

## Fluke 8845A/8846A statistics and histograms

### Application Note

“What is the output voltage of the power supply?” This is one of the most common measurements made with digital multimeters. Similar questions arise about the frequency of oscillators, the value of resistors, operating temperature, or the input to a voltage controlled oscillator. It’s easy to use a digital multimeter to take any of these readings. But taking a single reading gives you only part of the story. An equally important question is: “How stable is the output of the power supply?”

We can frame these questions more precisely in statistical terms: What is the average value of the output, and what is the standard deviation? The Fluke 884X Multimeter has integrated analysis functions that provide the answers to both questions.

#### What do averages and standard deviations tell you?

Averaging is a very common calculation. It’s used for test scores, scientific results and sports statistics. It’s used to quantify performance over time (for example: average number of goals per season). It’s also used to quantify typical performance of a population (for example: average number of goals per player). In engineering, we’re interested in both these characteristics: How will the output of my circuit change over time, temperature, or humidity? If I build 100 of these circuits, how can I expect each unit to perform?

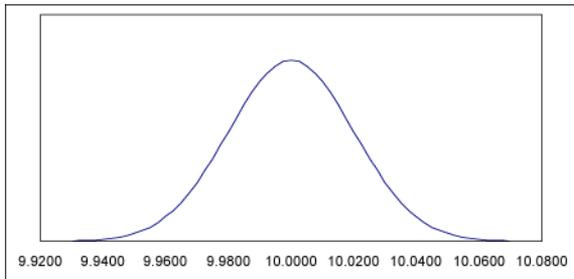
Inherent in each of these questions is the desire to predict performance. But we need more information to be able to use the average in this way. Say the temperature in a particular city has averaged around 21 °C (70

°C) for the past ten years. If we wake up the next day expecting the weather to be warm, we could be very surprised. This is because the temperature can vary over a wide range and still average 21 °C.

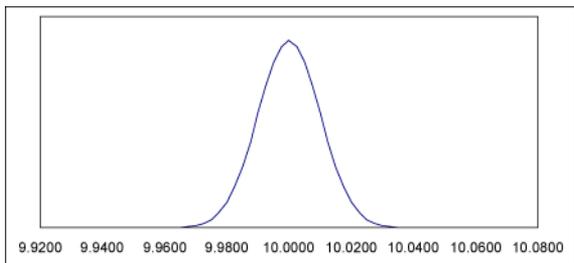


So we need to know how widely the temperature varies around the average. Knowing the variance will tell us the extent to which we can expect “average” performance in the future, or from other members of a population. This is the key to determining engineering specifications—uncertainties and tolerances.

Standard deviation ( $\sigma$ ) measures the variation or spread of a data set. In formal, mathematical terms, standard deviation is the square root of the variance in a set of data. A low standard deviation indicates a tight grouping around the average, and a high standard deviation indicates more “randomness.”



**Figure 1a.** Normal distribution with average = 10 and standard deviation = 0.02.



**Figure 1b.** Normal distribution with average = 10 and standard deviation = 0.01.

Figure 1a and 1b show normal data distributions that are typical of measurement data. Figure 1a shows a set of measurements with standard deviation of 0.02, while Figure 1b shows a set of measurements with a standard deviation of 0.01. There is less uncertainty in the measurement with the lower standard deviation and thus we can be confident setting tighter tolerance.

### How does the Fluke 884X deliver statistics?

The 884x has integrated statistics processing and can calculate and display both average and standard deviation of measurements. The data can be displayed either numerically, or thanks to the pixel display, graphically. The 8845A/8846A can perform statistics on the parameters listed in Table 1.

dc voltage	resistance
ac voltage	capacitance
ac voltage in dB	frequency
dc current	temperature
ac current	period

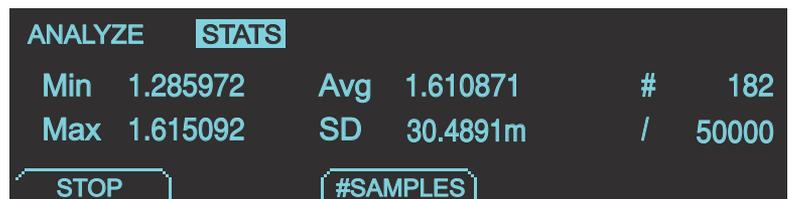
**Table 1.** The 884X can perform statistics on these measurements.

To illustrate how the 884X generates statistics, we will examine how a dc voltage changes over time. We will set up the 884X to measure dc voltage, and report the average and standard deviation.

First, select the measurement on which the statistics will be performed; for this example, dc volts. Then, press the ANALYZE button on the front panel to bring up a menu of math functions as shown in Figure 2. There are two selections on this menu that deliver statistical measurements, the STATS function and the HISTOGRAM function. Let’s look at the STATS function first.



**Figure 2.** The 884X menu link directly to STATS and HISTOGRAM.



**Figure 3.** Sample Min/Max/Avg/SD statistics.

### The STATS function

As soon as you press the STATS softkey, the meter begins calculating the average and standard deviation. It also stores the minimum and maximum measured values. You can reset the statistics function and start over again at any time by pressing the RESTART softkey.

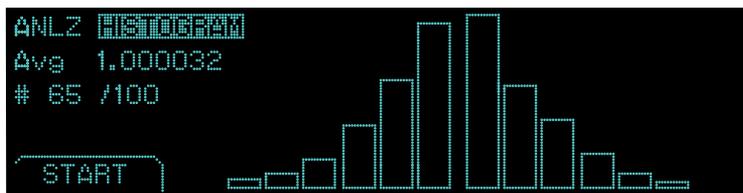
You can also set a number of measurements for the meter to take, by pressing the #SAMPLES softkey and specifying a number from 2 to 5000. The statistics calculations will automatically stop once the number of readings has been reached as shown in Figure 3.

### The HISTOGRAM function

Like the STATS function, the HISTOGRAM function conveys the average and standard deviation of a set of measurements. But the histogram mode delivers the information in a graphical representation that quickly and clearly indicates the distribution, or “spread,” of the measurements. For example, most measurements follow a normal distribution. That means the histogram should be symmetrical around the average and almost all of the measurements (99.7 %) should be within three standard deviations. A lopsided, broad, or bimodal (two-peaked) distribution would indicate unexpected instability or error in the unit under test.

Figure 4 shows an example of the histogram display. The histogram consists of 10 bars. The height of each bar represents the relative frequency of a range, that is, how often a range of readings occurs compared to the other ranges. The center of the display represents the average measurement. The bars on either side of the average represent measurements within one standard deviation from the average. The second bars from the average represent measurements between one and two standard deviations, and so on, out to five standard deviations.

Like the STATS function, the HISTOGRAM function starts as soon as the HISTOGRAM softkey is pressed. The calculations can be initialized and restarted by pressing the RESTART softkey.



**Figure 4.** Histogram display.



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Printed in U.S.A. 5/2007 3034669 A-EN-N Rev A