Lab Notes

Conducted By Steve Ford, WB8IMY
Assistant Technical Editor

Where Am I?

An alternative title for this month's column might be: Everything You've Always Wanted to Know About Coordinates and Grid Squares But Were Afraid to Ask.

As more hams explore the worlds of VHF, UHF, microwave and satellite operating, we receive an increasing number of questions about grid squares in particular and geographical coordinates in general. Mike Gruber, WA1SVF, ARRL Laboratory Engineer, walks you through this maze and helps you discover where you are—geographically, if not metaphysically!—WB8IMY

Q: I'm interested in trying my luck in an upcoming ARRL VHF/UHF or 10-GHz contest because I'm gunning for my VHF/UHF Century Club award. They say that* grid squares *are usually exchanged during these contests, but I'm not sure what a grid square is. How do I determine my own grid square?

A: Before we get into grid squares, let's take a quick look at one of the more common methods used to define locations. If you have a globe handy, get it now. If not, just about any map will do.

As you look at your globe or map, notice the lines that run north to south as well as east to west. These lines divide our entire planet into a system of coordinates. Any point on the globe can be defined by the intersection of two ordinate lines.

Q: I seem to recall this from my fifth-grade geography class. My apologies to Mr Conlin, an excellent teacher, but it really has been a few years for me. Can you refresh my memory?

A: Certainly—but first take a look at Figure 1. The latitude lines, sometimes called *parallels,* are the ones that run parallel to the Equator. They are defined by their position north or south of the Equator in degrees. The Equator is defined as 0° latitude and each pole is at 90° latitude. The north pole is +90° and the south pole is –90°.

Longitude lines, sometimes called *meridians*, are shown in Figure 2. Notice that they run from pole to pole perpendicular to the latitude lines. They are similarly expressed in degrees relative to the famous reference *prime meridian* (0°) running through the Royal Observatory in Greenwich, England. (The prime meridian was established in 1884 by the International Meridian Conference held in Washington, DC.) Longitude lines are positioned in degrees east and west of the prime meridian to the 180° point on the opposite side of the globe. This is the approximate location of the International Dateline. Notice that while longitude runs from 0 to 180° east or west, latitude lines run only from 0 to 90° north or south.

Two systems are commonly used to express a part, or fraction, of a degree. Take care not to confuse them. The easiest system to understand is the decimal method in which each degree is divided into tenths, hundredths, thousandths, and so on. It's similar to the way a dollar bill is divided into tenths (dimes) and hundredths (pennies). The decimal system is easy to calculate with a standard electronic calculator.

The second method divides the degree into minutes and seconds of arc. Each minute is *one-sixtieth* of a degree and a second is *one-sixtieth* of a minute (or one-three thousand six hundredths of a degree!). One not-so-obvious advantage of this more traditional system is compatibility with the nautical mile. Each nautical mile is equal to one minute of latitude, or approximately 6076.1 feet. One knot, by the way, a unit commonly used to express wind speeds, is equal to one nautical mile per hour. (Be sure not to express speed, or velocity, in "knots per hour." I've even heard my local TV weatherman commit this *faux pas*!)

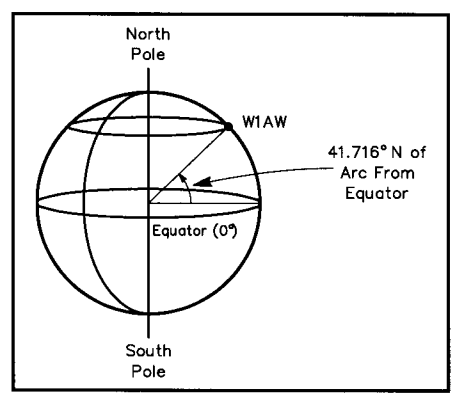


Figure 1—Latitude lines circle the Earth at positions north and south of the Equator. The latitude of station W1AW is 41° 42' 57" N (or 41.716° N).

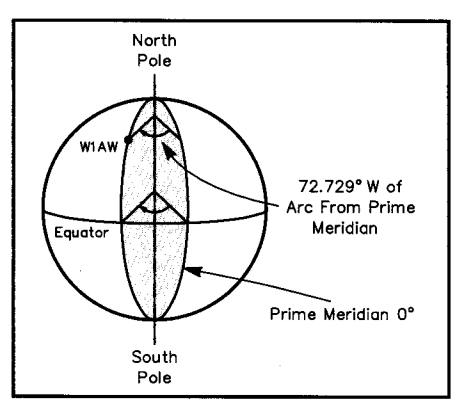


Figure 2—Longitude lines run north and south from pole to pole. Zero degrees longitude is known as the *prime meridian.* The longitude of W1AW is 72° 43' 43" W (or 72.729° W).

