Adaptive Sun Tracking algorithm for Incident Energy Maximization and Efficiency Improvement of PV Panels

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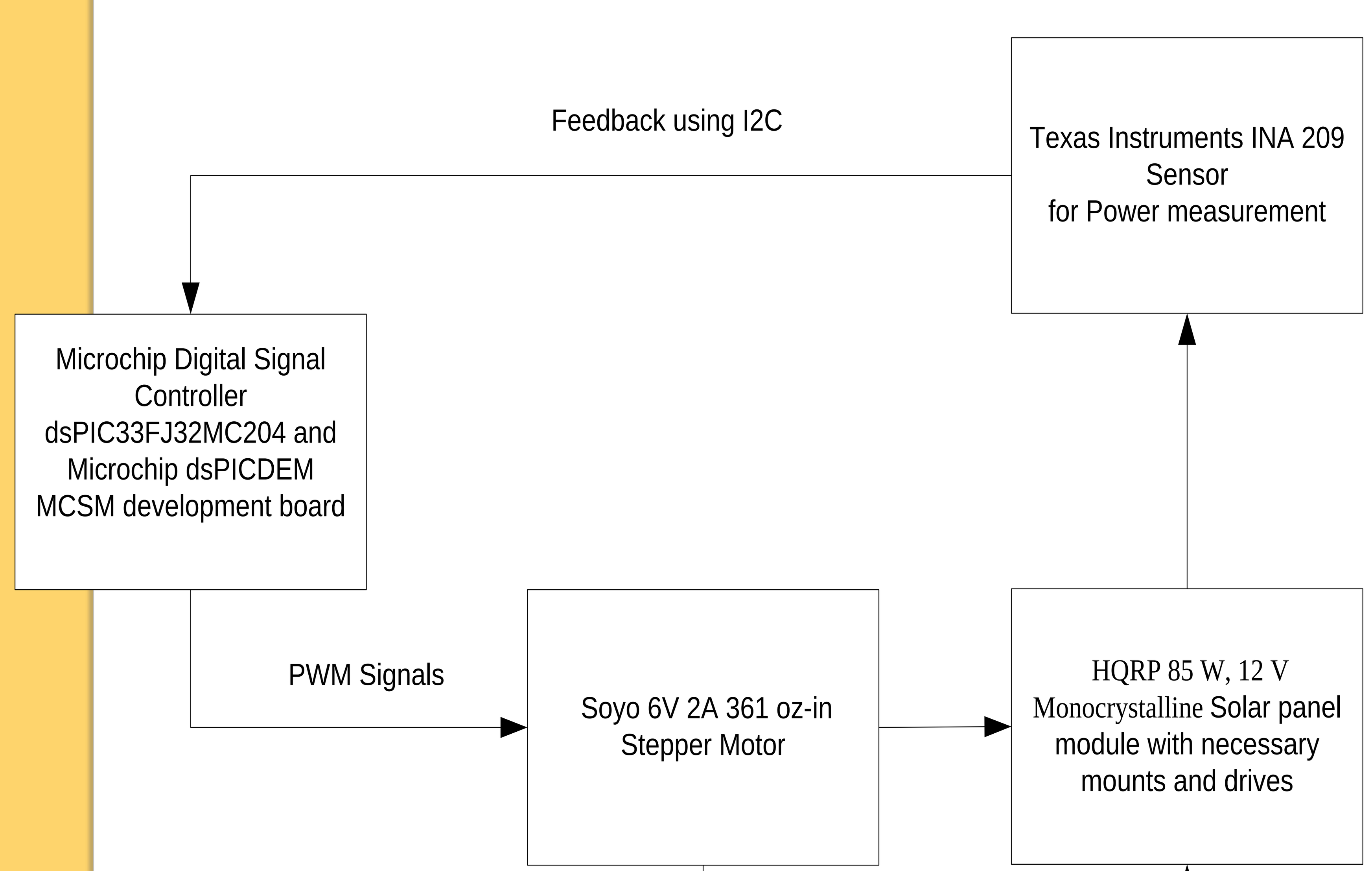
Introduction

Sun-tracking systems are designed in a way to track the sun on a single axis (according to the azimuth angle) or in a way to track the sun on both axes (according to the azimuth and solar altitude angles).The most commonly used system in sun-tracking systems is controlling the motor which moves the panel by evaluating the signals received from the photosensors placed to the PV panel ends through several control systems.

Proposed approach

- In this poster, a novel adaptive digital signal processing and control algorithm is presented that optimizes the overall PV system output power by adjusting the position angles of the solar panel on both the elevation and azimuth axes.
- Since the proposed approach is adaptive in nature, the optimal position angles for the solar panel are iteratively computed using the adaptive gradient ascent method, until the incident solar radiation, and hence the output power is maximized.
- Furthermore, a Taylor's series approximation is employed for generating a unique optimal position angle increment/decrement at each iteration. This eliminates the need for additional sensing hardware, and intensive computational resources.
- Simulation results show that the proposed technique demonstrates fast convergence and excellent tracking accuracy at all times of the day.

