Reverse Engineering Final Report (Verbatim 32Gb Flash Drive)

Braeden Bateman / MMFG CAD & Manufacturing / 2024-10-03

REVERSE ENGINEERING VERBATIM 32GB STORE ’N’ GO FLASH DRIVE

TABLE OF CONTENTS

Introduction.....3

Reverse Engineering Process.....4

Pictures/visual Documentation.....5

AutoCAD Sketch.....6,7,8

Bill of Materials (zoom in).....9

Principles & Purpose.....10

Conclusion.....11

Sources.....12

INTRODUCTION

This report provides an in-depth study of reverse engineering a USB flash drive, one of the most common portable storage devices. The primary focus is on studying the internal components, and dimensions of the device to gain a complete understanding of how it's designed. By deconstructing the USB flash drive, the goal is to explore the device, and the steps involved in potentially recreating a similar device. The process outlined in this report not only creates a better understanding of the USB's functionality but also serves as a practical demonstration of reverse engineering principles. This report also highlights how reverse engineering can be applied to study, deconstruct, and understand systems and devices.

Reverse Engineering the Verbatim Store n' go 32Gb USB Flash Drive

The Verbatim USB flash drive used in this report is easier to disassemble compared to many other flash drives that just like to break when opening. It contains a sliding mechanism that protects the USB port when not in use, along with an ergonomic design. To get started before deconstruction I took some initial measurements to configure my scale for AutoCAD (e.g., Fig.,5-6), when deconstructed, I discovered a double-sided PCB with surface-mounted components on both sides (e.g., Fig. 7-8). One side contains the passive components such as resistors, capacitors, ~~diodes~~, and the microcontroller, all of which I desoldered and measured to be accurate when recording the device's dimensions (e.g., Fig. 27), the other side houses the NAND flash chip, which is responsible for the device's storage. Based on the branding on the USB port and testing on my computer with chip genius, I confirmed that the flash drive has a capacity of 32GB and that I had the accurate controller for the BOM. All components are labeled and outlined on the PCB with Silkscreen, this allowed me to get a basic idea of what the components were before taking any measurements, as they are generally labeled with universal identifiers such as R, C, and D—representing resistor, capacitor, and diode, (e.g., Fig. 28-29). These labels are common across PCBs, but to be accurate, I tested and measured each component using a Keysight EDU34450A DMM. [7], [8], [9], [10]

REVERSE ENGINEERING PROCESS

Freeing the PCB

To free the PCB, apply a bit of force to the end of the flash drive, pulling it away from the housing. It shouldn't require much effort, and the PCB should easily come out of the sliding mechanism if done correctly. Once it's free, you'll see the PCB mounted in a plastic shell. Simply lift the PCB by the USB port, and it will come out of the plastic completely, leaving you with an exposed USB flash drive. Figure 2

Chip-Genius & Software Identification

Before Measuring dimensions and diving further into the device it's a good idea to test it and identify components you can through software, I used my desktop running windows 11, Verified in disk management that it was in fact 32Gb, to identify the IC chip used, I used Chip-Genius, a software that will show more in depth information about any drive on your computer. When selecting the flash drive Chip-Genius outputs the controller vendor name and part-number, along with other various hardware and manufacturer data. Figure 31

Measuring

Before and after the teardown, take the following measurements of the device:

➢ Housing dimensions: Width, length, and height • PCB with USB: Length • PCB without USB: Length and width • NAND chip: Dimensions of the chip	➢ Passive components: Ohm, and µF • Capacitors: Measured capacitance • Resistors: Measured resistance

Measurements in BOM.

Desoldering

A much more complex task but not too difficult with the right technique, this is essential to get an accurate measurement of the devices both electrically and dimensionally, I used a hot air station with the support of a lot of flux to get the components to flow, then simply pulled them off with tweezers. Figure 27

Reconstructing in AutoCAD & creating BOM

Now with all the data, an accurate sketch in AutoCAD can be made as well as a BOM that contains all the essential information, A hand drawn sketch is helpful before attempting to design the flash drive right in AutoCAD, using AutoCAD techniques learned, I was able to create a simple sketch, that I slowly added more detail to.

