

# BackBit

## BackBit Cartridge Documentation v1.4.0

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### Comparison

How does BackBit line up to other storage solutions for your vintage hardware? Let's find out!

	1541 	BackBit 	SD2IEC 	EasyFlash <sup>3</sup> 	Pi1541 	Ultimate-II+ 
Powered by Machine	N	Y	Y	Y	N	Y
C128 Compatibility	Y	Y	Y	N	Y	Y
VIC 20 Compatibility	Y	Y	Y	N	Y	N
Boot directly to menu	N	Y	N	Y	N	Y
# of Cables Required	2	0	Up to 2*	0	2	1
Maximum Capacity	170KB (per disk)	32GB (per card)	32GB (per card)	8MB	No Limit	No Limit
Max. Capacity/File	n/a	4GB (BBT)	16MB (DNP)	1MB (CRT)	800KB (D81)	1MB (CRT)
Typical Price	n/a	\$99	\$60	\$65	\$70	\$150
Fastloader Req'd for Maximum Speed	Y	N	Y	N	Y	Varies***
D64 Compatibility	n/a	Partial#	Partial#	Minimal****	Full	Full
Transfer Mechanism	n/a	SD	SD	USB	SD/USB	USB/RJ45

\* SD2IEC variations exist: (1) no cables plugging directly into IEC & cassette port on C64 (incompatible w/ C128 and SX-64); (2) no cables internally mounted (assembly required); (3) single cable plugging directly into tape port (incompatible w/ SX-64).

\*\* Speeds can be improved by using software fastloaders, KERNAL replacements (assembly required), and CRT format files.

\*\*\* Ultimate-II+ requires a fastloader for multi-file disk images; for onefile programs and cartridges it does not.

\*\*\*\* Using Disk2EasyFlash, it is possible to make conversions, but they are read-only and do not support SEQ/REL files.

# Compatibility is close to 100% with programs that use only standard KERNAL routines.

# Philosophy

When I had access to some Commodore 64s back in 2018, I was searching for the ideal solution to make it easy to load programs. The 1541 disk drive proved to be way too tedious, unreliable, and painfully slow.

I spent some time researching more modern media solutions for the Commodore 64, like the ones listed in the table above. While these solutions did provide some convenience as compared to a 1541 disk drive, they did not perform to my expectations. Individually all of these devices have some impressive features, but they all require a steep learning curve. I wanted something that was more of an effortless all-in-one solution.

My initial vision was to have something like popping a cartridge into the C64GS (Commodore 64 Games System). That was the final revision of the C64, produced in 1990 at a time when Sega & Nintendo had already taken over much of the gaming market (making it a flop). But what if something like the C64GS came out earlier? What if there was a device to turn any Commodore 64 into a C64GS? Well, that vision became BackBit.

My original sketch showed a device that essentially combined the best bits of the SD2IEC and the EasyFlash:

- Like the EasyFlash, it would plug into the cartridge port, allowing autostart;
- Like the SD2IEC, it would take an SD card so as to allow instant access to an effectively unlimited amount of storage (with no EEPROM flashing required);
- Like the EasyFlash, starting a game would be instant;
- It would have access to a large library of downloadable software.

I originally envisioned a device like a 3-legged octopus that would at the same time plug into the cartridge port (for autostart), tape port (for power), and IEC port (for data access). But I soon realized that I could make it simpler. The cartridge port provides power, making the tape port unnecessary. Furthermore, I discovered that I could override a part of the C64's built-in operating system, the KERNAL, to facilitate the loading of unmodified disk images without being physically plugged into the disk drive port (copy-protected images excluded).

While initially I saw the lack of full 1541 emulation as a limitation, I soon realized that it was a feature. With BackBit, you never have to wait for loading, and never have to swap a disk, EVER. To extend compatibility beyond single-disk non-copy-protected titles, I created the open source **BBT** file format, described later in this document under the section BackBit Tool, which offers a near unlimited-capacity one-file solution for developers and hobbyists alike.

# How It Works

Many storage solutions emulate the original 1541 disk drive, inheriting challenges such as:

- The need for fastloaders to provide reasonable loading speeds;
- The need for disk swapping to exceed 170K of program data and content;
- Typing convoluted commands to browse and load programs.

Other solutions allow for easy access to programs, but are often limited:

- They require intricate tools to set up;
- You have to choose between a limited number of titles;
- They don't support common file formats.

