The Sundial Primer
ZW2000 and Your Horizontal Sundial

created by

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At this point I assume that you have downloaded and set up ZW2000 on your computer and have also read the overview document. If not please read "Getting Started with ZW2000" and "ZW2000 and Your Sundial".

These instructions will help you learn how to use ZW2000 to design a horizontal sundial. Initiate the program ZW2000 and select "New Sundial". Figure 1 shows the ZW2000 data input screen that will be produced for a horizontal sundial that will display local apparent or sun time.

Figure 1: ZW2000 Data Input Screen

In this example the design information for the horizontal sundial entered in the "general layout" section is:

filename without extension	TEMP
kind of sundial	flat sundial
year	2007
standard meridian	90º West
local meridian	95º West
latitude	50º North

dial inclination	0 (horizontal)
dial declination	0
gnomon	15

As this data is entered the information in the next section is automatically being updated as the calculations are performed. The final information presented in the "constants of flat sundial" section is:

styleheight	50 (equal to the latitude for a horizontal sundial)
stylelength	19.58 (gnomon / sin (styleheight) = 15 / sin 50)
x style perforation	0 (style on the y axis)
x style perforation	-12.59 (gnomon / tan (styleheight) = 15 / tan 50)
hourangle substyle	0 (sub-style on the y axis)
angle substyle / y-axis	0 (sub-style on the y axis)

In the "kind of lines" section the following information is entered:

A local time	Select this box and a check mark will appear.
A local time begin	0
A local time end	24
A local time step	0.25
L declination lines	Select this box and a check mark will appear.
L declination lines 3 lines	Select this box and a check mark will appear.

The hour lines selected will indicate local apparent or solar time. The entire 24-hour day was entered with time intervals of 15 minutes between hour lines. ZW2000 does not include hour lines that are before sunrise and after sunset for the selected latitude. The declination lines for the solstices and equinoxes will appear on the sundial. They will be used to determine where the nodus will cast a shadow on the sundial.

It is a good idea to record this information, as you may need to reference it later. A table is provided at the end of this document for you to do just that.

Now select "calculate and draw". You may be warned that you are about to overwrite an existing file if you have not entered a new file name. Select the appropriate response. Figure 2 shows the completed sundial. The design consists of the hour lines and the declination lines. The horizontal red line at the top of the screen represents the "gnomon", that is the length of the pin gnomon perpendicular to the sundial's plane. The red cross below the lower declination line is the location of the "foot point" of the gnomon. This is where the pin gnomon with a length of 15 units is located. The point where all the hour lines start is the "intersection point of the style" or the origin. The hour lines and declination lines are not labelled. However because this sundial indicates local apparent time the noon line is the vertical hour line and the 6am/6pm line is the horizontal hour line. This makes it relatively easy to find the full hour lines and the 15-minute interval lines. As this sundial is designed for the Northern Hemisphere the hour lines are numbered clockwise with am to the left of the noon line and pm to the right. The