PICTURES/VISUAL DOCUMENTATION

Figure 1	Figure 2	Figure 3	Figure 4	Figure 5	Figure 6	Figure 7	Figure 8
Plain JPG Verbatim flash drive	PCB free	Basic teardown	Close up of Nand Flash side	Complete Flash Drive Length	Complete flash drive width	PCB+USB Length	PCB+USB Width
							
Figure 9	Figure 10	Figure 11	Figure 12	Figure 13	Figure 14	Figure 15	Figure 16
Basic sketch	Sketch with passive side	Sketch with Nand flash	IC Controller Width	IC controller Length	Resistor (R17) Length	Resistor (R17) Width	Resistor (R5) length

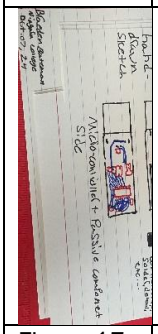
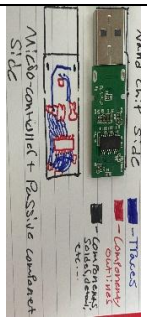
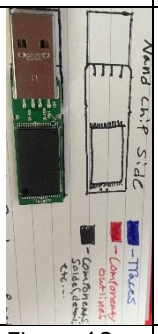
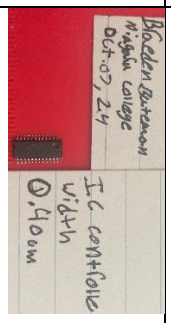
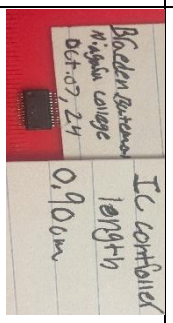
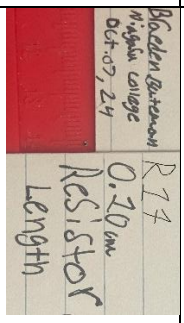
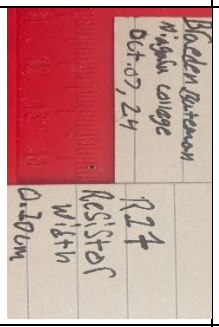
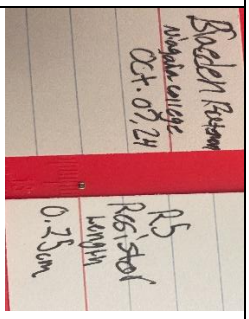

							

Figure 17	Figure 18	Figure 19	Figure 20	Figure 21	Figure 22	Figure 23	Figure 24
Resistor (R5) Width	Capacitor (C8) Width	Capacitor (C8) Length	Capacitor (C6) Width & Length	Capacitor (C10) Length	Capacitor (C10) Width	Capacitor (C4) Width & Length	Capacitor (C9) Width & Length

