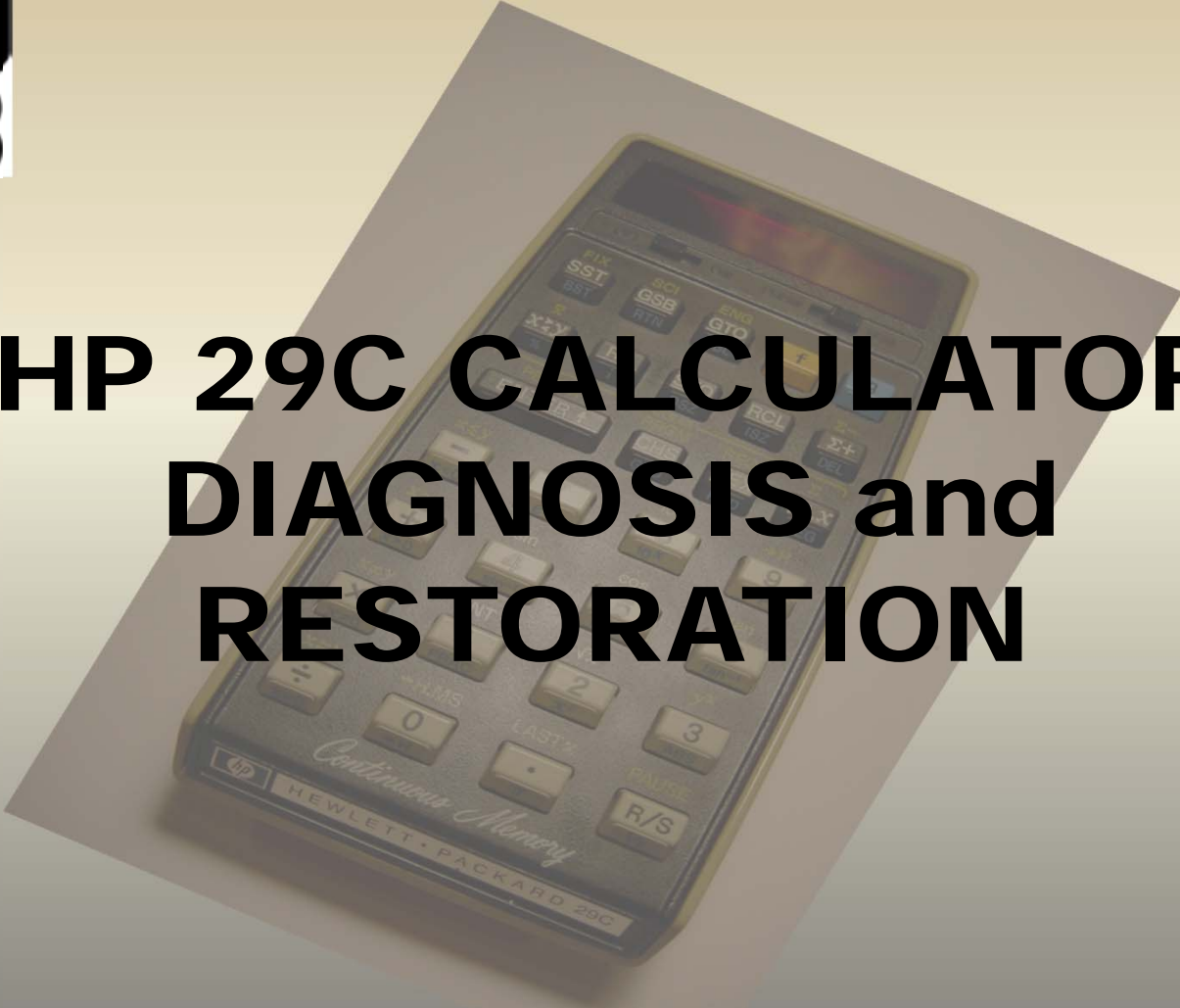


HHC
2013

A vintage HP 29C scientific calculator is shown at an angle, slightly faded, serving as a background for the title text. The calculator is dark grey with a light-colored keypad and a small LCD display at the top. It features various function keys like 'FIX', 'SST', 'SQ', 'GSE', 'ENG', 'GTO', 'RCL', 'TRZ', 'DEL', '2+', 'X', 'Y', 'Z', 'R/S', and 'LASTx'. The bottom of the calculator has the 'Continuous Memory' logo and 'HEWLETT-PACKARD 29C' printed on it.

HP 29C CALCULATOR DIAGNOSIS and RESTORATION

Presented by: Jim Johnson
HP Handheld Conference 2013 – Fort Collins, CO
September 21-22, 2013

RESTORATION of an HP 29C CALCULATOR

Agenda

- Synopsis
- Calculator acquisition – brief history
- Disassembly, Photos, Identification of Integrated Circuits and Power Supply
- Schematics
- Troubleshooting and Diagnosis
- Functioning HP 29C Calculator
- Contrast and Compare Past with Present
- Summary and Conclusions



A WORD OF

Never attach the charger of a Woodstock series unit to the calculator without a known good rechargeable battery in place. An AC charger connected to an HP 29C with a bad battery, bad contact or without a battery in place, has a high degree of certainty that the excess voltage will destroy or damage the unit.



RESTORATION of an HP 29C CALCULATOR

Setting Expectations

What this presentation is:

- A discussion of my passion and interest in vintage HP calculators from a hardware perspective
- Sharing information learned/not available on the web
- Troubleshooting methodology for HP Woodstock Series
- Bringing a vintage, rare HP 29C back to life!
- A brief contrast and compare of HP 29C versus a modern HP calculator



What this presentation is **not**:

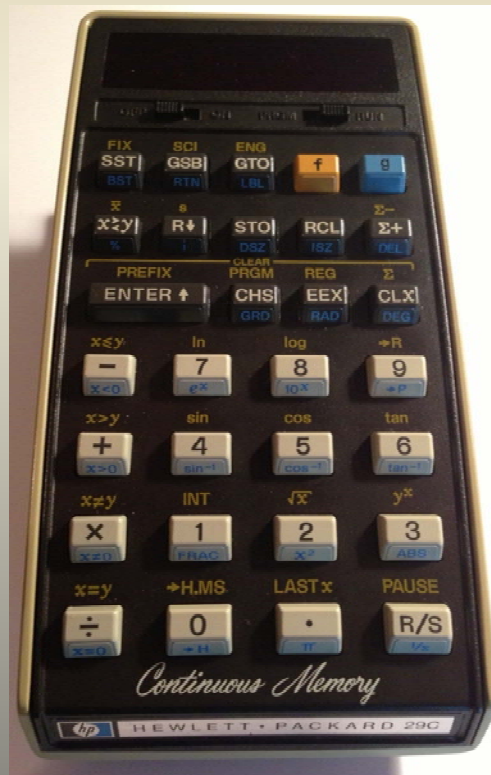
- Not an in-depth discussion of the operation of the HP 29C
- Not a critical examination of the routines or ROM firmware used in the HP 29C
- Not an exhaustive study of the mathematical concepts used to create “Bonnie”.

