GPIB Flash Drive User Guide for Tektronix 4050 computers

ABSTRACT

User Guide for my GPIB Flash Drive designed to support Tektronix 4051, 4052/4052A, and 4054/4054A computers.

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1. Background

Tektronix 4051 computer system was introduced in 1975 at the dawn of the personal microcomputer. The 4051 was a complete system including a Motorola 6800 microprocessor, up to 32KB of RAM, 32KB of BASIC ROM, integrated 1024x780 vector graphics with 11-inch direct-view storage tube (DVST) monitor, internal tape drive using 3M DC300 300KB data cartridges, integrated keyboard, graphics hard copy interface, joystick interface, GPIB interface, option ROM backpack with two-slots, and optional RS-232 serial interface.

Figure 1 - Tektronix 4051 computer with optional Tektronix 4924 GPIB tape drive and GPIB cable

I used a Tektronix 4051 for three years at work in the late 1970's and developed several graphics simulation programs including submission of a Cubic Spline Interpolation program to the Tektronix 4050 Application Library. The Tektronix 4051 was one of the first personal computers and was the first personal computer I had ever used. The 4051 can also be considered one of the first personal graphics workstation computers.

I collected and repaired a Tektronix 4052 computer in 2000, followed by a Tektronix 4054 computer, and found two other people that had collected 4051 computers. We began trying to share 4051 tapes we each had with various 4051 games and discovered that duplicating DC300 tapes was the only reliable way to share. As a computer design Electronics Engineer at Compaq Computer, I began trying to use the 4052 integrated GPIB interface connected to my PC

using the parallel port but quickly found the lack of PC support for GPIB made the GPIB interface too difficult to use for computer to computer communication.

I then wrote a BASIC program for my Tektronix computer to send files from Tektronix tape over RS-232 to my PC and found that the Tektronix made heavy use of control characters for printing. These controls characters were not understood by PC text editors that I had at the time, so my 4050 BASIC program converted all the control characters except CR into a 3-character sequence that I believed would not occur in Tektronix programs: "~X~" where X was the ASCII character typed on the Tektronix with the CTRL key. This serial program was cumbersome to use on more than a couple of files on a tape and was limited to 2400 baud on a 4051 or 9600 baud on the 4052 and 4054 so I did not recover many programs to my PC using this technique. My program also included delays to accommodate time to process the received data and delays to prevent overrunning the 4052 or 4054 if sending a program from the PC.

After copying several tapes and sending them to my new 'Tektronix 4050' friends, I lost interest in my Tektronix computers until I discovered and joined the vcfed.org website in 2018 and found a new set of people that had collected and restored Tektronix 4050 computers and had attempted to archive a couple of data tapes to their PCs.

I then dusted off my Tektronix 4052 and 4054 and found they both needed some repairs – but worse than that I found my data tapes that had worked in 2000 had broken tape belts and could not be used. Researching this issue on the web, I found this was common, and although other materials had been tried as data cartridge tape belt replacements – they had mixed results including short life.

During this search I encountered several websites that offered solid state drives as replacement for some vintage computers using these tape cartridges, however it appeared these solid state drives only worked with specific computers – such as vintage HP or Commodore computers, and I could not find anyone that had developed a replacement for the Tektronix 4050 series computer tapes and drive.

I posted on vcfed.org a thread "Tektronix 405x GPIB Flash Drive" in June 2018 and got several strong positive reactions, and in my second post in this thread I referenced a website that had used an Arduino to create a GPIB CONTROLLER. I wired up an Arduino based on their instructions – but the Tektronix 4050 computers could only operate as the GPIB MASTER CONTROLLER and communicate with GPIB DEVICE CONTROLLERs.

I found an interesting GPIB project on eevblog.com called AR488. This project turned an inexpensive Arduino board into a GPIB MASTER CONTROLLER that emulated the commands of a ProLogix GPIB MASTER CONTROLLER. I posted in this thread my interest in developing a GPIB DEVICE CONTROLLER which emulated the Tektronix 4924 GPIB Tape Drive. The author of AR488 accepted the challenge and we have created the Tektronix 4050 GPIB Flash Drive and tested it on a Tektronix 4051, 4052 and 4054A computers using hundreds of programs that I have recovered from Tektronix 4050 tapes, and many programs that I have written.

2. Flash Drive Overview

The Tektronix 4050 GPIB Flash Drive works with the entire series of Tektronix 4050 computers including the 4051, 4052, 4054 and A-Series 4052A and 4054A and does not require an Option ROM Pack to access programs or data. However, some of the programs on the Flash Drive do require option ROM Packs.

I have modified some of the tapes I have recovered to support the Flash Drive. The modifications are relatively simple – change any internal tape command to direct the command to the Flash Drive at GPIB primary address 5. My curated programs for the Flash Drive are posted in my github repository here:

https://github.com/mmcgraw74/Tektronix-4051-4052-4054-Program-Files/tree/master/Flash_Drive.

Some of these programs require an optional ROM Pack. One of the most interesting Tektronix ROM Packs is the R12 Graphics Enhancement ROM Pack which provides accelerated vector graphics performance (also called Fast Graphics by the primary author of the R12 ROM Pack) and even plays PWM (pulse-width-modulated) music on the Tektronix 4050 speaker! This ROM Pack was sold by Tektronix for both the 4051 and 4052/4054 computers. However this R12 ROM PACK is very rare. I found one person with an R12 ROM Pack and borrowed the ROM PACK to download the EPROMs and posted the files to my github repository. I created an R12 ROM Pack by erasing the EPROMs in a 4052 FFT ROM Pack and reprogramming them with the R12 code.

I later worked with Jos Dressen to reverse engineer my 4050E01 8-slot ROM Expander and Jos designed his 4052/4054 Multi-Function ROM Pack that has a single EPROM large enough to hold 8 4052 ROM Packs and he had room to add the 4052 RS-232 Printer Interface hardware and the TransEra RTC-741 Real-Time-Clock hardware based on my help reverse engineering the RTC-741 ROM Pack that I had in my collection. Jos still offers his 4052 Multi-Function ROM Pack to 4052 or 4054 owners.

I also had several 4051 ROM Packs in my collection and captured and uploaded their ROM images to my repository including the 4051R05 BINARY PROGRAM LOADER. This ROM Pack adds the capability for the 4051 to save and load BINARY programs to internal tape or external Tektronix 4924 GPIB Tape Drive. Since the Flash Drive emulates a 4924 GPIB Tape Drive – this R05 ROM Pack allows a 4051 to load and save programs in BINARY format. The BINARY programs load about 3 times faster than ASCII programs – since this format can be copied directly into 4051 RAM without needing to be parsed and tokenized by 4051 BASIC. This is such a big performance improvement that the 4052 and 4054 BASIC included the BINARY PROGRAM Calls in the 4052 and 4054 BASIC ROMs.

Fortunately, vintagetek.org sells a MAXIROM Pack for the 4051 on EBAY that contains the both the Fast Graphics 4051R12 Graphics Enhancement ROM and 4051R05 BINARY Program ROM and eight other 4051 ROM Packs!

Jos also had the Tektronix 4052/4054 Diagnostic ROM Pack which is essential in troubleshooting RAM or ROM errors. He designed an equivalent Diagnostic ROM Pack – which I used to extend the ROM CRC checks to all the option slots and ROM Expander slots – such as the 4050E01 which I have and the Multi-Function ROM Pack which emulates the 4050E01.

Bottom line on the option ROMs – some of the programs I have included in my Flash Drive program image zip file require an option ROM. I have designed the Flash Drive Main Menu program to test your 4050 computer to discover if you have the R05, R12 ROM, RTC ROM, or Diagnostic ROM (the last two are only available for a 4052/4054). Your computer configuration is then saved on a couple of files on the Flash Drive – and are used in the Main Menu to only allow you to run programs that will work on your computer. If you attempt to manually run a program that requires a ROM PACK that you don't have installed, you will get an error message indicating that ROM CALL was not found.

The Flash Drive emulates the internal tape drive as it uses a file number to access a file. The Flash Drive also has a directory feature, which allows multiple "tapes" to be stored on the Flash Drive. The Flash Drive uses a MicroSD card for file storage. In addition, the MicroSD card can removed from the Flash drive and plugged into a PC if the PC has a

MicroSD slot or plugged into a USB to MicroSD adapter (not included) to transfer Flash Drive program or data files to or from the PC or to backup and restore the entire Flash Drive.

You can also add your own directory to the Flash Drive with 4050 BASIC PROGRAM and DATA files.

Figure 2 - 4050 GPIB Flash Drive

The Flash Drive (Figure 2) is a small device that plugs directly into the Tektronix 4050 GPIB connector on the back of every Tektronix 4050 computer. There are no switches for GPIB address configuration – the Flash Drive is set to GPIB primary address 5 in the Flash Drive firmware.

The Flash Drive is powered separately from the Tektronix 4050 by a USB 5V at 1A power adapter which is readily available but is not supplied – as international users need a different power adapter connector than North America users. A USB-A power cord is supplied with the Flash Drive and has a USB MINI-B (5-pin) connector on the other end to plug into the Flash Drive and a USB power adapter.

Flash Drive file storage is provided by a MicroSD flash card plugged into the Flash Drive on the top board in Figure 2. A MicroSD card preloaded with files is supplied with the Flash Drive. This MicroSD card can be easily removed from the Flash Drive by gently pushing the MicroSD card into the connector which will release the catch and the MicroSD card will be released and can be removed from the Flash Drive. This allows the MicroSD card to be connected to a PC to backup or restore all the Flash Drive files or copy files or directories to or from the MicroSD card to a PC.

Making a backup of the Flash Drive files on the MicroSD card with your PC will be useful if you create new files – such as saving a game on the Flash Drive. Having a backup makes it very easy to restore all your program and data files to a MicroSD card if you cannot access a file.

If you get a Tek BASIC message that a Flash Drive file is NOT FOUND, use the instructions in the Troubleshooting Section of this manual to pinpoint what actions you should take.