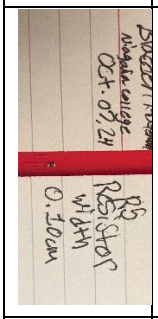
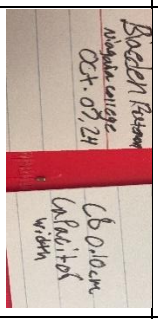
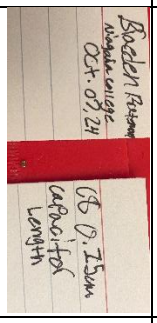
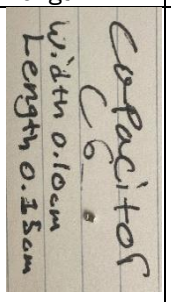
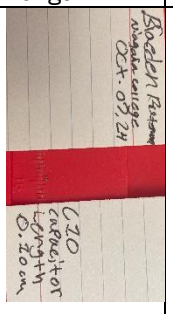
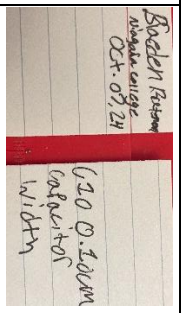
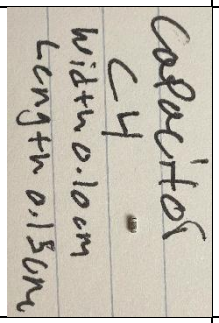
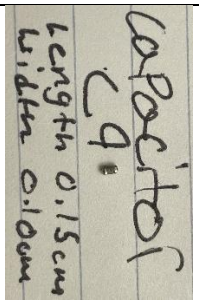
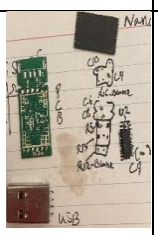
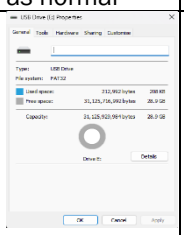
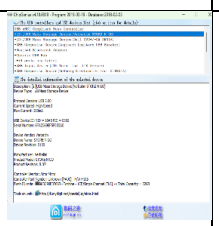
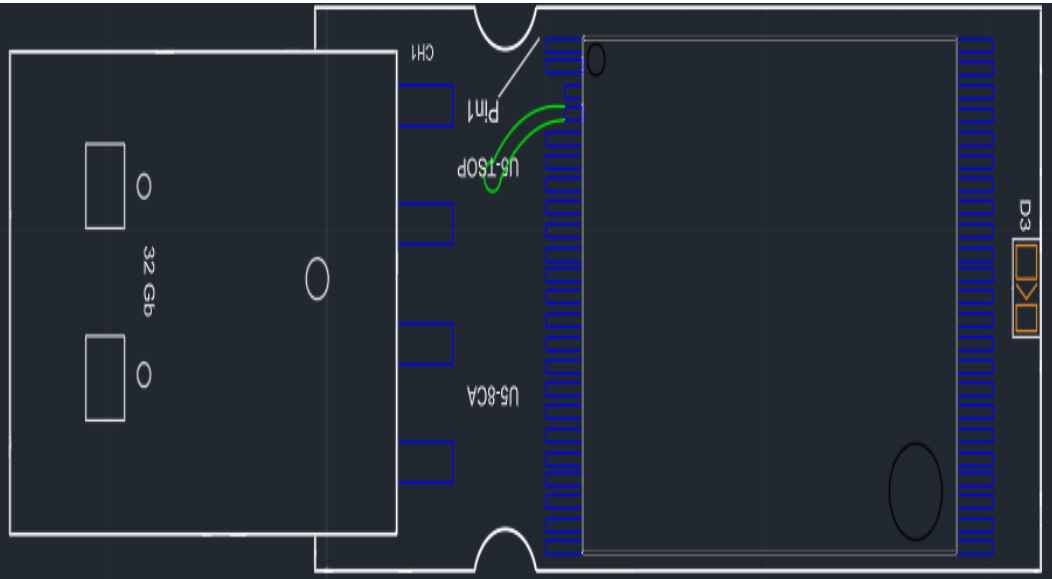

							

Figure 25	Figure 26	Figure 27	Figure 28	Figure 29	Figure 30	Figure 31	
Nand Flash Length	Nand Flash Width	All component removed and laid out	Results of reworking the passive side	Results of reworking the Nand chip	After reworking all components back onto the PCB, it works and functions as normal	Using chip genius to identify IC	
							



Verbatim 32Gb USB Flash Drive PCB Schematic

Scale 1:1 (mm)