RESTORATION of an HP 29C CALCULATOR

Acquisition of two HP-29C calculators

SN: 1811S20315

May 7, 2012 - eBay



SN: 1904S21718

June 28, 2012 - eBay

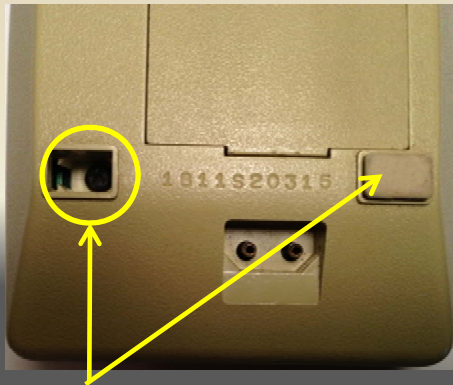


HP 29C's sell on eBay for range from \$81 - \$372. Avg. sell price \$202
Listing prices range \$0.99 - \$495.

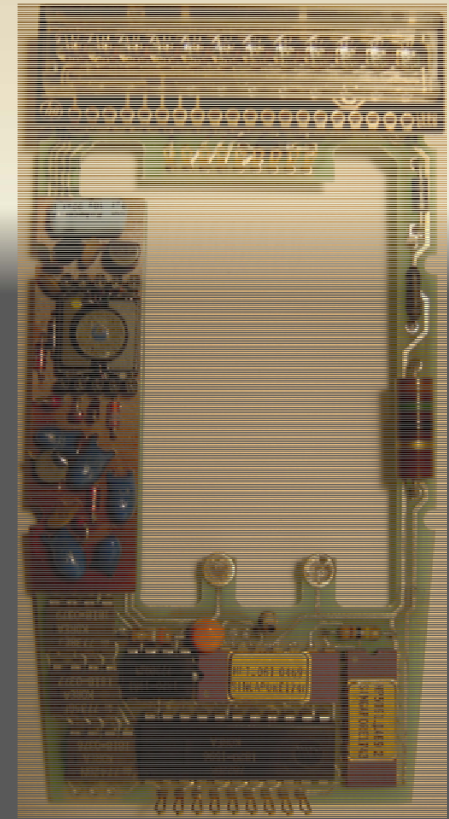
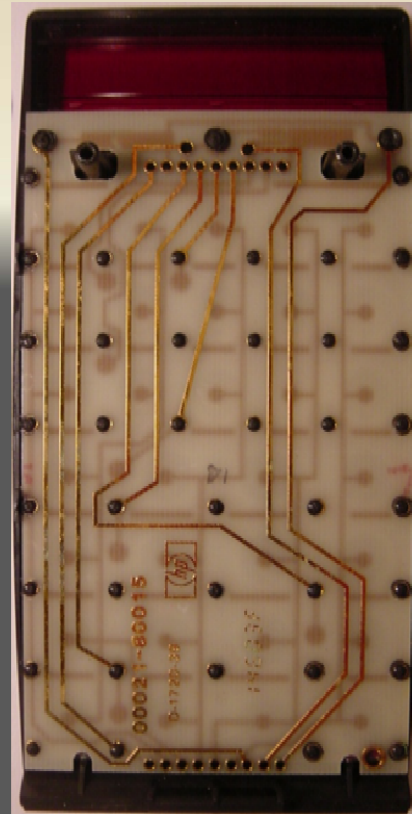
Note: According to the Museum of HP Calculators, the HP 29C sold new in 1977 for \$195.00 (USD).

RESTORATION of an HP 29C CALCULATOR

Disassembly, Photos, Identification of Integrated Circuits and Power Supply

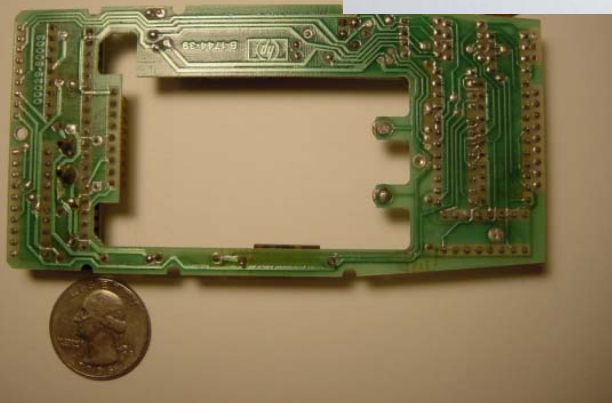
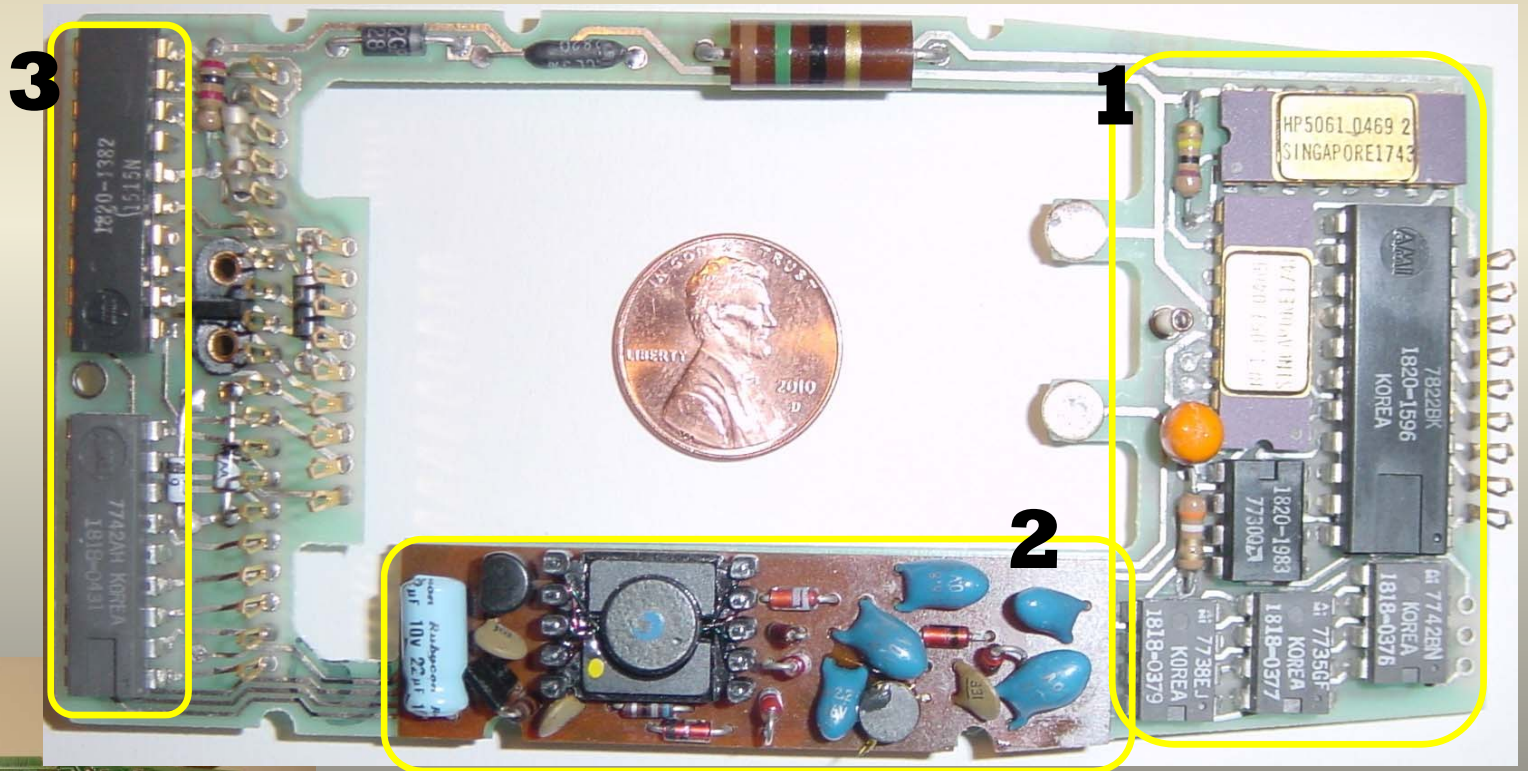


