AlphaLab Inc.

Earth Magnetometer Model EM2 Instructions

Assemble the three-segment black stick into a single stick. The plastic point (nearest the white sensor cube) should be on one end of the stick, and the small “L” shape should be on the other end. When using this meter, the plastic point is normally placed on the ground. Then the azimuth and elevation angles of the stick are adjusted to find the maximum value for displayed field strength.

Turn the unit on, or to “Backlight”. (With backlight, the battery life is about 24 hours; without backlight, life is about 20 hours. When the battery icon is down to one bar, remove the back two screws and replace the three AA alkaline batteries.) The meter will display the field in microtesla (uT) in the direction that the sensor is pointed. This is the lower of the two displayed numbers, and is under the word “FIELD”. Magnetic field is a vector, so if the sensor is pointed in the same direction as the actual field direction, the display will read a positive number. If pointed at right angles to the field, the display will read near zero, and if pointed in the opposite direction (180° away from the “same direction as the field”), the display will read negative. The meter can read up to 199.999 uT. Typical Earth field is between 30 and 60 uT. The field is not exactly horizontal in most locations on the Earth’s surface. In fact, it is nearly vertical (downward) in Northern Canada and upward at a corresponding region in the Antarctic.

The most direct way to use the meter is by finding the orientation of the stick that yields the highest “FIELD” reading, and that displayed (maximum) number is the correct field strength. This can be done by orienting the stick in various directions until the direction with the highest FIELD value is found. If done carefully, the field can be repeatably measured down to the last digit (0.001 uT = 1 gamma or 1 nT). In order to obtain the precision, the stick must be pointed to within 0.4° of the actual field direction. If the stick is 0.45° off, the display will read about 0.001 uT low; if it is 0.9° off, it will have four times the error (i.e., it will read 0.004 uT low). Additional features of the meter allow this “maximum” to be determined more easily, as is explained below.

The top number (PEAK) shows the highest field that the sensor experienced since the most recent time that the Reset button has been pressed. This peak-capture function updates much more rapidly than the display does. If at any time the stick was briefly pointed to within 0.4° of the correct direction for at least 10 milliseconds, the PEAK value displayed will be the true field strength at that location. This number is repeatable; that is, remeasuring at that location later will give the same result down to 0.001 uT (unless the field has changed). The upper right corner of the display is a circle which helps visualize whether the stick is pointed close to the correct direction. It becomes a small circle whenever the actual (FIELD) value is within a few counts of the PEAK value. (Remember that the PEAK by definition will never be less than the present FIELD value. Therefore it is always true that FIELD ≤ PEAK.) In areas close to civilization or vehicle traffic, the size of the circle may fluctuate significantly.

The white cube should be oriented so that the displayed FIELD is a positive number (no negative sign) when the stick is pointing straight down. This determination should be done only when the display is *not* showing “REL ZERO”. If the stick is pointed vertically and then it is gradually tipped toward a direction which becomes closer and closer to the true field direction, the FIELD value will increase continually, and the PEAK value will be equal to (or greater than) the FIELD value. (Therefore the peak value will also increase continually.) The light circle (upper right of display) will remain at minimum size, indicating that the FIELD is the same as the PEAK value. If the stick is tipped further and further, eventually the FIELD value will go through a maximum and will start to decrease. At this time, the PEAK remains constant at the highest previous value of the FIELD. The white circle will become large, because FIELD < PEAK.

To make measurements, place to stick on the ground vertically with the point (at bottom) downward. Press “Reset” for at least 1/2 second. Start tipping the stick toward the horizontal; this reduces the stick’s elevation angle (which is something like latitude on a globe). Continue tipping to find the elevation of maximum field. When you have gone too far, the white circle will become big. Tip back upward a little to return to the relative maximum field, then rotate the stick in the *azimuth* direction (like longitude) to find a new, higher maximum. Then change the elevation and then azimuth again to find the absolute maximum. This is displayed as PEAK and it is the field at that location. Walk to the next location and press “Reset” for the next measurement. Each measurement should require 10 seconds or less (with practice).

Compare the PEAK at one location with that of nearby locations to find magnetic variations. To make this comparison easier, the meter can automatically subtract the PEAK value (at a given location) from all the subsequent PEAK and FIELD values. At any initial location, this subtraction function can be initiated. Then at any subsequent location, the PEAK will show how many uT that new location's field is above or below the field of the initial location. To do this, find the field (as above) at an initial location of your choice. Now the PEAK number will be the field strength at that location. Then press the "Relative Zero Mode" button. That PEAK number will be subtracted from both PEAK and FIELD. The subtraction will remain in effect for all subsequent measurements (even if Reset is pressed) until "Relative Zero Mode" is pressed again or until the meter is turned off. For example, if at an initial location PEAK = 50.000 and FIELD = 41.000, then pressing "Relative Zero Mode" at that moment will cause the subtraction of 50.000 from both displayed numbers, meaning that immediately after pressing the button, PEAK will display "0.000" and FIELD will display "- 9.000". If the actual field value later increases from 41.000 to 42.120, then FIELD will display "-7.880" (= 42.120 - 50.000), but PEAK will continue to read 0.000; if the actual field increases further to 51.567, then PEAK will read "1.567" (= 51.567 - 50.000) and FIELD will read "1.567" also.

