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FEATURES

Extends RAM from 576K to 1088K

Adds Real Time Clock/Calendar

Adds A8PicoCart Capabilities

Adds SDrive-ng Mass Storage

Adds Full FujiNet Functionality

PRODUCT DESCRIPTION

This single do it all expansion board for the 576NUC+ alternative Atari 8-Bit computer system covers most if not all of the extra features one could ever want.

The original RAM of the 576NUC+ has been boosted up to a whopping 1088K, thus allowing large footprint games such as AtariBlast to be played from an SD card.

A Real Time Clock/Calendar has been included with 100% ICD R-Time 8 Cart compatibility.

And although it lacks a real cartridge port as normally seen in the Atari factory built systems, it makes up for this with an embedded A8PicoCart which provides multi-cart capability via its onboard flash storage, having the same speed of a physical cartridge.

Last but not least, we have the choice of two SD mass storage devices. The default SDrive-ng or the optional FujiNet which also sports Wi-Fi networking and printing via a FujiNet plug-in module.

Note: Only one of the SD devices is available at any given time, since both share the single SD card slot.



576NUCplus4 3D Printed Case

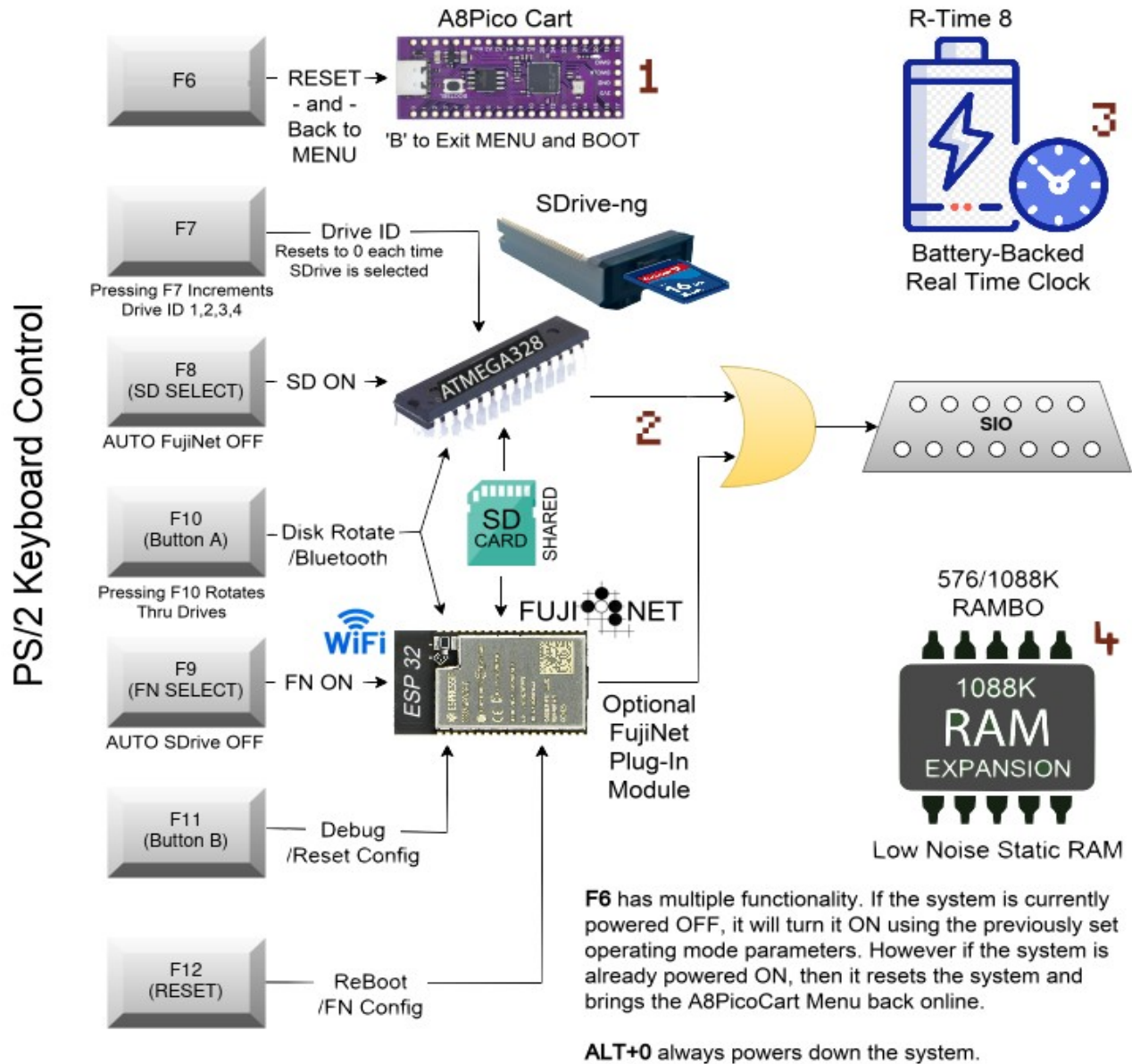
Note: The 576NUC+ embedded PIC16F1847 needs to be re-flashed in place, and thus requires a programmer such as the JOY2PIC or a PICkit. And while you're at it, the two PIC12F629 chips can be flashed with the same programmer(s). FujiNet and the A8PicoCart boards are flashed via a USB-C cable from a PC or MAC. The ATMEGA328P and the ATF22V10C-15PU chips can be flashed with a TL866II Plus programmer.

TBA ORDERING INFORMATION

PART NUMBER	FUNCTION
NUCplus4-Main	Main Daughter Board
NUCplus4-FN	FujiNet Plug-In Module
NUCplus4-Case	3D Printed Case with Hardware
NUCplus4-Chips	Hard to get and/or chips that require programming

Operational Block Diagram

576NUCplus4 Ultimate Expansion System

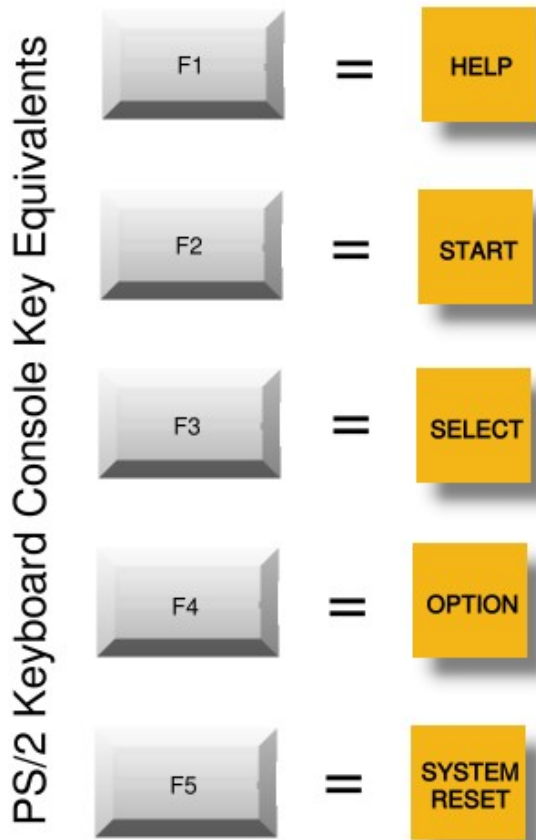


The A8PicoCart menu appears automatically following any power-up cycle. To exit this menu, “B” needs to be pressed which will initiate a cold reboot and disable the A8PicoCart. **F6** returns you to the A8PicoCart menu.

