

Woodstock Low Power Manual

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Manual Revisions

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Rev 1.05 june 2022 added 7-segment alphabet

Bernhard Emese, december 2017-2022 (c)



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Introduction

The “Woodstock Low Power” circuit is a replacement of the electronics for your vintage Hewlett Packard “Woodstock” calculator like HP-21/HP-25. It takes over all functions and adds new ones. Like its older brother, the “new ACT” circuit, it can repair your HP calculator in case the electronics should be damaged. But it is not meant to replace the “new ACT”, its main purpose is to give you the freedom of low current consumption and preserving your registers and the calculation state at any time.

You don't have to switch off your LED calculator any more to save batteries.

For converting your HP calculator into the LP version you normally just remove the two display driver chips, which are located below the LED display. Then you can place the new circuit inside. You don't have to unsolder all components from the original board, but you can if you like. While none of the old components are needed any longer, any repair will be possible. And as an unexpected bonus, the calculator will not longer surge battery power because the old switching power supply is disconnected. This unique feature gives the circuit its deserved name “Woodstock Low Power”.



The “Woodstock Low Power” circuit applies to HP-21, HP-22, HP-25, HP-25C, HP-27 and HP-29C calculators.

Contributions

Undoubtedly, the “*Woodstock Low Power*” like the “*new ACT*” could not have been built without the previous work of *Eric Smith*, who, over many years, explored these calculators and found out how they worked, he collected precious knowledge about ROMs, RAMs and the processor instruction set. Thus he wrote the first ACT emulator „nonpareil“ for HP calculators and put it into the public domain.

Emulators try to imitate the original chip as exactly as possible. They execute the original program of the calculator and show the results on the screen. The “*Woodstock Low Power*” is such an emulator. Although it has done many steps forward and invented some new ideas, it still has to be mentioned, that it stands on the shoulders of *Eric's* first emulator.

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

There are many others to mention and give thanks, that have made previous reengineering research, which was helpful in understanding all these undocumented things. I want to mention another name, late *Jaques Laporte*, who gave his excellent website with hardware, firmware and mathematics analysis of the “Classic” and the “Woodstock” calculators to the public.

Of course, I shouldn't forget to mention the “*Museum of HP Calculators*” as the central source of anything related to HP calculators. If you want to find something about HP calculators, you will find it here. Possibly you also found the “*Woodstock Low Power*” and the “*new ACT*” somewhere here.

Many thanks also to Hans-Peter Bieger

All photos in this manual are shot by his DSLR camera, which he sent me liberally for this purpose, because I gave mine to my son for a whole year trip through Australia.

Woodstock Low Power

Sometimes scientists speak about a quantum leap they have made. Although a quantum leap literally could be no more than a picometer which is a very small distance within an atom, it is the synonym for a very big progress with a single step. This is true because the quantum leap is the only step that can't be made in smaller steps.

With the introduction of the „Woodstock Low Power“ circuit such a quantum leap has been made. It shows that a new hardware can provide unexpected new features that even the best software enhancements alone could never achieve. The „Woodstock Low Power“ circuit replaces the „new ACT“ in many ways but hopefully doesn't make it obsolete. It is just a new approach for upgrading your „Woodstock“ calculator rather than just repairing it. The „new ACT“ repair is surely easier to handle, the LP circuit is more difficult to place inside the calculator because you have to remove more chips from the PCB instead of just replacing the ACT. And you have to solder additional small wires which lead from the display to the keyboard part of the calculator.

Which were the main goals of the LP version?

The „Woodstock LP“ circuit is a result of the idea to repair even those „Woodstock“ calculators which do not have a defective ACT but damaged display driver chips or both, or a non functioning power supply. Although it turned out that there were not many of them in the past, finally there are still a few out there and they also deserve a new life like any other Woodstock calculator.

Another goal was to overcome the alphanumeric limits of the old HP display drivers, which could only display numbers and five letters which in addition changed between the models and made it difficult to use the „new ACT“ in different calculators. This led to a circuit which is placed at the top side of the HP calculator because it should drive the many pins of the LED display which are located here.



The „Woodstock Low Power“ circuit

Suddenly this concept became even more remarkable. Because no more PMOS chips are needed also the two voltages 6,4V and -12V were obsolete, the complete switching power supply was needless now. The circuit could be run directly from the battery voltage.

And last but not least by developing a new circuit, there was the opportunity to add some new hardware and give it more flash memory. In the above image you can see from left to right 512kByte flash memory, the PIC processor and the two LED drivers.

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Which are the new features of the LP version?

There are many new features, but I have to mention, that also all features of the previous „new ACT“ chip are included.

Low Power

First it is a “Low Power“ version, which is the heart of the quantum leap. The calculator needs only 2-20 mA, when the display is on, compared to 110-180 mA of the original, and only microamps when the display is off. Equipped with two AA batteries the calculator will last for more than 100 hours while calculating and for years when in sleep mode. Furthermore, the processor register state is always saved. The calculator can be left ON all the time. What a crazy idea with a battery hungry LED calculator, you might think? No, not at all, because the 40 year old switching power supply, which had a lousy efficiency and was wasting the main part of power consumption, is not longer there, there is plenty of battery capacity left, more than we are used to have in our modern smart phones. To save even more power, after one minute without key press, it automatically enters sleep mode and consumes no more measurable current until a key press wakes it up again.

Real Time Clock

Next it contains a RTC chip, which will create a calculator with an integrated watch. It provides accurate time, date and alarm time. Also a piezo buzzer is attached for ringing the alarm. You can use the HP-25 LP to wake you up every morning, it is the first ever red LED calculator with integrated sound.

Number three: the stopwatch is controlled by the RTC and hence very accurate, it can count upwards, downwards and you can enter values via keyboard. It can be used as a countdown counter, which gives alarm when it reaches zero. There is no need for a calibration procedure any more. And it counts on even when in sleep mode.

Alphanumeric display

Now we arrive at the visible part, the eyes of the quantum leap. The „Woodstock Low Power“ display has full alphanumeric capabilities. It can show any text in the LED display and is no longer limited by the display driver chips, because they are completely removed. The LP circuit has taken over the display and it can control each segment independently. This leads to the remarkable new feature: you can read your programs in plain text instead of looking at the cryptic keyboard row column code. This really changes your HP-25/HP-29 calculator a lot. Your debugging and stepping through the program becomes much easier and it is a joy to read the mnemonics of each possible program step. It works within PRGM

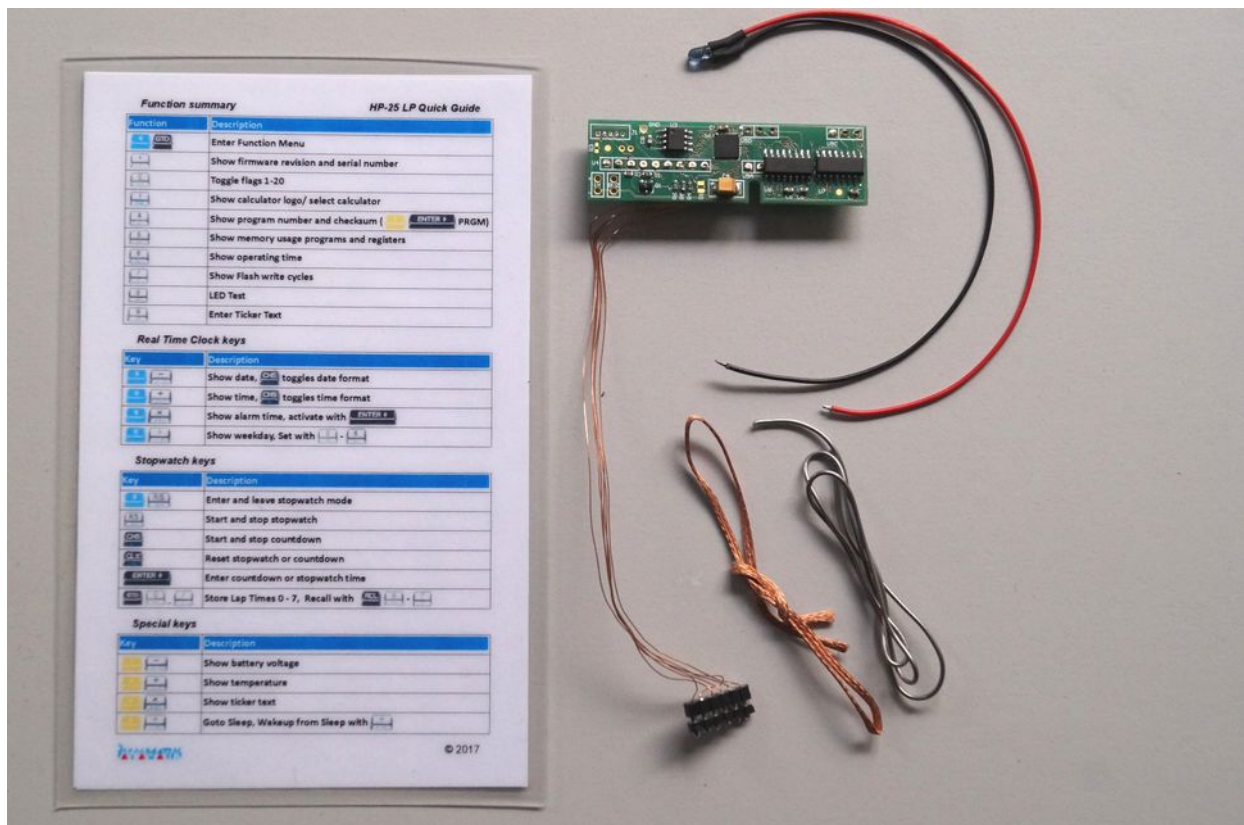
mode, and also in RUN mode when    are held down.

512kB Flash Memory

And last but not least there is a new big brain as part of the quantum leap. The Flash ROM memory has 512 kByte capacity, compared to 2k ROM of the original HP-25, or four thousand times more capacity if you would use it exclusively for storing HP-25 programs. But its size makes it possible to contain all Woodstock calculators in one, and the classics and the spice calculators, too. You can switch between these calculators whenever you want, because the emulator can run each of them.

The Low Power Upgrade kit

The upgrade repair kit consists of the “Woodstock Low Power” circuit, this manual as .pdf, a laminated Quick Guide card, some solder, a piece of copper mesh wire and ultra low profile socket strips already attached to the circuit. Also the IR diode and the piezo beeper is included. The additional connector leads to the keyboard at the bottom side of the calculator.



The new “Woodstock Low Power” goes a big step further in repairing your valuable vintage calculator than the “new ACT” did. It does not just replace the ACT chip, but replaces the complete calculator electronics. It even bypasses the internal power supply and the display driver chips and drives the LED display and keyboard directly. It should be called “The Total Repair Kit”, but I decided to name it after its outstanding main feature: the “Low Power” consumption.

With this kit all “Woodstock” calculators HP-21/22/25/25C/27/29C can be repaired¹, even if all components should be damaged or removed (even if your LED display has missing segments you can replace it by a PANAMATIK HP-25 display, as long as stock will be available). The power consumption is only a tenth of the original calculator and if you include the sleep mode, it doesn't consume power at all. Only 2-20 mA are used to drive the display, compared to 110-180 mA of the original. With modern AA batteries and 2500 mAh capacity you can run your calculator for 250-1000 hours without charging. Furthermore the calculator goes into sleep mode, whenever time passes without keystrokes or when you switch it OFF.

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Interestingly, even if you switch off the calculator, it is still running but consumes only 100 uA in sleep mode. Thus all data registers and the stack and display modes are kept for the next switch ON. It is like in modern LCD calculators. You will never need to switch off your calculator, it will instead be put into sleep mode after one minute. And you just press any key and the calculator's display is lighting up again, showing the previous contents.

With this feature the new circuit has the right to be called "Woodstock Low Power".

But this is not the only new feature. The Low Power circuit contains a Real Time Clock with Time, Date, Alarm and Stopwatch. This ± 3 ppm accurate RTC runs all the year and keeps the time and date as long as you have a battery inserted.

The time, date and stopwatch can be displayed even while your program is running. The stopwatch can be used to measure program run times or something else.

The alarm time can be programmed to set an alarm and an internal buzzer will wake you up, when the time matches the alarm time. Never before existed a LED calculator with an alarm buzzer.

Following the description of replacing the ACT there is a chapter how to install the "Woodstock Low Power" circuit into your calculator and another chapter describes its remarkable new features.

¹ As the name tells, the "Woodstock Low Power" kit cannot be used in an HP-67 calculator, but it can emulate the HP-67 firmware on a Woodstock calculator.

Disclaimer:

When using these instructions for upgrading or repairing your calculator, or in any other case of using the "Woodstock Low Power" circuit 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 we do NOT take responsibility for any damage that can occur directly or indirectly from using these instructions or using the new "Woodstock Low Power" circuit. 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

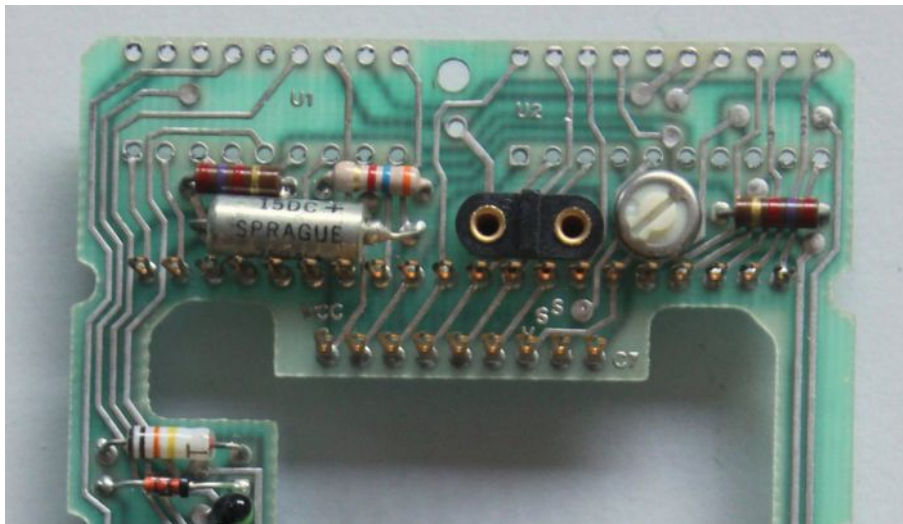
Replacement

You have got the “Woodstock Low Power” upgrade kit. Well decision. To install it you'll need moderate soldering skill, a small Phillips screw driver, tweezers, a soldering iron, a desoldering device and, optionally, a flux dispenser.

Please read the “Preparations” chapter in the “new ACT” manual to get a description how to use these tools and how to open the calculator. When you have separated the main board from keyboard, finally you can remove also the LED display. How to unsolder the chips is also described in detail in the “new ACT” manual.