Drawn by: Braeden Bateman

October 10, 2024

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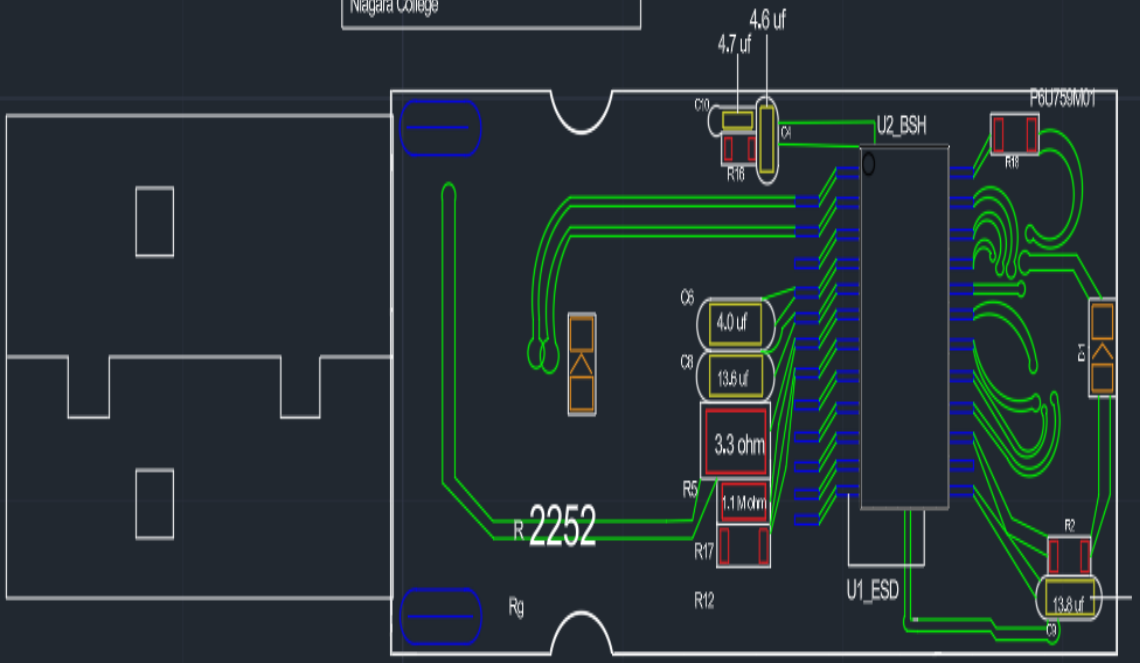
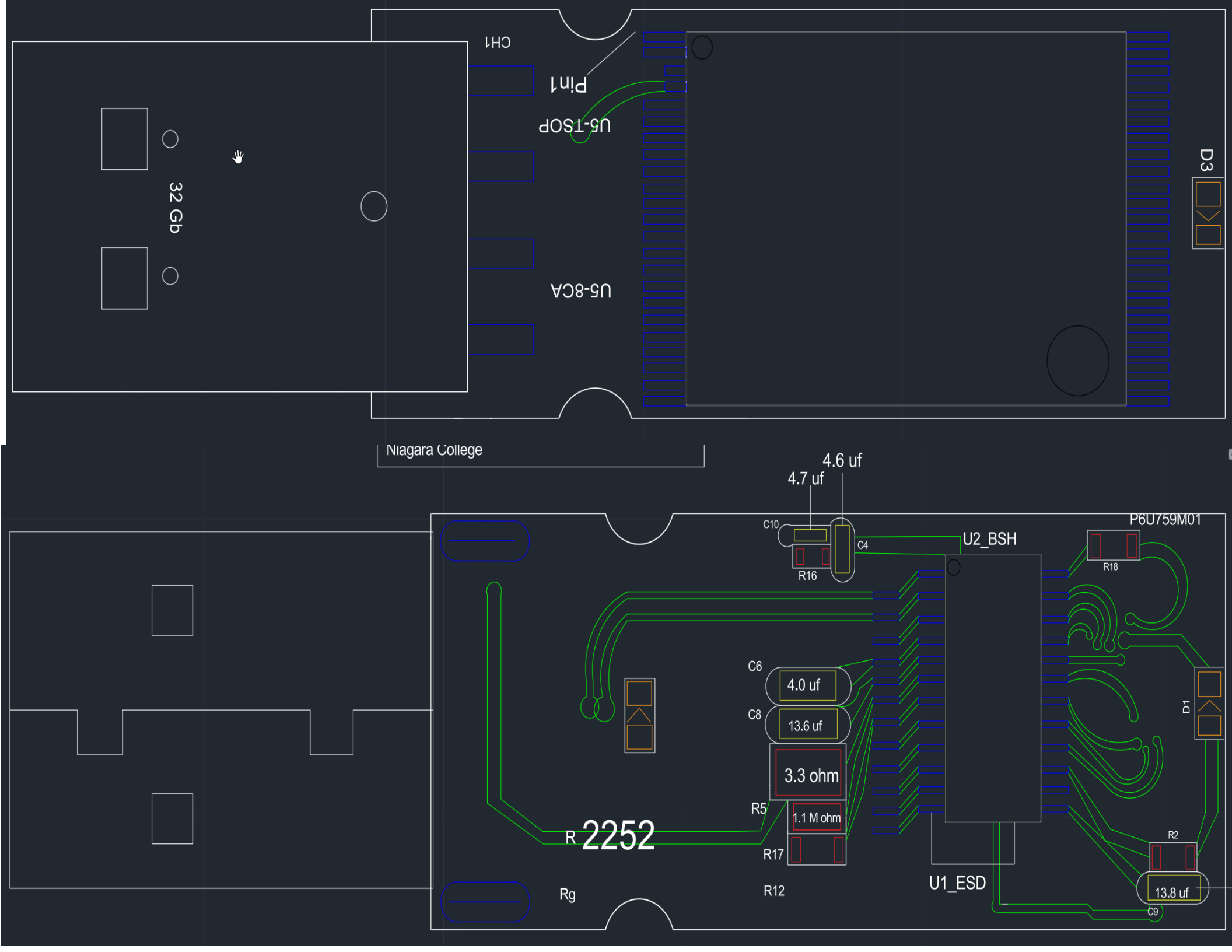
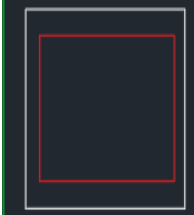
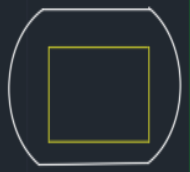


