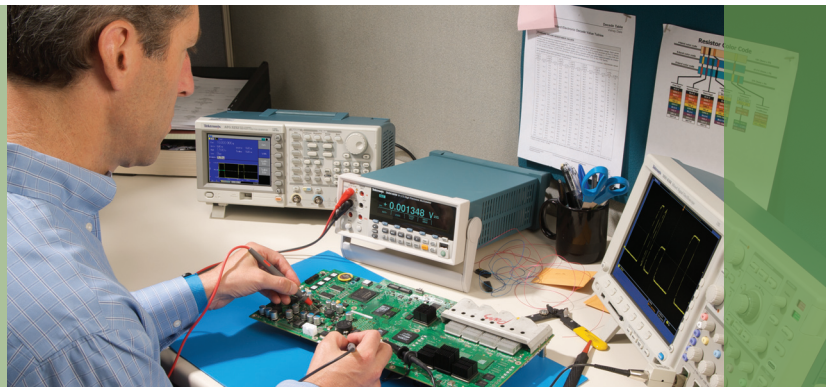

Measurement Statistics and Histograms with the Tektronix DMM4050 and DMM4040 Multimeters

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?" Understanding this, and other questions, requires looking at measurement statistics. What is the average value of the output? What is the standard deviation? The Tektronix DMM4050 and DMM4040 multimeters offer integrated analysis functions to help you answer these questions.

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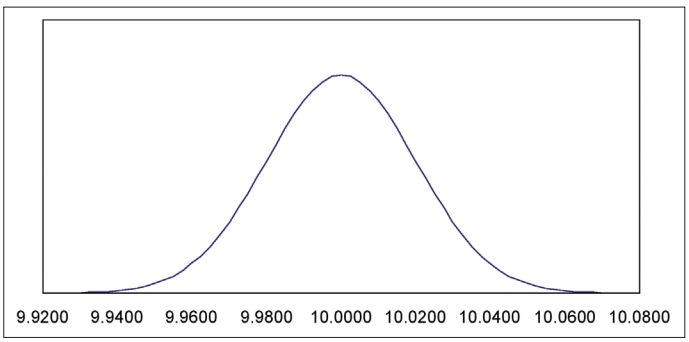

Figure 1a. Normal distribution with average = 10 and standard deviation = 0.02.

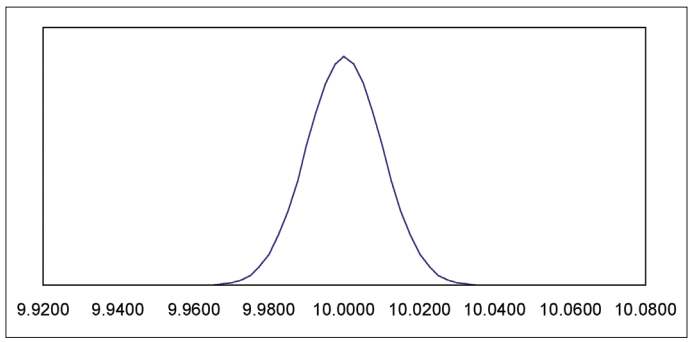

Figure 1b. Normal distribution with average = 10 and standard deviation = 0.01.

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

Table 1. The DMM4050 and DMM4040 can perform statistics on these measurements.

Measurement Statistics: Averages and Standard Deviations

Averaging is a common calculation used to quantify performance over time or to quantify typical performance of a population. In engineering, both of these characteristics are important: How will the output of your circuit change over time? If you build 100 units of a circuit, how will each unit perform?

Inherent in each of these questions is the desire to predict performance. However, more than just the average value of a set of data is needed. You need to also know how widely the data set varies around the average. Knowing the variance will tell you the extent to which you can expect "average" performance at any given time or from any particular device in the group. This is the key to determining engineering specifications – uncertainties and tolerances.

Standard deviation (σ) 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 a broader spread of data.

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 you can be confident setting a tighter tolerance.