Block Diagram of prototype sun tracking system



Algorithm update equations:

$$\theta_S(k+1) = \theta_S(k) - \frac{\sqrt{P(k+1)^2 - P(k)^2}}{2 * P(k)}$$

$$P(k+1) = P(k) + [\operatorname{sgn}(P(k) - P(k-1))] * (P(k) - P(k-1))$$

θ_S : elevation angle of the PV panel

P : output power of the PV panel

k : iteration index

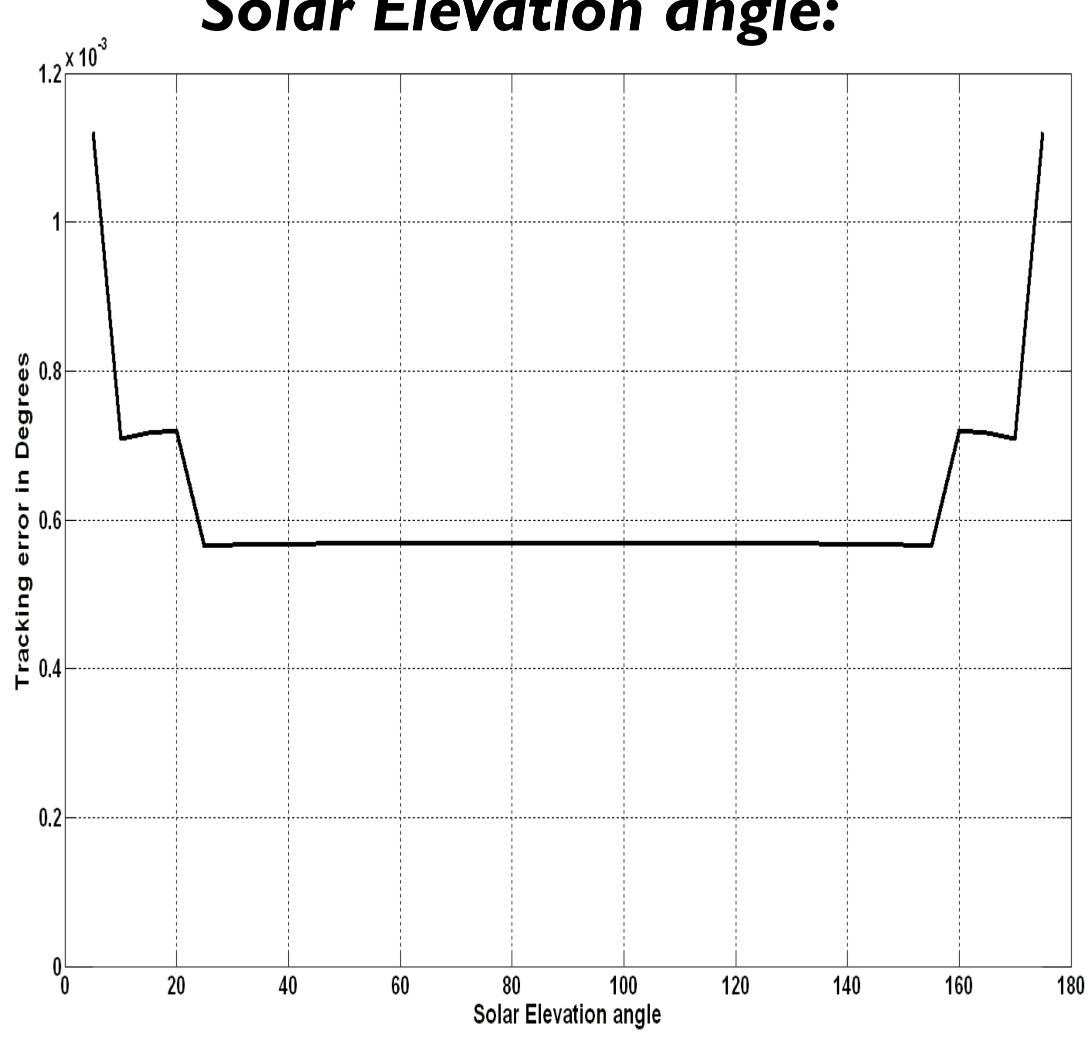
Computer Simulations

The proposed signal processing algorithm was tested on a 16 bit dsPIC33FJ32MC204 Digital Signal microcontroller by varying the solar elevation angle from 0 to 180 degrees (sunrise to sunset), and calculating the tracking error and speed of convergence in each case, after the proposed adaptive algorithm converges.