ALT+ ~ ,1,2,3,4 selects the operating mode configuration and power cycles the system.

The choice of SDrive or FujiNet is a non-volatile setting which might require a re-boot upon change. Although many times the transition between the two can be seamless, I wouldn’t suggest counting on it.

Console and Other Key Commands



The PS/2 function key mapping mimics the XEGS Console's Button Order from left to right (Start, Select, Option, Reset) as well as matches the Altirra emulator assignments for all except the Help key.

Other Key Commands

ALT+A = Arrow Mode Toggle (STD or CTRL'ed)
 ALT+Q = Quick Arrow Mode Toggle (fast moves)
 ALT+F = Macro Show Basic Free Memory
 ALT+R = Macro "RUN"
 ALT+L = Macro "LIST"
 ALT+C = Macro "CAR" (SDX Command)
 ALT+B = Macro "BASIC" (SDX Command)
 ALT+W = Macro Show Website Address
 ALT+? = Macro Show Firmware Version
 ALT+Insert = Special Editing Mode Toggle

Scroll Lock = CTRL+1 (start/stop listing)

Pause/Break = Atari Break Key

PS/2 ~` key (upper left) = Atari Inverse key

SHIFT or CTRL+Home = Clear Screen

Non-Volatile Commands

CTRL+ALT+K = Sequentially Select KeyMap 1-4

CTRL+ALT+V = VGATE Mode Toggle

CTRL+ALT+S = Screen Saver Toggle

ALT without CTRL Shows Present State

Operating Mode Commands (this is also how you turn the system ON or OFF)

HOT KEY	SLOT	RAM	OS	MODIFIER	POWER
ALT+0	---	---	---	---	OFF
¹ ALT+ ~	---	1088K	1	CONTROL	ON
ALT+1	1	576K	1	---	ON
ALT+2	2	576K	2	---	ON
² ALT+3	w/SELECT = 3	576K	1	SELECT	ON
² ALT+4	w/SELECT = 4	576K	2	SELECT	ON

¹ Pressed without CONTROL = OS 1, pressed with CONTROL = OS 2

² When exiting the A8Pico Menu (pressing B): Pressing SELECT will enable SLOT assignment. Because the system always powers up with the A8PicoCart active, in order to run a selected SLOT "B" needs to be entered from the A8PicoCart menu which will deactivate the A8PicoCart and do a cold reboot of the 576NUC+. The cold reboot means that SLOT 3 and 4 will not be present without first holding SELECT because they are XEGS GAME SLOTS which behave differently.

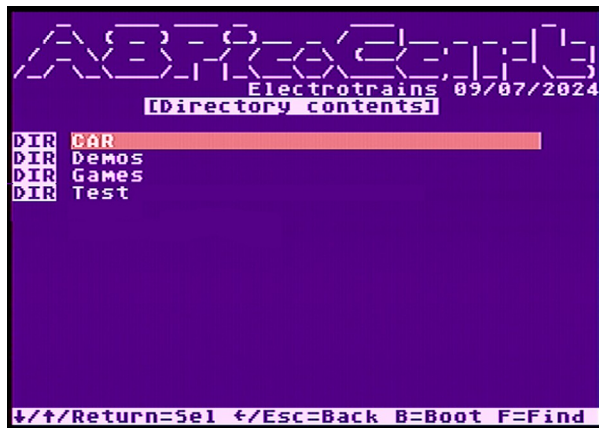
Operational Scenario

System Start-Up

To start-up your 576NUCplus4 system you have two basic scenarios. The first of which is to use the ALT+ ~ , 1,2,3,4 Operating Mode Commands talked about in the previous section. These not only turn on the power, but also select a system ROM configuration that is to be used (OS, SLOT, and RAM size).

The 2nd method is to press the F6 key which will turn on the power while retaining the Operating Mode that was previously selected.

In either case you should be greeted with the A8PicoCart Menu as seen below.



Essentially this is the “desktop”, and F6 will always return you to this menu.

From here you can either navigate what is contained in the A8PicoCart’s Flash Memory using the PS/2 arrows and other navigation keys (or the joystick), and then launch an app with the return key (or joystick trigger), or you can exit this menu by pressing “B”.

When exiting you’ll pass control to the active SLOT and either SDrive or FujiNet (these are selectable by either F8 or F9 respectively). If the SDrive is the active selection and its SD card is removed, no internal drives will be active.

The SDrive and FujiNet selections are non-volatile same as the Operating Mode selections, both of which are restored when resetting the A8PicoCart via the F6 key.

If you run a 128K customized version of SDX incorporating the FujiNet “FMALL” command from a CAR image on the A8PicoCart, it is possible to access FujiNet assigned drives directly via SDX by issuing that command to mount all FujiNet drives. This requires => divisor 3 setting for FujiNet.

Also when running SDX with R-Time 8 support you will have direct access to the built-in R-Time 8 clock and calendar chip of the NUCplus4. Using the SDX TIME and DATE commands you’ll be able to set it, and by entering the TD ON command, activate the on screen time/date line.

More Information

For more specific information about the SDrive and FujiNet aspects use these links...

<https://atari8bit.net/tutorials/de-re-sdrive-max/>

<https://fujinet.online/>

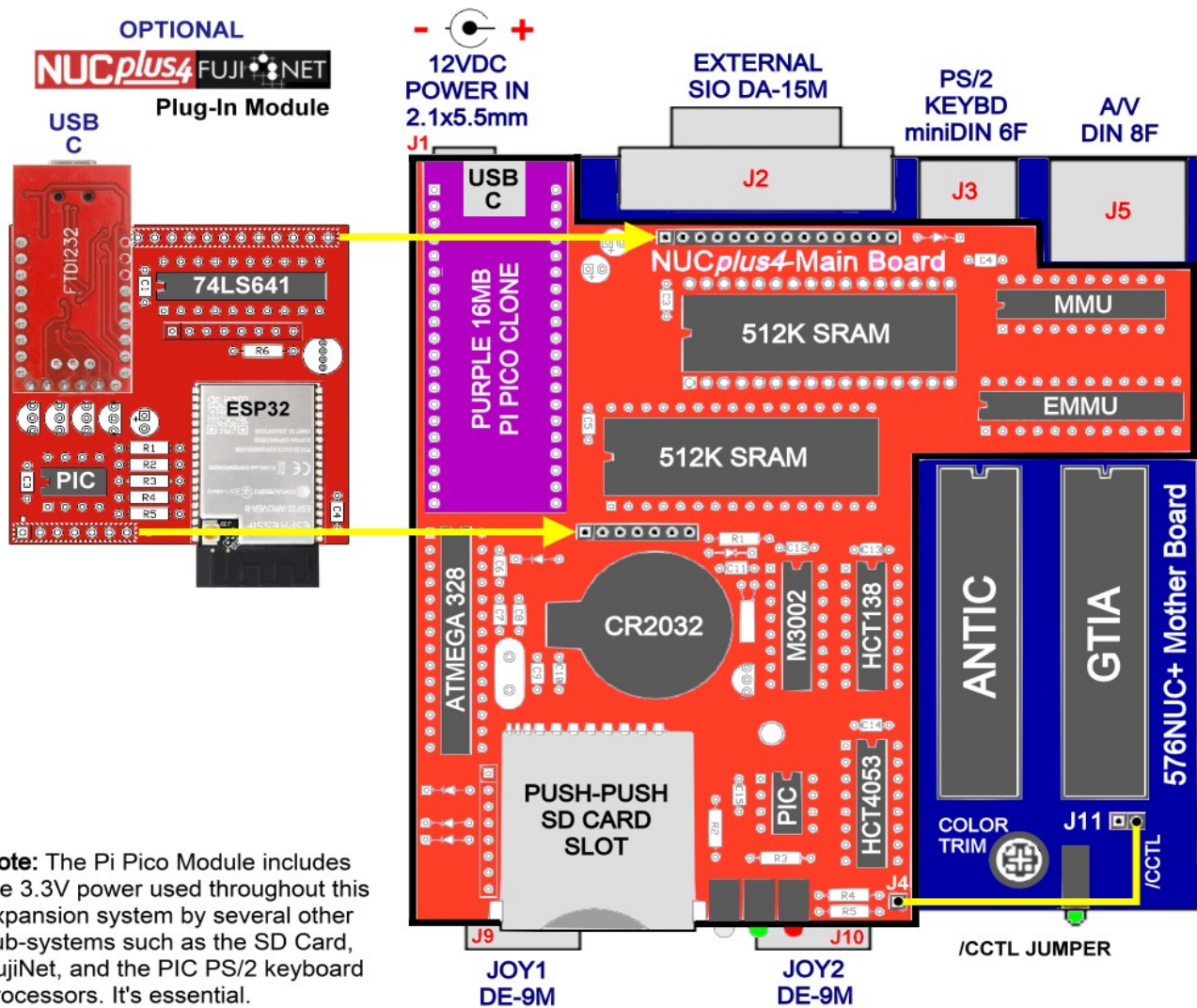
There is also a more universal version of the SDrive Control Program incorporating commands that take advantage of the PS/2 keyboard’s enhanced navigation aspects available at this link...

<https://ataribits.weebly.com/tk-ii-control.html>

Shutting OFF the System

There is no independent physical power switch like on a stock Atari system, so pressing ALT+0 (zero) on the PS/2 keyboard will effectively kill power to the system.

NUCplus4 System Layout



This is a Plug 'n' Play no soldering required installation, with only one jumper wire needed to pick up and route the /CCTL signal between the mother board and the daughter board.

The MMU is an Atari XEGS version, whereas the EMMU is a custom flashed SPLD chip for 1024K extended RAM which is specific to the NUCplus4 (also the 576NUC+ TK-II needs new firmware flashed to it as well).

Both PICs are custom coded as PS/2 sub-processors to allow specific function keys to

be assigned as control keys for the various peripherals that have been added in this expansion system.

Although the R-Time 8 clock has battery back-up, it normally runs off of the standby power in the 576NUC+ and only resorts to the battery when the unit is unplugged from the wall. Switch-over between power supplies is unfortunately not seamless, so there may be some glitching to the seconds count, with subsequent errors as a result. In the grand scheme of things these errors are insignificant to the task of time/date stamping files.

Technical Information 576NUC+ and plus4 Expansion

Insert Mode

Toggled via ALT+Insert. allows for a Word Processor like experience from a language such as Basic. When its ON, the Scroll Lock LED will be solidly lit to indicate an active Insert state.

Insert Mode allows entering text at the cursor position while existing text to the right of the cursor gets automatically pushed forward to make room for the new text that you are typing.

Similarly if you press the backspace key, characters are automatically rubbed-out under the cursor as text to right moves over to fill in.

This behavior mimics what a Word Processor normally does, but does so in a non-Word Processing environment. Try it from Basic to see it in action.

Caps Lock and Scroll Lock LEDs

Both of these serve no purpose in the TK-II since Pokey provides no feedback as to the state of either Caps or Scroll. So there would be no way to sync these up with the Atari in this regard. Thus the Scroll Lock LED has been re-purposed as an Insert Mode indicator.

Quick Arrow Mode (Fast Cursor Movement)

When toggled on via ALT+Q, the cursor will double step after a short delay when an arrow key is pressed, quickly traversing the screen in the arrows direction. This defaults to normal speed following a power-up cycle.

Arrow Mode Selection (Arrows vs. Symbols)

Pressing ALT+A toggles between Ctrl+Arrows vs. non-CTRLed Arrows. Normally the system defaults to CTRL+Arrows following a power-up cycle.

Sometimes you'll find a program that wants to see the non-CTRLed symbol on that particular Arrow key for navigating the screen or a menu. In that case toggling the Arrow Mode will give you the symbol, thus allowing that program to work properly.

Screen Saver

The Atari has a built in color cycling attract mode that activates after 9 minutes of no key activity. This is meant to prevent screen burn-in on old CRT televisions. Now days quite a few people use LCD screens instead, and the usefulness of this feature has greatly diminished. So TK-II uses a trick to allow you to deactivate the attract mode, and it does this by sending a single NULL key send (CTRL+SHIFT+A) every 3 minutes, thus resetting the attract mode time out timer. This is considered to be Screensaver = OFF.

To toggle the ScreenSaver ON or OFF, CTRL+SHIFT+S will do the deed.

Key Maps

CTRL+SHIFT+K will sequentially step you through 4 different key map selections (US, DE, UK, A8). The first 3 match up with a given countries unique PS/2 keyboard layout. The last one called "A8" tries to mimic a stock Atari keyboard layout on an ISO keyboard so that one could simply remark certain keys and have it feel like you are actually using the stock keyboard once again instead of the PS/2 keyboard.

VGATE

CTRL+SHIFT+V toggles this mode ON or OFF. When VGATE is ON, it limits over scan to what originally would have been seen on older televisions, and thus eliminates graphical garbage appearing in those areas.

Technical Information 576NUC+ and plus4 Expansion (cont)

System ROM (W27C512 EEPROM)

The 576NUC+ system ROM was based upon the 32K XEGS geometry and duplicated to create a banked version of 64K. So here's what that looks like.

64K System ROM Geometry

ROM ADDRESS	OS BANK	SLOT & OS Areas	SIZE
\$0000-\$1FFF	1	3 (GAME)	8K
\$2000-\$3FFF	1	1 (LANG)	8K
\$4000-\$7FFF	1	OS1	16K
\$8000-\$9FFF	2	4 (GAME)	8K
\$A000-\$BFFF	2	2 (LANG)	8K
\$C000-\$FFFF	2	OS2	16K

\$0000-\$7FFF is the first 32K bank of the 64K EEPROM, and \$8000-\$FFFF covers the 2nd 32K bank, 64K total.

SLOTS 3 and 4 are considered game slots, but can also be used for 8K applications with some particularities (requires holding SELECT function key F3 when exiting the A8PicoCart menu).

SLOTS 1 and 2 are the BASIC language slots, but can be used for any 8K application (e.g., Atari BASIC, Altirra Basic, Fast Basic, Atari Pilot, Assembler/Editor, SpeedScript).

The SLOT # also corresponds to the Operating Mode Hot Key selection, with SLOT 1 equating to ALT+1 and SLOT 4 equating to ALT+4.

Since the SLOTS are tied to a given OS bank, they are forever bound together. So this must be kept in mind when laying out a 64K ROM geometry. For instance the original 576NUC+ ROM had a HSIO patched OS for SLOTS 1 and 3 and a Stock XL/XE OS associated with SLOTS 2 and 4.

Various example ROM Geometries will be made available for download from the AtariBits website, including the individual components of such (Enhanced HSIO and stock XL/XE Operating Systems).

A8PicoCart Menu as the Desktop

As mentioned in the Operational Scenario section of this datasheet, I'm calling this the "Desktop" since it's what launches on every system start-up.

From this "desktop" you instantly have high-speed access to the A8PicoCart's 16MB FAT32 Mass Storage Flash Drive where Atari 8-bit XEX and CAR files can be run at cartridge speeds. As well as limited ATR support, although in many cases the SDrive or FujiNet can step in to give much better compatibility for this file type.

What are the USB-C Connectors for?

The one marked "FN" is for doing updates of the FujiNet firmware. This requires that the 576NUC+ be powered up, since the FujiNet Module derives it's 3.3V power from the Pi Pico module.

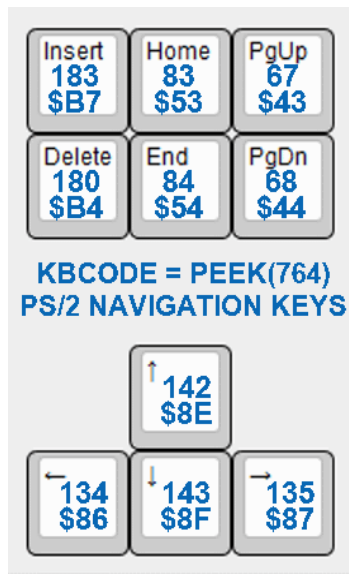
The one marked "PICO" is dual purpose, and can be used to either update the A8PicoCart firmware (by pressing the button on the Pi Pico module prior to USB insertion), or in normal use is presented as mass storage where you can drag and drop FAT32 files and folders from the attached PC or MAC. Those files should be Atari XEX or CAR types, but some ATRs will work as well (mileage may vary). Individual file size limit = 128K

Note: requires having the power OFF in order to update the A8PicoCart, whereas the FujiNet module needs the power ON. Best to pull the power plug, since the keyboard will need a power-up reset afterwards.

Technical Information 576NUC+ and plus4 Expansion (cont)

TK-II Special Navigation Keys

Some of the PS/2 keyboards extra navigation keys have been assigned to the 1200XL Shifted Function keys F1-F4, which are still retained in all XL/XE operating systems.



They are marked Home, End, Page-Up, Page-Down and have found special use in the latest versions of the A8PicoCart and the SDrive disk menu programs, and hopefully someday they'll get integrated into FujiNet as well, thus creating a more uniform user interface across all devices.

They are defined as follows...

HOME CURSOR FUNCTION

TK-II assignment: **PS/2 PAGE-UP**

Atari assignment: **SHIFT- F1** causes the cursor to move to the home position of the screen, KBCODE 43 (decimal 67).

CURSOR TO LOWER LEFT CORNER

TK-II assignment: **PS/2 PAGE-DOWN**

Atari assignment: **SHIFT- F2** causes the cursor to move to the lower left corner of the screen, KBCODE 44 (decimal 68).

CURSOR TO BEGINNING OF PHYSICAL LINE

TK-II assignment: **PS/2 HOME**

Atari assignment: **SHIFT- F3** causes the cursor to move to the far left of the physical line on which it is located, KBCODE 53 (decimal 83).

CURSOR TO FAR RIGHT WITHIN PHYSICAL LINE

TK-II assignment: **PS/2 END**

Atari assignment: **SHIFT- F4** causes the cursor to move to the far right side of the physical line on which it is located, KBCODE 54 (decimal 84)

A8PicoCart & SDrive Navigation Assignments



Move to Start of Directory



Move to End of Directory



Move Up the List
1 Page at a Time



Move Down the List
1 page at a Time



Move Up the List
1 File at a Time



Move Down the List
1 File at a Time



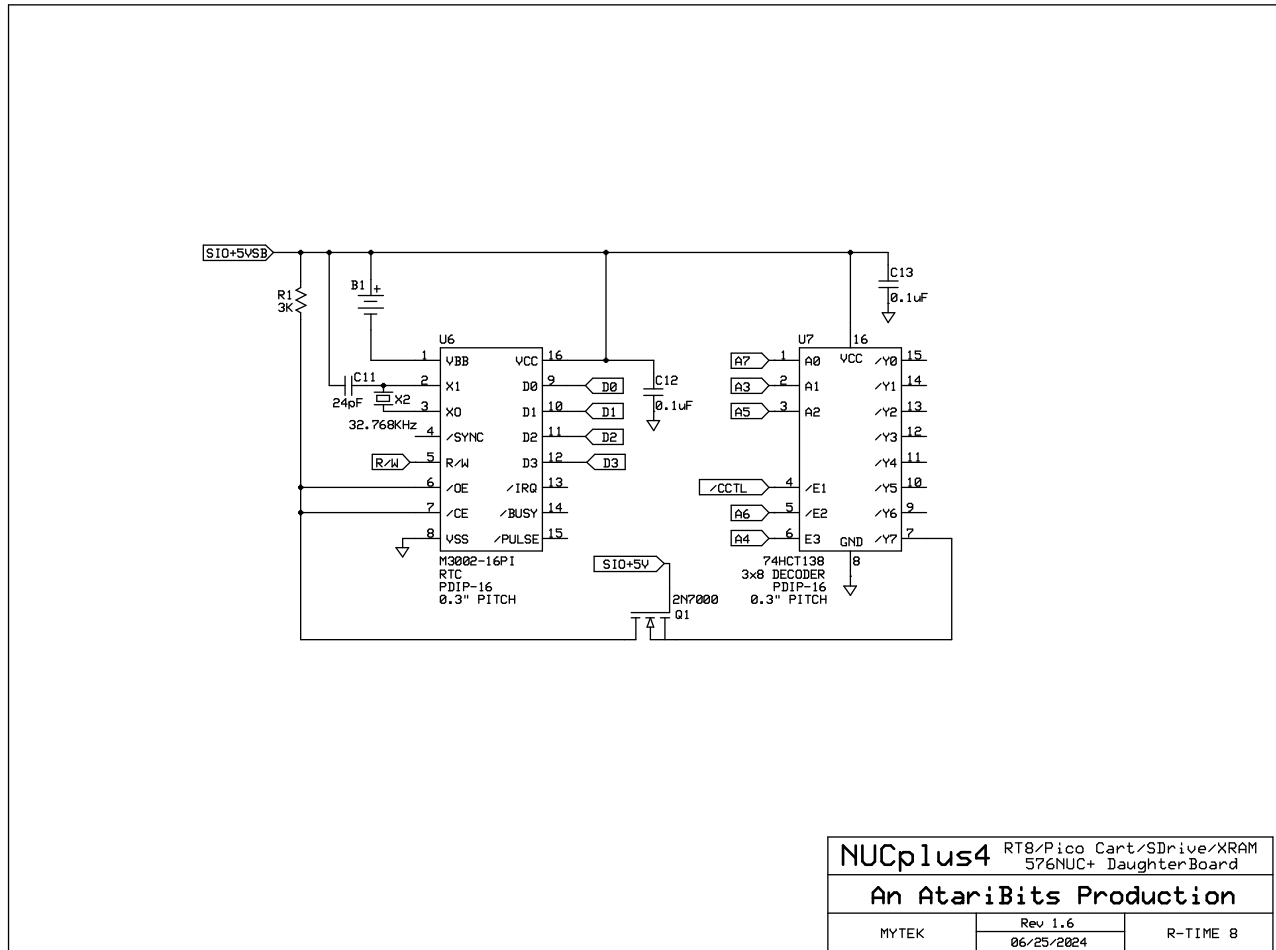
SDrive: the Left/Right Arrows mimic Page-Up & Page-Down

A8PicoCart: the Left Arrow = the "ESC" key

Note: PS/2 Arrows = Atari CTRL+Arrows

Schematics

R-Time 8



The original R-Time 8 was a cartridge developed by ICD in 1985 which added a battery backed clock and calendar function, which was used for time/date file stamping in SpartaDos and SDX.

In this particular application the 576NUC+'s standby 5V power is being utilized to power the clock chip (M3002-16PI) so that even when the system is turned off, clock power is still provided by the wall-wart power adapter. This results in more accurate time keeping, and preserves the back-up battery (CR2032 3V Coin Cell) for when it's really needed.

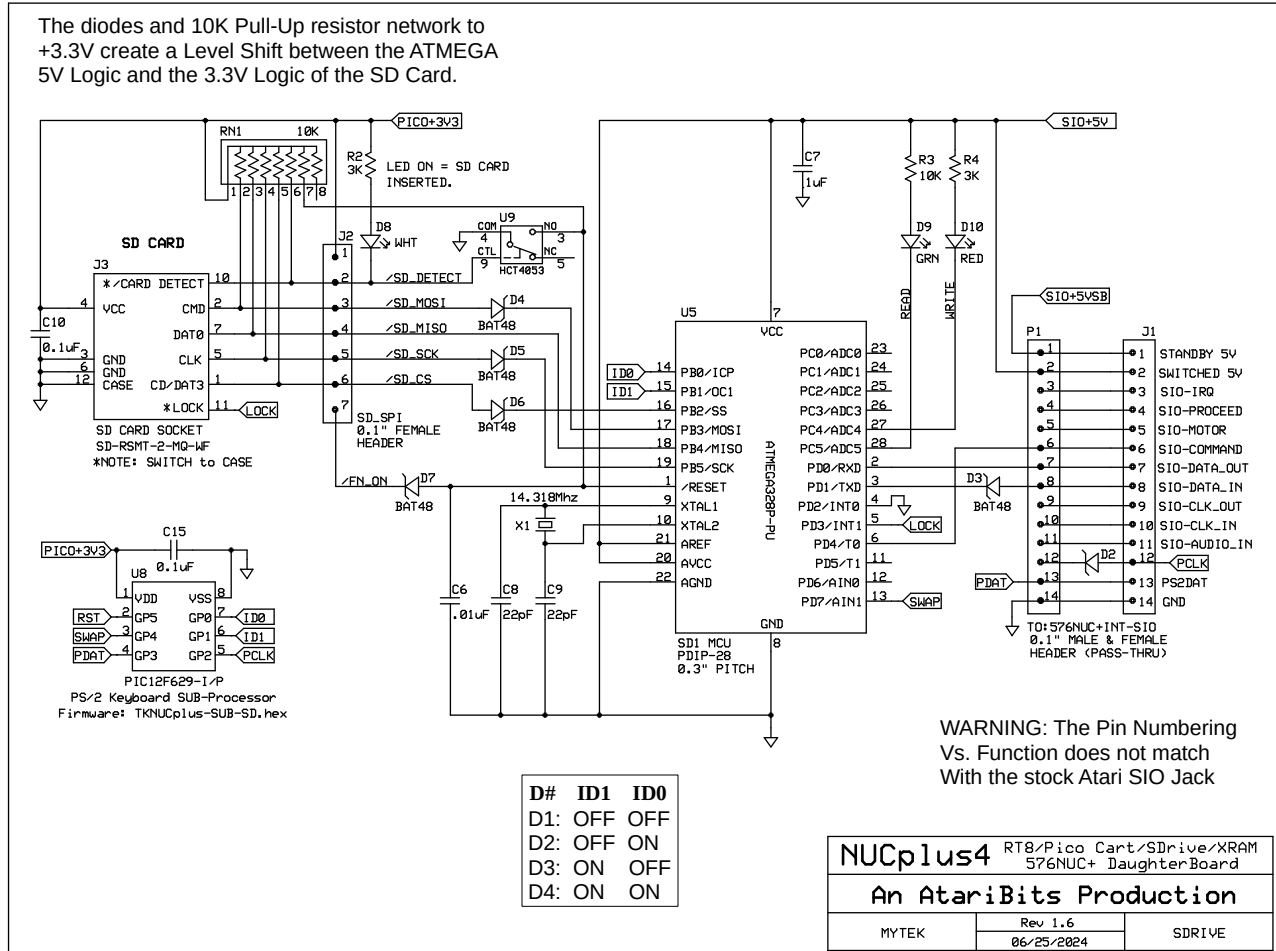
The 74HCT138 decoder chip enables the clock chip at memory address locations \$D5B8-\$D5BF.

To help prevent garbage data from being written to the clock chip during power switching, thereby corrupting the time and date registers, MOSFET Q1 disconnects the chip enable line whenever switched 5V power is not present.

Just like the original ICD cartridge version, when the battery needs replacing, SDX will not see the clock upon start-up, and issue a message that the R-Time 8 is not present.

Schematics

SDrive



The SDrive was first created by Bob!k (Robert Petruzela) and Raster (Radek Sterba) in the year 2008, and then modified in 2014 by AtariAge member Kbr to increase SD Card size and adapt it to the ATMEGA328P.

A Control Program (sdrive.atr) is required to be in the root directory of the SD Card in order to set-up virtual drives 1-4 and to select files to place in those drives. That Control Program and instructions are available at: <https://ataribits.weebly.com/tk-ii-control.html>

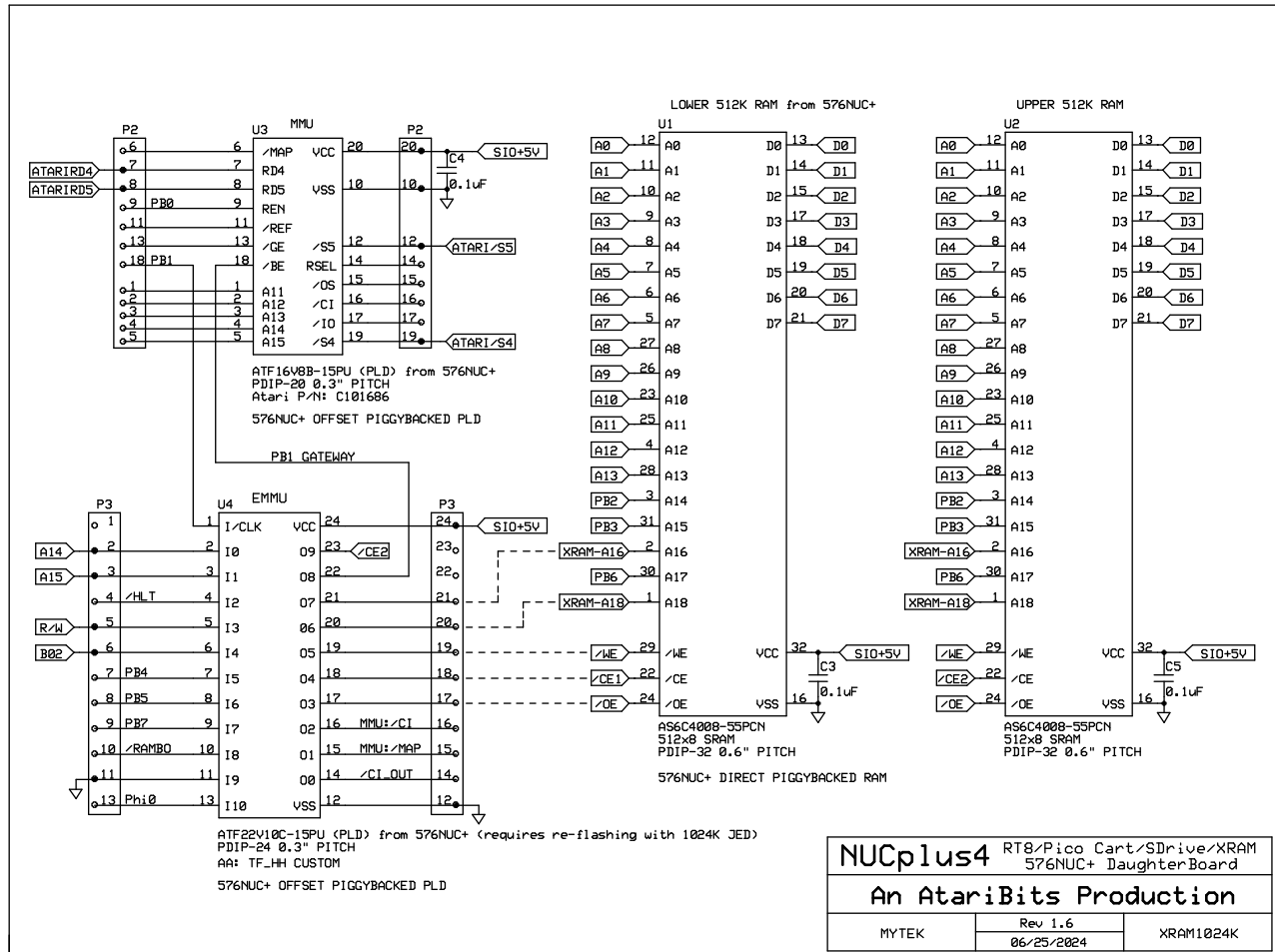
ATMEGA328P FIRMWARE FLASHING PROCEDURE

- Use TL866II Plus to Flash bootloader-sdNG.hex into ATMEGA328P
- Fuse Settings: Lfuse = 0xFE Hfuse = 0x08 Efuse = 0xFC
- Copy sdrive.bin file to root directory of SD Card & Insert card into Drive
- Power-up Drive to load Firmware into ATMEGA328P from SD Card
- After R/W LEDs stop blinking remove SD Card & Erase sdrive.bin

Note: Future upgrades will only require placing the binary update file in the SD Card.

