USBPRINT – USB41 Patched Printer ROM

Introduction

USB41 is a physical module developed by Diego Diaz that uses a variation of his great Clonix to add a serial port and USB adapter to allow printing into an emulated HP82143 printer on a host computer. With the full implementation of the HP82143 printer with graphics in the HP82240 emulator (by Christoph Giesselink) some modifications were done to the USB41 firmware and the PRINTER-1E ROM to fully support graphics printing

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1. Credits

Many thanks to Diego Diaz for the USB-41 printer emulator and his support and testing and Christoph Giesselink for finalizing the HP82143 support in his HP82240 emulator. Without Doug Wilders "HP82143 Printer Study" this project would not have been possible.

2. Conventions

`00FF`	Hexadecimal numbers are used to indicate addresses, leading zeroes are typically used to indicate the total possible range, e.g. 00FFFF. The 'x' character is used for a "don't care" situation
`0x040`	The 0x sequence is used to indicate hexadecimal values when context is not clear
`0b1010`	Binary values are preceded with the 0b sequence, the 'x' character is used for don't care bits
HP41	HP41 indicates all versions of the HP41 calculator, including HP41C, CV, CX, CL, DM41X
41CL	Is used when specifically referring to the HP41CL system, also 41CL is used
TEXT	in **blue** is actually typed as input in the examples, when quotes are used this means that the text is typed in ALPHA mode. When used in the text it refers to an actual HP41 command
[ALPHA]	when in a bracket this is an HP41 key
0.0000	is the result of an operation, what is in the display in green

3. Copyrights and Disclaimer

4. Table of Contents

5. Background

When working on YPRT (see references) I also realized that the USB41 module, designed by Diego Diaz, should be able to print into a serial printer simulator with graphics support. The USB41 module is a variation of his Clonix module, now with a serial interface connected to a serial to USB interface, creating a virtual serial port on a host computer. Alternative firmware can be programmed in the USB41 module for bi-directional data exchange between the HP41 and a host computer.

USB82143 (by Diego) is a text-only version of the printer emulator for Windows, and initial tests with the HP82240 emulator in HP82143 mode proved that it was capable of printing graphics, with some limitations. Research has shown that the limitations were due to the fact that the printer status bits for EOLL, EOLR, DWM, SCO and LCA were not implemented and saved in the original USB41 module firmware.

As a kind of side challenge I took the USB41 firmware and, with some hurdles and support from Diego, managed to implement these status bits. This also made flags 12 and 13 (Double Wide printing and Lower Case Alpha) behave as in the original HP82143 printer (Diego used these for TRACE and NORM mode). With the experience of patching YPRT I also made a version of the PRINTER 1E ROM to support the updated USB41 with support for flags 15 and 16 for a full implementation of MAN, NORM and TRACE mode. The section below documents the changes to the PRINTER ROM. The USB41 firmware is documented in the sources.

6. USB41 / Clonix changes

Base is the original USB41 firmware by Diego Diaz. The updated sources are commented, below is a summary of the changes

- Starting at HP41 Clock Phase 10:
    - Catch characters `0xD0..0xD7`, the 3 LSB's indicate the printer mode:
        - Bit 0: LCA, Lower Case Alpha -> Printer Status bit 7
        - Bit 1: SCO, Special Column Output -> Printer Status bit 6
        - Bit 2: DWM, Double Wide Mode -> Printer Status bit 5
- Starting at HP41 Clock Phase 11:
    - Catch characters `0xE0` and `0xE7`:
        - `0xE0`: EOLL, set EOL Status bit, clear TEO status bit
        - `0xE7`: EOLR, set EOL and TEO status bits
        - Any EOL type clears SCO mode
        - Any other character clears TEO and EOL status bits
- HP41 Clock Phase 45
    - Output status bit 3, EOL happens here. This was somehow masked by the fact that the output was cleared immediately. By moving the `crlf PORTB` instruction to the next phase this was fixed.