It is recommended that you plug the Tektronix 4050 computer and the USB power adapter for the Flash Drive into an outlet strip with surge protection.

3. 4050 GPIB Flash Drive Features

The GPIB Flash Drive has the following features:

1. Completely replaces 4050 internal tape drive for ALL program and data storage
2. Ready to run with **400 or more files** in 15 or more 'tape' directories including 35 games and 33 R12/Fast Graphics pictures on the MicroSD card
3. MicroSD card provides Gigabytes of program data and storage
    a. Plug MicroSD into USB-MicroSD adapter to transfer program & data files to/from your PC
4. Faster access and loading of all files than internal tape
5. Stores each 'tape' in separate directory – 100's of tapes can be stored on same Flash Drive
6. Flash Drive is compatible with **ALL** Tektronix 4051, 4052, 4052A, 4054 and 4054A computers
7. Supports all 4050 BASIC GPIB tape commands:
    a. FIND, MARK, KILL, OLD, BOLD, SAVE, BSAVE, APPEND, BAPPEN, PRINT, INPUT, READ, WRITE
8. Plugs into 4050 GPIB connector – no Option ROM needed to use the Flash Drive
9. First Time Setup – discovers your 4050 computer model and installed option ROMs
10. Main Menu – organizes access to curated directories and programs
    a. First Time Setup discovery of installed Options to ensure that Main Menu items are compatible with your 4050 computer detected configuration.
    b. Options detected include 4050 Model, Memory size, R05 BINARY Program Loader ROM, R12 Graphics Enhancement ROM, 4052 Diagnostic ROM, 4054/4054A Option 30 and TransEra 4052/4054 RTC.
    c. The Main Menu includes a File Browser selection allowing easy access to all the Flash Drive directories with a TLIST and Change Directory feature. Return to the Main Menu at any time by typing RUN.
11. Flash Drive AUTO LOAD – uses the RTC (Real-Time-Clock) Option (included in the 4052/4054 Multi-Function Option ROM available separately) to AUTO LOAD your 4050 computer at power-on to your Favorite Program and Directory which is the last selection you made from the Main Menu.
12. Flash Drive Micro-USB power cord included.
    a. USB 5V 1A power adapter is not included as it requires a country specific power connector.
13. One **Flash Drive zip file** with the all the latest 'tapes' and programs can be downloaded from the internet and be unzipped to your MicroSD card to update your Flash Drive: https://github.com/mmcgraw74/Tektronix-4050-GPIB-Flash-Drive
14. Vectrex game controller interface!
15. **New Flash Drive Firmware Feature** – Support for multiple Flash Drives, requires additional TI GPIB buffers connected to Flash Drive – not compatible with current Flash Drive GPIB PCB. Contact me for more details.
16. **Added Flash Drive GPIB Interface board schematic**

The GPIB Flash Drive zip file includes the following new/updated BASIC programs:

- Monopoly Game (work in progress), requires 4052R12 or 4051 Fast Graphics ROM (or 4051 MAXIROM)
- Five Color Demo, requires Option 30 and Option 31 Color Dynamic Graphics DVST
- Main Menu updates including adding Monopoly Game and Five Color Demo

4. Flash Drive Operation

Plug the Flash Drive micro-USB connector into a USB 5V @ 1A power supply (not included) and then plug the Flash Drive into the GPIB connector on the back panel of your 4051, 4052 or 4054 computer.

Turn on the 4050 computer. The Flash Drive starts in the ROOT directory of the MicroSD card, unless you have the RTC Option ROM which provides an AUTO LOAD feature to load file 1 in your Favorite Directory.

Flash Drive Command	Description
FIND@5: X	Opens file number X in the current directory
OLD@5:	Loads an opened flash drive file containing an ASCII program into 4050 memory
CALL "BOLD",5	Loads an opened flash drive file containing a BINARY program into 4050 memory
SAVE@5:	Saves the current 4050 program to the opened flash drive as ASCII Program
CALL "BSAVE",5	Saves the current 4050 program to the opened flash drive as BINARY Program
APPEND@5:	Appends opened flash drive file containing an ASCII program on current program
CALL "BAPPEN",5;Y	Appends opened flash drive file containing BINARY program to line Y in current program
INPUT@5: X$, Y	Inputs ASCII string or numeric data from an opened flash drive DATA file into the 4050
PRINT@5: X$, Y	Prints ASCII data into an opened flash drive DATA or NEW file from the 4050
READ@5: X$, Y	Reads BINARY string or numeric data from an opened flash drive DATA file into the 4050
WRITE@5: X$, Y	Writes BINARY string or numeric data into an opened flash drive DATA or NEW file
TYPE@5: X	Returns the type of the next BINARY data item in the current BINARY DATA file
MARK@5: X, Y	Creates X NEW files of size Y bytes at the opened file# and then marks a new LAST file
KILL@5: X	Finds and marks file X as NEW, does not change any other file
PRINT@5,9: "Directory"	Change to "Directory"
INPUT@5,9:X$	After a FIND@5: this will return the current directory string into X$
INPUT@5,19: X$	After a FIND@5: this will return that file header string into X$
PRINT@5,19: X$	After a FIND@5: this will replace the file header string with X$
INPUT@5,31:X,Y,A,B,C,D	Vectrex joystick controller, returns joystick X and Y and A,B,C,D buttons (1,2,3,4)

Figure 3 - Flash Drive Commands

The Flash Drive uses the file name as the file header with the file number as the first number in the file name. Easiest way to create a properly formatted filename is to copy an existing Flash Drive filename of the same type (ASCII PROGRAM for example) – changing the file number to the desired file number and editing the comment field. Be careful to not change the location of the ASCII/BINARY or PROGRAM/DATA field. You can test whether the created file name is correct by using the Main Menu "TLIST a DIR" command on that directory.

Here is the format of every Flash Drive filename:

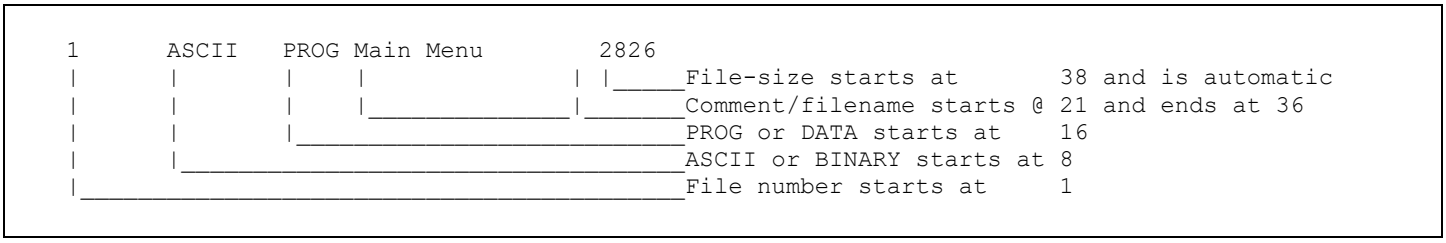


Figure 4 - Flash Drive Filename Format

This format is used by the Flash Drive to properly access the data requests from 4050 BASIC based on the file type. You may notice these character start positions are 1 less than on the tape header locations published in the 4050 programming reference. In that document the first character is always a space which is illegal in FAT and other filesystems. Our observation is that 4050 BASIC never automatically requests the file header from a 4924 GPIB tape drive using any of the commands in Figure 3. In addition, the 4050 TLIST command only works with the internal tape –

not the 4924 tape, so the MAIN MENU provides a routine to emulate TLIST for the selected Directory. There is also a "TLIST" program in file 119 in every directory. Load and run this file to list all the files in this directory.There is a 4050 BASIC command that can return the current open **internal tape** file header to BASIC: INPUT@5,9:X$. Note this is the command used by the Flash Drive to return the current DIRECTORY name to BASIC. I preferred to stick with the published 4050 GPIB Secondary Address table which indicates secondary address 9 for DIRECTORY and 19 for TLIST.

The 4924 Tape Drive service manual indicates the 4924 firmware uses the tape file header information to determine how to operate on 4050 BASIC READs and WRITEs, so that is how we designed the Flash Drive operation.

There is no Flash Drive command to create or delete directories on the MicroSD. That is easily done by unplugging the flash drive MicroSD card (push gently and remove card from adapter) and plugging it into a USB to MicroSD card reader (not supplied). Plug the MicroSD card reader into your PC and use the PC to create or delete a directory from the Flash Drive MicroSD card. Directory names should be limited to 10 characters.

SECRET files are NOT supported in the Flash Drive system.

a. Vectrex joystick controller interface

As I was developing my Battlestar Galactica Cylon Attack game for the Tektronix 4054A with Option 30 Dynamic Graphics – I encountered lots of flickering of the Cylon refresh object. Root cause was the Tektronix 4952 joystick interface uses the vector display digital to analog converters to convert the analog joystick X and Y values into digital values with code in Tek 4050 BASIC ROMs. This activity halts the Option 30 display of graphics until the joystick data conversion is complete – resulting in the very visible flickering.

Vectrex was a vector graphics video game system introduced in 1982. Vectrex had a game controller with an analog joystick and four buttons. I have a Vectrex system and decided to see if I could add a Vectrex joystick controller interface to the Flash Drive – by connecting the Vectrex joystick to unused pins on the Flash Drive.

I was successful and have now updated the Flash Drive firmware to add Vectrex joystick support!

This adds one more command to the Flash Drive: INPUT@5,31:X,Y,A,B,C,D – six numeric variables the BASIC program can substitute any numeric variable names as needed.

The X and Y joystick numeric variables are zero (or very close to zero) for a centered Vectrex joystick and have a minimum value close to -300 for X at full left and Y at full down, and a maximum value close to +300 for X at full right and Y at full up.

The A,B,C,D buttons return a value of 0 for a pressed button and 1 if the button is not pressed.

