.58=170 A		
Maximum power of single PV module	Vmax*Imax=305.2 W		
Maximum Power of PV module Array	Pmax=305.2*5*66=100650 W		

Inverter

1650-Hz (33*50) 3-level 3-phase VSC

The VSC converts the 500 V DC to 260 V AC and keeps unity power factor

For fig 5:(MATLAB DIGRAM FOR LOAD SUB SYSTEM)
We have done survey to find out load for 5 village of Gariyaband C.G India

Fig 6:(MATLAB DIGRAM FOR GRID SUB SYSTEM) Grid sub system model (25-kV distribution feeder + 120 kV equivalent transmission system)

Table 3
Village Amamora

Name of Village, Block & District	Village Amamora, Gariyaband Block Office, District Raipur
Distance from nearest rail-head	165 km from Raipur
Distance from electrical sub-station/11 KV line	32 km
No. of households	72

Table 4

Details of solar energy availability and electrical demand

Solar	Average annual insolation, clear sunny days in year	5.4 kWh/m^2
(a)	Household loads	8.6 kWe, street lights – 0.19 kWe
(b)	Commercial loads	Rice Huller at 7.5 kWe

Table 5
Village Kamepur

Name of Village, Block & District	Village Kamepur, Gariyaband Block Office, District Raipur
Distance from nearest rail-head	123 km from Raipur
Distance from electrical sub-station/11 KV line	3 km
No. of households	60

Table 6
Details of solar energy availability and electrical demand

Solar	Average annual insolation, clear sunny days in year	5.4 kWh/m^2
(a)	Household loads	7.2 kWe, street lights – 0.16 kWe
(b)	Commercial loads	2 Nos. Leaf Cup and Plate making – both at 300

Table 7
Village Kukrar

Name of Village, Block & District	Village Kukrar, Gariyaband Block Office, District Raipur
Distance from nearest rail-head	165 km from Raipur
Distance from electrical sub-station/11 KV line	32 km
No. of households	71

Table 8
Details of solar energy availability and electrical demand

Solar	Average annual clear sunny days in year	5.4 kWh/m^2
(a)	Household loads	8.5 kWe, Street lights – 0.187 kWe
(b)	Commercial loads	2 Nos. Leaf Cup and Plate making – both at 300

Table 9
Village Ode

Name of Village, Block & District	Village Ode, Gariyaband Block Office, District Raipur
Distance from nearest rail-head	157 km from Raipur
Distance from electrical sub-station/11 KV line	24 km
No. of households	52

Table 10
Details of solar energy availability and electrical demand

Solar	Average annual insolation,clearsunny days in year	5.4 kWh/m^2
(a)	Household loads	6.2 kWe, Street lights – 0.85 kWe
(b)	Commercial loads	Oil Expeller – both at 7 kWe

Table 11
Village Tendubey

Name of Village, Block & District	Village Tendubey, Gariyaband Block Office, District Raipur
Distance from nearest rail-head	124 km from Raipur
Distancefromelectrical substation/11 KV line	7 KM
No. of households	83

Table 12
Details of solar energy availability and electrical demand

Solar	Average annual insolation, clear sunny days in year	5.4 kWh/m^2
(a)	Household loads	9.9 kWe, Street lights–0.21kwe
(b)	Commercial loads	Oil Expeller – both at 7 kWe

Table 13

Load of 5 village

NAME OF VILLAGE	TOATAL NO OF HOUSE	TOTAL LOAD FOR VILLAGE(KW)
Amamora	72	16.29
Kamepur	60	7.36
Kukrar	71	8.687
Ode	52	7.05
Tendubey	83	12
	TOTAL	51.387

