## 2.20 Sun's Position to High Accuracy

## 高精度的太阳位置

The algorithms presented so far are accurate to within about 1° and are sufficient for most terrestrial photovoltaic applications. For flat plate modules the siting is only accurate to a few degrees and the errors introduced by the simple algorithms are negligible when compared to the unknown factors at the location such as atmosphere effects. For concentrator modules, where the modules track the sun and focus the light, the simple equations introduce an unacceptable degree of error. As the concentration increases so does the need for sun tracking accuracy. For systems with concentration ratios of 1000:1 the sun must be tracked to within 3.5 minutes (0.06°) of arc[1]. One possibility for tracking the sun is to use a look up table based on the Astronomical Almanac[2] or the computer implementation, the Multiyear Interactive Computer Almanac (MICA) available from the United States Naval Observatory. However, such a system would be unwieldy for the microcontrollers used in tracking systems. There are numerous algorithms developed for sun tracking with a trade off between accuracy and complexity. Before the advent of modern computers, the emphasis was on simplicity but now even small microcontrollers can handle quite complex mathematical formula.

我们目前所采用的计算太阳位置的算法可以精确到 1 度，这对于地面上的大多数光伏应用已经足够精确了。对于平板型太阳能组件，选址只精确到几度。相比于所在地的未知因素比如大气作用的影响，简单算法导致的误差可以忽略。对于聚光型太阳能组件而言，组件需要跟踪太阳并聚光，这样一来，简单计算公式导致误差就不可接受了。聚光程度越高，对太阳跟踪的精度的要求也越高。对于聚光比为 1000 比 1 的系统，太阳跟踪的时间差必须被控制在 3.5 分钟之内（0.06 度）[1]。一种解决方案是参考天文学年鉴中给出的对照表，另一种解决方案是使用美国海军天文台的多年交互式计算机年鉴 [2]。然而，跟踪系统中的微处理器无法驾驭这样的系统。人们开发了很多太阳跟踪的算法，它们需要权衡精确度和复杂度。在现代计算机出现之前，人们更多关注了算法的简便性。但是现在，即使是很小的微控制器也可以计算很复杂的数学公式。

Blanco-Muriel et al.[3] from the Plataforma Solar de Almerýa (PSA) review the accuracy of all the algorithms. Further they develop a simplified algorithm that is accurate to within 0.5 minutes of arc for the year 1999-2015. The PSA algorithm has been specially optimised in C++ code for microcontrollers and is available at http://www.psa.es/sdg/sunpos.htm. The code has been converted to work with the PVCDROM and is presented below.

西班牙阿尔梅里亚省太阳能平台（PSA）的布兰科·穆里尔等人研究了所有算法的准确性。更进一步，他们开发了一个对于 1999 年到 2015 年之间的太阳跟踪精度小于 0.5 分钟的算法。PSA 算法已经通过 C++代码对微控制器专门优化过，可以通过 http://www.psa.es/sdg/sunpos.htm 网址下载。代码经过转换后可以在 PVCDROM 上工作，如下所示。

A further refinement is available was reported by NREL[4] with an online implementation available at: http://www.nrel.gov/midc/solpos/spa.html



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NREL 对于上述代码做了进一步的改良[4]，他们推出的算法可以在线使用（网址：http://www.nrel.gov/midc/solpos/spa.html）。

**PSA algorithm for High Accuracy Tracking of the Sun**

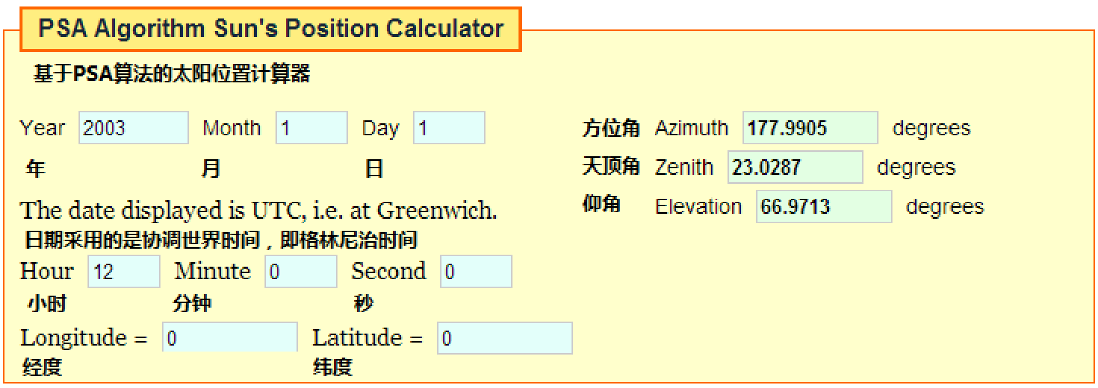
高精度太阳跟踪的 PSA 算法

The PSA algorithm uses Universal Time (UT) to remove the uncertainty caused by local time zones. The location is entered using longitude and latitude with the minutes and seconds converted to fractions of a degree. The azimuth angle is measured from true north not magnetic north and the zenith angle is measured from the vertical. The elevation angle is measured from the horizontal.

PSA 算法采用的是协调世界时间，这避免了因为地方时区导致的不确定性。它通过输入经度和纬度来确定地点，角度的分和秒需要转化成小数。太阳方位角的测量基于地理上的北而非磁极上的北，天顶角的测量基于竖直方向，太阳仰角的测量基于地平线。

The default values of midday on 1st January 2003, with a longitude and latitude of 0° (a location off east Africa) give an azimuth of 178°, denoting that the sun is almost due south. The zenith angle shows the sun is high in the sky but 23° from being directly overhead.

该算法的默认的数值为 2003 年 1 月 1 日中午 12 点，地点为经纬度都为 0 度的位置（位于东非的某处）。得到的太阳方位角为 178 度，这表明太阳基本上处于正南方向。天顶角表明天空中太阳位置很高，但距离太阳正在头顶的情况还差 23 度。

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