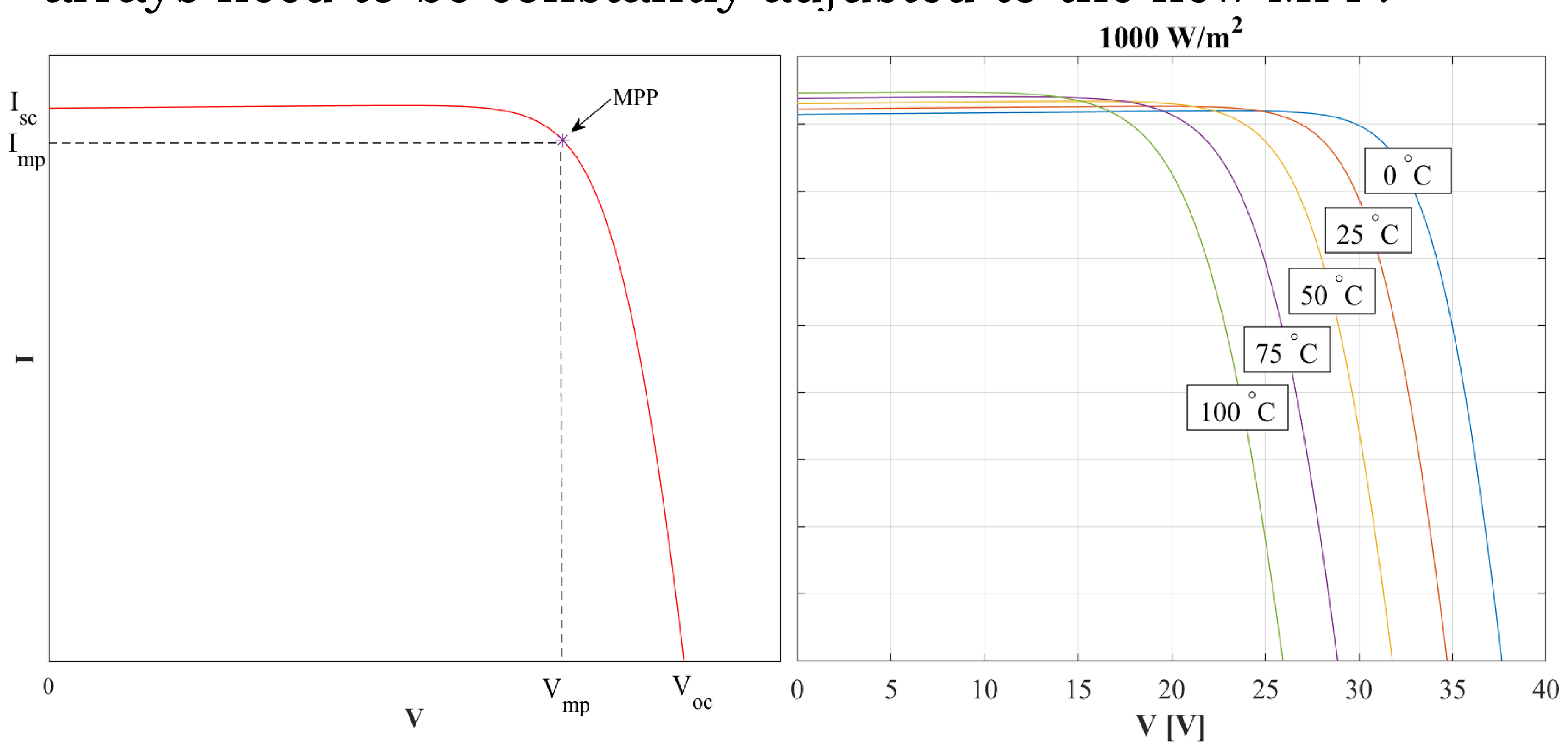
Adaptive Step Size Incremental Conductance Based Maximum Power Point Tracking

Eungkyun Kim, Indranil Bhattacharya
Electrical and Computer Engineering Department

