

Measuring Calculator Current – Nine Measurement Examples

Richard J. Nelson

Introduction

In *HP Solve*, issue #28 page 30, I described the importance and problems of measuring the current that a calculator draws from its “battery⁽¹⁾.” In that article I gave an example of the HP-41 and the current it draws under a very few selected conditions. I also described how the current a calculator draws frequently changes, often quite rapidly and drastically, depending on what the calculator is doing.

Low power consumption is essential

Nearly every reader has an extremely complex battery operated device such as a cell phone, game device, tablet, etc. Since we use these battery operated devices every day the need for drawing a minimum amount of current is a critical aspect of their design. Using the lowest possible power is the mantra for every circuit designer for battery operated products these days. What is amazing is the fact that since the digital circuits are able to operate so fast, and the sloth like human operators are so slow, that the circuit may be turned “off” and back on again while the human “decides” what to do, or how to deal with the previous result. Modern circuit design utilizes this current shut down concept in as many situations as possible throughout the complex circuitry.

One of the reasons to measure the current draw – in addition to troubleshooting – is to be able to estimate the battery life of the machine. In terms of doing this you have to be careful, however, because of the many possible operating conditions, and that they may change faster than your meter can respond.

Most calculators are, however; still relatively simple so making current measurements under carefully stated conditions is still a powerful diagnostic and battery-life-estimating tool.

Operating conditions

Suppose you need the square root of 13. The calculator sitting on the table is off and it is drawing a very small amount of current for two purposes. The first is being able to recognize that a key is being pressed. The idea of having an actual on/off power switch on a calculator has long been abandoned primarily because of the second reason. The second reason for “always being on” is to keep memory alive for programs, data, and display contents. This is our first operating condition, let’s call it **OFF**.

Our next step in calculating the square root of 13 is to press the “on” key. This is our second condition; let’s call it pressing the **ON KEY**. Now the calculator is on and ready for keying in our number, let’s call this state **ON**. Press the keys 1 and 3. When we press the square root key, however, the calculator is calculating a problem and the current will be another higher value, let’s call it **RUNNING**. These four different conditions are only a few state possibilities and high end calculators will have larger displays, and I/O capabilities that will draw even more current. The I/O activity itself is performed with the same current saving process of shutting down when nothing new is happening.

2012 HP calculator models

HP has made approximately 110 different models since 1972. Many of these are of similar design in terms of being in a family of machines and these machines have similar operating systems with similar current drawing values. The list of 2012 HP models is shown in Table 1. I selected three models from each category to measure the current drawn in the four states – **OFF, ON KEY, ON, & RUNNING**.

Table 1 – 2012 HP Calculator Products (24)

#	Financial Calculators	Scientific & Graphing	Home & Office
1	HP 10bII*	HP 10s	HP CalcPad 100
2	HP 10bII+	HP-15C Limited Edition*	HP CalcPad 200
3	<u>HP 20b</u>	HP 33s	OfficeCalc 100
4	<u>HP 30b*</u>	HP 35s*	OfficeCalc 200*
5	HP-12C*	HP 39gs	OfficeCalc 300
6	HP-12C 30 th Anniversary	HP 39gII*	PrintCalc 100*
7	HP-17bII+	HP 40gs	QuickCalc*
8		HP 48gII	
9		HP 50g	
10		SmartCalc HP 300s	

5 of 7 = 71% programmable 8 of 10 = 80% programmable None programmable

Notes: Programmable calculators are in blue. Underlined models are at or near end of life.

** Models that were measured for current drawn.*

Using a convenience current measuring test fixture

The techniques of making the current measurement were described in the previous article. Fig. 1 shows

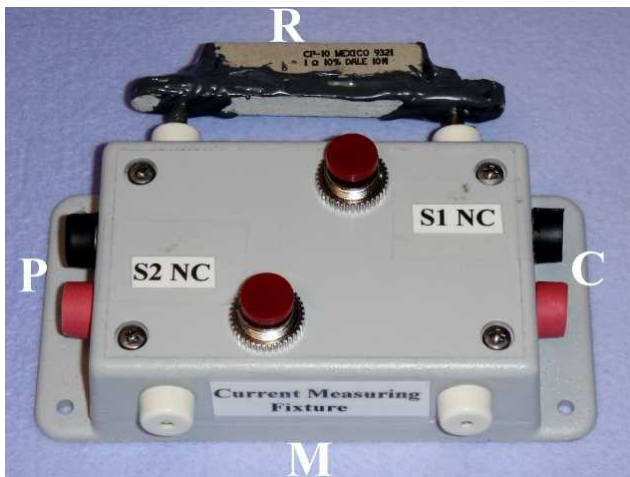


Fig. 1 – Current measurement test fixture.



Fig. 2 – Test fixture with test leads connected.

a simple current measurement test fixture. “M” is for Meter (DMM). “R” is for a series Resistor. “P” is for the power supply test leads. “C” is for the calculator test leads. These four pin jacks have heat shrink tubing added to identify polarity. The black “P” jack is connected to the closest “R” pin jack. The second “R” pin jack is connected to the black “C” jack. The S1 normally closed push button switch is connected between the two “R” pin jacks. The red “P” jacks are connected in a similar manner. The current normally flows through the test fixture and the two normally closed switches.

If, however, one of the two push button switches is pressed down the current is diverted through the respective pin jacks. As described in the previous article this arrangement allows the switching of the meter ranges without disturbing the calculator electronics. Fig. 2 shows the test fixture with the test leads that are used with calculators. The “P” leads have alligator clips on one end to connect to a suitable power source. Two “c” cells are shown. The “C” leads have micro hook connectors to be able to connect to most calculator cell terminals. A one ohm resistor is plugged into the negative “R” line to allow a

volt meter to be connected across it to measure voltage drop as described in the previous article. The second set of “M” pin jacks normally have a current meter⁽²⁾ plugged into them.

Making the measurements

Once you have a convenient test fixture it is easy to make measurements⁽³⁾. Fig. 3 shows the **OFF** (standby) current being measured for the HP-15C Limited Edition, LE. Fig. 4 shows the current drawn by pressing the **ON KEY**. Notice that the ratio of these two currents is 3,827 to 1. Fortunately turning the calculator on doesn't happen very often and this example illustrates how the current drawn changes

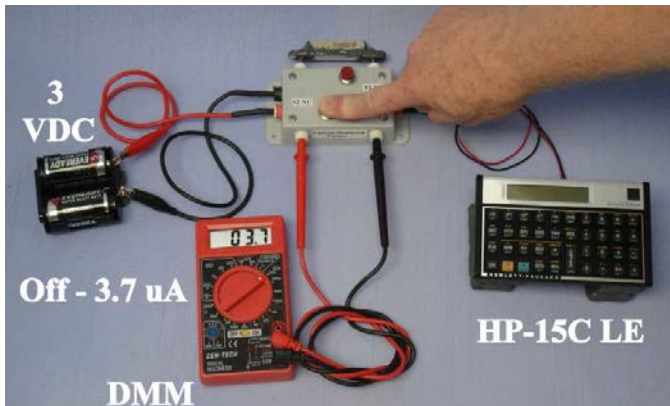


Fig. 3 – Off current being measured for HP-15C LE.

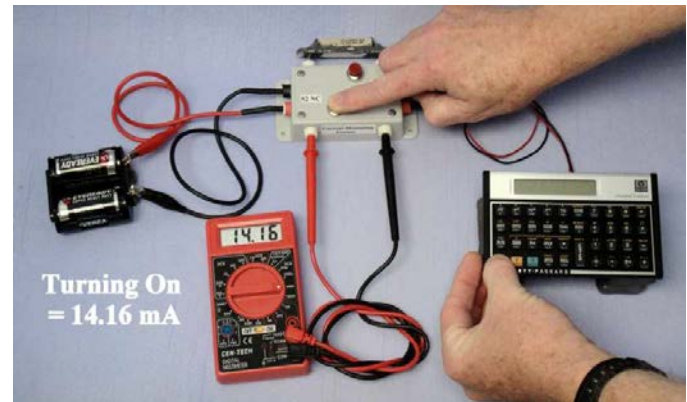


Fig. 4 – HP-15C LE turn on current being measured.

depending on what the user is doing. The student user should be aware of this because you will better understand why your calculator is DEAD when a book in your back pack was pressing the ON key. In the case of the HP-15C LE that uses a lithium CR 2032 cell with a capacity of 225 milliampere hours, $225/14.2 = 15.8$ hours of life. If you dropped your back pack at the end of the day and checked your calculator the next day the cell(s) would surely be dead. The actual life is considerably less than the calculation because of the heavy load which is not what the 225 milliampere hour specification is based on. The CR 2032 cell is rated at a 200 microampere continuous load. Actually the two cell holders of the HP-15C LE are connected in parallel so all values are doubled. More on this topic may be found in the “Cell holder comparison” section.