Coordinates by the way, are very handy to know. They can be used to determine Great Circle headings and distances for beam orientation, and may also be required for many types of ham radio software, including satellite tracking and propagation prediction programs.

Q: Great Circle headings? Great Scott! Now what are you talking about? Mr. Conlin never told me about those.

A: A Great Circle path is the shortest distance between two points on the globe. Because of the spherical shape of our Earth, Great Circle headings and distances cannot be readily determined by ordinary flat maps. Several peculiar and surprising phenomena are associated with Great Circle headings. For example, the Great Circle heading from your location to some other arbitrary location is probably *not* 180° different from the return heading to you from that location!

The best way to fully appreciate Great Circle paths is with a globe and a piece of string. Notice that if you stretch the string between two distant points on the 45th parallel, the string does not simply follow the path of the latitude line. Instead, the center of the string deviates northward. The string is following the Great Circle path. Experiment a bit with other points. Notice that the heading from true north of one point is not always 180° from the return path at the other point.

Equations for Great Circle headings can be found in Chapter 4 of the fourth edition of the *ARRL Operating Manual*, along with a list of coordinates for many cities around the world. Other related computer programs are also available; I'll be sure to include sources for them before we finish.

Q: Okay. I'm with you so far. But now that we've covered coordinates, how can I determine the coordinates for my specific location? My backyard doesn't have all those black lines painted on it!

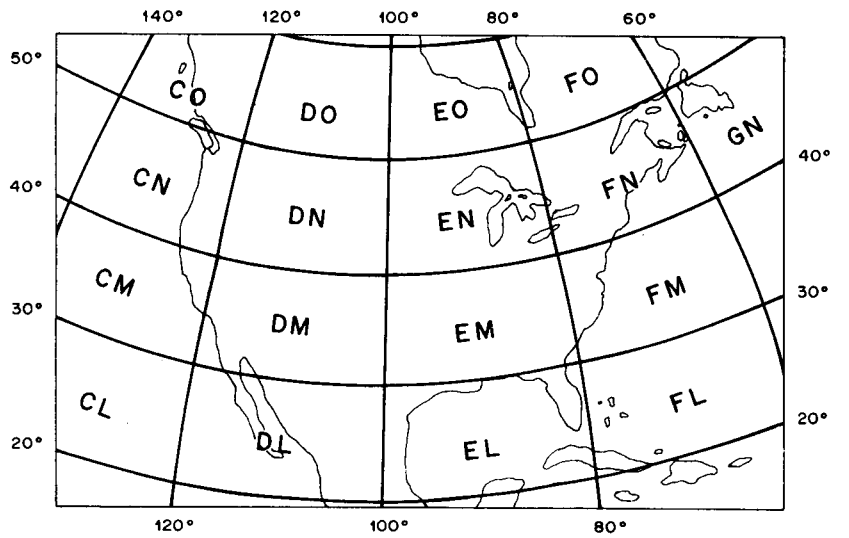
A: Well, presently there are three common methods available to you. Let's cover them one-by-one.

Maps and Charts: Although there are numerous maps and charts that amateurs can use to determine coordinates, the most useful are the US Geological Survey (USGS) topographical maps, or *topos* as they are often called. The USGS produced the first such map in 1879. Today they've

Table 1
How to Determine Your Grid Location

For further information on grid locations, two ARRL publications are helpful: the *World Grid Locator Atlas* (#2944, $5 postpaid) and the Grid Locator Map (which covers North America; #1290, $1 postpaid). Use the order form in the ARRL Publications Catalog elsewhere in this issue.

1st and 2nd characters: Read directly from the map.



3rd character: Take the number of whole degrees west longitude, and consult the following chart.

Degrees West Longitude	*Third Character*	*Degrees West Longitude*	*Third Character*	*Degrees West Longitude*	*Third Character*
60-61	9	88- 89	5	114-115	2
62-63	8	90- 91	4	116-117	1
64-65	7	92- 93	3	118-119	0
66-67	6	94- 95	2	120-121	9
68-69	5	96- 97	1	122-123	8
70-71	4	98- 99	0	124-125	7
72-73	3	100-101	9	126-127	6
74-75	2	102-103	8	128-129	5
76-77	1	104-105	7	130-131	4
78-79	0	106-107	6	132-133	3
80-81	9	108-109	5	134-135	2
82-83	8	110-111	4	136-137	1
84-85	7	112-113	3	138-139	0
86-87	6				

4th character: This number is the same as the *2nd single digit* of your latitude. For example, if your latitude is 41° N, the 4th character is 1; for 29° N, it's 9, etc.