Motivation

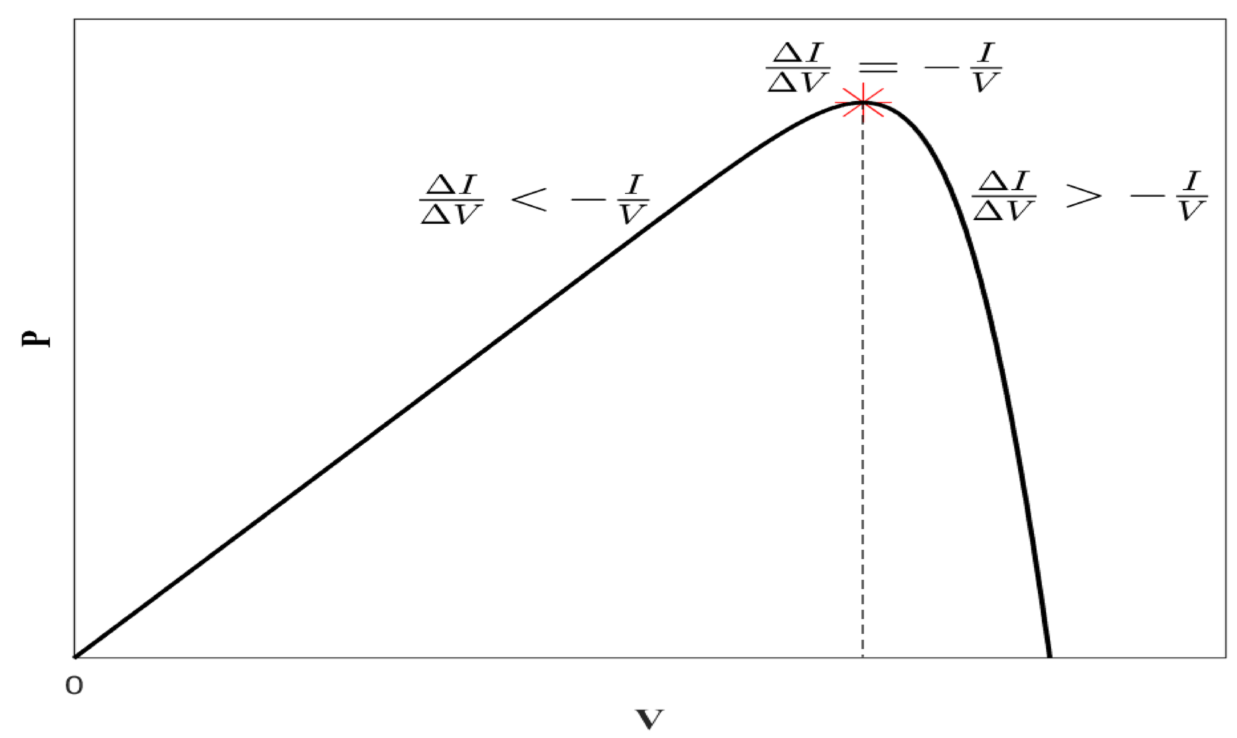
Extracting maximum power available from solar panels requires the system operating at maximum power point (MPP). Therefore, finding the MPP is necessary for efficient operation of photovoltaic (PV) arrays. Because MPP changes with environmental changes, the operating point of PV arrays need to be constantly adjusted to the new MPP.