My vcfed.org forum thread has more details on adding the Vectrex joystick interface:

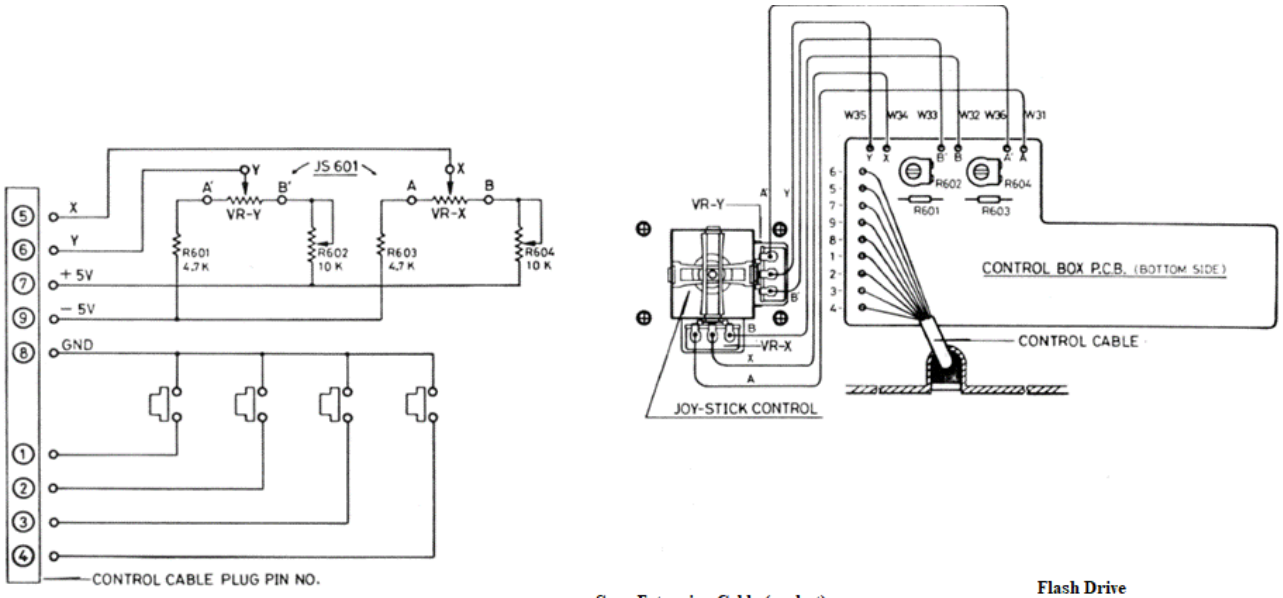
Tektronix 4050 Vector Graphics computers - need a game controller!

Figure 5 shows my Vectrex joystick controller and Figures 6 and 7 show the wiring from the Flash Drive controller pins to a Sega Extension Cable I purchased on Amazon here: https://www.amazon.com/dp/B073Z9ZD7Y

The bottom right of Figure 6 shows the extension cable **socket – note the pins are reversed on the socket compared to the Vectrex connector!** The colors of each wire may NOT match my cable so be sure to ohm each wire!

I cut off the other end of the extension cable and stripped the wires and soldered them directly to the Arduino Controller pins on the Flash Drive. I then secured the Sega extension cable with zip ties around the microSD adapter pins as shown in Figure 8. No modifications needed to the Vectrex controller – just plug it into extension cable.

Figure 5 - Vectrex game controller with analog joystick



VECTREX
PLUG CONNECTION

1 2 3 4 5
6 7 8 9

Sega Extension Cable (socket)

1 Red	- Button 1
2 Black	- Button 2
3 Gray	- Button 3
4 Orange	- Button 4
5 Brown	- X
6 Green	- Y
7 White	- +5V for X&Y pots
8 Blue	- GND for Buttons
9 Yellow	- GND for X&Y pots

Flash Drive IDE	Name	Silkscreen
0	PB0	0
1	PB1	1
2	PB2	2
3	PB3	3
A1	PA1	A1
A2	PA2	A2
	5V	5V
	GND	GN
	GND	GN

HAND CONTROL SCHEMATIC

Figure 6 - Vectrex to Sega Extension Cable wiring

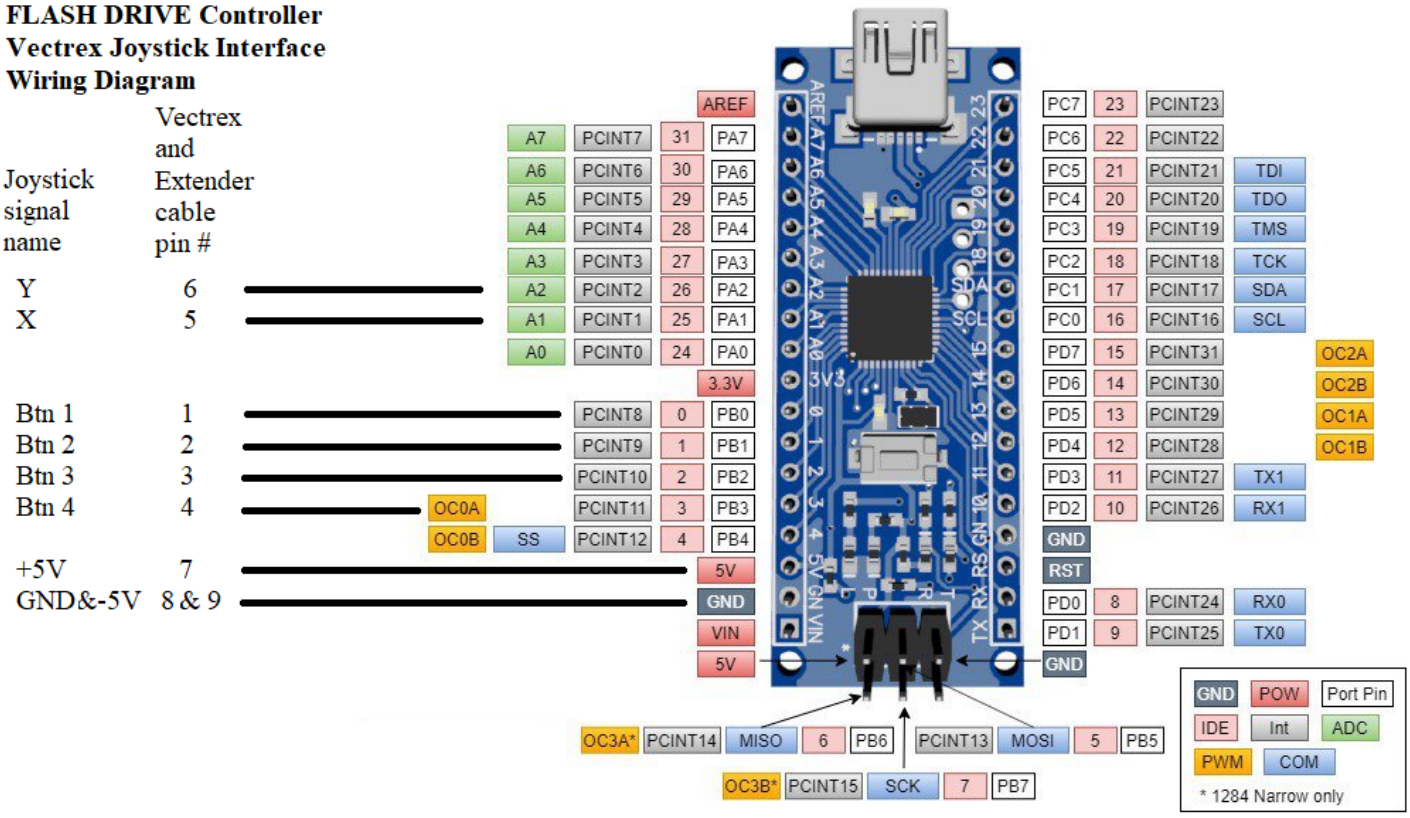


Figure 7 - Flash Drive to Vectrex Joystick Wiring Diagram

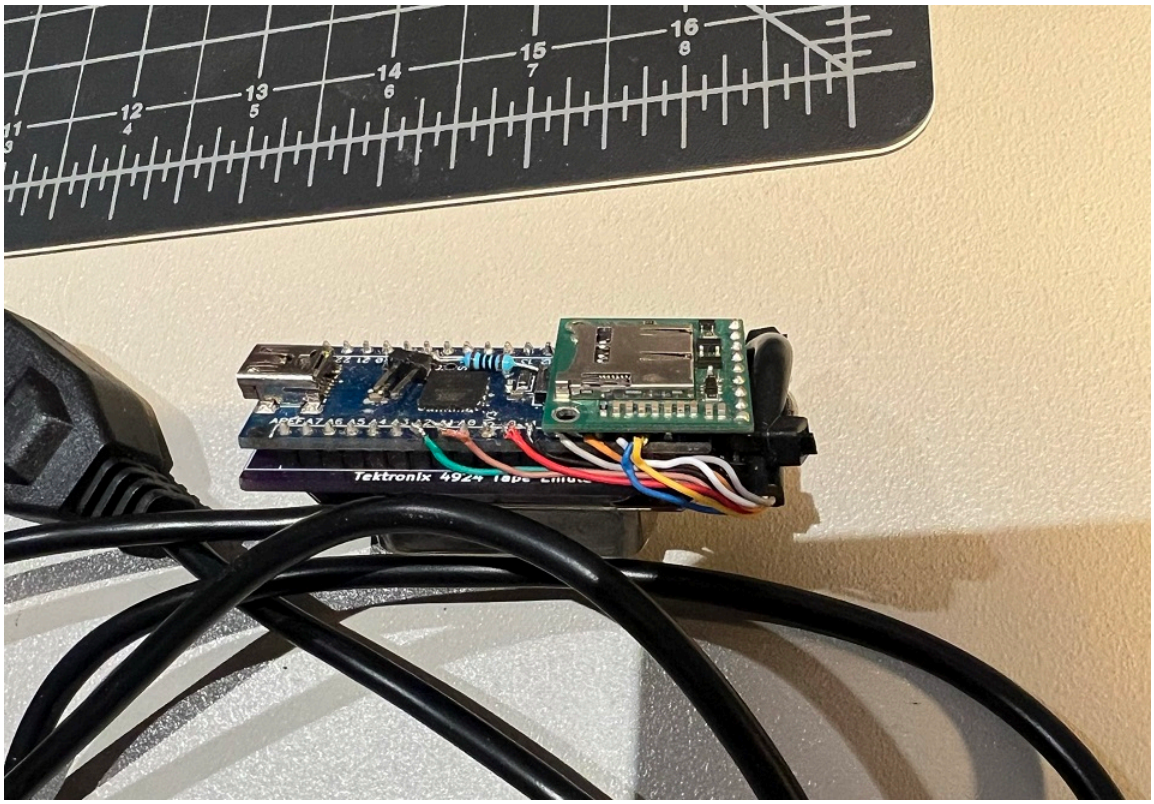


Figure 8 - Flash Drive with Sega Extension Cable

5. First Time Setup of your Flash Drive

First time you power on your 4050 Computer with the Flash Drive plugged into the GPIB connector and powered; the Flash Drive will start in the ROOT directory of the MicroSD card. Type the following to run the Main Menu program:

```
FIND@5:1
OLD@5:
RUN
```

You will see the screen PAGE followed by a message "CREATING NEW CONFIG FILES".