numbering is reversed for the Southern Hemisphere. The upper curved line is the declination line for the summer solstice, the lower curved line is the winter solstice and the horizontal line is the spring and fall equinoxes. These are reversed for the Southern Hemisphere. If a triangular gnomon is to be used the declination lines can be removed. If a pin or perpendicular gnomon were to be used the hour lines would not go beyond the two solstice lines.
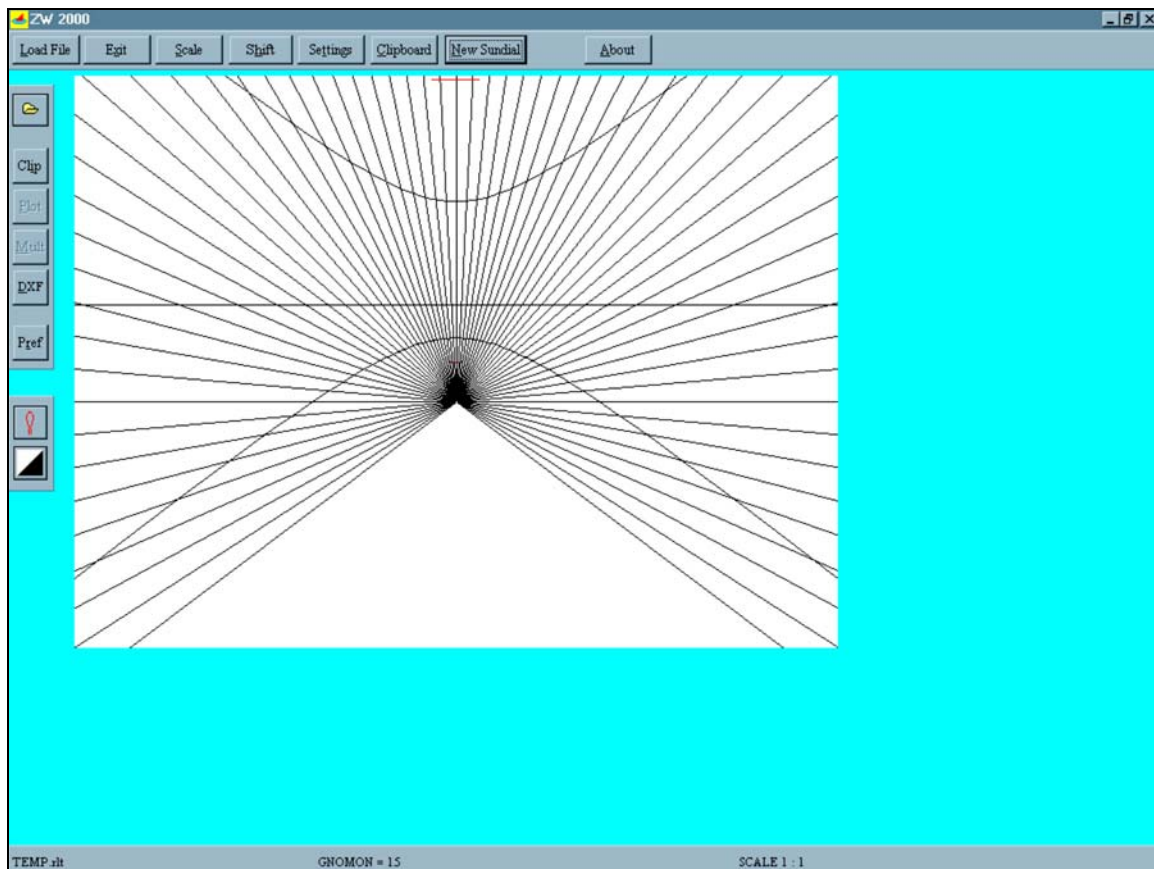

Figure 2: Local Apparent Time Horizontal Sundial Design

None of the configurations described above can be done using ZW2000. The sundial design can be saved as a dxf file as shown in Figure 3. Select the "DXF" button on the left of the screen and save the sundial design. The dxf file can now be opened in a computer aided design (CAD) software package such as DeltaCad. The drawing can be modified to remove or add anything you like.

