EVALUATION OF GRID CONNECTED PV SYSTEM FOR ENHANCEMENT OF POWER QUALITY OF INTELLIGENT CONTROLLER

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Abstract*:* We present a novel most extreme power point tracking technique for a photovoltaic framework comprising of a photovoltaic board with a power electronic converter; the entire is encouraging a battery. This most extreme power point relies upon the temperature and light conditions. A strong control utilizing a PI controller is utilized to track this greatest power point. The union of this controller has been accomplished by utilizing Bode technique. For having an exchange capacity of the framework, we have utilized a small flag displaying. Attractive hypothetical and reproduced results are exhibited. The recreation gives great outcomes.

Keywords : Photovoltaic Cells Mechatronics, DC/DC Converter

1. INTRODUCTION

Illustrating, generation, examination and appraisal shapes in Mechatronics arrangement contains two levels; sub-structures models and whole system appear with changed sub-system models working together like real condition, the subsystems models and the whole system show, are attempted and inspected, for needed structure necessities and execution [1]. For Mechatronics blueprint of sun controlled electric applications, this paper widens writer's past works, [2-3] and proposes Photovoltaic Converter (PVPC) structure control issues for Mechatronics sun fueled electric application plan, examination and affirmation. Differing control approaches and relating models are to be resolved, completed, and attempted to control the yield properties and execution of PVPC system's and load's, both or either, voltages and streams to meet needed characteristics. The proposed systems and models allow originator have the best yield data to pick, plot, control, test and separate the PVPC structure yield characteristics for needed yields under given PV board parameters, working conditions and variable commitment from PV module, to meet particular daylight based electric application requirements.

2. PVPC SYSTEM MODELING

The proposed structure contains three subsystems showed up in Figure 1, including; PV board, DC/DC converter with battery and control subsystems. An ordered delineation, fundamentals, logical and Simulink models of PV cell-board and converters can be found in various recourses including [2] The PVPC system numerical and Simulink models considered in this paper, are in reference to [2-3].

A. Design and Model of the PV system

Rated power (V_{mp})	200 W
Voltage at maximum power (V_{mp})	26.4V
Current at maximum power (I_{mp})	7.58 A
Open circuit Voltage (V_{oc})	32.9 V
Short ciruit current (I_{sc})	8.21 A
Total number of cells in series (N_s)	54
Total number of cells in parallel (N_p)	1

I_{ph}	Photo Current (A)	I_{ph}
I_{sc}	Short circuit current (A)	I_{sc}
K_i	Short circuit current of cell at 25°C and 1000W/m^2	0.0032
T	Operating temperature (K)	T
T_n	Nominal temperature (K)	298
G	Solar irradiation (W/m^2)	G
Q	Electron Charge (C)	1.6×10^{-19}
V_{oc}	Open circuit voltage (V)	V_{oc}
N	Ideality factor of the diode	1.3
K	Boltzmann's constant (J/K)	1.3×10^{-23}
E_{g0}	Band energy gap of semiconductor (eV)	1.1
N_s	Number of cells connected in series	N_s
N_p	Number of cells connected in parallel	N_p
R_s	Series resistance (Ω)	0.221
R_{sh}	Parallel resistance (Ω)	415.405
V_t	Diode thermal voltage (V)	-----