Then the program will PAGE again and you will see the First Time Setup screen below:

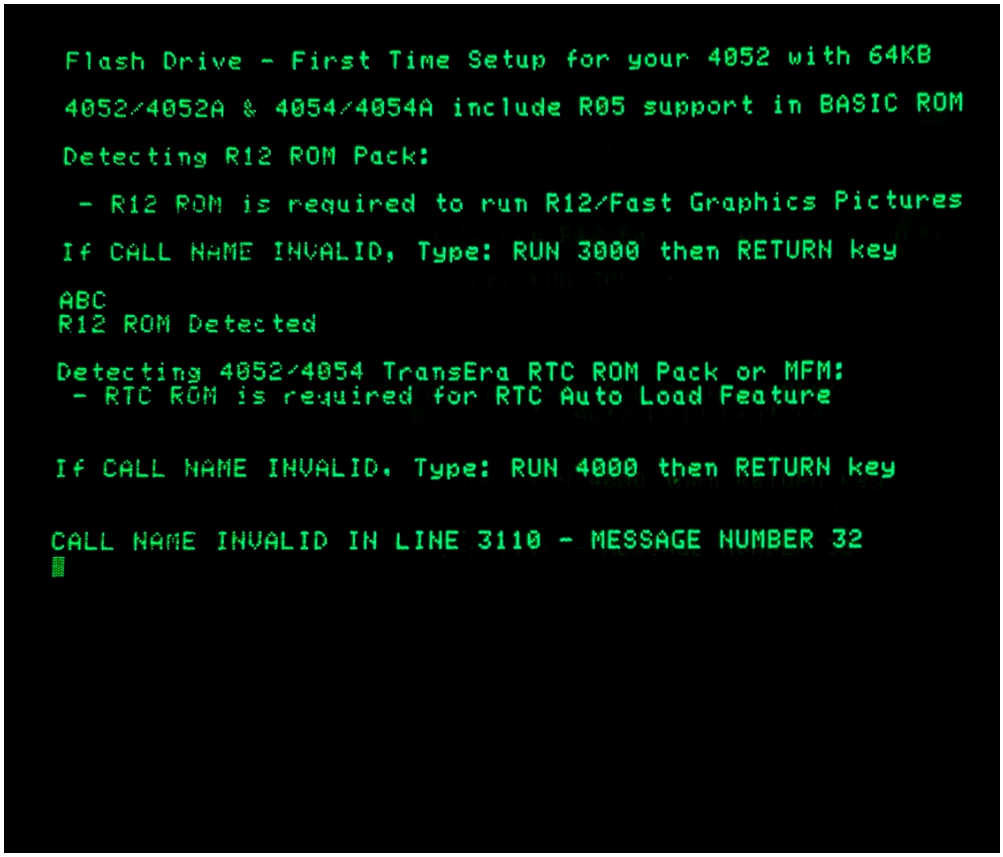


Figure 9 - First Time Setup on 4052

First Time Setup automatically discovers and prints on the top line of this screen:

`4050 Model Name`	4051, 4052, 4052A, 4054, or 4054A
`Memory Size`	32KB or 64KB
`Option 30`	Only available on 4054 or 4054A

Next the program tries to detect the following Option ROM Packs:

`R05 BINARY PROGRAM LOADER`	4051 only, included in 4052/4052A and 4054/4054A BASIC ROM

R12 GRAPHICS ENHANCEMENT	4051 MAXIROM or 4052/4054 and A-Series Multi-Function ROM PACK
RTC TransEra Real-Time Clock	4052/4054 and A-Series Multi-Function ROM PACK
Diagnostic ROM Pack	4052/4054 and A-Series Diagnostic ROM PACK

Option ROM Pack discovery is more difficult because the program must try to execute one of the ROM Pack commands. If you don't have that ROM Pack installed, you will get a BASIC error message "CALL NAME INVALID IN LINE XXXX", like the last line in Figure 9. In order continue to attempt to discover other Option ROMs, the program prints a message before trying to run a ROM Pack command:

IF **CALL NAME INVALID** IN LINE XXXX, Type **RUN YYYY** then **RETURN** key

If the ROM PACK is detected – example **R12 ROM Detected** in Figure 9, the program automatically proceeds to test the next Option ROM PACK in the list above. For the 4051 option ROM tests only the R05 and R12 ROM Packs are tested. For all the other 4050 models, all four option ROM Packs are tested.

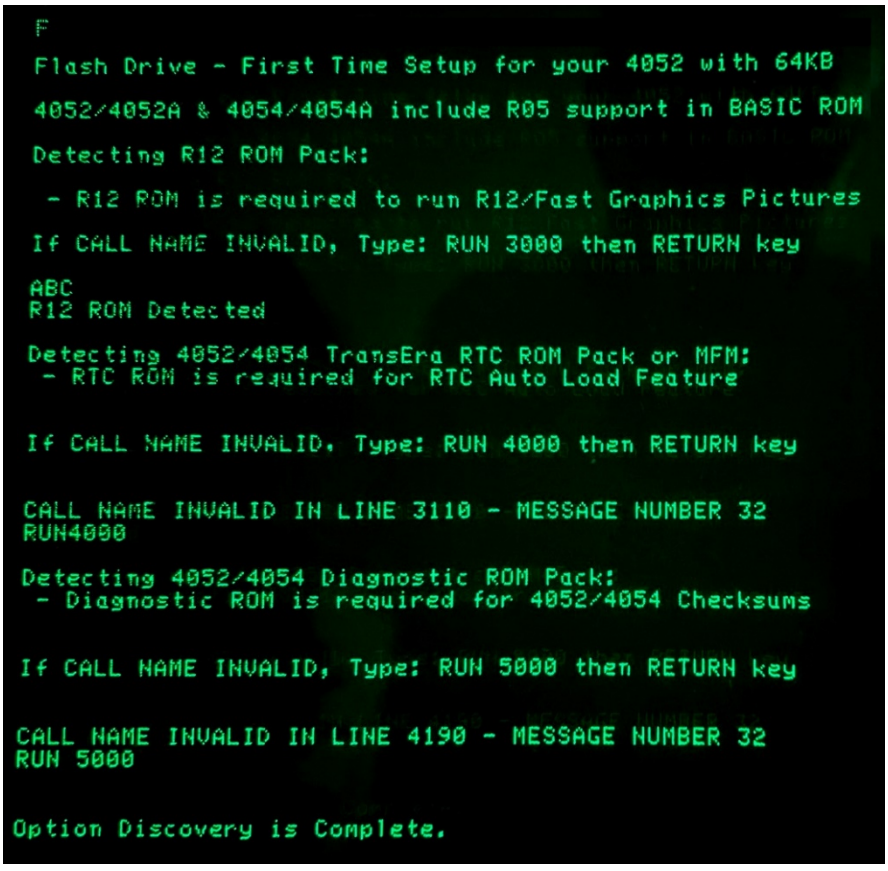


Figure 10 - First Time Setup Discovery is Complete

Figure 10 shows the screen when First Time Setup Option ROM Discovery is Complete. In this example on my 4052 the R12 ROM was detected, and the program immediately continued to attempt to detect the RTC ROM without needing to print a CALL NAME INVALID error message. However, the program did not detect an RTC ROM, nor did it detect a Diagnostic ROM, so in both of those cases there was a CALL NAME INVALID error message and I typed RUN YYYY based on the program printed instructions prior to the error message, for every Option ROM not detected.

WARNING: If the First Time Setup program fails to detect the `R05`, `R12`, `RTC` or `Diagnostic ROM` and prints the error message and stops: please be sure to type **`RUN`** before the **`YYYY`** line number or you will delete line **`YYYY`** in the Main Menu program and then you will have to clear the discovery `CONFIGURATION file 123` and reload the `MAIN MENU file 1` by typing the following commands. You also need to use these commands if you move the Flash Drive to a different 4050 computer or add or remove an Option ROM Pack.

FIND@5:123

PRINT@5:0

FIND@5:1

OLD@5:

RUN

Note: you may see the blinking F in the top left corner of the display at the end of Option Discovery as shown in Figure 10. This is typical 4050 BASIC behavior when the screen is FULL. Manually **`PAGE`** the screen to continue to the MAIN MENU.

```
                  4050 GPIB Flash Drive - Main Menu

          For your 4051 with 32KB, R05, R12


Games (*New)        Pictures (*New)    Demos              Utilities
---------------     ---------------    ---------------    ---------------
 1. Game Menu       11. Picture Menu   16. R12 Demo       20. Simple
 2. Artillery       12. *Bitmap Pics        (R12)              Benchmark
/3</Adventure            (R12)        ‡7</Option30/Demo  21. 4051 Checksums
     (64KB)         13. *PLOT10 Pics        (Option 30)        (4051)
 4. Invader I             (R12)        18. 4050 Tutorial  22</4052/Checksums
     (R12)          14. *SpacelabPics  19. Graphing T1         (Diag ROM)
 5. Lunar Lander          (R12)                              23. File Browser
 6. Star Trek       15. Star Wars
/7</Opt/30/Games         DROIDs (R12)
     (Option 30)
 8. *Cylon Attack
     (R12)
/9</*Cylon/Attack
     (Opt 30)
‡0</*Asteroids
     WIP (Opt 30)




              Type the item number and press RETURN: ?
```

Figure 11 - Flash Drive Main Menu

Figure 11 shows the Main Menu. The Main Menu will be used to access any of the programs or other Menus in the Flash Drive using the instructions in section 6 “Use the Flash Drive”. First Time Setup will only be run once – and the detected configuration including all detected Options will always be displayed at the top of the Main Menu.