The effects of changing "Scale" and "Shift" are obvious when you use them. Normally these settings do not need to be adjusted. Selecting "Settings" will allow you to change the colours of the lines. The selections made in the "kind of lines" will be highlighted in green in this screen. Select the box to the right of one of the highlighted items and a window will appear that will allow you to change the colour of that particular item. The lines do not change colour until you leave this window. Try these features out…you won't break anything!
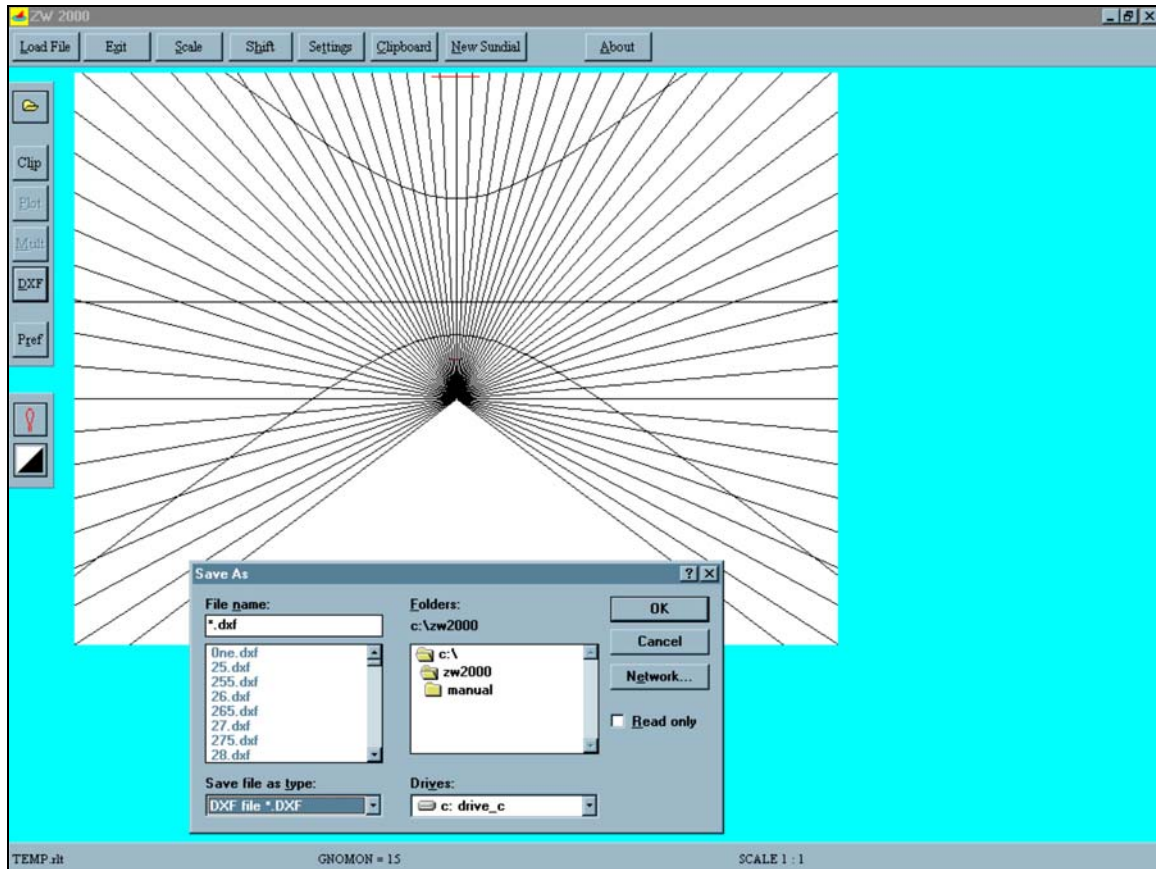
Figure 3: Local Apparent Time Horizontal Sundial DXF

In this next example we will design a horizontal sundial that indicates zonal solar time or local apparent time corrected for longitude. Figure 4 shows the ZW2000 data input screen that will be produce this horizontal sundial. The only change made is that "standard time" is now selected in the "kind of lines" section.

Figure 4: ZW2000 Data Input Screen

Figure 5 shows the completed sundial after "construct and draw" was selected. As you can see the hour lines are rotated, as they should be for a sundial with longitude correction applied to the hour lines. The noon line will no longer be vertical and the 6am/pm line will no longer be horizontal. There is an obvious problem here in that it is not obvious which lines are the full hour lines. What do you do? Where is the zonal solar noon line?

First calculate the longitude correction.

Longitude Correction (LC) = Standard Meridian (SM) – Local Meridian (LM)