The above changes emulate the regular behavior of the HP82143 printer, and the use of flags 12 and 13 is as originally intended (Double Wide and Lower Case Alpha printing). EOL handling is now correct and there is no need to suppress an extra EOL (one of the settings in the HP82240 emulator in HP82143 mode).

7. Changes to the PRINTER 1E ROM

The original USB41 module uses an unchanged image of the PRINTER 1E ROM. In order to be able to switch between NORM, MAN and TRACE mode (USB41 used flags 12 and 13 for that) changes had to be made to the original PRINTER 1E ROM. Goal was to use flags 15 and 16 for setting the printer mode, as is the case with the HP-IL printer, the DM41X and also the updated V41 HP82143 emulator.

Luckily the printer ROM has an area of NOPs at that can be used at `0x67DD` to `0x67FF`.

Flag 15	Flag 16	Printer Mode
clear	clear	MAN (manual)
clear	set	NORM (normal)
set	clear	TRACE
set	set	TRACE (TRACE with stack is NOT supported)

Flags 15 and 16 are always clear when the HP41 is powered up.

To implement the use of flags 15 and 16 the following changes had to be implemented:

1. Divert the OOPCHK routine at `0x6FDE`. This routine falls through to the exit of FS95 and messed up the regular FNSTS exit here. Replacement code is placed at `0x67F9` in the NOP area from `0x67DD` to `0x67FF`
2. Add additional code to the FNSTS exit at FS90 with a jump to `0x67DD`
3. Remove (set to NOP) the polling entry at `0x6FF8` (IO Service)
4. First function (Printer Name in catalog) is changed to -PRINTUSB
5. ROM Revision is changed to PR-1U (U for USB Print)
6. ROM Checksum is changed to the correct checksum for this ROM

The additional code reads the state of user flags 15 and 16, and sets the printer status flags 15 and 14 accordingly before restoring the CPU registers to the required exit condition. This routine uses the N register to save the C register, as no other register can be used. It turned out that the N register is used by the HP41 system ROM during partial key entry, and this may interfere with ROMs using these features (most notably Ángel Martin's OS/X rom). The Printer IO Service entry is used only to check the status of the printer keys, and since a printer emulator without any keys is used this is not relevant and therefore the IO Service entry is removed (set to a NOP).

The PRINTER 1E rom was patched and tested on an HP41CL calculator using DAVID Assembler, and on an HP41CX with an MLDL2000, also using DAVID Assembler. The final resulting ROM image was transferred to a host PC with the MLDL2000. Some minor patches (like removing the polling entry) were done directly on the ROM file with a HEX editor. The ROM file was turned into a .asm source file for the PIC assembler using the Clonix/NoVRAM configuration utility, and then manually edited to change the base address. The Clonix/NoVRAM configuration tool conveniently calls the PIC assembler, generates the .HEX file and launches the PIC programmer software.

Modified PRINTER 1E code at `0x6D7E` (part of FNSTS):

```
6D7E   OOPCHK 3E5    ?NC GO OOPEX  67F9   ; modified OOPCHK exit
6D7F          19E
6D80          000    NOP
6D81   OOP20  3D8    NOP
6D82   FS95   37C    RCR    12
6D83          375    ?NC GO RDFL   67DD   ; jump here to our extra code to read the flags
6D84          19E
```