This four-character (2-letter, 2-number) designator indicates your 2° × 1° square for VUCC award purposes.

Table 2
More Precise Locator

To indicate location more precisely, the addition of 5th and 6th characters will define the *subsquare,* measuring about 4 × 3 miles. Longitude-latitude coordinates on maps, such as U.S. Department of the Interior Surveys, can be extrapolated to the nearest tenth of a minute, necessary for this level of locator precision. *This is not necessary in the VUCC awards program.*

5th character: If your number of degrees longitude is an *odd* number, see Fig. A. If your number of degrees longitude is an *even* number, see Fig. B.

Odd Longitude° (Fig. A)

Minutes W. Longitude	*5th Character*
0- 5	L
5-10	K
10-15	J
15-20	I
20-25	H
25-30	G
30-35	F
35-40	E
40-45	D
45-50	C
50-55	B
55-60	A

Even Longitude° (Fig. B)

Minutes W. Longitude	*5th Character*
0- 5	X
5-10	W
10-15	V
15-20	U
20-25	T
25-30	S
30-35	R
35-40	Q
40-45	P
45-50	O
50-55	N
55-60	M

6th character: Take the number of *minutes of latitude* (following the number of degrees) and consult the following chart.

Minutes N. Latitude	*6th Character*
0- 2.5	A
2.5- 5.0	B
5.0- 7.5	C
7.5-10.0	D
10.0-12.5	E
12.5-15.0	F
15.0-17.5	G
17.5-20.0	H
20.0-22.5	I
22.5-25.0	J
25.0-27.5	K
27.5-30.0	L
30.0-32.5	M
32.5-35.0	N
35.0-37.5	O
37.5-40.0	P
40.0-42.5	Q
42.5-45.0	R
45.0-47.5	S
47.5-50.0	T
50.0-52.5	U
52.5-55.0	V
55.0-57.5	W
57.5-60.0	X

become a standard for both accuracy and content. Their most striking feature is the presence of *contour lines* that define elevation above sea level.

The best USGS topographical maps for determining coordinates cover 7½ minutes latitude by 7½ minutes longitude in areas called *quadrangles*. Each quadrangle is usually defined by a reference code and a prominent feature located within its area. These maps have a typical scale of 1:24,000 (1 inch = 24,000 inches = 2,000 feet), but some quadrangles, especially in some northeastern states, also have 1:25,000 maps that are more compatible with metric units (1 cm = 0.25 km) These maps will often show individual buildings and homes, making them excellent tools to pinpoint the coordinates of your particular residence. Contour lines are shown for 10-foot variations in elevation above sea level.

Topos usually display two different coordinate systems. The first is the one we just discussed. The second is called the *universal transverse mercator* (UTM) grid system. Its big advantage is that all hori-

zontal and vertical lines form perfect squares one kilometer on each side. (Recall that in the system we discussed, one degree of longitude constitutes a greater distance on the Earth's surface at the Equator than it does as we approach the poles.) It is important not to confuse the two systems when trying to determine your coordinates.

Topo maps are excellent sources for information on local terrain, roads and trails, bodies of water and other land features. The *angle of magnetic declination*, or difference between true north and magnetic north, as well as the map's grid north, is also given for each map. (Map grid north and true north do not always precisely agree because the map is really a projection of a curved surface onto a flat surface!) The angle of magnetic declination also changes with time. This is usually of little importance to hams, but it can be a problem if you need a precise angle and you're working from a very old map. For example, the declination here in Newington is currently about 14° but it increases at a rate of approximately 3 minutes per year. (The rate at which the declination changes is indicated on nautical charts.)

To order a topographical map, you need to know the reference code, map name and state. You'll find this information in the map index for your area. You can obtain further information on topo maps, such as pamphlets on map symbols, as well as a map index, by calling the Earth Science Information Center in Reston, Virginia, tel: 800-USA-MAPS (8 AM to 4 PM Eastern Time).

You can also obtain a map index, or order maps from:

USGS Map Distribution
Building 810
Box 25286 / Denver Federal Center
Denver, Colorado 80225
tel: 303-236-7476

The cost is $2.50 per map. Add $1 for postage and handling for orders of less than $10.