The HP-15C LE **OFF** current is far below this “continuous standard load” and the life would theoretically be $225/.2 = 1,125$ Hrs. (46.9 days). Since this current is less than the load assumed by the 225

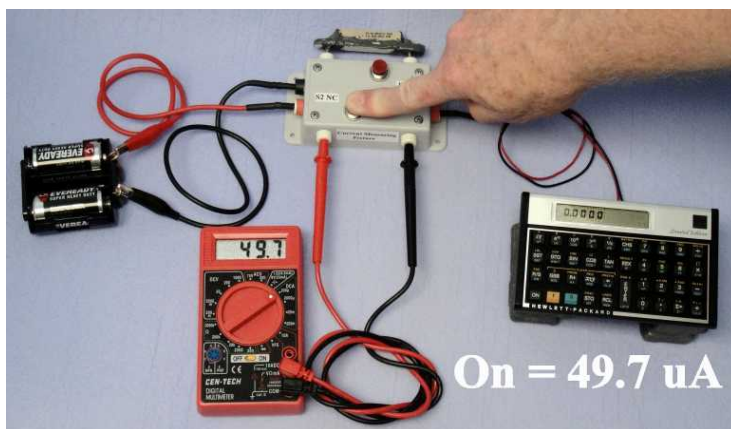


Fig. 5 – HP-15C LE ON current is being measured.

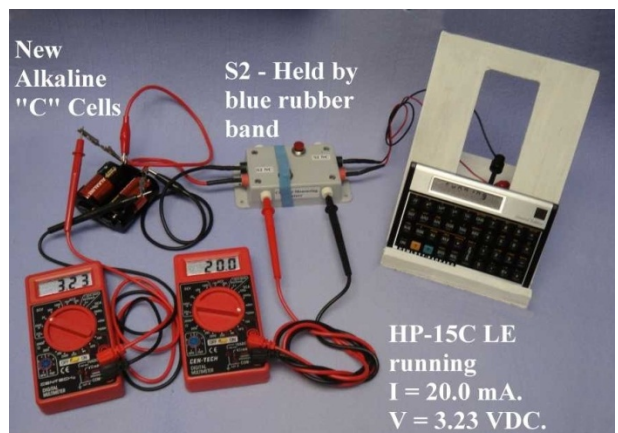


Fig. 6 – HP-15C LE running current measurement.

milliampere hour capacity the actual life will be much longer. Battery manufacturers provide load curves and from these values you can see that battery life is nearly impossible to calculate. One condition of many is the cut off voltage of the cell. The “standard” is an end of life of 2.0 VDC for the 3.0 VDC cell - 2/3 of the nominal cell voltage. And don’t forget about temperature affects, humidity effects (low humidity dries out the cells), calculator IC variances, etc. etc. It is not the intent of this article to describe how to predict calculator cell life, but to provide some perspective on why cell life is a very illusive issue.

Fig. 5 shows the calculator after it has been turned on, the **ON** state.

Fig. 6 shows the calculator in a running mode, usually running a program, calculating a function, or in a self-test mode (HP 39gII). Let’s call it the **RUNNING** state.

These four states are the ones that will serve to illustrate specific measurements made with the same equipment for three models of the three product lines shown in Figure 1.

The calculator shown in Figs 3 – 5 is sitting on four one pound lead weights to provide space for the micro hook leads to connect to the cell holder contacts. This was a klutzy situation so I built the calculator stand shown in the running measurement of Fig. 6. I also replaced the zinc carbon “C” cells with alkaline cells for a more consistent voltage for the Table 2 measurements. The display flashes running and I did catch the display at the right moment to show it. The stand provided a more convenient way of connecting the micro hooks to the delicate cell terminals. A close up view is provided by Fig. 7 which is the same as Fig. 8, *HP Solve* issue # 28 page 35, in the previous article.

The stand was designed to accommodate nearly all of the current models⁽⁴⁾. Fig 8 shows the three views of the stand. It is made of wood and the heavy base is intentional to provide stability. The height is based on the largest model the HP 39gII. The slot in the back is sized for the various Table 1 models and the location of their power cells.



Fig. 7 – Typical CR 2032 cell connections.