If the RTC ROM was detected on your 4052 or 4054 or A-Series computer, your computer will AUTO LOAD file 1 in the last directory you selected from the Main Menu – when your computer is powered on. This is the Flash Drive AUTO LOAD “Favorite Directory” feature.

Note that Main Menu items will be marked unavailable with “/” over the name for any Main Menu item that requires an Option that is not detected during First Time Setup. The name of the required Option will be listed in parenthesis after the name of that menu item.

For example: Figure 11 shows my 4054A computer with 64KB of RAM, R05, R12, and RTC Options detected.

If a particular Option ROM is not installed, or in the case of item 15 in Figure 11 requires 4051 for compatibility with that program, then the Main Menu will mark the item as unavailable. Only the menu items that are not marked with / can be selected by the Main Menu to provide friendly use to untrained 4050 computer users.

Another example in Figure 11 is item 4 – Adventure, which I ported to the 4050 computers from a Commodore PET BASIC program. Since Adventure for PET made extensive use of integer variables and string arrays – which are not in 4050 BASIC – my port requires 64KB of RAM and will therefore not run on a 4051 which had a maximum of 32KB of RAM.

As new Flash Drive image zip files are published, the Main Menu will be updated in the zip file to increase the number of menu items.

Some of the menu file 1 programs in directories like Picture Menu include a menu selection to continuously display all the pictures in sequence for an unattended demo. Two versions of Picture Menu are available in Figure 11 – selecting 2 will launch the version that will be accelerated graphics using the R12 option ROM. Selecting 3 will launch the version that does not require the R12 option ROM – but the vector drawing speed will be substantially slower.

New to this Flash Drive image is a File Browser – selection 17. The File Browser allows the user to TLIST a directory, Change to a different Directory or return to the Main Menu by typing RUN as shown in the following Figure.

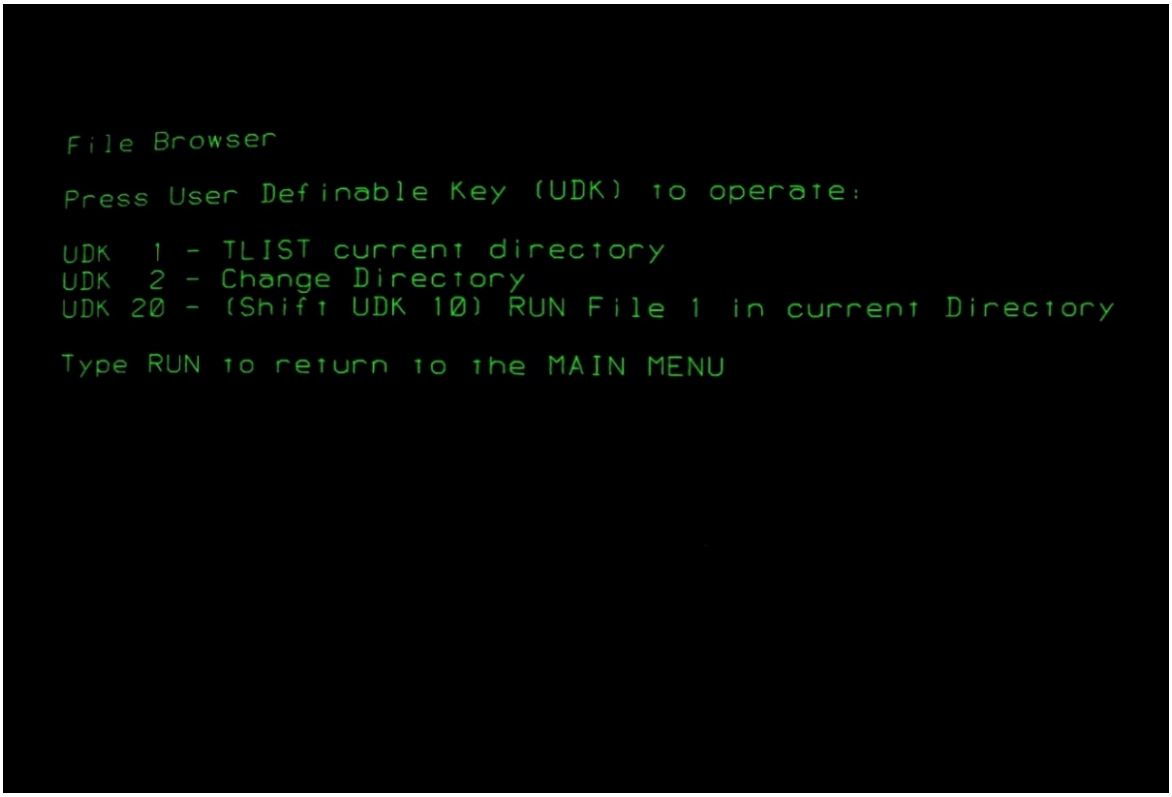


Figure 12 - File Browser

Pressing User Definable Key (UDK) 1 will PAGE the screen and display the current directory TLIST of files.

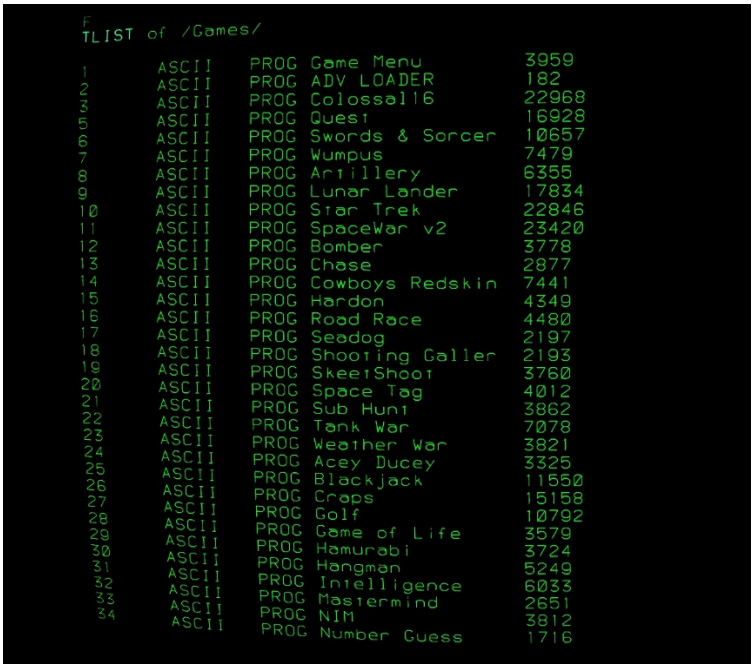


Figure 13 - TLIST

Pressing UDK 2 will PAGE the screen and display the list of Flash Drive directories. Type the directory number and press RETURN to change to that directory as shown in the next Figure:

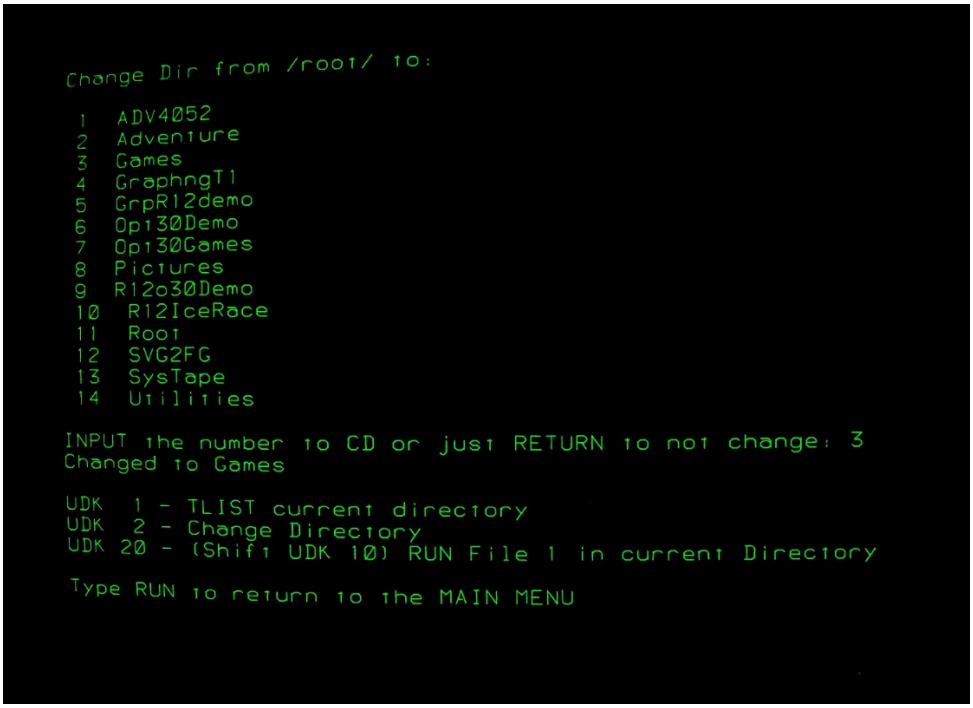


Figure 14 - Change Directory

Note the "F" above the word TLIST in Figure 13. This F will be blinking when text has filled the screen. Press the PAGE key to clear the screen.

Pressing UDK 20 which is accessed by pressing the SHIFT key and UDK 10 will RUN file 1 in the current directory.

