

Solar Power Generation with Maximum Power Point Tracking (MPPT) Control Technique

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3/10/2015

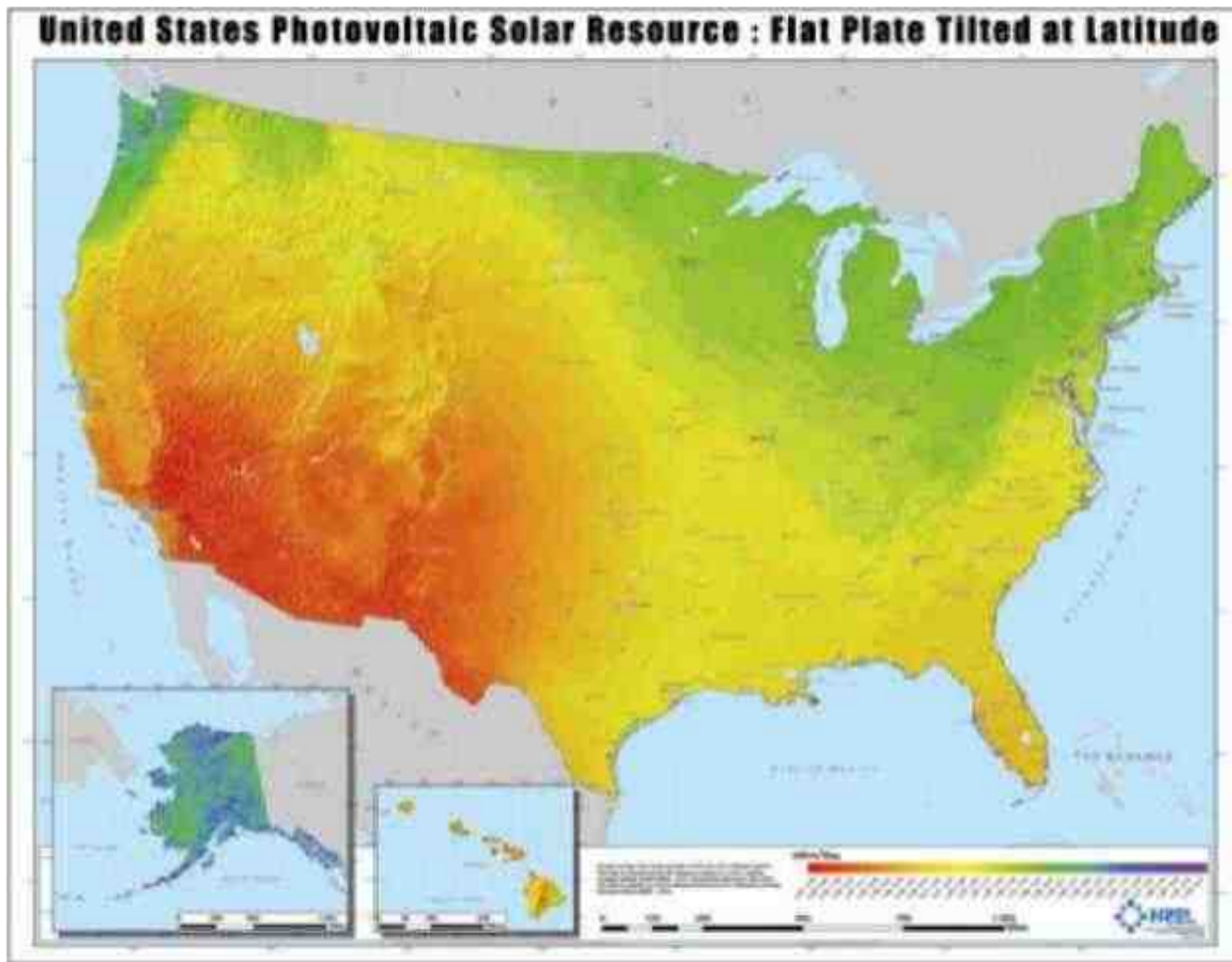
Overview

- ▶ Introduction
- ▶ Effect of irradiance and temperature
- ▶ MPPT
- ▶ MPPT techniques
 - ▶ Offline methods
 - ▶ Online methods
 - ▶ Hybrid methods
- ▶ Charge controller
- ▶ Conclusion