It works quite well except that I made one mistake. The tilt angle is 30 degrees from the vertical and I should have made it closer to 45 degrees. This would have provided better lighting for the LCD displays.

The cell holder has a third connection between the two “c” cells to provide 1.5VDC.

Measurements of selected models

As previously mentioned there are many different modes and operating conditions that affect the current that a calculator will draw from its power source. This current is ever changing and unless you are able to specify the current drawn under each possible condition, and the percentage of time it is in that state, it is impossible to calculate the cell life for any modern machine. Add to the calculator’s ever changing conditions and the changing conditions of the cell chemistry of the power source, and the problem complexity further increases. HP does not specify the minimum operating voltage of its machines and that is an essential value to include in the cell life conditions.

The four typical operational states of selected machines are measured and tabulated in Table 2.

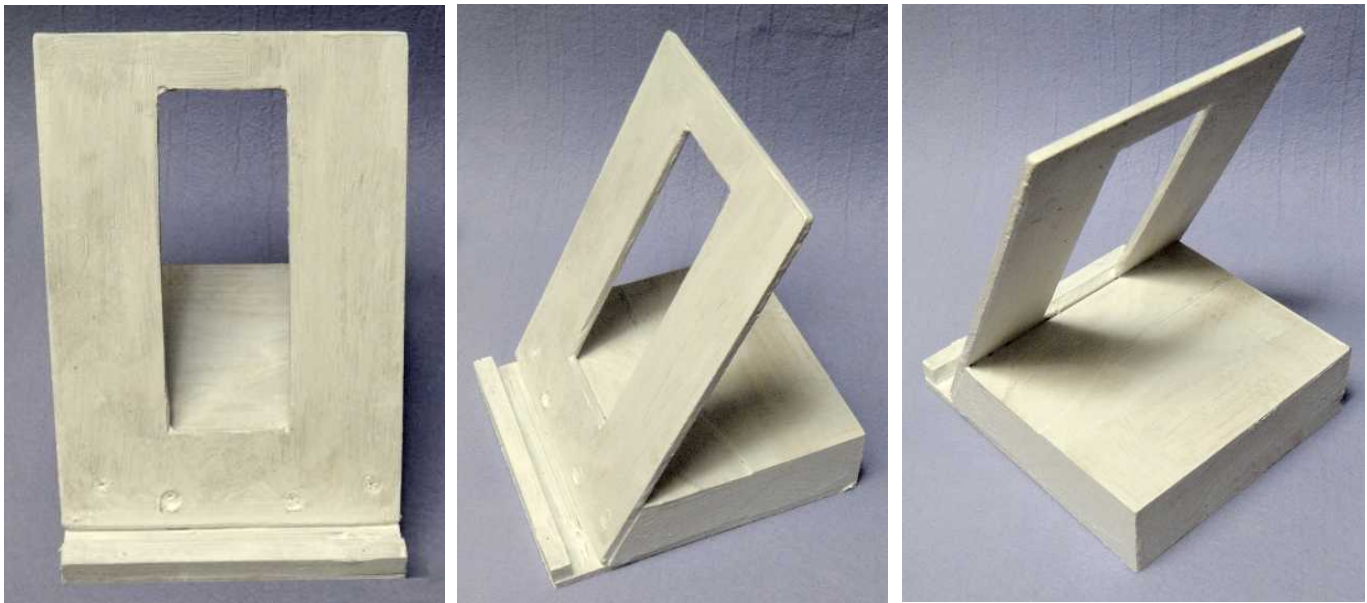


Fig 8a - Current measuring stand, front. Fig 8b - Current measuring stand, side. Fig 8c - Current measuring stand, back.

Table 2 – Selected HP Calculators and the Currents They Draw

#	Model	Voltage ¹	OFF ²	ON KEY ³	ON ⁴	RUNNING ⁵	Comments
1	HP 10bII	3.0 VDC	4.2 μ A	790 μ A	57.9 μ A	N/A	ON key \approx same as all other keys.
2	HP 30b	3.0 VDC	4.3 μ A	700 μ A	160 μ A	19,900 μ A	
3	HP-12C Platinum	3.0 VDC	0.1 μ A	98 μ A	12 μ A	1,560 μ A	Low ON KEY drain.
4	HP-15C LE	3.0 VDC	3.8 μ A	19,800 μ A	49.4 μ A	19,700 μ A	Works down to <2 VDC ⁶ .
5	HP 35s	3.0 VDC	8.4 μ A	32.0 μ A	28.2 μ A	4,590 μ A	Isolated two supplies
6	HP39gII	1.5 VDC	8.9 μ A	12,400 μ A	264 μ A	20,700/36,300 μ A ⁷	Isolated two supplies
7	OfficeCalc 200	1.5 VDC	4.2 μ A ⁸	13.5 μ A	12.0 μ A	N/A	See text.
8	PrintCalc 100	6.0 VDC	62.3 μ A	656 μ A	118 μ A	N/A, 145/185 μ A ⁹	4 AA cells.
9	QuickCalc	1.5 VDC	<0.1 μ A ¹⁰	8.8 μ A	2.7 μ A	N/A	Single cell. All 8's = 6.7 μ A.

