



A Step-By-Step Absolute Cavity Radiometer ACR-01 practical on-site manual

By

Hesham Hassan, Ph.D.

Scientific Research Department

Egyptian Meteorological Authority

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Acknowledgement and Disclaimer

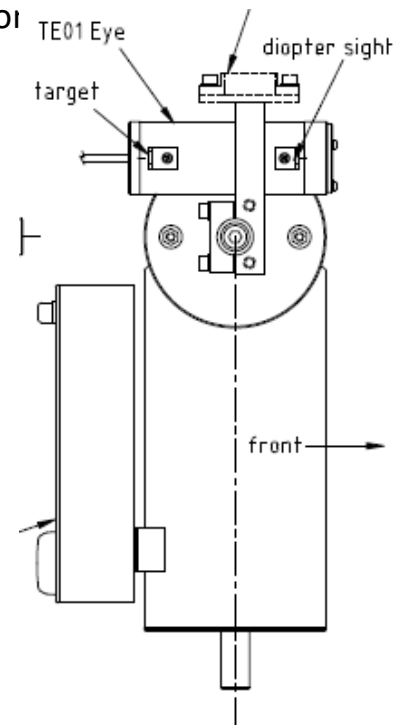
This work is not a replacement for the original user guide by the producing company (Middelton Solar), and it follows the instructions in the manuals^{1,2}. It is a site field manual that was made exclusively for the Egyptian Meteorological Authority and can't be used anywhere else without permission from Middleton Solar.

A special thanks to Mr. Mohammed El-Deeb for his invaluable contribution to the installation and operation of the ACR instrument, its tracker, and mounting. His critical thinking and out-of-the-box solutions were above and beyond expectations.



1-Physical adjustment of the instrument

- 1.1- Adjust the instrument balance (put the bubble in the center of the ring), adjustment will depend up on the flat bed you are using. **Don't proceed until you are sure it is adjusted, and keep eye on it through the process.**
- 1.2- Adjust the eye and sensor to be in horizontal position and facing sun direction as best as you can. **Don't tighten the tracker until it aims sun correctly.**
- 1.3- Cover the eye with an aluminum foil from direct sun and keep the cover of the sensor closed.
- 1.4- Switch the tracker power on.
- 1.5- The system will be in "GPS" mode now. (2 seconds on vs 2 seconds off)
- 1.6- Wait until system goes to passive tracking. (3 second on, one second off)



- 1.7- Remove aluminum foil cover and sensor cap, and manually adjust the eye and the sensor (**up and down, lose screws fist**) and the tracker (**horizontally, it's not tightened yet**) to aim the direct sun (as best as you can), this step makes your live easier with the desired adjustment.



Remember we are measuring the direct incident solar radiation. You should see the sun ray passing from the front pin hole to the rare grid point (for both eye and sensor)

Status Indicator	
<u>Normal Operation</u>	
loop <on 2s, off 2s>	= startup & GPS search
loop <on 3s, off 1s>	= Passive Tracking
loop <on continuous>	= Active Tracking
<u>Warning Conditions</u> (consult User's Guide)	
loop <on 3s, flash x 2>	= Eye disconnected, or faulty
loop <on 3s, flash x 5>	= GPS signal not available
loop <on 6s, flash x N>	= N days since last active tracking (N=8, for all N > 8)
<u>Fault Condition</u>	<flash at 1Hz> = hardware error

- 1.8- Now system should go to “**active tracking**” mode (continuously on). Now you system is physically adjusted and you can move to measurement phase.

2-Software and data logger setup:

- 2.1- Connect the “keysight” and your laptop to the system.
- 2.2- Switch on the “keysight” data logger (the white button)
- 2.3- From your laptop, double click on “Keysight BenchVue” icon.
- 2.4- It will open with the user guide at the beginning.
- 2.5- Then the “Keysight” data logger will show up at the top right corner of the screen with green check mark on it. This green check mark confirms that data logger is connected with your laptop.





- 2.6- Double click on the data logger icon, it will open BenchVue software main page.
- 2.7- If program was closed properly the last time of use, a dialogue with first choice **“Upload from Instrument (Config State) & create NEW Datalog file”**. Click on this choice.
- 2.8- A window will open with an icon in the top right corner reads **“BenchVue Test Flow”**, click on this icon.
- 2.9- The window now will split into two windows. On the right window click on the folder-like icon (when you hover around it will read **“Load a Sequence file.”**). It will take you to the desired folder and file **“Sequence.bvseq”**. If it didn't show up check the following path
C:\Users\ACR\Documents\Keysight\BenchVue
- 2.10- Double click on **“Sequence.bvseq”** file.
- 2.11- On the left window click on the folder-like icon (when you hover around it will read **“Load instrument state.”**) It will take you to the desired folder and file **“34972A State.state”**. If it didn't show up check the following path
C:\Users\ACR\Documents\Keysight\BenchVue
- 2.12- Double click on **“34972A State.state”** file.
- 2.13- Instrument is ready for measurement and plotting once you start scanning.
- 2.14- **Minimize plotting page from the icon in lower right part.** We want it to work in background not to close it.
- 2.15- At the lower right corner will find a three line icon. Click on this icon. A menu will show up. Click on **“My Instruments.”**
- 2.16- The **(DAQ)** data logger will appear on the right window now. Now you are ready to scan.
- 2.17- Click on the green **(Play)** button to start the sequence.
- 2.18- A window will show up to ask you for **“scan Zero”** duration in minutes. (this is **user choice**, let us start with 4 min).