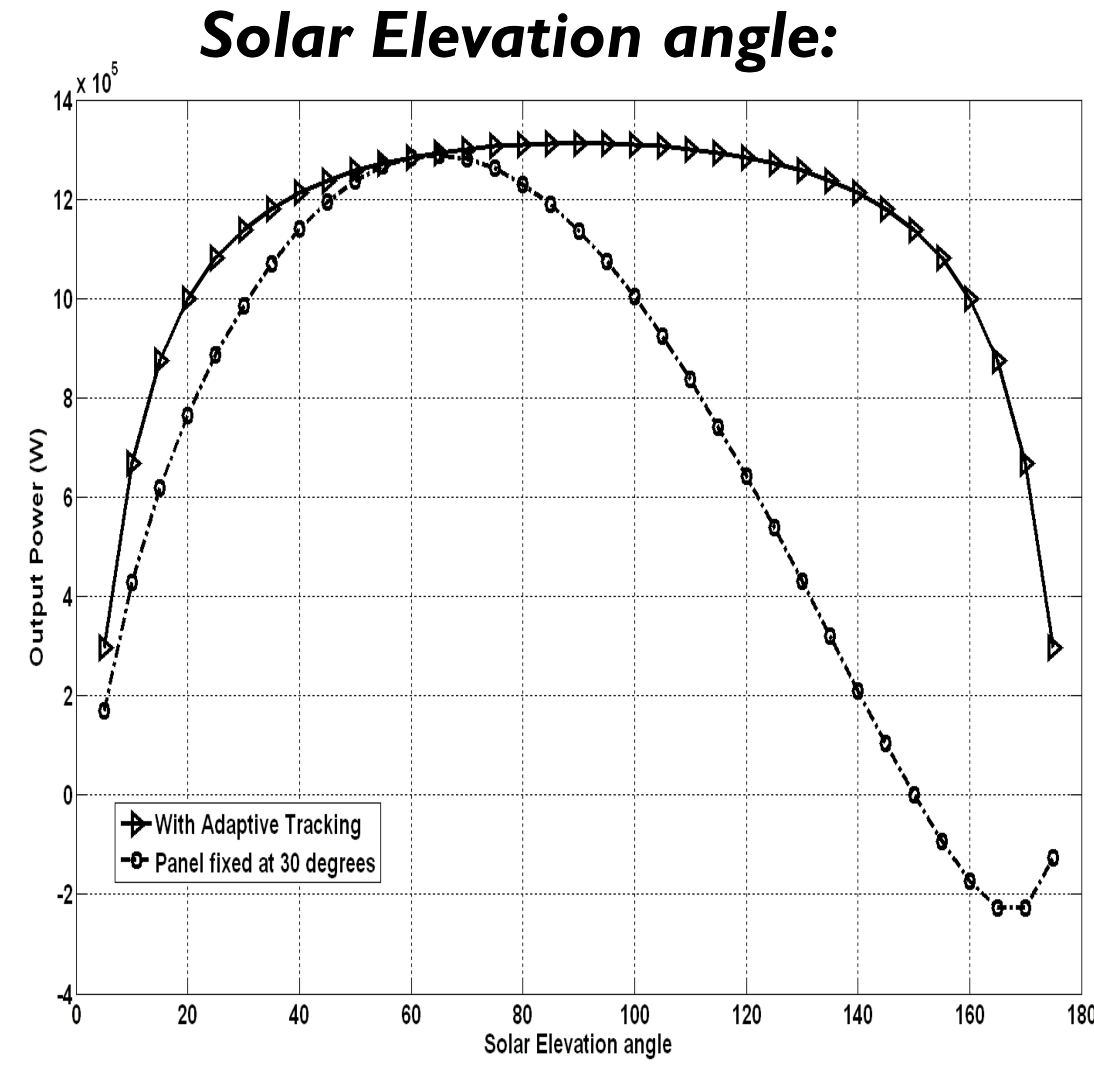
Components of the sun tracking system:

1. Microchip dsPICDEM MCSM Stepper motor development board with a 100 pin dsPIC33FJ323MC204 Digital Signal Controller Plug In Module (PIM) mounted on it .
2. A Soyo 6V 2A 361 oz-in unipolar stepper motor controlled by Pulse Width Modulation (PWM) signals.
3. A HQRP 85 Watt (Size of 80 Watt) Solar Panel Power 12V Monocrystalline PV Module, with necessary mounts.
4. A Texas Instruments INA 209 high-side current shunt and power monitor with an Inter Integrated Circuit (I2C) interface

Tracking Error vs. Solar Elevation angle:



Output Power vs. Solar Elevation angle:



Number of iterations vs. Solar Elevation angle: