Implementation Of Perturb And Obserbe Algorithm for Tracking The Maximum Power From Photo Voltaic Module Using MATLAB

Kamlesh K. Bharti[1], Sushil Kumar[2], Assistant Professor
Department of Electrical Engineering, invertis University bareilly, india
e-mail- kamlesh1787@gmail.com

Abstract- An improved MPPT converter with voltage and current (perturb &observe) method for photo voltaic (PV)-applications is presented in this paper. The proposed method used to implements maximum power point tracking (MPPT) by variable reference of voltage and current which is continuously changed during some time (up to 5 sec). In this algorithm a slight perturbation is introduce system. Due to this perturbation the power of the module changes. If the power increases due to the perturbation then the perturbation is continued in that direction. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses. When the steady state is reached the algorithm oscillates around the peak point. In order to keep the power variation small the perturbation size is kept very small. The algorithm is developed in such a manner that it sets a reference voltage of the module corresponding to the peak voltage of the module. It is also observed that this algorithm fails to track the power under fast varying atmospheric conditions.

I. INTRODUCTION

Renewable energy sources play an important role in electricity generation. Various renewable energy sources like wind, solar, geothermal, ocean thermal, and biomass can be used for generation of electricity and for meeting our daily energy needs. The power generated by a Photo Voltaic (PV) Module depends on the operating voltage and current of the photovoltaic cell and its voltage-current and voltage-power characteristic curves specify a unique operating point at which maximum possible power is delivered and the PV module is operated at its highest efficiency. One of the problems in designing efficient PV systems is to track the maximum power operating point for varying solar irradiance levels and ambient conditions. The photovoltaic generator exhibits nonlinear V-I characteristics and maximum power point varies with solar insolation. A dc-dc converter is used to match the PV system to the load and to operate solar array at maximum power point and an Inverter is used to connect the AC system. The cascaded H-bridge is a suitable topology for connecting multiple panels in series and sinusoidal PWM is employed to generate a sinusoidal terminal voltage and to control its magnitude so that it can be interfaced with the AC system.

A new MPPT algorithm based on the fact that the MPOP (maximum peak operating point) of a PV generator can be tracked accurately by comparing the incremental and instantaneous conductance of the PV array. The work was carried out by both simulation and experiment, with results showing that the developed incremental conductance (IntCond) algorithm has successfully tracked the MPOP, even in cases of rapidly changing atmospheric conditions, and has higher efficiency than ordinary algorithms in terms of total PV energy transferred to the load [1].

A robust oscillation method is used for implementing the maximum power point tracking for the solar arrays. The method uses only one variable that is load current for detecting the maximum power. This method is suitable for the battery charging application where MPPT is to be implemented. The algorithm is implemented through a simple circuit. The paper gives detailed discussion about design of a step up converter. Used for the MPPT [2].

A new kind of maximum power point tracking algorithm based on perturb and observe algorithm. The algorithm is fast acting and eliminates the need of a large capacitor which is normally used in perturb and observe algorithm to eliminate the ripple in the module voltage. The module voltage and current that are taken for processing are not averaged but are instantaneous this speed ups the process of peak power tracking [3].

This improved MPPT algorithm based on perturbs and observe. The algorithm uses the power as the control variable based on the perturbation and observation method. The algorithm requires two sensors. A better response for the system under rapid atmospheric condition variations is obtained by increasing the execution speed [4].

II. Model of the PV module

In electrical terminology Modeling of Photovoltaic cell means representing with its equivalent circuit. PV cell can be represented in three equivalent circuits.

A solar cell can be operated at any point along its characteristic current-voltage cure, as shown in figure 1. Two important points on this curve are the open circuit voltage (V_{oc}) and short-circuit current (Isc). The open-circuit voltage is the maximum voltage at zero current, where as the short-circuit current is the maximum current at zero voltage.

