50000-Count Digital Multimeters

Introduction

Hi, I am Tom, amateur radio call sign N8FDY. This summary is part of a series comparing digital multimeters. I will be comparing a group of 50000 to 60000 count digital multimeters for use in hobby electronics projects primarily related to amateur radio.

Disclaimer

I am not a professional, I am a hobbyist. This video is not sponsored; I bought these multimeters with my own money. I only used and tested the multimeters in CAT I and CAT II environments. I do not have a way to review or test the safety of these meters. I leave the CAT III and CAT IV environments to trained and licensed professionals. It may seem like I am a Fluke fan boy, but I recognize their flaws along with their advantages. There may be unintended mistakes and/or errors in this document.

Overview

I am comparing eight digital multimeters that range in price from $170.34 to $1,179.99. They all have similar resolutions (50000 to 60000 count) but vary in accuracy and features. Each meter also has a dedicated review document and video.

Resolution, Measurements and Accuracy

The resolution of a portable digital multimeter is usually described in counts. A 50000-count meter can display 49999 on the display. It could be 4.9999, 49.999, 499.99, 4999.9 or 49999. The accuracy of a portable digital multimeter is usually expressed in +- % of reading +- n least significant digits. An example would be ±(0.05% + 1), so a reading of 10.00 volts would give an uncertainty value of (10 X .0005) + (1 X .01) = (0.005)+(.01) = 0.015 volts, so the value could be from 9.985 Volts to 10.015 volts.

CAT I & CAT II

I am testing and demonstrating these multimeters in CAT I and CAT II measurement categories. CAT I is for measurements performed on circuits not directly connected to mains. For example, battery-operated electronics, or radio gear connected to 13V power supply.
CAT II is for measurements performed on circuits directly connected to the 120V (240V in some countries) power outlets at least 15 feet from the distribution panel. For example, your 120V AC to 13V DC power supply or a vintage piece of ham radio gear we lovingly call “boat anchors”.

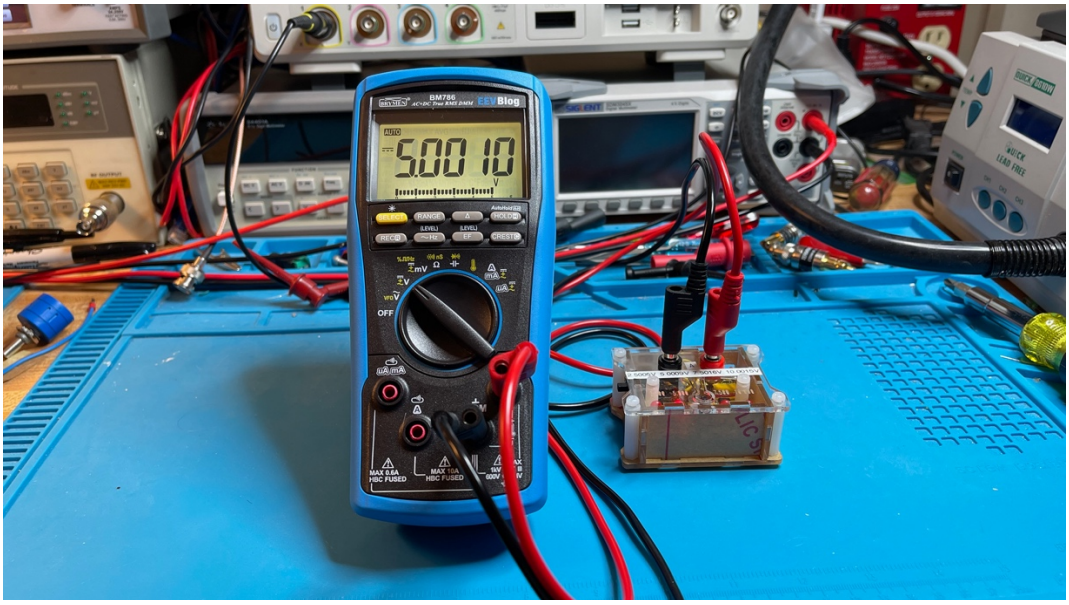
Overview

For each multimeter we will look at the features, pros, cons, and recommendations. Then we will compare the accuracy performance of the meters.

Test Leads

I will not be using the test leads that came with the meters. I have not liked any test leads that came with multimeters except the Fluke TL175 TwistGuard® test leads that were bundled with the Fluke 87V MAX. I also use Probe Master Series 8000 Test Leads.

EEVBlog Brymen BM786



Price: AU$215.00. ($145.14 US as of 9-5-2023) from the EEVBlog Store. Shipping was AU$29.38 ($19.82 US). Amazon US sells it for $199.00, so buying direct from EEVBlog Store was cheaper and it only took 7 days to get to the US.

Features

- UL C US Listed.
- 60,000 Counts.
- 31 Segment Analog Bar-graph Updates 50/Sec.
- True-RMS.
- DC+AC.
- Hold.
- AutoHold.
- Delta/Relative Zero Mode.
- Crest (Peak Hold) Captures MaxMin Changes > 0.25ms in Durations.
- MaxMinAvg.
- VFD-V & VFD-Hz Measures Fundamental V & Hz of Most Variable Frequency Drives.
- Three AAA batteries included.