Code to read user flags and set printer flags (originally a NOP area in PRINTER-1E ROM):

```
67DD   RDFL   3D8    C<>ST              ; we now have the correct exit in C
67DE          070    N=C                ; save C in N
67DF          144    CLRF   6           ; clear printer status bit 14
67E0          284    CRLF   7           ; clear printer status bit 15
67E1          3B8    READ   14(d)       ; read system flags
67E2          1BC    RCR    11          ; put flag 15+16 in position
67E3          1FA    C=C+C  M           ; if f16 was set, this will set the carry
67E4          013    JNC    RDFL10 +02  ; not set
67E5          148    SETF   6           ; set printer status bit 14
67E6   RDFL10 1FE    C=C+C  MS          ; put f15 in position
67E7          1FE    C=C+C  MS
67E8          1FE    C=C+C  MS
67E9          1FE    C=C+C  MS          ; if f15 was set, this will set the carry
67EA          013    JNC    RDFL20 +02  ; not set
67EB          288    SETF   7           ; set printer status bit 15
67EC   RDFL20 0B0    C=N                ; restore C
67ED          3E0    RTN                ; and exit


                                        ; code below is an exact copy of original
                                        ; printer code at 67DE-6784
67F9   OOPEX  00C    ?FSET        3     ; jump here from OOPCHK
67FA          013    JNC    OOP11 +02
67FB          248    SETF         9
67FC   OOP11  3D8    C<>ST
67FD          37C    RCR          12    ; original here is from FS95
67FE          3D8    C<>ST
67FF          3E0    RTN
```

All sources of the -PRINTUSB firmware files are available on my GitHub repository (see references). There are no sources ready for an assembler of the modified printer ROM image due to the method of modification. A complete side by side listing in Excel of the of the original PRINTER-1E and the -PRINTUSB rom's is available. The original printer listing is created by disassembling the rom file using the ROMHandler.

8. Use of the -PRINTUSB ROM

The -PRINTUSB ROM can be used as any other HP41 module and is intended to be used with the HP82240 simulator (for Windows) as designed by Christoph Giesselink. The -PRINTUSB ROM image must always be plugged in Page 6 (which should normally be the case for a complete USB41 module). It is possible to add other ROM images to the module with the Clonix/NoVRAM configuration unit.

8.1. Instructions

With the USB41 plugged in the HP41 and connected with a Host computer nearly all printer functions can be used in combination with the HP82240 emulator in HP82143 mode.

MAN, TRACE and NORM mode can be set with the User Flags 15 and 16. These flags are always clear when the HP41 is powered on.

Flag 15	Flag 16	Printer Mode
clear	clear	MAN (manual)
clear	set	NORM (normal)
set	clear	TRACE
set	set	TRACE (TRACE with stack is NOT supported)

The behavior of User Flag 21 is not changed. Double Wide and Lowercase modes (User Flags 12 and 13) behave as in the original HP82143 printer. Flag 55 will always test as set when USB41 is plugged in Port 6, even when the serial cable is not plugged in a host computer.

The power consumption of the HP41 with the USB41 module plugged will typically be a bit higher than normal. Please refer to the original Clonix/USB41 documentation for further details.

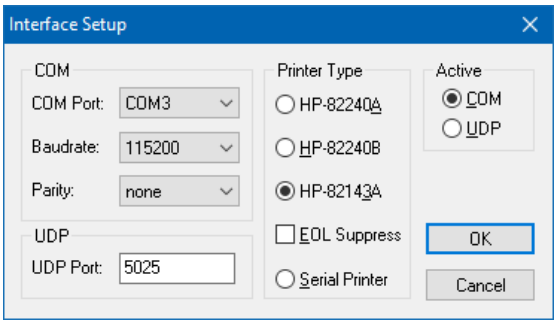
8.2. Printer simulator on the host computer

-PRINTUSB is designed to work with the HP82240 printer simulator developed by Christoph Giesselink (see references). *This program is available for Windows only*.

After plugging the USB cable of the USB41 module in your computer start the program and select File -> Settings -> Interface Setup and select the following:

- Ensure that COM mode is selected (not UDP) for operation with a COM port
- Select the proper COM port. The port number may vary depending on your configuration. The exact port may be verified by going to the Device Manager of your system.
- Select a baud rate of 115200 and no parity
- Select the HP82143A Printer Type
- The option EOL is for special applications and is not needed for normal use

Do not forget to enable graphic (in the application main window) in case you wish to print graphics. Double Wide printing applies to graphics mode only. For further details please refer to the documentation for the HP82240 simulator. As a special remark be aware that in HP82143A mode the print buffer is larger than in the original printer, also in graphics mode.