To open remove the top 2
Screws under the footpads



RESTORATION of an HP 29C CALCULATOR

Disassembly, Photos, Identification of Integrated Circuits and Power Supply



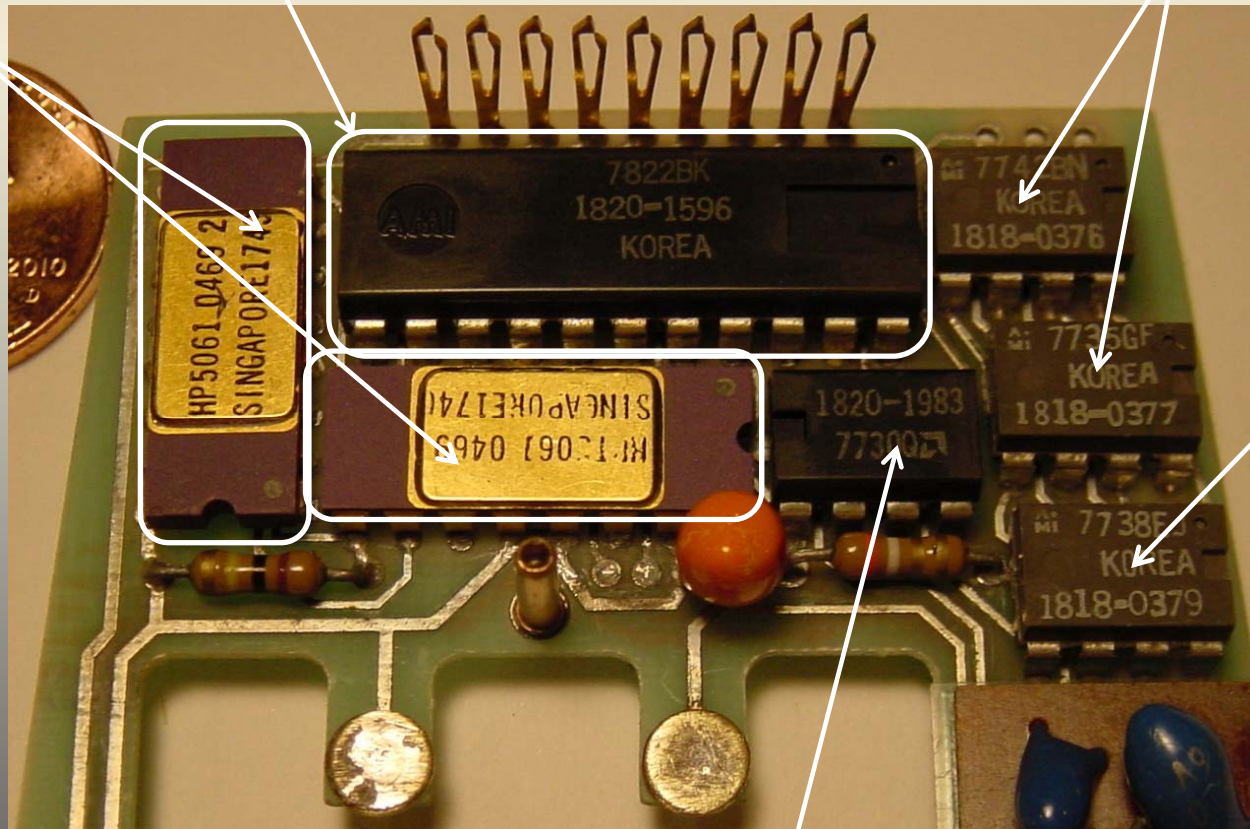
RESTORATION of an HP 29C CALCULATOR

Disassembly, Photos, Identification of Integrated Circuits and Power Supply
Arithmetic Control and Timing (ACT) IC, RAM, ROM, POR/Battery Low Comparator