Pros

- Third-party tested for safety by UL.
- Lowest cost 50,000-count meters tested.
- All measurements taken met the accuracy specifications in the manual.
- One of the best DC microamps accuracy specifications.
- One of the best low microfarad accuracy specifications.
- One of the smaller and lighter 50000-count meters

Cons

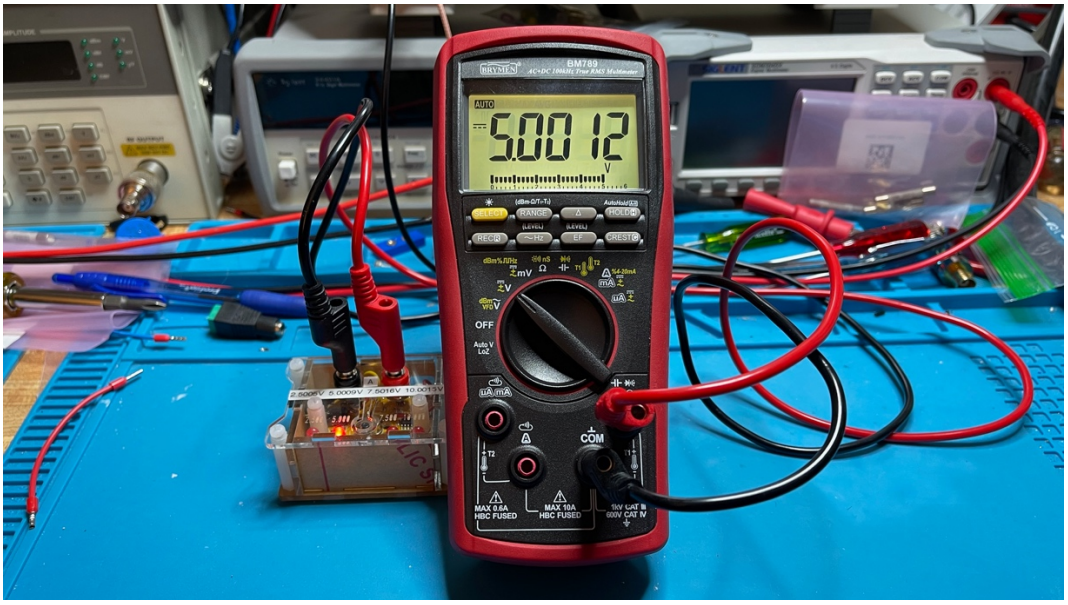
- Lowest 3dB cutoff frequency for AC Voltage for this group of meters.

- Worst AC volts accuracy specifications.
- Worst AC+DC volts accuracy specifications.
- Worst low megaohms accuracy specifications.
- Must disassemble the meter to change fuses.

Recommendation

The EEVBlog Brymen BM786 is one of two meters in the 50000-count group I tested that does not have some form of data logging. In general, it has higher accuracy specifications than 6000-count meters and of course higher resolution. It also has AC+DC True-RMS.
If you want an entry level 50000-count meter that does not do any data logging or dBm measurements, this is the meter for you.

Brymen BM789



Price: 158.82 € excl. VAT ($170.34 US as of 9-13-2023) from Welectron in Germany

Features

- UL C US Listed.
- 60000 Counts.
- ACV Bandwidth up to 100kHz.
- 31 Segment Analog Bar-graph Updates 50/Sec.
- True-RMS.
- DC+AC.
- Hold.
- AutoHold.
- Delta/Relative Zero Mode.
- Crest (Peak Hold) Captures MaxMin Changes > 0.25ms in Durations.
- MaxMinAvg.
- AutoV LoZ Ghost-Voltage-Buster.
- VFD-V & VFD-Hz Measures Fundamental V & Hz of Most Variable Frequency Drives.
- Dual Temperature Reading.
- Three AAA batteries included.

Pros

- Third-party tested for safety by UL.
- All measurements taken met the accuracy specifications in the manual.
- One of the best DC microamps accuracy specifications.
- One of the best low microfarad accuracy specifications.
- One of the smaller and lighter 50000-count meters

Cons

- Not available in the US, must buy from the EU.

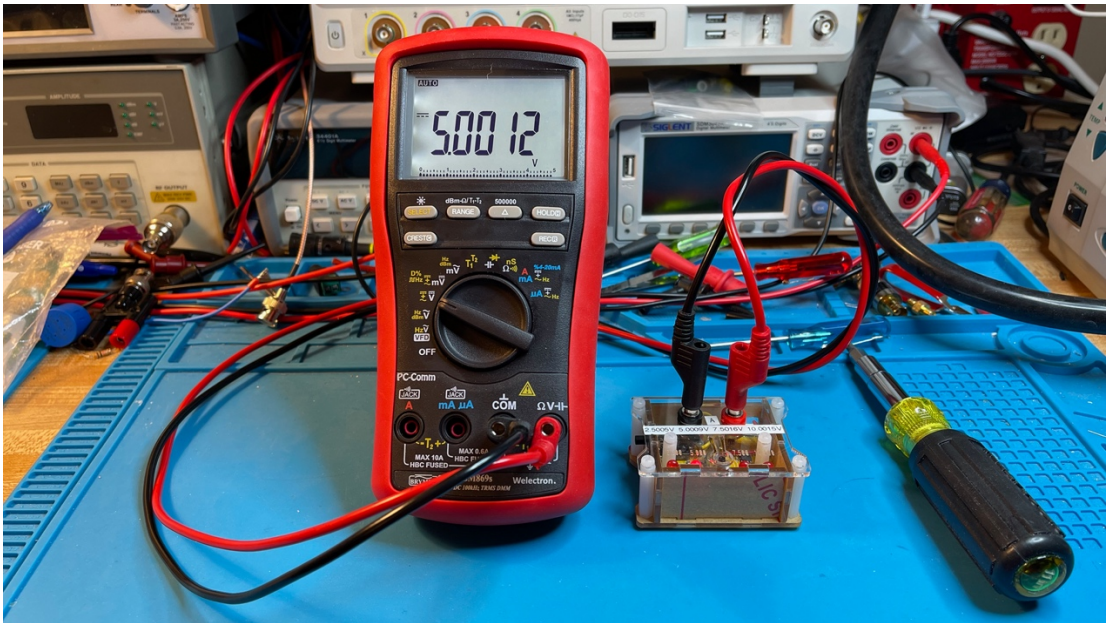
- Worst AC volts accuracy specifications.
- Worst AC+DC volts accuracy specifications.
- Worst low megaohms accuracy specifications.
- Must disassemble the meter to change fuses.