If the LC is positive the sundial is located east of the SM and the zonal solar noon hour line will be rotated into the afternoon. If the LC is negative the sundial is located west of the SM and the zonal solar noon hour line will be rotated into the morning. Bit if the time interval or "step" between hour lines is a small value it still may be difficult to find the noon line. You must calculate how many minutes the noon line has shifted earlier or later and then it is not difficult to find the zonal solar noon line.
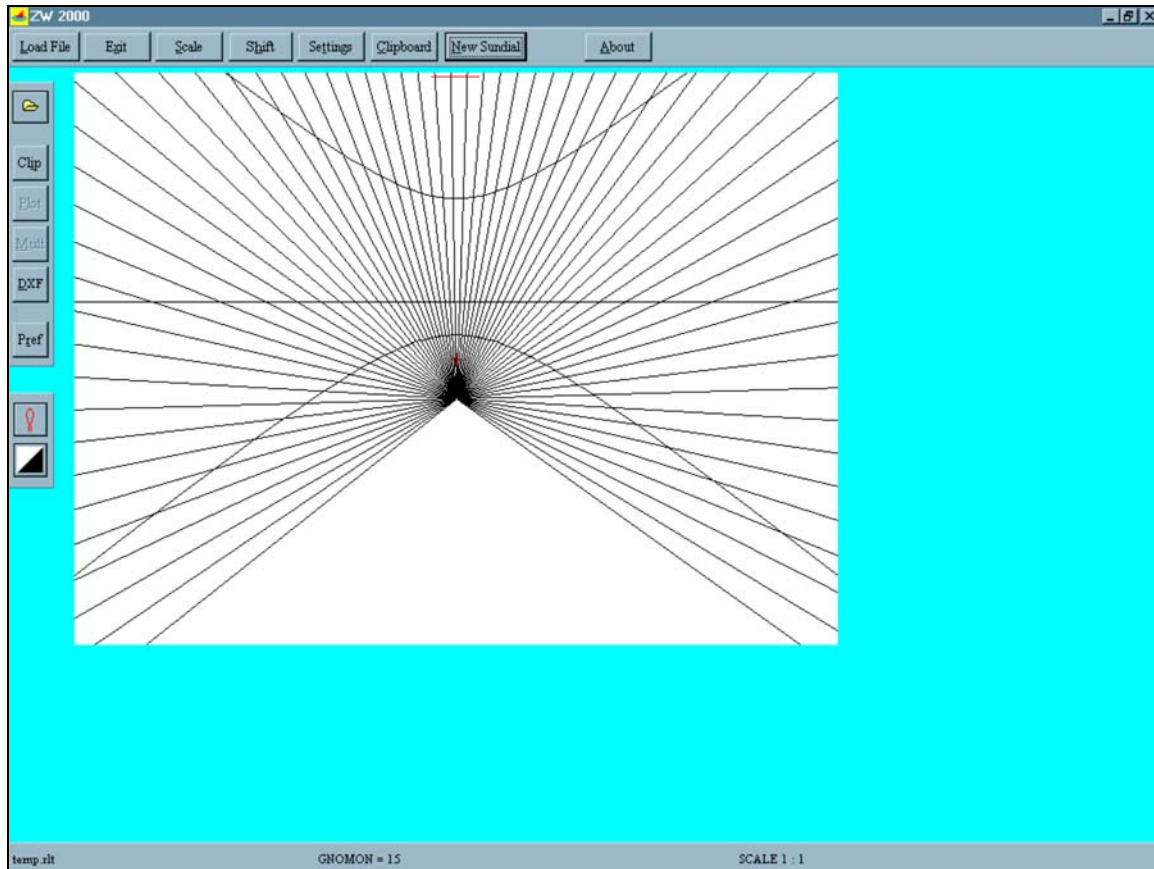
Shift = LC x 4 minutes

Figure 5: Zonal Solar Time Horizontal Sundial Design

OUCH!!! Okay, there is a simpler method that can be used to overcome this problem.

The first thing to do is select "standard time + full analemma" in the "kind of time" section. For this selection set "begin" to 12, "end" to 12 and interval to 1. Do not remove the "standard time" selection, as all the hour lines will be lost. Select "construct and draw" and the sundial in Figure 6 will appear. The only difference between this sundial and the one in Figure 5 is the analemma that appears on the zonal solar noon line. This is a very useful reference. Save this drawing as a dxf file. It's just that easy!

All the comments provided in the paragraph above Figure 3 for the local apparent time sundial design apply to the design of this sundial.