Arithmetic Control
and Timing (ACT) IC

ROM IC's

CMOS
Static RAM
I.C.'s



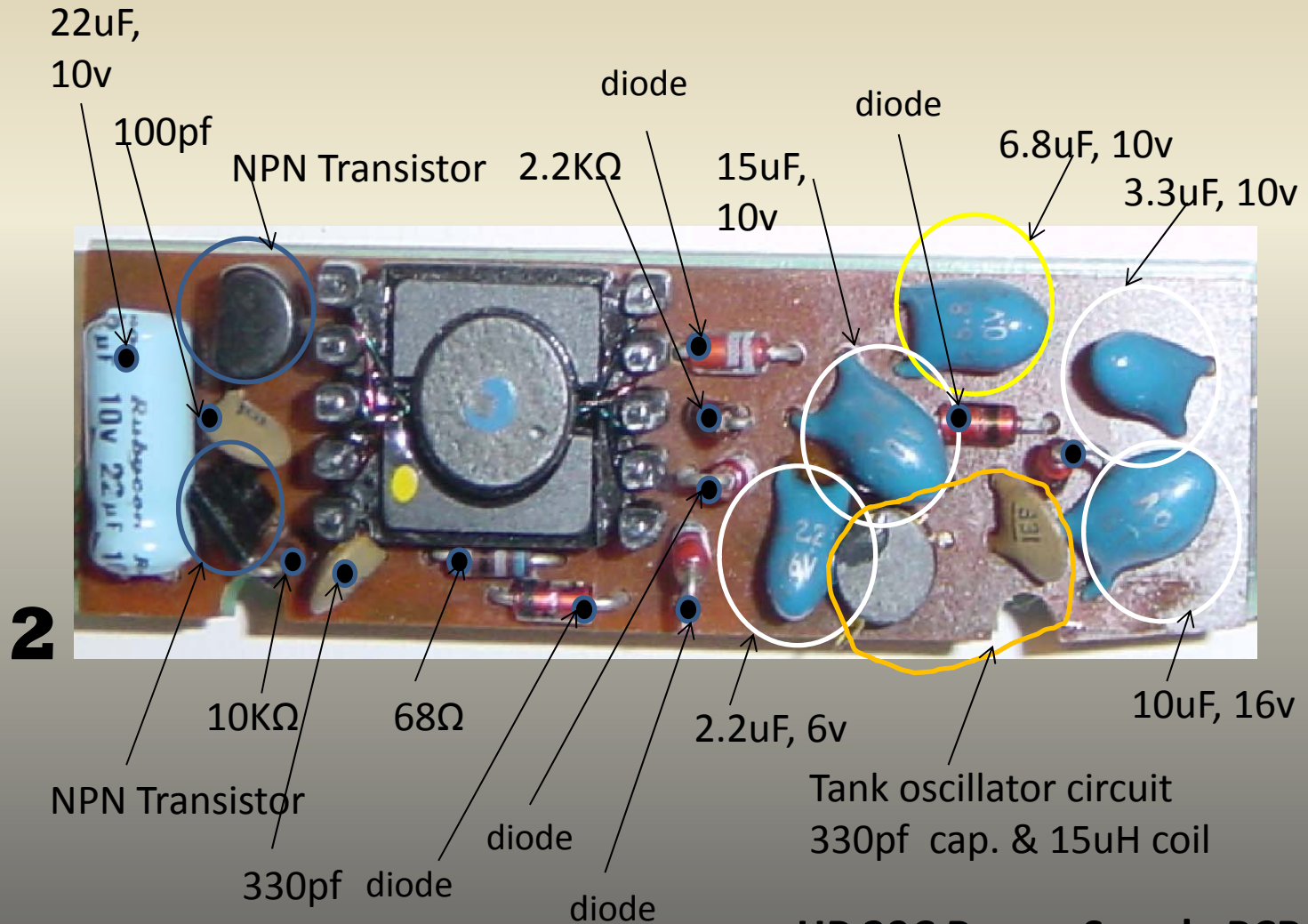
RAM/
ROM IC

POR (Power on Reset),
Battery Low Comparator IC

SN: 1811S20315

RESTORATION of an HP 29C CALCULATOR

Disassembly, Photos, Identification of Integrated Circuits and Power Supply



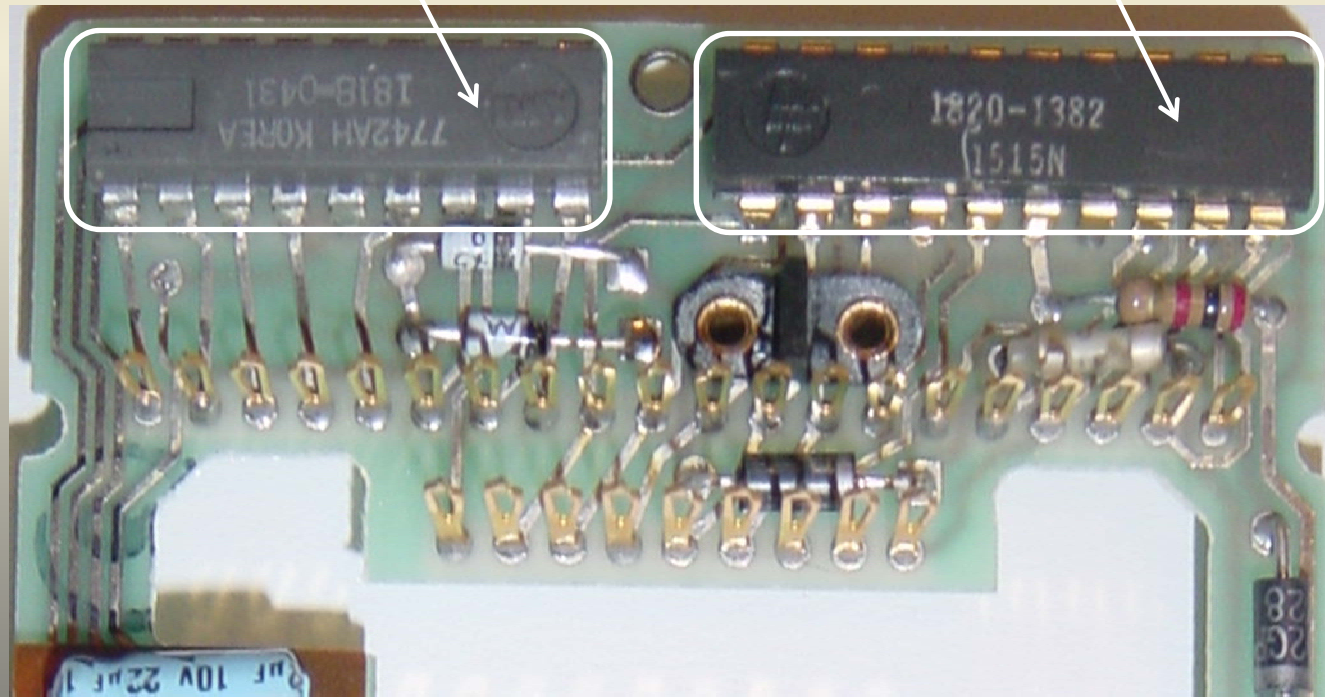
HP 29C Power Supply PCB
(Daughter Board)