Recommendation

The Brymen BM789 is one of two meters in the 50000-count group I tested that does not have some form of data logging. In general, it has higher accuracy specifications than 6000-count meters and of course higher resolution. If also has AC+DC True-RMS, albeit the lowest accuracy in the bunch. It also can measure dBm and a variety or impedances.

If the Brymen BM789 was available and supported in the US I would recommend it as a good entry level 50000-count meter for people in my country. If you are in the EU or any other area of the world that can buy the Brymen BM789 and get support in your country, then yes, if you want an entry level 50000-count meter that does not do any data logging, this is the meter for you.

Brymen BM869s



Price: 192,44 € ($206.60 US exchange rate as of 8-31-2023) from Welectron in Germany. The price included an bundle with a case that added about 11 € extra.

Features

- Dual display shows two measurements, such as AC voltage and frequency, at the same time.
- Beep-JackTM audible warning alerts the user with a beep and an error message on the LCD if the test lead is plugged into the mA ŒºA or A input terminal while the selector switch is not in the mA ŒºA or A position.
- AC bandwidth to 100 kHz for voltage or 20 kHz for current.
- MAX/MIN function which stores the maximum, minimum, and average.
- Crest capture mode to capture voltage or current signal peaks.
- Selectable between 50000 or 500000 counts resolution when measuring DC voltage.
- Relative zero mode.
- Automatic or manual ranging.
- Intelligent automatic power off.
- Backlighted LCD for reading in dim conditions.
- One-Year Warrantee.

Pros

- Third-party safety tested by UL.
- Met all accuracy specifications for all measurements taken.
- Leader in accuracy specifications in more categories than any other meter in this group.
- Dual Display with bright backlight.

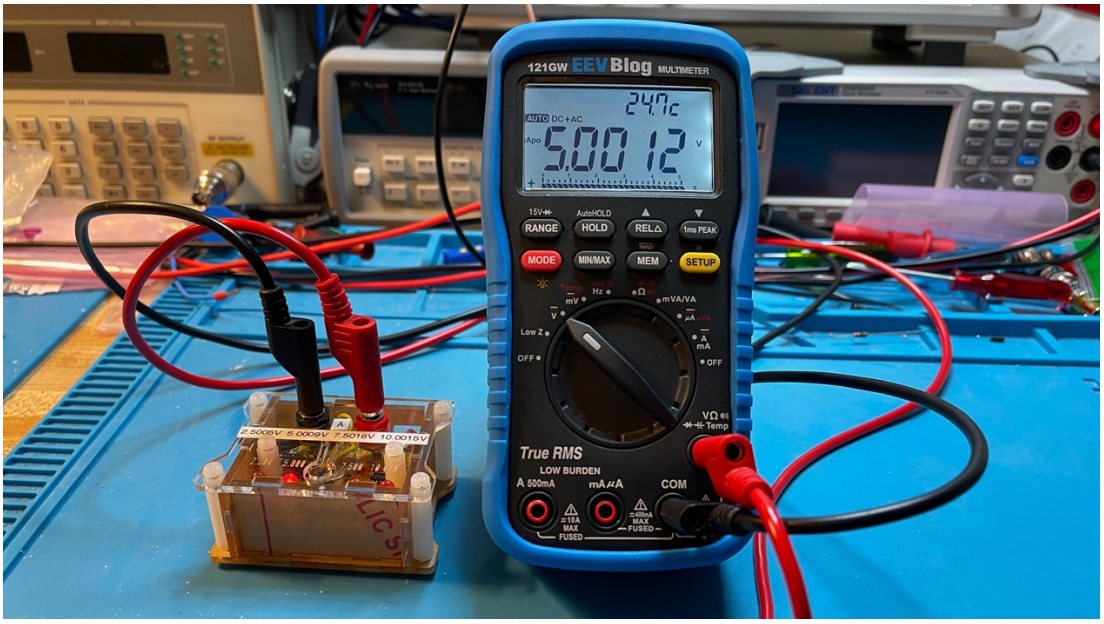
Cons

- USB PC interface is an extra-cost option.
- No Bluetooth support.
- Must disassemble meter to change fuses.

Recommendation

I think the Brymen BM869s is a very good price for performance meter. If you don't need the graphing functions of the two higher priced meters in this group of 50,000-count meters but you want the PC interface for an extra $36, this could be the one for you.

EEVblog 121GW



Price: 225.00 US from Amazon.com, US$204.29 from EEVBlog store.

Features

- Dual 50000-count display with bargraph.
- 0.05% + 5 Basic DCV Accuracy.
- Auto-Hold measurement.
- 600V CAT-III with independent UL 61010 certification by ETL.
- Safe operation through HRC fuse + TVS + PTC + MOV + Diode Bridge protection.
- Bluetooth connectivity (multi-device capability).
- Open-Source Cross Platform application software (Android + Windows).
- 15V Diode Test Voltage (useful for Zeners + LED strings etc.).
- VA Power measurement.
- Low Burden™ voltage.
- Unique burden voltage display.
- Micro SD Card data logging + firmware updating.

Pros

- Third-party safety tested by ETL for US and Canada.
- The AC Volts accuracy specification is the highest in this group of 50000-count meters.
- The high megaohm accuracy specification is the highest in this group of 50000-count meters.
- All measurements taken met accuracy specifications in the manual.
- Micro SD card and Bluetooth logging.
- Remembers last mode used at each switch position.
- Setup menu to customize many operations.
- Useful secondary display.
- VA measurements.
- Built-in ambient temperature reading.
- Fuses can be changed from the battery compartment.