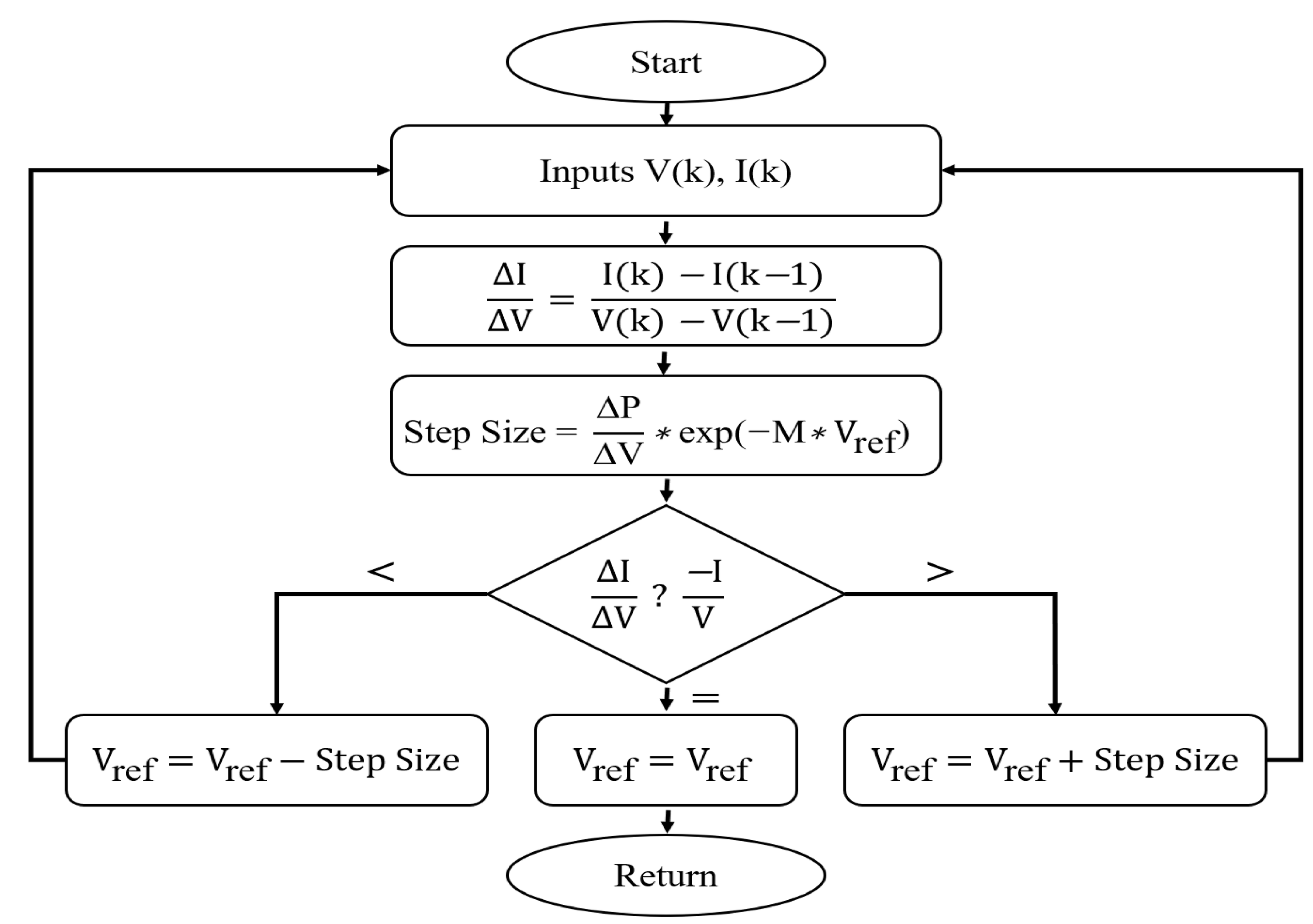
This means we need to find the MPP fast and accurately to avoid power loss. Traditionally, incremental conductance (IC) technique with fixed step size was used to find the MPP, which suffers from a trade-off between the convergence speed and accuracy. I developed an IC algorithm with adaptive step size, which mitigates the trade-off drastically by achieving faster convergence speed without the loss of accuracy.

Background

An IC algorithm finds MPP by comparing the incremental conductance (ΔI/ΔV) with the instantaneous conductance (-I/V), utilizing the fact that dP/dV at the MPP must be zero. The operating point is at MPP if ΔI/ΔV is equal to -I/V.