RESTORATION of an HP 29C CALCULATOR

Disassembly, Photos, Identification of Integrated Circuits and Power Supply

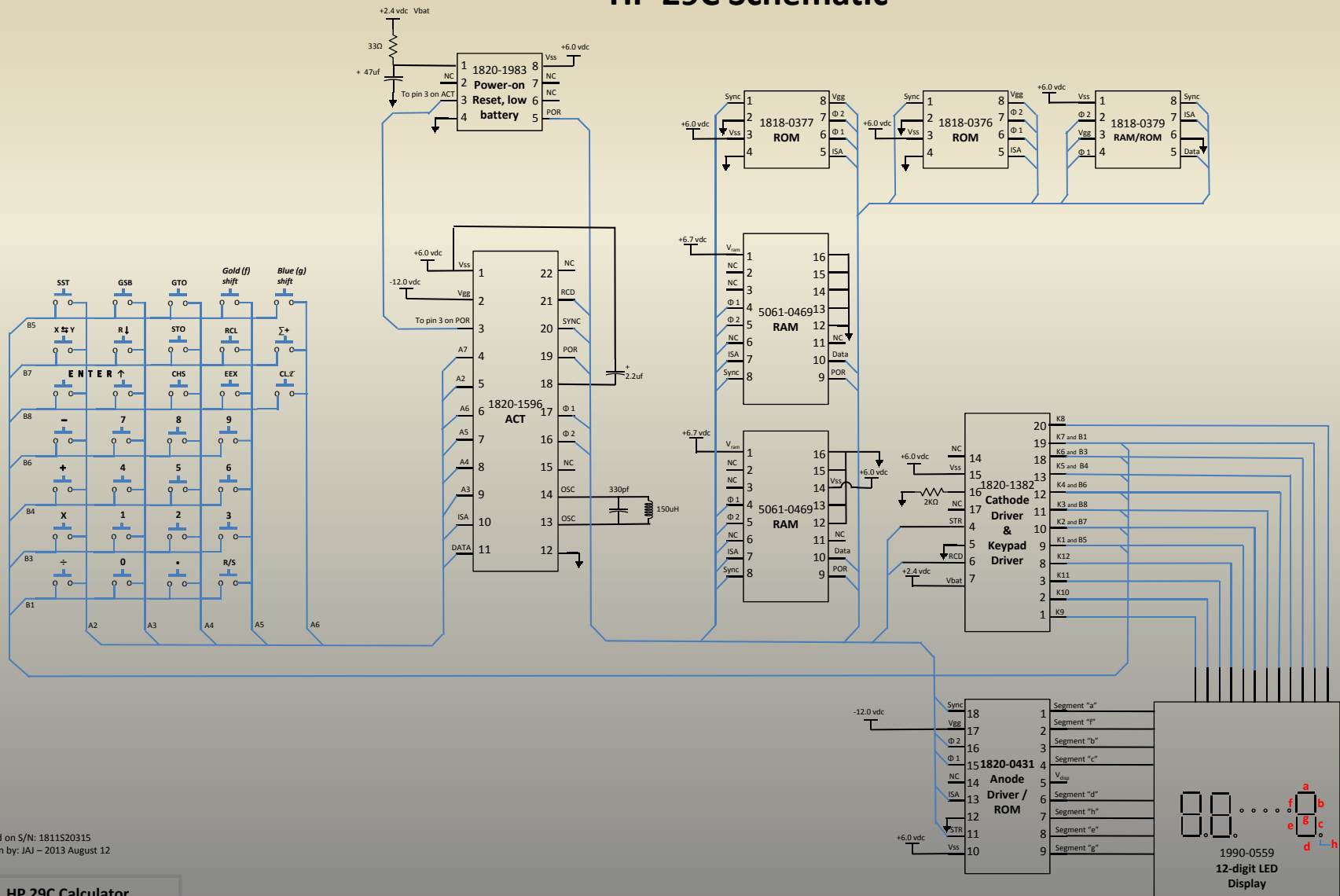
ROM/Anode Driver IC

Cathode Driver IC



RESTORATION of an HP 29C CALCULATOR

HP 29C Schematic



• Based on S/N: 1811S20315
 • drawn by: JAJ – 2013 August 12

HP 29C Calculator
 Hewlett-Packard



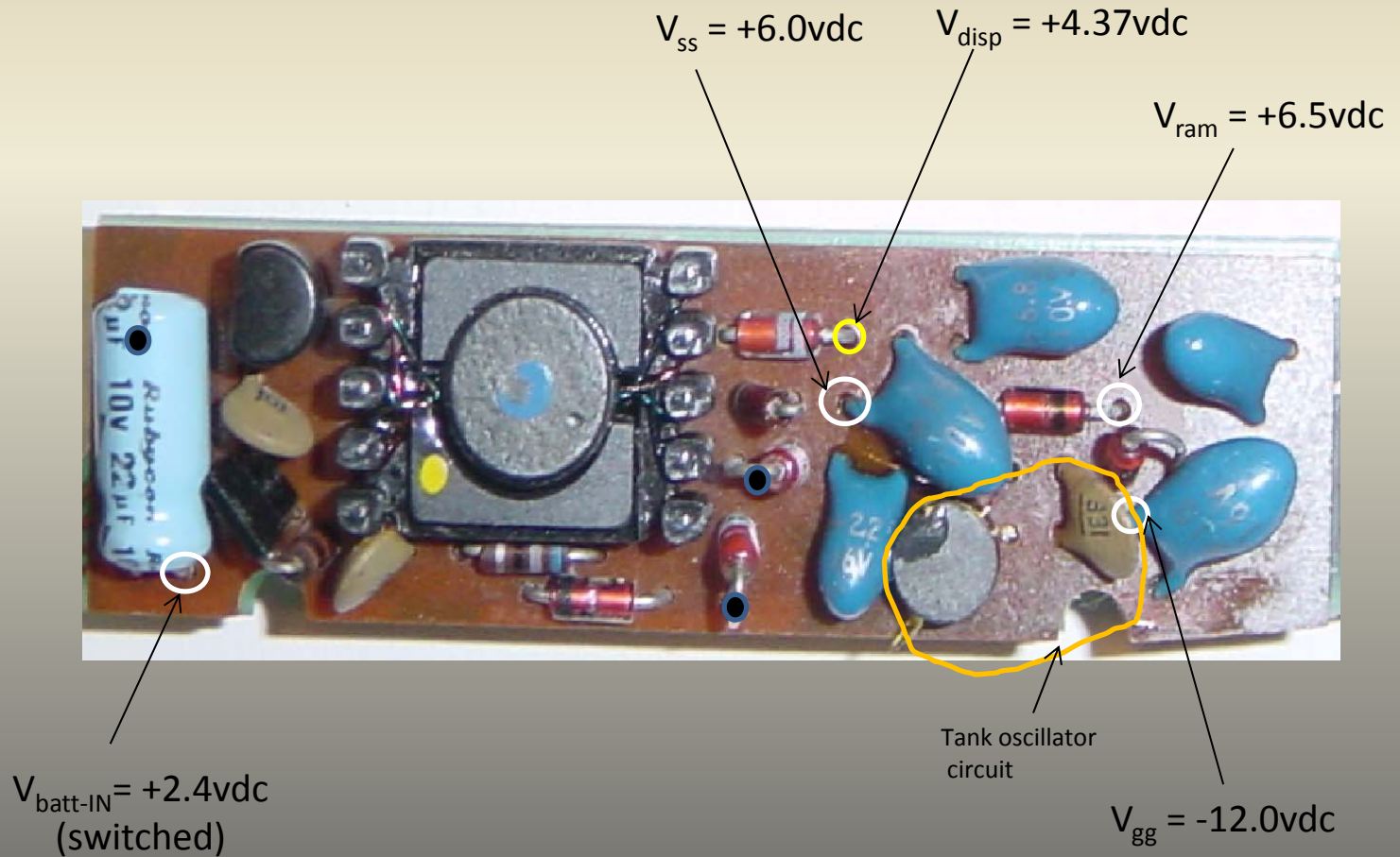
RESTORATION of an HP 29C CALCULATOR

Troubleshooting and Diagnosis

1. Acquired 1st HP29C. After examining the pc board for damage, put in charged battery pack and observed 12 zeroes lighting up on display. No keypad button presses would change the display.
2. Suspected one of the IC's was bad. Measured current of 300-400mA. Much higher current than HP25 and measured HP29C supply voltages. The supply voltages measured lower than normal.
3. Unsoldered all RAM/ROM IC's and applied power observing only one zero lit up in display (far RH digit in display). Suspect Anode/ROM IC.
4. Acquired 2nd HP29C (s/n: 1904S21718) which had no display when powered on. Power supply voltages measured good and the supply current measured good around 200mA.
5. I swapped the Cathode Driver and Anode/ROM Driver from s/n: 1811S20315 into s/n: 1904S21718 (2nd HP29C). No display in second HP29C.
6. Used good HP25 to measure signals on ACT: oscillator, data, I_{sa} , sync, $\phi 1$ and $\phi 2$. I measured same signals from s/n: 1811S20315 and found $\phi 2$ amplitude was low at 9vpp. Suspected the ACT in 1st HP29C may be damaged.
7. Installed low profile IC sockets in HP29C s/n: 1811S20315. Removed ACT from 2nd HP29C and installed into 1st HP29C.

RESTORATION of an HP 29C CALCULATOR

Troubleshooting and Diagnosis
Is the Power Supply Functional?