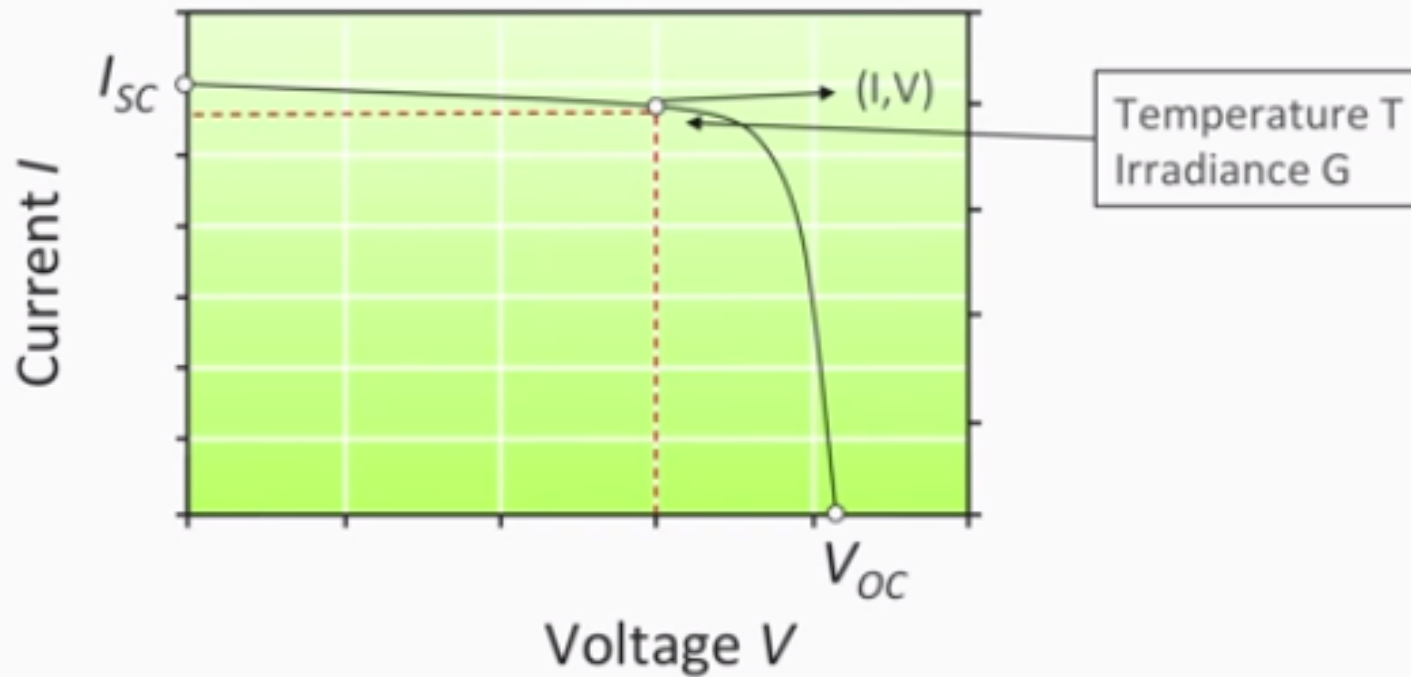
Introduction

- ▶ Solar Energy rapidly growing market
- ▶ Huge potential for innovations
- ▶ Low power conversion efficiency
- ▶ Influenced by weather conditions