BackBit incorporates the best of both worlds, completely eliminating the need for fastloaders, disk swapping, and the typing of convoluted commands, while offering a nearly unlimited capacity of common file formats, accessible on any microSD card.

## BackBit Levels

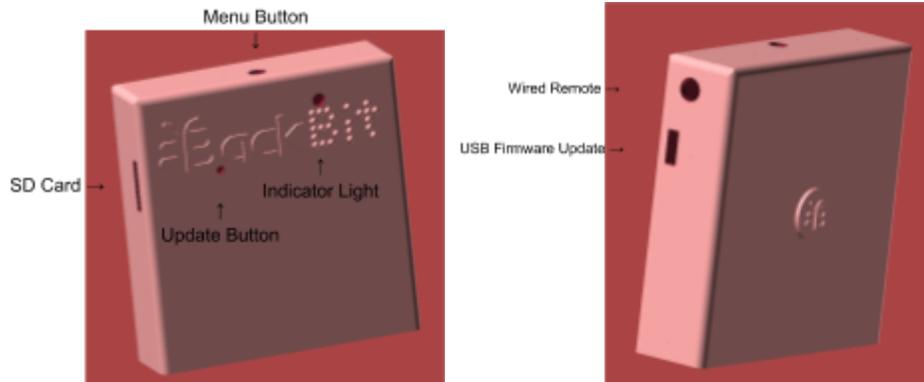
To make it easy to understand the operation of BackBit, you can break it down into 3 levels:

**LEVEL I** : Loads single-file programs, including programs up to 62KB in size and generic 16KB cartridges. Many devices can do this already, so this is just the basic functionality you would expect from a storage device.

**LEVEL II** : Emulates up to 8 disk images at the same time, spanning from device 8 to 15. Rather than relying on the IEC port, this emulation happens through KERNAL vectors. If a program does not implement copy protection, chances are it will work perfectly from the original disk image. Games that are a great example of this include Lode Runner, Ultimate Wizard, Jumpman and many games designed to work with IDE64. While only a single 1541/71/81 disk image can be used by default, you can create a BBT file with the BackBit Tool to use all 8 slots.

**LEVEL III** : Accesses up to 4GB of *extended data*. Is this really a limit? Not really, since it would take the C64 about a day just to process that much information. To access *extended data*, you must use the BackBit Tool to package a BBT file and then use the BackBit API to access the data. More details are explained later in this document.

# Anatomy



The **Menu Button** up top allows you to return to the menu once a program is running. The **Indicator Light** lets you know when requests are being made to the cartridge. The **SD Card** slot accepts any microSD card formatted to FAT32 or FAT16. The slot is designed so that cards will not “fall in” to the cartridge and will be easy to remove.

Connect a Micro USB cable to upgrade firmware. Once software is set up correctly, press the Update button to perform the update. It is not possible to “BRICK” the cartridge. In case of a failed update, you can easily restart the upgrade process.

The wired remote allows you to connect a BackBit Button (available for purchase separately), which simply breaks out the indicator light and menu button, so you don’t have to reach behind the computer, which can sometimes cause unacceptable static electricity interference.

## Summary of Features

- Load programs from microSD card formatted with FAT16/32 (32GB limit);
- Firmware is upgradeable via USB cable;
- “Rip & Burn” – built-in disk copier to facilitate archiving/reproducing real disks;
- Built-in SID player and Koala viewer
- Real time clock to facilitate accurate versioning of files (w/ replaceable CR2032 battery);
- Innovative BBT file format to assemble and run multi-disk programs w/o disk swapping;
- Extended data access provides up to 4GB of data per program;
- Physical button to return to menu from active program;
- Auto-Start mode: Automatically start a specific program w/o user interaction;
- Presentation mode for exhibiting programs non-destructively;
- Optional wired remote control (available for purchase separately).

# Firmware Upgrade

It is possible to upgrade the firmware via a USB cable. You will need a Micro USB cable and a paperclip to complete this process. Make sure the cable is a data cable, not merely a charging cable.

The latest firmware can be downloaded at <http://backbit.io/downloads/Firmware>.

The first time you upgrade, you will have to download some software:

<https://www.pjrc.com/teensy/loader.html>

Instal the Teensy software as instructed for your operating system. Just download the program, you don't need the LED Blink example program. Once it is downloaded, you may want to copy it to a more accessible place (Applications for OSX or start menu for Windows).

Plug in the USB cable—one end to your computer and the other end to the USB port on the BackBit cartridge. It doesn't matter if the cartridge is plugged into the Commodore 64 or not, or whether or not the Commodore 64 is turned on.

