Testing Equipment Blog

Testing equipment, particularly current clamps and scopemeters, have a substantial role to play in electrofishing sampling programs. I was first introduced to this notion years ago by A. Lawrence (“Larry”) Kolz and Jim Reynolds, two people that made substantial advances in the conceptual basis for electrofishing. Since then, Jan Dean and I have used test equipment in a number of situations, built Excel-based programs to utilize collected information, and have worked on identifying inexpensive yet accurate meter alternatives.

In this blog, I will attempt to describe purposes of testing equipment, some approaches and considerations regarding their use, share a few of our test results, and provide a list of suggested models.

The purposes of using testing equipment include:

- measuring voltage
  - to ascertain applied voltage associated with an electric field map
  - to map electric fields
  - as an input to determine electrode resistance for design and estimating equipment operating range
  - to follow voltage standardization tables
  - to check control box voltage meter accuracy
- measuring current
  - as an input to determine electrode resistance for design and estimating equipment operating range
  - to check if anode boom electrodes are similar and functioning properly
  - to follow current standardization tables
  - to check control box amperage meter accuracy

If your control box has accurate peak-reading voltmeters and ammeters, you don’t need testing meters (scopemeters, current clamps) to estimate electrode resistance or to follow voltage, current, or power standardization tables. You would still need testing meters to periodically check the accuracy of the control box meters, find out if both booms are functioning correctly or that the boom arrays are similar, and to map electric fields. Control boxes with good metering definitely simplify your work, however.
We have done a good amount of lab and field testing on the Velleman HPS140I and the Uni-T UT81B scopemeters, by comparing to the Fluke 124 Scopemeter. We also have tested the CP-05A current probe vs. the Fluke 80i-110s current clamp. These alternate equipment types compare extremely well, so the Fluke models are not the only choice for accuracy. We do not know how well the Velleman, Uni-T or CP-05A units hold up, how long they last. I have had a Fluke 124 and 80i-110s current clamp for several years.

Now, a bit about the scopemeters. First, pay strict attention to the maximum voltage input ratings to make sure they will accommodate expected voltages you wish to measure. Current measurements and field mapping are made in a very low voltage range, almost always less than 5 volts and often in millivolts, so no worries there. The high voltage consideration comes when you are measuring directly off your electrodes. Often, both AC and DC voltage maximums are given in the specifications. Remember that meter capacities for AC are given in RMS Volts, so the AC peak voltage limit should be about 1.4 times the rated RMS voltage (e.g., 600 Vrms x 1.4 = 840 peak Volts). If the DC maximum input is not listed, then it should be approximately 1.4 times the AC Vrms maximum.

Another important consideration is whether the scopemeter has cursors (or “markers”). Cursors are used to make exact voltage measurements or time duration measurements (e.g., pulse width). I think cursors are needed for mapping electric fields. Cursors may not be needed for making voltage measurements between the electrodes (often 100s of volts). I’ve seen good visual estimates but if your unit has cursors, you can go either with a visual or cursor-assisted estimate of peak voltage. Please note that scopemeters usually can have an automatic peak voltage readout. Our experience has been that these peak voltage readouts can differ a bit from the actual (cursor) readings, particularly on “ragged” square waves, so go with your cursor or visually-made readings.

You may wish to store waveforms for an equipment maintenance record, to compare among annual check-ups. Stored figures can be inserted into reports or other publications. I use the memory/download features a fair amount, primarily for adding content to training courses. As another option, you can always take pictures of the scopemeter screen.

Screen legibility. Glare during outside use can be a problem with some models, particularly if you are showing others the output waveforms. Jan compared the Fluke 124, Velleman HPS140I and the Uni-T UT81B during inside and outside conditions. Inside, all screen legibility was good, and Jan rated them as Fluke 124>Velleman>Uni-T. In outside conditions but in the shade, the legibility was Velleman>Uni-T>Fluke. In sunny situations, Velleman>Uni-T>Fluke. Overall, the Velleman had the most legible screen in the three lighting conditions despite having the smallest screen.