Topographical maps are also available from many local outdoor, sporting goods shops, camping supply dealers and bookstores. Other maps, including aviation charts and road maps, can also be used in some cases, but usually with reduced precision. Nautical charts are very useful if you are near a coastal environment.

Loran-C: The current version of *lo*ng *ra*nge *n*avigation (loran) is loran-C. It works by comparing the synchronized signals from loran ground stations operating at 100 kHz. Accuracy is good to within about 100 meters. Loran-C can be affected by skywave interference and other local conditions.The portability of a loran receiver is limited by its antenna. Loran is nonetheless very popular with boaters and loran receivers can be purchased at marine supply dealers. You'll find used loran gear selling at bargain prices as GPS systems become more popular (see below).

Global Positioning System (GPS): The satellite-based GPS system was originally conceived for military use. As such, it is a relatively recent innovation for civilian purposes.

The GPS operational system consists of 24 NavStar satellites. NavStars transmit on 1575 MHz, in an internationally assigned navigation band. Other intersystem UHF and microwave links are also required. At the heart of each satellite is an atomic clock accurate to within one second in 300,000 years!

A GPS receiver determines your coordinates by comparing the reported time and location from each received satellite. You must receive signals from three satellites to determine your latitude and longitude. If you can pick up four satellites or more, your approximate elevation can be determined as well (something that Loran-C cannot provide).

The Pentagon has reduced GPS accuracy for civilians to 330 feet. The more precise military GPS accuracy of 53 feet is encoded for security purposes.

To determine the status of the GPS system, you can contact the GPS Information Center (GPSIC) operated by the US Coast Guard in Alexandria, Virginia. You can listen to a taped GPS status announcement (updated daily) by calling 703-313-5900. Similar announcements can be heard on WWV at 14 and 15 minutes after every hour and on WWVH at 43 and 44 minutes after the hour.

Of particular interest to hams are portable hand-held GPS receivers that are now selling for well under $1000. They're similar in appearance to common calculators and can fit in a shirt pocket. The antenna is self contained. (See the review of the Trimble Navigation *Scout* GPS receiver in last month's *QST*).

Q: Great! But you still haven't told me about grid squares. How can I determine my grid square once I know my coordinates?

A: The *Maidenhead Locator System* was named after the village outside London where it was first conceived by a meeting of European VHF managers in 1980. Each grid square measures 1° latitude by 2° longitude and measures approximately 70 × 100 miles in the continental US. A grid square is indicated by two letters (the field) and two numbers (the square). Each subsquare is designated by the addition of two letters after the grid square. These more precise locators are used as part of the exchange in the 10-GHz contest. They measure 2.5 minutes latitude by 5 minutes longitude, roughly corresponding to 3 × 4 miles in the continental US.

The simplest way to determine a grid square is with a grid square map. If you're only interested in a grid square (not the subsquare), and are located some distance from the boundaries of the square, it is usually not necessary to determine the precise coordinates involved. A grid-square map and an atlas are available from the ARRL. (See the publications catalog elsewhere in this issue.)

If you know your precise coordinates, you can also determine your grid square manually. See Tables 1 and 2 for instructions.

Another method of determining your grid square is to simply plug your coordinates into a computer program. This approach is certainly faster and easier. Depending on the software, it may also calculate Great Circle headings to target stations at the same time. This can be of considerable help during a contest. Several such programs are available from the ARRL *Hiram* telephone BBS (tel 203-666-0578) and via Internet (by anonymous ftp) from world.std.com in the /pub/hamradio/ARRL/Server-files area:

GRID.COM—For IBM PCs and compatibles.

GRIDLOC.BAS—Calculates Maidenhead grid square from coordinates.

GRIDX.BAS—Calculates grid squares and Great Circle path headings.

Some GPS receivers, such as the Trimble Navigation *Scout*, will indicate your grid square automatically. This is particularly handy for roving VHF/UHF contesters.

Q: One final question: I don't live near a local marine supply dealer. I would sure like to look at all the GPS, loran-C and navigation tools available to boaters. Are there any mail-order marine suppliers?

A: Yes, there are several. One of the big ones with a detailed catalog is:

E&B Discount Marine
201 Meadow Road
PO Box 3138
Edison, NJ 08818-3138
tel: 800-533-5007

Note: Products and manufacturers are listed in this column for informational purposes only. No warranty or endorsement is expressed or implied.

We welcome your suggestions for topics to be discussed in *Lab Notes*, but we are unable to answer individual questions. Please send your comments or suggestions to: Lab Notes, ARRL, 225 Main St, Newington, CT 06111.

QST