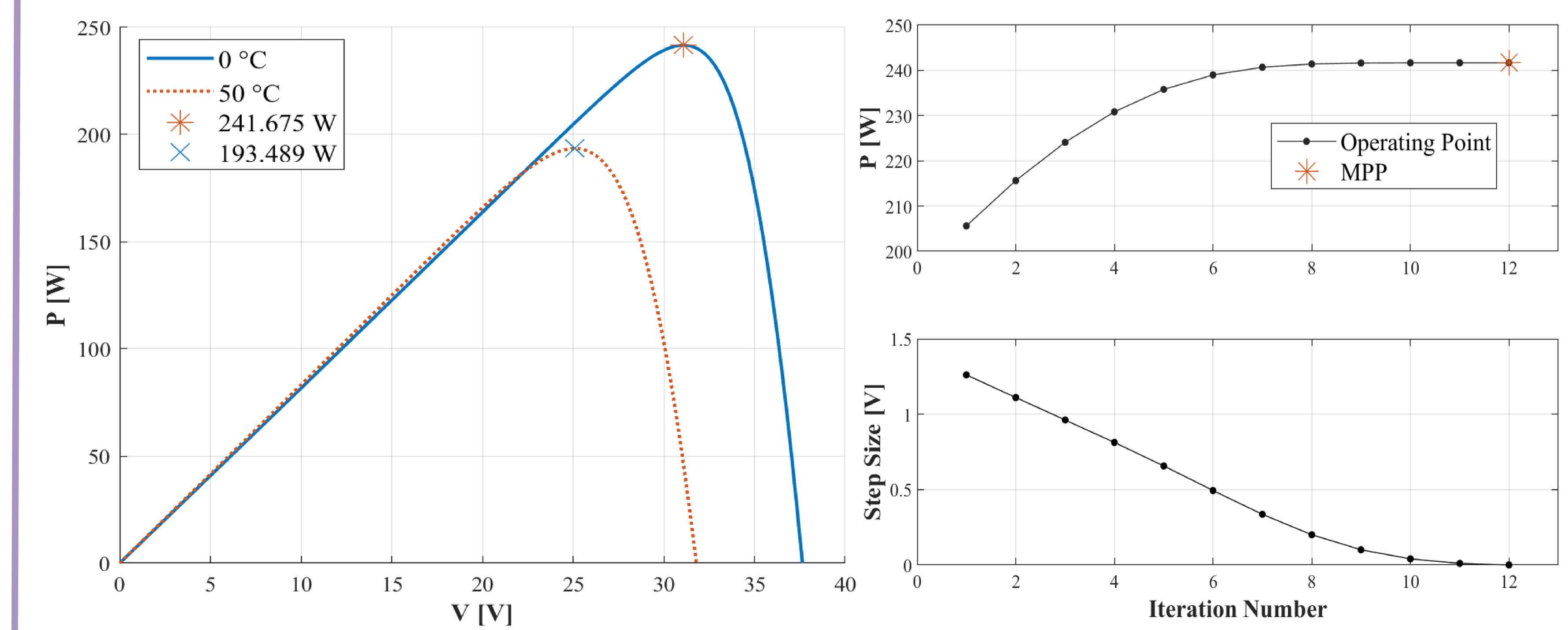
Algorithm



ΔI/ΔV is first measured, then it is compared with -I/V. If ΔI/ΔV is less than -I/V, operating voltage is decremented by the step size. Similarly, if ΔI/ΔV is greater than -I/V, operating voltage is incremented by the step size. This process is then iterated until the MPP is found. At each iteration, step size is adaptively updated to ΔP/ΔV*exp(-M* v_{ref}), which allows for the MPP to be found with much fewer iterations compared to the fixed step size IC technique.

Results and Conclusions

Simulations were done varying the temperature and irradiance and using both adaptive step size IC and the fixed step size IC techniques for comparison.



Above figures show how MPP shifts when temperature changes from 50°C to 0°C, and how my algorithm efficiently tracks MPP by adaptively changing step size. It only took 12 iterations to find MPP with only 0.00004% error with my algorithm, whereas the traditional algorithm took 599 iterations to find the MPP. More simulations were performed at different temperatures and irradiances to test the robustness of the algorithm, and the results are summarized in the table below. In all the cases, my algorithm allowed for the MPP to be found with much faster convergence speed with nearly the same accuracy compared to the traditional algorithm.

Change in Temperature [°C]		Change in Irradiance [W/m^2]		Change in MPP [W]		Accuracy [%]		Number of Iterations Taken to Find MPP	
Initial	Final	Initial	Final	Initial	Final	Fixed Step Size	Adaptive Step Size	Fixed Step Size	Adaptive Step Size
25	0	1000	1000	217.54	241.68	1.327e-9	6.438e-5	302	17
50	15	1000	1000	193.49	227.18	8.029e-6	3.140e-5	416	16
0	0	1050	170	253.61	40.821	3.168e-3	6.591e-5	134	21
0	0	330	970	79.454	234.50	6.057e-5	5.594e-5	64	12
45	0	200	900	38.058	217.71	2.235e-7	6.765e-5	701	25
-5	20	525	725	161.17	129.57	3.662e-5	6.284e-4	292	33
-12	7	1000	250	253.28	58.164	1.268e-3	1.054e-4	331	46

References

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