When the dxf file of the sundial in Figure 6 is opened in a CAD drawing the analemma is used to find the noon hour line. The remaining full hour lines are easy to find knowing the time interval between hour lines. The colour of these lines can be changed to ensure that they are not lost when the analemma is deleted if you do not plan on keeping it. The declination lines can also be removed if you do not want them as part of your design.
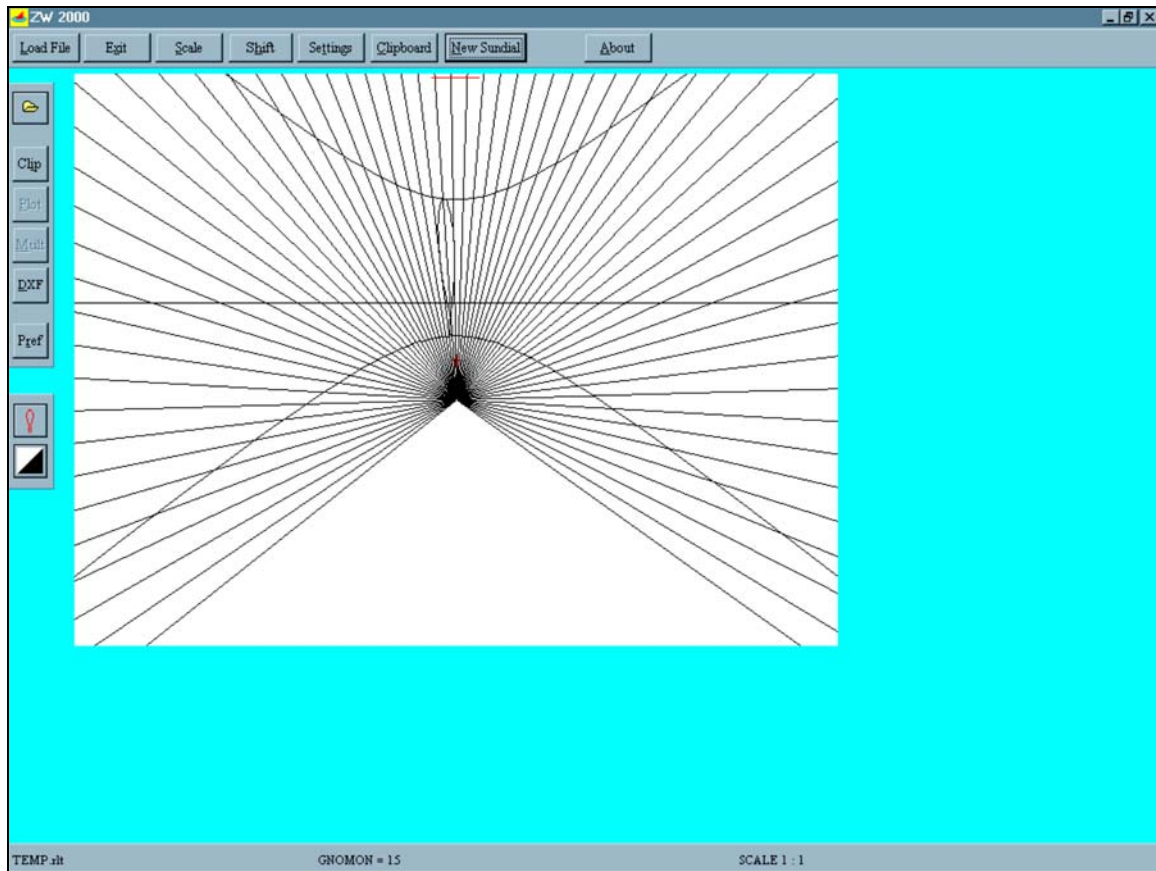
Figure 6: Zonal Solar Time with Analemma Horizontal Sundial Design

HAPPY DIALLING!

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ZW2000 Data Input Reference Table

general input		
filename without extension (8 characters max.)		
kind of sundial	flat sundial	
year (1900 – 2200)		
standard meridian (-180⁰ <= SM <= 180⁰)		
local meridian (-180⁰ <= LM <= 180⁰)		
latitude (-90⁰ <= phi <= 90⁰)		
dial inclination (0⁰ <= i <= 180⁰)		
dial declination (-180⁰ <= d <= 180⁰)		
gnomon (1 <= g <= 100)		
constants of flat sundial		
styleheight (degrees)		
stylelength		
x style perforation		
y style perforation		
hourangle substyle (degrees)		
angle substyle – y-axis (degrees)		
points every ? days	3 days	1 day
draw substyle	yes	no
draw points on half analemma (list dates)	yes	no

kind of lines			
	begin	**end**	**step**
A local time			
B local time + full analemma			
C local time + half analemma 21/12 – 21/6			
D local time + half analemma 21/6 – 21/12			
E standard time			
F standard time + full analemma			
G standard time + half analemma 21/12 – 21/6			
H standard time + half analemma 21/6 – 21/12			
M altitude lines			
N azimuth lines			
K date lines (month, day)	1/month	1,16/month	
choose			
L declination lines	3 lines	7 lines	
choose			