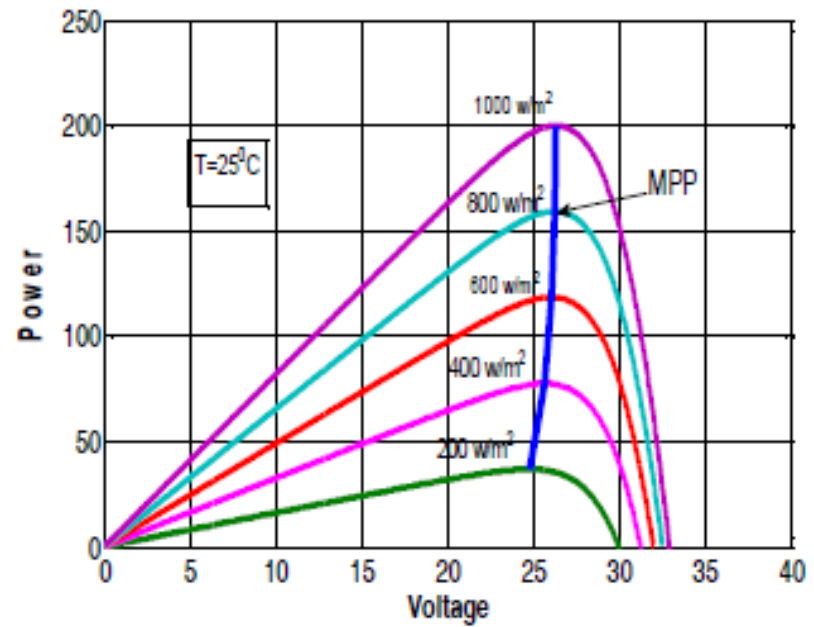
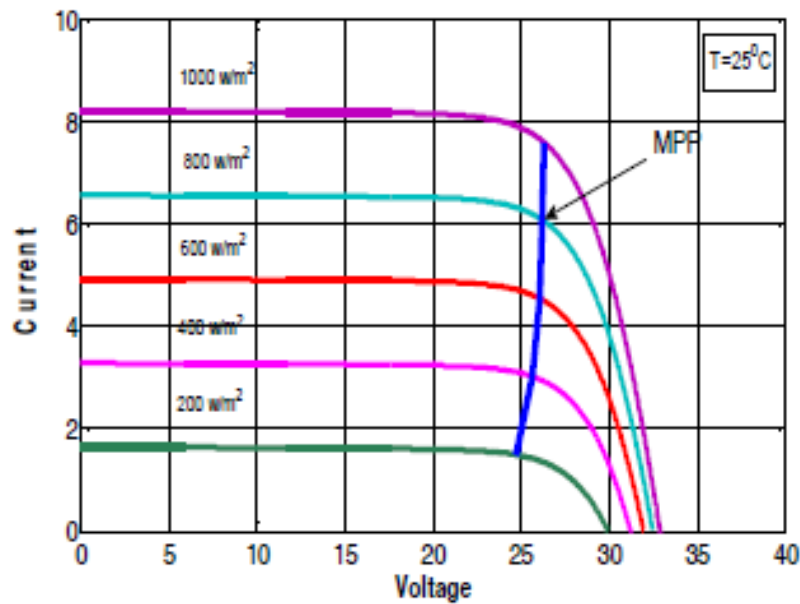
Solar Radiation in the US