Schematics

1024K Extended RAM



The 576NUC+ got its name from the 576K of onboard memory (64K base + 512K extended). The NUCplus4 extends that all the way up to 1088K.

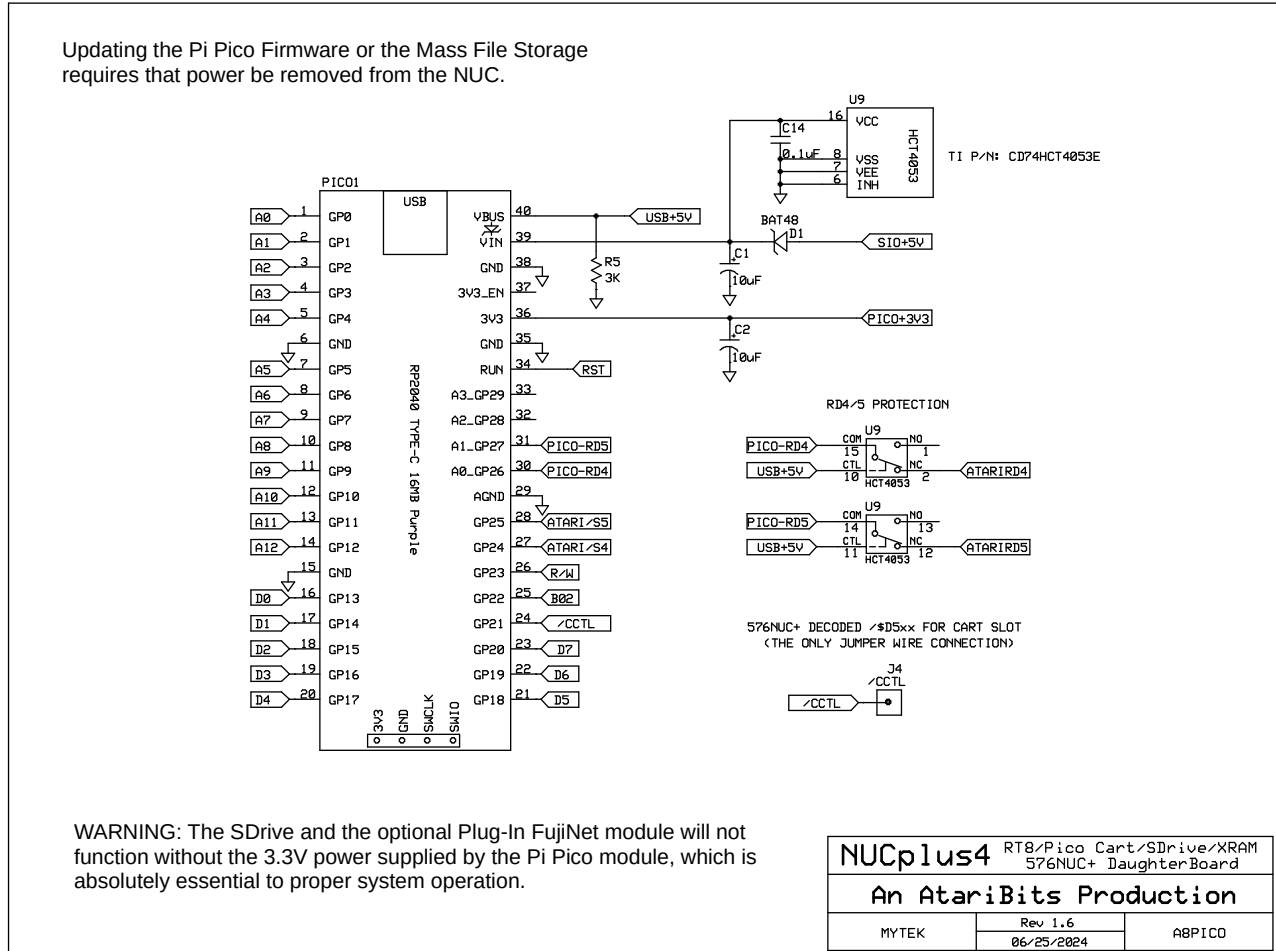
The original 512K hardware was loosely based upon Matthias Reich's (Hiassoft at AtariAge) design. The changes required to bring it up to 1024K of extended memory were created by Jurgen van Radecke (tf_hh at AtariAge) in 2023. This expanded memory design acted as a catalyst which eventually led to the creation of the NUCplus4 expansion system.

The EMMU PLD does require that a new JED be flashed to it in order to recognize the additional RAM. This can be done with the TL866II Plus programmer with the PLD chip out of circuit. The MMU remains the same, being functionally equivalent to the one used in the Atari XEGS.

The /RAMBO pin on the PLD now switches between 512 and 1024K operation, which is automatically executed by the TK-II PIC chip used in the 576NUC+ main board. This does require re-flashing the 576NUC+ embedded PIC16F1847 over to the NUCplus4 Version 1C firmware, via a Microchip PICKit programmer or the AtariBits [JOY2PIC](#) device.

Schematics

Pi Pico A8 MultiCart (aka: A8PicoCart)



This is the Pi Pico version of the UNO Cart also created by Robin Edwards (electrotrains at AtariAge). This new version was developed in 2023 by Robin and utilizes a Pi Pico 16MB purple clone purchased from AliExpress. Both XEX and CAR files are stored and accessed in the 16MB onboard memory.