Go to the File menu and click Open HEX File. Select the .HEX firmware file you downloaded (it will need to be extracted from the .ZIP container). Now use the paperclip and gently press the program button on the BackBit cartridge (in between the "B" and "a" letters in "Back", or if you have a bare cartridge it's the beige button next to the right of the SD slot.) You should see a progress bar indicating the firmware is transferring to the cartridge.

Once this process is complete, unplug the USB cable and reboot your Commodore 64. To verify the firmware version on the cartridge hold shift or activate shift-lock while the computer is booting up. The version is in the top-right corner.

**Troubleshooting:** If the Teensy application does not recognize the device, you may have to try rebooting your computer or using another cable.

# File Browser

The BackBit file browser allows you to navigate the entire contents of your SD card. There are a few restrictions in how your card must be arranged:

- Must be formatted in FAT32 (or FAT16);
- Must have a folder entitled **BACKBIT** (case-insensitive) in the root folder of your card;
- Folders over 1,000 files will show “<MORE>” at the end of the listing to browse additional files (due to memory restrictions of the device).

## Key Conventions:

↑ Key functions the same as SHIFT + ↑CRSR↓.

← Key functions the same as SHIFT + ←CRSR⇒.

 In many cases either Joystick #1 or Joystick #2 can be used instead of cursor keys.

Press any function key to see a reference of function commands on the status bar.

## Browser Commands:

 **Up** / ↑ / **SHIFT** + ↑**CRSR**↓ - Navigate to last files or item

 **Down** / ↑**CRSR**↓ - Navigate to next file or item

 **Left** / ← / **SHIFT** + ←**CRSR**⇒ - Navigate to last page

 **Right** / ←**CRSR**⇒ - Navigate to next page

 **Fire** / **RETURN** - Choose selected item

**↵** + **RETURN** / **CTRL** + **RETURN** - Open selected disk without automatically starting

**A - Z / 0 - 9 / Space Bar** - Search for title beginning with selected characters

**CLR HOME** - Reset search / Go to top of listing

**INST DEL** - Remove last search character / Close popup / Navigate to parent directory

**RUN STOP** - Open BASIC session

**RESTORE** - Refresh directory (useful after swapping SD Card or encountering error)

**F1 / ESC** - Show UTILS menu (not specific to any item), or hide if already visible.

**F3** - Show PROPS for current item, or hide if already visible.

**F5** - Show SAVES for current item, or hide if already visible.

**F7** - Show TOOLS for current item, or hide if already visible.

**SHIFT LOCK** - Select on bootup to show technical information

# Clock

BackBit comes with a Real Time Clock. This means that even when the power is shut off, your cartridge will remember the time of day. To set the clock for the first time, choose Set Clock from the UTILS menu. Use the cursor keys to navigate the fields and modify values. Be sure to set your time zone, indicated as an offset from UTC. Press return to save changes or menu button to abort.

# Loading Programs

## These file formats are supported:

- PRG/P00 (single program up to 62KB);
- T64 (only supports loading first program from tape image);
- BIN (generic 8K/16K/32K\* cartridges);
- CRT (incl. generic 8K/16K/32K\*/Ultimax, C64GS/System3, Dinamic, Funplay/Powerplay, Magic Desk, Ocean, Prophet 64, Simons Basic, Super Games, Zaxxon);
- VIC 20/VC20 cartridges: 20/40/60/70/A0/B0 (see more details in VIC 20/VC20 section below).
- D64/D71/D81 (1541/71/81 disk; emulated using KERNAL vectors);
- BBT (BackBit format; see BackBit Tool section).

(\*32K cartridges only work on C128)

The file formats are unsupported at this time, but support may be added for them in the future:

- G64/NIB files: BackBit does not physically connect to a disk drive, so it cannot generate these advanced formats. Use NIBTools to convert these files to D64;
- TAP files: BackBit does not emulate tape loading. Convert these to a format BackBit can recognize, like PRG or D64;
- T64 files with more than 1 program: Try converting these to individual PRG/D64 files;
- Disk-based programs that access the serial port directly at \$DDXX or through KERNAL serial device routines, incl. fastloaders: Since BackBit does not physically connect to the C64's serial port, it cannot handle these requests. Fortunately, there is a patching system being built into BackBit to make it possible to run a growing library of programs;
- Certain EasyFlash CRT files: These cartridges push the instant-access capacity of BackBit, however there is growing support to make the entire EasyFlash library work.