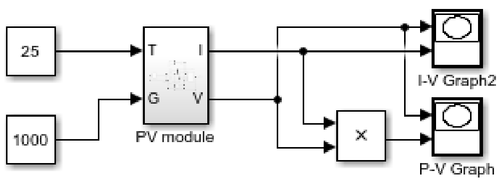

Figure 1. PV Module

B. V Current and Voltage

1. Io=Irs*(T/Tn)^3*exp[(q*Eg0*(1/Tn-1)/(n*K)]

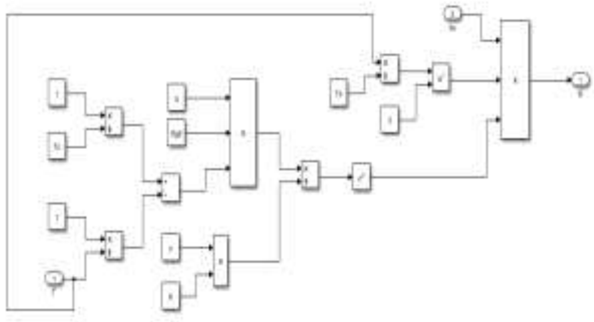

Figure 2. Saturation Current

2. $I_{rs}=I_{sc}/[\exp(q*V_{oc}/(n*N_s*K*T))-1]$

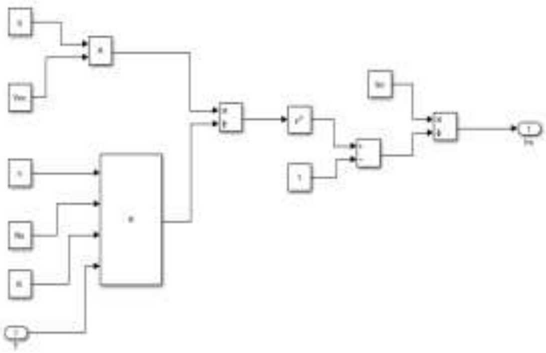

Figure 3. Reverse Saturation Current

3. $I_{sh}=(V+I*R_s)/R_{sh}$

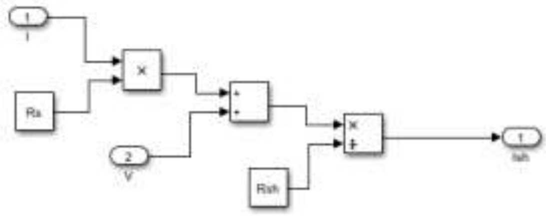

Figure 4. Shunt Current

4. $I_{ph}=[I_{sc}+\{k_i*(T-298)\}]*G/1000$

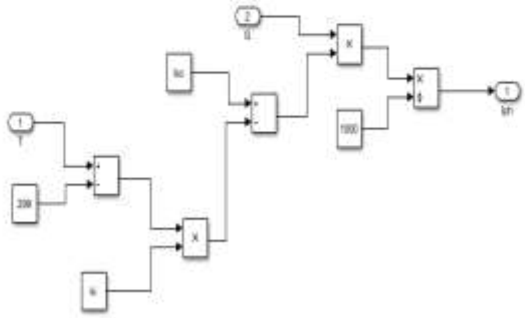

Figure 5. Photo Current

5. $I=I_{ph}-I_o*[exp\{(V+I*R_s)*q/(n*K*T*N_s)\}-1]-I_{sh}$

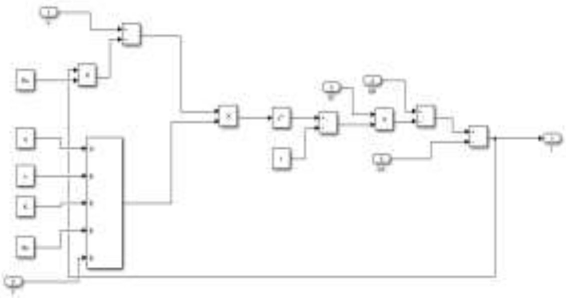

Figure 6. PV Current

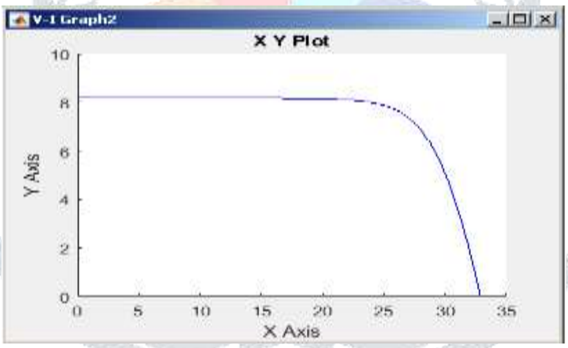

Figure 7. V-I Characteristics

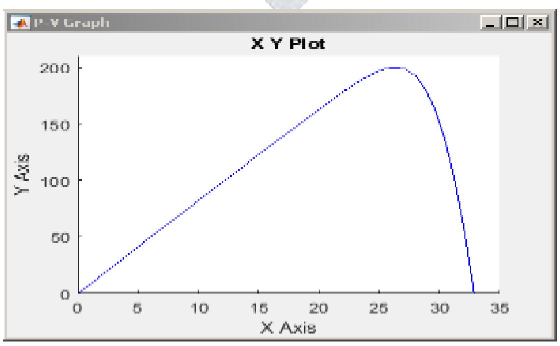

Figure 8. P-V Characteristics

The most direct proportional circuit of a PV sun situated cell involves a diode, a photo current, a parallel resistor imparting a spillage current, and a course of action resistor portraying an internal insurance from the present stream all is showed up in Figure 2(a), the yield voltage, current and intensity of PV bunch vary as components of sun based light level β, the temperature of the module T, (yield decreases as temperature rises) and load current or the voltage at which the pile is drawing power from the module.