- 2.19- A second window will ask you for “**Scan heat**” duration in minutes. (this is **user choice**, let us start with 4 min).
- 2.20- A third window will ask you for “**scan DNI**” duration in minutes. (this is **user choice**, let us start with 19 min)
- 2.21- A fourth window will ask you for “**repeat number**”. this also is user choice, let us start with 2 cycles.
- 2.22- Now scan will start, you will hear switches click. Plotting window we closed will start to plot now. You can maximize it, but will not be able to access it until all cycles finish.
- 2.23- When all cycles are completed, go to “**export**” icon at lower right corner, click on it. It will open a dialogue table to choose the format you want to export data with (MATLAB, MS Excel, MS Word, and CSV), the easiest for us now is to export it as excel.
- 2.24- Chose file location and name and click export.
- 2.25- On the graph, right click and chose save chart as image file and chose file location and name, and click save. **NB:** the main aim of the graph here is to follow how your radiometer is performing during measurements, i.e., know how readings are changing (not as an absolute value but as up and down variation)
- 2.26- **To end your session**, start by **closing the graph page** at the upper right close button.
- 2.27- Now go to the upper right corner (just **under the “BenchVue Test Flow” icon**), **click on the (X) button**. A dialogue box will appear chose “**don’t save**”.
- 2.28- Go to the upper right corner and **close from (X) button**.
- 2.29- Now the **data logger stopped scan and you can switch it off from the wight button (long press)”**



3-Direct Irradiance (DNI) Calculations:

$$DNI = C * \left(\frac{ACRSigV(Ch101) - Avg Zero (V)}{avg heat (V_{e_{close}}) - avg zero (V)} \right) * \left(\frac{avg heat U_i}{R_h} \right) * \left(U_h - \frac{U_i * R_c}{R_h} \right)$$

R_h = 100 Ω = constant. (precession shunt resistor to measure the heat current)

R_c = 0.25 Ω = constant. (heater leads correction resistance)

C = calibration characteristic ~35390.2 = $4 / (C_f * A_p^2 * \pi)$, C_f =correction factor
=0.9987, A_p =primary aperture diameter= 6mm

U_h = voltage across heater element (≈ 0.7 V) (last seven obs before the end ch 103)

U_i = voltage across heater resistor (R_h) (≈ 4 V) (last seven obs before the end ch 104)

V_{e_closed} = thermopile output ($\approx 2.9 \times 10^{-3}$ volts) last seven obs before the end (ch 101) (heat section)

V = thermopile zero off-set ($\approx 3 \times 10^{-3}$ volts) average of last seven obs in zero (ch 101) before heating – average of last seven obs in zero (Zero readings section)



4-Some common errors and how to troubleshoot them:

A) How to deal with the system if system was shut abruptly without stopping the scan?

- 1- First sign that system shut improperly, the data logger switch will be clicking once it powered on and before you start any scan.
- 2- The second sign can be seen when you start the software, the choices show up the beginning will be different, the first choice will be “continue & Append to Existing Datalog file”
- 3- Click on the third and last choice “Stop Data Logger”.
- 4- Now a new dialogue box will show up, click on “upload from instrument & Create NEW Datalog file”, the second choice in this case.
- 5- At this point you can either start scanning (new scan) or stop the system and shut it down.

B) Instrument stuck on “startup and GPS search” (i.e., on 2sec and off 2sec flash)?

- 1- Check the focus, if focus not well adjusted, then instrument will not move from this stage.
- 2- Check for potential GPS signal interruption (solar flares, solar storms, obstacles in the way, or noise creation instruments)

C) Noon-time adjustment loss.

When system is operating during local noon, it loses orientation. The reason for that -most probably- because when sun reaches it highest position in the sky and start to decline in the other direction, the tracker gears have lag time before it responds to movement.

- 1- Re-adjust the tracker, it will start looking for GPS.
- 2- Cover the eye to allow the system to go to passive tracking.
- 3- Once it goes to passive tracking, remove the cover and adjust the eye and sensor.



References:

- 1- A user's guide for Middleton solar ACR-01 Absolute Cavity Radiometer V2.4.
Downloadable from <https://www.middletonsolar.com/documents/ACRman.pdf>
- 2- A user's guide for Middleton solar AST-02 AST-03 AST-03T active solar tracking system
V3.3. downloadable from <https://www.middletonsolar.com/documents/AST2man.pdf>