## Presentation Mode

Accessible via the UTILS menu (F1), this puts the cartridge in Presentation Mode, identifiable with a blue border. This allows the cartridge to be used in an exhibit or party environment.

Presentation Mode operates similarly to the File Browser with these exceptions:

- Function Key menus and directory refresh are unavailable;
- The last directory navigated in the File Browser is the only one accessible;
- All contents of the current directory are recursively combined into one list;
- Hold menu button while physically resetting computer to disable Presentation Mode.

## Autostart Mode

Accessible via the Tools menu (F7), this puts the cartridge in Autostart Mode. In this mode, the selected program is started automatically upon bootup. Aside from aesthetics, this mode can be helpful for some cartridges that work better on a clean boot.

While in Autostart Mode, the following restrictions apply:

- The File Browser is inaccessible;
- The menu button resets the program;
- Hold menu button while physically resetting computer to disable Autostart Mode.

## Rip/Burn

With BackBit, it is possible to read and write disks with a real 1541 disk drive, simply by plugging the drive into your C64 at the same time the Cartridge is present.

To “Rip” a disk, select this option from the UTILS menu (F1). Then choose a device to read and press return. The disk will be saved as “New Disk” (or as a version inside that disk if one is already present).

To “Burn” a disk, select this option from the tools menu (F7). Only D64 images can be written to a 1541 drive. Then choose a device to write to and press return.

## CRT Support

By default, BackBit natively supports cartridges up to 128KB, and uses a patching system to support cartridges up to 1MB in size. Some C64 revisions, such as the NTSC C64C have a smaller window in which they require data to be sent from the cartridge. Because of this, there can be some flaky behavior with certain cartridges. To remedy this problem, you can enable CRT Support: Compatibility Mode through the UTILS menu (F1) to always use the patching system, regardless of cartridge size.

This mode usually improves compatibility, but there are a few titles (often PAL only) which will not work properly this way, which is why it is turned off by default. If you have any problems getting a particular CRT working on your system, please ask for help with your specific issue at <http://forum.backbit.io>.

# Ultimax Support

By default, BackBit emulates Ultimax cartridges as though they were normal programs. This is to improve compatibility. It is also possible to enable *Native* support through the UTILS menu (F1) which should work in most cases, but may create visual artifacts. Particularly useful here is the ability to autostart advanced cartridges such as Dead Test or KERNAL replacements.

## VIC 20/VC20 Adapter

There is an optional adapter to plug in the BackBit cartridge into your VIC 20/VC20 computer. The BackBit cartridge will detect which system it is being plugged into automatically. Although Commodore 64/128 cartridges are completely different than VIC 20/VC 20 cartridges, the adapter compensates for this difference, and BackBit has a completely different way of talking to the VIC 20/VC20.

Once this adapter is installed, you will be able to boot into BackBit from your VIC/VC computer with a limited 22-column screen. From the F1 menu, you can then select RAM Expansion, from 0K to 35K. Up to 24K will show up instantly in BASIC, and the rest will be accessible from machine code. Based on the amount selected, your program and screen location will change:

Expansion	Program start	Screen start	Color start
0K	\$1000	\$1E00	\$9600
3K	\$0400	\$1E00	\$9600
8K+	\$1200	\$1000	\$9400

In the F1 menu, C64-specific options like CRT and Ultimax support will be hidden.

About VIC 20/VC20 cartridges: These are raw binaries with no header. The extension must match the first 2 hex characters of the loading address, i.e. a \$A000-loading cartridge will be **.a0**. If you have a 2-part cartridge, i.e. some memory at \$2000 and some at \$A000, the autostart portion at \$A000 can simply be binary-appended to the first part, as BackBit will detect the autostart code, i.e. **cat cart.20 cart.a0 > combined.20** on a unix-compatible command-line or **copy /b cart.20 + cart.a0 combined.20** on Windows.

# C128 Mode

BackBit supports loading during “SLOW” mode, the default operating mode of the C128.

*Note that if you lock the C128 in C64 mode by modifying the reset vector at \$FFF8, it will not be able to start another C128 program without physically resetting the machine.*

## Properties

Access properties by pressing F3. This will give you detailed information about a file and allow you to rename it by pressing enter on the name. More options will be provided in future updates, as specifications are ironed out (such as the ability to configure menu-based access to documentation, graphics, title images and music).