The yield net current of PV cell I, insinuating [2] and (an), is given by Eqs. (1)(wqw),

$$I = I_{ph} - I_s\left(e^{\frac{q(V+IR_S)}{NKT}} - 1\right) - \frac{V + R_S I}{R_{sh}} \qquad (1)$$

The cell photocurrent ISC, is given by Eq. (2)

$$I_{ph} = \left(I_{sc} + K_i\left(T - T_{ref}\right)\right)\frac{\beta}{1000} \qquad (2)$$

The cell immersion current IS, differs with the cell temperature, or, in other words by Eq.(3)

$$I_S(T) = I_S\left[\frac{T}{T_{ref}}\right]^3 e^{\left[\left(\frac{1}{T_{ref}} - \frac{1}{T}\right)\frac{qE_g}{NKT}\right]} \qquad (3)$$

The turnaround immersion current IS at reference temperature can be roughly acquired by Eq.(4):

$$I_s(T_1) = \frac{I_{sc}(T_1)}{\left(e^{\left[\frac{qV_{OC}}{N_s KAT_1}\right]} - 1\right)} \qquad (4)$$

In the basic condition to address the genuine I-V characteristics of a sensible PV module and to get certifiable undertaking setbacks, a third present subject to Rs and Rsh, called shunt current IRsh and given by Eq.(5), is included:

$$I_{RSH} = \frac{V + R_S I}{R_{sh}} \qquad (5)$$

In light of decided conditions, the net current of the cell given by Eq.(1) and depends upon the PV cell voltage V, sun constructed irradiance β in light of PV module, and encompassing temperature T. The power conveyed by a lone PV cell isn't adequate for general use, where, each sun situated cell delivers about 0.5V; in like manner the PV cells are related in game plan parallel outline [2]. The present yield of given PV module contemplating the amount of parallel and game plan relationship of cells (NS , NP) is given by Eq.(6)

$$I = N_p I_{ph} - N_p I_s\left(e^{\frac{q\left(\frac{V}{N_S} + \frac{IR_S}{N_P}\right)}{NKT}} - 1\right) - \frac{\frac{N_p V}{N_s} + R_s I}{R_{sh}} \qquad (6)$$

The PV cell profitability is cruel to assortment in shunt block RSH , the effect of parallel resistance RSH can be expelled in Eq. (1), to have the casing, given by Eq.(7)

$$\mathrm{I} = \mathrm{I}_{ph} - \mathrm{I}_s\left(e^{\frac{qV}{NKT}} - 1\right) \tag{7}$$

The most extreme PV voltage can be spoken to by Eq. (8),

$$V = \frac{NKT}{q}\ln\left(\frac{I_{ph} + I_s + I}{I_s}\right) - IR_s \tag{8}$$

In light of these conditions, and implying [2], Simulink show showed up in Figure 2 is created, with relating two cover squares showed up, furthermore, in perspective of surmised conditions, PV module can be addressed in MATLAB/Simulink using customer described work frustrate as showed up in Figure 2(b), where the PV system is given as a component of (V,I) = f(V,G,T) with three data sources V, β, and T and two yields; PV voltage and current. In this model, a low pass channel is added to change over static model into a dynamic model (and to vanquish logarithmic circle issue). The trade limit of low-pass channel is given by Eq.(9) , with prefilter the present yield of given PV module work show, will be given by Eq.(10),

$$G(s) = \frac{I_{filter}}{I_{PV}} = k\,\frac{1}{Ts+1} \tag{9}$$

$$\mathrm{I} = N_P\left(\mathrm{I}_{ph}\right) - N_P\mathrm{I}_s\left(e^{\frac{q\left(\frac{V}{N_S} + \frac{I_{filter}R_S}{N_P}\right)}{NKT}} - 1\right) - \frac{\frac{N_P V}{N_S} + R_S I_{filter}}{R_{sh}} \tag{10}$$

where the present by and by is prefilter current.

For Mechatronics plan of daylight based electric applications, show showed up, is acclimated to result in a summed up PV module and showed up, this summed up model returns the most outrageous required numerical, visual and graphical data for blueprint, examination and check of a given PV board for given parameters, creating opposition and working conditions.