Cons

- Most ranges have the lowest accuracy specifications in this group of 50000-count meters.
- Only measures up to 600 Volts.
- Must send to Australia for service.
- Android software will not install on a device running 12L.
- Red writing around dial is difficult to read.

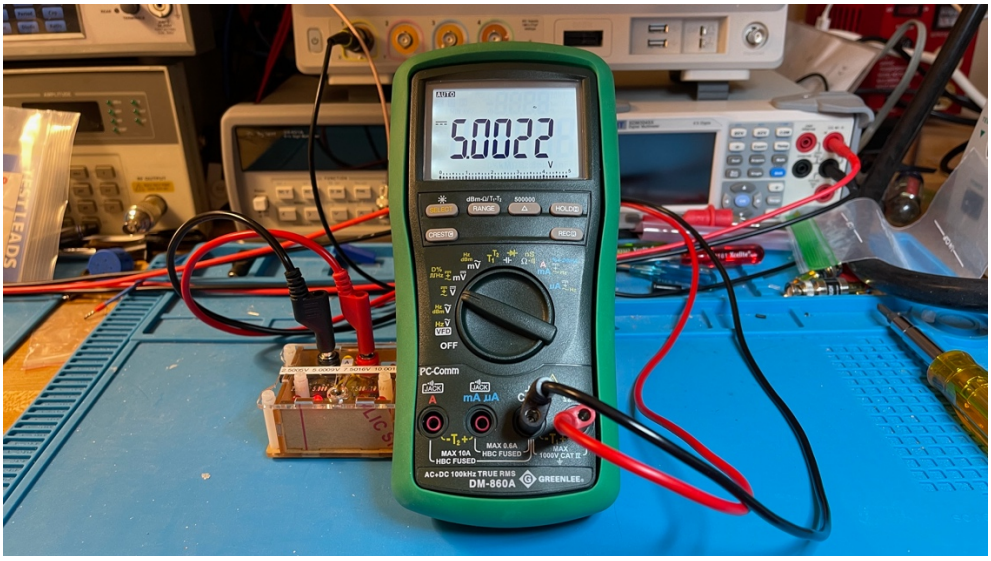
Recommendation

The EEVblog 121GW is the only meter in the 50000-count group I tested that that has a Micro SD card for data logging and firmware upgrade. It is also the only meter in this group that can measure AC Volt-Amps and DC power. If also has Bluetooth connectivity. In general, it has higher accuracy specifications than 6000-count meters and of course higher resolution. If also has AC+DC True-RMS. It also can measure dBm at 600Ω impedances.

The EEVblog 121GW has everything and more, except tight accuracy specifications. In many of my tests the reading exceeded accuracy specifications, but this is a random sample of one. So, this meter is a tradeoff between low price, many features, small size vs accuracy specifications.

After this meter testing project is done, this is one of the meters I am keeping.

Greenlee DM-860A



Price: $346.44 from The Electricians Shop.

Features

- Dual display shows two measurements, such as AC voltage and frequency, at the same time.
- Beep-JackTM audible warning alerts the user with a beep and an error message on the LCD if the test lead is plugged into the mA µA or A input terminal while the selector switch is not in the mA µA or A position.
- AC bandwidth to 100 kHz for voltage or 20 kHz for current.
- MAX/MIN function which stores the maximum, minimum, and average.
- Crest capture mode to capture voltage or current signal peaks.
- Selectable between 50000 or 500000 counts resolution when measuring DC voltage.
- Relative zero mode.
- Automatic or manual ranging.
- Intelligent automatic power off.
- Backlighted LCD for reading in dim conditions.

Pros

- Third-party safety tested by UL.
- Dual Display with bright backlight.
- Leader in accuracy specifications in more categories than any other meter in this group.
- Greenlee limited lifetime warrantee.

Cons

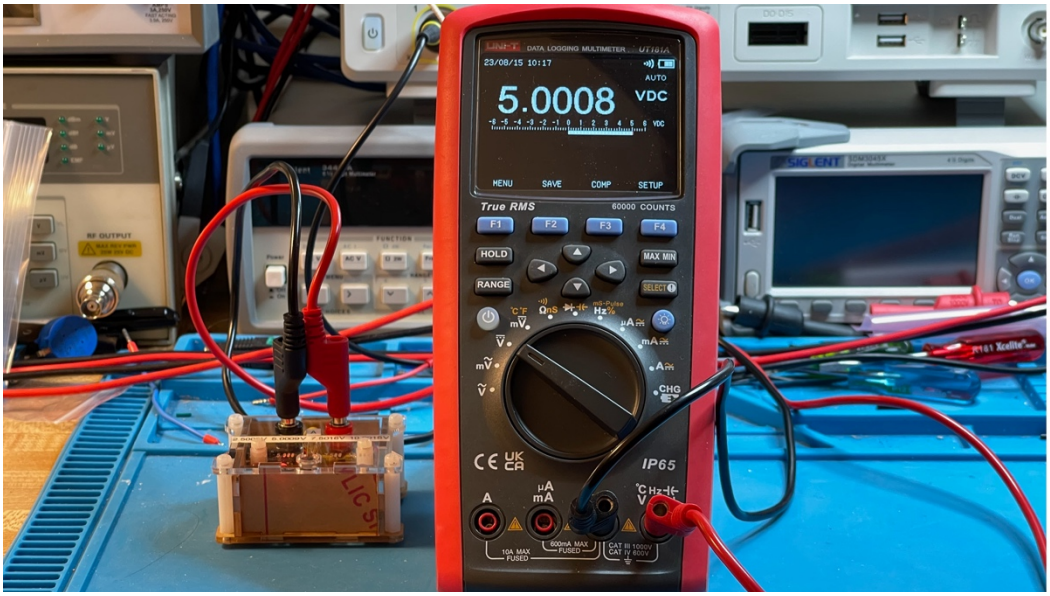
- Did not meet accuracy specifications on the 5-Volt DC range.
- USB PC interface is an extra-cost option.
- No Bluetooth support.
- Must disassemble meter to change fuses.