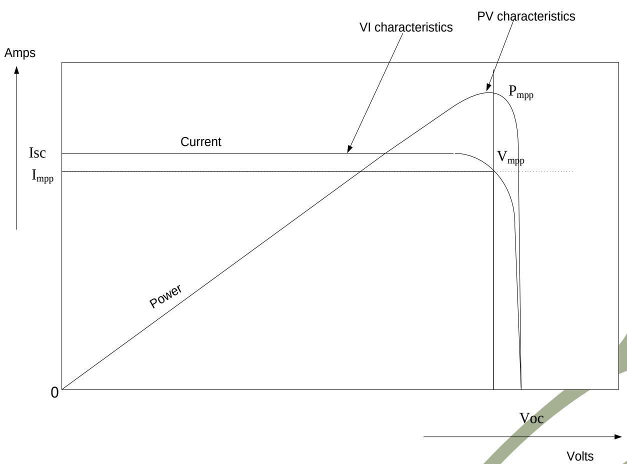

Fig1. Photovoltaic characteristics

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Model I

In model I the PV cell is represented with a current source in parallel with a diode. The current source generated the photo current I_{ph}, which is directly proportional to the solar irradiance E. The p-n transition area of the solar cell is equivalent to a big diode which is also integrated in the picture.

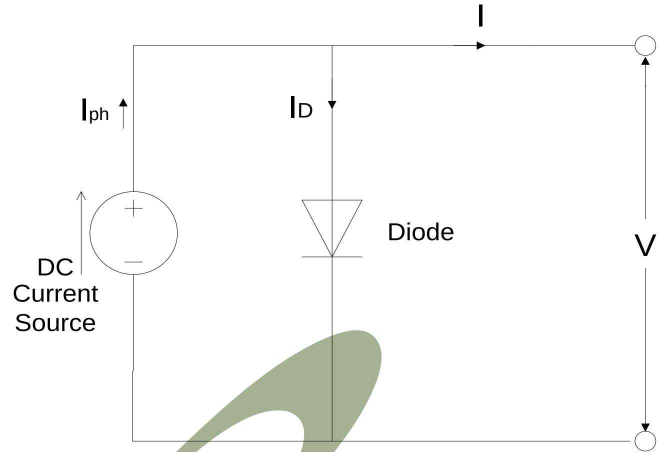

Fig2. PV ideal model

The V-I equation of the simplified equivalent circuit could be derived from Kirchhoff's current law.

$$I = I_{ph} - I_D = I_{ph} - I_s * \left(\exp\left(V / m \cdot v_T\right) - 1\right)$$

With

Iph	Photo current
I_D	Diode current
I_S	diode reverse saturation current
m	Diode "ideality factor" m=1…..5
v_T	Thermal Voltage v_T= (k.T/e)
k	constant of Boltzmann k= 1.380658*10^{-23} Jk^{-1}
T	absolute temperature, [T] =K (Kelvin)
E	charge of an electron e=1.6021733*10^{-19}

Model II

As mention above, the simplified equivalent circuit doesn't give an optimal representation of the electrical process at the solar cell. At real solar cells a voltage loss on the way to the external contacts could be observed. This voltage loss could be expressed by a series resistor, R_s. Furthermore leakage currents could be observed, which could be described by a parallel resistor, R_p.

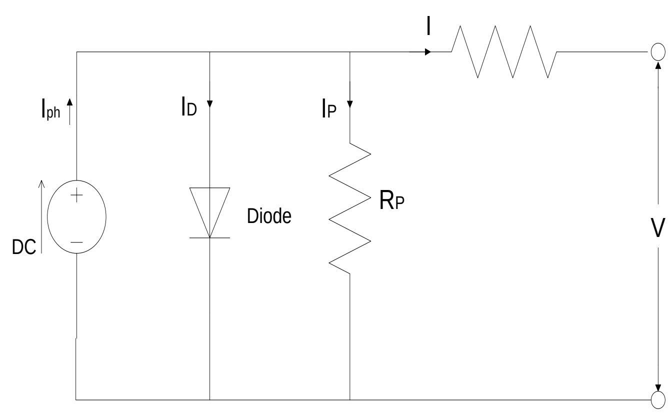

Fig3. PV real model

Derived from Kirchhoff's first law the equation for the extended I-V curve is achieved.

$$0 = I_{ph} - I_D - I_P - I$$

With $I_p = \frac{V_D}{R_P} = \frac{V + I \cdot R_s}{R_P}$ follows

$$0 = I_{ph} - I_s \cdot \left(\exp\left(\frac{V + I \cdot R_s}{m \cdot V_T} \right) - 1 \right) - \left(\frac{V + I.R_s}{R_p} \right) - I$$

$$\Rightarrow I = I_{ph} - I_s \cdot \left(\exp\left(\frac{V + I \cdot R_s}{m \cdot V_T} \right) - 1 \right) - \left(\frac{V + I.R_s}{R_p} \right)$$

Model III

An even more exact modeling could be achieved by the two-diode-model. Here two different diodes with different diode ideally factors *m* connected in parallel. At the equations of the diode it was always taken for granted that there is no breakthrough at operation in the inhibited direction of the diode, but at high negative voltages a breakthrough at solar cell could be observers. This was modeled at following figure 4 by a variable current source *I (VD)*.