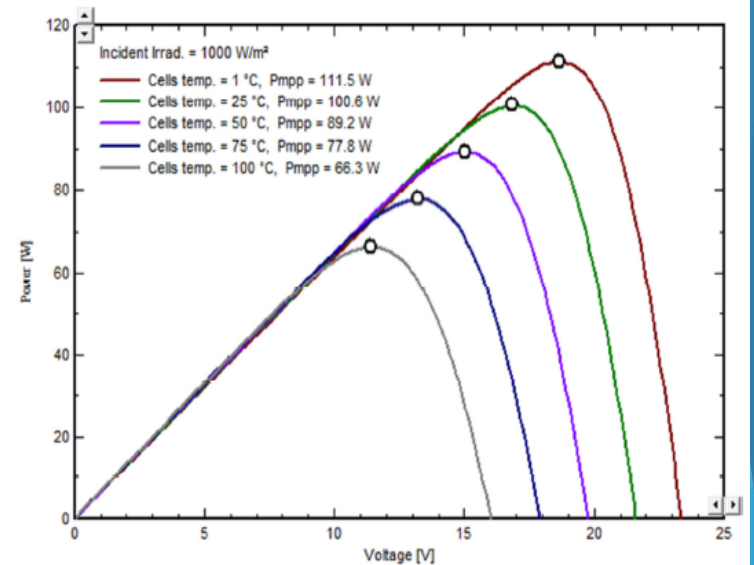
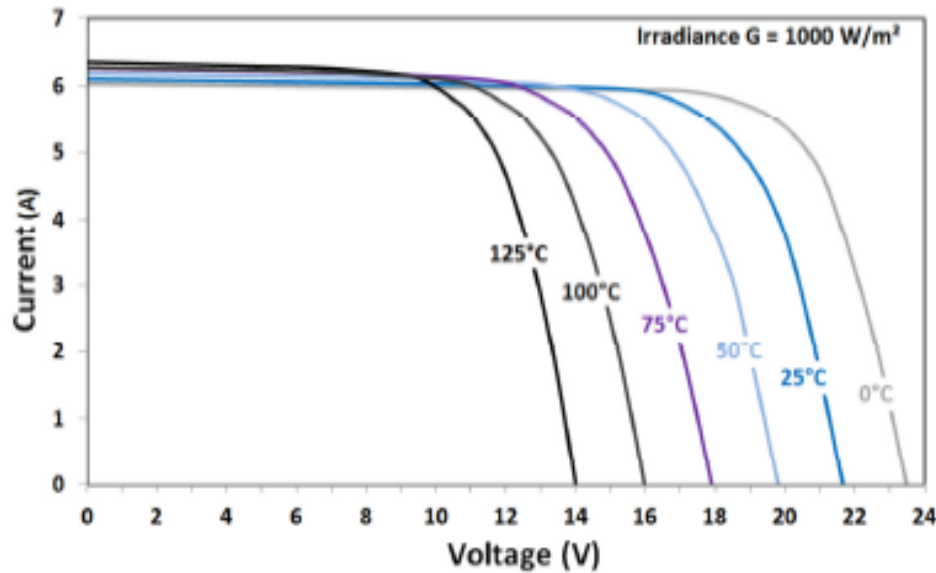
Operating point₁



Effect of Irradiance on Solar cells₂

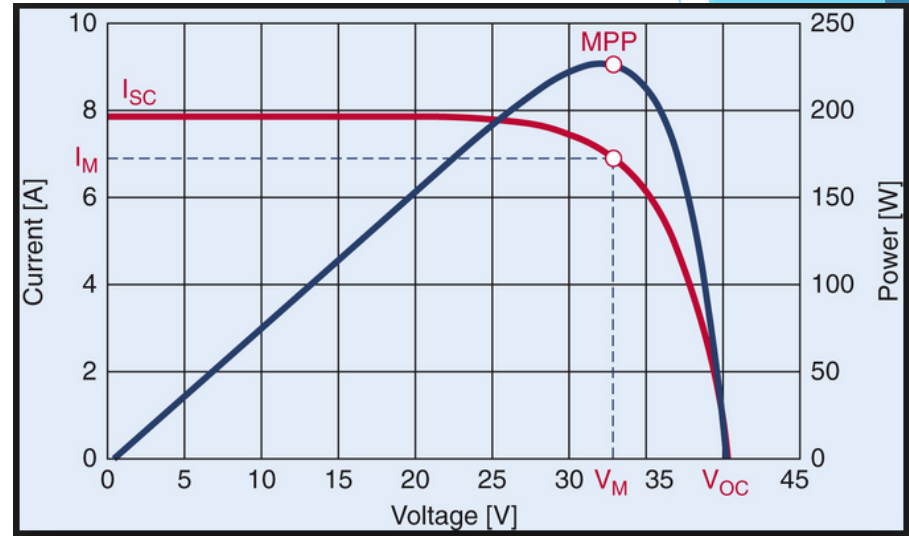


Effect of Temperature on Solar cells₃



Maximum Power Point (MPP)

- ▶ Corresponds to the peak of the P-V curve
- ▶ Or the knee of the I-V curve
- ▶ Maximum power is delivered at the MPP₁