## Saves

Access saves by pressing F5. Then choose an item with RETURN and it will show a popup menu with actions. Normally when you open a disk image, it loads the most recent modifications that have been made, such as high scores, user progress or levels. By selecting the original version here, you can load the original unmodified version of the program. You can also do many things with modified versions of the program:

- Open a specific version, i.e. an adventure game with your user’s progress;
- Rename the version;
- Duplicate, i.e. fork the version;
- Erase the version;
- Export to a regular disk image, so that the version doesn’t have to be associated with the original disk anymore.

# Destructive Operations

Preservation is a key goal in the BackBit user experience. By default, no original disk image will be modified. It's as though every disk in BackBit has a backup of the original stashed away. However, there are a few ways you can potentially destroy content, and they should be used with caution:

- Using the Erase option from the Tools menu (F7). There will be a popup that asks you if you are sure;
- In the Saves menu (F5), you can erase a specific version;
- Write errors may occur depending on the quality of the SD card you use, static electricity, or poor connections—so it is recommended that you periodically backup your data to another medium.

## BackBit Tool

The BackBit Tool is an open source cross-platform application available for Linux (32-bit and 64-bit), Mac (64-bit) and Windows (32-bit and 64-bit). Using the tool, you can assemble BBT files which are composed of 3 parts:

1. An auto-start program, i.e. PRG file that will be executed on startup (this is optional, and if not present, a disk image must be present).
2. Up to 8 disk images (D64/D71/D81), assigned automatically to devices 8 through 15. If there is no auto-start program specified, the application will start with LOAD"\*\*,8,1
3. A single binary file, no larger than 4GB that will be available through the API for extended data access.

The source code is available at <https://github.com/evietron/BackBit-Tool>.

The compiled application is free to download and available at <http://backbit.io/downloads>.

## BackBit API

The API is made of up “peeks” and “pokes” to the I/O area in memory related to the expansion port, i.e. memory locations \$DE00-\$DFFF in hex. You must have a knowledge of machine language programming to effectively implement features of this API, although it is also possible to use the BASIC programming language to work with most of these features. In that case, you will have to convert these hex numbers to decimal.

## Peek Commands

This section describes what is obtained when peeking bytes from the I/O area at \$DE00-\$DFFF.

Peek Commands: CODE	
\$DE00 - \$DE02	<b>Identifier.</b> These bytes always return the sequence \$BA \$CB \$17 while the cartridge is active.
\$DEFF	<b>Device Number Filter.</b> This is the maximum device # that the KERNAL emulation will bypass, so it will typically be one less than the first device # emulated, i.e. \$07 if you are using device 8. If KERNAL emulation is not active, this will be \$FF.

Peek Commands: DATA	
\$DF00 - \$DFFF	<b>Requested data.</b> Data appears here in 256-byte blocks when requested from Extended Data or Real Time Clock. Poke to \$DF## to configure which 256-byte block out of up to 64K can be accessible here, i.e. \$DF00 to get the first block and \$DFFF to get the last.

## Poke Commands

The cartridge interprets poke commands based on the address written to, **WHILE IGNORING WHAT DATA IS WRITTEN**. This means that you can interchangeably use STA, STX, or STY instructions when writing to the cartridge at \$DE00-DFFF, and can safely ignore the contents of the A/X/Y registers while doing so. The lower 8-bits of the address are interpreted as a command on the I/O1 channel (\$DE##) and as data on the I/O2 channel (\$DF##). For commands that require parameters, poke each parameter byte to \$DF##, then execute the command at \$DE##.

To prevent conflicts with programs that send non-BackBit requests to the \$DE## memory area, all commands, with the exception of disabling the cartridge memory, have a suffix of \$BB.

When a command is executed, the cartridge will temporarily become unavailable while it is performing the command. This does not interrupt the Commodore's CPU at all, but it makes any cartridge **memory, requests & KERNAL usage** inaccessible until the command completes. To determine if the operation has completed, check for the 3-byte identifier (BA CB 17) at \$DE00.

**Poke Commands: PARAMETERS**

\$DF00 - \$DFFF	<b>Send parameter data.</b> This will add the low byte of this address to the parameter buffer, i.e. \$DF00 will send \$00 and \$DF34 will send \$34. The parameter buffer is limited to 256 bytes, after which it resets and wraps around. In loader or extended data mode, the most recent parameter byte written is used to specify the high address byte.
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**Poke Commands: CONTROL**

These requests control basic interaction with the cartridge.

