CHAPTER FOUR

RESULT

4.1 Introduction:

In order to design a PV system by analytic method, equations in chapter three will be used. Then yield energy would be calculated by equation (3.14), then I-V, P-V curves results would be shown as a plot and analysis data of a modified IEEE 9 Bus testing grid performance would be done. At least when PV system is connected with the grid the performance of the new system would be shown by tables (4.2) (4.3) and plots in figure (4.7) and (4.8).

4.2 On Grid PV System Design:

A full design of on grid PV system is introduced below.

4.2.1 Inverter Sizing:

Since the inverter sizing must be equals the total watts, so choosing inverter operates in a range proportional to totals watts range. Choosing inverter operates in 225 KW. The specifications are attached in Appendix.

4.2.2 PV Array Sizing:

The ambient temperature for PV system located place is 46°C, So maximum effective cell temperature is equals 71°C.

According to the specifications of modules (specifications are attached in APPENDIX B.1.), maximum power voltage is 29.53 V and voltage temperature coefficient is 0.3 V/°C.

The efficiency of dc cable is 0.97.

To determine reducing in voltage at the maximum effective cell temperature by using equation number (3.1).

Vmp @ 71°C= 33.66V.

From inverter specifications, the MPPT range @ operating voltage is 36.55 V.

By using equation number (3.2), the minimum voltage allowed at inverter is 29.53V.

By dividing the result in equation number (3.2) by the result in equation number (3.1) we get the minimum number of module strings and recommended the result is always rounded up. So the minimum number of module strings is 1.14 ≈ 2modules.

The minimum temperature for this location is 12°C and so the minimum effective cell temperature equals13°C.

According to the modules specifications, open circuit voltage is 36.55V and voltage temperature coefficient is 0.3V/°C .By using equation number (3.3) the increasing at minimum effective cell temperature equals 40.45V.According to inverter specifications, max PV array open circuit voltage (V_{co}) is 110V and by using equation number (3.4) the maximum voltage allowed at inverter equals 104.5 V.

By dividing the result from equation number (3.4) by the result from equation number (3.3), we get the maximum number of modules and recommended the result is always rounded down. So the maximum number of modules equals 2.5 ≈ 2modules.

According to the modules specifications, the short-circuit current at STC is 8.26A and the Isc temperature coefficient is 0.04A/°C and the module temperature at a specified temperature is 71°C.

By using equation number (3.5) the short circuit current (I_{sc-mod}) equals 10.1A.

According to the inverter specifications, the maximum power (P_{max}) is 201KW and power factor (PF) is 1 and max PV array open circuit voltage (V_{co}) is 110V.

By using equation number (3.6), the maximum dc input current equals 1827.27A.

We get the number of strings by dividing the result from equation number (3.6) by the result from equation number (3.5) and recommended the result is rounded down. So the number of strings= 180.91 ≈ 181 strings.

According to the inverter specifications, Maximum inverter rated power is 201 kW the peak power of modules used in this design.

4.2.3 Cable Sizing:

Usually the voltage drop over the array cable (Dc cable) is 3% and the voltage drop over Ac Cable is 1%.

4.2.4 Energy Yield:

According to data sheet of modules, the manufacturing tolerance is 3% and temperature de-rating factor is 0.057 and dirt tolerance is 3%, so de-rating factor for dirt equals 0.97.

By using equation number (3.10), the actual DC energy from the solar array =572693.059 Wh.

Efficiency of the subsystem (cables) between the PV array and the inverter equals 0.97.By using the equation number (3.11), the DC system output energy =2412000 Wh.

According to the specifications of inverter, the inverter efficiency is 97%.

Therefore by using the equation (3.12), the AC energy delivered from the output of the inverter =2339640 Wh.

Efficiency of subsystem (cables) between the inverter and the grid (switchboard) is 99%.Therefore by using equation number (3.13), the AC energy from the inverter (and originally from the array) that will be delivered to the grid =253500 Wh.

4.2.5 Specific Energy Yield:

By using equation number (3.14), the specific energy yield =253500 KWh=194104.135 KW.

4.2.6 Performance Ratio:

By using equation number (3.16) the, ideal energy output of the array=216225W

And by using equation number (3.15), the performance ratio=92.95%.