6. Use the Flash Drive

Plug the Flash Drive micro-USB connector into a USB 5V @ 1A power supply (not included) and then plug the Flash Drive into the GPIB connector on the back panel of your 4051, 4052 or 4054 computer.

Turn on the 4050 computer. The Flash Drive starts in the ROOT directory of the MicroSD card when Flash Drive is powered up (unless the RTC is present – and the Flash Drive AUTO LOAD will load file 1 in the Favorite directory).

Type the following 4050 BASIC immediate commands to load and run the MAIN MENU:

```
FIND@5:1
OLD@5:
RUN
```

You should see the Flash Drive Main Menu:

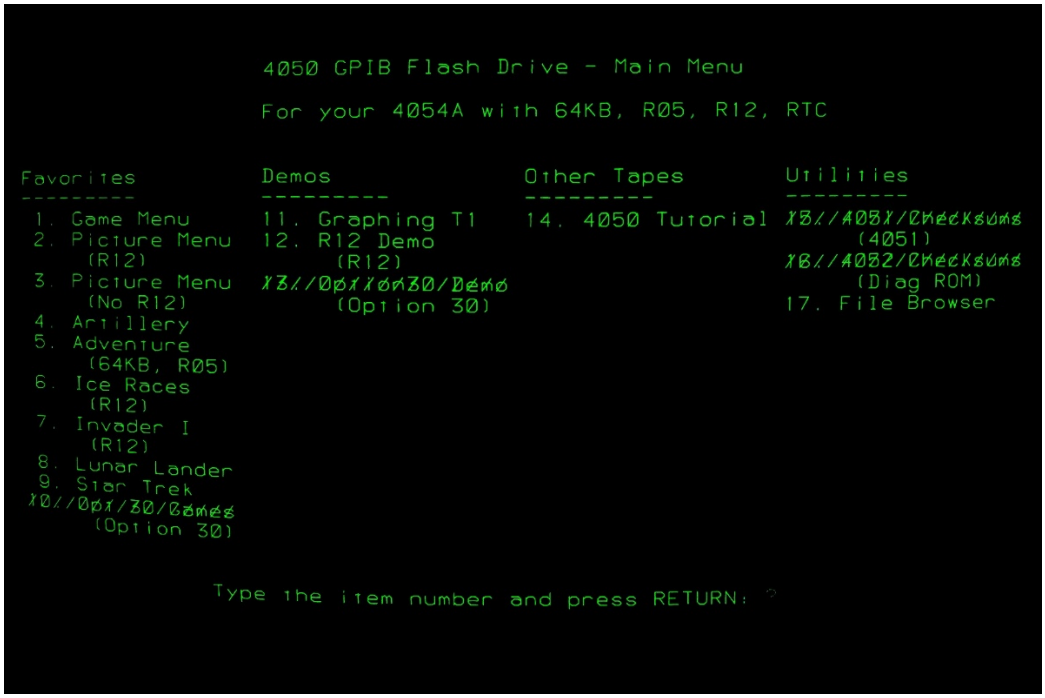


Figure 15 - Flash Drive Main Menu in ROOT directory

Most of the Main Menu items change to a different directory and either run a menu for that directory or a single program from a different directory than the ROOT directory which contains the Main Menu.

Simply type the item number and press RETURN to run the selected program.

Most of the programs on the Flash Drive have a quit or exit function that should return to a menu or to the MAIN MENU.

If a program doesn't have that feature, press BREAK twice and type the following statements to run the MAIN MENU.:

```
PRINT@5,9:"ROOT"
FIND@5:1
OLD@5:
RUN
```

7. Flash Drive hardware

The Flash Drive is comprised of three circuit boards:

1. CONTROLLER: Pandauino 644-Narrow or 1284-Narrow running the Flash Drive CONTROLLER firmware
2. MicroSD Adapter: Pololu #2587 MicroSD Card adapter with Level Shifter. Uses any GB size MicroSD Card
3. Tektronix 4050 Flash Drive GPIB Interface: connects CONTROLLER, MicroSD adapter and GPIB connector

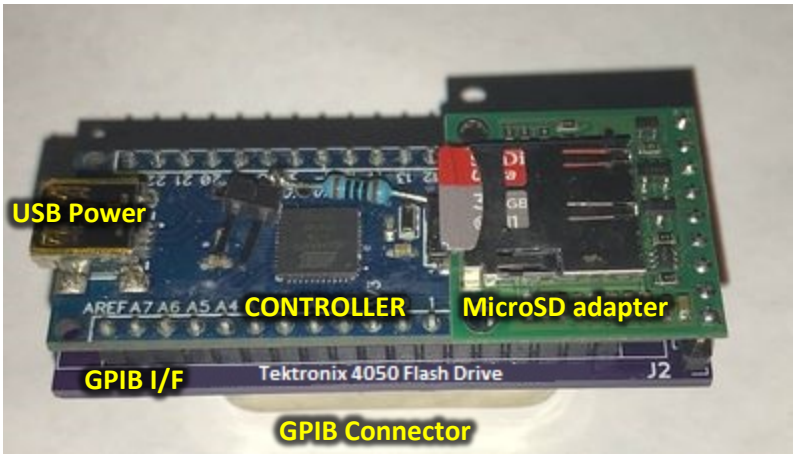


Figure 16 - Flash Drive hardware

8. Micro SD card files

The default directories and files on the Flash Drive MicroSD card are preinstalled if you have a board assembled by me.

Otherwise follow the following steps to add Flash Drive files to a new MicroSD card using a USB to MicroSD adapter:

a. Format your MicroSD card as FAT32 to enable long filename support.
b. Unzip the latest Flash Drive zip file from this site into your formatted MicroSD card and then remove the card from the USB adapter and plug the card into your Flash Drive

Any updates to these files or directories will be uploaded as a FlashDrive.zip file to:

https://github.com/mmcgraw74/Tektronix-4050-GPIB-Flash-Drive/tree/master

and here:

https://github.com/mmcgraw74/Tektronix-4051-4052-4054-Program-Files/tree/master/Flash_Drive

Easiest way to freshen or restore the Flash Drive directories and files is to delete all the directories and files from the MicroSD card using your PC and then unzip the FlashDrive.zip file to the MicroSD card.

9. Flash Drive firmware

The Flash Drive firmware is preloaded into the Flash Drive CONTROLLER for Flash Drives that are pre-assembled. Updates to the Flash Drive firmware will be posted in this directory:

https://github.com/mmcgraw74/Tektronix-4050-GPIB-Flash-Drive/tree/master/Arduino_Code

or here:

https://github.com/mmcgraw74/Tektronix-4051-4052-4054-Program-Files/tree/master/Flash_Drive/Arduino_Code

The Flash Drive CONTROLLER firmware can be updated from a PC using Arduino IDE software installed on your PC following the README.md instructions and Arduino code in that directory.

10. Flash Drive board assembly

BOM:
1. CS-Narrow-644 (or 1284) board (mouser.com)
2. 111-024-113L001 GPIB connector (mouser.com)
3. #2587 MicroSD board with Level Shifter (Pololu.com)
4. Tektronix 4050 Flash Drive interface board: https://oshpark.com/shared_projects/HIeNjLBF

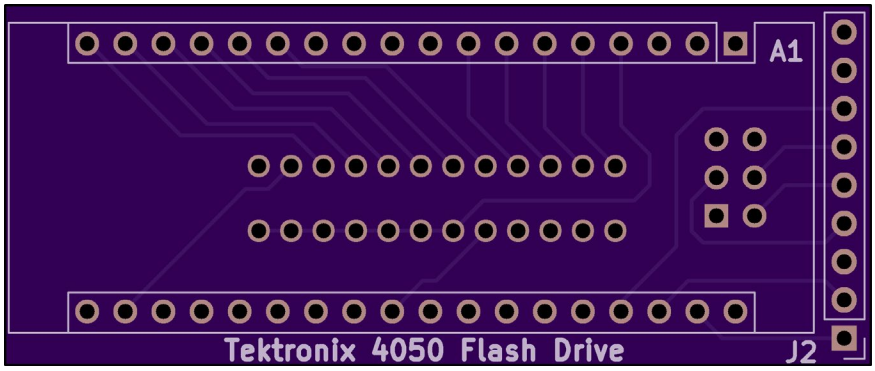


Figure 17 - GPIB Interface Board TOP

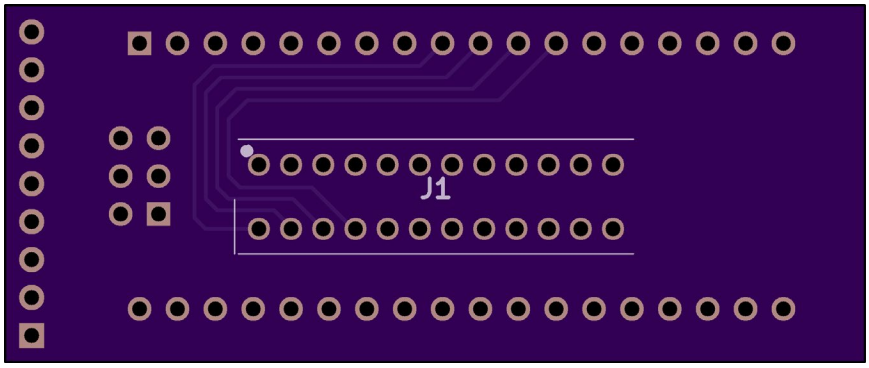


Figure 18 - GPIB Interface board BOTTOM

a. Solder the GPIB connector to the GPIB Interface board bottom side with the J1 connector label. Insert the "wide" part of the GPIB connector on the same side as the J1 connector PIN 1 dot. Trim the excess leads on the top side of the GPIB Interface board to prevent interference with the CONTROLLER board.
b. The CONTROLLER 644-Narrow and 1284-Narrow boards come with headers installed. The CONTROLLER is soldered to the pins in the A1 outline in Figure 10. The CONTROLLER connects to the two 18-pin outer headers and the inner six pins on the programming connector – so first melt the solder on one of the 6 inner pins on the CONTROLLER at a time and push that pin toward the bottom side of the CONTROLLER board. I pushed the pins only far enough to extend slightly from the GPIB connector side of the GPIB interface board. Then I clipped the pins on the top side of the CONTROLLER after I removed the 6-pin black plastic header spacer so each pin was slightly shorter than the height of the spacer and then reinstalled the spacer to prevent shorts on those pins with the MicroSD adapter board. Later, that spacer will also help keep the MicroSD card parallel to the Flash Drive Controller board.
    i. Once all six programming pins are moved down (be sure to check all these pins are still soldered to the CONTROLLER) – try to fit the CONTROLLER pins into the 'top' side of the GPIB interface board A1 outline. The programming pins that were moved down in step b will need to be slightly bent to fit in the GPIB interface board. I didn't have the correct offset of those holes when I designed my GPIB interface board. You may have to clean these 6 pins first with solder wick to remove factory solder

that sticks to the pin when you push the pin down, otherwise the solder may keep the pin from being inserted into the GPIB interface board.