Notes: 1 – Normal operating (cell) voltage.

2 – Calculator **OFF** current in microamperes.

3 – Turn **ON KEY** pressed current in microamperes.

4 – Machine (display) is **ON** with the current measured in microamperes.

5 – Current in microamperes **RUNNING** a loop program: LBL 1, 1 2 3 4 5 6 7 8 9 1 0, GTO 1.

6 – Variable DC supply was used to verify operation to 2/3 normal operating voltage.

7 – Measured with the hour glass annunciator on/ Self-test (ON + F4, 2, 2,) full power mode.

8 – Measured after the auto turnoff, there is no off key.

9 – Printing/paper advance.

10 – The 7 function CEN-TECH DMM has a very sensitive current range of 200 μ A.

QuickCalc is a special measurement challenge

The HP 10 QuickCalc is HP's smallest current calculator model. It runs on a single small button cell. You have to remove the 10 small front screws. Magnetize the small Philips screwdriver in order to better handle the screws. See Fig. 9. The metal cell holder has been unsoldered at "A" & "B" as shown in Fig. 10. "C" is the circuit board contact area for the negative terminal of the cell. A Popsicle stick (*cherry*) is slightly smaller than the thickness of the cell. A 14 Ga. wire is flattened at the end and held to the Popsicle stick with heat shrink tubing. It is then slid into the cell holder to make the negative cell contact.

See Fig. 11 and Fig. 12. Rubber bands hold the circuit board assembly to the front of the case so the key board may be used.

This model has the least **OFF** current and it is so low the DMM can't register it with its sensitivity of 0.1 μA (100 pico amperes). The estimated current has to be on the order of a few tens of picoamperes. It is not surprising that this machine is especially sensitive to meter ranges and meter range changes.

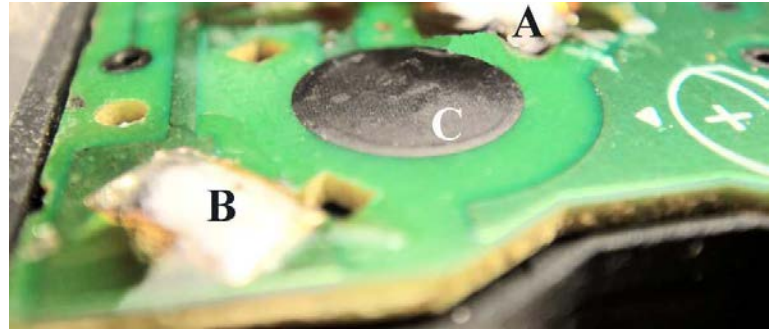


Fig. 9 – QuickCalc is HP's smallest calculator. Fig. 10 – Cell holder is unsoldered to show negative contact.

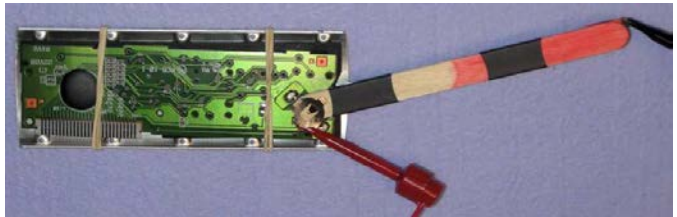
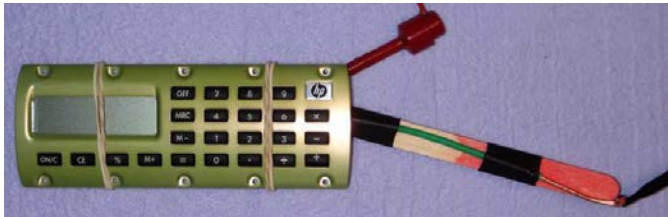


Fig. 11 – Popsicle stick replaces button cell. See text. Fig. 12 – Popsicle stick makes cell contact. See text.