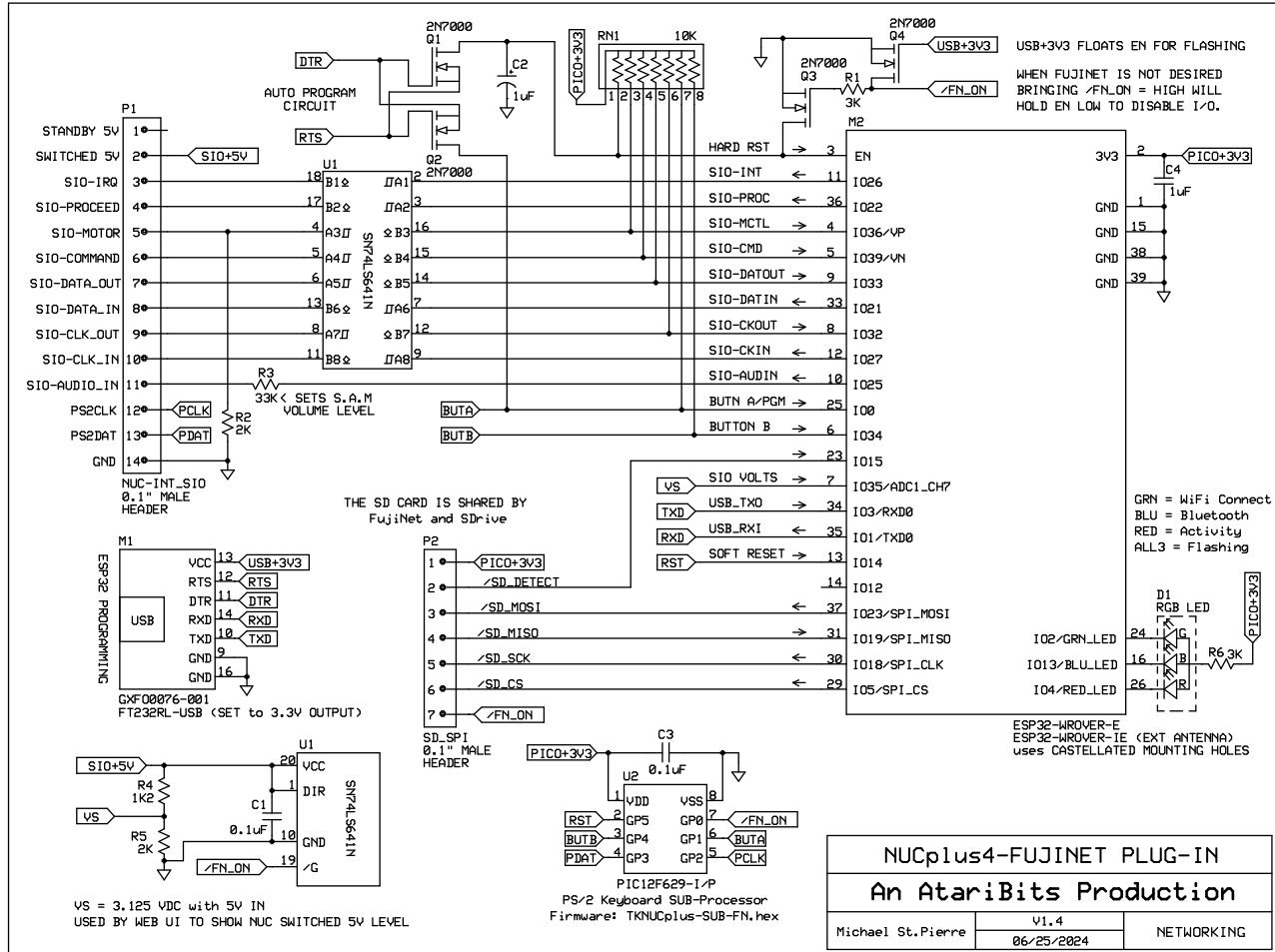
Because of the 5V tolerant I/O no level shifters were required in order to interface with the older 5V based hardware. This has proven to be true due to the many hours of testing by multiple users without a single known failure.

As implemented in the A8PicoCart project ([GitHub](#))...

- The Altirra LLE OS was used by permission from Avery Lee (phaeron at AtariAge).
- The XE Loader and OS modifications were thanks to Jonathan Halliday (flashjazzcat at AtariAge).
- Implementation of PS/2 specific keyboard navigation keys (home, end, page-up, page-down) were implemented thanks to the efforts of AtariAge members manterola and ascrnet.

Schematics

Optional FujiNet Module



This is a re-designed version of AtariAge member mozzwald's FujiNet hardware for the original Atari 8-bit systems. Albeit for expansion of the Atari 576NUC+ custom computer, implemented as a plug-in module for the NUCplus4 daughter board. Aside from the ESP32 module, this is a through-hole based design.

One unique aspect is a single SN74LS641 Transceiver chip has taken the place of the former 2 chip solution for the SIO to ESP interface. The overall design was not only simplified by this change, but also has additional noise immunity because of the Schmitt trigger inputs present on this device.

ESP-32 FIRMWARE FLASHING PROCEDURE (Requires that 576NUC+ is powered ON)

- Connect USB-C cable from PC to FujiNet Module
- With Chrome or Chromium browser connect to [Online FujiNet Flasher](#)
- Select Atari 8-bit Platform and latest firmware version from drop-downs
- Press Connect button and select FT232R USB UART, then press Connect again
- In the following prompts agree to install the firmware, then let it do its thing

Final Notes – some additional info



When updating the 16MB flash memory on the A8PicoCart, it requires that power be disconnected from the 576NUC+ motherboard.

This can be done either by pulling the coaxial power plug or unplugging the power adapter from the wall.

This allows the A8PicoCart's memory to be seen on the PC or MAC side of things, and it also restores PS/2 ON/OFF power control when the power connection is restored. This is something that gets deactivated if you simply shut-off the system via the PS/2 power-off command (ALT+0).



This also brings up an important point. In order for the 576NUC+ to see the PS/2 keyboard when connecting everything for the first time, the keyboard needs to be plugged in first before plugging in the external power pack. Hot plugging the keyboard rarely ever works properly, which is something the PS/2 protocol was never meant to do.

Firmware Flashing Procedure Pi Pico Module (aka: A8PicoCart)



- Disconnect Power
- Press BootSel button
- Plug-in USB-C to PC/MAC
- When a window opens, release the button and drag and drop .uf2 firmware file
- When 2nd window opens disconnect USB from PC
- Update is Done – Firmware has been Flashed!

You are now ready to add files to the cart.

Alternate A8PicoCart Reset

Pressing F6 will reset the A8PicoCart and take you back to its menu. However this is a full cold reset which will clear memory. Usually this is the most fool proof way to get back to the menu. However for a softer approach pressing CTRL+F6 will only attempt a warm boot of the system, thus retaining system memory, which may be preferable in certain situations. However it doesn't always work properly to bail you out of whatever game or program may be running, whereas pressing F6 all by itself will.

Using CTRL+F6 to Save the SDrive Assignments

Normally the SDrive will lose all of its drive slot assignments when the 576NUC+ is powered-down. However by using CTRL+F6 you can exit the SDrive Control program without losing those assignments or the current SIO divisor setting, and get yourself back to the A8PicoCart Menu. From there you can launch into an SDX car image and have full access from within SDX to work with DOS formatted ATR disk images that were previously assigned to SDrive Slots 1-4.

The only caveat is that you must have an SDrive divisor setting of 4 or above in order for SDX to properly access those drive slots. Anything less will probably cause a system lock-up.

The NUCplus4 as a DIY Project

Hopefully an Assembly/Installation manual will be forthcoming. However to build one of these requires quite a bit of PCB assembly skill at a fairly high degree of expertise. The manual will only cover the basics, and assumes that whoever takes on this venture brings their best game to the table.