ii. Tack solder the four corner pins of the two outside rows on CONTROLLER board to the GPIB interface board to hold those boards in place. You will need to slightly bend the CONTROLLER pins that are touching the GPIB connector away from the GPIB connector to get both the CONTROLLER 18-pin header spacers to sit flush with the GPIB interface board.

iii. Solder the CONTROLLER programming pins to the GPIB interface board - between the GPIB connector and the 4050 Flash Drive interface board.

iv. Solder all the remaining CONTROLLER pins to the GPIB interface board and trim the excess leads on the GPIB connector side of the interface board to prevent shorts with the GPIB connector.

c. If you want to add the Vectrex joystick controller interface cable – you should do that before soldering the MicroSD adapter, although you can add the interface cable to an assembled Flash Drive.

d. Ohm check the CONTROLLER 644/1284 CPU pins for connectivity to J2 on the GPIB interface board:

i. 644/1284 CPU PIN 1 MOSI (has a dot on the PCB) – to J2 PIN 4
ii. 644/1284 CPU PIN 2 MISO - to J2 PIN 5
iii. 644/1284 CPU PIN 3 SCK - to J2 PIN 6
iv. 644/1284 Arduino board pin 4 (next to 5V) - to J2 PIN 7
v. You can also check Arduino board pin 5V - to J2 PIN 2
vi. Arduino board pin GN - to J2 PIN 1

e. Follow the instructions in section 9 Flash Drive firmware to load the latest firmware into your board.

f. Unzip the Flash Drive zip file to install all the directories and files onto the MicroSD card plugged either directly into the PC or plugged into a MicroSD adapter. Then first use the PC software to eject the MicroSD card from your PC – to ensure that all the files have been written to the MicroSD card. Now the MicroSD card can be safely removed from your PC. Install the MicroSD card into the connector on the MicroSD adapter by gently pushing the MicroSD into the connector and it should lock into position where the MicroSD card is only slightly visible as in Figure 9.

g. Bench test the Flash Drive firmware before soldering the MicroSD to the GPIB Interface board:

i. Insert the header into the GPIB Interface board J2 holes, the insert the MicroSD adapter in the header pins. Gently lift the MicroSD interface board with card installed on the side over the Arduino board – while performing the following tests (otherwise the firmware hangs and DOES NOT provide any serial output if it does NOT detect the MicroSD card)
    i. If you don't see any text on the monitor for a test below, press the 644/1284 reset button
ii. Plug the 644/1284 Arduino board into your PC
iii. Launch the Arduino IDE Serial Monitor from Tools | Serial Monitor. Set speed to 115200 baud.
    i. You should see "AR488-Store ready (device)." on the monitor window
iv. Type ++ver and press Enter key or click Send button on the monitor
    i. You should see "AR488 GPIB storage ***Device 5***, /w Gamepad, ver. 0.05.90, 22/04/2024"
v. Type ++tlist and press Enter key or click Send button on the monitor window
    i. You should see a list of files in the MicroSD /root directory
vi. If the tests are successful, unplug the USB cable to the 644/1284 board and continue next steps
    i. If you get no text responses – repeat step d and repair open connections

h. Solder the Pololu MicroSD adapter to the interface board J2 connector outline with the included header pins so the MicroSD adapter is parallel to the CONTROLLER board with the adapter components away from the CONTROLLER board and with the adapter resting on the programming pin black spacer and parallel to the CONTROLLER board.

i. Flash Drive Board assembly is complete.

11. Troubleshooting

Highly Recommended: print out the 4050 Series BASIC Reference Guide June 1983 booklet. This booklet includes all the 4050 BASIC commands for the 4051, 4052, 4054, 4052A and 4054A computers including the Error Messages:

Figure 19 - 4050 Series BASIC Reference Guide

http://www.bitsavers.org/pdf/tektronix/405x/070-2142-02_Tek_4050_Series_Basic_Reference_Jun83.pdf

a. Flash Drive File Not Found

1. Plug the Flash Drive USB power connector into a USB power adapter 5V@1A.
    a. You should see the Flash Drive BLUE power LED light ON.
        i. If **Flash Drive BLUE LED is not ON** – check that the USB power adapter is working.
2. Plug the Flash Drive into the 4050 computer GPIB connector and ensure it is fully seated in the GPIB connector.
3. Power on the Tektronix 4050 computer.
4. Type these two commands into the 4050:
    a. `INPUT @5,19:A$`
        i. If you see **GPIB I/O Bus Error – Message 69** check the following reasons!
            1. The Flash Drive is not plugged into the 4050 GPIB connector
            2. The Flash Drive is not powered on the Flash Drive USB connector
            3. The Micro SD is not FAT32 formatted
            4. Flash Drive Micro SD does not contain the files from the zip on github
                a. NOTE: if /ROOT is missing from the MicroSD the firmware will halt
    b. `A$`
5. You should see ROOT printed to the 4050 screen. This is the default directory for the Flash Drive after Flash Drive power-on.
6. Type these commands into the 4050:
    a. `FIND @5:1`
    b. `OLD @5:`
        i. **If you see No Program Found – Error 59** the MicroSD card is not installed in the Flash Drive or the MicroSD card does not have Flash Drive files installed.
    c. `LIST`
7. You should see the Flash Drive ROOT Main Menu program listing on the 4050 screen.

8. If the File NOT Found error message occurred on a file that was not in the ROOT directory, type the following commands to change to the ROOT directory and run the Main Menu program:
    a. `PRINT@5,9:"ROOT"`
    b. `FIND@5:1`
    c. `OLD@5:`

b. GPIB I/O Bus Error - Message 69

1. If this error occurs after the Flash Drive has been working, try steps in 11.a.4 above.
2. If you still get a Message 69, unplug Flash Drive power cable, then plug Flash Drive power cable back and check steps 11.a.1 through 7.

c. No files found on MicroSD plugged into PC

1. If this error occurs after the Flash Drive has been working the MicroSD card may need to be reformatted and the directories and files reinstalled from the FlashDrive.zip file
2. A recommended free utility is here: https://www.sdcard.org/downloads/formatter/
   Quick Format as FAT32 selected to reformat the MicroSD card with this utility.
3. Use the Restore MicroSD image steps in 10d to install the Flash Drive files either from a backup.zip that you have created or an image zip file from the Flash Drive web site.

d. CALL INVALID – Message 32

1. This error indicates a ROM Pack is missing or not working. This message should include the line number with the error. Type that line number and press the 4050 keyboard "Recall Line" key (see Figure 7) to see what ROM CALL was not found. If you don't have that ROM Pack or 4051 MAXIROM or 4052/4054 MFM ROM Pack you will not be able to run this 4050 program.

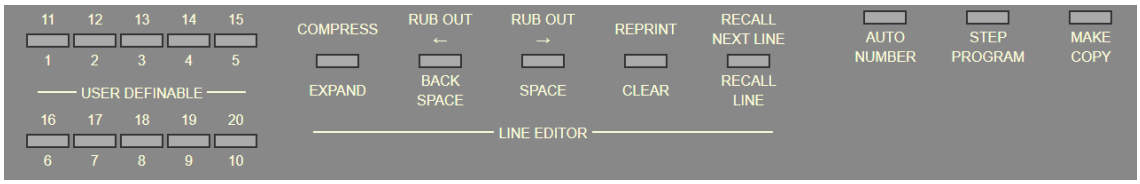


Figure 20 - Tektronix 4050 keyboard User Definable and Editing keys

12. Flash Drive NOTES

a. Unplug Flash Drive power BEFORE inserting or removing MicroSD Card!

b. Flash Drive 'TLIST'

i. 4050 BASIC TLIST command only supports the internal tape drive, not a GPIB tape drive like the 4924 or Flash Drive. The Main Menu in ROOT provides a TLIST routine that can read Flash Drive file headers and print a "TLIST" to the screen. This routine allows you to pick one of the Flash Drive directories to TLIST. In addition – each directory includes a file 119 TLIST program that can be loaded and RUN to display files in that directory.

c. Flash Drive File Header Description/Comment field

i. Maximum of 15 characters – no \ or / characters
ii. Upper or Lower Case insensitive, alpha and numeric characters ok

d. Flash Drive Directory Names

i. Maximum of 10 characters – no \ or / characters
ii. Upper or Lower Case letters including spaces, minus sign, underline, and numbers are ok

e. Flash Drive file numbers do not have to be contiguous

i. The Flash Drive supports non-contiguous file "numbers".
ii. The Flash Drive 'TLIST' routine in ROOT Main Menu file 1 skips file numbers that are missing and stops when it finds a "LAST" file.
iii. This feature allows special files like RTC AUTO LOAD program to be stored at the same file 121, regardless of how many files are needed in a particular directory. The largest number of files encountered on tapes I have recovered is 104 on the Tektronix 4050 System Software Tape.

