

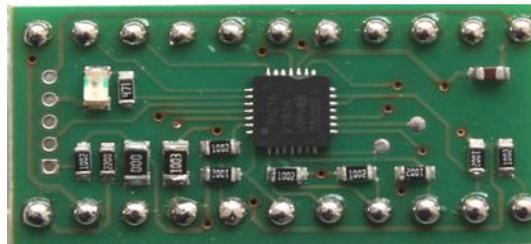
**ACT Repair Kit Manual**

# **The new ACT**

**Arithmetic Control Timing**

**a new generation PMOS/NMOS circuit**

**Repair Kit HP-21A, HP-22A, HP-25A, HP-27A**



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Bernhard Emese , March 2019, Rev. 1.00**



# ACT Repair Kit Manual

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## ACT Manual Revisions

Rev 1.00 March 24th 2019 initial release adapted from ACT Manual Rev. 1.14

Rev 1.01 HP-29A removed because not enough SRAM

## ACT Repair Kit Manual

### Introduction

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Congratulations! You are about to repair your Woodstock calculator with the new HP-25A (Advanced) ACT circuit. For convenience I will use in this manual the name HP-25A even though the circuit can contain other Woodstock firmware like HP-21A or HP-27A, because the most common Woodstock calculator is the HP-25. The HP-25A is the smaller brother of the HP-25E (Extended) ACT circuit. It has no additional key sequences and only a few extras. The reason is a smaller processor with less memory. Its reduced price may let you think about just restoring your calculator instead of upgrading it.

As you might already know, ACT is the abbreviation for „Arithmetic Control Timing“. This chip was used throughout the second generation of HP calculators, the “Woodstocks”, like the HP-21, HP-22, HP-25, HP25C, HP-27, HP-19C/HP-29C, and later in HP-67, HP-91 and HP-97 as well. Hence Hewlett-Packard was very innovative at that times, the models differ significantly, even more inside, than can be assumed from the outside. There were two major changes made in silicon techniques between the first and the last models, starting with PMOS (P-channel Metal Oxide Semiconductor). The PMOS design of the HP-21, HP-22, HP-25 used P-doped silicon, the signal levels were different to our modern mainly N-doped silicon chips, they used negative voltages for signals and the threshold voltages were above the normal TTL logic levels. With the advent of the HP-25C, another technique came into life: CMOS (Complementary Metal Oxide Semiconductor). Although the rest of the circuit remained PMOS, the RAM chips were made of the new CMOS material. Soon came another change, introduced with the HP-27 hardware, HP used NMOS (N-channel Metal Oxide Semiconductor) silicon, which needs the more common voltages that we use in our modern circuits, however today with lower voltages.



The new ACT HP-25A does work well in all HP-21, HP-22, HP-25, HP-25C, HP-27 calculators.

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### Contributions

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Undoubtedly, the “*new ACT*” could not have been built without the previous work of *Eric Smith*. He wrote the first ACT emulator „nonpareil“ for HP calculators and put it into the public domain.

Emulators try to imitate to perform exactly the same as the original ACT chip did. They execute the original program of the calculator and show the results on the screen, the “*new ACT*” is such an emulator. It is based on *Eric's* pioneer work, although it must do some very tricky additional tasks in real time, to establish communication with the other components inside, and maintains a stable keyboard scan and display timing, which was never done before.

Many, many thanks and appreciation to *Eric Smith* for his really great pioneer work!

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### The idea of the “HP-25A”

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There was never the intention to reduce the functionality of the existing HP-25E ACT circuit. It happened as a pure accident.

In 2018 I had to change the manufacturer of the ACT boards after I was kicked out unfriendly from the customer list of the previous manufacturer, mainly because there was not enough profit for him. In 2019 I found a new friendly manufacturer and ordered a batch of 48 ACTs, paying all the one time cost a second time, and had to send him the manufacturer files including the bill of materials for assembly. I don't know how exactly it happened, but I send him an old one with the wrong processor listed. When I received the boards I detected my error to my greatest horror. I immediately spoke with the manufacturer and asked him what to do. Soon I had to recognize, that there was no way of replacing the processor, but only to make a new batch of boards, this time with a carefully edited bill of materials.

The incorrectly assembled PIC16F1516 processor has only half the flash memory and half of RAM of the larger PIC16F1518. And as I squeezed the firmware already as much as I could for the larger processor, there was no way that the firmware would fit. Clearly it was my fault. But should I throw away the boards? Why not program these boards with a reduced firmware, which could fit into the half sized flash memory? Why not sell them for the manufacturer price? The idea of the “Low cost HP-25A new ACT” was born, I don't know whether it is a good idea or not, but anyway.