In contrast to the replacement of only the ACT, two more chips have to be removed: the anode and the cathode display drivers. They are located below the LED display. Some Woodstock calculators have plastic, others have gold plated ceramic integrated circuits. But this makes no difference. For low current consumption in sleep mode also the ACT chip needs to be removed or at least its power lines have to be cut. All other chips including the RAMS and ROMs can be left in place or they can be removed as well and used for repairing another calculator. Even the parts of the switching power supply can be removed which, however, is a lot of work and not recommended.

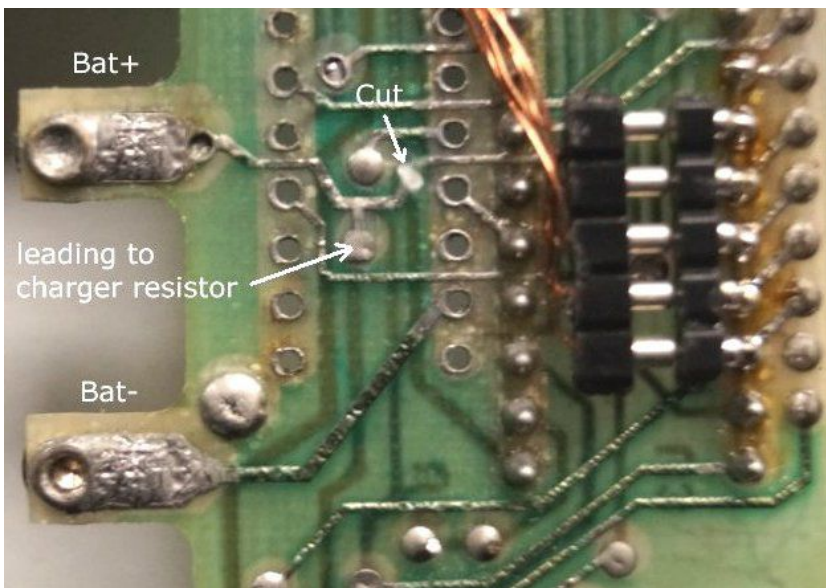
Here is an example of an HP-21 board. Some boards have a small round potentiometer and the capacitor shown below. In this case you have to remove them to get enough space for the board.



The charger connector, which is the black part in the middle will stay in place. Its fin will fit into the gap of the LP board. The small resistors can be left where they are.

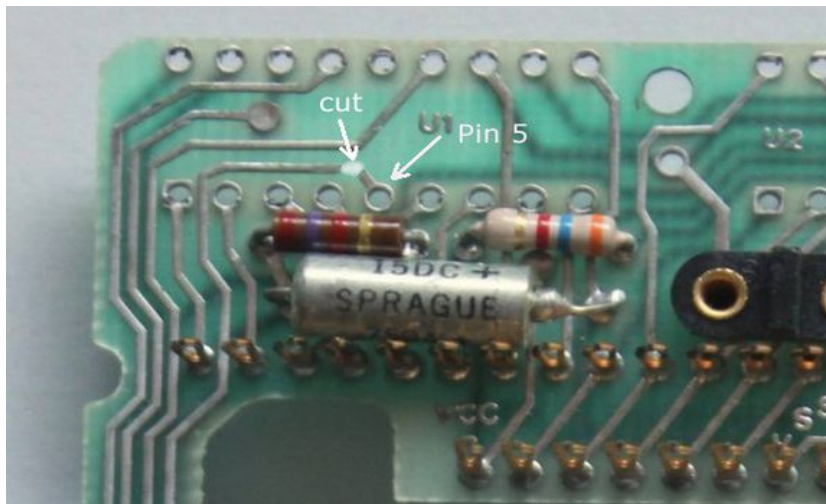
Before you can insert the Low Power circuit, you have to cut three copper traces. We need to connect the LP circuit directly to battery plus (Bat+) and to cut the connection to the original HP circuit. Also the PRGM/RUN switch has to be disconnected from the power supply voltage and will be connected to Bat+ instead. Where to disconnect the copper traces depends on your board layout.

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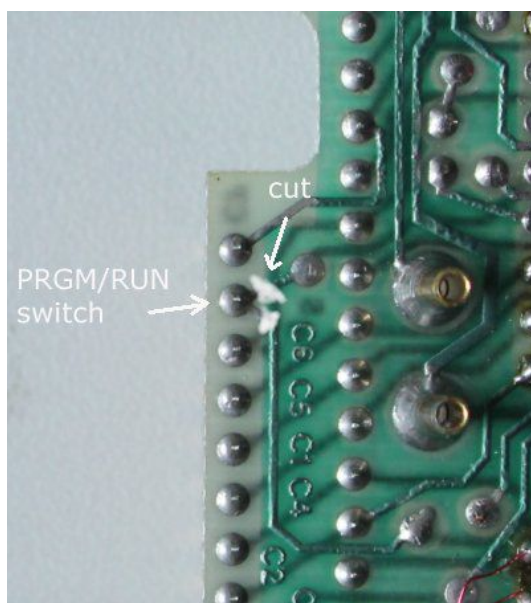


The image on the left shows where to cut the Bat+ line, which otherwise would lead to the internal power supply via the ON/OFF switch.

The trace coming from Bat+ is cut after the branch, which is leading to the charger resistor. Leaving this connection allows you to charge your batteries with the original charger.

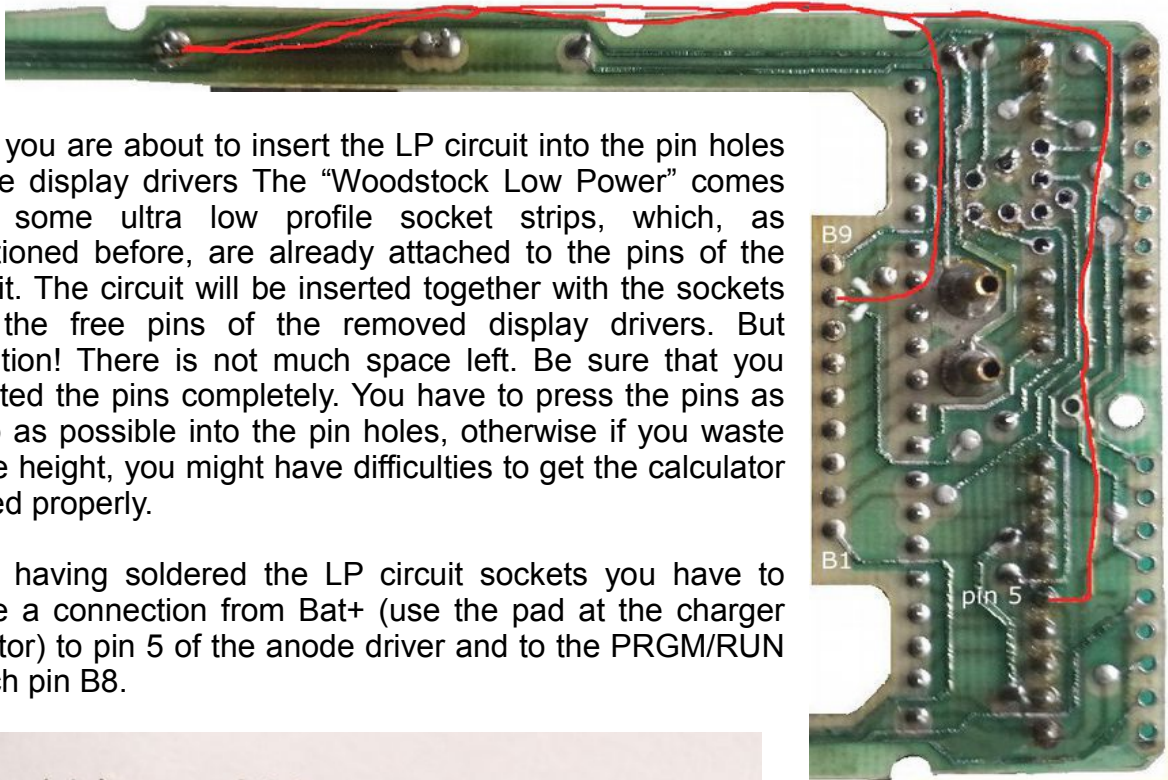


You also have to cut the trace leading from pin 5 of the anode driver to elsewhere as shown in the left image. This may be a trace at the assembly side of the HP board or the soldering side, depending on your board layout.



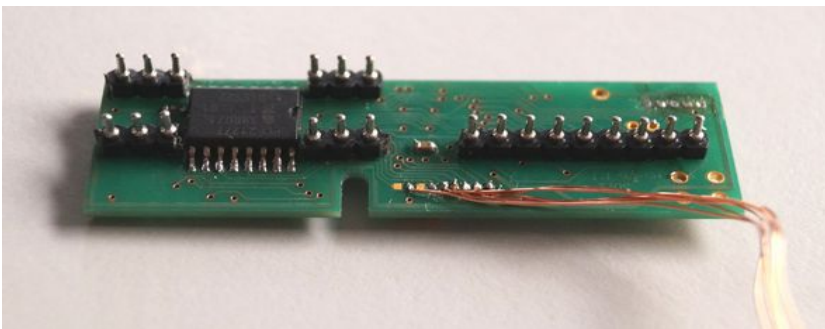
Last but not least, the pin PRGM/RUN switch has to be disconnected from the power supply voltage, which is done by cutting the traces leading from this pin shown on this image. The PRGM/RUN switch pin connects to pin 4 of the ACT when the slider is in the RUN position.

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Now you are about to insert the LP circuit into the pin holes of the display drivers. The “Woodstock Low Power” comes with some ultra low profile socket strips, which, as mentioned before, are already attached to the pins of the circuit. The circuit will be inserted together with the sockets into the free pins of the removed display drivers. But attention! There is not much space left. Be sure that you inserted the pins completely. You have to press the pins as deep as possible into the pin holes, otherwise if you waste some height, you might have difficulties to get the calculator closed properly.

After having soldered the LP circuit sockets you have to make a connection from Bat+ (use the pad at the charger resistor) to pin 5 of the anode driver and to the PRGM/RUN switch pin B8.



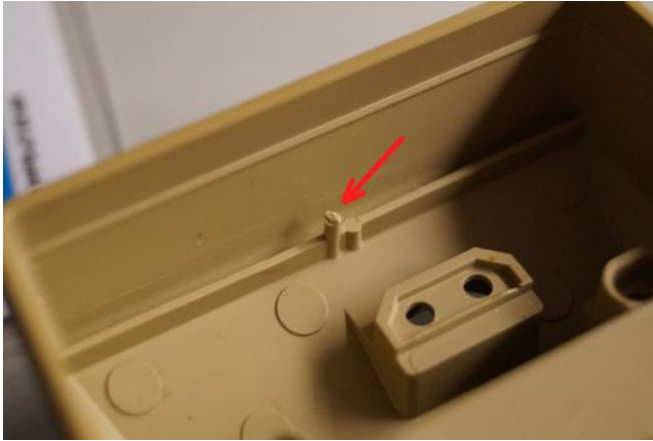
But there is no achievement without some problem. Unfortunately there are different layouts made for the mass production of the Woodstock calculators and I found that some of them didn't have the same distance between the two chips. This leads to a severe problem. The 'LP' circuit will not fit into these boards when using sockets. The pin positions and distances are measured exactly from an HP-25C board, they are the same for many Woodstock boards. I tested some HP-25 and even an HP-27 board, which fitted well. If you want to be sure, that your board is not affected, measure the distance between the two display driver chips pin 1 to pin 1, it must be 29 mm.

But don't worry, if you encounter this problem with your calculator, I have a workaround: Remove either the 9 pin socket strip or the 4*3 sockets. The side you have to choose depends on your layout. The charger connector component must fit into the gap of the LP circuit. You can insert the circuit with the socket strips of only one chip, the pins of the other chip can be bent slightly to fit into the pin holes. You could solder them now, however I do not recommend this, because it will become really difficult to get the board unsoldered again - which on the other hand hopefully never will be necessary. Leave only one pin for soldering and cut the other pins to make them shorter and connect them by isolated copper wires with the corresponding pins on the HP board. I know this is a lot of work, but

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makes it easier to remove the board if necessary, perhaps because you have forgotten to interrupt one of the traces below the board as will be described in the following chapter, or you want to add the GPS module later.

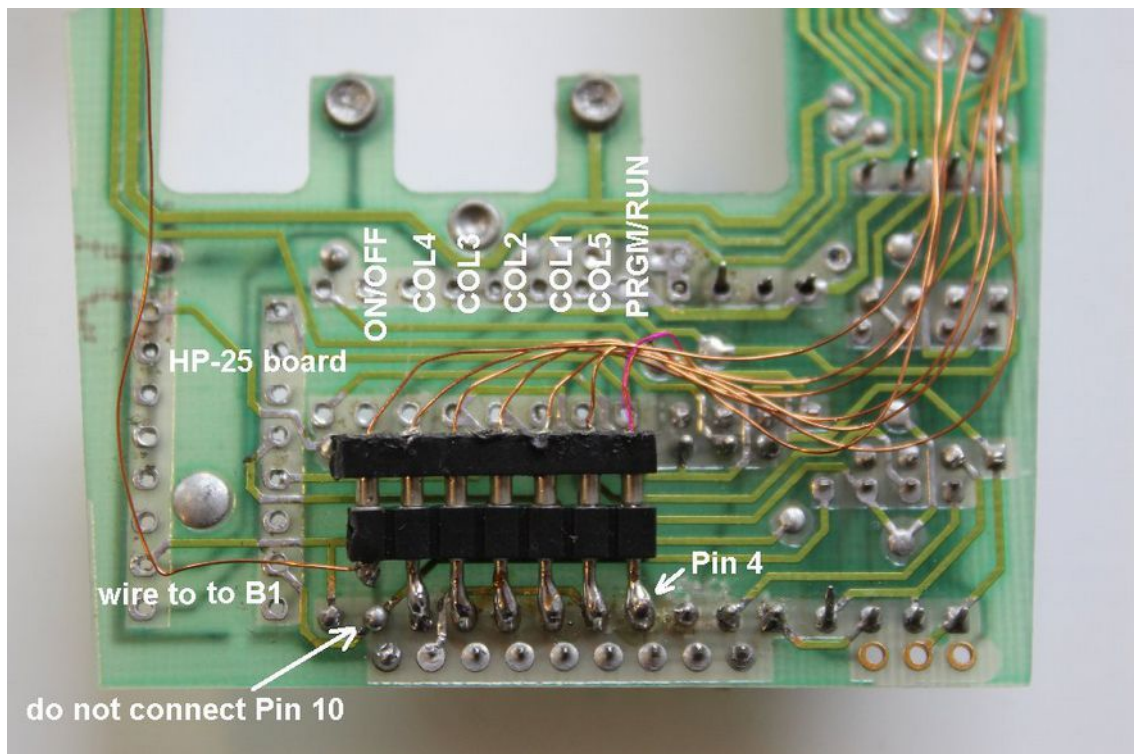
But hopefully, as I observed, only some early HP-21 boards have an unsuitable layout.



If you ever want to remove the LP circuit, use a small screw driver and try to get it between the sockets and the pins, then lift the pins carefully mm by mm from the sockets without bending the board too much.

Before bringing the parts together, note that the bottom case has a small plastic bolt which has to be cut. It will otherwise stick out and press against the LP board and closing the case will not be possible.

Because the display driver pins have no connection to the keyboard you have to establish a separate connection. For this purpose there is already a small cable tree delivered with a 7-pin connector: the **Keyboard Adapter**. Solder the keyboard adapter to pin 4-9 of the removed ACT chip as shown below. Pin 4 is marked with a red wire. Connect the ON/OFF wire to B1 as described later, if you want to use the optional ON/OFF feature.



The image above shows the Keyboard Adapter in the HP-25 board.

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There is a difference in the keyboard lines between HP-21 and all other Woodstock boards. The five keyboard columns of HP-21 are connected to ACT pin 5-9 in this order. The later Woodstock calculators have rotated these lines: keyboard columns 1-4 are connected to ACT pins 6-9 and column 5 is connected to pin 5. Nobody knows why, perhaps the ACT designers made a mistake and the rest of the team had to adjust the layout accordingly.

The 7-pin keyboard connector will be delivered fitting for HP-25 (HP-22-29) boards. If you use an HP-21 board you have to rotate the wires and solder them according to the table below. The PRGM/RUN wire remains always connected to ACT pin 4.

External Signals	HP-21 ACT pin	HP-22/25/27/29 ACT pin	Description
1	5	6	COL1 keyboard column 1
2	6	7	COL2 keyboard column 2
3	7	8	COL3 keyboard column 3
4	8	9	COL4 keyboard column 4
5	9	5	COL5 keyboard column 5
8	4	4	PRGM/RUN
9	do not connect	do not connect	ON/OFF connect to B1 Pin

Keyboard adapter wiring table

If you don't have additional hardware like the infrared printing or the GPS navigation module, you are already done.

If you have established all connections right you can close the calculator and insert the batteries. Immediately, the display should power up, regardless whether the calculator is switched OFF or ON, and welcome you with a message like “**HP-25 LP**”, where LP stands for Low Power.

HP - 25 LP

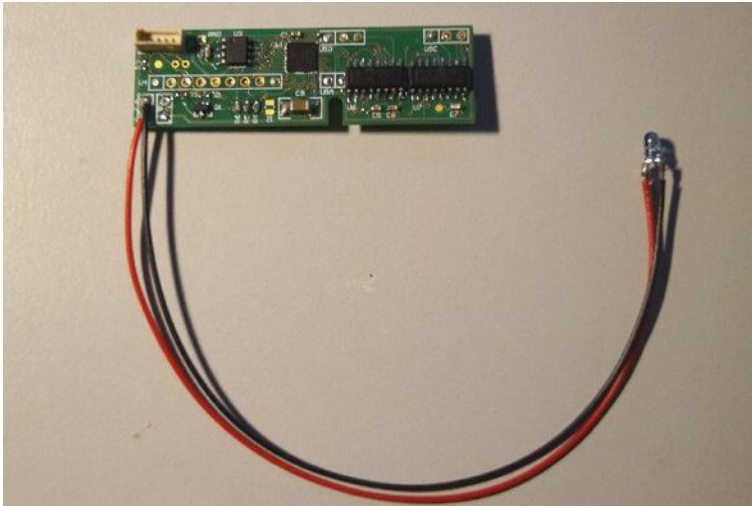
Congratulations! You made it.

You will have to set the date and time and your personal configuration now. Please read the chapter about the key sequences of the “Woodstock Low Power”. It contains all the features of the “new ACT” and some remarkable new ones.

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IR Diode

The infrared printing feature is available for each LP circuit. You just have to add the Infrared diode, which is part of the kit.



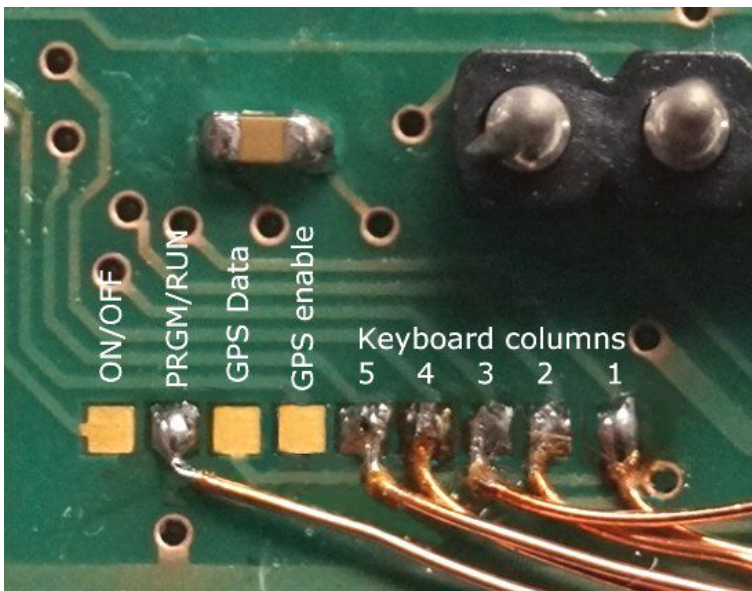
Solder the red (+) and black (-) wire to the board, where IR + and IR - is written and place the IR diode as described in the “new ACT” manual.

To activate the IR printing select the IR Print flag in the User Flags menu.

There are two more flags, which select between MANUAL, NORM and TRACE print mode.

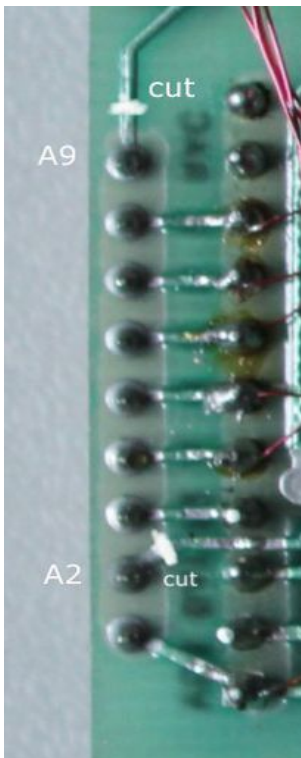
External Signals Connector

For adding some extras, there is a tiny connector, actually only some gold plated copper pads, on the bottom side of the LP circuit. 6 wires are already connected to the keyboard adapter. If you want to use the optional ON/OFF switch or the GPS module you have to solder the appropriate wires to the free pads.



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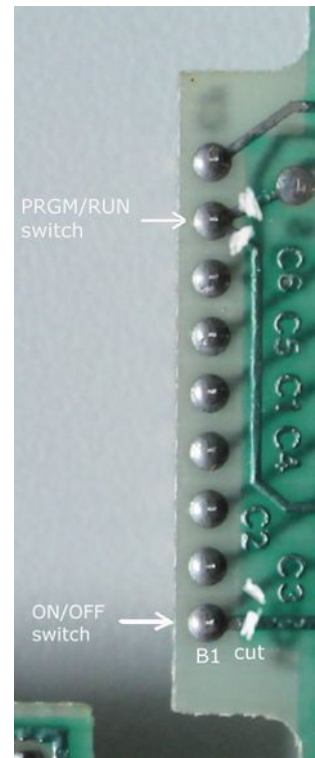
ON/OFF switch



This is an optional possibility. If you want to use the ON/OFF switch for going to sleep mode and wakeup when you switch ON, you have to add two separate wires, which are not part of the keyboard connector.

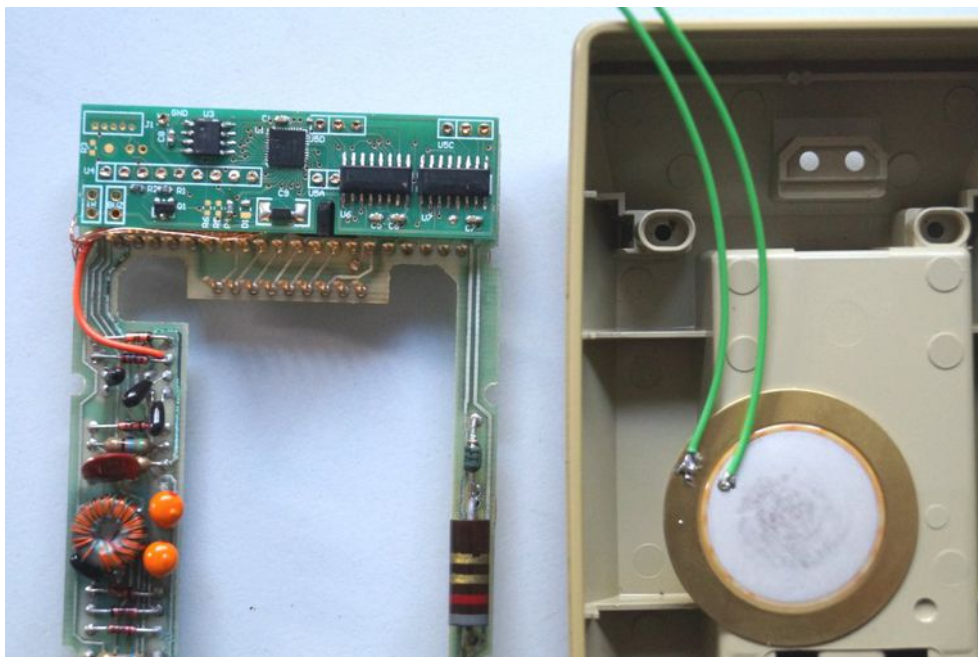
First you have to cut all traces leading from the pins A2, A9 and B1. Then connect B1 with the ON/OFF pad of the external signals connector and connect A2 to GND using two wires. Be careful not to misalign the prongs while soldering the wires.

Now you can switch ON your calculator just as usual with ON/OFF switch and go to sleep when switching OFF.



Buzzer

The piezo beeper will be connected by two wires to the pins near the IR diode, labeled with „BUZ“. The polarity doesn't matter. It will wake you up in the morning if you like or can be used within a HP-25 program to beep friendly when a calculation is finished. It is important to isolate the two solder joints, otherwise they can have contact with the keyboard, which is placed here when closing the case.



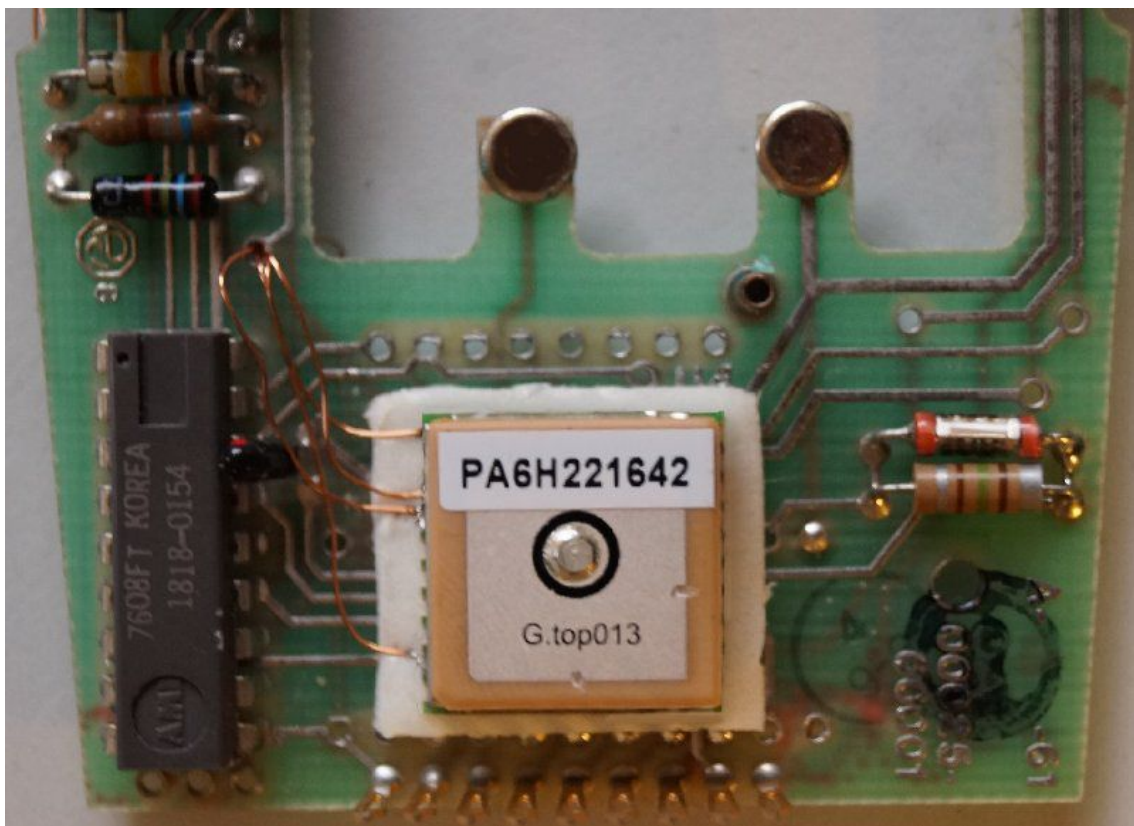
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GPS Receiver

The optional GPS receiver is a wonderful gimmick, which can be attached to the LP circuit. I recommend to place the GPS module on the top side of the PCB and to use 0,3 mm isolated copper wire. You have to remove the ACT and RAM chip to get enough space. After having placed the two components and having connected the power supply with the GPS module you need to connect two wires (14 cm) to the 9-pin "External Signals" connector. The "GPS enable" signal must lead to the "/SHDN" signal of the 3.3 Volt supply, the "GPS Data" signal must lead to GPS module Pin 9.