Finally, some scopemeters are single channel and some are dual channel. For our work in electrofishing, single channel works fine.

It is a good place here to mention the drawback of multimeters. First, multimeters must be peak-reading, not just provide RMS readout. This is because fish primarily react to peak voltage and current, not average. So, if you are using a pulsed DC waveform, you won’t get peak with a RMS-only multimeter
and since electrofishing gear does not generate alternating current with a true symmetrical sine-wave, you will not have a conversion factor from RMS to peak voltage or current.

If you purchase a peak-reading multimeter, there are still concerns. First, they cost more than RMS multimeters (a Fluke 87 V peak-reading multimeter retails for $350 and up). That said, we have seen the Fluke 87 V digital multimeter provide excellent peak voltage readings with a nice square pulse. On the other hand, we have also observed some strange and erroneous readings, which we weren’t able to explain. The Fluke 87 V is good at capturing very short-term voltage spikes which unfortunately may have little or no significance to the fish. You can’t know what the multimeter is reporting without seeing the waveform on a scopemeter trace. Having a graphical display is the best answer.

In addition, you don’t know under what conditions the meter works accurately. We tested a GTC CM600 multimeter, and while the CM600 may accurately read peak voltage, the DC pulse width must be at minimum 2.25 milli-seconds, and cannot be “rounded” (as from a rectified AC, and the output from control boxes as the Smith-Root GPP series or the Type VI).

Regarding current clamps (or “current probes”), the same thing goes. Do not trust the ones that incorporate their own display meter without an evaluation. We recommend using current clamps that combine with a scopemeter for making voltage measurements. That said, the Columbia Fish and Wildlife Conservation Office (U.S. Fish and Wildlife Service) found excellent correspondence between the pulsed direct current peak amp readings taken by a CM600 and the control box metering of either a MLES Infinity or an ETS MBS. (Again, with rectangular pulses at least 2.25 ms in width). Jan Dean found that the GTC CM100 gave accurate peak amperage readings when spot-checked against backpack metering and a scopemeter. Jan also notes that the CM100 measures current in very low amounts (range 1 milliamp to 100 Amps), and as such would be preferable for using with backpack shockers. So, for checking output levels, consider a CM600 for boats and a CM100 for backpacks, as long as you are measuring rectangular waves ≥ 2.25 ms in width.
Here’s a budget implication. Unless you need to use the meters constantly (as if you were using them as an external volt or amp meter to follow standardization tables), a field office does not necessarily need their own equipment. For example, a field map of a particular electrode arrangement only needs to be made once unless there are changes in the electrode design or sampling environment for example. You could develop a central clearinghouse to provide particular test equipment when requested. Or you could buy less expensive meters for every office and then get a more expensive meter for headquarters that has more capacity and capability. The more expensive meter, as a Fluke 124, can be used to check the accuracy of the less expensive equipment over time, serve as the “standard”, and evaluate future inexpensive models for potential use.

So finally the rundown. (There are a number of vendors for these items but I’m mostly noting Amazon which has competitive prices).

The following are some possible model combinations to measure volts and amperage, with emphasis on less expensive alternatives to Fluke scopemeters:

Field mapping: Velleman HPS140I scopemeter (recommended) with a homemade voltage gradient probe, other scopemeters include the Fluke 124, UNI-T UTD1025CL, UNI-T UTD1050DL, and the UNI-T UTD1025C.


If you are looking for an inexpensive alternative to a Fluke 124, the first real option is the Uni-T UT81B. It has a high voltage capacity and a good safety rating (600V CAT III, 1000V CAT II) to protect against transient currents which shouldn’t be a concern anyway on an electrofishing boat. One drawback is that this model does not have cursors. However, you can get very good visually estimating peak from the screen and you can get confirmation by dividing the average voltage readout by the displayed duty cycle. Both Jan and I have done some comparison testing with the Uni-T UT81B, especially Jan using a Fluke 124 for a standard, and we find it accurate. You can also use the Fluke 124 to help calibrate your eye. The other drawback is, quite frankly, it is made by a rather hard to reach Chinese company and there might be some irritation due to that (no real customer service).