I tried to strip all extras to a minimum, at least to restore the original functionality of the woodstock calculators. When I removed the additional HP25 100 user programs, which were be stored in flash memory, I could save a lot of program space. And indeed, I needed two days for removing carefully all unnecessary functions and took all precautions not to produce any errors in the new firmware from the hand crafted HP-25E firmware. I compiled different versions for all calculator models, even for the SPICE models the CLASSICS and the HP-67 running on a Woodstock calculator. Some of them like HP-29C, HP-34C and HP-67 did not fit, even when reduced to the pure emulator code. But for most of the Woodstock calculators all went well.

[Especially for the non programmable models HP-21,HP-22 and HP-27, which just need a repair but no extras, this low cost alternative could be a good idea.](#)

This is the honest story, which lead to the idea of the “HP-25A”.

[I hope it was worth the effort when the new ACT can restore the charming 0.00 LED digits to appear again after a successful repair.](#)

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### The Repair Set

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The repair set consists of the “new ACT” circuit, this manual as .pdf, some solder, a piece of copper mesh wire and two ultra low profile socket strips.

Unlike the HP-25E it does not contain a laminated Quick Guide, because there are no additional key sequences available.

### Replacement and Preparations

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The chapters “Preplacement” and “Preparations” are identical to the corresponding chapters in the new ACT Manual. Please read the chapter there.

#### Disclaimer:

When using these instructions for repairing your calculator, or in any other case of using the new ACT for any purpose, you are aware, that you alone have the responsibility. Due to the limited availability of vintage calculators and their versatility, PANAMATIK was not able to predict any possible circumstances, which may occur. Therefore it does NOT take responsibility for any damage that can occur directly or indirectly from using these instructions or using the new ACT. We assure, that we tried to take care and took any precautions to provide you with all the information required for a successfully repair. Proceed only if you agree with these terms.

PANAMATIK

## ACT Repair Kit Manual

### Features

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If you purchased the “new ACT” HP-25A repair kit, it will restore your complete calculator with all its original functions. Other than the HP-25E it has no additional key sequences. It is like the original and you can hardly distinguish it.

But there are at least a few extras, which didn't need much program space.

#### 1.) *Continuous Memory*

Like the HP-25E the HP-25A has continuous memory, because your actual program and registers are saved into Flash memory. Even after removing the batteries, the program will remain stored. With the ACT replacement you transform your HP-25 automatically into an HP-25C.

Please note, that the behaviour will be slightly different, because “*Continuous Memory*” will be stored in Flash Memory instead of battery buffered RAM. The original CMOS RAM will not be used. Flash Memory will be updated, whenever the PRGM/RUN  switch is moved, either back to RUN mode or to PRGM mode. The disadvantage is, if you switch off the calculator before you saved the memory, the last few entries will be lost. The advantage is, that memory is kept even when batteries are removed. If you want to be sure, that the registers and your program will be saved in “*Continuous Memory*”, just switch the PRGM/RUN switch to the other side before you switch off your calculator .

#### 2.) *Continuous Stack*

In case of the HP-25E the four stack registers, display mode and trigonometric mode will be saved in flash memory too when you move the PRGM/RUN switch before switching OFF. When you switch ON again, you will see the last used X-register in the display, and the stack contents when rolling the stack.

#### 3.) *Power Up Keys*

Some features can be invoked and flags can be individually enabled/disabled by holding down specific keys at power up. The keys are described in detail later.

#### 4.) *Toggle Flags*

There are ten flags, which can be individually set or reset by the power up keys. Whenever you press the buttons 0-9 at power up one of the flags are toggled and if set it enables a specific feature.

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### List of Power Up Keys

Eleven features can be invoked or individually enabled/disabled by pressing one of the following keys at power up.

Key	Function
	Show revision and serial number
	Toggle „Standby Mode“ flag
	Toggle „Show Logo“ flag
	Toggle „Battery Check“ flag
	Toggle „Annunciators“ flag
	Toggle „Repeat Key“ flag
	Toggle „Fast/Slow Mode“ flag
	Toggle “Flicker suppression” flag
	Show LED Test
	Toggle „Original Mode“
	Toggle „HP-21 Hardware“ flag HP-25: set, HP-21: reset
	HP-25: reset if the flag was set accidentally
	HP-21: set if the flag was not set before.

When changing one of the Toggle Flags 0-9 the actual state of the flags are shown.