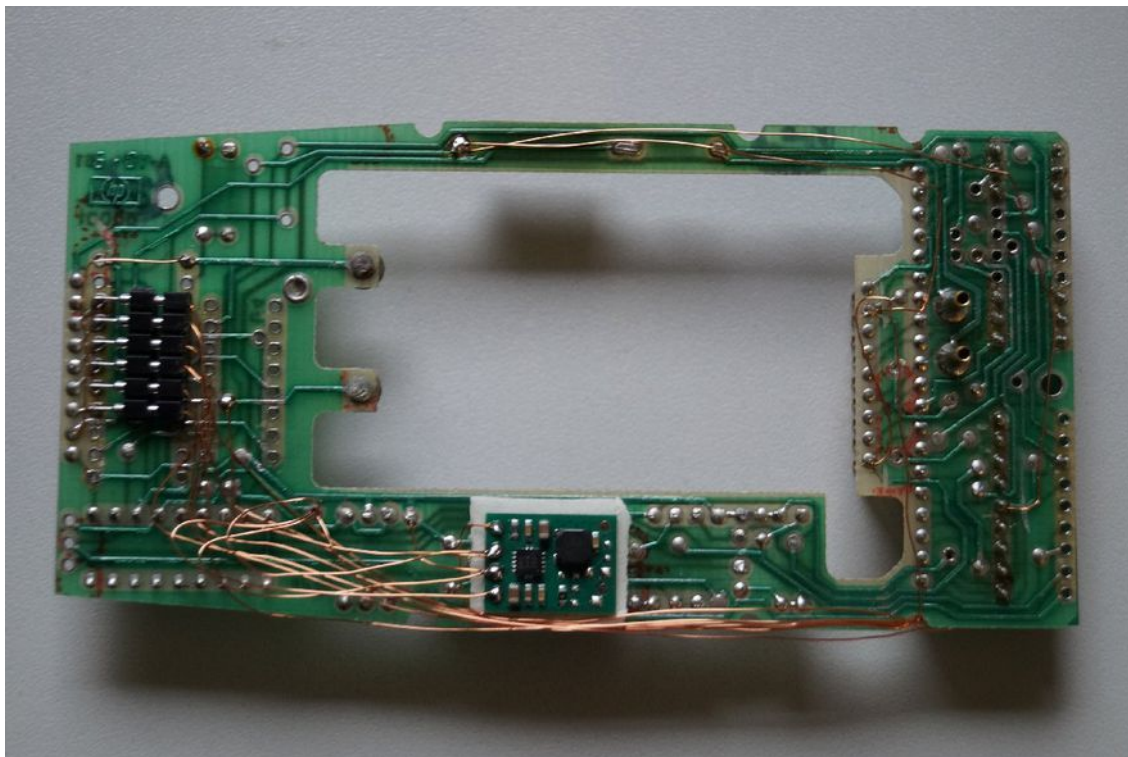
This is your wiring table



GPS Module	Converter	External Signals	HP board	Comment
Pin 3	Pin 3	-	Bat -	GND
Pin 1	Pin 4	-	-	VOUT +3,3 Volt
Pin 4	Pin 2	-	Bat +	VIN + 2,5 Volt
-	Pin 1	Pin 6 GPS enable	-	/SHDN
Pin 9	-	Pin 7 GPS Data	-	NMEA serial data




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Here is shown a possible placement and wiring with isolated copper wires. Isolate the bottom side of the GPS module and the power supply with double sided adhesive tape, which also holds them in place.



To activate the GPS menu type the key sequence   or with double prefix depending on your selected calculator. The battery should be charged enough, because the GPS module consumes 40 mA extra current. If you have inserted weak old batteries, the calculator will reset when switching on the GPS module. You will find more information about using this remarkable add on in the “new ACT” manual.

With GPS module you have two Real Time Clocks in your calculator, one is located on the bottom side of your LP circuit and another is orbiting several hundred km above in the sky.

If you want to synchronize them just press the  button. It will copy the precise UTC time from the satellites to your local Real Time Clock.


Features

For getting a detailed description of the new features of the “Woodstock Low Power” it is mandatory to read the “new ACT” manual first, because the LP circuit includes all features of the “new ACT” chip in its latest version.



But there are some unique new features, which the ACT never could perform. They are described in this manual. Some features just differ a little bit, because of the new alphanumeric possibilities or another reason, others are completely new. Lets start with the differences.

Differences between “new ACT” and “Woodstock LP”

1.) Power Up Keys

The LP circuit doesn't have Power Up keys (except for emergency “Reset”). It will not check which key was pressed at Power Up, because normally there is no Power Up any more and wake up from sleep mode is done always with the  key. All flags, which could be toggled by power up keys with the “new ACT” now can be set/reset by the flags function.


2.) Sleep Mode

The Sleep Mode replaces the Standby Mode of the “new ACT”. You enter Sleep Mode manually by pressing   or move the ON/OFF slide switch to the OFF position. If you want to shut down your calculator to a minimal current consumption when you don't use it, then enable the sleep mode flag. The calculator will switch OFF after one minute automatically. If you want your display staying ON infinitely, that is until you switch it OFF manually, then deactivate this flag.

Sleep mode flag is toggled by pressing    .

If it is active, your calculator will enter Sleep mode after one or five minutes without keyboard activity.


SLEEP

As soon as you press the  button, the display will show its previous contents. You can also select to wake up your calculator by any button of the last keyboard row if you set the appropriate flag, which is described later.

3.) HP Calculator

You can tell the “Low Power” circuit to show the calculator's name if it wakes up from

Woodstock Low Power Manual

Sleep mode. This reminds you which calculator model is currently selected. You can show or hide this feature by toggling the HP Calculator flag .

HP - 25 LP

4.) External/Internal ROM

There is no external ROM any more, even if you left the ROM chips in place, there is no communication between them and it is not needed any more. The new LP circuit always reads the HP firmware from its huge internal flash ROM.

5.) Slow/Fast Speed

There is no slow mode any more. The new LP always emulates the firmware as fast as it can. The speed depends on the selected calculator model and normally is about three to four times faster than the original calculator. Actually the emulator is written in pure assembler code. You will benefit from this optimization by a very fast execution speed.

When a running program encounters a PAUSE instruction, it will automatically slow down for one second for you to have time for reading intermittent results.

6.) *Continuous Memory*

The “Woodstock LP” gives you back a real “Continuous Memory”. After wake up you will find any number, any display mode and trigonometric mode, the stack and your registers, and the current program as it was when the calculator went to sleep. You don't have to switch the PRGM/RUN slider for storing the register contents, because it is stored in battery buffered internal RAM like the original 25C and 29C models.

This concept, however, differs from the “new ACT”. Other than the “new ACT” you will lose the register contents when you remove the battery pack for more than some seconds. But your program library and register sets are still saved in flash memory and will stay there even when you remove the batteries.

Not only your currently loaded program and your registers and display mode and trigonometric mode were saved in “Continuous Memory”, but also the stack contents and even a running program. If you switch ON the calculator, which went to sleep while a program was running, it will continue to run from where it was interrupted.

7.) Original mode

There is no original mode any more, the LP version doesn't hide its features.

8.) Stopwatch

There is only one stopwatch counter available and therefore the Chess Clock function had to be removed. It couldn't be implemented anymore, because the stopwatch is now hardware controlled and only one stopwatch register was available. However, because the stopwatch is controlled by the RTC chip it is very accurate and calibration is not necessary anymore.

9.) ROM Code

“Show ROM Code” and “Show ROM checksum” are no longer part of the firmware. Because there are no external ROM chips connected showing their contents is obsolete.

What is still the same?

1.) Program Library

You can store up to 100 plus 10 user programs in flash memory. Even the bigger HP-29 and HP-67 programs.

2.) Register sets

You still have 10 register sets, which you can use for variables of your programs.

3.) Constant Collection

You have access to 20 predefined physical constants and 80 constants of your own. The constants are common to all calculators, which have access to constants.

4.) Program Overlay

You still can overlay the programs to achieve a single contiguous program of up to 5000 steps and more.

5.) Many more

Generally spoken, all the small helpful additional key sequences used in the “new ACT” and described in the ACT manual are still present in the LP firmware.

What's new?

After having mentioned the differences and what's kept the same between the “new ACT” and the “LP” circuit, here is a list of the completely new features, which were not present in the previous “new ACT” firmware.

1.) Real Time Clock

The accurate RTC chip allows you to show the time, date, weekday and to set an alarm time. The clock is running as long batteries are inserted. It will keep the accurate time for you and the alarm can even wake you up in the morning.

2.) Show program step mnemonics

Your program steps can be shown as mnemonics rather than as row column code. Generally, all possible texts can now be shown, because the 7-segment display is not longer limited by the original display driver chips, and can show each combination of segments, which includes the full alphanumeric character set.

3.) Ticker Text

You can enter any text up to 64 characters, which will be shown as ticker text whenever you want. This is nice feature improves the previous 12-digit welcome text, which was limited to only a few alphanumeric characters.

4.) Show Battery Voltage

You can show the battery voltage for monitoring the charge state. This improves the original low battery display by showing all the dots. You can keep track of the charge state just by reading its current voltage.

5.) Show Temperature

Not very accurate, but at least an approximation of the ambient temperature will be displayed. Sometimes however it shows a temperature way off. It seems the temperature sensor of the PIC processor doesn't behave according to the data sheet. Perhaps an update is necessary.

6.) Sleep Mode

Whenever no calculation is made and the program is not running, the calculator can enter sleep mode and doesn't consume battery power until waked up again.

7.) Beeper

The integrated piezo beeper can be programmed to wake you up when a calculation is finished or the programmed alarm time matches the current time.

8.) *Program Directory*

You can enter names for your programs. When you want to load one of them, you can step through the directory of program names and load it with one click. Also saving a new program is much easier, you step through the directory until you find a free slot and save your program with one click.

9.) *PC Communication*

Even more possibilities are given, when you connect your calculator via USB/TTL serial converter with the PC application. You can upload/download programs and data and perform a complete backup in less than a minute.

10.) *Many calculators in one*

As mentioned before, you can switch between all Woodstock calculator models and even the classic and spice models and HP-67 are available.

The following chapters, which describes the key sequences for the above mentioned new features in detail, are valid for the HP-25 calculator. Most of them are the same for other calculators, but some might differ due to the different available physical keys. All key sequences separately listed for each calculator model, are shown in Appendix A.

Functions

The “LP” has quite the same set of function keys as the “new ACT”. These are not mathematical function keys, but some additional routines, which display useful information.

Functions are called by the key sequence:

followed by the decimal key or a number from to ¹.

All Function menus either show some text or you can edit something within. The menu will stay there as long as you want and waits for keyboard entry. You can leave and close all functions and return to calculator mode when you press the key.

¹ Because the HP-21 doesn't have a key, the sequence for functions on the HP-21 is .

1.) Show Revision and Serial Number



If you press these keys you will see the revision and serial number of your LP circuit.



r 1.00 Sr 00001

The Firmware Revision Number is shown at the left as “r 1.00” for example, on the right appears the serial number, “Sr 00001” in this case. This display is shown until you press any key.

2.) Show Flags



There are 20 flags available, which were represented by ten dots and ten minus signs preceded by the letter “F” at the far left. The dots from left to right show flags 0-9, the minus signs show flags 10-19. Each flag has a special meaning and can be toggled here by pressing its key. The new state will be reflected in the display.



F . - . - . -

The flags are described in detail in the following chapter.

3.) Show HP Calculator



This feature gives you the possibility to show, which calculator you are currently running.

HP-25 LP

If the Infrared printing mode is enabled the display will show

HP-34 Ir

And when the GPS receiver is activated you will see GPS in the display.

HP-29 GPS

Also, you can switch to another calculator by stepping through the available calculators.





4.) Program directory





(only prior to V 1.07, see next chapter for V1.07)



5.) Program directory and Enter program name









There is a surprising feature hidden in this menu: It's your program directory. You can step through all your programs by holding down  , or pressing   for fast forward/backward.

You will see your program names and you can decide to load this program into your memory by just pressing the  key.

If you want to save your current program to this memory location then press the  button. In addition, if the currently shown program is not a free slot, the decimal dot on the far right will be shown. Stepping to the next free slot makes sure, that you don't accidentally overwrite one of your other programs.

If you don't want to load or store the program press  to leave the menu. Unique to an LED calculator from the golden era: You can give your program a name. Each program can be labeled with a text, which makes it easy to identify. Whenever you load a program from your library its name will be shown in the display. To enter the name for your program, use this menu. The text can be entered like the ticker text, but is limited to 12 characters. If you press  a blinking cursor will appear and you can edit the name by using the

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    keys. If you press  again the program name of the currently loaded program will be updated, or press  if you want to cancel the edit.



6.) Show program checksum



If you call this function it shows the number of the currently loaded program and its checksum. The number, preceded by the letter **P**, is either a single digit from **0 - 9** if it is loaded from the “Program Memory”, or like in the picture a two digit number from **00 - 99** if it is loaded from the “Program Library”. The checksum is shown as a 4 digit octal number. This can be useful, if you want to compare it with your own records.

An empty program has checksum **0000** and even if it matches with another empty program somewhere in your storage, will display **P - -**. If your program doesn't match with any of the stored programs only the letter **P** is shown without number.



P r . 5 4 4 0 4 3

This function is also available by the shorter sequence   in PRGM mode.




7.) Show available Memory/ Register and Program usage




The HP-25 LP has a greatly improved version for showing the available memory compared to the “new ACT”, it gives you detailed information about your programs and registers. You can see which of them are free and which are occupied at a glance.

When you use the  or  key you will see numbers and dots like in the following image. They represent occupied registers or programs.


r 0 0 3 . . . 6 . 7 .

In the above example register set 0 “**r0**” is displayed. The digits show the used registers which were previously saved by    and indicate, that registers 0,3,6,7 of this register set are used, hence 1,2,4,5 are free and contain value zero. The additional dots show the registers 8-15 if available, depending on the calculator. Registers 8-10 are free and 11-15 (the statistical registers of HP-29) are occupied in this example.

With the  button the next register set will be displayed, up to 10 register sets (80/160


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registers) are available. The  button shows the previous register set.

If “**reg**” is shown at the left you will see the used registers, where you have stored values with the  button. ¹



rEG 012

¹ Please note, that the HP-34C has a combined register and program memory. If you have loaded a program which is longer than 70 steps, registers are used for program memory and therefore will be shown as used here, actually they are only part of the loaded program.

But you will also need a quick overview for your programs. You can easily show the program usage by pressing the  button. You will see a program set with up to ten numbers.

Pr. 1 3


P5.01 3 5 9

If “**Pr.**” is shown, the numbers show the occupied fast access programs 0-9, which were saved by   followed by a number. In the above example Program 1 and 3 are used, 2 and 4-9 are free. Each line beginning with “**Pn.**” where n is a number from 0-9, represents 10 programs of your available up to 100 library programs. In the above example “**P5.**”, the programs 50 to 59 are shown; 50,51,53,55 and 59 are occupied, the remaining programs are empty and free to use.

[With this improved function you get a quick overview of your register and program usage and you can find free locations for your next program in one second.](#)

8.) Operating time and battery time



There are two timer counters, that are counting the operating time in hours and minutes, when you are using your calculator. Whenever you switch on, the operating time is counting up. The first timer value can be up to 10000 hours, is not resettable, and will be stored in Flash Memory. The second operating time counter can be used for any purpose like measuring how long the battery life time was since the last full charge or how long you used your calculator in one week. Its range is up to 100 hours. This second counter is resettable by the  key.

0000.24 00.01 h

9.) Flash write Cycles



Every time, when you save a program or registers the data is written into Flash memory. Each Flash memory has a limited amount of guaranteed write cycles. For transparency the total number of performed write cycles can be shown here with this function. It will be incremented by one whenever you save a program or register set.

F 0 0 0 0 3

The flash memory used in the hardware of your LP circuit guarantees at least 100000 write cycles, before writing could become unreliable. You will not get to this limit within years and the limit can be exceeded normally several times beyond the guaranteed value, before it really fails to write.

I'm sure there will be a lifetime necessary for going beyond the limit of write cycles.

10.) LED Test



After invoking the LED Test function by number 8, all segments of all digits must be on, 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 wiggle the display connector a little bit. 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.



8 8 8 8 8 8 8 8 8 8 8 8 8 8

11.) Ticker Text entry





With this function you have the possibility to “personalize” your vintage HP-25 LP calculator and display your text message on the display. You may create any text of up to 64 characters. Finally I could build a complete alphanumerical calculator for you, because the LP circuit has control over all LED segments. This was not possible with the “new ACT”.

When you enter this function you will be shown the Ticker Text. An underline cursor is blinking.

With   you can move the cursor to the location you want to edit. If it reaches the rightmost or leftmost digit of the display the text will be automatically scrolled in the desired direction. Other than in the “new ACT”s welcome string these keys have repeat









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functionality which is comfortable for the much larger array of characters.

You can enter the numbers  -  and some characters and minus sign and space directly with the appropriate keys:

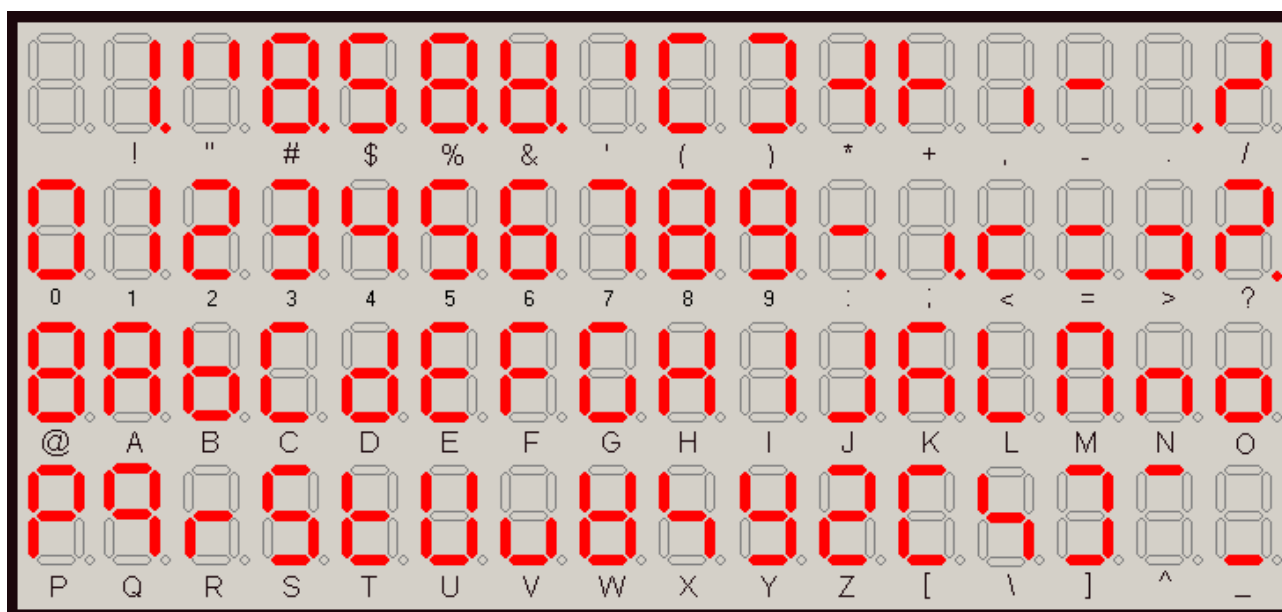


For access to all available characters there are two new buttons available.

Use the   keys to step through the alphabet forward or backward until the right character is found. Then press  or  to advance to the next/previous character location. You can toggle a decimal dot to each character with  if you like. Finally you need to determine the end of your text, unless you want use the complete 64 character buffer. Place the cursor to the end of your text and press the  key. This will insert the EOT (End Of Text) character, which is shown as "8." (all segments on) during text entry. When the ticker text is displayed and encounters the EOT character it will start from the beginning. Press  to save the text to flash memory or  to leave the text entry without saving.

7-Segment Characters
















Although the 7-segment digits were invented for displaying only numbers, they are not bad for the whole alphabet. Most characters can be read very naturally as small or capital letters, only a few have limited readability, X and W for example, and some letters like M and N or U and V must be learned to distinguish.









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Flags

The flags have the following meaning:

-  “Sleep mode” This flag will activate or deactivate automatic sleep mode. Sleep mode will be entered after one minute without key entry.
-  “HP Calculator” When set shows the selected calculator every time at wake up.
-  “Battery check” Switching off this flag can be used to suppress HPs low battery indicator: inverting all decimals points. The battery threshold voltage is set to 2,3 Volt. If you switch off “Battery check” you will not be warned, when the battery is going to get empty.
-  “Show annunciators” Shows annunciators for current trigonometric mode and prefix keys.
-  “Repeat keys” Activates auto repeat for SST BST and some other keys like XY key and ROLL.
-  “Right aligned display” When activated, shows the numbers right aligned in the display. Other than in normal mode, when all digits start from the left, the number is entered from the right. Only numbers with exponent or with many decimals need the whole display and start from the left.
-  “Symbolic display” When activated the mathematical constants “PI” and “E” were shown by its name instead by its value.
-  “Show Mnemonics” With this flag you decide whether you want to show plain text instead of row column code in your program steps. Highly recommended!
-  “Date format US” When this flag is set the date will be shown mm-dd-yy, if not set it will use the european dd-mm-yy format.
-  “Time format 24h or AM PM” When activated shows time and alarm time in 12 hour AM/PM format, otherwise in 24 hour.
-  “Infrared Print Mode” toggles infrared printing mode. When set printing is enabled and after wake up “HP-25 Ir” is shown if “HP Calculator” is enabled.
-  “Norm mode” When printing is enabled, this flag switches on Norm mode, where all of your manual calculations are printed on paper. All calculations are printed except the result to save paper lines.
-  “Trace Mode” When this flag is set and printing is enabled, the arithmetic result is printed automatically after each calculation.
-  “Wakeup all keys” When this flag is set each key in the last row will wake up your calculator. If not set, only the  key will wake up the calculator.

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-  **"Sleep time"** When activated the time before going to sleep is about five minutes instead of one minute without key stroke .
-  **"Flicker suppression"** When this flag is set a running program is shown without the characteristic original flickering display and intermediate results remain stable in the display until the next value is shown.
-  **"Run time Measurement"** This button enables the automatic program time measurement. If your program is running also the stopwatch is running and will be stopped automatically when the program ends. Thus you can measure exact calculation times.
-  **"Data interchange"** When switching to another calculator, normally all storage registers will change their value to the new calculator's workspace. If you have set this bit registers 0-7 will keep their value and thus can be interchanged between the calculators.
-  **"Function Text"** When you have activated this flag and hold down a key, which is associated to a mathematical function, the function name will appear on the display.
-  **"Write Protect"** (since V1.07). You cannot overwrite your user programs when this flag is set. This prevents also accidentally overwriting the HP-34C applications.

The Flags display mode will be quit and the flags will be saved when the  or  key is pressed.

Show Free memory



This function informs you about the amount of free program memory and register memory. There are a maximum of 110 programs available for your own self-written programs, 10 directly accessible in the *"Program Memory"* and 100 in the *"Program Library"*. If a program contains at least one program step, it is considered as used. Hence the memory usage can show you **"P-00"** to **"P-110"**. If **"P-00"** is shown, all programs are occupied.



P.35 84 FrEE

There are a maximum of 88 (or 176 depending on calculator) registers available. The number of free registers is shown to the right of the free programs. If all programs and





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registers are free you will be informed by “P-100 88 FrEE” in the display.

Function Text

When you press a key that executes a mathematical function, normally you will immediately see the result on the display. But if you hold down the key for more than one second its function name will be displayed. After you release the key it will vanish from the display and again shows the result in the X register. In this example the keys   were pressed, which calculated the inverse sinus function.

SIN - 1

This remarkable use of the alphanumeric capabilities of the LP circuit can be activated by the „Function Text“ user flag    . It is available for HP-25/29C, HP-33/34/67 functions, which also have the trace functionality for printer output. However the complete set of functions including GTO, FIX, SCI, ENG are shown only on the display, rather than are printed in NORM or TRACE mode, which saves you printer paper.

Error Messages

There are only a few possible „Error“ messages, which could be displayed by the LP firmware after trying some wrong key sequences. The messages are shown as text in the display. The calculators themselves can show many more errors under different circumstances, which are described in their respective manual.

Load Error




Loading a program which doesn't exist, i.e. is greater or equal 110.

Save Error

Trying to store a constant in the fixed constant area 0-19.

Application programs

As mentioned in the “new ACT” manual there are 100 HP-25 user programs that can be accessed by the call like



   followed by a number from 00 to 99.

These programs are also present in the LP and are empty when you get your circuit. As long as you didn't change their names they have predefined standard program names like

Program 01

There are additional 55 application programs from the HP-25 Applications book preprogrammed. But in contrast to the ACT, they don't share the same program space with the 100 user programs and don't take away 55 storage locations.

They will be recalled separately from the read only applications program library by a double prefix sequence:

    followed by a number from 00 to 54.

The 55 HP-25 application programs have predefined names like

MOON LANDER

The programs cannot be overwritten, but their names can be changed if you prefer your own labelling. If you take the “HP-25 Applications Programs” book you easily will identify these programs.

HP-25 Applications

Nr	Name	Book
00	Battle ships by PANAMATIK	„new ACT“ manual
01	Plotting/Graphing	
02	Quadratic Equation	
03	Complex Arithmetic (+,-,x, :)	
04	Complex Functions ($ z $, z^2 , $1/z$, \sqrt{z})	
05	Determinant and Inverse of a 2 x 2 Matrix	
06	Number in Base b to Number in Base 10	
07	Number in Base 10 to Number in Base b	





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08	Vector Cross Product	
09	Angle between, Norm, and Dot Product of Vectors	
10	Simultaneous Equations in two Unknowns	
11	Accumulated Interest / Remaining Balance	
12	Payment Present Value, Number of Periods	
13	Interest Rate	
14	Compound Amount	
15	Periodic Savings, Future Value, Number of Periods	
16	Discounted Cash Flow, Net present value, Internal Rate of Return	
17	Calendar, Day of week, Days between two Dates	
18	Moon Landing Simulator	
19	Nimb	
20	Teach Arithmetic	
21	Great Circle Plotting	
22	Rhumblin Navigation	
23	Sight Reduction Table	
24	Great Circle Navigation	
25	Newton's Method Solution to $f(x)=0$	
26	Numerical Integration, Simpson's Rule	
27	Numerical Solution to Differential Equations	
28	Linear Interpolation	
29	Linear Regression	
30	Exponential Curve Fit	
31	Logarithmic Curve Fit	
32	Power Curve Fit	
33	Covariance and Correlation Coefficient	

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34	Moments and Skewness	
35	Normal Distribution	
36	Inverse Normal Integral	
37	Factorial	
38	Permutation	
39	Combination	
40	Random Number Generator	
41	Chi Square Evaluation	
42	Paired t Statistic	
43	t Statistic for two means	
44	Field Angle Traverse	
45	Area by double Meridian Distance	
46	Inverse from Coordinates	
47	Coordinate Translation and Rotation	
48	Triangle Solution B,b,c	
49	Triangle Solution a,b,c	
50	Triangle Solution a,A,C	
51	Triangle Solution a,b,C	
52	Triangle Solution a,B,C	
53	Hyperbolic Functions	
54	Inverse Hyperbolic Functions	

HP-67 Standard Pac

The HP-67 calculator was delivered with some prerecorded magnetic cards, the so called „Standard Pac“. These 15 programs are already built in in your LP hardware. When you have selected the HP-67 calculator you just call one of them with     followed by the number of the program or more easily by selecting it through the program directory.

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Nr	Name	
01	Moving Average	
02	Tabulator	
03	Curve Fitting	
04	Calendar Functions	
05	Annuities and Compound Amounts	
06	Follow Me	
07	Triangle Solutions	
08	Vector Operations	
09	Polynomial Evaluation	
10	Matrix Operations	
11	Calculus and Roots of $f(x)$	
12	English - SI Conversions (Metric Conversions)	
13	Arithmetic Teacher	
14	Moon Rocket Lander	
15	Diagnostic Program	

Neither the HP-25 application programs nor the HP-67 Standard Pac programs can be overwritten by calculator keys, but they can be replaced by any other programs via the PC upload/download possibility.

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HP-29C Applications

Since WLP Version 1.07 there are about 50 HP-29 Application programs preprogrammed. They are read only and can be recalled by



Nr	Name	Book
00	CUBIC EQUATION	Mathematics Solutions
01	SYNTHETIC DIVISION	Mathematics Solutions
02	HYPERBOLIC FUNCTIONS/ INVERSE HYPERBOLIC	Mathematics Solutions
03	POLYNOMIAL EVALUATION REAL OR COMPLEX	Mathematics Solutions
04	ROOTS OF $F(X) = 0$ IN AN INTERVAL	Mathematics Solutions
05	3 x 3 MATRIX INVERSION	Mathematics Solutions
06	BASE b ARITHMETIC	Mathematics Solutions
07	GAUSSIAN QUADRATURE FOR $\int_{a-b} F(X) dx$	Mathematics Solutions
08	GAUSSIAN QUADRATURE FOR $\int_{a-\infty} F(X) dx$	Mathematics Solutions
09	BESSEL FUNCTION $J_n(X)$	Mathematics Solutions
10	GAMMA FUNCTION	Mathematics Solutions
11	SINE COSINE AND EXPONENTIAL INTEGRALS	Mathematics Solutions
12	RESISTIVE/REACTIVE CIRCUIT CALCULATIONS	Electrical Engineering
13	IMPEDANCE OF LADDER NETWORK	Electrical Engineering
14	T-ATTENUATOR	Electrical Engineering
15	PI-ATTENUATOR	Electrical Engineering
16	WYE-DELTA OR DELTA-WYE TRANSFORMATION	Electrical Engineering
17	PI NETWORK IMPEDANCE MATCHING	Electrical Engineering
18	ACTIVE FILTER DESIGN	Electrical Engineering
19	BUTTERWORTH FILTER DESIGN	Electrical Engineering
20	STANDARD RESISTANCE VALUES	Electrical Engineering

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21	SMITH CHART CONVERSIONS	Electrical Engineering
22	RACETRACK	Games Solutions
23	PINBALL MACHINE	Games Solutions
24	BALL ROTATION POOL	Games Solutions
25	ROULETTE	Games Solutions
26	TIC-TAC-TOE	Games Solutions
27	BELL FRUIT	Games Solutions
28	BLACKJACK (21)	Games Solutions
29	CANNIBALS & MISSIONARIES	Games Solutions
30	HUNT A MOVING SUBMARINE	Games Solutions
31	ARTILLERY GAME	Games Solutions
32	DISTANCE TO OR BEYOND HORIZON	Navigation Solutions
33	DISTANCE BY HORIZON ANGLE AND DISTANCE SHORT OF HORIZON	Navigation Solutions
34	DISTANCE OFF AN OBJECT BY TWO BEARINGS	Navigation Solutions
35	VELOCITY TRIANGLE	Navigation Solutions
36	COURSE TO STEER	Navigation Solutions
37	ESTIMATED TIME OF ARRIVAL	Navigation Solutions
38	GREAT CIRCLE NAVIGATION	Navigation Solutions
39	GREAT CIRCLE COMPUTATION	Navigation Solutions
40	COMPOSITE SAILING	Navigation Solutions
41	RHUMB LINE NAVIGATION	Navigation Solutions
42	RHUMB LINE DEAD RECKONING	Navigation Solutions
43	CELESTIAL NAVIGATION AND DEAD RECKONING	Navigation Solutions
44	SIGHT REDUCTION TABLE	Navigation Solutions
45	JULIAN DAY by Geir Isene	More Solutions
46	PROGRAM 156	spare

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47	PROGRAM 157	spare
48	PROGRAM 158	spare
49	PROGRAM 159	spare

HP-34C Applications

Since WLP Version 1.07 there are about 50 HP-34 Application programs preprogrammed. Some of them are stored in read only memory and others share the program space with the 100 user programs.

