HIGH ACCURACY HCPV TRACKING SYSTEM BASED ON DOUBLE LOOP ALGORITHM

Filippo Paredes[1], Fabio Montagnino[1], Ignazio Dentici[1], Sergio Milone[1], Alessandro Buscemi[1], Luca Venezia[1], Marco Barbera[2,3], Ugo Lo Cicero[3], Franco Gelardi[2], Marco Cannas[2]

[1] IDEA s.r.l., Termini Imerese (PA), Italy

[2] Dipartimento di Fisica e Chimica, Università di Palermo, Via Archirafi 36 ,90123, gaetano.bonsignore@unipa.it, Palermo, Italy

[3] Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy

Abstract

FAE "Fotovoltaico ad Alta Efficienza" ("high efficiency photovoltaic") is a project proposed to the Sicilian Regional Government (which founded it) by a consortium of public research institutes (University of Palermo, National Institute of Astrophysics) and of private companies in 2011. One of the prime goals of FAE is to design innovative components for HCPV systems with high efficiency obtaining a reduction of costs. Since the HCPV FAE system is conceived to work at an extremely high solar concentration, exceeding 2000, big effort was put in the design of a new sun tracking system, capable to fulfil the accuracy required from high concentration value, but also paying attention on the cost reduction.

The mount of the tracking system is specifically designed for an easy installation on roof tops (both, horizontal and inclined) but is also suitable for larger CHP fields. It is of Alt-Alt type, each module is composed by a long "primary" axis (which can be mounted horizontal or inclined, typically but not necessarily in N-S direction), that can be extended mounting different modules on the same main axis, supporting a number of short (about 1 m) "secondary" rotation axes (each one moving two optical concentrators and cells) orthogonal to the main axis. All the secondary axes are moved by a single actuator via a parallelogram transmission. The tracking system consists in the combination of two control closed loop algorithms: an absolute position feedback algorithm and a solar-sensor feedback based algorithm.

The absolute position algorithm is based on a digital clock, geographical coordinates and principal axis inclination and orientation: starting from the clock data and the geographical coordinates, the controller performs an ephemeris calculation and then, using azimuth and zenith calculated values and considering the main axis inclination and orientation, operates a coordinates transformation in order to obtain the absolute position set points for the two actual tracking axis. The controller drives the tracking system actuators based on the calculated set points, closing the loop with an absolute positioning; then the solar sensor feedback loop is enabled.

The solar sensor feedback algorithm is a second loop based on a four quadrant sun sensor: the sensor active area is a four quadrant photodiode aligned with the direction of the HCPV optics whose plane is normal to the sun vector direction, so that the tracking is fulfilled when the sensor is in the direction of the sun. In addition, the axis of the four quadrant are aligned with the tracking system axis. The controller analyzes the analog (current or voltage) values coming from the four quadrant photodiodes and elaborates them in order to calculate two errors, one for each orthogonal tracking direction. Then the tracker actuators are driven from the controller in order to zero the two errors (read by the analog feedback values) and so correct the positioning with an accuracy of a small fraction of degree. The authority of solar-sensor feedback based loop is smaller than the absolute positioning authority, but the accuracy is greater.

While the absolute positioning loop guarantees that the tracking system is working properly in each and every operational condition, the solar sensor based loop improves tracking accuracy especially in sunny conditions where the HCPV system mainly works. Moreover the combination of the two loops can control the mount in all circumstances (day and night, sunny and cloudy weather, operational and "safety" positions). The simplicity and the modularity of the system allows also to reach the target of a low cost sun tracking system.