When working in the relative zero mode, the display will show "REL ZERO". Press the Reset button at each new location as before. Typically, the field only varies a few times 0.001 uT from one measurement location to the next. Therefore, in the Relative Zero Mode, the displayed PEAK value will generally be only a few counts up or down from zero, making it easier to see relative field strengths and to write down the raw numbers, if required.

If the "Relative Zero Mode" is held down for at least 3 seconds, a sound will be heard that corresponds to the difference between PEAK and FIELD. A sound icon will appear. This sound is similar in function to the displayed circle. (Holding this down 3 sec or more will *not* put the meter in relative zero mode. A separate button press of *less than* 3 sec will do that.) Pressing for 3 or more sec again will disable the sound.

If FIELD reads negative with the stick pointing down, slide off the white cube and slide it back onto the stick, with the cube pointing 180° away from its initial orientation. This is usually required in the Southern hemisphere. In some locations, the field is nearly horizontal. Then the lowest segment of the stick (the segment with cube and point) should be removed and connected to the top L- shaped link on the stick. For these nearly-horizontal magnetic measurements, the point is again placed on the ground (with the cube near the ground as before). For the PEAK to operate correctly, the sensor orientation must be such that the displayed PEAK number is positive (i.e., no negative sign).

A faster "scanning" technique can be used to find localized magnetic objects, but it is generally not repeatable down to 0.001 uT. Simply let the stick hang straight down (avoid swinging it or letting the wind blow it away from vertical). Read the FIELD value while walking along. You will notice that a small amount of deviation from vertical will produce a significant difference in the reading even if *not* near a magnetic object. This problem occurs because the Earth field is a vector, so the reading is dependent the angle of the stick. The dependence limits the usable sensitivity of this technique.

Determining the depth: Buried magnetizable objects or materials will usually increase the field strength in the vicinity (although if reverse-magnetized, it is possible that an object can *reduce* the field strength directly over itself). Generally, directly over a buried object, the deviation of field strength is at a maximum. For example, the field may be 45.722 uT directly over an object, compared to an average field of around 44.620 uT away from the object. As you approach this object, the deviation from the background 44.821 uT becomes larger and larger, peaking at 45.722 uT (1.102 uT higher than the average field) directly over the object. A certain distance along the ground away from this peak is a zone where the deviation is only about half as much, or 0.551 uT. (This "zone" will actually be approximately a circle surrounding the object). The depth that the object is buried is generally between 1 1/3 and 2 times the radius of this circle, and the radius is the distance from the point where the deviation is maximum, to any point where the deviation is half that much.

Contrary to popular belief, underground water generally does *not* produce any magnetic field. This is true whether or not the water is flowing. The only way that water can produce a (DC) magnetic field is if (DC) electric current is flowing through it. Without any DC current, the presence of water can only occasionally be inferred in instances where the underground stream of water displaces magnetic minerals; in other words, if the "absence" of magnetic minerals is caused by displacement by water.

Certain objects, such as cell phones, GPS devices, boot zippers, and key chains, may be magnetized. If these are too close to the sensor block, the readings may be affected. You can check to see if anything you're wearing will affect the

sensor (and how close you have to get to affect the sensor). Set the rod against a wall pointing in approximately the direction of maximum field. Look for any changes in the FIELD as you walk closer or move the questionable objects near the sensor block. Remember that the orientation of the objects in space (if held vertically upward, or east-west, etc) will affect the amount of the reading. When making measurements, keep these objects at least twice as far away as the distance required to make the display change by 0.010 uT. The battery in the meter may also affect the sensor block, but it will not cause a problem if kept at least 2 ½ feet away (line-of-sight distance) from the sensor.

The flow of DC current in the ionosphere may cause the magnetic field at the surface to change by as much as 0.030 uT per hour during the day. This change affects large areas on the surface very uniformly, so if one location becomes 0.030 uT higher, another location a mile away will also be 0.030 uT higher. At night this random fluctuation is weaker. Because of this fluctuation, frequent return to the reference location to check for any change in the regional field is advised, especially for measurements during the day. However, this step can be avoided by looking for the *difference* in field strength between one location and the adjacent locations (gradiometry) if all adjacent locations are measured within two minutes of each other.

SPECIFICATIONS: Earth Magnetometer Model EM2 (0 to 43°C)	
Range/Resolution:	199.999µT/ 0.001µT (1 nT)
Accuracy:	+/- 0.5 % of reading +/- 0.001µT
Drift with temperature:	< 1.15 nT/°C
Meter Size:	7.6 x 3.9 x 1.7 inches; 194.7 x 100.6 x 44.3 mm
Weight:	1.16 lbs (525 grams) with stick
Battery:	3 AA alkaline (~ 10 hour life w/ backlight, ~15 hour life without backlight) / "Battery Life " indicator

The warranty period for this meter is one year from the date of delivery.

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