The first part can be recalled from user program library with



67 to 99

Nr	Name	Book
67	Curve Fitting	HP-34C Applications
68	Hyperbolic Functions	HP-34C Applications
69	Polynomial Evaluation	HP-34C Applications
70	Annuities and Compound Amounts	HP-34C Applications
71	Discounted Cash Flow Analysis	HP-34C Applications
72	Moon Rocket Lander	HP-34C Applications
73	Nimb	HP-34C Applications
74	Timers	HP-34C Applications
75	Random Number Generator	HP-34C Applications
76	Moving Average	HP-34C Applications
77	System of Linear Equations with Three Unknowns	Mathematics Applications
78	Determinant and Inverse of a 3x3 Matrix	Mathematics Applications
79	Numerical Integration by Discrete Points	Mathematics Applications
80	Differential Equations 1	Mathematics Applications
81	Differential Equations 2	Mathematics Applications
82	Vector Operations	Mathematics Applications

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83	Triangle Solutions	Mathematics Applications
84	Coordinate Transformation	Mathematics Applications
85	Circle Determined by Three Points	Mathematics Applications
86	Complex Operations	Mathematics Applications
87	Base Conversions	Mathematics Applications
88	Basic Statistics for Two Variables	Statistics Applications
89	Factorial, Permutations and Combinations	Statistics Applications
90	Moments, Skewness and Kurtosis	Statistics Applications
91	Normal Distribution	Statistics Applications
92	Inverse Normal Distribution	Statistics Applications
93	Chi-Square Distribution	Statistics Applications
94	t Distribution	Statistics Applications
95	F Distribution	Statistics Applications
96	t Statistics	Statistics Applications
97	Chi-Square Evaluation	Statistics Applications
98	Contingency Table	Statistics Applications
99	Azimuth-Bearing Conversions	Navigation Applications

Be aware, that you can overwrite these programs by your own user programs. If you have accidentally done this you must type them in again from the solutions handbook. For preventing accidentally overwriting your user programs you can set the WRITE PROTECT flag.

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18 more programs can be recalled from the read only application program library by



00-17.

Nr	Name	Book
00	Traverse, Inverse, and Sideshots	Navigation Applications
01	Traverse Adjustment	Navigation Applications
02	Bearing-Bearing and Distance-Distance Intersections	Navigation Applications
03	Offset and Bearing-Distance Intersections	Navigation Applications
04	Curve Solutions	Navigation Applications
05	Horizontal Curve Layout	Navigation Applications
06	Ohm's Law	Student Applications
07	Reactans Chart	Student Applications
08	Impedance of a Ladder Network	Student Applications
09	Series-Parallel Resistor Adding and Standard Resistor Values	Student Applications
10	Ideal Gas Equation of State	Student Applications
11	Conduit Flow	Student Applications
12	Equations of Motion	Student Applications
13	Kinetic energy	Student Applications
14	Mohr Circle for Stress	Student Applications
15	Simply Supported Beams	Student Applications
16	Section Properties	Student Applications
17	Equilibrium	Student Applications

Real Time Clock


The Real Time Clock is running all the time, even when the calculator is in sleep mode. It consumes nearly no current, because it is made for these kinds of standalone applications. The chosen PCF2127T chip is a so called "Accurate Real Time Clock" with integrated temperature compensated quartz. The specification according to the data sheet is ± 3 ppm from $-30\text{ }^{\circ}\text{C}$ to $+80\text{ }^{\circ}\text{C}$. What does this mean? It means after 1 million seconds it will deviate by ± 3 seconds. As a year has 31,5 million seconds, the deviation will be about 1 1/2 minute per year or 8 seconds per month. These are theoretical values and I don't know yet the real accuracy, which also depends on environment influences and rapid temperature changes. A normal clock quartz has a specification of ± 20 ppm and is 6 times less accurate.

It delivers five different functions: date, time, alarm time, weekday and stopwatch. The following chapter describes the key sequences for accessing the Real Time Clock functions, which can be shown in RUN mode.



1.) Date



The current date will be shown. It can be set from any date from 01-01-2000 to 12-31-2099.

With  you can change between dd-mm-yy and mm-dd-yy format.


10-21-2017

If you want to enter a new date, just enter 6 digits and  and the new date will be written into the RTC. First two digits are always day, then month, then year. You can't enter the century. With the  button you can reset your entry or you can leave the date display and return to the calculator.

2.) Time






The current running time will be shown with hours minutes and seconds.

With  you can switch between 24h and 12h AM/PM format. This affects also the alarm time display mode.

08.21.20 PM

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If you want to enter a new time, just enter up to 6 digits followed by . The first two digits are hours, then minutes, then seconds. You always have to enter 24h time, even when AM/PM mode is active. Thus, if you want to enter 5:34 PM you have to enter 1734. You don't need to enter minutes or seconds, if you want to set the time to the full hour or minute. At the moment when the  key is pressed, the time will be set within one second accuracy.


With the  button you can reset or discard your entry and you can leave the time display and return to calculator mode.

3.) Alarm



The alarm time is shown or can be set like the normal time, but the separators are not the dot, but dot and minus. If the alarm is armed, there is a minus sign shown at the right end of the display.


12-.00-.00-


If you just press  without having entered a time, the alarm activation will be changed, shown by the minus sign at the right. If you press again and you see a minus and a dot on the right this indicates the daily alarm.

If the daily alarm is activated the alarm is triggered every day at the same time. If the daily alarm is not activated, the alarm will be automatically disarmed after the first match and you have to activate it for the next day manually.

4.) Weekday





You should never forget which day it is. For this reason you can set the weekday of the RTC. It will automatically count with the date every day. The display shows the current weekday in plain text. If you want to change it just enter a number key from 0 to 6 followed by .

Perhaps you have a free weekend, then you can press  which is

Saturday





5.) Stopwatch

Just press   in RUN mode¹ and a stopwatch with minutes at the left and 1/100 seconds at the right will appear. Only if the time exceeds one hour also the hours are shown.

00-00-19.65

You can Start/Stop the timer, and reset it to zero. When the stopwatch is active, all calculator keyboard entries are bypassed and interpreted by the stopwatch.

Start/Stop/Reset

Start and Stop function is placed on the  button. Reset to zero is naturally done by the  Button after the stopwatch has been stopped. If you switch back to calculator mode² with another  , while the stopwatch is running, it is still counting in the background and you can switch back whenever you want and read the elapsed time. Probably it tells you how much time you have needed to solve your current mathematical problem?

Storing and Recalling Lap Times

You can store up to eight lap times with   to . Recalling these values is possible with   to .

The stored lap times can be read in calculator mode and you can do calculations with them. The storage format is the same as used for the ->HMS function. Digits left of the decimal point are hours, followed by minutes, seconds and 1/100 seconds.

¹ g NOP is still available in HP-25 PRGM mode. HP-21 is always in RUN mode and uses g DSP button.

² Also switching the PRGM/RUN button returns to calculator mode.






The stopwatch of the Low Power circuit is different to the stopwatch of the ACT. The LP circuit has only one stopwatch and cannot be used as a game watch. But don't be disappointed. This has some reason. The reason for only having one stopwatch is, that it is a hardware stopwatch, which is located inside the RTC clock and there is only one stopwatch possible.

But what do you get for it: First, this stopwatch is very accurate, it does not need a calibration procedure like the ACTs stopwatch. And it can be run as a countdown, giving an alarm when it reaches zero. And not least it can be run also when the calculator is switched off. This should be worth the missing of two timers.

You can start the stopwatch from zero or stop with the  key. Or you can enter a

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starting time just by keying in 6 numbers, hours minutes seconds, and , which sets the stopwatch to a start value. Then you can decide to count forward with  or backward with the  key. If the stopwatch counts backwards and reaches zero it will trigger an alarm and the beeper will be heard for one minute.

The stopwatch will count also in sleep mode and will wakeup automatically if the countdown reaches zero.

How the stopwatch is implemented?

Getting the stopwatch running also in sleep mode is done in a rather tricky way.

As the RTC chip does not have a stopwatch function, neither the PIC processor does have one, nor the other chips of the LP circuit, how is it done then? In fact when the time will be set, it will be written into the RTC and the RTC will do the counting. Also the date is managed stand alone in the RTC. The RTC chip also offers an alarm time register, which perfectly fulfill our needs, it can wake up the PIC processor if the activated alarm matches the current time. But none of them can handle a stopwatch. And it is impossible to emulate a running stopwatch if the RTC has no stopwatch or with a sleeping processor. There was only one solution. They had to help each other.

If the PIC processor has shutdown all its clocks and has fallen deep asleep, it still accepts a single external clock signal at one of its input pins, which is able to count an internal 16-bit timer register upwards. And the RTC is able to deliver that accurate clock signal, which can be connected to this external clock input. So both together can build a counting unit, which does not need to wake up the processor when counting. As the stopwatch counts in 1/100 seconds, it would be desirable to have a 100 Hz clock from the RTC. But according to the data sheet this is not possible, it can generate either a 1 Hz or 1024 Hz signal. 1 Hz is too slow, 1024 Hz is too fast. But by using a 1:8 prescaler in the PIC timer module, the 1024 Hz can be divided to 128 Hz and voilá, this is a good approximation. 128 pulses represent one second of stopwatch count. Now it is easy to calculate the 1/100 seconds from 1/128 seconds just by making a multiplication. In fact, there have to be done some more calculations to get the stopwatch displayed from the timer value, as the stopwatch is able to also count downwards and the 16-bit hardware timer can only count upwards and it can count only 512 seconds (8 minutes 32 seconds) before it overflows. Fortunately the overflow can be programmed to wake up the processor. If a wakeup occurs by timer overflow, which happens about every 8 minutes if stopwatch is running, the processor just adds or subtracts 512 seconds to the stopwatch base value and goes to sleep again. If a button is pressed the display shows the stopwatch as the stopwatch base value plus the current timer value. That's it.

Theoretically the stopwatch could count for years with only one battery charge, but in reality it will overflow any 99 hours.




Special Functions

1.) Battery Voltage



This new display shows the currently measured battery voltage within 50 mV accuracy.

2.75 Volt

You will normally get numbers between 2,5 and 3,0 Volts and this assures you that the batteries are still OK. However if the battery voltage gets below 2,2 Volts you can estimate that you need to change your batteries soon. It is an additional battery information to the standard low voltage dots, which are shown in calculator mode. The dots appear when the voltage has dropped below 2,3 Volts and are enabled by   .

You can return to the calculator display with the  key.



2.) Temperature




Similar to the new voltage display also the current temperature can be shown. There is an internal temperature sensor in the PIC processor, which gives a rough estimate of the ambient temperature.

21 °C

69 °F

Because the temperature measurement circuit has different characteristics for each chip, use the   keys to calibrate the sensor when you know the current ambient temperature. The calibration value will be stored in flash memory and no further calibration is necessary.

Press the  key to change between °C (Celsius) and °F (Fahrenheit).

Try to run your calculator in your refrigerator, I promise your programs will not slow down, but don't go below zero degrees, only positive temperatures will be displayed correctly.

3.) Ticker Text



When you call this key sequence the „Ticker Text“ is shown. Because the text can be up to 64 characters, it is shown as a running ticker text.

The Ticker Text replaces the steady 12-digit „Welcome Text“ of the ACT by a much longer text. It was worth to increase the text length, because of the improved alphanumeric capabilities of the new LP circuit.

If you like to show your text slower or faster, just press the or keys to adjust the ticker speed. If you slow down to the very extent, the text will stop and will show only the first twelve characters. This allows you to show also a steady text, if you want.

You can enter your personal „Ticker text“ by .

4.) Random Quote of the day



The “Woodstock LP” holds more than 300 inspirational quotes for you. They are related to mathematics, physics, the universe and god and everything. The author's name follows each quote. Enjoy what you discover. ¹

If you like to show your text slower or faster, just press the or keys to adjust the ticker speed.

¹ This was the undocumented LP hidden feature, which is now revealed in this manual version.

5.) Sleep Mode



If you want to enter Sleep mode, when you don't need the calculator for the next time, you have four possibilities.

- a.) Either you enter this key sequence and you will send your calculator to sleep manually.
- b.) or you can wait one minute (or 5 minutes if “Sleep Time” flag is activated) and the calculator automatically switches off the display and goes to sleep. It will show “**SLEEP**” for some seconds and then switch off.
- c.) or you just move the ON/OFF slider to the OFF position. The display will show “**OFF**” for some seconds then the calculator shuts off. There is no difference between “**OFF**” and “**SLEEP**”.

d.) and last not least you press for 3 seconds. This is a universal key for all calculators, also for those which do not have any additional key sequences like the classics.

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The “Automatic Sleep Mode” needs the “Sleep Mode” flag to be enabled by



And you have the possibility to choose between one minute or five minutes as ON time. The longer time is selected by setting the “Sleep Time” flag with





If you are running a user program, the calculator assumes, that you want to get the result before the calculator goes to sleep, therefore “Automatic Sleep Mode” is suspended until the program stops¹

If you get an unexpected “**SLEEP**” message, because the minute is over while you are contemplating about some calculation results, you can abort the sleeping process. Press any key and just go on contemplating.