Flags 5,6,9 are reserved for future use.

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### 1.) Revision and Serial Number

If you press  at power up you will get displayed the revision and serial number of your ACT.



r 1.00 Sr 0001

The firmware revision number is shown at the left as “r 1.00” for example, on the right appears the serial number, “Sr 0001” in this case. This display is shown until you press any key.

### 2.) Standby Mode

This flag will activate or deactivate sleep mode. Sleep mode will be entered after one minute without key entry and saves up to 80 mA.

It cannot be compared to modern standby modes, where you can leave the batteries in your machine for years before you have to replace them, because the calculator needs only microamps to run a LCD display. The old LED technique draws much more current from the batteries, normally the Woodstock calculators need between 120 to 180 mA at 2.5 Volts, depending on how many digits are shown. With modern 2500 mA accumulator cells, this will be enough for 10-15 hours. But the standby mode helps you to get one third more battery lifetime, just by reducing the number of displayed segments after one minute without keyboard activity.

There will be shown only one decimal point moving slowly from the left to the right side of the display, signalling that the calculator is still switched on and waiting for input. As soon as you press a button, the display will show its previous contents regardless which button you choose.



Standby mode is toggled by pressing  at power up.

### 3.) HP Logo

You can show or hide this feature by pressing the  button at power up.



HP-25A

If you switch on the calculator, its name „HP-25A“ or „HP-21A“ etc. will show up until you press any key. This is not the original behaviour of a woodstock. You can show this to your friends as evidence, that you really have a “new ACT” chip inside, because the original ACT always came up with „0.00“ in the display.

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### 4.) *Battery check*

Switching on/off this flag can be used to allow/suppress HPs low battery indicator: inverted decimals points. If your calculator has a battery detection, that shows too often low battery, then you can switch off "Battery check". However you will not be warned, when the battery is going to get empty.

Use  Power Up Key to toggle this flag.

### 5.) *Annunciators*

Shows annunciators for current trigonometric mode and prefix keys. There was always a lack of knowing which trigonometric mode is active at the moment and whether a prefix key is pending. This is accomplished now by annunciators in the display.

#### *Trigonometric mode*

There are three trigonometric modes, DEG, RAD, GRD. But you couldn't see which of them are currently selected. Now you can activate the annunciator display. If RAD trigonometric mode is selected, you will always see a decimal point at the far right. If GRD is selected, the decimal point will be shown at the second digit from the right. The most convenient DEG mode, where a full circle is measured in 360 Degrees, doesn't show any dot, so most of the time you will see the usual display with a number and its regular decimal point. This annunciator is shown only in RUN mode.

#### *Prefix key*

The second annunciator will be shown at the far left of the display. It shows whether a prefix button was pressed and waits for completion of its key sequence. All prefixes were combined in one dot at the leftmost digit, where the minus sign is shown.

Use  Power Up Key to toggle this flag.

### 6.) *Repeat Keys*

Press and hold the  key at power up to enable/display the repeat functionality. There are six keys, that have an automatic repeat function when hold down.

The  key can be hold down to show the X and Y registers, and the  button displays all four stack registers with only one keystroke.

In PRGM mode using the  and  buttons steps forward or backward in the program. Just keep it pressed and the program steps will increment or decrement automatically, you do not need to press the buttons many times.

Also the  and  keys have auto repeat functionality in RUN mode. If you fill the stack with a constant and hold down these keys you can calculate the continuous sum or

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the growth of a value.

### 7.) *Slow/Fast Speed*

Press and hold the  key at power up to toggle between slow and fast speed mode.

The emulator, which executes the original HP Code is written in pure assembler code. You will benefit from this optimizing by a very fast execution speed. As the emulator can run about four times faster than the original, you will see a big difference when running programs with trigonometric functions. Please note, that when a PAUSE instruction is executed in Fast mode, it will be slowed down automatically within the pause, otherwise you would not have enough time to read the result in the display.

### 8.) *Flicker Supression*

When this flag is set by the  Power Up Key, a running program is executed without the characteristic original flickering display and calculated intermediate results remain stable until the next value is shown. This feature offers a new dimension of glancing at your calculator. Whenever a program is started the HP-25 showed the characteristic flickering display, that indicated a running program. This could be charming, but can also be a pain, when you are waiting for periodic results with the PAUSE instruction, which are shown only for one second; the result vanishes too early and your eyes were filled with the flickering segments and you try to remember what you just have seen.