Measurement Statistics with the DMM4050/4040

The DMM4050/4040 multimeters offer integrated statistics processing for calculating and displaying both the average and standard deviation of measurements. The data can be displayed either numerically or graphically. The DMM4050/4040 can perform statistics on any of the parameters listed in Table 1.

Generating statistics on the DMM4050/4040 multimeter requires just a few buttons pushes. First, select the measurement on which the statistics will be performed; for 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. After the STATS or HISTOGRAM function is chosen, the multimeter will begin calculating your measurement statistics.

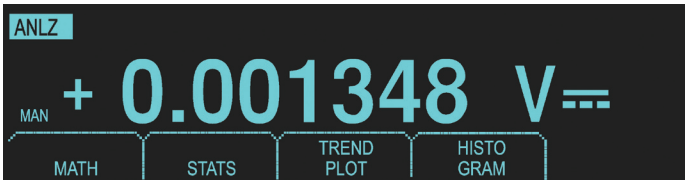

Figure 2. Analyze menu links to STATS and HISTOGRAM.

Figure 3. Sample of Min/Max/Avg/SD Statistics.

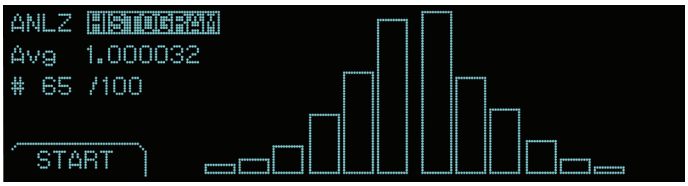

Figure 4. Histrogram Display.

The STATS Function

Once the STATS softkey is pressed, the multimeter 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 the 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 sofkey.

Analyze Your Device with the DMM4050/4040 Analysis Modes

The built-in STATS and HISTOGRAM functions of the DMM4050/4040 simplify calculation of measurement statistics when analyzing a device. Viewing your data as a histogram or looking at the measurement statistics will allow you to track how signal parameters are changing over time, revealing signal quality issues like drift, intermittent transients and stability.

Which multimeter is right for you?

The DMM Series offers a range of models to meet your needs and your budget. The following multimeters offer analysis modes.

	DMM4050	DMM4040
Resolution	6.5 digit	6.5 digit
Basic V dc accuracy	0.0024%	0.0035%
Measurements	V ac, V dc, I ac, I dc, Ω, Continuity, Diode, Frequency, Period, Temperature, Capacitance	V ac, V dc, I ac, I dc, Ω, Continuity, Diode, Frequency, Period
Analysis Modes	TrendPlot™, Statistics, Histogram	TrendPlot™, Statistics, Histogram
USB Port (Front Panel)	Yes	Yes

Contact Tektronix:

ASEAN / Australasia (65) 6356 3900
Austria +41 52 675 3777
Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777
Belgium 07 81 60166
Brazil +55 (11) 3759-7627
Canada 1 (800) 661-5625
Central East Europe, Ukraine and the Baltics +41 52 675 3777
Central Europe & Greece +41 52 675 3777
Denmark +45 80 88 1401
Finland +41 52 675 3777
France +33 (0) 1 69 86 81 81
Germany +49 (221) 94 77 400
Hong Kong (852) 2585-6688
India (91) 80-42922600
Italy +39 (02) 25086 1
Japan 81 (3) 6714-3010
Luxembourg +44 (0) 1344 392400
Mexico, Central/South America & Caribbean 52 (55) 54247900
Middle East, Asia and North Africa +41 52 675 3777
The Netherlands 090 02 021797
Norway 800 16098
People's Republic of China 86 (10) 6235 1230
Poland +41 52 675 3777
Portugal 80 08 12370
Republic of Korea 82 (2) 6917-5000
Russia & CIS +7 (495) 7484900
South Africa +27 11 206 8360
Spain (+34) 901 988 054
Sweden 020 08 80371
Switzerland +41 52 675 3777
Taiwan 886 (2) 2722-9622
United Kingdom & Ireland +44 (0) 1344 392400
USA 1 (800) 426-2200
For other areas contact Tektronix, Inc. at: 1 (503) 627-7111
Contact information updated 4 August 2009

For Further Information

Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

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