8.3. Limitations

The current version of -PRINTUSB / USB41 has the following limitations:

- The -PRINTUSB / USB41 module uses Page 6, make sure this page is not used by any other device in your calculator (other Clonix/NoVRAM, HP41CL, MLDL)

- A print buffer is not implemented in the module, this is in the printer simulator on the host computer. The HP82240 emulator in HP82143A mode actually implements a larger printer buffer (also for graphics). This means that any original limitations due to the print buffer size of the HP82143A printer are not relevant
- There is no throttling or handshaking of the serial stream of print data
- The baud rate of the serial port is always set to 115200 baud by the USB41 module. The speed of the serial port on the host computer must be set accordingly
- The number of the COM port on the host computer may vary
- The printer is always detected as powered on, even when no host computer is connected and Flag 55 is always set
- Plug and unplug the USB41 module only when the HP41 is switched OFF!
- There is no detection of printer buttons, printer status or out of paper
- The -PRINTUSB ROM image and the USB41 module can only be used in a real physical HP41 calculator (HP41C, CX and even the HP4CL). Do not attempt to use the ROM image on V41 or the DM41X. It will probably work but is not tested.
- Do not plug the USB41 module in a calculator together with the original HP82143 or in combination with the HP-IL module when the Printer of the HP-IL module is enabled

Remember that with the USB41 module plugged the power consumption of the calculator is higher.

8.4. Configuration

-PRINTUSB is available in a number of configurations:

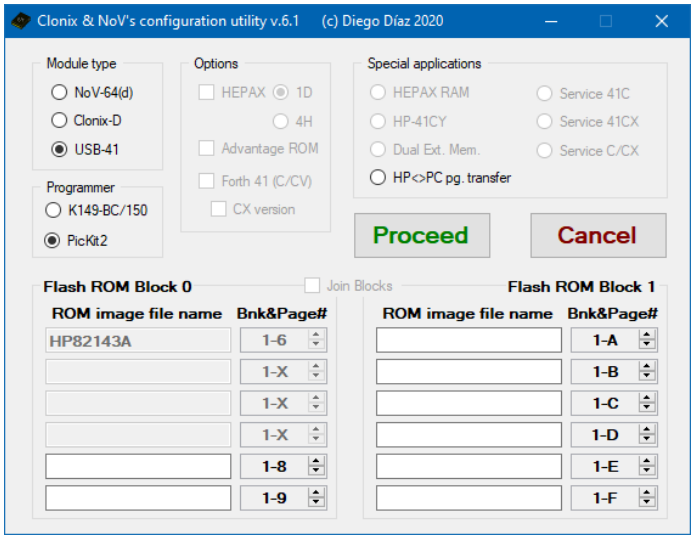
- Complete pre-programmed USB41 module with cable (available from Diego Diaz)
- HEX file with updated firmware and -PRINTUSB ROM image included, ready for programming in your own USB41 module (using one of the available programmers)
- HP41 ROM file (cannot be used to program the USB41 module with the ClonixConfig tools), provided just for information
- Excel workbook with the documented changes to the original PRINTER 1E ROM
- Sources files in .asm format of both the -PRINTUSB ROM image and the modified USB41 firmware sources, ready to be recompiled by the Clonix/NoVRAM configuration utility