Table 14

Monthly Energy production

MONTH	RADIATION IN KWH/M2/MONTH	SYSTEM CAPACITY	AVERAGE SUNSHINE(IN HOURS/DAY)	MONTHLY POWER GENERATED(KWH)
JAN	4.39	100KW	7.2	22320
FEB	5.27	100KW	7.7	21560
MAR	5.98	100KW	7.1	22010
APRIL	6.64	100KW	8.8	26400
MAY	6.43	100KW	12.5	38750
JUNE	4.86	100KW	2.7	8100
JULY	3.89	100KW	2.8	8680
AUG	3.75	100KW	2.8	8680
SEP	4.22	100KW	5.9	17700
OCT	4.96	100KW	4.1	12710
NOV	4.64	100KW	6.8	20400
DEC	4.3	100KW	7.0	21700
AVERAGE	4.93	100KW	6.28	19084.16

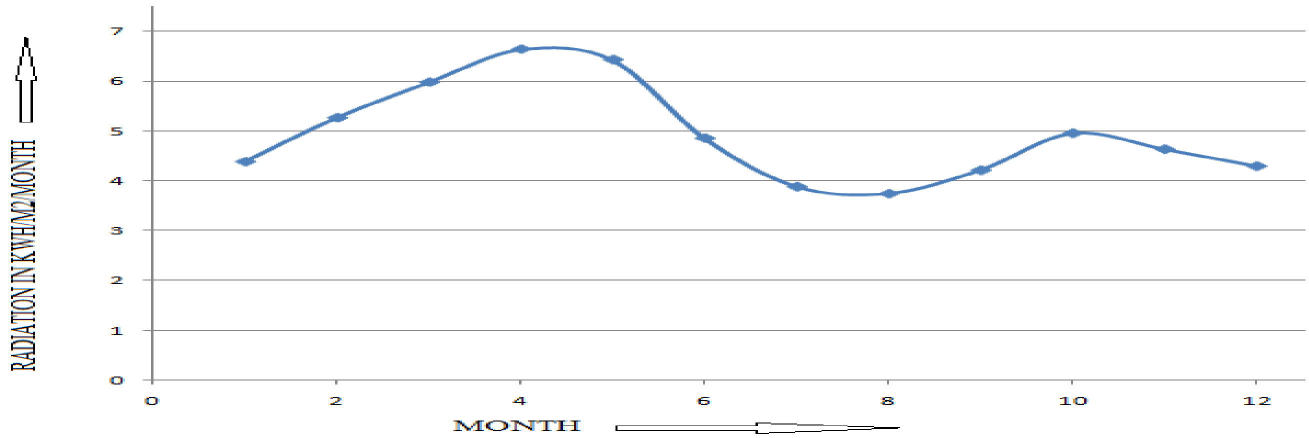

Fig 7: Graph Monthly Energy production

III. Simulation Results

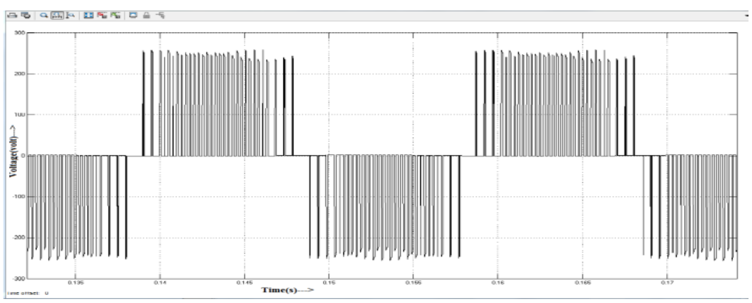

Fig 8: Inverter output

PV power

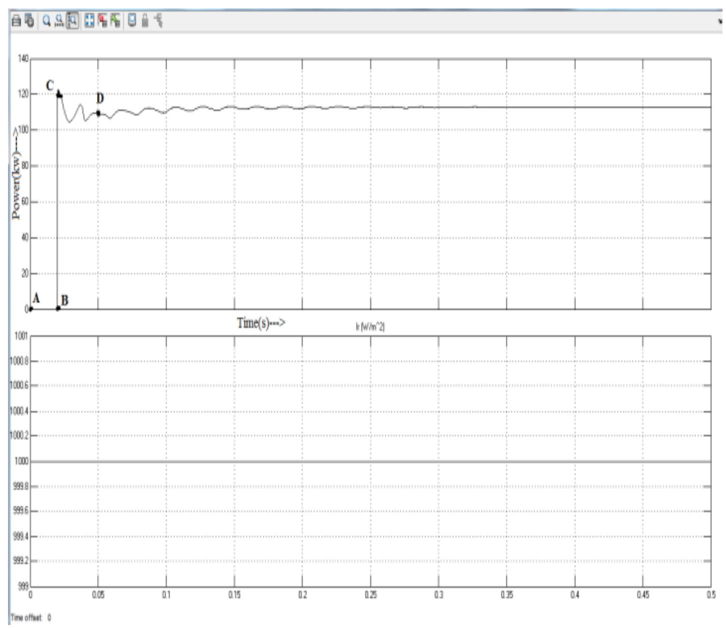

Fig 9: PV power develop

We analyze that the output power remains zero from A to B and B to C is of transient nature and between C to D its start moving towards a steady state condition of 116 KW.

GRID POWER

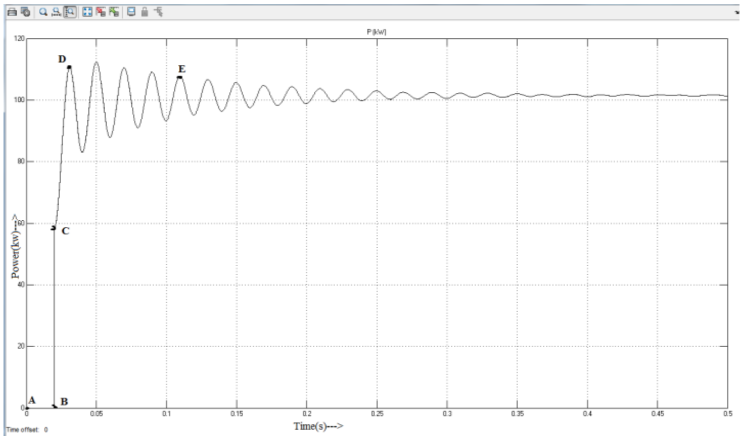

Fig 10: grid power

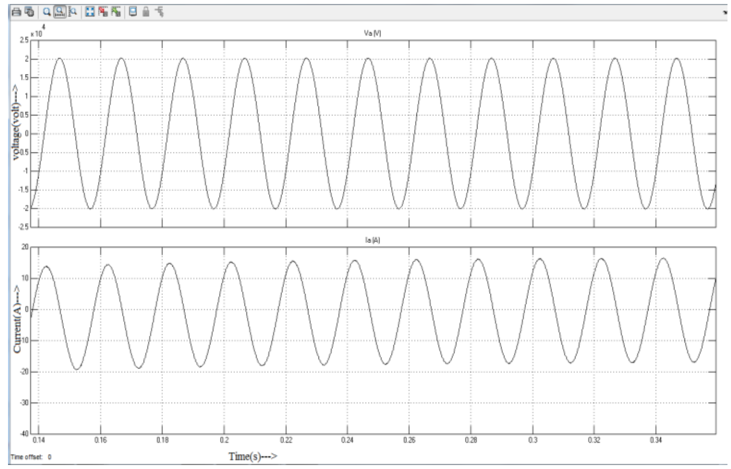

Fig 11: grid current & voltage

We see that grid power is zero from A to B than there is a transient increase in power from B to C after that a gradual linear increase between C to D which result in attenuation of grid power from D to E.

GRID CURRENT AND VOLTAGE

IV. Conclusion

This paper presents the design of power system using pv cell for five villages of Chhattisgarh. The increasing demand of electricity is maintained by solar cell connected to grid directly. The operation of the power system connected to grid in addition to the pv cell is simulated by using Matlab simulink. In it solar energy is consumed by villages during day time and the remaining generated energy is delivered to grid. At night the amount of energy delivered to grid during day is consumed. This results in approximately zero billing at villages. This has a large scope in future due to problem of supplying energy in large distance low density areas.

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