Recommendation

This is a rebranded Brymen BM869s. I think the Greenlee DM-860A is a very good price for a performance meter if you consider that it includes a limited lifetime warrantee from Greenlee. The only concern is the slight out- of-specification 5-Volt DC range on my unit. At worst it was 1.1 millivolt out. Am I going to lose any sleep over 1.1 millivolt? No.

If you don't need the graphing functions of the two higher priced meters in this group of 50000-count meters but you want the Greenlee limited lifetime warrantee and a PC interface for an extra $78, this could be the one for you.

Uni-T UT181A



Price: $400.99 at the Unit-T Direct store on Amazon.com.

Features

- Third patty safety tested by ETL.
- Trend capture.
- Data logging: 20,000 points.
- Data comparison.
- 3.5-inch 64k color TFT LCD.
- Dual temperature measurement.
- Low pass filter.
- 2000mAh Li-ion battery.
- Real time and date.
- Peak hold.
- Bluetooth/APP.
- USB interface cable /PC software CD.
- IP65.
- 18 Month Warrantee from **Unit-T Direct at Amazon.**

Pros

- Third party safety tested by ETL for US and Canada.
- 3.5-inch 64k color TFT LCD.
- All but two readings met accuracy specifications as stated in the manual.
- Store and graph readings on local screen.
- Includes USB interface cable.
- Bluetooth option available.
- No cost Windows PC and mobile software available for download.

Cons

- 490 volts reading missed its accuracy specifications by 155.4 mV.
- 1 mA AC 100Hz Squarewave reading missed its accuracy specifications by 38 µA.
- Can't use meter while recharging battery.

Recommendation

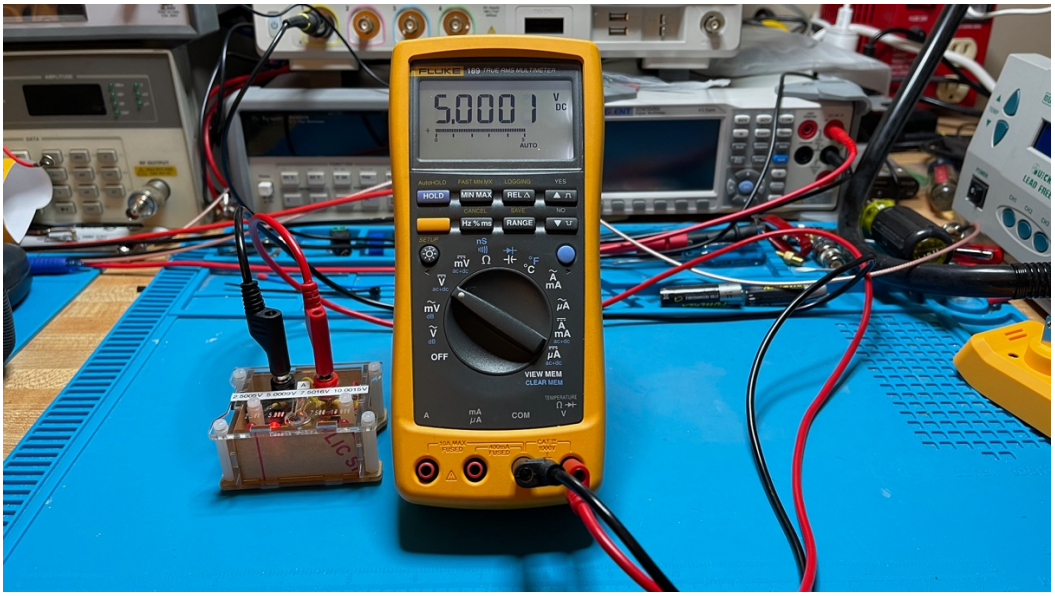
The Uni-T UT181A is the only meter in the 50000-count group I tested that has a color screen. This meter is very good for graphing data, PC interface and good at mobile interface (at least iOS, I could not test Android). The meter is good for voltage except for the 490 volts reading (sample of 1 so insignificant). It is strong in resistance measurements and weak in capacitance measurements.

For the first six months I had this meter it had a strange odor like some sort of solvent or strange plastic. When I decided to keep this meter, I left it out of its case for a few weeks and the odor finally disappeared.

I you want a graphing meter, take a close look at the Uni-T UT181A. The current price of the Uni-T UT181A ($400.99) combined with the Bluetooth interface ($29.99) is $430.98 while the equivalent Fluke 289/FVF/IR3000 with a monochrome screen cost $1,179.99. The Fluke has the lifetime limited warrantee and the reputation for quality, but for a hobbyist I don't this it is worth it.

I prefer the Uni-T UT181A over the Fluke 289. If you buy the Uni-T UT181A from the Amazon Uni-T Direct store you get a 30-day Money Back Guarantee for any reason and an 18-month Warranty for quality-related issues from Uni-T Direct.

Fluke 189



Price: $650 from HRS EQUIPMENT OUTLET on eBay, open box new old stock (NOS).