4.2.6 Performance Ratio:

4.3.1 I-V Curve:

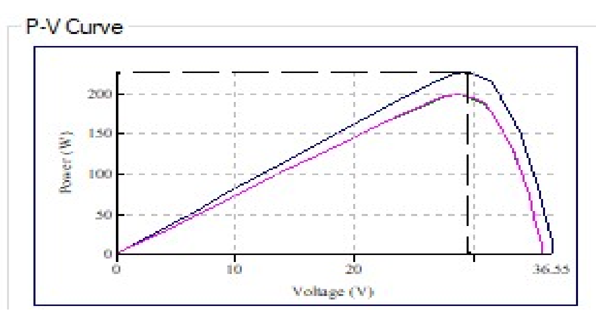

Figure (4.1)

4.3.2 P-V Curve:

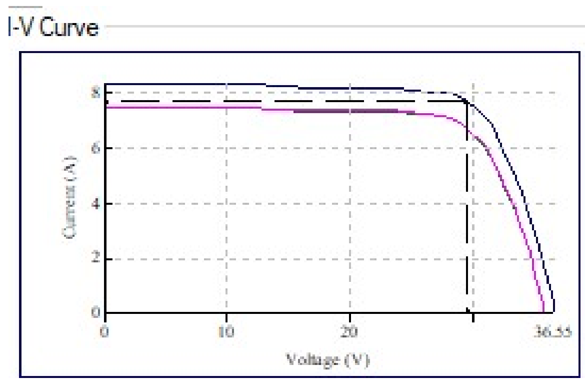

Figure (4.2)

4.4 Load Calculations:

The consensus is to add wattage of the equipment that is going to be powered using the PV system so make table and fill it with data. Other data that needs to be entered is number of each appliance that is going to be used and number of hours the appliance is supposed to remain ON. Then you can calculate total energy consumed or the wattage of PV system. See the table (4.1).

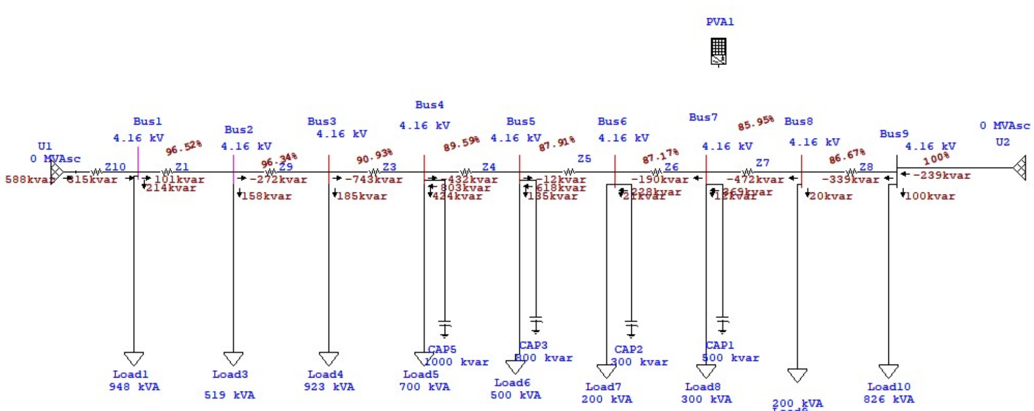

Figure (4.3)

Figure (4.3): shows L.F analysis before connecting PV system

Table (4.1): shows result of load flow analysis before connecting PV:

	Reg % 1	Voltage KV	P losses 1 KW	Q losses 1 KVAr
Bus 0		4.16	0	0
Bus 1	3.48	4.015	215	237
Bus 2	3.66	4.008	13	115
Bus 3	9.07	3.783	428	656
Bus 4	10.41	3.727	191	113
Bus 5	12.09	3.657	145	285
Bus 6	12.83	3.626	21	169
Bus 7	14.05	3.575	23	270
Bus 8	13.33	3.606	14	145
Bus 9	0	4.16	2	200

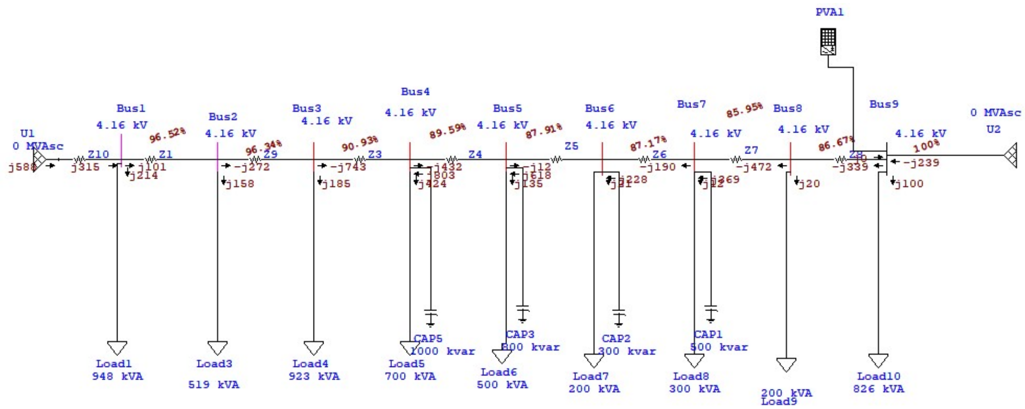

Figure (4.4)