¹ only for HP-25/29/34/67, others like HP-33C,38C,HP-55 etc. will go to sleep always)

6.) Wake Up

To wake up the calculator just press the  key. You can also configure your HP-25 LP to wake up by any of the last row keys, if you set flag 13 by using .

Alternatively, you can wake up the calculator with the ON/OFF switch.

If you have entered Sleep Mode there are two events, which will wake up your calculator automatically - if the alarm time is activated and the time matches the alarm time, or if the stopwatch countdown timer is activated and reaches zero.

In both cases the text “**Alarm**” appears in the display and the beeper will intermittently beep for about one minute. You can stop the alarm beep by pressing any key. If you do not press a key, maybe because you are not there, the calculator will go to sleep again after the alarm stops.

7.) Beep



This key sequence was already a programmable step in the original HP-25, shown as “**15 25**” in PRGM mode. But it executed no operation and was perhaps only a relict of programming for a feature that never was implemented or just a bug, because the key did not have a blue function printed on the slanted side.


Now it has found its destiny and invokes the beeper for one second. You can enter the keys in RUN mode directly or use them in your program. It does not slow down the calculation, because the program is executing the next steps while the beeper is active. Often you can combine a STOP instruction with the beeper if you have longer calculations and you are waiting for the result.

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The beeper will also be used when an alarm is triggered or when the countdown timer reaches zero.

8.) Reset

Because the context of each calculator is stored in flash memory, which keeps its data even when battery is removed, you could be worried about what happens, if a calculator hangs somehow. Even when taking out the batteries nothing will change. For this purpose you can reset all calculators to the state as if they were just switched ON. Most of them will just show “0.00” in the display, some will show “Error” or “Pr Error” when they are used the next time.

You have to remove the battery pack, hold down the  key and then insert the battery pack. You will see the display showing “Reset” for some seconds then the currently selected calculator will start.

RESET

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Mnemonics

As a result of replacing the display drivers, the new „Woodstock Low Power“ circuit has the ability to show alphanumeric texts. It has finally overcome the limitations of having only 5 characters available due to the hard coded display drivers.





Using these new alphanumeric possibilities, the display can show your program steps in plain text. This is done for the first time with an HP LED calculator. You don't have to translate the keyboard row and column codes any more. Each program step shows near the line number its real mnemonic like a printer. This changes a lot. It makes your calculator much more readable. And it makes you smile when you see it.



last forty years

now

The implementation of showing the program steps as text, which previously only the printer could perform, is not just a side effect of alphanumeric possibilities, it is an obvious and very welcome feature.

You can activate the mnemonic display with setting flag 7 with    .

Upload/Download Data

The Low Power circuit can be connected to a PC via an USB/TTL serial converter. It is the same converter that is used for transferring updates to the „new ACT“ chip. But now a firmware update can be made without the need to enter the boot loader at power up. It can be invoked from the normal running calculator at any time. If the boot loader is entered you will see all digits and dots blinking „8.8.8.8.8.8.8.8.8.8.“

The PC connector is not only used for software updates, but can be used to upload your programs and register data from the calculator to the PC or download them in the other direction.

The PC application for using all the communication features of the „Woodstock Low Power“ is in development. The detailed description of how to perform all these operations will be part of the users manual of the PC application.

Remote Control

Besides the data transfer capability of the USB/serial interface, there is a remote control included. When you press buttons on the PC emulator, these buttons will be executed on the real calculator. Also the other direction is possible. Any keystroke and the calculation result on the real calculator will be shown on the PC screen. The PC emulator will be a copy of the real calculator.

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512kB Flash memory

Many of the new enhancements of the „Woodstock Low Power“ are only possible because there is a big Flash memory on board. Its size is a thousand times bigger than the program memory of the original HP-25 and it can store all your programs and data registers you ever will have written. But it would be overkill to use it just for storing some 49 step programs. No, the concept of the „Woodstock Low Power“ uses this big data area to store the original firmware of all Classic, Woodstock and Spice calculator models and even the HP-67. This can be expanded in the future even to the voyager models HP-11C or HP-15C, which could make these models running for the first time on a LED calculator.

It contains also the mnemonics used for printing and thus saves valuable program space inside the PIC processor. Indeed, the big flash memory cannot be used to store executable programs, only emulatable programs, thus the program area for executable code is still inside the PIC flash memory and limited to 16k words of the PIC16LF1619 processor.

Here is a brief list, which data is stored in the flash memory.

110 programs per calculator from 49 steps HP-25 to 224 steps of HP-67

10 register sets per calculator, either 8 registers or 16 registers in some models

100 constants recallable and writable shared among all calculators.

“Continuous Memory” and register context for every calculator.

The original HP firmware for emulating every calculator.

Keyboard codes for every button for every calculator.

List of key sequences for all extended functions for every calculator.

Printer Mnemonics for program listings of every calculator.

Display Mnemonics for program steps of every calculator.

Texts to display like “Error”, “Sleep”, or “Speed”, “Track”, “Heading” in GPS mode.

Print Norm/Trace Mnemonics for every button function to be printed.

There is still a lot of free memory left. New calculators could be added in the future to the LP circuit just by writing new data into the external flash memory without changing the PIC program. But if necessary also the PIC program can be changed when an update is available.

Execution Speed

The execution speed of the the Low Power circuit is significantly faster than the original calculator. This is not apparently visible, because the PAUSE function doesn't seem to be faster. Yes, because it is artificially prolonged to show the value for quite the same time as the original. But if you execute a trigonometric function or run a program, you can see the new speed. The main reason for a speed increase, even compared to the „new ACT“, is that the LP circuit does not need to send display information serially to some old HP chips with slow data rates.

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But there are also some new tasks, which slow down the calculation. The concept of the new „Woodstock Low Power“ is the big 512 kByte flash memory, which contains the firmware of all Woodstock calculators. It is an external serially addressed flash memory. During execution of the HP firmware, each instruction has to be read serially from the flash, because it cannot be stored internally in the PIC chip. But with a high speed rate of 4 MHz theoretically up to 50000 instructions can be read per second, compared to 3000 of the original calculator. You will not suffer from a slow calculation speed.

Switching between calculators



You don't need a PC connection and send an update for switching to another calculator. The existence of plenty of HP calculator firmwares in the „Low Power“ flash memory allows you to run many of them just by selecting a new calculator. This key sequence, which shows the selected calculator, can be followed by or keys to select another calculator type. If you leave the menu by the the new calculator will be started, with you leave the menu without switching.

Because the above key sequence might not be present in some models, there is a shortcut, which works all the time from whatever state. Just press the key for more than 3 seconds in calculator mode and miracoulusly the same menu will appear. Because the key will be processed immediately I recommend to press the key before, this avoids stack lift and overwrites only the X register.

Follwing Calculators can be selected:

Woodstock : HP-21/HP-22/HP-25C/HP-27/HP-29C
Spice : HP-31E/HP-32E/HP-33C/HP-34C/HP37E/HP38C
Classic : HP-35/HP-45/HP-55/HP-65/HP-70/HP-80
Topcat : HP-67/HP-99X
Voyager : HP-11C/HP-12C/HP-15C/HP-16C

Well, I admit the HP-99X doesn't exist. Also the voyager models HP-65 and HP-11C to HP-16C are not yet included, but they could be in the future when these calculators also will be part of the LP firmware.

The Classic models don't have additional functions, they are like they are. However the programmables HP-25C/29C/33C/34C/67 (except the financial HP-38C) have plenty of additional functions and support printing (see Appendix A for key sequences).

Preserving “Continuous Memory”

Every time you switch to another calculator, its “Continuous Memory”, consisting of the registers and the currently loaded program, and depending on the calculator sometimes also the display mode and some other data, are loaded from flash memory. And the memory of the now suspended calculator is saved for the next time. Thus you will always get the calculators memory restored to the state, when you last used it. Also your program library and the register sets are saved to individual memory for each calculator. Perhaps you might not have been aware of it until you now have read these lines, the LP circuit gives you 110 programs for each of the programmable calculators, a total of 5500 programs, some of them use up to 224 program steps. Wow!

Context switch

But even more, the complete processor context will be switched. The ACT registers are saved and restored when switching to another calculator. You will get back the calculator in the same state as you left it. For example, if you have selected an HP-25, then switch to HP-29, then return to the HP-25 calculator, the stack will be the same as you left it. And if you switched into PRGM mode, the same program step is shown as before.

But lets go one step further. If you have started a program, which is now running and you switch to another calculator model, make some calculations, and return to the same calculator, the program will still be running. Or you can even start a program in HP-25 mode and HP-29 mode at the same time and whenever you switch back, the programs will continue. However, a program cannot be running in the background, it was halted when the calculator was suspended, but kept in its exact state and when switched back, it is now proceeding as nothing would have happened.

Charging Batteries

[Are you allowed to charge your batteries, when the calculator is switched ON?](#)

I hoped this most discussed question for many years had come to a simple answer with the LP circuit.

Yes, you are allowed to charge the batteries with the original HP charger when the calculator is switched ON. Especially because the LP circuit cannot be switched OFF any more, because it is always connected to the batteries.

But there is still a problem:

When the battery pack is not inserted, running the calculator from the original charger could harm the LP circuit, even if the ON/OFF switch is in OFF position!

The LP board schematic contained a simple overvoltage protection, a Zener diode, which limits the voltage internally to 3,6 Volt. This would prevent damaging the circuit even if no batteries are inserted. But I had to discover that the diode consumed 2,5 mA in sleep mode, 25 times more than allowed. Therefore it is not assembled. Perhaps a better protection could be found in a later LP hardware version. But I don't see it at the moment,

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and the best solution would be to modify the original charger instead.

Charging the calculator with batteries inserted is a necessary achievement. It wouldn't make sense to charge the batteries externally, because you will lose the time and date and the current state of the calculator, when you remove the battery pack, which was not in the range of ideas of the developer.

Before plugging in the charger, to be sure, that the batteries are connected properly, just switch ON the calculator to see if the display lights up. This assures you that charging will not harm the electronics.

Bugs and Side Effects

I hope there are no serious bugs left in the LP firmware version 1.11 (2022), but due to the complexity and so many calculators I don't know. What I know is that I had to make some compromise. The 1kB RAM of the PIC processor was not enough for all functions. For example if you have switched ON the GPS module then you cannot enter „Program Names“ and „Ticker Text“, because they share the same RAM memory. The text edit buffer will be overwritten every second when a NMEA string is received. You have to switch „GPS OFF“ before editing.

The models HP-65 and HP-01 could not be included and cannot be selected, because the 28kB PIC ROM program space was not sufficient to add their additional instructions to the emulator. I'm sure I have already squeezed the ROM code as tight as possible using assembler code and swapping data areas to the 512kB external flash ROM. But I'm also sure that an HP-01 emulation running on a woodstock calculator may not really be necessary, and the HP-65 would not be used very often for programming.

The Classic calculators HP-35/45/55/70/80 don't have any extended functions. I decided, that they are not really necessary. Even if I could have added 8 additional storage registers to the HP-35, it will not be needed in practice.

Sometimes it was rather complicated to add features like recall a constant or hexadecimal conversion or clearing the prefix button after an extended function to all calculators. The HP-33C for example needs to press XY button twice after recalling a constant to show it in the display. The HP-37 has no „clear prefix“ function and executes the „Amortization“ function after invoking extended functions.

Some calculators, like HP-33, need a SST after having loaded a program to refresh the display for showing the current program step. These are minor bugs in my opinion.

Last but not least HP-55 does not offer its timer function, because there is no timer switch, but this could be added in a future version by some key sequence.

The programmable beeper function is only available to the HP-25. It could be added somehow to the HP-29 in a future version.

In conclusion I may be allowed to say „Nothing is perfect“. And if a software finally has become bug free, it is outdated.

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Rules for Key Sequences

Some of the additional functions of the LP calculator should be available from whatever calculator is selected. When using many calculators with only one keyboard, it is sometimes difficult to remember, which key sequence to use. Therefore I will outline some general rules for the most important sequences.



Single prefix versus double prefix



If a single prefix sequence exists for this calculator, then the double prefix sequence will invoke the same function. Single prefix is of course one keystroke shorter.



Function Menu

As an example, the HP-25 Function Menu is called by   , HP-29 needs 
  , because the single sequence is already occupied. For compatibility also the HP-25 can use the double prefix. Generally all calculators will try to use this same sequence for invoking the functions menu, sometimes the button is not labeled GTO, but the button at the same position is used. Some calculators have the shorter additional 
 sequence like HP-21.

Real Time Clock and Special Functions

Generally the Real Time Clock functions are invoked by  followed by an arithmetic key and the special functions by  and arithmetic key in RUN mode. Normally all programmable calculator have the compare functions placed on these keys, which are free in RUN mode. If the prefixed arithmetic keys are occupied however like in HP-21, then a double prefix is used for the special functions and the single prefix numbers 7 4 1 0, which are located at the right of the arithmetic keys will invoke the RTC functions.

To invoke the stopwatch normally   is used. If this is occupied by a calculator function other than NOP, then double prefix is chosen. Also in PRGM mode, when NOP should be remain a programmable instruction, the double prefix must be used.

To invoke the hexadecimal entry   must be used. If this sequence is occupied, then the double prefix will do. If you don't want to think about the right sequence, always use the double prefix and it will work.



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Also the GPS menu should be available from each calculator. Its sequence is always



, or the double prefixed version, if this is already used.











The long press keys

There is no exception of the rule “No rule without exception”, the HP-35 is the only calculator, which does not have any prefix key, therefore none of the additional function are accesible. Really None? No, at least two functions are valid from each calculator, pressing the  key for switching back to another calculator, and pressing the  key for going to sleep.

The first row keys

The “Classic” models and the HP-67 have five buttons more than the Woodstock calculators. To access these invisble buttons we use a trick. To be more precise we use two tricks. For the HP-35, which doesn't have a prefix key, if you press the upper row button normally, then the second row button of the HP-35 executes. If you press for more than a second, then the first row key will be executed. This is very easy to describe and very easy to use.

If you press the upper row button normally with the HP-67 it is the same as the HP-35, you will invoke the second row functions. But executing the first row buttons is different. Because a f prefix key is present, it is more comfortable to hold down the prefix key when pressing simultanously an upper row button, to invoke the first row buttons A-F of the HP-67. Also a repeated key press is possible while holding down the f key. There is one exception, because the LP hardware cannot detect two keys in the same keyboard row, it is not allowed to press the the f prefix and the upper left key at the same time. The A key is the only key which needs a long press to execute (without holding down the prefix key). Try this when have your HP-67 selected and you will understand very easy how it works.