Features

- Third party safety tested by UL and CSA.
- Meets Category III 1000V and Category IV 600V safety standards.
- True-RMS, 100 kHz bandwidth for precise measurement of nonlinear signals.
- 0.025 % dc accuracy, 1 microvolt resolution.
- Large bright white display with dual parameter readout.
- Built in data logger records reading and time of day for catching intermittent problems.
- View stored readings on the meter.
- MIN / MAX with timestamp to record signal fluctuations.
- Peak capture to measure transients as short as 250 µS.
- Relative mode to monitor small variations.
- Isolated IR communication port to send data to a PC.
- Auto and Manual ranging.

Pros

- This meter is at least 16-year-old and all measurements taken met the accuracy specification.
- Don’t have to turn the meter off to get to setup mode.
- Has almost as much customization as the EEVBlog 121GW.

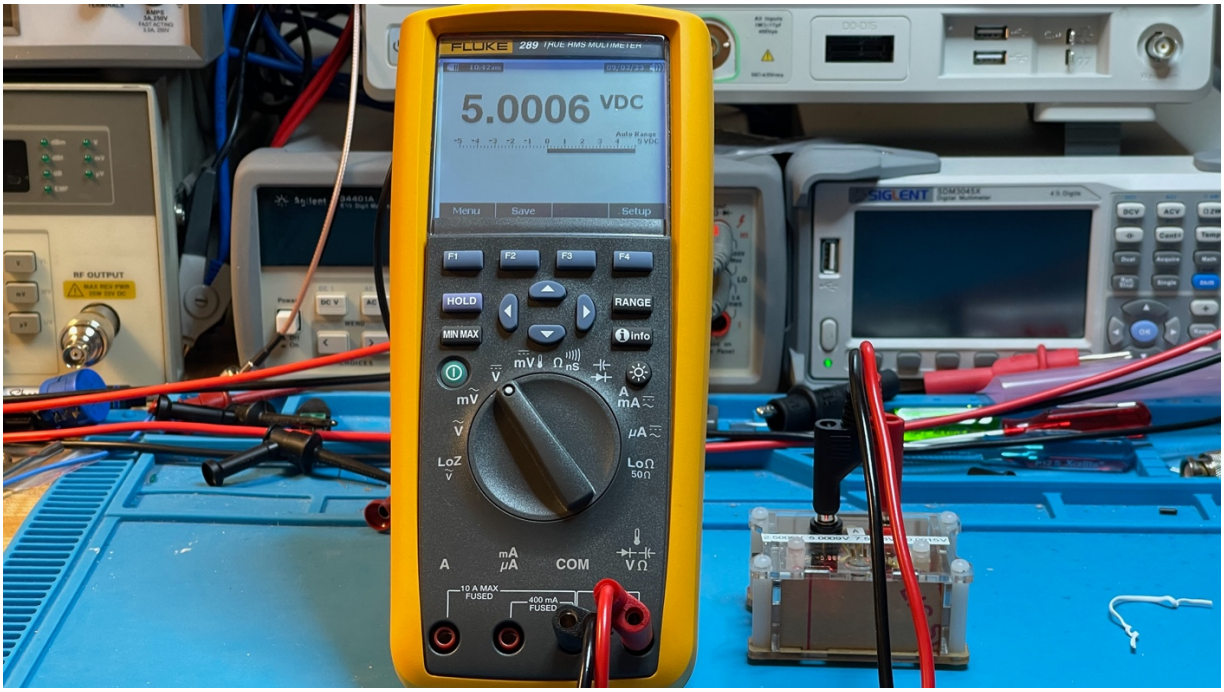
Cons

- Discontinued around 2008, can only buy used or NOS (New Old Stock).
- PC Interface an extra cost option.

Recommendation

I do not recommend the Fluke 189, don't get me wrong I like this meter a lot and I am keeping it. But for your first meter it is too expensive, eBay prices range from $350 for a beat-up looking unit to $800 for NOS (New Old Stock) unit from Japan. I bought my unit as NOS from a company in Texas (May 2023) and it works great. If you are willing to spend up to $800, consider one of the other meters in this summary.

Fluke 289



Price: $1,179.99 (289/FVF/IR3000 bundle) at TEquipment.com

Features

- Third party safety tested by CSA.
- 50,000 count, 1/4 VGA dot matrix display with white backlight.
- 15,000 recorded events memory.
- 50-ohm range.
- True-RMS with 100 kHz bandwidth
- AC+DC RMS.
- AC Low Pass Filter.
- dBm and DBV.
- Measure up to 500 MΩ resistance.
- Real time clock.
- USB PC interface and Bluetooth mobile interface.
- Fluke limited lifetime warranty.

Pros

- Third party safety tested by CSA.
- Best accuracy specifications in this group of 50000 count meters for High DC Volts, AC+DC RMS, DC current, Low kΩ, Low MΩ and High µF ranges.
- Easy access to change fuses.
- Fluke limited lifetime warranty.