The next UNI-T with a reasonable voltage capacity is the:

UNI-T Handheld Digital Oscilloscopes 25MHz UTD1025C 25GS/s 2CH

The issue here is the cost, and we have not tested this model (we just assume it is accurate because the much cheaper UNI-T UT81B functions well).

Current measurements of boat conductors: Velleman HPS140I scopemeter and CP-05 current clamp (recommended). Or use a UNI-T UTD1025CL, UNI-T UTD1050DL, UNI-T UTD1025C, or Fluke 124 scopemeter with a CP-05 current clamp. An accurate but most expensive combination is the Fluke 124
and Fluke 80i-110S current clamp. Finally, under conditions of a clean pulsed direct current square waveform having a pulse width greater than 2.25 ms and with minimal spike, a CM600 is a low cost option.

Not to overlook some evidence for the above arguments, the following are two comparisons of less expensive models with the Fluke 124 that were made by Jan Dean.

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<th>Voltage Reading Comparison between the Fluke 124 and Uni-T UT81B Scopemeters</th>
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<td>Fluke 124</td>
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These readings were made with waveforms ranging from 60 – 300 pulses per second, and duty cycles from 20 – 40%.
Model List:

**Fluke 124/003 Industrial ScopeMeter, 40 MHz Frequency**
- cursors
- 1,250 V AC or DC
- dual channel
  - $1,615 (Amazon)
Disadvantage: screen is hard to read during the day due to glare

**VELLEMAN HPS140I HANDHELD POCKET SCOPE 40MS/s (probe included)**
- cursors
- 100 Vpeak AC+DC (but comes with a 10:1 probe)
- single channel
- $120 (Amazon)

*New versions of the Velleman HPS140I now available (Velleman HPS140MK2, Velleman HPS50)*

**UNI-T UT81B Handheld LCD Digital Scopemeter Oscilloscope Multimeter**
- no cursors
- 750 Vrms AC, 1000 V DC
- single channel
- $169 (eBay), $211 (Amazon)

**UNI-T UTD1025CL Handheld Digital Oscilloscope 1 channel 25MHz**
- cursors
- 400 Vrms AC, 400 V DC
- single channel
- $290 Amazon, $300 (eBay)

**UNI-T UTD1050DL Handheld Digital Oscilloscope 50 MHz**
- cursors
- 400 Vrms AC, 400 V DC
- dual channel
- $434 (Amazon)

**UNI-T Handheld Digital Oscilloscopes 25MHz UTD1025C 25GS/s 2CH**
- cursors
- 700 Vrms AC, 1000 V DC
- dual channel
  - $660 (eBay), $739 (Amazon)

**Fluke 801-110S AC/DC Current Probe, 600V AC rms Voltage, 70A AC/100A DC Current**
- $720 (Amazon)
Disadvantage: small gape on the clamp allows for only smaller sized conductors
CP-05A Oscilloscope Current Probe, DC~200KHz (-3db), 40A
- wide clamp accommodates larger conductor sizes
- $115 (Ali Express)

GTC CM100 1 mA to 100 Amps AC/DC Low Current Clamp Meter
- the low amperage range makes this model useful for measuring output from backpacks (provided the output are rectangular waves ≥ 2.25 ms in width)
- the meter is self-enclosed so there is no need for a scopemeter
- $145 (Amazon)

GTC CM600 600 Amps AC/DC Current Clamp Meter
- the high amperage range makes this model useful for measuring output from boats (provided the output are rectangular waves ≥ 2.25 ms in width)
- the meter is self-enclosed so there is no need for a scopemeter
- wide clamp accommodates larger conductor sizes
- $145 (Amazon)