Legend

Resistor	Capacitor	Diodes	Pins	Traces	Chips(NAND/IC)	USB Connector	Silkscreen
							Silkscreen outlines of components and text are white. Oval for Capacitor, Rectangle for resistor.
A red rectangle will represent resistor, with the white silkscreen outline, some resistors are empty and will look like this figure below. Values inside the resistors	Oval shaped figures are capacitor silk screen and the yellow rectangle represents the capacitor its self. values inside the capacitors	This board has no diodes in place so the two small rectangles represent solder pads and the arrow-like figure is the polarity indicator coloured orange.	Small Rectangles Coloured Blue.	Small lines Coloured Green.	Black reclangles with circles are the IC & NAND.		
				Some of the traces are true to the board and others (right side of UD1) are more of a base idea for the direction of the traces			


CH1
Pin1
U5-TSOP
32 Gb
U5-8CA
D3
Niagara College
4.6 uf
4.7 uf
C10
C4
R16
U2_BSH
P6U759M01
R18
C6
4.0 uf
C8
13.6 uf
3.3 ohm
R5
1.1 M ohm
R17
R 2252
Rg
R12
U1_ESD
D1
R2
13.8 uf
C9

Legend

Resistor	Capacitor	Diodes	Pins	Traces	Chips(NAND/IC)	USB Connector	Silkscreen
							Silkscreen outlines of components and text are white, Oval for Capacitor, Rectangle for resistor.
A red rectangle will represent resistor, with the white silkscreen outline, some resistors are empty and will look like this figure below. Values inside the resistors	Oval shaped figures are capacitor silk screen and the yellow rectangle represents the capacitor its self. values inside the capacitors	This board has no diodes in place so the two small rectangles represent solder pads and the arrow-like figure is the polarity indicator coloured orange.	Small Rectangles Coloured Blue.	Small lines Coloured Green.	Black rectangles with circles are the IC & NAND.		
				Some of the traces are true to the board and others (right side of UD1) are more of a base idea for the direction of the traces			