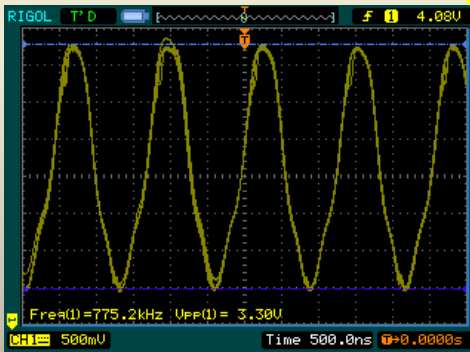


RESTORATION of an HP 29C CALCULATOR

Troubleshooting and Diagnosis

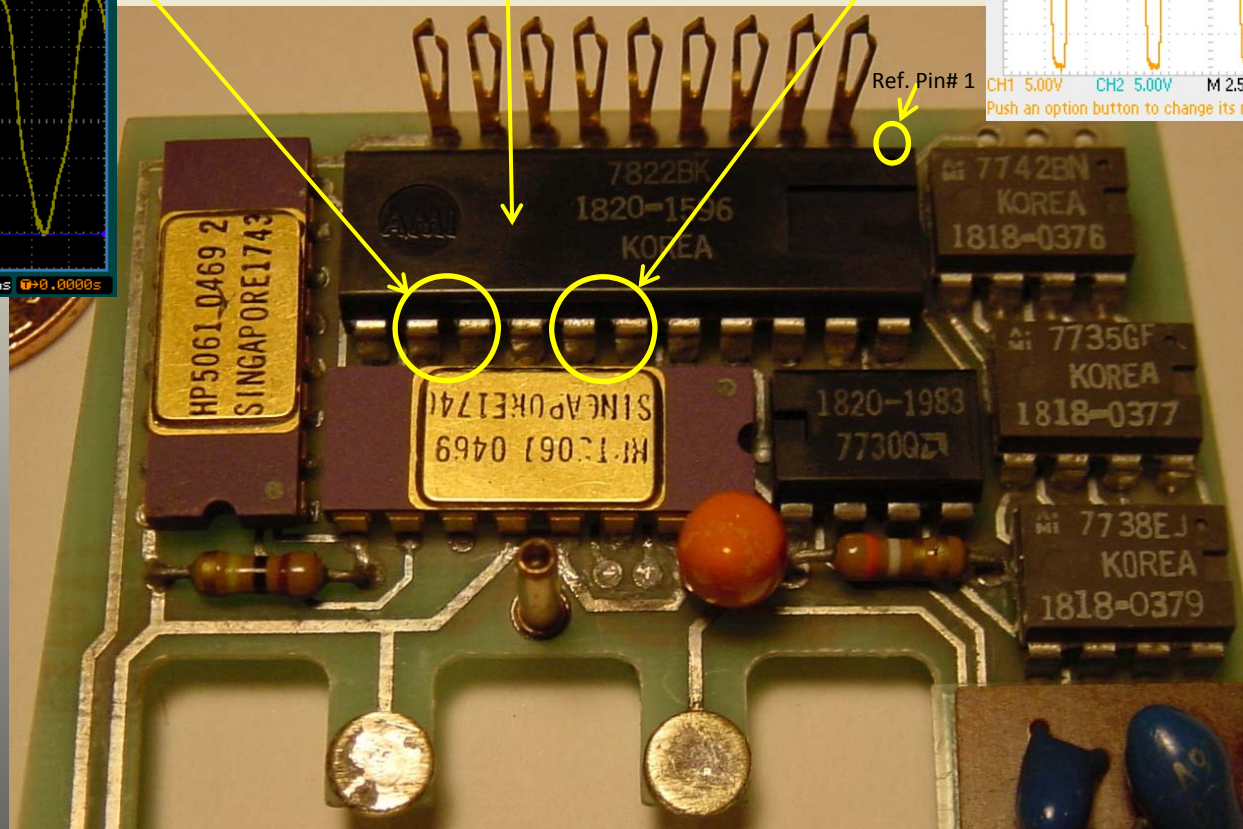
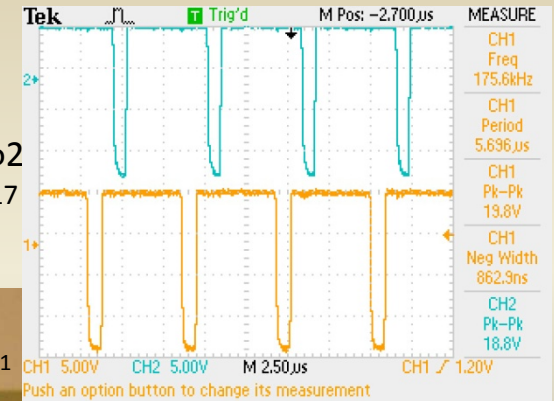
Is the ACT Functional?

Oscillator
Pins 13 & 14



Arithmetic Control & Timing IC (ACT)

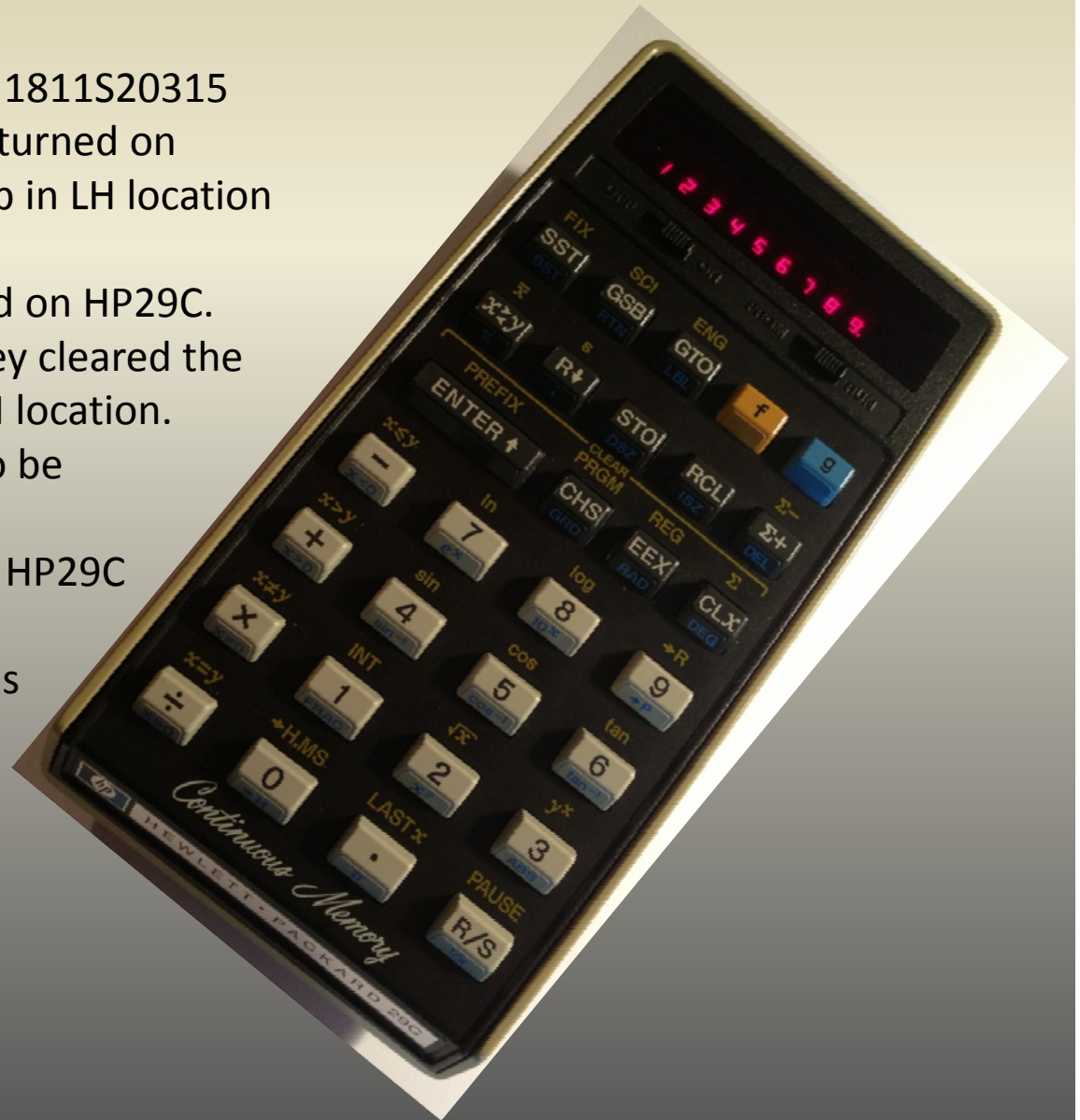
$\phi 1$ and $\phi 2$
Pins 16 & 17



RESTORATION of an HP 29C CALCULATOR

Functioning HP-29C Calculator (SN: 1811S20315)

8. Installed original IC's from s/n: 1811S20315 with ACT from 2nd HP29C and turned on power switch. Single zero lit up in LH location on display.
9. Plugged in RAM IC's and turned on HP29C. Display showed "error". CLX key cleared the display to "0.00" showing in LH location.
10. EUREKA! Calculator seemed to be functional!
11. Continued to test functions on HP29C and tested programming examples in HP29C Applications Book. All functions worked perfectly!