3. GRID INTEGRATED PV SYSTEM

A. Basic Controls of Three-Phase Grid-Connected PV System

The essential controllers are MPPT control, open power control, grid synchronization, and structure supporting features. The control goals of a three-organize system [6] can be isolated into PV controller to expel the best power from the data source, arrange controller control the dynamic power passed on to the grid, responsive power trade with the cross section, high capability and nature of the injected power, threatening to islanding affirmation and network synchronization. The control system associated with the three-organize PV inverters has two fell circles as seeks after. (an) Inner Current Control Loop (ICCL) and (b) Outer Current Control Loop for Current Reference Generation. The ICCL controls the power quality issues and current assurance of the inverter. The current controllers, for example, Proportional Resonant (PR), Resonant Control (RSC), Repetitive Controller (RC), and Deadbeat Controller (DB) can be embraced specifically [6-7]. Stop change (αβ to dq) lead the Proportional Integral (PI) controllers to direct the infused current, and again reverse Park transformer (dq to αβ) is connected. The PR controller with Harmonic Compensators indicates great execution as far as quick unique reaction and precise tracking contrasted with the PI controller [8].

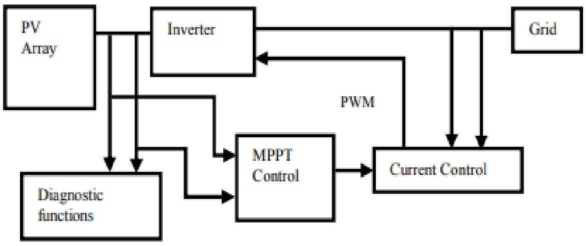

Figure 9. PV system control structure with additional diagnostic functions

B. Controller in Synchronous Reference Frame

Park transformation to a three-arrange voltage and current controls the dq for a three-organize structure. It uses the reference diagram change module (abc to dq) to change the grid voltage and current waveforms into a reference plot which turns synchronously with the system voltage. This makes control factors as DC sums. Every deviation in the system voltage and current will be appeared to the relating d-rotate and q-center point fragments, accordingly it filter through by controlling using PI. In Figure 2 (a), the DC-interface voltage is controlled by the pined for yield control. This yield is used as the reference for the dynamic current controller; however the responsive current reference is set to zero in common assignment. Exactly when the responsive power must be controlled then open power reference must be given to the control system. A Phase-Locked Loop (PLL) system is incorporated this control structure to synchronize the grid current and voltage and moreover makes organize edge which is key in abc to dq change. For this controller, the impediment is the poor compensation capacity of the low-organize music because of PI based controllers despite when cross-coupling terms and voltage feed-forward control are grasped to upgrade the execution [7].

C. Implementation of Controller in Stationary Frame

Execution of the controller in a stationary reference layout, generally called αβ control, or, as it were Figure 2 (a). The control structure, the control factors are changed using the abc to αβ module. The resultant αβ reference plot is sinusoidal. Diverse controllers should be incorporated since the PI controller does not take out the steady state botch when the banner is time variety. The PR controller has the capacity of getting rid of the persisting state screw up while controlling sinusoidal waveforms (αβ). Harmonic Compensators (HC) related in parallel for low-organize harmonics like third, fifth, and seventh demand for improving the imbued current quality. The trade limit of a PR with HCs controller is showed up as seeks after.

$$G(s) = k_p + k_r \frac{s}{s^2 + {\omega_o}^2} + \sum_{h=3,5,7....} \frac{k_{rh} s}{s^2 + (h\omega_o)^2} .....$$

Where, kp is the proportional gain, kr is the fundamental resonant control gain, krh is the control gain of the h-order resonant controller, ω0 is the grid fundamental frequency.

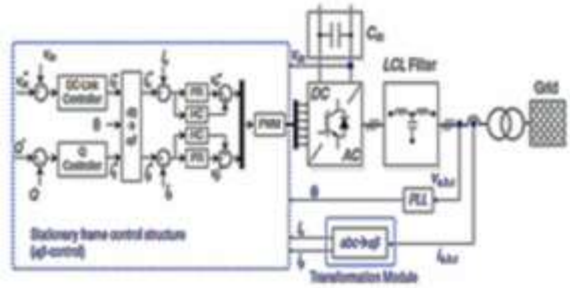

Figure 10. (a) General Structure of a three-phase PV inverter with stationary frame control and (b) Three-phase PV inverter with natural frame control [7]

D. Control Structure in Natural Reference Frame

In this control technique (abc-control), an individual controller is associated with each stage lattice current. Execution of abc-control is showed up in Figure 2 (b). The DC-associate voltage is controlled to deliver the dynamic current reference in dq-plot which is changed into three current references using the contrary Park change and the stage edge of the system voltages. The slip-up banner conveyed by differentiating and the contrasting evaluated system current goes into the present controller. These individual current controllers are essential to convey the commitment cycles for the PWM. Any of the controllers like PI controller, PR controller, hysteresis controller, knave controller and dreary controller [6, 9], can be held onto as the three current controllers in the general reference diagram control structure reliant on the control multifaceted nature and its dynamic execution.

