HP Calculator Displays

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Anyone who has seen photographs of more than just a few HP calculator models has probably noticed that the display shown in calculator photographs appears to be inconsistent in terms of what might be expected. If you have ever tried to photograph a calculator you have experienced the difficulty of getting a good quality image that shows all of the keys *and* the display clearly and accurately.

Professional photographers will often photograph the whole machine and then photograph the display only and paste the display image on to the calculator image. Each display technology has its own lighting issues and the more common LCD displays (segmented and dot matrix) often have limited contrast which adds to the photographer's challenge. Optimum lighting for the machine over all is usually not optimum lighting for the display for maximum clarity and good color rendition. Because an LCD display is comprised of glass plates you also have multiple surface and shadow issues to contend with. These technical issues are not the topic of this article. The purpose of this article is to explore the content of the display and to answer the question,

> "What should/could be in the calculator display when the calculator is photographed?

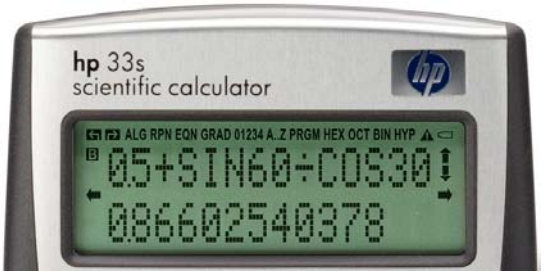
If you look at HP's literature over the 37 years of producing and advertising 96 models (January 1972 to March 2009) you could make the following observations about what is commonly shown in the display.

1. **Many displays are simply blank**. I have an old HP color photo (14" wide x 9-3/4" high, see Appendix A) given to me by Henry Horn in the early eighties that shows all machines made to that date. It shows 27 machines from the HP-35A to the HP-41C. The HP-41C has a 14 segment LCD and all the other 26 machines are seven segment LEDs. All of the calculator displays are blank. The professional photographer simply didn't want to bother with having something meaningful in each display. He was primarily concerned with layout and lighting. Besides, the machines will turn off after ten minutes, and the displays would have to be re-entered in each machine – they would have to be AC powered. This is very troublesome.

2. **Some displays are chosen for marketing purposes**. Many of the finance machines, especially the multi-line models will show numbers or text that represents a major feature of the machine. Simple one line displays that are dot matrix will show mixed text and numbers, e.g. an HP 14B (12/89 brochure) display has "PROF%=14.14." Graphing models will often show a plot in the display and one brochure of the Business Consultant II (11/88) shows a sine curve in the display. The Computer Scientist HP 16C shows 11100010 b in an 11/84 brochure. An HP 48GX 4/93 brochure shows a wire frame plot in its display.

3. **Some displays simply show the model number**. This was popular for many years, especially for numeric only models. Examples are: An HP-41CX calculator display showed * HP-41CX * in a 3/88 brochure. The HP 10B shows 10.010, and the HP 12C shows 12,000.00 in the display of a November 1992 brochure. An HP 20S machine shows 20.020 in its display in a 4/93 brochure.

4. **Some displays show technical display information**. If you are going to show the display you might show as much display information as possible. An LED calculator might show all the digits: 1234567890. While this is a boring display it is technically informative. This was used in the HP-15C display (segmented LCD) in a march 1988 brochure. The more recent HP 33s display (from HP's website) is a good example that is technically informative.



From these examples it is clear that a non-blank display is desirable, but an interesting and informative display requires considerable thought, planning, and effort.

With the above examples in mind I wondered what would be the simplest, easiest calculator display to use if I had to photograph a calculator. To answer this question I decided on a list of practical requirements.

i. A simple, mathematically interesting, and informative number to be used for 8 to 15 digit displays.
ii. The number should include as many of the 0 to 9 digits as possible.
iii. The number must be easily and quickly input with one or two keystrokes, i.e. function produced.
iv. A general method of generating the number should not require extensive knowledge of the machine.

What makes a number interesting? Two ideas come to mind. Normal numbers are either rational or irrational. Irrational numbers are much more interesting. Certain numbers are well known and easily recognized because they show up frequently in mathematics.

Another "interesting" number may be one that "begs to know what it means." One such number (6.0030000004) appeared on the case of the HP38g some years ago, and it drove everybody nuts because it was assumed to have meaning. Many in the HP user Community searched for the function. It turned out that this number was an "artistic creation" (chosen because it had "balance"), and it had no mathematical meaning and no function generated it.

With these considerations in mind here are a few numbers that could work. Keep in mind the non-conventional processing of (guard) digits that HP traditionally uses[(1)]. Bold bracket numbers indicate number of missing digits.