You have the choice of getting your result displayed steadily until the next result is calculated. There is no flickering display any more, only a small dot is blinking at the right, indicating that the program is still running. During a PAUSE instruction the dot stops blinking for one second, then starts again.

### 9.) *HP-21 Hardware*

This flag must be set, when the new ACT is used in an HP-21 board. The keyboard lines of the HP-21 hardware are different to the HP-22,HP-25,HP-27,HP-29C boards. If you use an HP-21 board for the new ACT you have to tell the software the board type. The keyboard lines are automatically rotated and keyboard entry will work as expected.

Normally the flag is changed by the  key. But be aware, that also the Power Up keys are rotated if the this flag is set incorrently. If the „HP-21 Hardware flag“ is accidentally set in an HP-25 hardware, you will see that button  enters the digit „2“, then you have to press  at power up to clear this flag. If on the other hand you encounter that pressing  enters the digit „1“ on HP-21 hardware, then the HP-21 Hardware flag is not set and you have to press  at power up to set the flag.

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### 10.) Original mode

With this key you toggle between “Original Mode” and “Normal Mode”. In Original Mode the calculator behaves like the original and has no additional features. Be aware, that all other power up keys are inactive in “Original Mode”. You have to press  again to get back to “Normal Mode”.

If you are a purist and don't like the new features, you can switch off all features and the calculator will behave as far as possible like the original.

Whenever you don't want to see the additional features, which were not part of your original calculator, like sleep mode or showing a logo at start up, you can switch your calculator to this mode, which is as close as possible to the original calculator. Original mode is toggled by holding the  key pressed at power up.

### 11.) LED Test



After invoking the LED Test function with the  Power Up Key, all segments of all digits will be displayed, showing the digits “8.8.8.8.8.8.8.8.8.8.8.”, including their decimal points. If the same segment of all digits is not showing up, this is a contact problem with the display connector, you have to open the calculator and check the display connector, whether it has good contacts. Then, normally it will work again. If there is missing only one segment of only *one* digit, this is a more severe problem inside the segment module, and cannot be repaired easily.

### 12.) Toggle Flags

If you press any toggle key at power up the display shows the actual state of the flags as numbers in the display. There are ten flags displayed, which were represented by ten numbers preceded by the letter “F” at the far left<sup>1</sup>. The displayed numbers show flags 0-9 when they are set. In the example below Flags 0 1 2 7 9 are set, 3 4 5 6 and 8 are not set.



<sup>1</sup> HP-21 shows H for High instead, because letter F is not available.

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### HP-25A vs. HP-25E

The HP-25A emulates the original ROM code always from its internal ROM inside the PIC processor. There is no access to the external HP ROM chips, which would not very useful anyway, in case they were damaged too.

There is still a bootloader present, which could be used for firmware updates.

There are no additional key sequences. The only keys are the Power Up Keys.

There is no extra memory space to store more programs than the single 49 steps user program (or 98 steps in case of HP-29C). There are no constants and extra register sets.

There is no welcome string except the HP Logo.

There is no right justified number entry.

There is no stopwatch feature.

There is no decimal to hexadecimal conversion

There is no HP-82240 Infrared printer functionality

There is no GPS module to be connected.

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### Appendix B

#### 1.) ACT Pinout

Pin	Name	Description	Pin	Name	Description
1	VSS	positive power supply 6,4Volt	22	n.c	
2	VGG	negative power supply -12Volt	21	RCD	Reset Counter Display
3	Batt	Battery Low indicator	20	SYNC	Synchronisation signal
4	PRGM /RUN	Program/Run switch	19	n.c	
5	Col5	Keyboard column 5 (1 HP-25)	18	POR	Power On Reset
6	Col4	Keyboard column 4 (5 HP-25)	17	Phi1	Bus clock one
7	Col3	Keyboard column 3 (4 HP-25)	16	Phi2	Bus clock two
8	Col2	Keyboard column 2 (3 HP-25)	15	n.c	
9	Col1	Keyboard column 1 (2 HP-25)	14	OSC	720 kHz Oscillator
10	ISA	Main Communication line	13	OSC	720 kHz Oscillator
11	DATA	Data Communication line	12	GND	Ground 0 Volt, negative battery

If you measure while the new ACT is running, you should measure the above DC Voltages at Pins 1,2, and 12. You should measure about 3,2 kHz at pin 20 SYNC and 180kHz on either Phi 1 and Phi 2. Pins13/14 are not used. You should measure 720 kHz only with the original ACT on both pins. POR must be low level.

The keyboard columns are rotated in HP-22/25/27/29 hardware

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## 2.) ACT Schematic