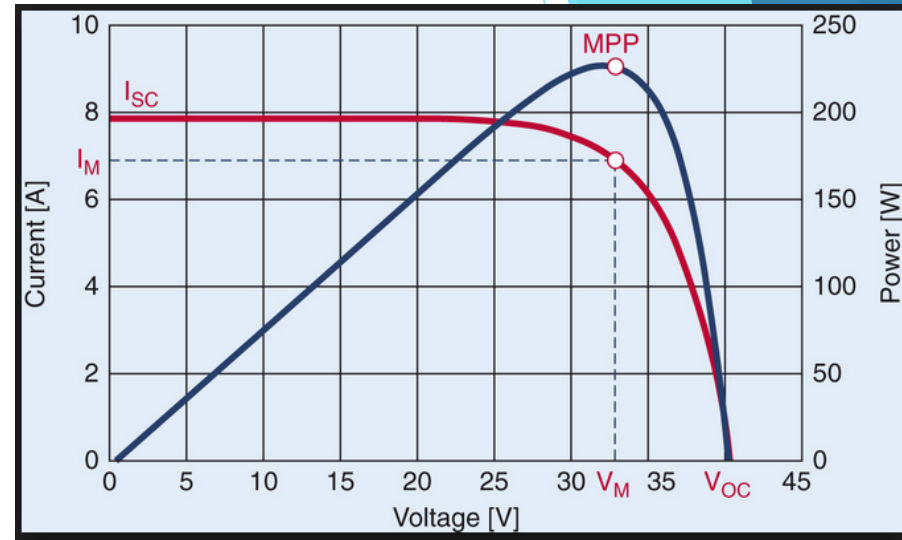


Need for MPPT

- ▶ Atmospheric conditions cause change in operating point
- ▶ MPP keeps varying

Maximum Power Point Tracking (MPPT)

- ▶ Tracks the MPP at all times₁
- ▶ Is not affected by changing weather conditions
- ▶ Maximum power is delivered at all times



MPPT Techniques

- ▶ Offline Methods
 - ▶ Constant Voltage (CV) method
 - ▶ Open Circuit Voltage (OCV) method
 - ▶ Short Circuit Current (SCC) method
- ▶ Online Methods
 - ▶ Perturb & Observe (P&O) Method
 - ▶ Incremental Conductance (IncCond) method
- ▶ Hybrid methods

Constant Voltage (CV) method

- ▶ Operating point is made to match with a V_{ref}
- ▶ V_{ref} is made equal to MPP voltage
- ▶ Assumptions of irradiance and temperature

Open Circuit Voltage (OCV) method

- ▶ MPP can be measured by Open Circuit Voltage
- ▶ $V_{MPP} = V_{OC} \times k$
- ▶ $k = 0.7-0.8$ for crystalline silicon
- ▶ Loss of power due to disconnection
- ▶ Use of pilot cells

Short Circuit Current (SCC) method

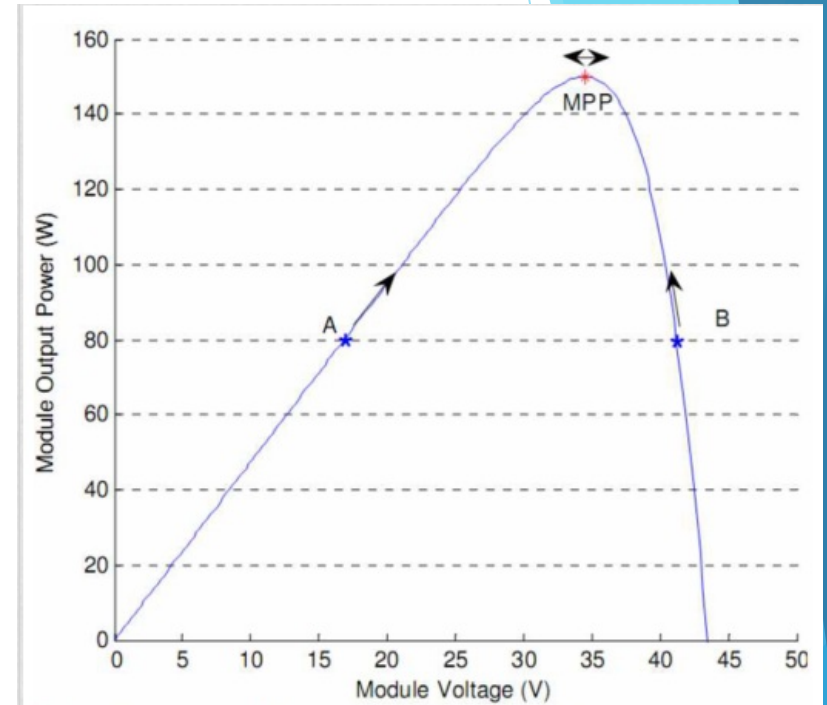
- ▶ Similar to OCV method
- ▶ MPP can be measured by Short Circuit Current
- ▶ $I_{MPP} = I_{SCC} \times k$
- ▶ $k = 0.8-0.9$ for crystalline silicon