Large OfficeCalc 200 display measurably affects current drawn

The OfficeCalc 100, 200 & 300 are solar cell powered with a single 1.5 VDC small button cell as a backup power source. The machine works using only the solar cell - without the button cell - in normal room light. The current measurements were made with a piece of black paper taped over the solar cell.

This “simple” machine nicely illustrates how various conditions will affect the current draw even though it is in the low tens of microamperes. The 14 digit segmented display is the primary current drain. “1”s in the display will draw less current than “8”s; 14 “1”s = 18.6 μA while 14 “8”s = 22.9 μA . Pressing any key increases the current drain a few tenths of a microampere plus the function involved plus the display result. I didn't find a **RUNNING** state to measure.

Cell holder comparison

Of the 24 current HP calculator models all but seven have two or more cell holders. The single cell models are the HP 12C, HP CalcPad 100, HP CalcPad 200, HP OfficeCalc 100, HP OfficeCalc 200, HP OfficeCalc 300, and HP 10 QuickCalc.

Fig. 13 shows the cell holders of the three selected finance models. Current versions of the HP 12C uses a single CR2032 coin cell.

Fig. 14 shows the cell holders of the three selected scientific and graphing models. The CR2032 coin

cell is one of the most popular cells used in today's models.

Fig. 15 shows the Home & Office models. These calculators use the largest size cell, AA, and the smallest, GP- 189, cells. Table 3 provides a summary of the cells and cell holders used.

Comparing the current drain results

Which measured calculator model is the most energy efficient? Let's compare the Table 2 results using an un-weighted and a weighted value.



Fig. 13 – Finance Calculator cells.



Fig. 14 – Scientific and Graphing Calculator cells.



Fig. 15- Home and Office Calculator cells.

Table 3 – Selected HP Calculator Cell Usage Comparison

#	Model	Voltage ¹	Cells Used	Holders	Connected	Comments
1	HP 10bII	3.0 VDC	CR3032	Two	Parallel	
2	HP 30b	3.0 VDC	CR3032	Two	Parallel	
3	HP-12C Platinum	3.0 VDC	CR3032	one	N/A	
4	HP-15C LE	3.0 VDC	CR3032	Two	Parallel	Quick OFF if one cell is missing.
5	HP 35s	3.0 VDC	CR3032	Two	Diode Iso. ¹	
6	HP39gII	1.5 VDC	AAA	Four	Diode Iso. ¹	Top two and bottom two parallel ² .
7	OfficeCalc 200	1.5 VDC	GP-189	One	N/A	
8	PrintCalc 100	6.0 VDC	AA	Four	Series	
9	QuickCalc	1.5 VDC	GP-189	One	N/A	

Notes: (1) Diode isolation allows the two cells to power the circuits in such a way that as long as one cell is present memory (usually data registers and program memory) will not be erased.

(2) The calculator will run on one cell with a shorter life.

The un-weighted comparison is the sum of the microampere current four states, e.g. the HP-15C LE is $0.1 + 98 + 12 + 1,560 = 1,670.1 \mu\text{A}$. Rounded to two places = 1700. This number doesn't convey very much information. The highly desirable low **OFF** state value disappears and the high **ON KEY** dominates when it is only drawn for ½ second or less.

Let's assign a usage time weight for each value to more closely approximate how the calculator is being

used. Suppose a student uses a calculator three times per day for ten minutes (on average). This means that the **OFF** time is $23.5 \text{ hours}/3 = 7.7 \text{ Hr.}$ or 470 minutes per usage. Let's also assume when turning on, **ON KEY**, the calculator it takes $\frac{1}{2}$ second. Since the calculator typically turns off after ten minutes let's use the **ON** time as 10 minutes. For the final state value, **RUNNING**, let's assume 15 seconds or 0.25 minutes. A single usage cycle is **OFF** = 470 minutes, **ON KEY** = 0.008 minutes, **ON** = 10 minutes, **RUNNING** = 0.25 minutes. The total is 480.258 minutes. The ratio (weight factor) for each is: **OFF** = 0.97894, **ON KEY** = 0.00002, **ON** = 0.02082, **RUNNING** = 0.00052.

