Young Researcher Symposium IEEE Benelux Chapter IAS/PES/PESC,
April 24 – 25, 2014, Ghent, Belgium

# SUN POSITION ALGORITHM FOR SUN TRACKING APPLICATIONS

Arslan A. Rizvi*, Abdelrahman El-Leathy*, K. Addoweesh* (SM IEEE), M. Babar**

*Sustainable Energy Technologies, King Saud University, Riyadh, KSA
Email: aarizvi@ksu.edu.sa
**Department of Electrical Engineering, Technology University of Eindhoven, Eindhoven, The Netherlands

**Abstract** The efficiency of solar power systems, either concentrating or non-concentrating, can be increased by incorporating a tracking system. The tracking controller requires the position of sun in the sky which can be obtained by using a sun position algorithm that calculates sun position in a certain coordinate system. This papers presents a method to calculate the sun position which could be useful in tracking sun without sensors. The proposed algorithm is a compilation of different equations that compute solar position.

**Keywords:** Acceptance Angle, Azimuth, Elevation, Sun Position Algorithm, Sun Tracker.

## INTRODUCTION

The knowledge of sun position is used in many areas of science. One of its applications is in sun tracking systems in solar power applications and for calibration of solar radiation measurement equipment. The aim of this paper is to present a sun position algorithm and describe different associated concepts.

A sun position algorithm calculates the position of the sun in a certain coordinate system. Time and location are given as input while reference frame coordinates of sun are given as output by the algorithm. The selection of coordinate system depends upon the application e.g. for solar power calculations the horizontal coordinate system is used because the sun seems to move in the sky [1]. The horizontal coordinate systems is the most used coordinate system for solar engineering applications [2], routine astronomical calculations and calibration of solar radiation measuring equipment [3]. It describes the position of any celestial object in terms of two angles i.e. Azimuth angle and Elevation Angle. The elevation angle is the angle of the object above the horizon from the point of observation while the azimuth angle has diversified definitions. For instance, in ISO 19115, it is the angle measured clockwise from north to the horizontal projection of the line connecting the object being observed and the observation point.[4]. The point directly above the point of observation is known as zenith. Figure 1 depicts the concept of azimuth ($\gamma$) and elevation angles ($\alpha$).

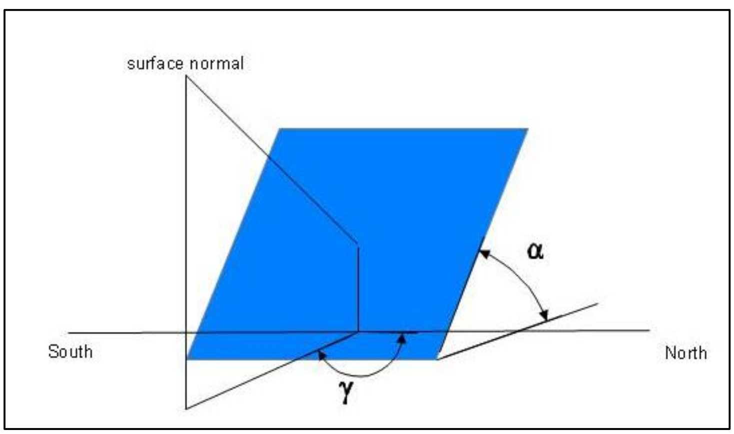


**Figure 1: Azimuth angle according to ISO 19115 is measured clockwise from North**

## CALCULATION OF SUN POSITION

The calculation of sun position in terms of azimuth and elevation angles requires calculation of certain parameters. These parameters will be discussed in the full paper. However few important equations are given below.

### Local Standard Time Meridian (LSTM)

$$LSTM = 15\ (|Local\ Time - GMT|)$$

### Equation of Time (EoT)

$$EOT = 9.87\sin(2B) - 7.52\cos(B) - 1.5\sin(B) \quad 2$$

Where

$$B = \frac{(d-81)360}{365} \quad 3$$

d is the day number, with d =1 for January 1 and d = 365 for December 31.

### Time Correction Factor

$$TC = 4\,(Longitude - LSTM) + EOT \quad 4$$

### Local Solar Time

$$LST = LT + \frac{TC}{60} \quad 5$$

Where LT is the local clock time.

### Solar Hour Angle (h)

$$h = 15°\,(LST - 12) \quad 6$$

### Solar Declination Angle (δ)

$$\delta = 23.45\sin\left[\frac{(d-81)360}{365}\right] \quad 7$$

### Solar Elevation Angle ($\alpha_s$)

The solar elevation angle as described before, is the angle above the horizon to the object from the point of observation and sun. It can be calculated using the following relation.

$$\alpha_s = \sin^{-1}[\sin\delta\sin\varphi + \cos\delta\cos\varphi\cos h] \quad 8$$

### Solar Azimuth Angle ($\gamma_s$)

Solar azimuth angle can be calculated by using the following relation.

$$\gamma_s = \cos^{-1}\left[\frac{\sin\delta\cos\varphi - \cos\delta\sin\varphi\cos h}{\cos\alpha_s}\right] \quad 9$$

## CONCLUSION

The complete paper will present the proposed algorithm which simply calculates the azimuth and elevation angle of sun in horizontal coordinates. The accuracy of the algorithm will be tested and verified with NOAA sun position charts and the mean difference will be shared. The advantage of using this algorithm is that it can easily be programmed into a microcontroller and a very cheap tracking system can be manufactured for low or non-concentrating systems.

## REFERENCES

[1] M. Iqbal, *An introduction to solar radiation*. Toronto: Academic Press, 1983.

[2] M. Blanco-Muriel, D. C. Alarcón-Padilla, T. López-Moratalla, and M. Lara-Coira, "Computing the solar vector," *Solar Energy*, vol. 70, pp. 431-441, // 2001.

[3] I. Reda and A. Andreas, "Solar position algorithm for solar radiation applications," *Solar energy*, vol. 76, pp. 577-589, 2004.

[4] R. Kittler and S. Darula, "Determination of time and sun position system," *Solar Energy*, vol. 93, pp. 72-79, 2013.