Drawbacks of Offline methods

- ▶ Interruption of power due to disconnection
- ▶ K is an estimated value
- ▶ True MPP can never be tracked constantly

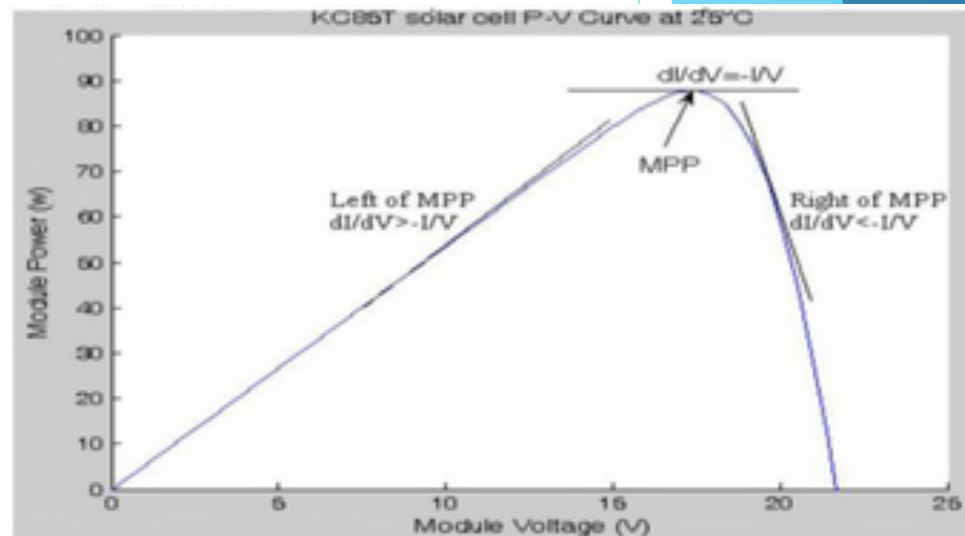
Perturb & Observe (P&O) method

- ▶ Increase in voltage causes increase or decrease in power
- ▶ The operating point is shifted left or right
- ▶ Never converges on the MPP
- ▶ Usage of small perturbation steps₄



Incremental Conductance (IncCond) method

- ▶ At MPP, slope of P-V is zero
- ▶ The operating point is shifted left or right
- ▶ Converges on the MPP
- ▶ Better accuracy than P&O
- ▶ Difficult hardware implementation₅



Hybrid Methods

- ▶ Combination of offline and online methods
- ▶ Estimates a value by offline method
- ▶ Tracks using perturbations towards MPP using online methods
- ▶ Faster convergence rate
- ▶ Variable amplitudes of perturbation

MPPT Charge Controllers

- ▶ Devices that control the voltage delivered to the battery
- ▶ Most modern charge controllers have MPPT
- ▶ Uses the extra voltage from PV array₅



Conclusions

- ▶ MPPT can improve the power conversion efficiency of PV panels
- ▶ Produces maximum power at all times
- ▶ High cost of MPPT controllers but no change in LCOE

Questions?

Bibliography

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