E. Grid Synchronization

In lattice synchronization an inside reference signal is made by the control figuring of a system related power converter. Synchronization ensures that the current imbued in the system is sinusoidal and in stage with the grid voltage having solidarity control factor. In the dq PLL uses the Park's change, as showed up in Eq. 2, to unravel the abc regular transforming reference plot into the dq-Synchronous Reference Frame (SRF).

4. RESULT ANALYSIS

The graph for

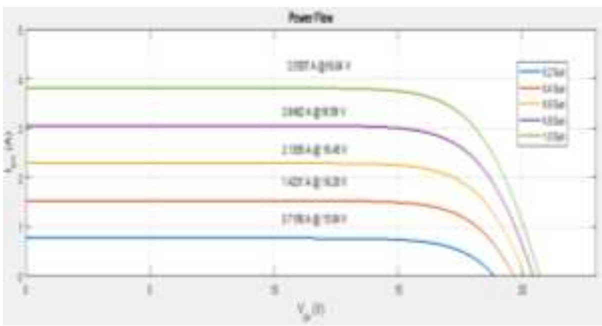

Figure 11. Power flow

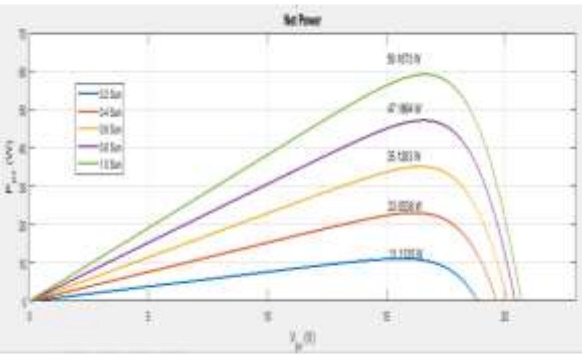

Figure 12. Net load power

5. CONCLUSION

This paper portrays about the cross section consolidated sun based PV structure illustrating, improvement of controllers in refining the dynamic response yield. In the controller, the harmonic capacitor is pursued to keep up the apparent harmonics. The synchronization execution of SRF-PLL with the inverter yield into the cross section is couple of milliseconds. The unadulterated sinusoidal waveform is made as the harmonics are diminished by LCL channel. In the midst of the advancement time span switches are perpetually worked, as a result of this the temperature is extended with high incidents thusly warm examination has been found in the converters.

REFERENCES

[1] R. Karki and B. Roy, "Reliability/cost implications of PV and wind energy utilization in small isolated power systems", IEEE Transactions on Energy Conversion, vol.16, no.4, pp.368-373, 2001.

[2] B. Parida, S. Iniyan and R. Goic, "A review of solar photovoltaic technologies", Renewable and sustainable energy reviews, vol.15, no. 3, pp.1625-1636, 2011.

[3] Y. Hamakawa, "Recent advances in solar photovoltaic technology and its new role for environmental issue", Renewable energy, vol.5, no. 1, pp. 34-43, 1994.

[4] G. K. Singh, "Solar power generation by PV (photovoltaic) technology: a review", Energy, vol.53, no.1, pp.1-13, 2013.

[5] H. Ravaee, S. Farahat, and F. Sarhaddi, "Artificial neural network based model of photovoltaic thermal (pv/t) collector", The Journal of Mathematics and Computer Science, vol.4, no.3, pp.411-417, 2012.

[6] J. A. Gow and C. D. Manning, "Development of a photovoltaic array model for use in power-electronics simulation studies", IEE Proceedings-Electric Power Applications, vol.146, no.2, pp.193-200, 1999.

[7] H.L. Tsai, C.S. Tu and Y.J. Su, "Development of generalized photovoltaic model using MATLAB/SIMULINK", In Proceedings of the world congress on Engineering and computer science, vol. 2008, pp. 1-6, 2008.

[8] M. G. Villalva, J. R. Gazoli and E. R. Filho, "Comprehensive approach to modeling and simulation of photovoltaic arrays", IEEE Transactions on power electronics, vol.24, no.5, pp.1198-1208, 2009.

[9] M. Datta, T. Senjyu, A. Yona, T. Funabashi and Chul-Hwan Kim, "A coordinated control method for leveling PV output power fluctuations of PV–diesel hybrid systems connected to isolated power utility", IEEE Transactions on Energy Conversion, vol.24, no.1, pp.153-162, 2009.

[10] F. Blaabjerg, Z. Chen and S. B. Kjaer, "Power electronics as efficient interface in dispersed power generation systems", IEEE transactions on power electronics, vol.19, no.5, pp.1184-1194, 2004.

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