Now we can add our total weighted currents to make a better comparison. The HP-15C LE weighted value = $3.71997 + 0.39600 + 1.02851 + 0.01024 = 5.15472$. Comparatively speaking the lower this value is the better. Keep in mind that the type of calculator is also an important efficiency consideration factor. These values are tabulated in Table 4.

Table 4 – Selected HP Calculator Currents Drawn Comparison

#	Model	Voltage	Unweighted	3 Weighted	4 Weighted	3 Wt. Ratio	4 Wt. Ratio	Comments
1	HP 10bII	3.0 VDC	N/A	5.33	N/A	34.6x	N/A	ON key \approx same as all other keys.
2	HP 30b	3.0 VDC	20,746.3	7.55	17.9x	49.0x	10.5	
3	HP-12C Platinum	3.0 VDC	1,670.1	0.350	1.7x	2.27x	REF	Very low ON KEY drain.
4	HP-15C LE	3.0 VDC	19,872.9	5.14	5.1x	33.4x	3.0	Works down to $<2 \text{ VDC}^6$.
5	HP 35s	3.0 VDC	4,658.6	8.81	11.2x	57.2x	6.6	Isolated two supplies
6	HP39gII	1.5 VDC	33,372.9	14.4	25.2x	93.5x	14.8	Isolated two supplies
7	OfficeCalc 200	1.5 VDC	N/A	1.23	N/A	7.99x	N/A	See text.
8	PrintCalc 100	6.0 VDC	N/A	63.5	N/A	412x	N/A	4 AA cells.
9	QuickCalc	1.5 VDC	N/A	0.154	N/A	REF	N/A	Small button cell.

The HP-12C Platinum (and all 12C's) is the most energy efficient when all four measured values are used. The worst is the HP 39gII at 15 times more current for all four values. The second most efficient calculator is the HP 35s.

If the **RUNNING** value is not used and all nine machines are compared the most efficient machine (non-programmable) is the QuickCalc (used as the reference value) with the HP-12C a close second.

Using Table 2 values to diagnose the calculator

Every serious repair/service bench has a power source that provides the electrical power parameters – voltage, current and power – of the device under test. In the case of a calculator it is the current measurement fixture shown in Figs 1 – 6. Knowing the **OFF** current immediately tells the user that the calculator circuits are at least receiving power and drawing the normal amount. Any other value (over or under $\pm 20\%$) indicates something is wrong. Of course multi tens of milliamperes is a sure sign of excessive current due to a leaky capacitor or “cooked” IC's.

Pressing the **ON KEY** is the next step to having a clue of what might be wrong. If the current is within $\pm 20\%$ of the table 2 value the microprocessor circuitry is scanning the keyboard and responding to the key press. The newer designs (OfficeCalc 200) have less of a current increase; 3.2 times while the HP 39gII is the worst at 1,300 times more current.

If the display turns on the machine is much closer to being able to work properly. Of course physical defects such as a cracked display, black display, etc. indicates a display issue.

The primary value of seeing the current change – assuming a proper operating voltage - under various conditions is to know if something is wrong with the power source such as a broken wire or cracked circuit board.

Summary, observations, and conclusions

Measuring the current drawn by a calculator is a difficult measurement because of the requirement of inserting a meter (series connection) into the power supply circuit. This is part two of a two part series with part one, *HP Solve*, issue #28 page 30, describing the mechanical issues. This part applies the methods described in part one to measure nine representative models of the current 24 HP calculator models.

A very low cost (FREE to \$9.99) Digital Multi-meter is used to measure the four most common calculator state current values – **OFF, ON KEY, ON, & RUNNING**. The increasing number of calculator operating conditions (states) make these measurements important for diagnostic and power supply life estimates. The various power supply cell holders are described and four tables provide the technical data for each of the selected nine machines.

Notes: Measuring Calculator Current – Nine Measurement Examples

- (1). *Technically a battery is composed of two or more cells. Very often popular and marketing usage of the term battery is used in place of cell. All current HP calculators operate from one or more cells using one to four cell holders.*
- (2). *The CEN-TECH 7 Function meter shown below is a low cost but quite accurate Digital Multi-Meter, DMM, marketed by the US national chain Harbor Freight. This DMM normally ranges in cost from free to \$9.95. I have seen this model on the market for at least seven years. See Fig. 16 and Fig. 17 for additional details. First visit a Harbor Freight store and sign up to receive their snail mailers and you will be able to buy one on sale (or you may order from their website) or even get one free. The FREE coupons often appear with a single item 20% discount coupon in various magazines such as Sunday paper supplements. I have gotten two*



Fig. 16 – Seven function CEN-TECH DMM costs.