Verbatim 32Gb USB Flash Drive PCB Schematic

Scale 1:1 (mm)

Drawn by: Braeden Bateman

October 10, 2024

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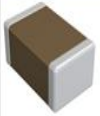
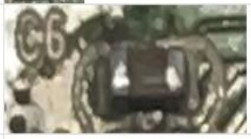
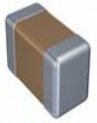
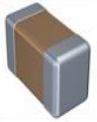
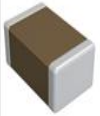
Verbatim 32Gb Store 'n' Go USB Flash Drive Bill of Materials

No.	Name	Picture from USB PCB	Description	Dimensions	Cost CAD	Supplier	Mfr.	Mfr. Part #	Data Sheet	Mfr./Supplier Picture	Notes
1	Male USB-Type A		Standard Male USB Type-A 2.0 (Labeled CN1)	17.58mm-12.00mm-4.50mm	$1.13	Mouser	Same Sky	UP2-AH-1-TH	PDF		4 pin SMT pins, 2 through hole and Horizontal orientation is required.
2	PCB		Standard flash drive PCB	33.00mm-14.00mm-1.00mm	$2.00	jlcpcb	jlcpcb				Needs to be custom made from a manufacturer to be accurate, can recreate with any flash drive PCB but components won't be accurate.
3	Nand Flash Chip		32 Gb TSOP 48-pin Nand Chip	18.00mm-11.00mm-1.00mm	$67.72	Mouser	Micron	MT29F32G08ABAAAWP-ITZ:A TR	PDF		Can be upgraded/ downgraded or replaced with an equivilent chip but must be TSOP and 48-pin.
4	IC Controller(Alcor AU6989SNCS-TA)		SSOP24 flash drive controller (Labeled U2)	9.00mm-4.00mm-1.50mm	$4.03	AliExpress	Alcor Micro	AU6989	PDF		24-pin SMT pins, The AU6989 chip has many different form factors and pinlayouts, this pcb reuires the AU6989SNCS-TA model.
5	Capacitor		0603 4.6 uf Ceramic Capacitor (Labeled C4)	1.60mm-0.80mm-0.50mm	$0.28	DigiKey	Murata	GRJ21BR61E106KE01K	PDF		The capacitors were hard to measure but none exceed the max capacitance value for all these capacitors so they should work
6	Capacitor		0603 4.0 uf Ceramic Capacitor (Labeled C6)	1.60mm-0.80mm-0.50mm	$0.28	DigiKey	Murata	GRJ21BR61E106KE01K	PDF		The capacitors were hard to measure but none exceed the max capacitance value for all these capacitors so they should work
7	Capacitor		0603 13.6 uf Ceramic Capacitor (Labeled C8)	1.60mm-0.80mm-0.50mm	$0.56	DigiKey	TDK Corp	C1608X5R1A156M080AC	PDF		The capacitors were hard to measure but none exceed the max capacitance value for all these capacitors so they should work
8	Capacitor		0603 13.8 uf Ceramic Capacitor (Labeled C9)	1.60mm-0.80mm-0.50mm	$0.56	DigiKey	TDK Corp	C1608X5R1A156M080AC	PDF		The capacitors were hard to measure but none exceed the max capacitance value for all these capacitors so they should work
9	Capacitor		0402 4.7 uf Ceramic Capacitor (Labeled C10)	1.00mm-0.50mm-0.50mm	$0.30	DigiKey	Murata	GRM219R6YA475MA73D	PDF		Capacitor C-10 is sized 0402 which is smaller than 0603 C4-C9.
10	Resistor		0603 3.3 Ohm (Labeled R5)	1.60mm-0.80mm-0.50mm	$0.016	Newark	Panasonic	ERJH3GJ3R3V	PDF		Resistor R5 happens to be labeled "3R3", Universally the "R" signifies a decimal, Measured with the keysight EDU34450A DMM to be accurate.
11	Resistor		0402 1.1 M Ohm (Labeled R17)	1.00mm-0.50mm-0.50mm	$1.45	Newark	TT Electronic	ASC0402-1M5FT10	PDF		Resistor R17 is 0402 which is smaller than R5which size is is 0603
12	Housing		Two-Piece plastic shell	4.80cm-2.00cm-0.75cm	$5.31	DigiKey	Hammond	1551USB2TSK	PDF		Reuse Verbatim's stock housing or can find a cheap equivilent, most wil be standard to flash drive PCB's.