RESTORATION of an HP 29C CALCULATOR Contrast and Compare Past with Present

HP 29C



- 98 program steps (with fully merged keycodes)
- 30 storage registers. (16 were directly or indirectly addressable and the rest were only indirectly addressable.)
- 3 levels of subroutines and 10 labels
- 4 level stack (X, Y, Z, T)
- Indirect storage, recall, branching and subroutine calls
- Execution speed ~ 3,000 instructions/sec.
- Continuous memory
- Rechargeable batteries

Math

$+, -, \times, \div, 1/x, \sqrt{x}, x^2$

LOG x, 10^x , LN x, e^x , y^x , pi

%, INT, ABS

Trig (SIN, COS, TAN)

Modes (degrees, radians, grads)

Statistical

Mean, std. deviation (2 variables)

Summation of n, x, x^2

Summation of n, x, x^2 , y

Summation of n, x, x^2 , y, xy

Summation of n, x, x^2 , y, y^2 , xy

Polar/rectangular conversion

Dec. hrs./hrs.min.sec. conversion

- 928 program steps in RAM
 - 107 global general purpose registers
 - 112 global user flags
 - 6014 program steps in flash memory
 - 30 byte alpha register
 - 16 local flags and 144 local registers
 - 6 (min) levels of subroutines
 - 8 level stack
 - 34 digit decimal accuracy
 - Continuous memory
 - CR2032 (2x) disposable batteries
- #### Math
- $+, -, \times, \div, 1/x, \sqrt{x}, x^2$
- LOG x, 10^x , LN x, e^x , y^x , pi
- %, INT, ABS
- Trig (SIN, COS, TAN)
- Hyperbolic Trig. (SINH, COSH, TANH)
- Modes (degrees, radians, grads, fractional)

Conversions and Constants

88 conversions available

50 fundamental constants

Pre-programmed Functions

HP-42S function set (solver, integration, matrix operations, curve fitting, etc.)

HP-16C function set (Logical operators, floating pt. decimal math)

HP-21S probability function set (Distributions, linear regression, Chi-squared, etc.)

+Euler's Beta and Riemann's Zeta functions, Bernoulli and Fibonacci numbers, +Lambert's W, the error function, and the Chebyshev, Hermite, Laguerre, and Legendre orthogonal polynomials

+ many statistical distributions and their inverses: Poisson, Binomial, Geometric, Cauchy-Lorentz, Exponential, Logistic, Weibull, Lognormal, and Gaussian,

+ programmable sums and products, first and second derivatives, solving quadratic equations for real and complex roots,

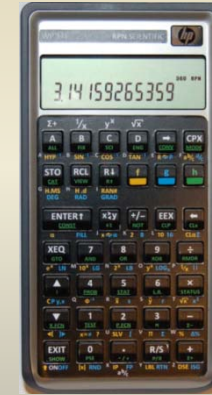
+ testing for primality,

+ integer computing in fifteen bases from binary to hexadecimal,

+ extended date and time operations and a stopwatch3 based on a real-time clock,

+ financial operations such as mean rate of return and margin calculations

WP 34S



RESTORATION of an HP 29C CALCULATOR

Summary and Conclusions

- The goal of this paper was to share HP29C information with the HHC 2013 audience as well as other HP calculator enthusiasts.
- Diagnosis of the HP29C begins with examination of the overall condition of the calculator, disassembling, cleaning and using a known good power source.
- Measure the four power supply voltages in the power supply section.
- Once the power supply voltages are verified good, then you can move on to check the oscillator, $\phi 1$ and $\phi 2$ signals.
- If integrated circuits are damaged, either from battery corrosion or from excess applied voltage, the only alternative is to find a “donor calculator”.
- If ACT IC is damaged; same applies in that you’ll need to find another ACT.
- Finally, the restoration of these fine pieces of history is satisfying and rewarding and keeps part of Hewlett-Packard history alive for future generations.





RESTORATION of an HP 29C CALCULATOR

Acknowledgements

1. Tony Duell (UK) – Information on MoHPC site and email exchange in 2012.
2. Jacques Laporte – HP Calculator Forum (www.jacques-laporte.org/forum) email exchange and the very excellent paper “*The ‘Woodstock’ generation*”.
3. Museum of HP Calculators – (<http://hpmuseum.org>)
4. Geoff Quickfall (Canada) – Email exchange regarding HP calculators, particularly the HP19C.
5. Dave Colver (UK) – Email exchange regarding HP29C schematics.
6. Randy Sloyer – (www.fixthatcalc.com) email exchange in 2012.
7. Eric Smith – Email and posts on MoHPC.
8. Katie Wasserman – email exchange regarding HP29C.



RESTORATION of an HP 29C CALCULATOR

Thank you!