Fig. 17 – Mailed coupon gets you one for FREE.

FREE DMMs in the last month (August). A third one was obtained from a Labor Day Sale Coupon similar to the one shown in Fig. 17. This is certainly great news for students. I have over a dozen of these DMMs (FREE or \$3 sale) because I use them to measure multiple nodes of a circuit at the same time. A quick photo

“collects” the circuit values for future reference. The lowest current range, 200 μ A, is even lower than several DMMs that I have that cost many times that of the CEN-TECH. The primary negative aspect of this low cost DMM is that it does NOT have an auto turn off and it is easy to forget and leave it on which results in a DEAD 9 VDC battery. Fig. – 18 shows the specifications.

CEN-TECH 7 Function DMM

ITEM	DESCRIPTION
Frequency	45-450 Hz
DC Amps	Ranges: 200 μ A/2000 μ A/20mA/200mA, 10A
Accuracy	(@200 μ A-200mA) 1.2% \pm 2D; (@10A) 3% \pm 2D
DC Voltage	Ranges: 200mV/2000mV/20/200/1000V
Accuracy	(@200mV) 0.5% \pm 1D; (@2000mV-200V) 1.0% \pm 1D; (@1000V) 1.0% \pm 2D
AC Voltage	Ranges: 200/750V
Accuracy	(45-450 Hz) 1.2% \pm 10D
Resistance	Ranges: 200/2000/20K/200K/2000K Ohm
Accuracy	(@200-200K Ohm) 0.8% \pm 2D; (@2000K Ohm) 1.0% \pm 2D;
Sampling Rate	2.5 times/Secon
Overload Protection	Fast-Acting 500mA/250V Fuse
Operating Temperature	Range: 32° - 104° F
Display	1/2" high 3-1/2-digit LCD
Battery	One 9 V (included)
Weight	.45 lb.
Features	32" Test Leads, Transistor (NPN and PNP) Testing Function, Battery Testing Function, and Automatic Polarity and Zero Adjust

Fig. 18 – CEN-TECH 7 Function DMM specifications

- (3). Making current measurements is always a physical challenge. The hook connectors work if large enough (and you use tape to hold them in place if needed) because they tend to pop off the coin cell holders.
- (4). The OfficeCalc 100, OfficeCalc 200, and OfficeCalc 300 calculators are much larger than the stand. The PrintCalc 100 has a paper roll and is not practical to place on the stand.
- (5). The early versions of the HP-12C used three button cells in series (4.5 VDC.). For a more complete description of this calculator see [HP Solve](#), issue #25 page 10 (especially pages 11 & 15). The comparison of button cells (slightly larger than the ones used currently) of Silver or Lithium chemistry was noted in Note 5 with a table that is reproduced here.

<p>Early HP-12Cs used 3 Lithium or Silver button cells. Here is a price comparison. Silver has twice the life.</p>		<p style="text-align: center;">32¢ Li vs. 52¢ Ag in 500 piece quantity.</p>
<p style="text-align: center;">Sony Batteries LR44 Alkaline Watch Battery</p> <p>SONY LR44 (A76) Alkaline Button Cell 1.5V, Blister 1 pc Replaces - LR44H, 357A, RW82, KA, A76, 208-904, SB-F9, GPA76, L1154, AG13, G13-A, L1154, A76, V13GA, LR44, AG-13, AG 13, PX76A, 675A, 303, Duracell PX-76A Button Cell Battery, G13A, Energizer A76 Man</p>	<p style="text-align: center;">Bulk Batteries 357 Batteries Silver Oxide Watch Battery Tray Pack</p> <p>Watch Battery Tray Pack Cross Reference With - 1131SO SR44 D357/303 SP357 SR44W V357 AG13 G13 A76 PX76 675 1166A PX76A A76-1 LR44H V13GA GP76A L1154 RW82 As Low as \$0.41 Per Battery</p>	<p style="text-align: center;">\$1.00, 10 for \$6.50, 200 for \$70.00, 500 for \$160.00</p>
<p style="text-align: center;">\$0.70, 50 for \$35.00, 150 for \$88.50, 450 for \$234.00, 1500 for \$690.00, 3000 for \$1,230.00</p>		

Fig. 18 – Silver & Lithium button cell comparison. →