What's a half digit, anyway?

Martin Rowe -January 29, 2012

4 Comments

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Most manufacturers of digital multimeters (DMMs) specify their meters in terms of digits such as 3¾ or 5½. While this specification gives some useful information about a DMM, it doesn't tell the whole story. Manufacturers use these fractional terms differently, so you'll have to do a little research to find a DMM that meets your needs.

To interpret a DMM's specs, you need to begin with an understanding of the relationship between a fractional digit and a full digit. A full digit has 10 possible states. The states range from 0 to 9. Does that mean a ½ digit has five states, from 0 to 4? No. A ½ digit has two states, either 0 or 1.

A simple way to remember this is apply what I call the fractional rule of digits, where

$$\text{Fractional digit} = \frac{\text{Maximum value the digit can attain}}{\text{Number of possible conditions}}$$

To better understand this, simply remember that a ½ digit has a maximum value of 1 and has 2 possible conditions (0 or 1). There's your ½. A ¾ digit, therefore, has a maximum display of three values, and it has 4 possible conditions (0, 1, 2, and 3). (**Fig. 1**) A digit with a maximum count of 4 would, to continue this reasoning, be a 4/5 digit.

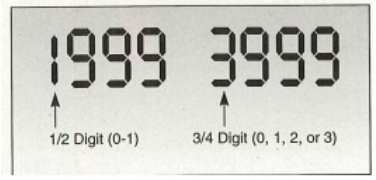

Figure 1. While a full digit can

display up to 10 digits (0 to 9), 1 ½-digit can display only two digits and has a maximum value of 1; a ¾-digit displays four digits: 0, 1, 2, and 3.

If you apply the functional rule to typical DMMs, you'd expect a 3½- digit DMM to have 2000 counts (from 0 to 1999), a 4½-digit DMM to have 20,000 counts (from 0 to 19,999), and a 3¾-digit DMM to have 4000 counts (from 0 to 3999). Meters with a ½-digit display normally have full-scale voltages of 200mV, 2V, 20V, and 200V; meters with a ¾-digit display have full-scale voltages of 400 mV, 4V, 40V, and 400V.

You might think that the number of digits in a DMM relates to its resolution (the smallest change in input that the instrument can detect), but there's no connection between the two specifications. A 3½- digit DMM's maximum display on the 2-V scale is 1.999V, with 1-mV resolution. A 3¾-digit DMM on the 4-V scale can measure up to 3.999V, also with 1-mV resolution. Both the 3½-digit and 3¾-digit meters offer 1-mV resolution, even though the 3¾-digit meter has twice the range of counts.

Select the right meter

To select the meter that is right for your application, you need to decide what combination of resolution and full-scale voltage you need. If you want to measure a 1-mV change in a 1-V signal, then either a 3½- or 3¾-digit meter will do. Both have resolution of 1 mV.

To make a 3-V measurement, however, the 3½-digit meter must use its 20-V scale. At 20-V full scale, the meter's resolution is 10 mV, and you can't measure the 1-mV change anymore. To make this measurement, you'll need a 3¾-digit meter or a 4½-digit meter. In fact, if you want to measure a 1-mV change, your meter should probably have 100-µV resolution because noise-induced errors limit the accuracy of the last digit.

Be aware, though, that you can't select a meter based solely on its number of digits. Many benchtop and system DMMs don't have full scale that matches the full counts of all their digits. Even though a manufacturer specifies a meter having 6½ digits, the meter may not have a range of 1,999,999 counts on a 2-V full-scale range.

Consider the **Hewlett-Packard 34401A** as an example. HP says the meter has a 6½-digit display. By applying the fractional rule, you would predict that the meter has a maximum display of 1,999,999 counts. The 34401A's specs, however, show that the meter's full count is 1,200,000. If the HP 34401A really a 6½-digit meter despite its counts? Yes; each of the full digits can display the full range of 0 to 9, and the ½-digit displays 0 or 1. For example, a 99.9999 reading on the HP 34401A is possible, but a 199.9999 reading is not. Therefore, you can't assume that a meter with a ½ digit will have full-scale readings of 199.9V, 1.999V, or 19.99V.

Similarly, **Keithley's Model 2000** also has 6½ digits, but its highest count is 1,000,000. That's only one count higher than 999,999-or six full digits. So, the ½ digit really gets you only one more count, not the 1 million extra counts you would expect.

Resolution is the real spec

The specifications that really matter when you're selecting a DMM are resolution and full-scale voltage. You can determine these specs by inspecting the meter's full-count range and resolution specs. Make sure that the meter has enough resolution for the measurements you want to make. If you need to measure tens of microvolts out of, say 18V, look for a 6½ digit DMM with a 20-V scale, or look for a meter with more digits.

4 Comments

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Figure 1 is a scan of the figure published in the original print edition. As for the text, well, I had to retype it. But this article is always applicable.

Oct 28, 2013 11:53 PM EDT

0 | 0 Reply

Les Hammer

Shouldn't "Hewlett-Packard" and "HP" be written as "Agilent" or "Agilent-Split-Again"? :-)

Oct 28, 2013 6:51 PM EDT

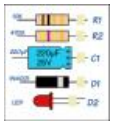
0 | 0 Reply

Measurement.Blues

Les, I was thinking of the Bill and Dave Instrument company, or something like that. See my suggested logo.
http://www.edn.com/electronics-blogs/rowe-s-and-columns/4423326/Come-home--Bill-and-Dave

Oct 28, 2013 11:36 PM EDT

0 | 0 Reply



anonymous user

Thanks for the useful article. The 1/2 digit mystery has been revealed!

Feb 13, 2012 7:36 AM EST

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