The most popular and very easily entered number is Pi, π

1. π = **3.14159 26535 89792**. This number provides all but three of the digits 0 – 9.

   8 digits: 3.14159 27 are missing 0, 6, & 8. **[3]**
   10 digits: 3.14159 2654 are missing 0, 7, & 8. **[3]**
   12 digits: 3.14159 26535 9 are missing 0, 7, & 8. **[3]**

Another popular well recognized irrational number is **e**, but from a digit perspective it falls considerably short.

2. **e = 2.71828 18284 59045**

   8 digits: 2.71828 18 are missing 0, 7, 3, 4, 5, 6, & 9. **[7]**
   10 digits: 2.71828 1828 are missing 0, 7, 3, 4, 5, 6, & 9. **[7]**
   12 digits: 2.71828 18284 5 are missing 0, 7, 3, 5, 6, & 9. **[6]**

A very popular and easily recognized number is the square root of two.

3. $\sqrt{2}$ = **1.41421 35672 373095** This number provides all but three of the digits for the longer displays.

   8 digits: 1.41421 36 are missing 0, 5, 7, 8, & 9. **[5]**
   10 digits: 1.41421 35672 are missing 0, 8, & 9. **[3]**
   12 digits: 1.41421 356724 are missing 0, 8, & 9. **[3]**

A less recognizable irrational number is the square root of three.

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(1) See the HHC 2007 HP Calculator Calendar (2007/2008) December2007 page for an HP accuracy description.

4 . $\sqrt{3}$ = **1.73205 08075 68877** This number provides all but three of the 8, 10, 12 display digits 0 – 9.

8 digits: 1.73205 08 are missing 4, 6, & 9. **[3]**
10 digits 1.73205 0808 are missing 4, 6, & 9. **[3]**
12 digits: 1.73205 08075 7 are missing 4, 6, & 9. **[3]**

The digit count for the above single digit number/function combination is not especially impressive. What about another function that is found on most scientific calculators, perhaps a trigonometric function?

5. Tan 7 (degrees) = **0.12278 45609 02906**. This number provides all but one of the digits 0 – 9 for a 12 digit display.

8 digits: 0.12278 46 are missing 3, 5, & 9. **[3]**
10 digits: 0.12278 4561 are missing 3, & 9. **[2]**
12 digits: 0.12278 45609 0 are missing 3. **[1]**

Probably the most interesting, but least recognized number, is the golden ratio, φ, $\frac{1+\sqrt{5}}{2}$. However φ takes six keystrokes to put it into the display. The 12 digit φ display is digit competitive only missing three digits.

6. φ = **1.61803 39887 49894** . . .

8 digits: 1.61803 40 are missing 2, 5, 7, & 9. **[4]**
10 digits: 1.61803 3989 are missing 2, 4, 5, & 7. **[4]**
12 digits: 1.61803 39887 5 are missing 2, 4, & 9. **[3]**

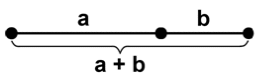
What makes φ interesting and perhaps the-most-interesting-display number?

1. It's reciprocal has the same decimal digits. $1/\varphi$ = **0.61803 39887 49894 . . .**
2. It's square is the same as adding 1. φ^2 = **2.61803 39887 49894** . . .
3. Solving for φ using #2 as a quadratic equation has the same + and – solution decimal digits.

   $\varphi^2 - \varphi - 1 = 0$

   φ = **1.61803 39887 49894** . . . ($\frac{1+\sqrt{5}}{2}$)

   $-\varphi$ = **-0.61803 39887 49894** . . . ($\frac{1-\sqrt{5}}{2}$)
4. φ has been known since at least 300 BC when the Greek mathematician Euclid described it (its construction) in *Elements*.
5. φ may have been a factor in the design of the Great Pyramid in circa 2540 BC.
6. φ and $1/\varphi$ are irrational numbers. Its value has been calculated: to 10 million digits in December 1996 and to 1.5 Billion digits in May 2000.
7. φ expressed in any base does not have any ultimate repeating pattern in their digits.
8. φ and the Fibonacci numbers are related and it may be shown how the Fibonacci number (ratio of successive Fibonacci numbers) arise from φ.
9. φ cannot be expressed as a fraction because it is irrational.

10. Geometrically the golden ratio may be expressed as: 

$$\frac{a+b}{a} = \frac{a}{b} = \varphi$$

11. φ has artistic value in that it is used to hang paintings and size rectangles because these proportions are aesthetically pleasing and have been used since the renaissance period. In #10 above if length ab is unity, a= 61.8%, b =38.2%.