\$DE00	<b>Disable cartridge memory.</b> Disables access to cartridge memory at \$8000-\$AFFF. Facilitates hiding the cartridge from a loaded program. Does not affect the I/O area at \$DE00-\$DFFF.
\$DE01 [BB]	<b>Enable cartridge memory.</b> Re-enables access to cartridge memory.
\$DE02 [BB]	<b>Return to browser.</b> Informs the cartridge that the program is done and should go back to the browser.
\$DE03 [BB]	<b>Turn on LED until next request.</b> LED remains <b>on</b> until next request.
\$DE04 [Y# M# D# H# M# S# Z# BB]	<b>Adjust real time clock.</b> Modifies the time to <b>Year (+2K) / Month (1-12) / Day (1-31) Hour:Min:Second in Zone (signed, +/- UTC).</b> Time is retained by the cartridge even after powering off the machine.
\$DE05 [BB]	<b>Request real time clock.</b> After calling, access the values here: \$DF00 - \$DF03: Year in ASCII \$DF04 - \$DF05: Month in ASCII \$DF06 - \$DF07: Day in ASCII \$DF08 - \$DF0B: Matches values you'd expect in \$DC08 - \$DC0B. \$DF0C: Time zone (signed byte, +/- UTC).

## Poke Commands: EXTENDED DATA

This feature allows BackBit to access up to 4GB of data from a single program. While this command can take a fraction of a second to run, it sets up a full 64K of data for instant access, 256 bytes at a time. Requested data will be available at \$DFXX with bank switching triggered by writes to the same area. A single poke to \$DFXX switches between 256 byte blocks instantly. Use the BackBit Tool to attach data to a BBT file which uses this feature.

\$DED0 [A# BB]	<b>Access data.</b> Specify 8-bit 64K bank, i.e. \$00 <b>A</b> #0000
\$DED1 [A# B# BB]	<b>Access data.</b> Specify 16-bit 64K bank, i.e. \$ <b>B</b> # <b>A</b> #0000
\$DED2 [A# B# C# BB]	<b>Access data.</b> Specify 24-bit offset, i.e. \$00 <b>C</b> # <b>B</b> # <b>A</b> #
\$DED3 [A# B# C# D# BB]	<b>Access data.</b> Specify 32-bit offset, i.e. \$ <b>D</b> # <b>C</b> # <b>B</b> # <b>A</b> #

## Coding Examples

Example BASIC program to turn on cartridge LED:

```
10 POKE 57275,0 This accesses location $DFBB, sending the $BB parameter
20 POKE 56835,0 This accesses location $DE03, sending the LED command
```

Example machine language program to access extended data at address \$HHMMLL:

```
STA $DFHH ; access specified 64K data bank
STA $DFBB ; send BB command suffix
STA $DED0 ; extended data access command
JSR WaitForAlive ; make sure memory at $DE00...$DE02 returns $BA,$CB,$17
; note that while waiting for process to complete, KERNAL methods are inaccessible
STA $DFMM ; access 256-byte block of requested data bank
LDA $DFLL ; access single byte of specified 256-byte block
```

Note that you can make unlimited requests to data inside a 64K bank once the bank is requested, and you can make unlimited requests for a byte within a 256-byte block once it is requested. So in summary, these are the access times for any given data:

- 4-6 CPU cycles for the LDA/X/Y to access single byte (w/ optional increment and offset);
- 4-7 cycles for STA/X/Y (w/ optional increment/offset) to get next 256-byte block;
- Fraction of a second to queue up another 64K of data using command request and polling to determine when cartridge comes back online. During this time the C64 can perform other processing.

## Optional Accessories

There are many fun and useful accessories to go along with your BackBit cartridge!

- Case: The case is 3D printed with ABS, making it sturdy and protective of static discharge.
- BackButton™ Wired Remote: Allows you to reset your BackBit back to the menu without having to reach to the back of the cartridge (particularly convenient for models such as the C128D and SX-64).
- TwoBit™ Joystick Doubler: Lets one joystick control both ports.
- VIC 20 Adapter (Pre-Order): Lets you use your BackBit cartridge with the VIC 20!
- Gen-Assister (Pre-Order): Lets you plug a Sega Genesis/MegaDrive joystick safely into your Commodore 64, and supports dual fire buttons.
- All accessories are available for purchase at <http://store.backbit.io>.

## The BackBit Forum™

This cartridge is being actively supported, so if you have any trouble whatsoever, please join the public forum at <http://forum.backbit.io>.