THE COMPUTER CORNER

No. 290: How Close Are Your Measurements?

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How close to what? When you measure a voltage in a circuit, for example, if your VOM reports 2.56 VDC (DC volts), what does that mean? If you next measure it at a nearby connection on the other side of a solder joint and it measures 2.53 VDC, what does that mean? That the joint is a bad solder joint and there is a 0.9 VDC drop in the joint? Or your meter needs a new internal battery and it is rapidly loosing accuracy? What is accuracy? Or is it that your meter is simply off a bit when you make repeated measurements. Maybe its measurements are not very precise. What does precise (precision) mean? Shouldn't it read exactly the same thing each time you measure?

Let me give you another example. I purchased two indoor/outdoor thermometers not long ago. These are little square battery powered gadgets that you place outside somewhere, and they transmit a signal to another little square battery powered receiver that sits inside your house. The inside gadget receives a signal from the outside box, converts it to temperature and displays the result on a little screen on its face. It also displays the "indoor temperature" the temperature that the inside gadget senses. So the inside gadget displays two temperatures – inside and outside. They are not very expensive – on the order of less than $15 for a set of two – a remote sensor box for outside and another receiver box for inside with its reporting display of indoor and outdoor temperature, with a pair of AAA batteries for each of the two. For less than $30 you can have four (two sets), and park one outdoor sensor in your front yard and a second sensor in your back yard. Shouldn't the two temperatures be the same at these two sites? Well, that is another bag of worms, because studies have clearly shown that the microclimate in two places such as a front yard and a back yard can vary quite a bit. Think of winds, for example, and how air currents can be affected by buildings such as your house. Lets not get off on that tangent – back to precision and accuracy and such.

Anyway, I was curious so I put one set of two boxes (outdoor and indoor) on my dining room table 4 inches from each other, followed by a special mercury thermometer. Because I was trained as a biomedical scientist and had need, often, to measure temperature for some of the experiments I was doing over the years, I had in my possession (even 27 years after retiring) a couple of glass mercury thermometers that were verified by what used to be called then the National Bureau of Standards. So that mercury standard is what I trusted as my absolute standard. On the other side of the Mercury Standard were the two little boxes of unit 2. Take a look at the results, rounded to the nearest whole degrees Fahrenheit in the following table.

DAY AND TIME	UNIT 1 OUTSIDE	UNIT 1 INSIDE	MERCURY STANDARD	UNIT 2 OUTSIDE	UNIT 2 INSIDE
5:00 p.m., 18 Aug	80	78	81	78	79
7:30 a.m., 19 Aug	77	76	77	77	76
5:00 p.m., 19 Aug	81	82	83	82	82
7:30 a.m., 20 Aug	77	77	79	77	77
7:30 a.m., 22 Aug	76	76	77	77	76

As you can see, the first day (an hour after unpacking and setting up) they were off by as much as 3 °F, while the next morning they were off from the standard mercury glass thermometer by not more than 1 °F. During the ensuing days, all the little boxes were within 2 °F of the value shown by the standard mercury glass thermometer. Not too bad.

But the point of all this is twofold, accuracy versus precision. First, consider accuracy. Accuracy is how close a measurement is to the ***true*** value. In this case, the true value is my glass mercury standard thermometer, whose accuracy can be traced back to the National Bureau of Standards. Unless this sealed glass thermometer has been damaged in some way (there is no evidence of this), it is certainly accurate to within one degree (F). But what about that 25.6 VDC measurement you made that was described in the first paragraph of this article? Guess what? It could just as easily been 24.6 VDC true value, or truly 26.7 VDC for that matter. Unless you can compare a measurement with some sort of standard, the value reported by your measuring instrument is suspect. You have no way of deciding if it is accurate. For a few bucks, you can build a gadget that will generate voltages that are accurate to 1%. A nice way to check up on your electronic VOM.

Second, is precision. Precision is how close repeated measurements, under the same conditions, are to each other. If I had measured the temperature on my dining room table and it was 77 °F, then I measured it again 1 second later, and again after another second, and so on (if nobody opened a door or started a vacuum cleaner and the furnace did not go on) if all the measurements were 77 °F, we could say the measurements were reasonably precise.

But, precision and accuracy are independent of one another. It is possible to be very precise but not very accurate. It is also said to be possible to be accurate without being precise. Think about that for awhile. Happy Computing!