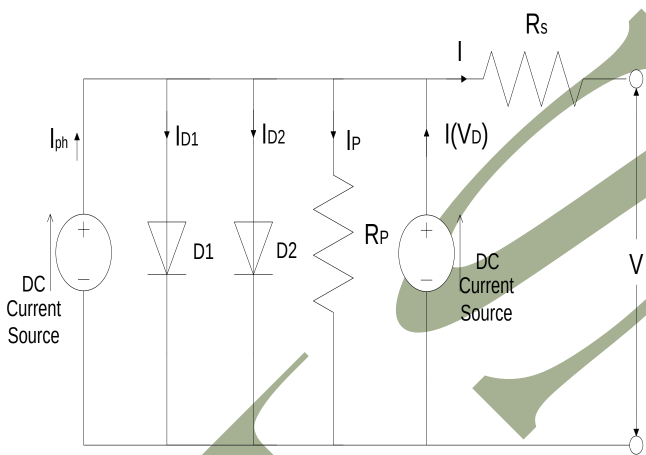

Fig4. Two-diode model

III. MATLAB MODEL OF THE PV MODULE

The simulation of solar PV module characteristics, perturb & Observe(P & O) algorithm of Maximum power point tracking (MPPT), PV model along with MPP tracking is done on the MatLab/Simulink.

IV and PV characteristics of Solar PV model is shown in the figure 5&6
open circuit voltage (V_{oc}) = 22.22V
Short circuit current (Isc) = 5.45 A
Current at Pmax = 4.95A
Votage at Pmax=17.2 V
Diode "ideality factor" *m*=2

Thermal Voltage = v_T= (k.T/e)
constant of Boltzmann *k*= 1.380658*10^{-23} Jk^{-1}
charge of an electron *e*=1.6021733*10^{-19} As
Insolation= $800W / M^2$

The MATLAB code computes model parameters *Io*, *Rs*, *Rp* based on the model parameters (short-circuit current *Isc*, circuit voltage *Voc*, rated voltage *Vr*, and rated current *Ir*).

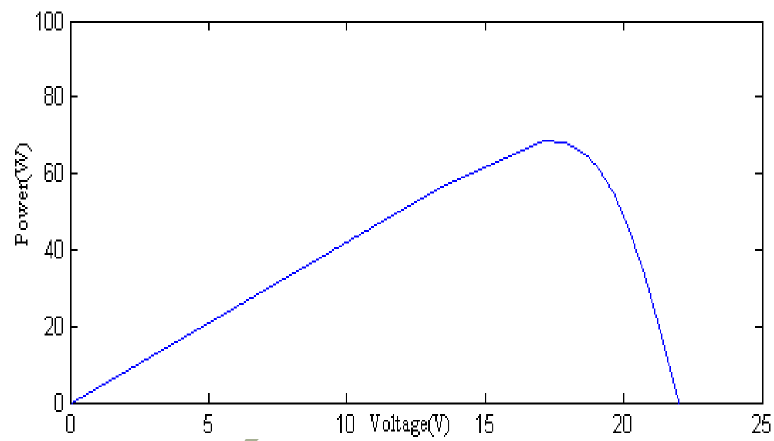

Fig5. P-V Characteristics of PV Module

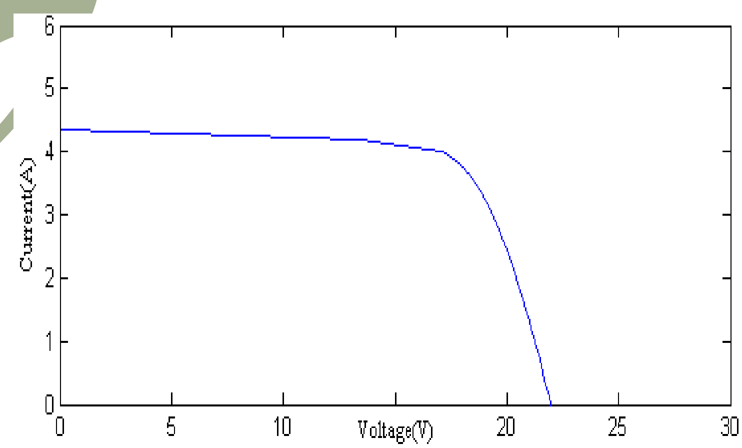

Fig6. I-V Characteristics of PV Module

III. CHARACTERISTICS OF SOLAR PV MODULE AT DIFFERENT INSOLATION

Insolation = 200, 400, 600, 800, 1000 W / M^2

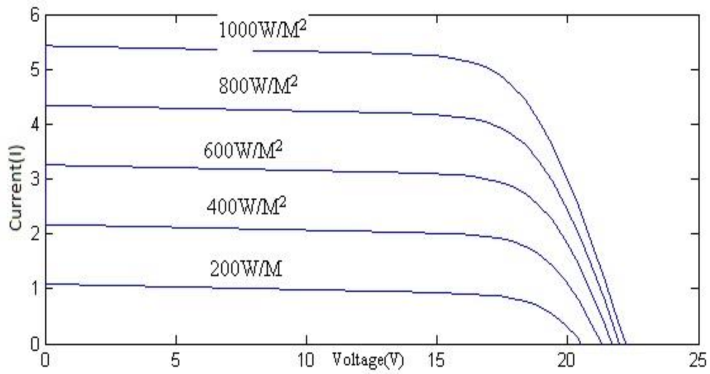

Fig7. I-V Characteristics of PV Module at different Insolatiom

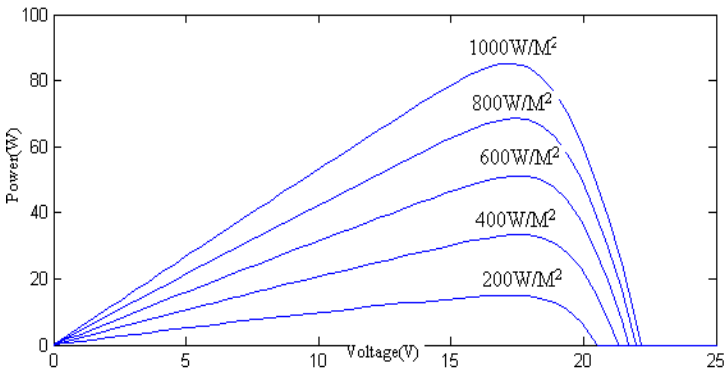

Fig8. P-V Characteristics of PV module at different insolatiom

IV. ALGORITHM TO TRACK THE MAXIMUM POWER POIN

Perturb and observe:

In this algorithm a slight perturbation is introduce system. Due to this perturbation the power of the module changes. If the power increases due to the perturbation then the perturbation is continued in that direction. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses

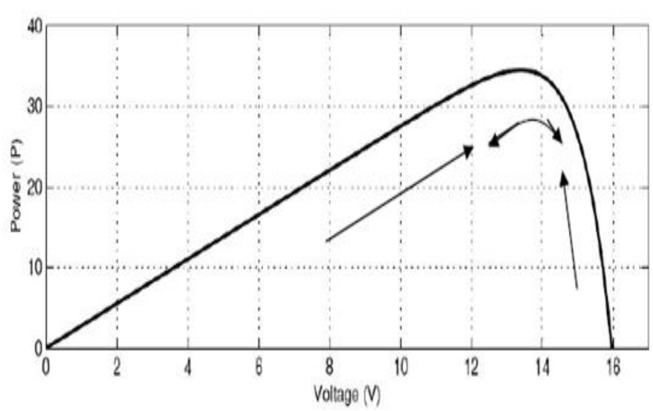

Fig9. Perturb and observe

When the steady state is reached the algorithm oscillates around the peak point. In order to keep the power variation small the perturbation size is kept very small. The algorithm is developed in such a manner that it sets a reference voltage of the module corresponding to the peak voltage of the module. A PI controller then acts moving the operating point of the module to that particular voltage level. It is observed that there some power loss due to this perturbation also the fails to track the power under fast varying atmospheric conditions. But still this algorithm is very popular and simple.

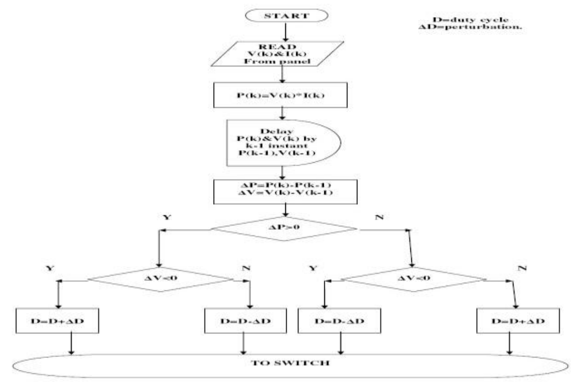

Fig10. Perturb and observe algorithm

The simulink setup of the MPPT system is shown in the figure 13. The MPPT bock takes the module voltage and current through the multimeter. The MPPT block contains the algorithm which is explained below in figure 10. The insolation and the temperature are kept fixed and are not varied. The simulink implementation of the algorithm is shown in figure12. For implementing the perturb & observe(P&O) algorithm the value of the all

Component given as:

PV Pannel specification:

Light generated current I_{ph}=5.6 A

PV Series resistance Rs=.1 ohm

PV Parallel resistance Rp=64.413

Buck converter specification:

L=.01 H

C=.00050 F

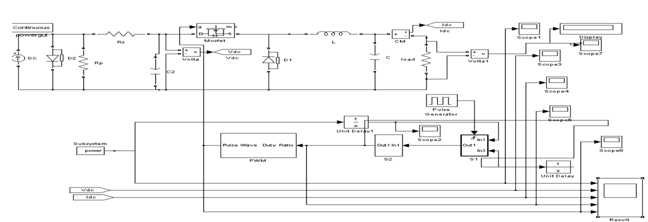

Fig11. complete simulink model Perturb&rve algorithm

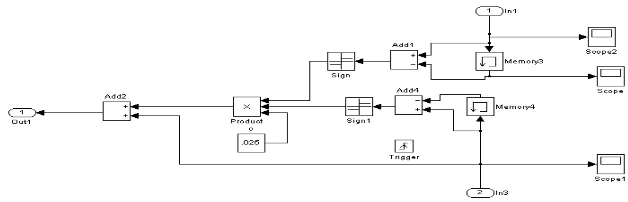

Fig.12 Algorithm implementation in SIMULINK (S1) for duty ratio

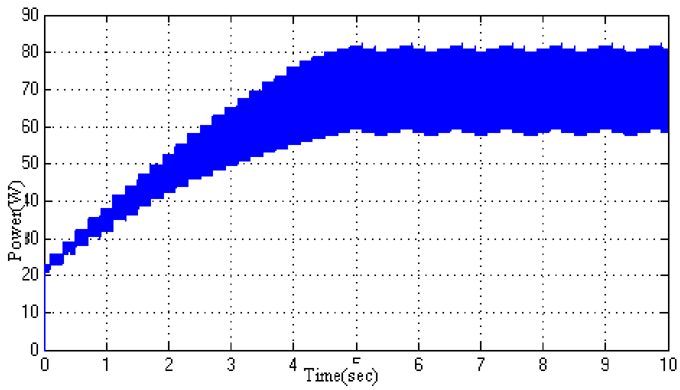

Fig13. Power Vs time

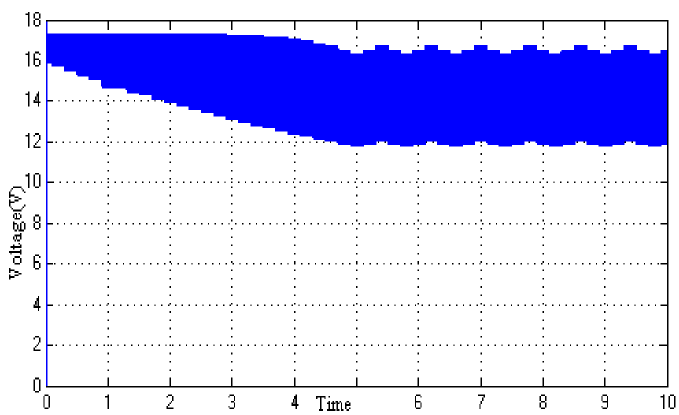

Fig14. Voltage Vs time

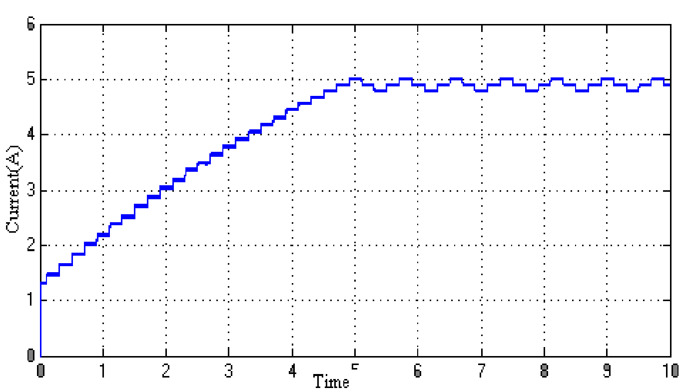

Fig15. Current Vs time

Fig13 is power vs time. Initially power drawn from solar panel is less. Then duty ratio is increased via algorithm. Fig14 is voltage versus time. Initial condition is more towards open circuit condition due to which voltage is high. As duty ratio increases current drawn (Fig16) from solar panel increases which result in drop in voltage. Finally, when the power is reach to the maximum point duty ratio is set and power is oscillate around the maximum power. Here maximum power is 82watt

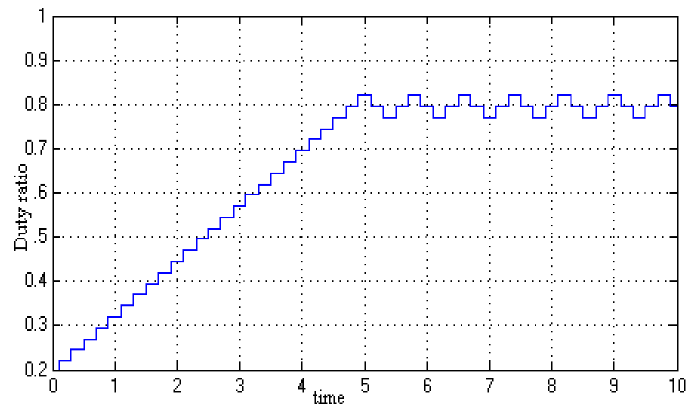

Fig16. Duty ratio Vs time

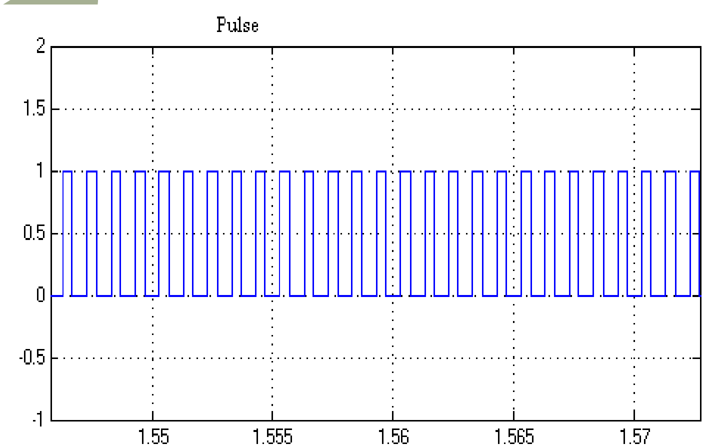

Fig.17 switching pulse for the switch of the buck chopper

Fig17 shows the pulses which is generated by the perturb and observe algorithm of maximum peak power point ,this pulses is used for the drive the switch(MOSFET) of the DC Buck converter for extracting the maximum power from solar photovoltaic module.

V. CONCLUSION

Power output of module improves with the MPPT system. It is observed that the module gives the peak output power up to 82 watt. The temperature has effect on the peak power. From the plots fig 7 and 8 it was observed that as the insolation increases the peak increase.

VI. References

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