12. An alternate name for the golden ratio is the golden section.

13. Da Vinci, during the renaissance, claimed that there were a number of applications of the golden ratio in the human body. He found that a perfectly structured human body would have the golden section between:
    - first finger joint and second - second joint to both
    - hand to lower arm - both hand and lower arm
    - many proportions creating the perfect face
    - so on, all over the body

14. The Pearl Musical company of Japan positions the air vents on its four Masters Premium drum models based on the golden ratio. The company claims that this arrangement improves bass response and has applied for a patent on this innovation.

This article was written because HP needed an HP-35A photograph for a special event. See a description of this in Appendix B.

Reader challenge. What other numbers are interesting? Is there a better single digit angle and trig function that produces all the digits for a ten digit display? What other functions may be used to generate numbers?

I would be interested to hear from readers with other universal and interesting numeric display ideas.

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Appendix A – Classic to Nut Machines - Page 1 of 1

The photograph below was taken by a professional photographer who had to arrange all the calculators in order to take the photograph. It is a scanned image of a 28 year old "yellowed" print. The calculators turn off after approximately ten minutes. Can you imaging having to have a specific number in the display of each of the 27 machines and have each display be clear and readable? It would be nearly impossible. I was thinking of this photograph when I listed the four (i. to iv) display number guidelines above.

Fig. A1- HP photograph, 14" wide x 9-3/4", of all calculator models from the HP-35A to the HP-41C. Note displays are off.

Appendix B – IEEE Celebration of the HP-35A - Page 1 of 1

HP needed a photograph of an HP-35A calculator and I sent them two. The first was the one used for the HHC Calendar covers, the same one on Wlodek's book cover, *A Guide to HP Handheld Calculators and Computers*. The second one I took myself and HP used it for the invitation shown here.

What should I put into the HP-35A display? This led to a discussion on "interesting" numbers for display use. See my article on this topic titled, *HP Calculator Displays*.

Fig. 1 – IEEE invitation text printed on back of HP-35A.

Fig. 2 – HP-35A with most interesting display number.

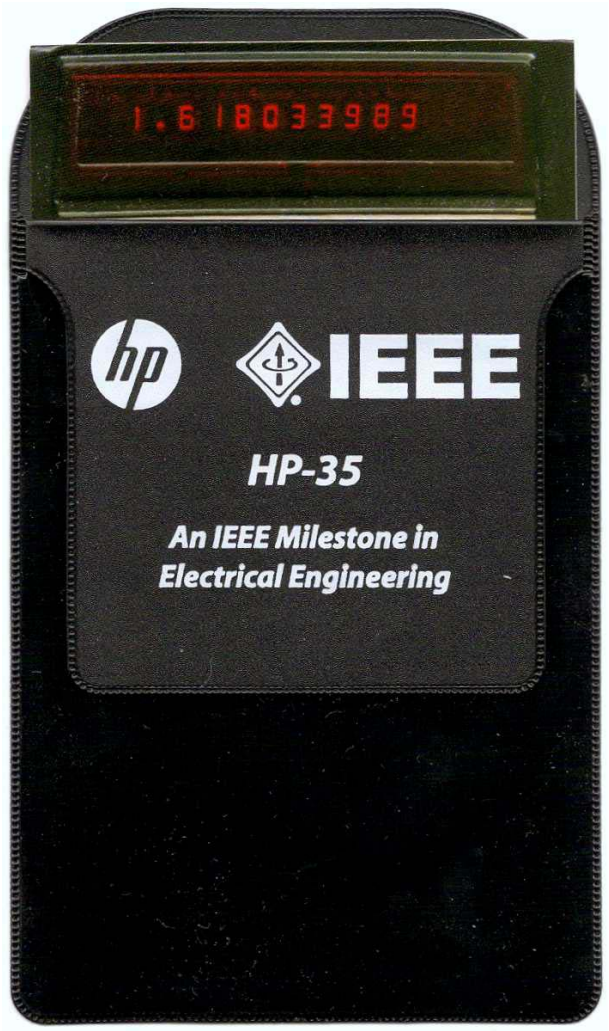

Fig. 3 – Pocket protector for the photo in fig. 2.

The IEEE is attempting to capture the history and technology used for computing. Calculators are part of that effort. This is very important because the calculator as a stand alone product is under constant convergence pressure in the market place. *Remembering the HP-35A* is a detailed historical description, 30 pp., of buying an HP-35A in 1972. It contains scanned documents not found else where.

http://holyjoe.net/hhc2007/Remembering%20The%20HP35A.pdf

Fig. 4 – Envelope of the invitation.