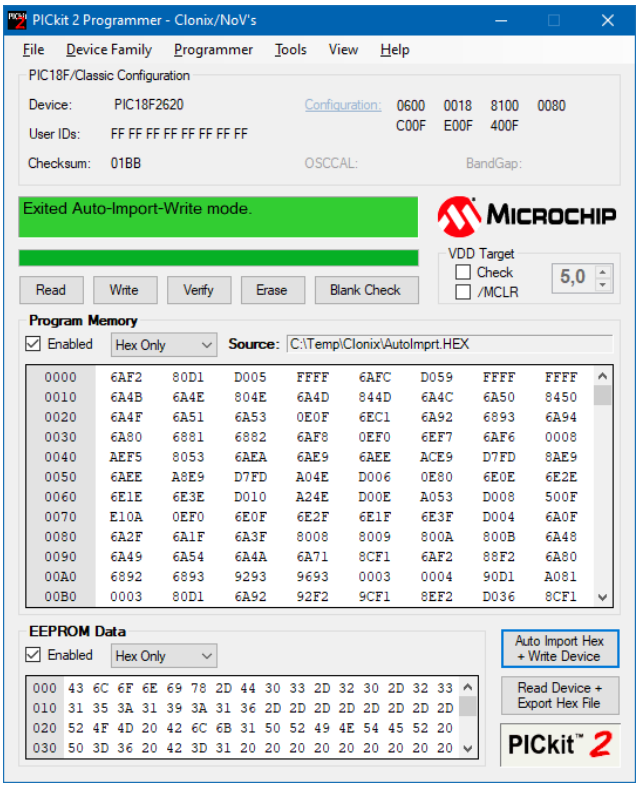
Reconfiguration, changing sources files, recompilation and/or re-programming of an existing or new USB41 module is entirely at your own risk.

To configure the USB41 module with the updated firmware you can follow the process below:

- Use your own Clonix/NoVRAM programmer and the Clonix Configuration utility (ClonixConfig61 for Windows). For documentation and download see the www.clonix41.org website (see references) and first read the documentation provided. Make sure that all required tools (MPASM and the programming utility) are installed in you host computer. The source files Clonix-P.asm (the modified version, but with the same name as the original !) and the printusb.asm (modified PRINTER-1E ROM) must be present in the current directory. In the configuration utility select the following:
    - Under *Module type* select USB-41

- Under Programmer select your programmer type and click **Proceed**
- Connect your programmer to your computer and insert the USB41 module
- If successful this will open a window if the assembly succeeded. Now click OK to open the programming tool. At this point you can click on the button [Auto Import Hex + Write Device]





9. List of files

File	Description
USB41 HP82143 Update.pdf	This document, description of the project and manual
Clonix-P.asm	Source file for PIC2620 processor in USB41 configuration with modifications to support HP82143A graphics printing. This file has the same name as the original file, this is needed for correct assembly
PRINTUSB.HEX	HEX file for programming the USB41 module. No need to do the assembly, simply load this file in the programmer.
printusb.asm	Source file as included in Clonix-PRINTUSB.asm with the ROM image for the modified PRINTER-1E module
PRINTUSB.rom	ROM image file for -PRINTUSB. This is provided for reference or disassembly or possible other use. This file is not needed for assembling the programming file for the USB41 hardware. Do not use this ROM image an MLDL device, V41 emulator, DM41X or HP41CL.
USB41 Printer Workbook.xlsx	Excel file with the original PRINTER-1E source and -PRINTUSB side by side for comparing. The second sheet contains development notes

10. References

Reference	URL	Description
USB41, Clonix, NoVRAM and HP82143 emulator	https://www.clonix41.org/	Diego's website with hardware plug-in configurable modules, and the original USB41 printer emulator
HP82240 printer emulator	www.hp41.org and https://hp.giesselink.com/hp82240b.htm	HP82240 and HP82143 printer simulator for Windows
V41 emulator	www.hp41.org and https://hp.giesselink.com/v41.htm	HP41 emulator for Windows
HP Museum Forum	https://www.hpmuseum.org/forum/index.php	The best place to get help and general information
HP41.org	www.hp41.org	The best source for manuals, books, ROM images
YPRT	https://systemyde.com/hp41/documents.html	HP82143 serial printer ROM image for the HP41CL. Manual in the link, the ROM image itself is in the set of FROM files.
USB41-HP82143	https://github.com/mjakuipers	Repository for my own HP41 creations, including sources and other files for this project
Printer Study by Doug WIlder	www.hp41.org	In-depth study of the HP82143 ROM and the printer operation

11. Change log

Version 0.9	April 2023	Initial version for beta release
Version 1.0	August 2023	Final release after beta testing, no changes to the code. Documentation updates.