As an example for entering “LBL A” press  (f prefix) then  (LBL) then long press  (A button). For “LBL B” press  then , then hold down  and press  (B button). For the small character label “LBL a” press  (g prefix) then  (LBL) then long press  (A button).

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Vinyl Overlays

However you might need to change the keyboard or apply a vinyl overlay which matches the chosen calculator, if it differs from the original. Or at least you have to know the buttons and their new functions.

There are four vinyl overlays available which can be applied to any Woodstock calculator. These are HP-25C, HP-29C, HP-34C and HP-67. But they are self adhesive and cannot be changed after they once are applied. They are nearly perfect copies of the original labeling. I didn't add any new functions, because they would clearly overload the design. Perhaps you can make some bezels of thick paper by yourself and apply the vinyl stickers to them. Then at least the printed labels around the buttons can be changed very easily by using one of the bezels.
















The four available overlays

To apply an overlay just remove it from its sheet and try to still leave the vinyl buttons where they are. Perhaps use a small screw driver or anything similar to get the buttons separated while removing the overlay from its background. Then remove the superfluous frames from the buttons and holes and then place the self adhesive overlay carefully adjusted over the buttons of your calculator. My experience was that it is rather easy to adjust everything before fixing it by pressing firmly. Then you should transfer the button labels calmly one by one, very accurately adjusted, to the buttons. I recommend to bend the buttons by 90 degrees at the edge with your fingers before attaching them.







There could be interference with the original printed labels and color, when removing the self adhesive overlays after having it applied. PANAMATIK will not take any responsibility for using the vinyl overlays causing any damage to your calculator. You agree to use them on your own responsibility, otherwise don't apply them!

Appendix A Key Sequences

Function menu










Function	Description
  	Enter Function Menu
	Show firmware revision and serial number
	Toggle flags 1-20
	Show calculator / Select calculator
	Show/Enter program name, Load selected program
	Show program number and checksum
	Show memory usage programs and registers
	Show operating time
	Show Flash write cycles
	LED Test
	Enter Ticker Text

Repeat keys














Key	Description
	Show stack
	Show XY registers
	Show program steps forward in PRGM mode
	Show program steps backward in PRGM mode
	constant growth
	constant sum

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

Special keys

Key	Description
 	Show ticker text
 	Show battery voltage
 	Show temperature
 	Goto Sleep, Wakeup from Sleep with 

Real Time Clock keys


















Key	Description
 	Show date,  toggles date format
 	Show time,  toggles time format
 	Show alarm time, activate with 
 	Show weekday, Set with  - 

Stopwatch keys




















Key	Description
 	Enter and leave stopwatch mode
	Start and stop stopwatch
	Start and stop countdown
	Reset stopwatch or countdown
	Enter countdown or stopwatch time
  - 	Store Lap Times 0 - 7
  - 	Recall Lap Times 0 - 7

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Print keys

Key	Mode	Description
  	RUN	Paper Advance
  	RUN	Print X
  	PRGM	Print Program
   	RUN/PRGM	Toggle Print Mode enable
   	RUN/PRGM	Toggle "Trace mode" flag































































GPS keys

Key	Mode	Description
  	RUN/GPS	Enter/Leave GPS Mode
 - 	GPS	Select value to display
	GPS	Next value to display
	GPS	Automatic value display
	GPS	GPS power On/Off
	GPS	Stop dynamic storage to register 0-7
	GPS	toggle between knots and km/h
	GPS	Show Position Latitude, Longitude
  - 	GPS	Store value to register 0-7
   - 	GPS	Store value to register 0-7 dynamically
	GPS	Set RTC time from GPS UTC Time

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







































1.) Key sequence summary

HP-21 LP

Key sequence	Mode	Description
  	RUN	Enter stopwatch mode
 	RUN	Enter Hexadecimal entry
     	RUN	Recall constant 0-99
     	RUN	Store constant 20-99
 	RUN	Show mantissa/PrintX
  	RUN	Paper Advance
    	RUN	Enter function menu
   	RUN	Enter function menu
 	RUN	Undo restore stack registers
 	RUN	Show date,  toggles date format
 	RUN	Show time,  toggles time format
 	RUN	Show alarm time, activate by 
 	RUN	Show weekday, Set with  - 
  	RUN	Show ticker text
  	RUN	Show battery voltage
  	RUN	Show temperature
  	RUN	Goto Sleep, Wakeup with 
  	RUN	Enter GPS Mode

2.) Key sequence summary

HP-22 LP

Key sequence	Mode	Description
  	BEG/END	Enter stopwatch mode
 	END	Enter Hexadecimal entry
 	END	Show mantissa/Print X
  		Paper Advance
  		Show registers 0 to 9
    - 		Enter function menu
    - 	END	Enter function menu
  		Enter GPS Mode
  	RUN	Show date,  toggles date format
  	RUN	Show time,  toggles time format
  	RUN	Show alarm time, activate by 
  	RUN	Show weekday, Set with  - 
  	RUN	Show ticker text
  	RUN	Show battery voltage
  	RUN	Show temperature
  	RUN	Goto Sleep, Wakeup with 










3.) Key sequence summary

HP-25 LP

Key sequence	Mode	Description
	RUN	Enter stopwatch mode
	RUN	Enter Hexadecimal entry mode
-	RUN	Store register set in Storage Memory 0 to 9
-	RUN	Recall register set from Storage Memory 0 to 9
	RUN	Recall constant 0-99 from Constant Collection
	RUN	Store constant 20-99 to Constant Collection
	RUN	Show mantissa/Print X
	PRGM	Show program number and checksum
	RUN	Free Memory/Paper Advance
	RUN	Show registers 0 to 7
	RUN	Sound Beep
	RUN	Enter GPS Mode
	PRGM	Insert program step
	PRGM	Delete program step
	PRGM	Show program steps/Print program
	RUN	Single Step Debug
	RN/PR	Undo stack registers/Undo program step
	RN/PR	Enter function menu
	PRGM	Goto program step 00 to 49
/	RN/PR	Switch to RUN mode/Switch to PRGM mode
	PRGM	Load program 00 to 99 from Program Library
	PRGM	Store program 00 to 99 to Program Library
	PRGM	Load HP-25 Application program








































































4.) Key sequence summary

HP-27 LP

Key sequence	Description
  	Enter stopwatch mode
  	Enter Hexadecimal entry
 	Show mantissa/Print X
  	Paper Advance
    	Enter function 0-9 (see function table)
  	Show registers 0-9
  	Store register set in Storage Memory 0 to 9
  	Recall register set from Storage Memory 0 to 9
 	Show date,  toggles date format
 	Show time,  toggles time format
 	Show alarm time, activate with 
 	Show weekday, Set with  - 
 	Show ticker text
 	Show battery voltage
 	Show temperature
 	Goto Sleep, Wakeup from Sleep with 
  	Enter GPS Mode

5.) Key sequence summary

HP-29 LP


























































Key sequence	Mode	Description
  	RUN	Enter stopwatch mode
 	RUN	Enter Hexadecimal entry
   	RUN	Store register set in Storage Memory 0 - 9
   	RUN	Recall register set from Storage Memory 0 -9
   	RUN	Recall constant 0-39 from Constant Collection
   	RUN	Store constant 00-39 to Constant Collection
 	RUN	Show mantissa/Print X
 	RUN	Paper Advance
 	PRGM	Show Program Checksum
  	RUN	Show registers 0 to 9
  	PRGM	Show program steps
  	RUN	Single Step Debug
   	PRGM	Goto program step 00 to 98
 	PRGM	Switch to RUN mode
 	RUN	Switch to PRGM mode
   	PRGM	Store program 0 - 9 to „Program Memory“
   	PRGM	Load program 0 - 9 from „Program Memory“
   	PRGM	Load program 00 - 99 from „Program Library“
   	PRGM	Store program 55 -- 99 to „Program Library“
    	RN/PR	Enter function menu
 	RUN	Show date,  toggles date format
 	RUN	Show time,  toggles time format

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	RUN	Show alarm time, activate with
	RUN	Show weekday, Set with -
	RUN	Show ticker text
	RUN	Show battery voltage
	RUN	Show temperature
	RUN	Goto Sleep, Wakeup from Sleep with
	RUN	Enter GPS Mode

























































6.) Key sequence summary

HP-31 LP

Key sequence	Description
  	Enter stopwatch mode
  	Enter Hexadecimal entry
 	Show mantissa/Print X
  	Paper Advance
  	Show registers 0 to 9
    - 	Enter function menu
    - 	Enter function menu
  	Enter GPS Mode
  	Show date,  toggles date format
  	Show time,  toggles time format
  	Show alarm time, activate by 
  	Show weekday, Set with  - 
  	Show ticker text
  	Show battery voltage
  	Show temperature
  	Goto Sleep, Wakeup with 





































































7.) Key sequence summary

HP-32 LP






Key sequence	Description
  	Enter stopwatch mode
  	Enter Hexadecimal entry
 	Print X
 	Paper Advance
  	Show registers 0 to 9
     -  	Enter function menu
  	Enter GPS Mode
  	Show date,  toggles date format
  	Show time,  toggles time format
  	Show alarm time, activate by 
  	Show weekday, Set with   -  
  	Show ticker text
  	Show battery voltage
  	Show temperature
  	Goto Sleep, Wakeup with  

8.) Key sequence summary

HP-33 LP





























































Key sequence	Mode	Description
  	RUN/PR	Enter stopwatch mode
 	RUN	Enter Hexadecimal entry
 	RUN	Print X
 	RUN	Paper Advance
  	RUN	Show registers 0 to 9
     - 	RUN/PR	Enter function menu
  	RUN	Enter GPS Mode
 	PRGM	Switch to RUN mode
 	RUN	Switch to PRGM mode
    - 	RUN	Store register set in Storage 0 to 9
    - 	RUN	Recall register set from Storage 0 to 9
    	RUN	Recall constant 0-99 from Constant Collection
    	RUN	Store constant 20-99 to Constant Collection
    	PRGM	Load program 00 to 99 from Library
    	PRGM	Store program 00 to 99 to Library
 	RUN	Show date,  toggles date format
 	RUN	Show time,  toggles time format
 	RUN	Show alarm time, activate by 
 	RUN	Show weekday, Set with  - 

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
	RUN	Show ticker text
	RUN	Show battery voltage
	RUN	Show temperature
	RUN	Goto Sleep, Wakeup with 

9.) Key sequence summary

HP-34 LP






Key sequence	Mode	Description
  	RN/ PR	Enter stopwatch mode
  	RUN	Enter Hexadecimal entry mode
 	RUN	Print X
 	RUN	Paper Advance
 	RUN	Show registers 0 to 9
  	PRGM	Show program steps
  	RUN	Single Step Debug
 	PRGM	Switch to RUN mode
 	RUN	Switch to PRGM mode
   	RN/ PR	Load programs/regs 0 - 9
   	RN/ PR	Store programs/regs 0 - 9
     	RN/ PR	Load programs/regs 00 - 99
     	RN/ PR	Store programs/regs 00 - 99
    - 	RN/PR	Enter function menu
   - 	RN/PR	Enter function menu
 	RUN	Show date,  toggles date format
 	RUN	Show time,  toggles time format
 	RUN	Show alarm time, activate by 

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 	RUN	Show weekday, Set with  - 
 	RUN	Show ticker text
 	RUN	Show battery voltage
 	RUN	Show temperature
 	RUN	Goto Sleep, Wakeup with 









































































Repeat keys

HP-34 LP

Key	Mode	Description
	RUN	Show XY registers
 	PRGM	Show program steps forward in PRGM mode
 	PRGM	Show program steps backward in PRGM mode

10.) Key sequence summary

HP-67 LP




Key sequence	Mode	Description
  	RN/PR	Enter stopwatch mode
  	RUN	Enter Hexadecimal entry mode
    - 	RUN	Store register set in Memory
    - 	RUN	Recall register set from Memory
 	RUN	Show Mantissa/Print X
 	RUN	Paper Advance
  	PRGM	Show Checksum
  	PRGM	Show Memory
 	RN/PR	-x- Print X
 	RN/PR	STK Print Stack
 	RN/PR	SPACE Paper Advance
  	PRGM	Show program steps
  	RUN	Single Step Debug
 	PRGM	Switch to RUN mode
 	RUN	Switch to PRGM mode
    	PRGM	Store program 00 - 99 to Library
    	PRGM	Recall program 00 - 99 from Library
    - 	PRGM	Store program to Memory 0 - 9
    - 	PRGM	Recall program from Memory 0 - 9
    	PRGM	Recall Standard Pac program 00 - 15
    - 	RN/PR	Enter function 0-9

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 	RUN	Show date,  toggles date format
 	RUN	Show time,  toggles time format
 	RUN	Show alarm time, activate by 
 	RUN	Show weekday, Set with  - 
 	RUN	Show ticker text
 	RUN	Show battery voltage
 	RUN	Show temperature
 	RUN	Goto Sleep, Wakeup with 

Repeat keys

HP-67 LP

Key	Description
	Show program steps forward in PRGM mode
	constant growth
	constant sum

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Appendix B Connectors

1.) Woodstock Low Power Pinout

Pin	Name	Description	Pin	Name	Description
1	U4/1	segment a	1	U5/1	K3 digit 3
2	U4/2	segment f	2	U5/2	K4 digit 4
3	U4/3	segment b	3	U5/3	K5 digit 5
4	U4/4	segment c	8	U5/8	K6 digit 6
5	U4/5	VCC battery plus	9	U5/9	K7 digit 7
6	U4/6	segment d	10	U5/10	K8 digit 8
7	U4/7	segment dot	11	U5/11	K9 digit 9
8	U4/8	segment e	12	U5/12	K10 digit 10
9	U4/9	segment g	13	U5/13	K11 digit 11
10	U4/12	GND battery minus	18	U5/18	K12 digit 12
			19	U5/10	K1 digit 1
			20	U5/20	K2 digit 2

2.) External Signals Connector J2 Pinout

Pin	Name	Description
1	ACT/5 (HP-21 ACT/6)	keyboard column 1
2	ACT/6 (HP-21 ACT/7)	keyboard column 2
3	ACT/7 (HP-21 ACT/8)	keyboard column 3
4	ACT/8 (HP-21 ACT/9)	keyboard column 4
5	ACT/9 (HP-21 ACT/5)	keyboard column 5
6	U4/6	GPS /SHDN shutdown green wire to GPS Power supply
7	U4/7	GPS data yellow wire to GPS module
8	U4/8	PRGM/RUN switch
9	U4/9	ON/OFF switch

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3.) PC Connector J1

Pin	Name	Description	USB/Serial converter
1	MCLR	Master Clear Reset	not used
2	RX	Receive Data Signal	connect to TX
3	TX	Transmit Data	connect to RX
4	VCC	Supply Voltage Bat+	not used
5	GND	Ground	connect to GND

Appendix C Woodstock Low Power Schematic