Figure (4.4): shows L.F analysis after connecting PV system at Bus with highest regulation

Table (4.2): shows result of load flow analysis after connecting PV at highest regulation:

	Reg %	**Voltage KV**	**P losses 2 KW**	**Q losses 2 KVAR**
Bus 0		4.16	0	0
Bus 1	3.48	4.015	215	237
Bus 2	3.66	4.008	13	115
Bus 3	9.07	3.783	428	656
Bus 4	10.41	3.727	191	113
Bus 5	12.09	3.657	145	285
Bus 6	12.83	3.626	21	169
Bus 7	14.05	3.575	23	270
Bus 8	13.33	3.606	14	145
Bus 9	0	4.16	2	200

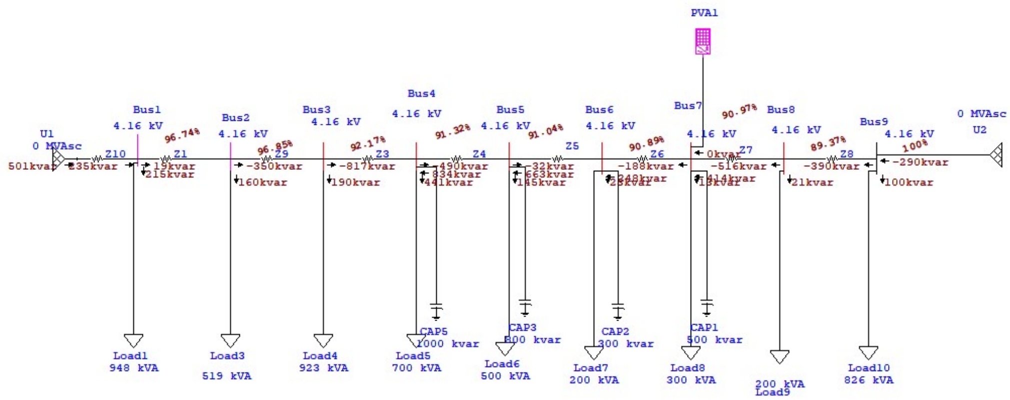

Figure (4.5)

Figure (4.5): shows L.F analysis after connecting PV system at Bus with lowest regulation

Table (4.3): shows result of load flow analysis after connecting PV system at lowest regulation:

	Reg % 3	**Voltage KV**	**P losses 3 KW**	**Q losses 3 KVAr**
Bus 0		4.16	0	0
Bus 1	3.26	4.024	80	1
Bus 2	3.15	4.029	4	491
Bus 3	7.83	3.834	172	657
Bus 4	8.68	3.799	76	114
Bus 5	8.96	3.787	69	313
Bus 6	9.11	3.781	7	165
Bus 7	9.03	3.874	129	513
Bus 8	10.63	3.718	186	147
Bus 9	0	4.16	0	200

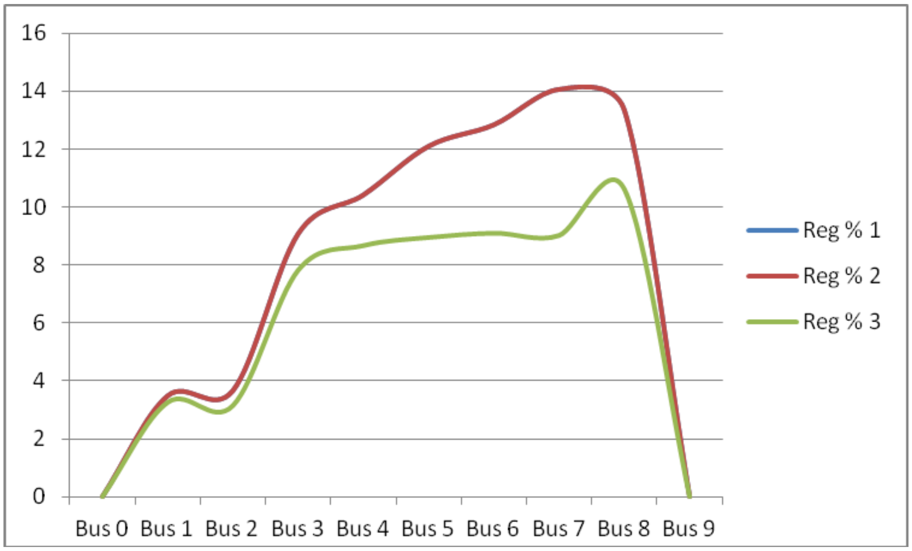

Figure (4.6)