Cons

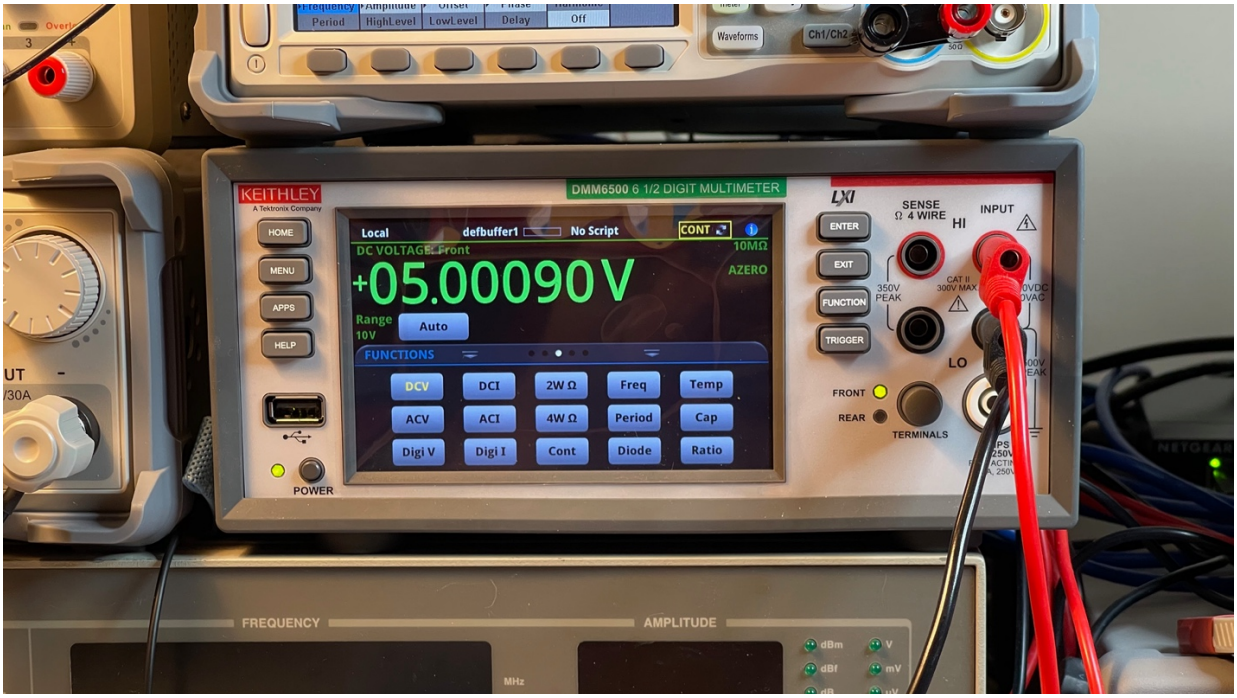
- Did not meet accuracy specifications for 1 reading in the mV range, 3 reading in the high DC voltage range and 1 reading in the low ohms range.

- Worst accuracy specifications in this group of 50000 count meters for the High MΩ range.
- Six AA batteries only provide 100 hours of operation.

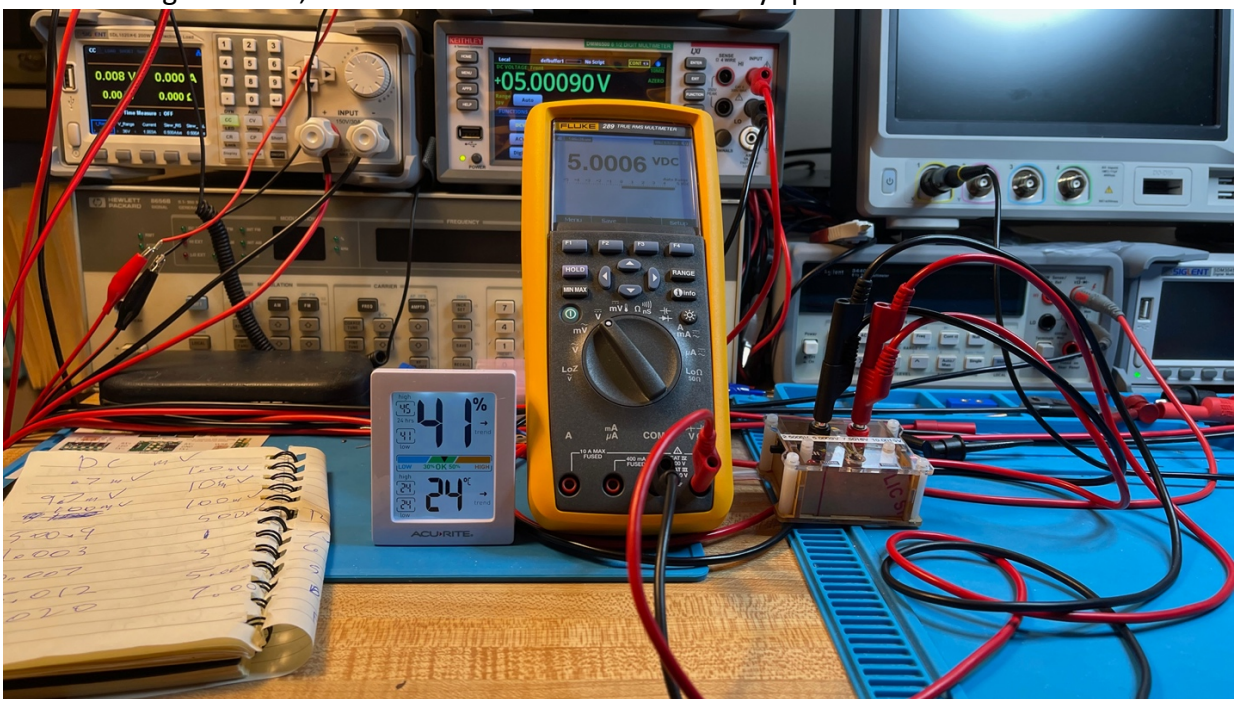
Recommendation

The Fluke 289 has lots of features and has the Fluke reputation and limited lifetime warranty. Unlike the 6000 count meters where Fluke dominates the accuracy specifications, the Fluke 289 is in second place compared to the Brymen 869s and the Greenlee DM-860A (rebranded by Greenlee with limited lifetime warrantee). I was disappointed that my 289 had 5 readings out of specification, the most in this group of 50000 count meters.
I can't recommend this meter for hobby use, if you need graphing on the meter, consider the Uni-T UT181A. If you only need logging to a PC and mobile device, then consider the Greenlee DM-860A or the almost identical (some specifications are different when comparing the manuals) Brymen BM869s depending on what is available in your country. If you want logging to a microSD card, the only choice is the EEVblog 121GW. If you don't need logging the Bryman BM789 or the slightly lesser (no dBm, lower bandwidth) EEVBlog BM786 depending on what is available in your country.