Niagara College Braeden Bateman October 12, 2024

PRINCIPLES & PURPOSE OF REVERSE ENGINEERING

The principles of reverse engineering include deconstruction, which involves the teardown of a system or device to study its components and structure. It also involves studying design intent and choices, focusing on understanding why certain design decisions were made, such as material selection and functionality. Material data collection involves gathering measurements, analyzing dimensions, and identifying key materials used in the device. Finally, prototyping includes creating virtual models or physical mockups, using tools like AutoCAD, to replicate or improve the design. [14]

Principles of Reverse Engineering

- Software Reverse Engineering - Disassembling and studying code of programs, games, proprietary software, etc...
- Hardware Reverse Engineering - Deconstructing a device to study & understand its components and functionality
- PCB Reverse Engineering - Studying & Building a schematic from a PCB (printed circuit board)
- Automotive Reverse Engineering - Studying a vehicle's components & design

[13]

The purpose of reverse engineering is to gain insight into the design, function, and operation of a system. It enables the replication of obsolete parts, helps in identifying vulnerabilities, and supports the improvement of existing products. Reverse engineering also ensures compatibility, facilitates the right to repair when documentation is missing, and allows companies to study competitors' products to inspire innovation in their own designs. [13]

Purpose of Reverse engineering

- Obsolescence - When manufacturers discontinue parts or products
- Security Testing - Reverse engineering software or hardware can expose vulnerabilities.
- Product Development - Understanding a competitor's product for innovation.
- Medical - Reverse engineering medical devices to improve safety, or new technologies.

[13]

The principles of reverse engineering are applied in my report through the teardown of the device to understand its components; by disassembling the flash drive, I could study its design, including component choice and the arrangement on the PCB. AutoCAD and desoldering were used for prototyping, where I created a model to try and replicate the design, and replicate remanufacturing, this applies to product development purpose of engineering. [13]

CONCLUSION

In conclusion, reverse engineering the Verbatim 32Gb Store 'n' Go USB flash drive wasn't a walk in the park but gave me detailed understanding of how a basic USB Flash Drive works and what exactly goes into it, e.g.... Documenting all measurements with pictures as well as looking at datasheets of different components, and Desoldering the components. These are necessary tasks for copying the exact measurements of the components, and different details of the device, a tedious task but worth it to completely understand the device, and my USB still functions after all the poking around, using software like chip genius and stock windows programs like disk manager is an easy and effective way to get information from the USB without getting your hands dirty. The hardest part about the reverse engineering process of the USB flash drive is trying to replicate traces in AutoCAD, it is very tedious and difficult to get everything just right, I also struggled with the scale of my model for a bit but worked through it, overall this was a fun assignment and I can say I've learned a lot about USB flash drives and the overall process and purpose of reverse engineering especially in the tech world.

SOURCES

[1] Torx, “Alcor U2 MP V20.09.16.00 (6989SN-GTC/GTD/GTE/ta),” ALCOR U2 MP v20.09.16.00 (6989SN-GTC/GTD/GTE/TA) - FlashBoot.ru, https://flashboot.ru/files/file/683/ (accessed Oct. 4, 2024).

[2] Alcor Micro – [usbdev.ru], https://www.usbdev.ru/files/alcor/ (accessed Oct. 5, 2024).

[3] Idea&Creation, “3000 flash,” PC, http://www.pc-3000flash.com/solbase/solution.php?task_id=5657&lang=eng (accessed Oct. 7, 2024).

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