f. Flash Drive "MARK" command

i. 4050 BASIC MARK command and the Flash Drive requires a FIND command to open the existing file to overwrite, and the size and optionally number of the required file(s) in bytes. Typically, this is command is executed starting with the LAST file.
ii. If the MARK command is executed on any file other than the LAST file - will result in THAT file and ALL subsequent files being overwritten and followed by a LAST file.
iii. Since the default Flash Drive image has a file 119 for TLIST, file 121 for RTC AUTO LOAD, and file 124 for LAST in every directory (plus a couple more files in the ROOT directory), the easiest way to create files with lower file numbers without using the MARK command is to move the Flash Drive microSD card to the PC with a USB adapter (not supplied) and copy the LAST file in the ROOT directory to the desired directory and change the file number to the file number desired and change the type from LAST to NEW – ensuring that if the file number is not 3-digits to insert spaces to keep the file type at the proper location. Make sure you add a space when editing the file type from LAST to NEW to preserve the character location of the ASCII/BINARY program type field.

g. Using the 4051 Emulator with Flash Drive support to develop programs

i. An alternate technique is to drag your 4050 ASCII program or DATA file into the Storage pop-up window of the 4051 Emulator fork that supports Flash Drive and Option ROMs located here: https://github.com/Twilight-Logic/Tek405xEmulator
ii. The latest version in the experimental directory supports dual Flash Drives and huge files.
iii. Then edit the new file number and file name fields and save the program into the 4051 emulator. You can then use the Storage Export (select 4050 Tape Emulator Files) to create a zip of all current 4050 Tape Emulator files and extract your new PROGRAM or DATA file(s) to your desired folder on the microSD card – properly formatted for Flash Drive file header syntax.
iv. The 4051 Emulator will run ALL the Flash Drive programs supported by the 4051 and includes the 4051R05 and 4051R12 Option ROMs.

h. Flash Drive hot-plug power

i. The Flash Drive may be plugged or unplugged from the Tektronix 4050 computer while the 4050 computer or Flash Drive is powered on or off.
ii. The Flash Drive USB power cable can be plugged or unplugged from the Flash Drive while the Flash Drive is connected or disconnected to the 4050 computer.
iii. It is recommended to unplug the USB power cable from the Flash Drive before removing or inserting the MicroSD card into the Flash Drive.
iv. It is recommended to unplug the Flash Drive from the 4050 computer before removing or inserting the MicroSD card into the Flash Drive.

i. Program does not have a return to Menu command

i. Some of the programs don't have a way to quit, or return to a Menu. Simply press the BREAK key twice to stop the program. Then type the following four commands to return to the ROOT Menu:

```
PRINT@5,9:"ROOT"

FIND@5:1

OLD@5:

RUN
```

j. Connecting other GPIB Devices with Flash Drive connected to the 4050

i. Requires Flash Drive hardware changes and firmware using Arduino IDE. Contact me for details at mmcgraw74@gmail.com

13. Flash Drive AUTO LOAD

a. Tape AUTO LOAD

i. The 4050 computers with tape inserted into the internal tape drive slot will rewind the tape to the beginning and attempt to automatically load and run tape file 1 (if an ASCII Program) when the computer is powered on. This feature only works with the internal tape drive and is NOT supported on the Flash Drive.

b. Flash Drive AUTO LOAD with 4052 Multi-Function Module TransEra RTC

i. The 4052/4054 Multi-Function Module from Jos Dreesen includes a TransEra 741-RTC Real-Time-Clock module with CR2032 battery backup. One of the features of this RTC is a "Power Up String" command listed on page 5-4 of the manual that I scanned and uploaded to my Tektronix 4050 Program repository:

https://github.com/mmcgraw74/Tektronix-4051-4052-4054-Program-Files/blob/master/TransEra_ROM_Packs/TransEra_741_RTC_Real_Time_Clock/TransEra_741-RTC_Operators_Manual_1.0_May1983.pdf

ii. Here is the Flash Drive RTC AUTO LOAD string that I created - note the elimination of SPACE characters in the string to reduce the string length. The 4050 keyboard typeahead buffer is only 28 characters according to the RTC manual. This string stored in the RTC will be pushed into the 4050 keyboard typeahead buffer when the 4050 is powered on. I selected file 121 for the RTC AUTO LOAD program since the tape with the largest number of files in my repository is the 4050 System Software Tape (SysTape directory on the Flash Drive image) with 105 files including LAST.

Tektronix 4050 AUTO LOAD STRING pushed into the keyboard typeahead buffer by the RTC ROM:

```
1FIN@5:121
2OLD@5:
RUN
```

Here is the 4050 BASIC program I wrote to send this string into the MFM RTC. Note that the CR character must be inserted into the string with a REP statement replacing the SPACE character for each line of the program including the RUN statement:

```
100 B$=CHR(13)
110 A$="1FIN@5:121 2OLD@5: RUN "
120 A$=REP(B$,11,1)
130 A$=REP(B$,19,1)
140 A$=REP(B$,23,1)
150 CALL "!SETPU",A$,1
```

iii. Here is the 4050 BASIC program I saved to Flash Drive ROOT file 121 for the RTC AUTO LOAD string to execute. Note this program is 182 characters – far larger than the 28 character limit for the 4050 keyboard typeahead buffer:

```
100 REM  program file 121 in EVERY directory
110 INIT
120 CALL "!PAUSE",10
130 PRINT@5,9:"ROOT"
140 FIND@5:120
150 INPUT@5:D$
155 INPUT@5:F
160 PRINT @5,9:D$
170 FIND @5:F
180 OLD@5:
```

Line 120 delays the program by 10 seconds with an RTC call to allow the 4050 DVST to warm up
Line 130 changes the directory to ROOT
Line 140 opens file 120 which contains the Favorite Directory
Line 150 fetches the Favorite Directory string
Line 155 fetches the Favorite Program file number
Line 160 changes the directory to the Favorite Directory
Line 170 opens file F in the Favorite Directory
Line 180 loads the program and automatically RUNs that program

Flash Drive AUTO LOAD to Favorite Program feature will change the Flash Drive directory at the next power-up of the Tektronix 4050 computer to the Favorite Directory – regardless of whether the Flash Drive remained powered-on while the 4050 was powered off.

14. Support

Post requests for assembled Flash Drives, Flash Drive bug reports, comments or feature requests in this thread:

https://forum.vcfed.org/index.php?threads/tektronix-4050-gpib-flash-drive-now-available.1238891/

15. Flash Drive GPIB Interface PCB Schematic

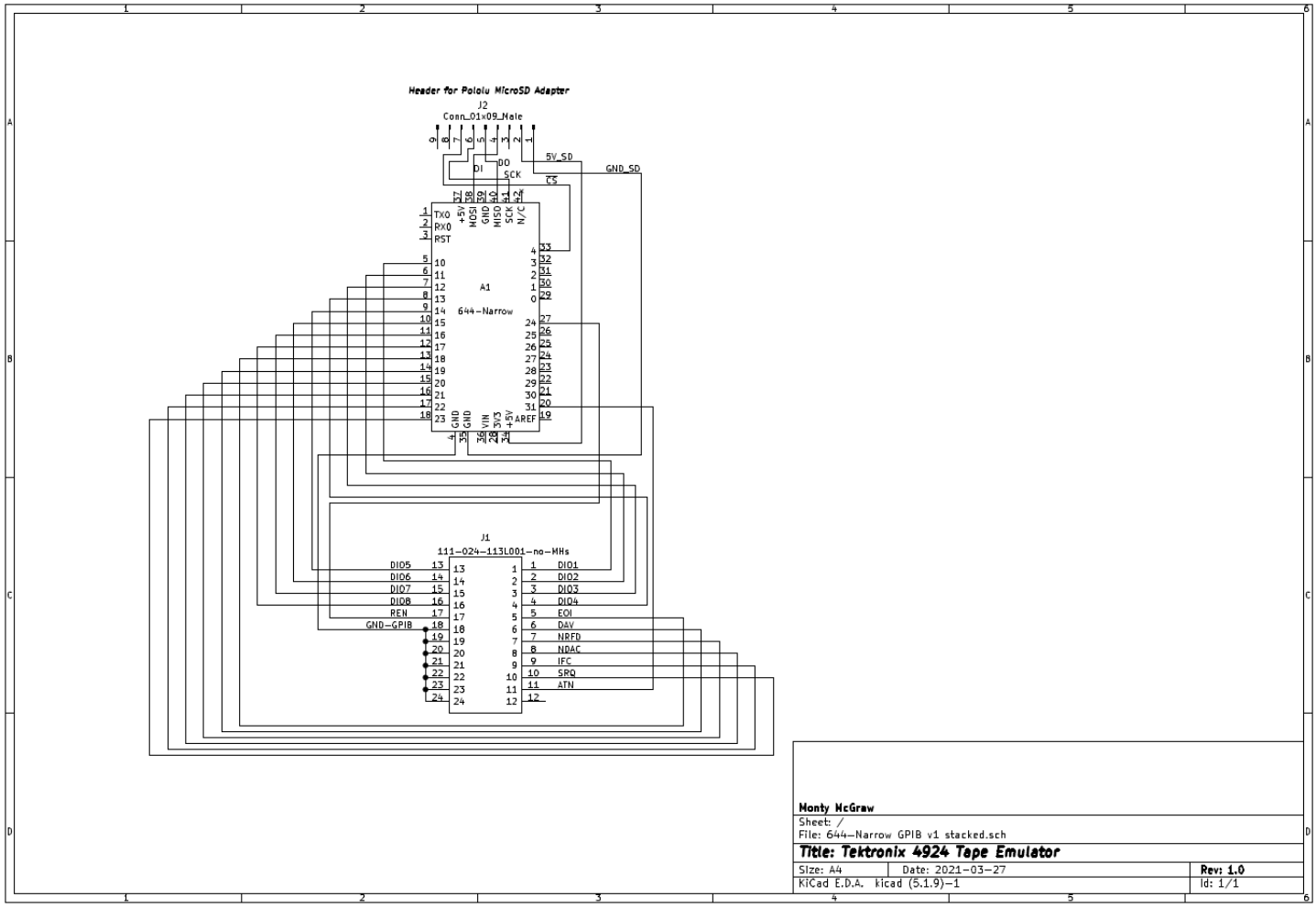


Figure 21 - Flash Drive GPIB Interface PCB Schematic