Accuracy



I do not have reference standards. I use a Keithley DMM6500 that was calibrated recently to measure voltages, currents, resistances, and capacitances. I take a reading from the Keithley and based on the Keithley stated tolerance for that range and reading, I compute the lowest and highest value the reading could be, then I take the meter under test and take a reading. I compute the meter-under-test reading uncertainty value and subtract it from the lowest value and add it to the highest value and if the reading is within the range of the lower and higher limits, it meets meter-under-test accuracy specification.



For example, I have a voltage source that is 5 volts. I take a reading with the Keithley and I get a value of 5.00090 and based on the Keithley specifications for that range **±**(0.0025% of reading + 0.0005% of range); that value could be anywhere from 5.00072 to 5.00108. I then use the meter under test (for this example my Fluke 289, my most accurate hand-help meter for DC Volts) reading of 5.0006. The Fluke 289's accuracy at this range is **±**(0.025% of reading + 2 least significant digits) for an uncertainty value of 0.00145015 Volts. So,

subtracting this from the lowest value the Keithley reading gives us 4.99927V for the low value limit and adding to the highest value the Keithley gives us 5.00253V for the high value limit. The meter-under-test reading (5.0006) is within the limits, so the meter under test meets its accuracy target for 5 volts.

Accuracy Specifications

Value	EEVblog Brymen BM786	Brymen BM789	Brymen BM869s	EEVblog 121GW	Greenlee DM-860A	Uni-T UT181A	Fluke 189	Fluke 289FVF
Cost	$154.11	$158.82	$202.78	$225.00	$346.44	$400.99	$650.00	$876.59
Count	60,000	60,000	50,000	50,000	50,000	60,000	50,000	50,000
DC mV Low	0.03%+2	0.03%+2	0.02%+2	0.1%+10	0.02%+2	0.025%+20	0.1%+20	0.05%+20
DC mV High	0.03%+2	0.03%+2	0.02%+2	0.1%+10	0.02%+2	0.025%+5	0.03%+2	0.025%+2
DC V Low	0.03%+2	0.03%+2	0.02%+2	0.05%+5	0.02%+2	0.025%+5	0.025%+10	0.025%+2
DC V High	0.05%+5	0.05%+5	0.04%+2	0.1%+10	0.04%+2	0.03%+5	0.1%+2	0.03%+2
AC mV	0.5%+30	0.5%+30	0.3%+20	0.8%+10	0.3%+20	0.6%+60	0.4%+40	0.3%+25
AC V	0.5%+30	0.5%+30	0.4%+30	0.3%+10	0.3%+30	0.3%+30	2%+80	0.3%+25
AC V + DC V	0.7%+40	1.2% + 40	0.7%+80	1.0% + 10	0.5% + 80	1% + 80	0.5%+40	0.5% + 80
DC µA	0.075%+20	0.075%+20	0.15%+20	1.5%+15	0.15%+2	0.08%+20	0.25%+20	0.075%+20
DC mA	0.15%+20	0.15%+20	0.15%+20	0.25%+5	0.15%+20	0.15%+10	0.15%+10	0.15%+2
DC A	0.3%+20	0.3%+20	0.5%+20	0.75%+15	0.5%+2	0.5%+10	0.5 %+10	0.3%+10
AC µA	0.9%+20	0.9%+20	0.5%+50	2.0%+20	0.5%+50	0.6%+40	0.75%+20	1%+20
AC mA	0.9%+20	0.9%+20	0.5%+50	1.0%+5	0.5%+50	0.8%+40	0.75%+20	0.6%+5
AC A	1%+30	1%+30	0.5%+50	1.5%+15	0.5%+50	1%+20	1.5%+20	0.8%+20
Ω	0.085%+10	0.085%+10	0.07%+10	0.5%+20	0.07%+1	0.05%+10	0.05%+10	0.15% + 20
Low kΩ	0.085%+4	0.085%+4	0.07%+2	0.2%+5	0.07%+2	0.05%+2	0.05%+2	0.05%+2
High kΩ	0.15%+4	0.15%+4	0.1%+2	0.2%+5	0.1%+2	0.05%+2	0.05%+2	0.05%+15
Low MΩ	1.5%+5	1.5%+5	0.3%+6	0.3%+5	0.3%+6	0.3%+10	1.0%+4	0.15%+4
High MΩ	2.0%+5	2.0%+5	2%+6	1.2%+20	2%+6	2%+10	10.0%+2	3.0%+2
Low nF	1%+10	1%+10	0.8%+3	2.5%+5	0.8%+3	3%+10	2%+5	1%+5
High nF	1%+2	1%+2	0.8%+3	2.5%+5	0.8%+3	2%+5	1%+5	1%+5
Low µF	1%+2	1%+2	1.5%+3	2.5%+5	1.5%+3	2%+5	1%+5	1%+5
High µF	1.8%+4	1.8%+4	5% + 5	3.0%+5	5% + 5	5% + 5	1%+5	1%+5

The accuracy specifications are from the meters' respective manuals. Red lettering for the meter's name indicates the meter has failed to meet an accuracy specification. The red lettering in the accuracy specification indicates that one, or more meter readings did not meet this accuracy specification. The background color code shows the extreme low and high accuracy specifications. Green is the highest, yellow is lowest, and white is everything in-between.

Conclusion

There is no clear winner like there were in the 6000-count meter comparison. All the meters in this comparison are third party safety tested, so I have no reservations on safety. Find the one that matches your requirements and budget. In the course of troubleshooting and build electronic project you may come a time when you want more than one meter, so picking two that complement each other may be useful.