Figure (4.6): shows the plot regulations at table (4.1), (4.2) and (4.3).

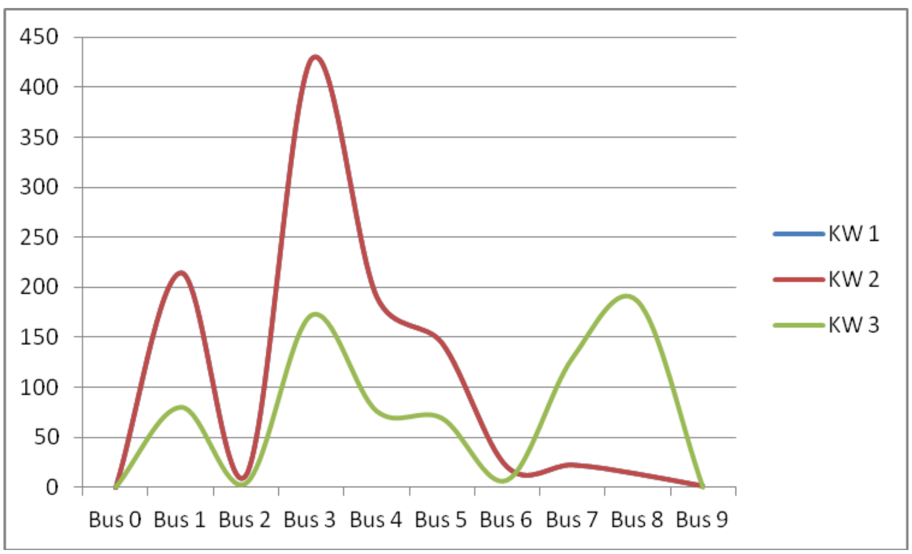

Figure (4.7)

Figure (4.7): shows the plot real power losses at table (4.1), (4.2) and (4.3).

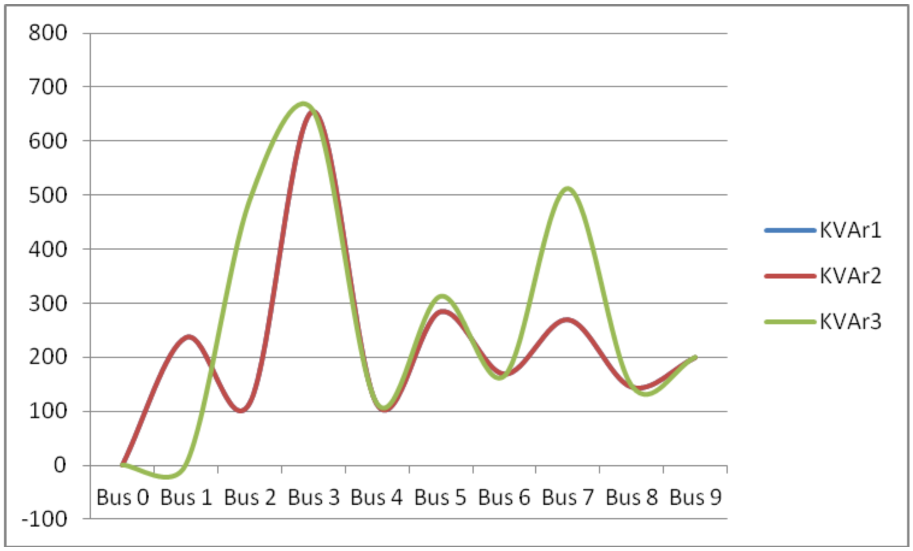

Figure (4.8)

Figure (4.8): shows the plot reactive power losses at table (4.1), (4.2) and (4.3).

4.5 Result discussion:

As result shown in figures 1, 2 and 3 when PV system is connected to bus, with highest regulation we found no change in regulation, real power or reactive power losses but when PV system is connected to a bus with lowest regulation we found that regulations have improved, real power, reactive power losses are reduced.