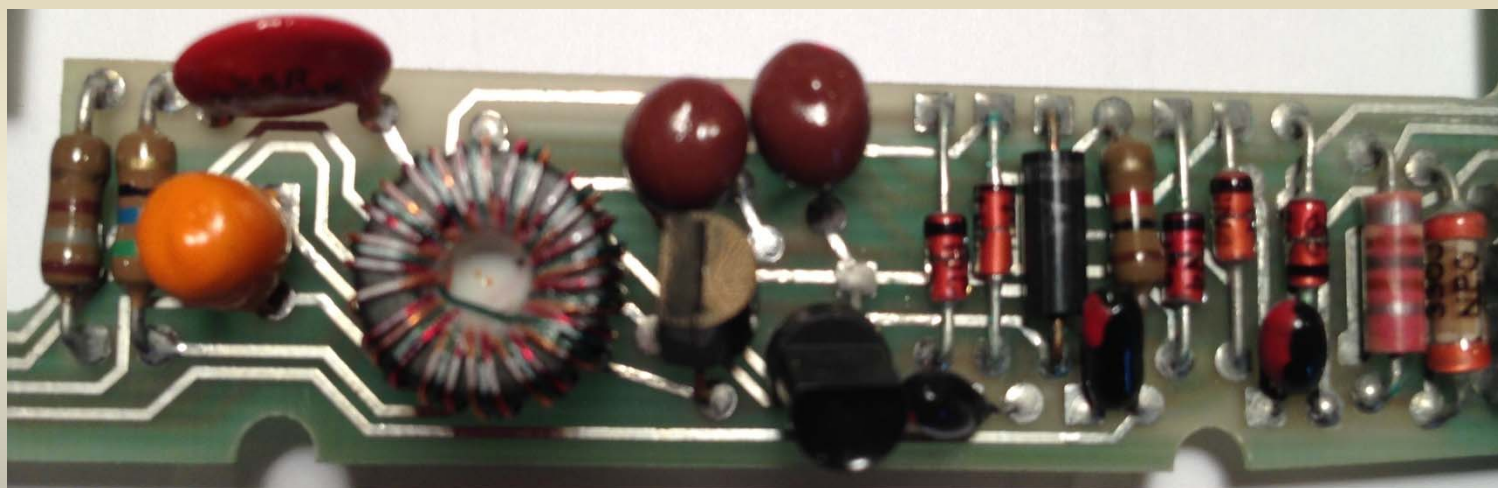
RESTORATION of an HP 29C CALCULATOR

APPENDIX



RESTORATION of an HP 29C CALCULATOR

Additional photos

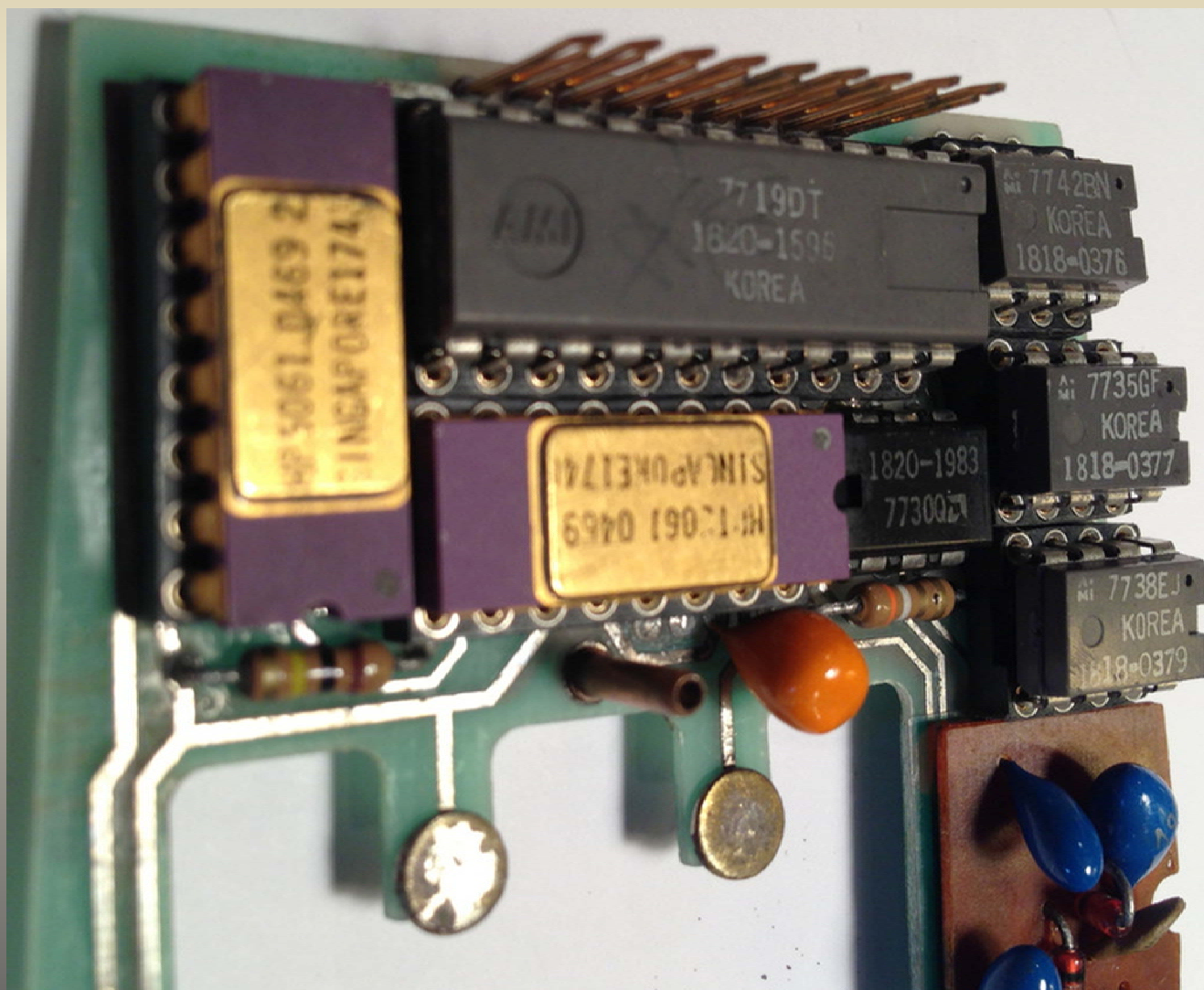


Single level HP 29C Power Supply Integrated into Main PC Board
SN: 1904S21718



RESTORATION of an HP 29C CALCULATOR

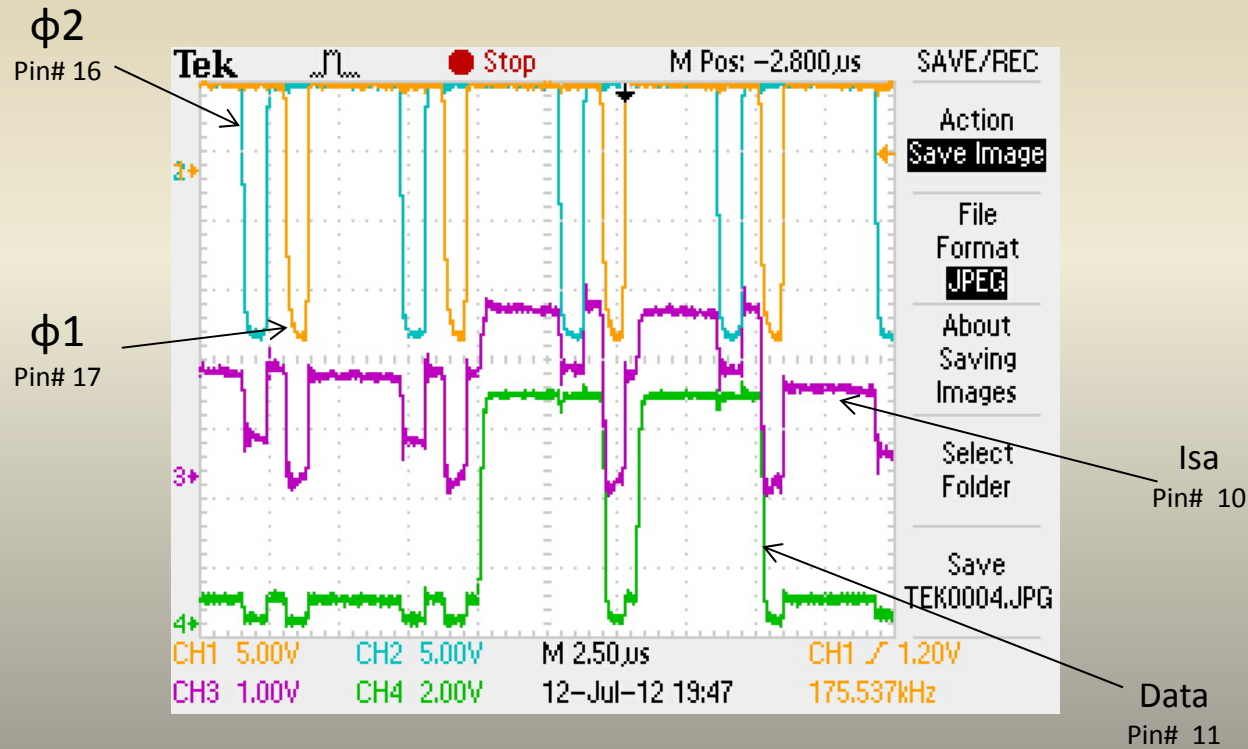
Socketed HP 29C PC Board





RESTORATION of an HP 29C CALCULATOR

Additional Waveforms



HP 25 Calculator Waveforms

$\phi 1$ &
 $\phi 2$

I_{sa} &
 $\phi 1$

Data &
 $\phi 1$

Sync &
 $\phi 2$

Data &
 $\phi 2$

Display

